CSA Z245.1:22

Steel pipe

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Preface

This is the eleventh edition of CSA Z245.1, *Steel pipe*. It supersedes the previous editions published in 2018, 2014, 2007, 2002, 1998, 1995, 1993, 1990, 1986, and 1982.

This Standard covers the requirements for steel pipe intended to be used for transporting fluids as specified in CSA Z662.

The main changes to this edition are the following:

a) updated optional product ordering requirements (Clause 4.1.2);
b) revised requirements for product analysis retests (Clause 6.3.5);
c) revised requirements for Charpy V-notch impact tests (Clause 7.6, Table 7, Figure 4, and Annex C);
d) revised weld notch-toughness test requirements for electric-welded pipe (Clause 8.5.2);
e) updated requirements for visual inspection of defects (Clause 11.6.1);
f) updated required markings (Clauses 15.2 and 15.4);
g) updated purchase order requirements for elevated temperature service pipe (Clause 17.2);
h) new requirements for pipe for strain-based design (Clauses 18 and 19.7);
i) new hydrostatic test pressure reporting requirements (Clause 19.10); and
j) new requirements for records (Clause 19.11).

This Standard was prepared by the Subcommittee on Materials, under the jurisdiction of the Technical Committee on Petroleum and Natural Gas Industry Pipeline Systems and Materials and the Strategic Steering Committee on Petroleum and Natural Gas Industry Systems, and has been formally approved by the Technical Committee.

Notes:

1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
3) *This Standard was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*
4) *To submit a request for interpretation of this Standard, please send the following information to inquiries@csagroup.org and include "Request for interpretation" in the subject line:*
   a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
   b) *provide an explanation of circumstances surrounding the actual field condition; and*
   c) *where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.*

   Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are available on the* Current Standards Activities *page at standardsactivities.csa.ca.*
5) *This Standard is subject to review within five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line:*
   a) *Standard designation (number);*
   b) *relevant clause, table, and/or figure number;*
   c) *wording of the proposed change; and*
   d) *rationale for the change.*

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Steel pipe

1 Scope

1.1 General

This Standard covers seamless pipe, electric-welded pipe (flash-welded pipe continuously welded and low-frequency electric-welded pipe excluded), and submerged-arc-welded pipe primarily intended for use in oil or gas pipeline systems.

Notes:

1) *Flash-welded pipe is pipe manufactured by a process using electric-resistance heating to produce a simultaneous coalescence over the entire area of the abutting edges and the application of pressure for joining.*
2) *Low frequency is less than 70 kHz.*

1.2 Outside diameter, grade, and category

Note: *It is not intended that pipe be available in all combinations of size, grade, category, and manufacturing process. The individual pipe manufacturers should be consulted to ascertain the availability of specific pipe items.*

1.2.1 Outside diameter

This Standard covers pipe having specified outside diameters (ODs) from 21.3 to 2032 mm. The standard ODs are given in Table B.1.

1.2.2 Grade

For other than sour service, this Standard covers pipe from Grade 241 to Grade 825. For sour service, this Standard covers pipe from Grade 241 to Grade 483.

Note: *The standard grades are Grades 241, 290, 359, 386, 414, 448, 483, 550, 620, 690, and 825; however, intermediate grades may also be used.*

1.2.3 Category

This Standard covers pipe in the following categories:

a) Category I: pipe without requirements for proven pipe body notch-toughness properties;
b) Category II: pipe with requirements for proven pipe body notch-toughness properties in the form of energy absorption and fracture appearance; and
c) Category III: pipe with requirements for proven pipe body notch-toughness properties in the form of energy absorption.

1.3 Terminology

In this Standard, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the Standard; “should” is used to express a recommendation or that which is advised but not required; and “may” is used to express an option or that which is permissible within the limits of the Standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below.

Note: *In cases where the editions listed below are amended, replaced by new editions, or superseded by another standard during the life of this referencing Standard, it is the responsibility of the users of this Standard to investigate the possibility of applying those amendments, new editions, or superseding standards.*

CSA Group

Z662:19
Oil and gas pipeline systems

API (American Petroleum Institute)

5T1:1996 (R2010)
Standard on Imperfection Terminology

RP 5L3:2014 (R2020)
Drop-Weight Tear Tests on Line Pipe

ASME International (American Society of Mechanical Engineers)

BPVC SEC IX–2021
ASME Boiler and Pressure Vessel Code, Section IX — Welding, Brazing and Fusing Qualifications

B1.20.1-2013 (R2018)
Pipe Threads, General Purpose, Inch

ASNT (American Society for Nondestructive Testing)

SNT-TC-1A (2020)
Recommended Practice: Personnel Qualification and Certification in Nondestructive Testing

ASTM International

A370-20
Standard Test Methods and Definitions for Mechanical Testing of Steel Products

A751-21
Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A941-22a
Standard Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

E18-20
Standard Test Methods for Rockwell Hardness of Metallic Materials

E21-20
Standard Test Methods for Elevated Tension Tests of Metallic Materials

E29-13 (2019)
Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E92-17
Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials

E94/E94M-17
Standard Guide for Radiographic Examination Using Industrial Radiographic Film

E140-12B(2019)e1
Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness

E165/E165M-18
Standard Test Method for Liquid Penetrant Examination for General Industry

E384-17
Standard Test Method for Microindentation Hardness of Materials

E709-21
Standard Guide for Magnetic Particle Testing

E747-18
Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E1025-18
Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology

CGSB (Canadian General Standards Board)

CAN/CGSB 48.9712-2014/ISO 9712:2012
Non-destructive Testing — Qualification and Certification of Personnel

ISO (International Organization for Standardization)

2566-1:2021
Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels

5579:2013
Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules

19232-1:2013
Non-destructive testing — Image quality of radiographs — Part 1: Determination of the image quality value using wire-type image quality indicators

NACE International (National Association of Corrosion Engineers)
ANSI/NACE TM0284-2016
Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking

3 Definitions

In addition to the definitions in API 5T1 (imperfection terminology) and ASTM A941 (steel product and heat treatment terminology), the following definitions shall apply in this Standard. The definitions in this Standard shall take precedence.

Analysis —

Heat — the chemical analysis reported by the steel producer as being representative of the heat of steel.

Product — the chemical analysis made on a sample taken from the finished pipe or from material representative of the finished pipe.

Arc burn — an imperfection that results from an arc and consists of any localized remelted metal, heat-affected metal, or change in the surface profile of any part of a weld or parent metal.

Belled end — the expanded end configuration required for a mechanical interference fit method of joining.

Certificate of compliance — a document that states that the product was manufactured, sampled, tested, and inspected in accordance with the requirements of this Standard (including year of publication) and of the purchase order, and was found to have met such requirements.

Daughter coil — the portion of steel removed via slitting, cutting, or shearing from the mother coil which could be used to produce one or more pieces of pipe.

Daughter plate — the portion of steel removed via slitting, cutting, or shearing from the mother plate which could be used to produce one or more pieces of pipe.

Defect — an imperfection of sufficient magnitude to warrant rejection based on the requirements of this Standard.

Dent — a depression caused by mechanical damage that produces a visible disturbance in the curvature of the pipe wall without reducing the wall thickness.

Flattening test — a weld ductility test in which a pipe ring is flattened between parallel plates.

Grade — a designation of the pipe based on strength.
Note: *A grade designation is nondimensional; however, it is numerically equivalent to the specified minimum yield strength in megapascals.*

Guided-bend test — a weld ductility test in which a transverse-weld test specimen is wrapped in a closed helix around a cylindrical pin or guided and forced between two faces of a die by a radiused plunger or cylindrical pin.

Heat — the batch of steel tapped from a melting furnace.

Heat-affected zone — that portion of a weldment consisting of base metal that has not been melted but whose microstructure or mechanical properties have been altered by the heat of welding.

Hooked fibre — a metal separation along an upturned fibre in the weld area of electric-welded pipe.

Imperfection — a material discontinuity or irregularity that is detectable by inspection in accordance with the requirements of this Standard.

Incomplete fusion — a lack of bond between beads or between the weld metal and the parent metal.

Ingot casting — a casting process wherein steel is gravity-poured into a nonoscillating mould where it is solidified.

Lamination — any metal separation generally aligned parallel to the surface of the pipe or skelp.

Mother coil — the entirety of a hot rolled coil of steel processed from a single reheated slab which could be used to produce one or more pieces of pipe.

Mother plate — a hot rolled plate of steel processed from a single reheated slab which could be used to produce one or more pieces of pipe.

Notch toughness — the resistance of the steel to fracture under suddenly applied loads at a notch.

Pipe —

Cold-expanded — pipe that has received a permanent increase in circumference throughout its length while at ambient mill temperature (e.g., by internal hydraulic pressure in closed dies or by internal expanding mechanical dies).

Electric-welded — pipe having a longitudinal welded seam in which the formed edges were heated by electric induction or electric resistance techniques to the coalescence temperature and then joined by mechanical pressure without the addition of extraneous metal.

Seamless — pipe manufactured without a welded seam.

Submerged-arc-welded — pipe having a welded seam in which the formed edges were joined by submerged arc welding.

Pressure casting — a casting process wherein molten steel is bottom-poured into a graphite mould.

Radiographic inspection — the use of X-rays to detect imperfections in the pipe and to present their images on a recording medium.

Radiological inspection — film radiographic inspection, fluoroscopic inspection, or radiographic inspection using nonfilm radiographic imaging techniques.

Sensitivity check — an inspection process to determine whether the response established during the previous standardization has been maintained within acceptable limits.

Skelp — the flat-rolled product intended to be formed into pipe.

Skelp end weld — the weld joining the ends of two lengths of skelp.

Standardization — the adjustment of a nondestructive inspection instrument to an arbitrary reference value.

Strand casting — a casting process wherein molten steel is poured through an oscillating, open-ended, liquid-cooled mould to initiate solidification into a continuous strand.

Undercut — a groove melted into the parent metal adjacent to the weld toe and left unfilled by the deposited weld metal.

Welding —

Flux cored arc — an arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and the work, with shielding provided by a flux contained within the tubular electrode.

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

Gas-metal-arc — an arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and the work, with shielding obtained entirely from an externally supplied gas or gas mixture.

Shielded metal arc — an arc welding process that produces coalescence of metals by heating them with an arc between a covered metal electrode and the work, with shielding obtained from decomposition of the electrode covering.

Note: *Pressure is not used, and the filler metal is obtained from the electrode.*

Submerged arc — an arc welding process that produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and the work, with arc and molten metal shielded by a blanket of granular fusible material on the work.

Note: *Pressure is not used, and the filler metal is obtained from the electrode and sometimes from supplemental sources (e.g., fluxes, metal granules, or combinations thereof).*

4 General requirements

4.1 Product ordering requirements

4.1.1 Standard requirements

The following information shall be included in purchase orders for pipe:

a) the designation and year of publication of this Standard;
b) quantity;
c) grade;
d) category (see Clause 1.2.3);
e) specified pipe test temperature for Category II or III pipe (see Clauses 8.4.2 and 8.5.1.2);
f) process of pipe manufacture (see Clause 1.1);
g) specified OD (see Clause 1.2.1);
h) specified wall thickness (see Table 1 and Clause 10.1.1);
i) nominal length (see Table 2 and Clause 10.5);
j) end finish (see Clause 10.7); and
k) delivery date and shipping instructions.

Notes:

1) *The relationship between pipe dimensions, weight classes, and schedule numbers for pipe up to 323.9 mm OD is given in Annex A.*
2) *The relationship between pipe sizes up to 2032 mm OD and the nominal sizes of matching components is given in Annex B.*

3) *A summary of destructive testing requirements is given in Annex C.*

4.1.2 Optional requirements

Where applicable, purchase orders shall include the following optional requirements:

a) pipe expansion (see Clause 5.4.3);
b) pipe weld and heat-affected zone notch toughness (see Clauses 5.4.6, 7.6, and 8.5);
c) alternative transverse body tension test (see Clause 7.2.4.3);
d) alternative transverse weld tension specimen preparation (see Clause 7.2.5.2);
e) root guided-bend tests on electric-welded pipe (see Clause 8.3.1.2);
f) increased absorbed energy acceptance criterion for Category II pipe (see Clauses 8.4.4.2, 8.5.2.2 and 8.5.2.3);
g) increased absorbed energy acceptance criterion for Category III pipe (see Clause 8.4.5.2);
h) CVN impact tests from weld fusion line of electric-welded Categories II and III pipe with a specified test temperature of lower than –5 °C (see Clause 8.5.2.2);
i) alternative hydrostatic test calculation (see Clause 9.4.2);
j) increased hydrostatic test pressure (see Clause 9.1);
k) supply of mill-jointers (see Clause 10.6.1);
l) alternative values for maximum number of jointers on an order item (see Clauses 10.6.2 and 10.6.4);
m) pipe end bevel (see Clause 10.7.1.2);
n) removal of outside weld reinforcement (see Clause 10.7.1.6);
o) threaded and coupling details (see Clause 10.7.2.2);
p) plant inspection by the purchaser (see Clause 11.2);
q) alternative pipe end OD measurement technique (see Clause 11.4.2.5);
r) special or alternative tolerances on length (see Clause 11.4.6 and Table 2);
s) marking location (see Clause 15.3);
t) coating (see Clause 15.6);
u) sour service (see Clause 16.1);
v) hydrogen-induced cracking testing for sour service (see Clause 16.7);
w) report of steelmaking process and casting method (see Clause 19.2);
x) report of type of skelp rolling mill used (see Clause 19.3);
y) alternative tolerances on wall thickness (see Table 3);
z) alternative tolerances on mass (see Table 4);
aa) elevated temperature service (see Clauses 17.1 and 17.2); and
ab) pipe for strain-based design [see Clause 18.2 a), b), and c)].

4.2 Joinability

4.2.1 Weldability

In general, the weldability of pipe depends on the pipe's chemical and mechanical properties, the pipe end dimensions, the welding procedure, and the welding conditions. Pipe shall be capable of being welded when the welding procedures are in accordance with the requirements of CSA Z662.

4.2.2 Mechanical interference fit method

Pipe specifically supplied with ends prepared for joining by the mechanical interference fit method shall be capable of being so joined when the joining procedures are in accordance with the requirements of CSA Z662.

4.3 Rounding procedure

Except as otherwise required by this Standard, 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 the rounding method of ASTM E29.

4.4 Quality program

The manufacturers of slab/billet, hot rolled coil/plate and pipe shall comply with the requirements of a nationally- or internationally-recognized quality management system.

5 Materials and manufacture

5.1 Steelmaking process

Pipe shall be made from open hearth, electric furnace, or basic oxygen process steel using ingot casting, pressure casting, or strand casting methods.

5.2 Deoxidation practice

Pipe shall be made from semi-killed or killed steel.

5.3 Skelp

5.3.1

Skelp widths for helical seam pipe shall not be less than 0.8 times or more than 3.0 times the pipe's specified OD.

5.3.2

For welded pipe, a coil/plate rolling practice shall be defined and documented stating all critical variables (with tolerances) required to achieve the necessary mechanical properties in the finished pipe. The rolling practice shall be designed and controlled to ensure a suitable uniformity of properties along the entire length of plate/coil intended for manufacture of pipe and among the coil/plates rolled to the same rolling practice from the same heat lot.

5.3.3

The ability of the rolling practice to achieve the pipe mechanical properties shall be demonstrated by way of representative historic data and/or pre-production trials. For grades higher than Grade 359, if the coil/plate is purchased from an external supplier, the pipe manufacturer shall conduct an initial 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.

5.4 Pipe manufacture

5.4.1 Weld passes

For submerged-arc-welded pipe, at least two weld passes shall be used, with at least one pass made from the inside and at least one pass made from the outside.

5.4.2 Skelp end welds

Skelp end welds shall not be permitted in finished pipe except for helical seam pipe having its skelp end welds manufactured by submerged arc welding or a combination of gas metal arc and submerged arc welding. For such helical seam pipe, skelp ends shall have been properly prepared for welding and at least two weld passes shall have been used, with at least one pass made from the inside and at least one pass made from the outside.

5.4.3 Pipe expansion

Unless otherwise specified in the purchase order, the manufacturer shall have the option of making the pipe nonexpanded or cold-expanded.

5.4.4 Weld zone

5.4.4.1

The weld zone of electric-welded pipe shall receive a normalizing heat treatment or a continuous in-line heat treatment, with a minimum temperature of 620 °C, that will control the structure so that the mechanical properties in the weld zone approximate those of the parent metal.

5.4.4.2

Except as allowed by Clause 5.4.4.3, the macrohardness of the weld zone shall not exceed 24 HRC or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E140. (For sour service, see also Clause 16.)

5.4.4.3

For non-sour service grades 483 and higher, the macrohardness of the weld zone shall not exceed 30 HRC or an equivalent value obtained by conversion from another macrohardness scale in accordance with ASTM E140.

5.4.5 Heat-treated pipe identification

Heat-treated pipe shall be identified in accordance with the requirements of Clause 15.2.

5.4.6 Welding procedure qualification

The longitudinal, helical, and skelp end welds, whichever are applicable, of submerged-arc-welded pipe shall be made using welding procedures qualified in accordance with the requirements of the *ASME Boiler and Pressure Vessel Code,* Section IX. Where specified in the purchase order, Charpy V-notch impact tests shall be conducted on test specimens taken from the deposited weld metal and the heat-affected zone of the welding procedure qualification test weld. The test temperature shall be as specified in the purchase order. The absorbed energy (based on full-size test specimens) for each test shall be equal to or greater than 18 J or such higher value as is specified in the purchase order. (For sour service, see also Clause 16.3. For weld impact testing, see Clause 8.5.)

Note: *The supplementary essential variables specified in the* ASME Boiler and Pressure Vessel Code*, Section IX, apply.*

6 Chemical test requirements

6.1 General

Except as allowed by Clause 6.3.5, the methods, practices, and definitions pertaining to chemical analysis shall be in accordance with the requirements of ASTM A751.

6.2 Heat analysis

The requirements for heat analysis shall be as given in Table 5.

6.3 Product analysis

6.3.1 General

The requirements for product analysis shall be as given in Table 5.

6.3.2 Frequency

Product analyses shall be conducted twice per heat, taken from two separate product items.

6.3.3 Sampling methods

Samples for product analysis shall be taken as follows:

a) Seamless pipe — At the option of the manufacturer, samples for product analysis shall be taken from tension test specimens or several locations around the circumference of the pipe. Where applicable, drillings shall be made with a drill size of at least 12.5 mm and shall be made through the thickness after both surfaces have been ground clean.

b) Welded pipe — At the option of the manufacturer, samples for product analysis shall be taken from the pipe or skelp. Samples shall be taken from locations that are representative of the pipe body. Where applicable, drillings shall be made with a drill size of at least 12.5 mm and shall be made through the thickness after both surfaces have been ground clean.

6.3.4 Preparation

Sample preparation and analytical methods shall be such that product analyses are representative of the full thickness of the material. Precautions shall be taken to ensure that contaminated surface layer material is not included in the analytical samples.

6.3.5 Retests

6.3.5.1

Where the product analysis of only one of the samples representing a lot fails to conform to the specified requirements, at the manufacturer's option, the lot shall be rejected or retested using two additional samples taken in the same location from the length represented by the initial analysis that failed.

6.3.5.2

Samples for retests shall be taken and prepared in the applicable manner specified in Clauses 6.3.3 and 6.3.4.

6.3.5.3
Where both retest analyses specified in Clause 6.3.5.1 conform to the specified requirements, the lot shall be accepted.

6.3.5.4
Where the product analysis of both samples representing a lot fails to conform to the specified requirements, or where one or both retest analyses specified in Clause 6.3.5.1 fail to conform to the specified requirements, at the manufacturer's option, the lot shall be rejected or retested using samples taken from two additional lengths of pipe from the affected lot.

6.3.5.5
Where both retests specified in Clause 6.3.5.4 conform to the specified requirements, the lot shall be accepted, except for the length represented by the initial analysis that failed.

6.3.5.6
Where one or both of the retests specified in Clause 6.3.5.4 fail to conform to the specified requirements, the nonconforming lengths shall be rejected and, at the manufacturer's option, the lot shall be rejected or the remaining lengths in the lot shall be tested individually, with any nonconforming lengths being rejected. For such individual length testing, the determinations may include only those elements that failed to conform to the specified requirements in the preceding tests of the affected lot.

7 Mechanical test procedures

7.1 General

7.1.1
Test specimens shall not be heat treated but shall be taken from pipe in the same heat-treatment condition as the finished bare metal pipe and shall be representative of the pipe in the plain end condition.

7.1.2
For any of the mechanical tests specified in Clauses 7.2 to 7.8, test specimens showing defective preparation or material imperfections unrelated to the intent of the particular mechanical test, whether observed before or after testing, may be discarded, and replacements shall be considered as original test specimens. Where the imperfection revealed is such that the conformance of the pipe to this Standard is in doubt, the length of pipe from which the test specimen was taken shall be reinspected.

7.2 Tension tests

7.2.1 General
Except as otherwise required by this Standard, test specimens and testing procedures shall be in accordance with the requirements of ASTM A370. Testing shall be conducted with the test specimens at room temperature. Yield strength and tensile strength results shall be rounded to the nearest megapascal.

7.2.2 Yield strength

For Grade 241 to Grade 620, the yield strength shall be the tensile stress required to produce a total extension under load of 0.5% of the gauge length. For grades higher than Grade 620, the yield strength shall be determined by the 0.2% offset method.

7.2.3 Longitudinal tension tests

7.2.3.1

Longitudinal tension tests shall include determinations of yield strength, tensile strength, yield-to-tensile-strength ratio (where applicable), and elongation.

7.2.3.2

Except as allowed by Clause 7.2.3.4, tension test specimens shall be full-section test specimens or strip test specimens as shown in Figure 1, at the option of the manufacturer.

7.2.3.3

Strip test specimens from seamless pipe may be taken from any location, at the option of the manufacturer. Strip test specimens from longitudinal seam pipe shall be taken approximately 90° from the weld. Strip test specimens from helical seam pipe shall be taken parallel to the axis of the pipe and at such a position that the centre of the test specimen is located one-quarter of the distance between adjacent weld convolutions.

7.2.3.4

Strip test specimens shall be tested using suitable curved-face testing grips or by cold flattening the test specimen in the grip area and using flat-face testing grips. Strip test specimens shall be 38 mm (+3 mm, –6 mm) wide in the gauge length unless the size of the pipe or the character of the material to be tested makes the use of subsize test specimens necessary. For such cases, the test specimens shall be 19 mm (+3 mm, –6 mm) wide for pipe 88.9 mm OD or smaller and 25 mm (+3 mm, –6 mm) wide for pipe larger than 88.9 mm OD up to 168.3 mm OD.

7.2.3.5

Longitudinal test specimens shall represent the full wall thickness of the pipe from which the test specimens were taken and shall be tested without flattening, except as allowed by Clause 7.2.3.4.

7.2.4 Transverse body tension tests

7.2.4.1

Transverse body tension tests shall include determinations of yield strength, tensile strength, yield-to-tensile-strength ratio (where applicable), and elongation.

7.2.4.2

Except as allowed by Clause 7.2.4.3, tension test specimens shall be strip test or round test specimens, as shown in Figure 1.

7.2.4.3

Subject to agreement by the purchaser, yield strength may be determined using the ring expansion method.

7.2.4.4
Test specimens from longitudinal seam electric-welded and submerged-arc-welded pipe shall be taken opposite the weld.

7.2.4.5
Test specimens from helical seam submerged-arc-welded pipe shall be taken with the centre of the test specimen located approximately one-half of the distance between adjacent weld convolutions.

7.2.4.6
Test specimens shall be taken at 90° to the axis of the pipe. Hot flattening of the test specimens shall not be permitted.

7.2.4.7
Round test specimens shall be obtained from nonflattened pipe sections, and their nominal diameter shall be as given in Table 18. For test specimens having a specified gauge length less than 50 mm, the measured elongation after fracture shall be converted to a percentage elongation in 50 mm in accordance with ISO 2566-1.

7.2.4.8
When strip test specimens are used, the manufacturer shall follow a written procedure for flattening the test coupon.

7.2.5 Transverse weld tension tests

7.2.5.1
For electric-welded pipe, transverse weld tension tests shall include determination of tensile strength. For submerged-arc-welded pipe, transverse weld tension tests shall include determination of tensile strength and elongation.

7.2.5.2
Test specimens shall be taken at 90° to the weld with the weld at the centre, as shown in Figure 1, and shall represent the full wall thicknesses of the pipe from which the test specimens were taken. Unless otherwise agreed to by the purchaser, or where all or part of the weld reinforcement is removed for the full length of the weld as part of the manufacturing process, the weld reinforcement shall not be removed. Test specimens shall not be hot flattened.

7.2.6 Retests

7.2.6.1
Where the tension test representing a lot fails to conform to the specified requirements, at the manufacturer's option, the lot shall be rejected or retested using test specimens taken from two additional lengths of pipe from the affected lot.

7.2.6.2
Test specimens for retests shall be taken in the applicable manner specified in Clauses 7.2.3 to 7.2.5.

7.2.6.3

For pipe grades less than Grade 414, where both retests conform to the specified requirements, the lot shall be accepted, including the initial test length (the length from which the initial test specimen was taken), provided that the following locations, as applicable, in such a length are subsequently tested and such retests conform to the specified requirements:

a) where the length does not contain a skelp end weld, both ends of the length; or
b) where the length contains a skelp end weld, both ends of the initially tested portion of the length.

7.2.6.4

For pipe Grades 414 and higher, where both retests conform to the specified requirements and provided individual pipe traceability to mother coil/plate location, the manufacturer shall test additional lengths adjacent to (before, after, and beside, as applicable) the initial failure within the mother coil or plate considering adjacent daughter coil(s) or plate(s) as applicable. Pipe testing shall continue until satisfactory results (see Clause 8.2.1) surround the non-conforming section of the mother coil/plate. The pipes from the nonconforming section of mother coil/plate shall be rejected, and the remainder of the pipe from the lot shall be accepted, including the initial test length (the length from which the initial test specimen was taken), provided that the following locations, as applicable, in such a length are subsequently tested and such retests conform to the specified requirements:

a) where the length does not contain a skelp end weld, both ends of the length; or
b) where the length contains a skelp end weld, both ends of the initially tested portion of the length.

7.2.6.5

Where one or both of the retests fail to conform to the specified requirements, the nonconforming lengths shall be rejected and, at the manufacturer's option, the remaining lengths in the lot shall be rejected or tested individually, with any nonconforming lengths being rejected.

7.3 Flattening tests — Electric-welded pipe

7.3.1 General

Flattening tests shall be made on test rings at least 65 mm long that shall be flattened between parallel plates. No openings in the specimen shall occur before the distance between the plates is one-half of the specified OD of the pipe. Precautions shall be taken so that test rings can be identified with respect to the pipe from which they were taken.

7.3.2 Electric-welded pipe produced in single lengths

7.3.2.1 Procedure

For electric-welded pipe produced in single lengths, two test rings taken from each end of each pipe shall be tested with the weld alternately at 0° and 90° to the applied force, except that for pipe subjected to root guided-bend testing in accordance with the applicable requirements of Clause 7.5.2, the 0° tests need not be done.

7.3.2.2 Retests

Where one or more of the flattening tests representing a pipe fail to conform to the specified requirements, the affected pipe shall be rejected or retested using additional test rings taken from the nonconforming ends until the requirements are met, provided that such retesting does not reduce the pipe's length by more than 20%.

7.3.3 Electric-welded pipe produced from coiled skelp

7.3.3.1 Specific definition

For each coil welded, a multiple length is the tubular product that is bounded by the following:

a) for coils welded without an intermediate weld stop, the leading and trailing coil end locations; or
b) for coils welded with one or more intermediate weld stops,
   i) the leading coil end location and the first subsequent weld stop location;
   ii) any two consecutive intermediate weld stop locations; and
   iii) the last intermediate weld stop location and the trailing coil end location.

7.3.3.2 Procedure

For electric-welded pipe produced from coiled skelp in multiple lengths and subsequently cut into single lengths, for each multiple length two test rings from the leading end of the first pipe and two test rings from the trailing end of the last pipe shall be tested with the weld alternately at 0° and 90° to the applied force, except that for pipe subjected to root guided-bend testing in accordance with the applicable requirements of Clause 7.5.2, the 0° tests need not be done.

7.3.3.3 Retests

Where one or more of the flattening tests representing a multiple length fail to conform to the specified requirements, the affected multiple length shall be given one of the following dispositions:

a) The pipes produced from the affected multiple length shall be rejected.
b) The satisfactory portion of the affected multiple length shall be accepted. All test results representing locations adjacent to and within such satisfactory portions shall conform to the specified requirements. The defective portion at nonconforming ends of the affected multiple length shall be removed, as confirmed by retesting and obtaining conforming flattening test results (0°, 90°, or both, depending on which test results were originally nonconforming) for
   i) both ends of the first satisfactory pipe adjacent to the defective portion; or
   ii) the extreme end (that end corresponding to the adjacent nonconforming end location) of the first two consecutive satisfactory pipes adjacent to the defective portion.

7.3.4 Hot reduced electric-welded pipe

7.3.4.1 Procedure

For hot reduced electric-welded pipe, two test rings taken from one end of a pipe from each lot shall be tested with the weld alternately at 0° and 90° to the applied force.

7.3.4.2 Retests

7.3.4.2.1

Where one or both of the flattening tests representing a lot fail to conform to the specified requirements, the nonconforming pipe shall be rejected and the affected lot shall be rejected or retested using test rings (at 0°, 90°, or both, depending on which test results were originally nonconforming) taken from each of two additional pipes from the remainder of the affected lot.

7.3.4.2.2

Where both retests conform to the specified requirements, the remainder of the affected lot shall be accepted.

7.3.4.2.3
Where one or both of the retests fail to conform to the specified requirements, the nonconforming pipes shall be rejected, and the remaining pipes in the affected lot shall be rejected or tested individually, with any nonconforming pipes being rejected.

7.4 Bend tests — Electric-welded pipe

7.4.1 Procedure
A full-section test specimen of appropriate length shall be taken from one end of a pipe from each lot and shall be bent cold through 90° around a mandrel having a diameter not greater than 12 times the specified OD of the pipe being tested, with the weld located approximately 45° from the point of contact of the test specimen and the mandrel. No opening on the outside surface of the pipe shall occur during the entire bending operation.

7.4.2 Retests

7.4.2.1
Where the bend test representing a lot fails to conform to the specified requirements, the nonconforming pipe shall be rejected, and the affected lot shall be rejected or retested using test specimens taken from two additional pipes from the remainder of the affected lot.

7.4.2.2
Where both retests conform to the specified requirements, the remainder of the affected lot shall be accepted.

7.4.2.3
Where one or both of the retests fail to conform to the specified requirements, the nonconforming pipes shall be rejected and the remaining pipes in the affected lot shall be rejected or tested individually, with any nonconforming pipes being rejected.

7.5 Guided-bend tests

7.5.1 Submerged-arc-welded pipe

7.5.1.1 Procedure

7.5.1.1.1
One face-bend and one root-bend test specimen, in accordance with the requirements of Figure 2, shall be obtained from a pipe from each lot and bent cold approximately 180° in a jig substantially in accordance with the requirements of Figure 3.

Note: *The wraparound jig type should be used for grades higher than Grade 690 to ensure uniform deformation around the mandrel.*

7.5.1.1.2
Except as allowed by Clauses 7.5.1.1.3 and 7.5.1.1.4, the test specimens shall not fracture completely and no opening in the weld metal or between the weld metal and the parent metal exceeding 3 mm in any direction shall occur during the entire bending operation.

7.5.1.1.3
Openings that originate at an edge of a test specimen and are less than 6 mm long shall not be cause for failure of the guided-bend test.

7.5.1.1.4
Openings that are less than 12.5% of the specified wall thickness in depth and result from a subsurface discontinuity in the parent metal shall not be cause for failure of the guided-bend test.

7.5.1.2 Retests

7.5.1.2.1
Where one or both of the guided-bend test specimens representing a lot fail to conform to the specified requirements, the affected lot shall be rejected or retested using test specimens obtained from two additional pipes from the remainder of the affected lot.

7.5.1.2.2
Where both retests conform to the specified requirements, the remainder of the affected lot shall be accepted. The initial nonconforming pipe shall be rejected unless the manufacturer qualifies it by
a) inspection;
b) evaluating the nature of the defective material;
c) removing the defective portion of the pipe;
d) retesting the affected ends of the pipe; and
e) obtaining guided-bend test results that conform to the specified requirements.

7.5.1.2.3
Where one or both of the retests fail to conform to the specified requirements, the nonconforming pipes shall be rejected and the remaining pipes in the affected lot shall be rejected or tested individually, with any nonconforming pipes being rejected, unless the manufacturer qualifies them by
a) inspection;
b) evaluating the nature of the defective material;
c) removing the defective portion of the pipe;
d) retesting the affected ends of the pipe; and
e) obtaining guided-bend test results that conform to the specified requirements.

7.5.2 Electric-welded pipe

7.5.2.1 General
Root guided-bend test specimens shall be in accordance with the dimensional requirements of Figure 2 and shall be bent cold approximately 180° in a jig substantially in accordance with the requirements of Figure 3. The test specimens shall not fracture completely and no opening larger than 3 mm shall occur during the entire bending operation.

7.5.2.2 Electric-welded pipe produced in single lengths

7.5.2.2.1 Procedure
For each end of electric-welded pipe produced in single lengths, one root guided-bend test shall be conducted.

7.5.2.2.2 Retests

Where one or both of the root guided-bend tests representing a pipe fail to conform to the specified requirements, the pipe shall be rejected unless the manufacturer qualifies it by

a) inspection;
b) evaluating the nature of the defective material;
c) removing the defective portion of the pipe;
d) retesting the affected ends of the pipe; and
e) obtaining guided-bend test results that conform to the specified requirements.

7.5.2.3 Electric-welded pipe produced from coiled skelp

7.5.2.3.1 Procedure

For electric-welded pipe produced in multiple lengths (see Clause 7.3.3.1) and subsequently cut into single lengths, one root guided-bend test shall be conducted for the leading end of the first pipe and the trailing end of the last pipe of each multiple length.

7.5.2.3.2 Retests

Where one or both of the root guided-bend tests representing a multiple length fail to conform to the specified requirements, the affected multiple lengths shall be given one of the following dispositions:

a) the pipes produced from the affected multiple lengths shall be rejected; or
b) the defective portion at nonconforming ends of multiple lengths shall be removed, as confirmed by retesting and obtaining conforming root guided-bend test results from both ends of the first satisfactory consecutive pipes adjacent to the defective portion or, alternatively, from the extreme end (that end corresponding to the nonconforming end location) of the first two satisfactory consecutive pipes adjacent to the defective portion, so that all test results representing locations adjacent to and within satisfactory portions of multiple lengths conform to the specified requirements.

7.6 Charpy V-notch impact tests

7.6.1 General

7.6.1.1

Except as allowed by Clause 7.6.1.2, Charpy V-notch impact tests shall be conducted as specified in ASTM A370, with the notch perpendicular to the surface of the pipe. An impact test shall consist of testing three adjacent test specimens taken from a single test coupon. The result shall be the average of the results of the three test specimens and shall be rounded to the nearest per cent or joule, whichever is applicable. The test result is acceptable when the following conditions are met:

a) the test result (average of three specimens) equals or exceeds the specified test minimum value (as specified in Clauses 8.4 and 8.5);
b) the individual value for not more than one specimen measures less than the specified test minimum value; and
c) the individual value for any specimen measures not less than two-thirds of the specified test minimum value.

7.6.1.2

For pipe having a specified OD and wall thickness combination that is not covered by Table 7, full-size, subsize, or nonstandard subsize test specimens may be used, provided that

a) the test specimens are taken from pipe;
b) for pipe body tests, the test specimen orientation is transverse to the pipe axis;
c) for pipe weld tests, the test specimen orientation is transverse to the weld axis;
d) the central portion of the test specimen is fully machined; and
e) where practicable, the specified wall thickness is at least 1.0 mm more than the test specimen width.

Note: *CSA Z662 does not require that notch toughness be proved for such pipe sizes, and in some cases, the test results will not be meaningful.*

7.6.1.3

Test specimens for pipe weld tests shall be etched prior to notching to enable proper placement of the notches. For deposited weld metal tests, the axis of the notch shall be located as close as practical to the centreline of the outside weld bead and as close as practical to the outside surface. For HAZ tests, the axis of the notch shall be located as close as practical to an edge of the outside weld bead.

For weld fusion line tests of electric-welded pipe, the notch shall be located within 0.5 mm of the fusion line. For weld zone tests of electric-welded pipe, the notch shall be located within 3 mm of the weld fusion line.

7.6.2 Test specimen size

7.6.2.1

Except as allowed by Clauses 7.6.1.2 and 7.6.2.3, the test specimen size shall be as given in Table 7.

7.6.2.2

Where subsize test specimens are used, the minimum energy absorption value requirements shall be those specified for full-size test specimens (see Clause 8.4.4.2, 8.4.5.2, 8.5.1, or 8.5.2, whichever is applicable) times the ratio of the test specimen width to the full-size test specimen width, with the calculated values rounded to the nearest joule.

7.6.2.3

Where the energy needed to break a test specimen of the size specified in Table 7 is expected to exceed 80% of the capacity of the impact testing machine or where the actual wall thickness at the critical cross-section is expected to be too thin to permit machining to the specified test specimen size, the next smaller test specimens size shown in Table 7 may be substituted.

7.6.3 Test specimen type, orientation, and location

7.6.3.1

Except as allowed by Clause 7.6.1.2, the type of test specimen (nonflattened or flattened) shall be as given in Table 7.

7.6.3.2

For pipe body tests, the test specimen orientation shall be transverse to the pipe axis. For pipe weld tests, the test specimen orientation shall be transverse to the weld axis.

7.6.3.3
For welded pipe, pipe body test specimens shall be taken from a location approximately 90° from the weld, measured transversely to the pipe axis.

7.6.4 Retests — Pipe body

7.6.4.1
Where the impact test representing a lot fails to conform to the specified requirements, at the manufacturer's option, the lot shall be rejected or retested using test specimens taken from two additional lengths of pipe from the affected lot.

7.6.4.2
Where both retests conform to the specified requirements, the lot shall be accepted, including the initial test length (the length from which the initial test specimen was taken), provided that the following locations, as applicable, in such a length are subsequently tested and such retests conform to the specified requirements:

a) where the length does not contain a skelp end weld, both ends of the length; or
b) where the length contains a skelp end weld, both ends of the initially tested portion of the length.

7.6.4.3
Where one or both of the retests fail to conform to the specified requirements, the nonconforming lengths shall be rejected and, at the manufacturer's option, the remaining lengths in the lot shall be rejected or tested individually, with any nonconforming lengths being rejected.

7.6.5 Retests — Pipe weld

7.6.5.1 Submerged-arc-welded pipe

7.6.5.1.1
Where the impact test representing a lot fails to conform to the specified requirements, at the manufacturer's option, the lot shall be rejected or retested. The retest shall be conducted using test specimens obtained from two additional pipes from the affected lot or at the test frequency specified by the purchaser.

7.6.5.1.2
Where the retests conform to the specified requirements, the lot shall be accepted, including the initial tests length (the length from which the initial tests specimens were taken), provided that

a) any skelp end weld or circumferential weld that initially failed is removed; and
b) both ends of any longitudinal or helical seam weld that initially failed are retested and such retests conform to the specified requirements.

7.6.5.1.3
Where one or more of the retests fail to conform to the specified requirements, the nonconforming lengths shall be rejected and, provided that the defective weld is a longitudinal or helical seam weld, at the manufacturer's option, the remaining lengths in the lot shall be rejected or tested individually, with any nonconforming lengths being rejected.

7.6.5.2 Electric-welded pipe

Where the impact test representing a lot fails to conform to the specified requirements, the manufacturer may elect to perform one or more of the following steps (see Figure 4):

a) Remove all sequentially welded material between the last acceptable test result and the failed test on that welding line. Pipe made after the original failure shall not be considered to meet the requirement until a test on a pipe is achieved that meets the requirement [see Figure 4 a)].
b) Conduct additional testing to more precisely isolate the population of sequentially welded pipes affected by the failure condition:
    i) Test two additional lengths, one either side of the original failure. The selection of the lengths for retesting is at the manufacturer's discretion and need not be adjacent to the original failure or be part of the original lot. If both of the new tests meet the acceptance criteria, then only the material between these tests shall be considered not to meet the requirement [see Figure 4 b) i)].
    ii) Subsequent additional testing closer to the original failure may be performed to refine the extent of the failure condition and reduce the amount of material that is not considered to meet the requirement [see Figure 4 b) ii)].
    iii) The length from which the initial test specimens were taken may be accepted, provided that
        1) pipe testing on either side of the initial tested length (original failure) meets the requirement;
        2) any skelp end weld or circumferential weld that initially failed is removed;
        3) both ends of the weld seam that initially failed are retested; and
        4) both such retests conform to the specified requirements.
c) If any retest fails to meet the original acceptance criteria, the manufacturer may elect to continue testing pipe that was made on the same sequential weld line further away from the original failure and failed retest until an acceptable test result is achieved. All pipe between adjacent acceptable sequentially welded pipe tests shall be considered not to meet the original test criteria [see Figure 4 c)].

Note: *Weld Charpy V-notch testing is considered a process test for electric-welded pipe and is treated accordingly in a retesting procedure. For this purpose, weld Charpy V-notch retesting is considered independent of the defined lot (see Table 10). The intent of this Clause is to outline a bracketing process for retesting in order to find the beginning and end of the failure condition to identify and remove the population of pipe that does not meet the required test criteria.*

7.7 Drop-weight tear tests

7.7.1 General

Drop-weight tear tests shall be conducted in accordance with the requirements of API RP 5L3. A test shall consist of testing two adjacent test specimens, with the fracture appearance value being the average of the two individual test specimen results, rounded to the nearest per cent.

7.7.2 Orientation and location

Drop-weight tear test specimens shall be oriented transversely to the pipe axis as shown in Figure 5. For welded pipe, test specimens shall be taken at a location approximately 90° from the weld, measured transversely to the pipe axis.

7.7.3 Test specimen evaluation

7.7.3.1

Test specimens shall be evaluated by determining the per cent shear area of the fracture surfaces.

7.7.3.2
Where there are disputes concerning the results obtained using different methods of evaluation allowed by API RP 5L3, the referee method shall be planimetric measurement.

7.7.4 Retests

7.7.4.1
Where the drop-weight tear test representing a lot fails to conform to the specified requirements, at the manufacturer's option, the lot shall be rejected or retested using test specimens taken from two additional lengths of pipe from the affected lot.

7.7.4.2
Where both retests conform to the specified requirements, the lot shall be accepted, including the initial test length (the length from which the initial test specimen was taken), provided that the following locations, as applicable, in such a length are subsequently tested, and such retests conform to the specified requirements:

a) where the length does not contain a skelp end weld, both ends of the length; or
b) where the length contains a skelp end weld, both ends of the initially tested portion of the length.

7.7.4.3
Where one or both of the retests fail to conform to the specified requirements, the nonconforming length shall be rejected and, at the manufacturer's option, the remaining lengths in the lot shall be rejected or tested individually, with any nonconforming lengths being rejected.

7.8 Hardness tests
Where required, hardness tests shall be conducted in accordance with the requirements of

a) ASTM E18 or ASTM E92 for macrohardness tests; and
b) ASTM E92 or ASTM E384 for microhardness tests.

8 Mechanical properties

8.1 General
Mechanical properties shall be determined in accordance with the applicable procedures specified in Clause 7.

8.2 Tensile properties

8.2.1 Body tension tests

8.2.1.1
The room temperature tensile properties of the finished pipe shall conform to the requirements of Table 8 and shall be determined on

a) transverse body test specimens for welded pipe 219.1 mm OD or larger;
b) transverse or longitudinal body test specimens for seamless pipe 219.1 mm OD or larger; and
c) longitudinal body test specimens for pipe smaller than 219.1 mm OD.

8.2.1.2
Tension tests shall be conducted at the frequency given in Table 10.

8.2.2 Transverse weld tension tests

8.2.2.1
Transverse weld tension tests shall be conducted on welded pipe 219.1 mm OD or larger.

8.2.2.2
For longitudinal and helical welds, tests shall be conducted at the frequency given in Table 10.

8.2.2.3
For skelp end welds, tests shall be conducted at the frequency of one test per lot of 100 lengths containing skelp end welds.

8.2.2.4
The room temperature tensile strength shall be as given in Table 8.

8.2.2.5
For tests of longitudinal, helical, and skelp end welds of submerged-arc-welded pipe, the elongation in 50 mm shall be 10% or more.

8.3 Ductility tests

8.3.1 General

8.3.1.1
Submerged-arc-welded pipe shall be subject to the requirements of the guided-bend test. Electric-welded pipe 60.3 mm OD or larger shall be subject to the requirements of the flattening test. Electric-welded pipe smaller than 60.3 mm OD shall be subject to the requirements of the bend test.

8.3.1.2
Where specified in the purchase order, electric-welded pipe 60.3 mm OD or larger shall also be subject to the root guided-bend test. (For pipe for sour service, see Clause 16.6.)

8.3.2 Flattening tests — Electric-welded pipe

8.3.2.1
Except as required by Clause 8.3.2.2, for electric-welded pipe 60.3 mm OD or larger, flattening tests shall be conducted at the frequency specified in Clause 7.3.

Note: *Such testing is not required for electric-welded shells (the tubular product intended to be processed into hot reduced electric-welded pipe).*

8.3.2.2
For hot reduced electric-welded pipe 60.3 mm OD or larger, flattening tests shall be conducted at the frequency of one test per lot of 400 lengths of pipe.

8.3.3 Guided-bend tests

8.3.3.1 Submerged-arc-welded pipe

8.3.3.1.1
For longitudinal and helical welds, face and root guided-bend tests shall be conducted at the frequency of one test per lot of 100 lengths of pipe or one test per welding shift, whichever is the more frequent.

8.3.3.1.2
For skelp end welds, face and root guided-bend tests shall be conducted at the frequency of one test per lot of 100 lengths containing skelp end welds.

8.3.3.2 Electric-welded pipe
Where required by Clause 8.3.1.2, root guided-bend tests shall be conducted at the frequency specified in Clause 7.5.2.

8.3.4 Bend tests
For electric-welded pipe smaller than 60.3 mm OD, bend tests shall be conducted at the frequency of one test per lot of 400 lengths of pipe.

8.4 Notch-toughness tests — Pipe body

8.4.1 Frequency
The applicable drop-weight tear tests and Charpy V-notch impact tests required by Clauses 8.4.4 and 8.4.5 shall be conducted at the frequency given in Table 10.

8.4.2 Test temperature

8.4.2.1
The applicable drop-weight tear tests and Charpy V-notch impact tests required by Clauses 8.4.4 and 8.4.5 shall be conducted at the test temperature specified in the purchase order, except as required by API RP 5L3 or allowed by Clause 8.4.2.2.

8.4.2.2
Tests conducted at temperatures lower than those required by Clause 8.4.2.1 shall be considered acceptable, provided that the applicable requirements for fracture appearance and energy absorption are met at such lower test temperatures.

8.4.3 Category I pipe notch-toughness requirements
Category I pipe has no requirements for proven notch-toughness properties.

8.4.4 Category II pipe notch-toughness requirements

8.4.4.1 Fracture appearance

8.4.4.1.1
For pipe 457 mm OD or smaller, Charpy V-notch impact tests shall be used.

8.4.4.1.2
For pipe larger than 457 mm OD, drop-weight tear tests shall be used.

8.4.4.1.3
Drop-weight tear tests or Charpy V-notch impact tests, whichever are applicable, shall exhibit a fracture appearance shear area of 60% minimum for any test, with no individual test specimen exhibiting less than 50% shear area. In addition, for order items filled using pipe from five or more heats, the all-lot average shear area for any such order item shall be not less than 85%.

8.4.4.2 Absorbed energy
The absorbed energy (based on full-size test specimens) for each Charpy V-notch impact test shall be equal to or greater than
a) 27 J for pipe smaller than 457 mm OD;
b) 40 J for pipe 457 mm OD or larger; or
c) such higher value as is specified in the purchase order.

8.4.5 Category III pipe notch-toughness requirements

8.4.5.1 Fracture appearance
Category III pipe has no requirements for fracture appearance.

8.4.5.2 Absorbed energy
The absorbed energy (based on full-size test specimens) for each test shall be equal to or greater than 18 J or such higher value as is specified in the purchase order.

8.5 Notch-toughness tests — Weld

8.5.1 Submerged-arc-welded pipe

8.5.1.1 Frequency
The applicable Charpy V-notch impact tests required by Clause 8.5.1.3 shall be conducted at the frequency given in Table 10.

8.5.1.2 Test temperature

8.5.1.2.1
The applicable Charpy V-notch impact tests required by Clause 8.5.1.3 shall be conducted at the test temperature specified in Clause 8.4.2.1, except as allowed by Clause 8.5.1.2.2.

8.5.1.2.2
Tests conducted at temperatures lower than those required by Clause 8.5.1.2.1 shall be considered acceptable if the applicable requirements for energy absorption are met at such lower test temperatures.

8.5.1.3 Notch toughness requirements

For Categories II and III pipe, Charpy V-notch impact tests shall be conducted on test specimens taken from the deposited weld metal and heat-affected zone of submerged-arc-welded pipe for

a) pipe with a specified test temperature lower than –5 °C; or
b) where specified in the purchase order, pipe with a specified pipe test temperature of –5 °C or higher.

The absorbed energy (based on full-size test specimens) for each test shall be equal to or greater than 18 J or such higher value as is specified in the purchase order.

8.5.2 Electric-welded pipe

8.5.2.1 General

Where weld fusion line Charpy V-notch impacts tests are conducted at the test temperature for body notch toughness specified in the purchase order, weld zone Charpy V-notch impacts tests are not required provided that the properties meet the requirements of 8.5.2.2.

8.5.2.2 Weld fusion line tests

For Categories II and III pipe, weld fusion line Charpy V-notch impact tests shall be conducted at –5 °C, or a lower specified test temperature if agreed.

Testing shall be conducted in accordance with the applicable requirements of Clause 7.6 and at the frequency specified in Table 10.

For Category II and III pipe, the minimum absorbed energy (based on full-size test specimens) for each test shall be 18 J or such higher value as is specified in the purchase order.

Tests conducted at temperatures lower than those required by Clause 8.4.2.1 shall be considered acceptable, provided that the applicable requirements for energy absorption are met at such lower test temperatures.

8.5.2.3 Weld zone tests

For Categories II and III pipe, weld zone Charpy V-notch impact tests shall be conducted in accordance with the applicable requirements of Clause 7.6 and at the frequency specified in Table 10.

For Category II pipe, the absorbed energy (based on full-size test specimens) for each test shall be equal to or greater than

a) 27 J for pipe smaller than 457 mm OD;
b) 40 J for pipe 457 mm OD or larger; or
c) such higher value as is specified in the purchase order.

For Category III pipe, the absorbed energy (based on full-size test specimens) for each test shall be equal to or greater than 18 J or such higher value as is specified in the purchase order.

The test temperature shall be as specified in the purchase order for body notch toughness tests. Tests conducted at temperatures lower than those required by Clause 8.4.2.1 shall be considered acceptable, provided that the applicable requirements for fracture appearance and energy absorption are met at such lower test temperatures.

8.6 Hardness tests

For electric-welded pipe, hardness testing of the weld zone and the parent metal shall be conducted at the frequency of one test per welding shift. The test results shall conform to the requirements of Clause 5.4.4 and, where applicable, Clauses 16.4 and 16.5.

9 Mill hydrostatic testing

9.1 Mill hydrostatic testing requirements

Except as allowed by Clause 14, each length of pipe shall withstand, without leakage, a mill hydrostatic test to the minimum pressure required by Clause 9.4 or to a higher minimum test pressure specified in the purchase order.

9.2 Test duration

Test pressures for all sizes of seamless pipe and for welded pipe in sizes 457 mm OD or smaller shall be held for not less than 5 s. Test pressures for welded pipe larger than 457 mm OD shall be held for not less than 10 s.

9.3 Verification of test

In order to ensure that every length of pipe is tested to the required test pressure, each tester on which seamless, electric-welded, or submerged-arc-welded pipe is tested shall be equipped with a recording gauge that will record the test pressure and time elapsed for each length of pipe. Alternatively, the tester shall be equipped with a positive and automatic or interlocking device to prevent pipe from being classified as tested until the test requirements (pressure and time) have been met. The associated records or charts shall be available for examination.

9.4 Test pressures

9.4.1

Except where allowed by Note 2 to Table 1, where a value is not given in Table 1, the minimum test pressure shall be the value calculated in accordance with the following equation, with the result rounded to the nearest 0.1 MPa:

$$P = 2\left(\frac{St}{D}\right)$$

where

P = minimum hydrostatic test pressure, MPa

S = calculated hoop stress (equal to the applicable specified minimum yield strength times the appropriate percentage given in Note 1 of Table 1), MPa

t = specified wall thickness, mm

D = specified OD, mm

Note: *Hydrostatic test pressures are mill test pressures and are not intended as a basis for design. Such test pressures are not necessarily related to working pressures.*

9.4.2

Subject to the agreement of the manufacturer and purchaser, if pressure testing involves an end-sealing ram that produces a compressive longitudinal stress, the minimum hydrostatic test pressure may be determined using the following equation, with the result rounded to the nearest 0.1 MPa, provided that the required test pressure produces a hoop stress in excess of 90% of the specified minimum yield strength:

$$P = \frac{S - \left(\frac{P_R \times A_R}{A_p}\right)}{\frac{D}{2t} - \frac{A_I}{A_p}}$$

where

P = minimum hydrostatic test pressure, MPa

S = hoop stress, equal to a percentage of the specified minimum yield strength of the pipe, see Table 1, Note 1, MPa

P_R = internal pressure on end-sealing ram, MPa

A_R = cross-sectional area of end-sealing ram, mm^2

A_p = cross-sectional area of pipe wall, mm^2

D = specified OD, mm

t = specified wall thickness, mm

A_I = internal cross-sectional area of pipe, mm^2

10 Dimensions, masses, and lengths

10.1 General

10.1.1

Standard values for ODs for pipe from 21.3 to 48.3 mm and the corresponding standard wall thickness shall be as given in Table 1.

Note: *Pipe ODs, wall thicknesses, or both intermediate to those listed in Table 1 might be available.*

10.1.2

Plain end masses per unit length shall be calculated in accordance with the following equation:

$$M_\ell = 0.02466(D - t)t$$

where

M_ℓ = plain end mass per unit length, kg/m

D = specified OD, mm

t = specified wall thickness, mm

10.2 Outside diameter

ODs shall be within the tolerances specified in Clauses 11.4.1 and 11.4.2.

10.3 Wall thickness

10.3.1
Each length of pipe shall conform to the wall thickness requirements.

10.3.2
The wall thickness at any place shall be within the tolerances specified in Clause 11.4.4, except that for welded pipe, the weld area shall not be limited by the plus tolerance and the minimum wall thickness at the weld area of electric-welded pipe shall be in accordance with the requirements of Clauses 11.5.5 and 11.5.6.

10.3.3
Wall thickness measurements shall be made with mechanical calipers or properly calibrated nondestructive testing devices of appropriate accuracy. In cases of dispute, the measurements determined by the use of mechanical calipers shall govern. Mechanical calipers shall have contact pins with nominal 6.4 mm circular cross-sections. The end of the pin in contact with the outside surface of the pipe shall be flat or rounded to a radius of not less than 38 mm.

10.4 Mass
Each length of pipe larger than 114.3 mm OD shall be weighed separately and the carload masses determined, except that for jointers the individual lengths comprising the jointer or the jointer itself may be weighed. Lengths of pipe 114.3 mm OD or smaller shall be weighed either individually or in convenient lots, at the option of the manufacturer, and the carload masses determined. Single lengths and carload lot masses shall conform, within the mass tolerances specified in Clause 11.4.5, to the masses calculated using the length of pipe and the masses per unit length derived from the equation in Clause 10.1.2.

10.5 Nominal length
The nominal length, as given in Table 2, shall be as specified in the purchase order.

10.6 Mill-jointers

10.6.1 General
Where given in the purchase order, mill-jointers may be furnished within the limits of requirements on length. No length used in making a mill-jointer shall be less than 1.5 m during the joining operation. Mill-jointers shall comply with the requirements of Clause 14.

10.6.2 Single-jointers
Single-jointers (two pieces welded together to make a length shorter than 15.0 m) may be furnished to a maximum of 5% of the order item or an alternative value agreed to by the purchaser.

10.6.3 Double-jointers
Double-jointers (two pieces welded together to make a length 15.0 m or longer) may be furnished for the entire order item or any portion thereof.

10.6.4 Triple-jointers

Triple-jointers (three pieces welded together to make a length 15.0 m or longer) may be furnished to a maximum of 5% of the order item or an alternative value agreed to by the purchaser.

10.7 Pipe ends

10.7.1 Plain end pipe

10.7.1.1

Pipe intended for joining by welding shall be furnished with plain ends in accordance with the requirements of Clauses 10.7.1.2 to 10.7.1.5.

10.7.1.2

Unless otherwise specified in the purchase order, pipe shall be furnished with ends bevelled to an angle of 30° (+ 5°, –0°) measured from a line drawn perpendicular to the axis of the pipe and with a root face of 1.6 ± 0.8 mm.

10.7.1.3

Pipe ends shall have all burrs removed from both the inside and outside edges.

10.7.1.4

Pipe ends shall be cut square within 1.6 mm.

10.7.1.5

Both ends of submerged-arc-welded pipe shall have the inside weld reinforcement removed for a minimum distance of 75 mm from the end of the pipe such that the inside weld bead does not extend above the inside surface of the pipe by more than 0.5 mm.

10.7.1.6

Where specified in the purchase order, both ends of submerged-arc-welded pipe shall have the outside weld reinforcement removed for a distance of at least 120 mm from the end of the pipe such that the outside weld bead does not extend above the outside surface of the pipe by more than 0.1 mm.

10.7.2 Special end pipe

10.7.2.1 Mechanical interference fit pipe

Where specified in the purchase order, pipe shall be furnished with ends prepared for joining by the mechanical interference fit method. Such ends shall be prepared in accordance with the ordered end configuration. Belled ends of welded pipe shall be nondestructively inspected in the weld area by ultrasonic, magnetic particle, or liquid penetrant methods to indicate defects (i.e., open welds, cracks, seams, and slivers). Magnetic particle inspection and liquid penetrant inspection shall be in accordance with the requirements of Clauses 12.7 and 12.8, respectively. Defects shall be removed in accordance with the applicable requirements of Clause 11.6.

10.7.2.2 Threaded and coupled pipe

10.7.2.2.1

Where specified in the purchase order, pipe ends shall be provided with threads that are in accordance with the gauging practice and tolerances of ASME B1.20.1.

10.7.2.2.2

Where specified in the purchase order, one end of each length of pipe shall be provided with a steel coupling. The coupling threads shall be in accordance with the gauging practice and tolerances of ASME B1.20.1. The coupling shall be taper-tapped or straight-tapped, at the option of the manufacturer, and shall be applied hand-tight unless power-tight is specified in the purchase order.

10.7.2.3 Plain end pipe for special couplings

Where specified in the purchase order, plain end pipe shall be furnished with ends prepared for joining using special couplings. Such pipe shall be sufficiently free of indentations, projections, and roll marks for a distance of 200 mm from the pipe ends so that proper makeup of the coupling can be effected. Such ends shall be prepared in accordance with the ordered end configuration.

11 Inspection, tolerances, and work quality

11.1 Inspection

Pipe shall be inspected visually or by a combination of visual and nondestructive methods to detect defects and determine compliance with the dimensional and work quality requirements.

11.2 Inspection notice

When the purchase order states that the inspector representing the purchaser intends to inspect the pipe or witness the tests at the manufacturer's plant, the manufacturer shall give the purchaser reasonable notice of the production schedule.

11.3 Plant access

While work on the purchaser's order is being performed, the inspector representing the purchaser shall have unrestricted entry at all times to all parts of the manufacturer's plant that are involved in the manufacture of the pipe ordered. The manufacturer shall afford the inspector all reasonable facilities to ensure that the pipes are being manufactured, sampled, tested, and inspected in accordance with the requirements of this Standard and the purchase order. Inspections shall be conducted without interfering unnecessarily with the operation of the plant.

11.4 Tolerances on dimensions and mass

11.4.1 Tolerances on outside diameter — Pipe body

11.4.1.1

Tolerances on OD shall be as given in Table 11.

11.4.1.2
For pipe 114.3 mm OD or larger, the OD measurements on the body of the pipe shall be made at the pipe mill with a diameter tape on a random basis, but not fewer than three measurements per working shift shall be taken.

11.4.2 Tolerances on outside diameter — Pipe ends

11.4.2.1
Pipe 273.1 mm OD or smaller shall be not more than 0.4 mm smaller than the specified OD for a distance of 100 mm from the ends of the pipe and shall permit the passage over the ends, for a distance of 100 mm, of a ring gauge that has a bore 1.6 mm larger than the specified OD of the pipe.

11.4.2.2
Pipe larger than 273.1 mm OD but not larger than 457 mm OD shall be not more than ±0.50% of the specified OD, but with a maximum of ±1.6 mm for a distance of 100 mm from the ends of the pipe.

11.4.2.3
For pipe 457 mm OD or smaller, the manufacturer shall have the option of measuring the minimum OD with a diameter tape or a device that measures OD across a single plane.

11.4.2.4
Except as allowed by Clause 11.4.2.5, pipe larger than 457 mm OD shall be not more than ±1.6 mm from the specified OD for a distance of 100 mm from the ends of the pipe, as measured with a diameter tape.

11.4.2.5
Subject to agreement between the purchaser and the manufacturer, for pipe larger than 457 mm OD the tolerances on OD at the ends of the pipe (see Clause 11.4.2.4) may be applied to the inside diameter at the ends of the pipe.

11.4.3 Tolerances on out-of-roundness

11.4.3.1
For a distance of 100 mm from the ends of pipe larger than 457 mm OD, and with a diameter-to-thickness ratio (D/t) greater than 75, the maximum OD shall be not more than 1% larger than the specified OD and the minimum OD shall be not more than 1% smaller than the specified OD.

11.4.3.2
For a distance of 100 mm from the ends of pipe larger than 457 mm OD and with a diameter-to-thickness ratio (D/t) less than or equal to 75, the maximum differential between the minimum and maximum diameters shall not exceed the following values:

a) 12.7 mm for pipe less than or equal to 1067 mm specified OD; and
b) 15.9 mm for pipe greater than 1067 mm specified OD.

Note: *Tolerances on out-of-roundness apply to the maximum and minimum diameters as measured with a bar gauge, caliper, or other similar device that measures actual maximum and minimum diameters.*

11.4.4 Tolerances on wall thickness
The tolerances on wall thickness shall be as given in Table 3.

11.4.5 Tolerances on mass
The tolerances on mass shall be as given in Table 4.

11.4.6 Tolerances on length
Unless otherwise specified in the purchase order, the tolerances on length shall be as given in Table 2.

11.5 Work quality

11.5.1 Radial offset at weld seams

11.5.1.1
For electric-welded pipe, the radial offset (high-low) of the abutting edges of the parent metal at the longitudinal weld seam shall not exceed 10% of the specified wall thickness or 0.8 mm, whichever is greater.

11.5.1.2
For submerged-arc-welded pipe, the radial offset (high-low) of the abutting edges of the parent metal at the longitudinal, helical, and skelp end weld seams shall not exceed
a) 10% of the specified wall thickness or 0.8 mm, whichever is greater, at the pipe ends; and
b) 10% of the specified wall thickness or 1.5 mm, whichever is greater, away from the pipe ends.

11.5.2 Tack welds in submerged-arc-welded pipe
All evidence of tack welds shall be removed by the submerged arc weld or by repair welding.

11.5.3 Misalignment of weld seam of submerged-arc-welded pipe
Misalignment of the weld seam shall not be cause for rejection, provided that complete penetration and complete fusion have been achieved, as indicated by nondestructive inspection.

11.5.4 Height of inside and outside weld beads of submerged-arc-welded pipe

11.5.4.1
Except as allowed by Clause 11.5.4.3, the completed as-deposited inside and outside weld bead surfaces shall not extend above the applicable adjacent original parent metal surface by more than 4.0 mm.

11.5.4.2
Except as allowed by Clause 11.6.1 f), the completed as-deposited inside and outside weld bead surfaces shall not be below the prolongation of the applicable adjacent original parent metal surface.

11.5.4.3
The manufacturer shall have the option of grinding or machining weld beads to acceptable heights.

11.5.5 Trim of outside weld flash of electric-welded pipe
The outside weld flash of electric-welded pipe shall not extend above the outside surface of the pipe by more than 0.2 mm; any localized thickening resulting from upset forging shall be excluded from such

measurements. The minimum wall thickness at the trim shall be not less than 95% of the specified wall thickness.

11.5.6 Trim of inside weld flash of electric-welded pipe

11.5.6.1

The inside weld flash of electric-welded pipe shall not extend above the inside surface of the pipe by more than 1.5 mm; any localized thickening resulting from upset forging shall be excluded from such measurements.

11.5.6.2

The depth of groove resulting from the removal of the internal weld flash of electric-welded pipe shall be not greater than the amount given in Table 12. In addition, the minimum wall thickness at the trim shall be not less than 95% of the specified wall thickness. Notwithstanding the minimum wall thickness requirements of this Clause, to minimize trim tool chatter the resulting finish shall exhibit a uniform profile along the weld length with no change in height exceeding 0.5 mm.

11.5.7 Hard spots

The surfaces of welded pipe 323.9 mm OD or larger shall be inspected visually to detect irregularities in the curvature or surface texture of the pipe. Where such inspections indicate that the irregular surfaces can be attributable to hard spots, the macrohardness of the areas in question shall be determined. The affected areas shall be considered to be defects if their hardnesses

a) exceed 300 HV30 or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E140; or
b) away from any pipe weld areas exceed 225 HV30 or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E140 and exceed the hardnesses of the surrounding unaffected areas by more than 75 Vickers hardness points.

The sections of pipe containing such defects shall be cut out as cylinders and rejected.

11.5.8 Location of weld seams

11.5.8.1 Location of skelp end welds

11.5.8.1.1

Skelp end welds shall not be present in finished longitudinal seam pipe.

11.5.8.1.2

Skelp end welds may be present in finished helical seam pipe, provided that

a) the skelp ends have been properly prepared for welding;
b) the skelp end weld was manufactured by submerged arc welding or a combination of gas metal arc and submerged arc welding; and
c) at least two weld passes were used, with at least one pass having been made from the inside and at least one pass having been made from the outside.

11.5.8.1.3

Junctions of skelp end welds and helical seam welds shall be located at least 300 mm from the finished pipe ends and any jointer welds.

11.5.8.1.4
Skelp end welds may be located at finished pipe ends, provided that there is at least 150 mm of circumferential separation between the skelp end weld and the helical seam weld at the pipe end.

11.5.8.1.5
Skelp end welds may be located at jointer welds, provided that there is at least 150 mm of circumferential separation between the skelp end weld and the helical seam weld on the same side of the jointer weld.

11.5.8.2 Location of seam welds at jointer welds

11.5.8.2.1
For jointers of helical seam pipe, there shall be at least 50 mm of circumferential separation between the junction of the helical seam weld and the jointer weld on each side of the jointer weld.

11.5.8.2.2
For jointers of longitudinal seam pipe, there shall be 50 to 200 mm of circumferential separation between the junction of the longitudinal seam weld and the jointer weld on each side of the jointer weld.

11.5.9 Straightness
Pipe smaller than 114.3 mm OD shall be reasonably straight. Pipe 114.3 mm OD or larger shall be randomly checked for straightness and deviation from a straight line shall not exceed 0.2% of the length. Straightness may be measured by holding a taut string or wire from end-to-end along the side of the pipe and measuring the greatest deviation.

11.5.10 Geometric deviations
Geometric deviations from the normal cylindrical contour of the pipe within 200 mm of each pipe end that occur as a result of the pipe-forming process or manufacturing operations (e.g., roll marks, flat spots or peaks) shall not exceed 3 mm, measured as the gap between the extreme point of the deviation and the prolongation of the normal contour of the pipe.

11.6 Defects

11.6.1
Finished pipe shall be visually inspected and free of the following defects:

a) Dents deeper than 6 mm or having a length in any direction exceeding one-half of the pipe OD, or both, shall be considered defects and shall be cut out as cylinders and rejected. Dents that are 6 mm or less in depth and contain stress concentrators shall be considered defects and shall be cut out as cylinders and rejected or shall be repaired by grinding to remove the stress concentrators, provided that the remaining wall thickness is within specified limits.
b) Leaks shall be considered defects and shall be cut out as cylinders and rejected, or the pipe shall be rejected.
c) Arc burns shall be considered defects. Pipe containing such defects shall be given one or more of the following dispositions:
    i) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits. The resultant cavity shall be thoroughly cleaned and checked for complete removal of altered metallurgical structure by etching with a 9 to 11% solution of ammonium

persulphate or a 5 to 10% solution of nital. Provided that removal is complete, the cavity shall be merged smoothly into the original contour of the pipe by grinding.

ii) The section of pipe containing the defect shall be cut out as a cylinder and rejected.

iii) The pipe shall be rejected.

Notes:

1) *Contact burns (intermittent marks adjacent to the weld line of electric-welded pipe resulting from the electrical contact between the electrodes supplying the welding current and the pipe surface) are considered arc burns.*

2) *Because lower metal temperatures and the age of the etchant can adversely affect the results obtained, the effectiveness of the etchant should be periodically tested by obtaining a positive indication from an arc burn.*

3) *For lower carbon steels, concentrations of nital stronger than 5% could be needed to clearly identify arc burns.*

d) Surface cracks shall be considered defects regardless of dimensions. Pipe containing such defects shall be given one or more of the following dispositions:

i) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits. The resultant cavity shall be thoroughly cleaned and checked for complete removal of the defect by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively. Provided that removal is complete, the cavity shall be merged smoothly into the original contour of the pipe by grinding.

ii) Where allowed by Clause 13.3, the defective area shall be repaired in accordance with the requirements of Clause 13.4.

iii) The section of pipe containing the defect shall be cut out as a cylinder and rejected.

iv) The pipe shall be rejected.

Note: *Hooked fibres (metal separations along the upturned fibres in the weld area of electric-welded pipe) open to the surface are considered a type of surface crack.*

e) Laminations extending into the face or bevel of the pipe and having a transverse dimension exceeding 6 mm shall be considered defects. Pipe containing such defects shall be cut back until such laminations are removed.

f) Undercuts deeper than 0.5 mm shall be considered defects. Pipe containing such defects shall be given one or more of the following dispositions:

i) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits.

ii) The defective area shall be repaired in accordance with the requirements of Clause 13.4.

iii) The section of pipe containing the defect shall be cut out as a cylinder and rejected.

iv) The pipe shall be rejected.

Notes:

1) *Undercuts can best be located visually.*

2) *Shallower undercuts need not be removed.*

g) Other defects: Surface imperfections having depths greater than 12.5% of the specified wall thickness shall be considered defects. Pipe containing such defects shall be given one or more of the following dispositions:

i) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits.

ii) Where allowed by Clause 13.3, the defective area shall be repaired in accordance with the requirements of Clause 13.4.

iii) The section of pipe containing the defect shall be cut out as a cylinder and rejected.

iv) The pipe shall be rejected.

11.6.2

Any lamination in the body of the pipe shall be considered a defect if its nondestructively determined dimensions exceed both of the following:

a) a width of 20 mm; and
b) an area of 7000 mm^2.

11.7 Residual magnetism

Note: *These requirements apply to measurements made at the pipe manufacturing facility before shipment. Measurements of residual magnetism made after shipment can be affected by procedures and conditions imposed on the pipe during and after shipment.*

11.7.1

The longitudinal magnetic field shall be measured on the root face or square-cut face of pipe.

11.7.2

Measurements shall be made using a Hall-effect magnetic flux density meter or another type of calibrated instrument; however, in case of dispute, measurement made with a Hall-effect magnetic flux meter shall govern. The magnetic flux meter shall be operated in accordance with the manufacturer's documented procedures that have been demonstrated by the pipe manufacturer to produce accurate results.

11.7.3

Measurements shall be made on each end of a pipe selected at least once per 4 h per operating shift.

11.7.4

Residual magnetism on the pipe shall be measured in the pipe manufacturing facility. For pipe handled with magnetic equipment after the measurement of residual magnetism, such handling shall be performed in a manner demonstrated not to cause residual magnetism exceeding the levels specified in Clause 11.7.5.

11.7.5

For pipe smaller than 168.3 mm OD, at least two readings shall be taken approximately 180° apart around the circumference of each end of the pipe. For pipe 168.3 mm OD or larger, at least four readings shall be taken approximately 90° apart around the circumference of each end of the pipe. The average of such readings shall not exceed 3.0 mT and no individual reading shall exceed 3.5 mT.

Note: *Measurements made on pipe in stacks or bundles are not considered valid.*

11.7.6

Any pipe that fails to meet the requirements specified in Clause 11.7.5 shall be considered defective. In addition, except as allowed by Clause 11.7.7, all pipe produced between the defective pipe and the last acceptable pipe shall be individually measured.

11.7.7

If the pipe production sequence is documented, pipe may be measured in reverse sequence, beginning with the pipe produced immediately before the defective pipe, until at least three consecutively produced pipes meet the requirements. Pipe produced before the three acceptable pipes need not be measured.

11.7.8
Pipe produced after the defective pipe shall be measured individually until at least three consecutive pipes meet the specified requirements.

11.7.9
Defective pipes shall be demagnetized and remeasured.

12 Nondestructive inspection

12.1 General

12.1.1
Seamless pipe and the welded seams of electric-welded and submerged-arc-welded pipe shall be nondestructively inspected for their full length, except that it is recognized that a short length at the pipe ends might not be able to be so inspected.

12.1.2
Where a cold expansion operation is used, the nondestructive inspection shall be carried out after that operation.

12.1.3
Pipe shall be nondestructively inspected in the same heat-treatment condition as the finished bare metal pipe.

Note: *Pipe that has been subjected to a quench-and-temper heat treatment will, in some cases, require nondestructive inspection to ensure freedom from quenching cracks.*

12.1.4
Where there are optional nondestructive inspection methods, the manufacturer, where requested, shall advise the purchaser of the options available and the option to be used on a specified order.

Note: *In some cases, such information will not be available on pipe purchased from manufacturer's or jobber's stock.*

12.2 Methods of inspection

12.2.1 Electric-welded pipe

12.2.1.1
The weld seam of electric-welded pipe shall be inspected for longitudinal imperfections using
a) ultrasonic or electromagnetic methods for pipe smaller than 273.1 mm OD; and
b) ultrasonic methods for pipe 273.1 mm OD or larger.

12.2.1.2
Electric-welded pipe produced from single lengths of plate skelp shall additionally have the weld seam at the pipe ends inspected for at least 200 mm by manual ultrasonic methods or by other methods agreed on by the purchaser and the manufacturer.

12.2.2 Submerged-arc-welded pipe

12.2.2.1
The longitudinal or helical weld seam of submerged-arc-welded pipe shall be inspected for longitudinal and transverse imperfections by radiological or ultrasonic methods or both.

12.2.2.2
The weld seams at the field ends of submerged-arc-welded pipe shall be inspected for at least 200 mm by film radiographic methods or nonfilm radiographic imaging techniques, in accordance with the requirements of Clause 12.4.

12.2.2.3
Where the weld beads are ground off the pipe end after the radiographic inspection required by Clause 12.2.2.2, the ground welds and the weld areas at such pipe ends shall be inspected by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively, and shall be in accordance with the requirements of Clause 11.6.

12.2.2.4
Where the pipe ends of longitudinal seam pipe are cold sized more than 0.4% after the radiographic inspection required by Clause 12.2.2.2, the cold-sized welds and weld areas at such pipe ends shall be inspected by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7and 12.8, respectively, and shall be in accordance with the requirements of Clause 11.6.

12.2.2.5
Where the pipe ends of helical seam pipe are cold sized more than 0.4% after the radiographic inspection required by Clause 12.2.2.2, the cold-sized welds and weld areas at such pipe ends shall be inspected by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively, and shall be in accordance with the requirements of Clause 11.6.

12.2.3 Skelp end welds

12.2.3.1
Skelp end welds composed solely of submerged-arc-weld beads shall be inspected for longitudinal and transverse imperfections by radiological or ultrasonic methods or both.

12.2.3.2
Skelp end welds containing one or more gas-metal-arc weld beads shall be inspected for longitudinal and transverse imperfections by ultrasonic methods.

12.2.3.3
Junctions of skelp end welds and helical seam welds shall be inspected by ultrasonic methods, film radiographic methods, or nonfilm radiographic imaging techniques, in accordance with the requirements of Clause 12.4 or 12.5, as applicable.

12.2.4 Circumferential jointer welds

The weld seams of circumferential jointer welds shall be inspected for their full length by ultrasonic methods, radiological methods, or both in accordance with the requirements of Clause 12.4 or 12.5, as applicable, except that the standards of acceptability for such welds produced by other than double submerged arc welding shall be in accordance with the requirements of Clause 7.11 or 7.15.10 of CSA Z662, as applicable. In addition, for sour service applications, the requirements of Clause 16.9.3.3 of CSA Z662 shall be met.

12.2.5 Seamless pipe

Seamless pipe shall be inspected for longitudinal and transverse inside and outside imperfections using either electromagnetic methods in accordance with the applicable requirements of Clause 12.6.2 or electromagnetic or ultrasonic methods in accordance with the requirements of the manufacturer's documented procedure.

12.3 Qualifications of personnel

The qualifications of personnel performing fluoroscopic, ultrasonic, radiographic, magnetic particle, or liquid penetrant inspection shall be in accordance with CAN/CGSB 48.9712/ISO 9712, ASNT SNT-TC-1A, or equivalent. The manufacturer's program for training personnel and qualifying operators shall be directed by supervisory or technical personnel qualified to Level II or III of CAN/CGSB 48.9712/ISO 9712, ASNT SNT-TC-1A, or equivalent for the applicable nondestructive test method.

12.4 Radiological inspection

Note: *Radiological inspection is a generic term that covers film radiographic inspection, fluoroscopic inspection, and radiographic inspection using nonfilm radiographic imaging techniques.*

12.4.1 Equipment

The equipment used for radiological inspection shall direct X-rays through the weld onto the following:

a) for film radiographic inspection, a suitable radiographic film;
b) for fluoroscopic inspection, a fluorescent screen that is viewed
   i) directly; or
   ii) indirectly using an imaging device that produces analog or digital signals that are converted to images that are viewed on a suitable monitor; and
c) for radiographic inspection using nonfilm imaging techniques,
   i) a fluorescent screen that is viewed indirectly using an imaging device that produces analog or digital signals that are converted to images that are viewed on a suitable monitor; or
   ii) an X-ray-sensitive imaging device that produces analog or digital signals that are converted to images that are viewed on a suitable monitor.

12.4.2 Procedure

Inspections shall be performed in accordance with the guidelines of ASTM E94/E94M. Radiographic film shall be GI or GII, as classified by ISO 5579, and the exposed film density shall be within the range of 1.5 to 4.0 throughout the area of interest. Records of the results of radiological inspections shall be kept for at least five years. Film radiographs and nonfilm radiographic images shall be traceable to the pipe identity and shall be kept for at least two years. Nonfilm radiographic images shall be stored in a manner that safeguards them against loss, deterioration, and damage and allows them to be readily retrievable.

12.4.3 Sensitivity

Radiological inspection shall be performed using a technique of sufficient sensitivity to display the image of the image quality indicator and the essential hole or wire. Fluoroscopic inspection shall not be performed at speeds greater than those at which the image quality indicator can be read definitively.

12.4.4 Image quality indicators

12.4.4.1 General

Image quality indicators shall be used to indicate the sensitivity of the radiological image. They shall be placed on the source or film side of the pipe for film radiographic inspection and the corresponding side for fluoroscopic inspection and radiographic inspection using nonfilm radiographic imaging techniques.

12.4.4.2 Type

Hole-type image quality indicators shall be in accordance with the requirements of ASTM E1025. Wire-type image quality indicators shall be in accordance with the requirements of ASTM E747 or ISO 19232-1. The thickness of hole-type image quality indicators and the wire diameter for wire-type image quality indicators shall be as given in Table 13 for the applicable weld thickness being inspected. The image of the essential hole shall be clearly defined. The essential hole in hole-type image quality indicators shall be the 4T hole for fluoroscopic inspection and the 2T hole for radiographic inspection.

12.4.4.3 Hole-type placement

Where hole-type image quality indicators are used in radiographic inspection, such indicators shall be placed adjacent to the weld and shimmed, as needed, with radiologically similar material so that the total thickness being inspected under the image quality indicator is approximately equal to the weld thickness.

Where hole-type image quality indicators are used in fluoroscopic inspection other than sensitivity checks, such indicators shall be placed adjacent to the weld and shimmed, as needed, with radiologically similar material so that the total thickness being inspected under the image quality indicator is approximately equal to the weld thickness.

12.4.4.4 Wire-type placement

Where wire-type image quality indicators are used, such indicators shall be placed across the weld, with the wires perpendicular to the longitudinal axis of the weld.

12.4.4.5 Frequency of application

12.4.4.5.1

The image quality indicator shall be used to check the sensitivity of equipment as specified in Clauses 12.4.4.5.2 to 12.4.4.5.5, as applicable.

12.4.4.5.2

For fluoroscopic inspection, the image quality indicator shall be used on one pipe in every lot of 50 pipes.

12.4.4.5.3

For film, the image quality indicator shall be used on each film.

12.4.4.5.4

For nonfilm radiographic imaging, the image quality indicator shall be applied

a) on each image; or
b) at least twice every working shift, before any planned shutdown of the radiographic equipment during production, and at the end of production for systems where
   i) the tube dimension, tube material, and testing parameters (e.g., geometry, X-ray source setting, and detector settings) remain unchanged;
   ii) a suitable interlock device to prevent alternation of the essential parameters during operation is utilized; and
   iii) the manufacturer can document the ongoing stability of the system.

12.4.4.5.5

Where the image quality indicator image does not meet the requirements of Clause 12.4.3, all pipe inspected after the last acceptable image quality indicator image shall be re-inspected after an acceptable image quality indicator image has been re-established.

12.4.5 Acceptance limits

12.4.5.1

Individual elongated slag inclusions shall not exceed 1.5 mm in width or 50 mm in length. The total length of such imperfections in any 300 mm length of weld shall not exceed 50 mm.

12.4.5.2

The maximum dimension of any circular slag inclusion or gas pocket shall not exceed 3 mm or 25% of the specified wall thickness, whichever is less. The number of such imperfections in any 150 mm of weld length, expressed in terms of the projected area on the radiological image, shall not exceed the applicable value given in Table 14. (See Figure 6 for an example of each of these permissible amounts.)

12.4.5.3

Cracks, lack of penetration, and incomplete fusion shall be unacceptable regardless of location (weld or heat-affected zone).

12.4.5.4

Imperfections that are not acceptable based on the requirements of Clauses 12.4.5.1 to 12.4.5.3 shall be considered defects. Pipe containing such defects shall be given one or more of the following dispositions:

a) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits.
b) Where allowed by Clause 13.3, the defective area shall be repaired in accordance with the requirements of Clause 13.4.
c) The section of pipe containing the defect shall be cut out as a cylinder and rejected.
d) The pipe shall be rejected.

12.5 Ultrasonic inspection

12.5.1 Equipment

12.5.1.1 Ultrasonic instrument

The ultrasonic instrument shall be capable of generating, receiving, amplifying, and displaying high-frequency electrical pulses at the frequencies, pulse rates, and energy levels necessary for inspection. The pulse rate shall be sufficient to produce multiple pulses acting on any given point on the weld at the inspection speed to be used.

12.5.1.2 Search units

The search units shall contain one or more transducers with crystals capable of producing ultrasonic shear wave vibrations that are generally between 45° and 80° from radial in the pipe wall, as measured from the radial at the sound entry surface. Search units shall be located on both sides of the weld line.

12.5.1.3 Couplant

A couplant that is capable of conducting ultrasonic vibrations from the transducer to the pipe shall be placed between the face of the search unit and the pipe. Corrosion inhibitors, wetting agents, or both may be added to the couplant. Coupling effectiveness shall be checked by visual or electronic monitoring of the ultrasonic vibrations reflected from one of the pipe surfaces.

12.5.1.4 Gating

The ultrasonic instrument shall contain one or more gating devices to electronically monitor a selected segment of the distance trace. The gate width shall be set to include the weld area of interest plus an allowance for tracking error. The gate width required for inspection in the static mode may differ from the gate width required for inspection in the dynamic mode.

12.5.1.5 Alarms

Audible and visible signal devices denoting any signal that exceeds the alarm limit shall be used.

12.5.1.6 Marking

Unattended inspection systems shall have devices to mark the pipe at locations that cause signals that exceed the alarm limit.

12.5.2 Reference standards

12.5.2.1

Except as allowed by Clauses 12.5.3.3 and 12.5.3.4, the reference standard shall be a length of pipe, or a coupon taken from a length of pipe, with both OD and wall thickness within the tolerances specified for the production pipe to be inspected. The reference standard material and the production pipe material shall have similar acoustic properties, surface finish, and heat-treatment histories. The reference standard may be of any convenient length, as determined by the manufacturer.

12.5.2.2

Reference standards shall contain selected machined reference indicators as shown in Figure 7; however, reference notches shall not be required for pipe smaller than 60.3 mm OD. For each type of reference notch, there shall be one on the inside surface and one on the outside surface of the reference standard, and the reference notches shall be parallel and separated by a distance sufficient to

enable separate and distinguishable signals to be produced. The reference holes shall be drilled through the wall and shall be perpendicular to the surface of the reference standard as shown in Figure 7.

Notes:

1) *The reference indicators should be located in the weld area.*
2) *The reference indicators specified in this Clause are convenient standards for standardization of the nondestructive inspection equipment. The dimensions of these reference indicators should not be construed as the minimum size of imperfections detectable by such equipment.*

12.5.3 Standardization

12.5.3.1

In accordance with using the reference standard specified in Clause 12.5.2, the inspection equipment shall be adjusted to produce well-defined indications when the reference standard is scanned by the inspection unit.

12.5.3.2

Search units for detecting transverse imperfections shall be standardized using the 1.6 mm hole or the T notches.

12.5.3.3

Search units for detecting longitudinal imperfections in continuous welded or electric-welded pipe shall be standardized using the 3.2 mm hole. Except as permitted by Clause 12.5.2.2, N10 or V10 notches shall be used to verify that the sound beam is being directed perpendicular to the weld line; however, the reference standard need not have a wall thickness within the tolerances specified for the production pipe to be inspected.

12.5.3.4

Search units for detecting longitudinal imperfections in submerged-arc-welded pipe shall be standardized using the 1.6 mm hole. Where applicable to the ultrasonic system being employed, N5 notches shall be used to verify that the sound beam is being directed perpendicular to the weld line; however, the reference standard need not have a wall thickness within the tolerances specified for the production pipe to be inspected.

12.5.3.5

Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause 12.5.6.1, and at the start of inspection after any shutdown of the ultrasonic inspection equipment during production. The inspection equipment shall be adjusted to obtain, from the applicable reference indicators used to establish the acceptance limits (see Clause 12.5.4.1), signals that are within the gate width (see Clause 12.5.1.4) and that exceed the alarm limit (see Clause 12.5.5) when the reference standard is scanned in a manner duplicating or simulating inspection in the dynamic mode.

Note: *The standardization is normally done in the static mode and then verified in a manner duplicating or simulating inspection in the dynamic mode.*

12.5.4 Acceptance limits

12.5.4.1

For each of the search units, a signal height not more than that obtained from one of the applicable reference indicators (see Clauses 12.5.3.2 to 12.5.3.4) shall be used as the height of acceptance limit signals for production pipe inspection.

12.5.4.2

For ultrasonic inspection of electric-welded production pipe in the dynamic mode, imperfections that produce signals higher than the acceptance limit shall be inspected in the static mode or considered defects. Pipe containing such defects shall be given one or more of the following dispositions:

a) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits. The resultant cavity shall be thoroughly cleaned and checked for complete removal of the defect by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively. Provided that removal is complete, the cavity shall be merged smoothly into the original contour of the pipe by grinding. The repaired section of pipe shall be inspected by ultrasonic methods.
b) The section of pipe containing the defect shall be cut out as a cylinder and rejected.
c) The pipe shall be rejected.

12.5.4.3

For ultrasonic inspection of electric-welded production pipe in the static mode, imperfections that produce signals higher than the acceptance limit shall be considered defects. Pipe containing such defects shall be given one or more of the following dispositions:

a) The defect shall be removed by grinding, provided that the remaining wall thickness is within specified limits. The resultant cavity shall be thoroughly cleaned and checked for complete removal of the defect by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively. Provided that removal is complete, the cavity shall be merged smoothly into the original contour of the pipe by grinding. The repaired section of pipe shall be inspected by ultrasonic methods.
b) The section of pipe containing the defect shall be cut out as a cylinder and rejected.
c) The pipe shall be rejected.

12.5.4.4

For ultrasonic inspection of submerged-arc-welded production pipe in the dynamic mode, imperfections that produce signals higher than the acceptance limit shall be rejected, ultrasonically inspected in the static mode, or inspected using film radiographic methods or nonfilm radiographic imaging techniques in accordance with the requirements of Clause 12.4.

Note: *The detectability of imperfections can be affected by their orientation.*

12.5.4.5

For ultrasonic inspection of submerged-arc-welded production pipe in the static mode, imperfections that produce signals higher than the acceptance limit shall be rejected or inspected using film radiographic methods or nonfilm radiographic imaging techniques in accordance with the requirements of Clause 12.4.

Note: *The detectability of imperfections can be affected by their orientation.*

12.5.4.6
The manufacturer shall have a documented procedure for the evaluation and disposition of discontinuities that produce ultrasonic signals higher than the acceptance limit but that are considered acceptable on inspection using film radiographic methods or nonfilm radiographic imaging techniques.

12.5.5 Alarm limits
Alarm limits shall be set equal to or less than the acceptance limits established in accordance with the requirements of Clause 12.5.4.

12.5.6 Inspection sensitivity checks

12.5.6.1
The inspection sensitivity shall be checked at least twice every working shift, before any planned shutdown of the ultrasonic equipment during production, and at the end of production using the reference standard specified in Clause 12.5.2. Where the signal obtained from the reference indicator selected in accordance with the requirements of Clause 12.5.4.1 to establish the acceptance limit is more than 3 dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be reinspected after restandardization has been accomplished.

12.5.6.2
The inspection system sensitivity shall be checked periodically by metallographically examining samples of detected imperfections.

12.6 Electromagnetic inspection

12.6.1 Weld inspection

12.6.1.1 Equipment

12.6.1.1.1
Equipment for inspecting the weld seam shall be capable of continuous uninterrupted inspection for outer surface and inner surface longitudinal imperfections.

Note: *The sensitivity of eddy current testing is at a maximum at the outside surface of the pipe and decreases with increasing distance from the test coil. The capability of the test equipment to detect inside surface imperfections is determined primarily by the wall thickness and the eddy current excitation frequency.*

12.6.1.1.2
The inspection shall be done in such a manner that the measured flux density in the finished pipe complies with the requirements of Clause 11.7.

12.6.1.1.3
Audible and visible signal devices denoting any signal that exceeds the alarm limit shall be used.

12.6.1.1.4
Unattended inspection systems shall have devices to mark the pipe at locations that cause signals that exceed the alarm limit.

12.6.1.2 Reference standards

12.6.1.2.1

The reference standard shall be a length of pipe with both OD and wall thickness within the tolerances specified for the production pipe to be inspected. The reference standard material and the production pipe material shall have similar electromagnetic properties, surface finish, and heat-treatment histories. The reference standard may be of any convenient length, as determined by the manufacturer.

12.6.1.2.2

Reference standards shall contain the following machined-reference indicators, as shown in Figure 8:

a) a radially drilled hole having a nominal diameter not larger than 1.6 mm; and
b) for pipe 60.3 mm OD or larger, an N10 notch located on the outside and inside surfaces of the pipe.

Note: *The reference indicators should be located in the weld area.*

12.6.1.3 Standardization

Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause 12.6.1.4.1 and at the start of inspection after any shutdown of the electromagnetic inspection equipment during production. After adjusting the equipment to obtain a signal-to-noise ratio of at least 2.5:1, the reference standard specified in Clause 12.6.1.2 shall be used to produce a separate, well-defined indication when each of the required machined-reference indicators is encountered during processing in a manner simulating or duplicating inspection of the production pipe.

12.6.1.4 Inspection sensitivity checks

12.6.1.4.1

The inspection sensitivity shall be checked at least twice every working shift, before any planned shutdown of the electromagnetic inspection equipment during production, and at the end of production using the reference standard specified in Clause 12.6.1.2. Where the signal obtained from the reference indicator is more than 3 dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be reinspected after restandardization has been accomplished or shall be inspected ultrasonically in accordance with the applicable requirements of Clause 12.5.

12.6.1.4.2

The inspection system sensitivity shall be checked periodically by metallographically examining samples of detected imperfections.

12.6.1.5 Acceptance limits

Imperfections that produce signals higher than the acceptance limit shall be considered defects. Pipe containing such defects shall be given one or more of the following dispositions:

a) The pipe shall be inspected ultrasonically in accordance with the requirements of Clause 12.5.
b) The imperfection shall be removed by grinding in accordance with the requirements of Clause 12.6.1.7, and the pipe shall be reinspected by electromagnetic or ultrasonic methods in accordance with the applicable requirements of Clause 12.5.
c) The section of pipe containing the defect shall be cut out as a cylinder and rejected.
d) The pipe shall be rejected.

12.6.1.6 Alarm limits

Alarm limits shall be equal to or less than the acceptance limits established in accordance with the requirements of Clause 12.6.1.5.

12.6.1.7 Grind repair procedure

The procedure for grind repair shall be as follows:

a) The cavity shall be thoroughly cleaned and checked for complete removal of the imperfection by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively.
b) If removal of the imperfection is complete, the cavity shall be merged smoothly into the original contour of the pipe by grinding, provided that the remaining wall thickness is within specified limits.

12.6.2 Body inspection

12.6.2.1 General

Where required by Clause 11.1 or 12.2.5, the pipe body shall be electromagnetically inspected for transverse or longitudinal imperfections, or both, as applicable, located on the outside or inside surface, or both.

12.6.2.2 Equipment

12.6.2.2.1

Equipment for inspecting the pipe body shall be capable of continuous uninterrupted inspection for surface imperfections.

Note: *The sensitivity of eddy current testing is at a maximum at the outside surface of the pipe and decreases with increasing distance from the test coil. The capability of the test equipment to detect inside surface imperfections is determined primarily by the wall thickness and the eddy current excitation frequency.*

12.6.2.2.2

The inspection shall be done in such a manner that the measured flux density in the finished pipe complies with the requirements of Clause 11.7.

12.6.2.2.3

Audible and visible signal devices denoting any signal that exceeds the alarm limit shall be used.

12.6.2.2.4

Unattended inspection systems shall have devices to mark the pipe at locations that cause signals that exceed the alarm limit.

12.6.2.3 Reference standards

12.6.2.3.1

The reference standard shall be a length of pipe with both OD and wall thickness within the tolerances specified for the production pipe to be inspected. The reference standard material and the production pipe material shall have similar electromagnetic properties, surface finish, and heat-treatment histories. The reference standard may be of any convenient length, as determined by the manufacturer.

12.6.2.3.2

As appropriate for the particular inspection being performed, reference standards shall contain one or more of the following machined reference indicators:

a) a radially drilled hole that has a nominal diameter not larger than 3.2 mm and is located away from any longitudinal weld;
b) for pipe 60.3 mm OD or larger, an N10 notch, as shown in Figure 8, located away from any longitudinal weld and on the outside or inside surface of the pipe, or both; and
c) for pipe 60.3 mm OD or larger, a T notch, as shown in Figure 8, located away from any longitudinal weld and on the outside or inside surface of the pipe, or both.

Note: *The reference indicators are convenient standards for the standardization of the electromagnetic inspection equipment. Because of the varying sizes and orientations of imperfections common to the body areas of line pipe, the varying surface finishes to be expected, and the limitations inherent in the application of electromagnetic principles to pipe inspection, it should not be assumed that all defects are capable of being detected regardless of size or orientation.*

12.6.2.4 Standardization

Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause 12.6.2.5.1, and at the start of inspection, after any shutdown of the electromagnetic inspection equipment during production. After adjusting the equipment to obtain a signal-to-noise ratio of at least 2.5:1, the reference standard specified in Clause 12.6.2.3 shall be used to produce a separate, well-defined indication when each of the required reference indicators is encountered during processing in a manner simulating or duplicating inspection of the production pipe.

12.6.2.5 Inspection sensitivity checks

12.6.2.5.1

The inspection sensitivity shall be checked at least twice every working shift, before any planned shutdown of the electromagnetic inspection equipment during production, and at the end of production using the reference standard specified in Clause 12.6.2.3. Where the signal obtained from the reference indicator used to establish the acceptance limit is more than 3 dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be reinspected after restandardization has been accomplished.

12.6.2.5.2

The inspection system sensitivity shall be checked periodically by metallographically examining samples of detected imperfections.

12.6.2.6 Acceptance limits

Pipe containing imperfections that produce signals higher than the acceptance limit shall be given one or more of the following dispositions:

a) The imperfection shall be removed by grinding in accordance with the requirements of Clause 12.6.1.7.
b) The section of pipe containing the imperfection shall be cut out as a cylinder and rejected.
c) The manufacturer shall demonstrate by other methods that the imperfection is not a defect.
d) The pipe shall be rejected.

12.6.2.7 Alarm limits

Alarm limits shall be equal to or less than the acceptance limits established in accordance with the requirements of Clause 12.6.2.6.

12.7 Magnetic particle inspection

12.7.1 Procedure

Magnetic particle inspection shall be conducted in accordance with the requirements of ASTM E709.

12.7.2 Equipment

The equipment used for continuous magnetic particle inspection shall produce a circular magnetic field, transverse to the weld, of sufficient intensity to indicate weld area defects (i.e., open welds, partial or incomplete welds, intermittent welds, cracks, seams, and slivers). Such defects shall be removed in accordance with the requirements of Clause 11.6.

12.7.3 Reference standard

Where requested by the purchaser, arrangements shall be made by the manufacturer to perform a demonstration for the purchaser's representative during production of the order. Such a demonstration shall be on the basis of pipe in process or sample lengths of similar pipe retained by the manufacturer for that purpose and exhibiting natural or artificially produced imperfections of the character specified in Clause 12.7.2.

12.8 Liquid penetrant inspection

Liquid penetrant inspection shall be conducted in accordance with the requirements of ASTM E165/E165M.

13 Repair of pipe containing defects

13.1 General

Where allowed by Clause 11 or 12, pipe containing defects may be repaired by grinding or by grinding and welding.

13.2 Grinding

Where surface conditioning is performed by grinding, it shall be done in an appropriate manner.

13.3 Welding

Repair by welding may be performed only for defects in the weld seam of submerged-arc-welded pipe. Repairs shall be made in accordance with the requirements of Clause 13.4.

13.4 Procedure for repair of defective welds by welding

Repairs of defective welds by welding shall conform to the following requirements:

a) Cracks shall be completely removed by grinding and the resultant cavity shall be thoroughly cleaned. Complete removal of the cracks shall be verified by magnetic particle inspection or liquid penetrant inspection in accordance with the requirements of Clauses 12.7 and 12.8, respectively.
b) Defects other than cracks shall be completely removed, and the resultant cavity shall be thoroughly cleaned.

c) The rim of the resultant cavity shall not extend into the parent metal by more than 3 mm, as measured along the pipe surface, perpendicular to the weld.
d) The depth of the resultant cavity, excluding any contribution from the weld bead height, shall exceed 1.5 mm but shall not exceed two-thirds of the specified wall thickness.
e) The minimum length of repair shall be 50 mm.
f) Back-to-back repairs by welding shall not be permitted.
g) The repair shall be made by submerged arc welding, gas-metal-arc welding, shielded metal arc welding, or flux cored arc welding. Except for repair welds made by automatic submerged arc welding, repair welds shall be made in accordance with a procedure qualified on the basis of testing in accordance with the requirements of Clause 13.5 and by a repair welder qualified on the basis of welds made in the flat position and tested in accordance with the requirements of Clause 13.6. The manufacturer shall maintain a record of the results of procedure tests and performance tests. (For pipe for sour service, see Clause 16.3.)
h) Where the heat input during repair by welding is less than 1 kJ/mm, the area of the pipe to be repaired shall be preheated to a temperature of at least 120 °C. Care should be taken to prevent overheating and no part of the area shall be heated above 200 °C unless the effects of the time-temperature relationship on the mechanical properties of the pipe are taken into consideration.
i) The repair shall be examined by ultrasonic inspection in accordance with the requirements of Clause 12.5. If the defect was originally detected using radiological inspection, the repair shall also be examined by film radiographic methods or nonfilm radiographic imaging techniques in accordance with the requirements of Clause 12.4.

13.5 Repair welding procedure tests

13.5.1 General

For each test specified in Clauses 13.5.3 and 13.5.4, repair welding procedure tests shall be made on two test specimens of every grade. The specimens shall be made of material that has a carbon equivalent not more than 0.05 lower than that of the pipe on which repair welds will be made and shall be at least as thick as the pipe on which repair welds will be made. The repair welding procedure test shall be made at a pipe temperature equal to or less than the lowest pipe temperature at which repair welds will be made. The weld shall be made in a groove having the configuration shown in Figure 9. (For pipe for sour service, see Clause 16.3.)

13.5.2 Radiographic test

The welds of the test specimens required by Clause 13.5.1 shall be examined by film radiographic methods or nonfilm radiographic imaging techniques in accordance with the requirements of Clause 12.4. The radiographic test shall be considered acceptable if all radiographs meet the acceptance criteria specified in Clause 12.4.5.

13.5.3 Transverse weld tension test

The transverse weld tension test specimen shall be as shown in Figure 10. The weld reinforcement shall be removed. The tensile strength shall be at least equal to the minimum specified for the applicable grade.

13.5.4 Transverse guided-bend test

The transverse guided-bend test specimen shall be as shown in Figure 11. The test specimen shall be bent approximately 180°, with the centreline of the weld located at the maximum point of bending in a jig that is substantially as shown in Figure 12, and with the exposed surface of the weld in tension. The

bend test shall be rated for acceptance in accordance with the requirements of Clauses 7.5.1.1.2 to 7.5.1.1.4.

13.6 Repair welder performance tests

13.6.1
The performance of the repair welder shall be tested by film radiographic methods or nonfilm radiographic imaging techniques and transverse guided-bend testing of two test specimens from a test weld. The test requirements shall be as specified in Clauses 13.5.2 and 13.5.4. Where any test result fails to conform to the specified requirements, four test specimens shall be required if the retest is made immediately or two test specimens shall be required if the repair welder takes further instructions in the practice before making the retest. To be acceptable, all retests shall conform to the specified requirements.

13.6.2
Acceptable performance test results shall automatically qualify the repair welder to make repair welds on pipe of grades equal to or lower than, and with specified wall thicknesses equal to or less than, the grade and thickness of the material used in the performance test.

13.6.3
Performance tests shall be performed at least annually. They shall also be performed if the repair welder is not engaged in the tested repair welding procedure for three months or more or if there is some reason to question the ability of the welder.

14 Procedure for welded mill-jointers

14.1
Circumferential jointer welds shall be made using a procedure qualified in accordance with the requirements of the *ASME Boiler and Pressure Vessel Code,* Section IX. (For pipe for sour service, see Clause 16.3 of this Standard.)

14.2
Portions of pipe used in the making of mill-jointers shall have passed inspection, including hydrostatic testing. Alternatively, the completed mill-jointer may be hydrostatically tested.

14.3
The ends of pipe to be welded together shall be prepared in accordance with the requirements of the process to be used. The location of the weld seams shall be in accordance with the requirements of Clause 11.5.8. Completed jointers shall be straight, in accordance with the requirements of Clause 10.6; however, mill-jointers shall not be straightened by bending at the jointer welds.

14.4
The maximum allowable offset (high-low) between the outside surfaces of adjoining lengths of pipe shall be 2.5 mm.

14.5
Completed circumferential jointer welds shall be substantially uniform around the circumference of the pipe.

14.6
Except as allowed by Clause 11.6.1 f), the completed as-deposited outside weld bead surface shall not be below the prolongation of the adjacent original parent metal surface.

14.7
Except as allowed by Clause 14.8, the completed as-deposited outside weld bead surface shall not exceed the applicable adjacent original parent metal surface by more than the following amounts:

a) away from weld bead overlap areas, 2.5 mm if the specified wall thickness is 10.0 mm or less and 3.5 mm if the specified wall thickness is greater than 10.0 mm; and
b) 5.0 mm at weld bead overlap areas.

14.8
The manufacturer shall have the option of grinding or machining weld beads to acceptable heights.

14.9
Manually welded mill-jointers shall have markings that identify the welders.

14.10
The full length of circumferential jointer welds shall be nondestructively inspected in accordance with the requirements of Clause 12.2.4.

15 Markings and coating

15.1 General
Pipe shall be legibly marked in accordance with the requirements of Clauses 15.2 to 15.4; however, additional markings as desired by the manufacturer or as requested by the purchaser may be used. Except as allowed by Clause 15.5, die-stamping marks shall not be permitted on pipe.

Note: *Additional markings include bar code markings. One-dimensional bar code markings should be of the Code 39 type and any two-dimensional bar code markings should be of the PDF417 type.*

15.2 Required markings
The required markings shall be as follows:

a) manufacturer's name or mark;
b) CSA Standard designation: Z245.1:22;
c) the specified OD in millimetres;
d) the specified wall thickness in millimetres;
e) the pipe grade designation;
f) for pipe with requirements for proven pipe body notch toughness, the pipe category designation: CAT II or CAT III;
g) for pipe with requirements for proven pipe body notch toughness, the test temperature. The temperature marked on the pipe shall not be lower than the pipe test temperature, excluding any applicable test temperature reduction required by Clause 8.4.2.1 or allowed by Clause 8.4.2.2. The temperature shall be marked using the designation MXC or PXC, where M and P signify minus and

plus, respectively, and X signifies the numerical value of the temperature in degrees Celsius (e.g., M45C for –45 °C);
h) for sour service pipe, the symbol SS;
i) the following symbols to indicate the process of manufacture:
   i) seamless pipe: S;
   ii) electric-welded pipe: E;
   iii) continuous welded pipe: F; and
   iv) no type marking for submerged-arc-welded pipe;
j) the following symbols for pipe that is ordered and supplied in the heat-treated condition:
   i) normalized or normalized and tempered: HN;
   ii) quench and tempered: HQ;
   iii) subcritical stress relieved: HS; and
   iv) subcritical age hardened or precipitation hardened: HA;
k) for elevated temperature service pipe, the symbol ET;
l) for pipe for strain-based design, the symbol SBD;
m) for pipe 48.3 mm OD or smaller, the individual pipe length (as measured on the finished pipe and shown in metres to two decimal places) or the total length of pipe in the bundle (shown in metres to two decimal places). For pipe larger than 48.3 mm OD, the individual pipe length (as measured on the finished pipe and shown in metres to two decimal places) shall be marked. For pipe furnished with couplings, the length shall be measured to the outer face of the coupling;
n) for pipe 60.3 mm OD or larger, where the specified hydrostatic test pressure calculated in accordance with Clause 9.4.1 is higher than the minimum required by Clause 9.4.1, such specified hydrostatic test pressure in kilopascals or megapascals; and
o) the heat number or a code traceable to the heat number.

15.3 Marking location and method of application

15.3.1

For pipe 48.3 mm OD or smaller, the required markings shall be
a) painted on the outside surface of each length of pipe;
b) printed on an adhesive weather-resistant label attached to the outside surface of each length of pipe; or
c) marked on a tag fixed to the bundle of pipe, except that some of the required markings may be printed on the straps or banding clips used to tie such bundles.

15.3.2

For pipe larger than 48.3 mm but smaller than 508 mm OD, the required markings shall be painted on the outside surface of each length of pipe or printed on an adhesive weather-resistant label attached to the outside surface of each length of pipe, except that where agreed on by the purchaser and the manufacturer, some or all of the markings may be placed on the inside surface.

15.3.3

For pipe 508 mm OD or larger, except where it is agreed by the purchaser and the manufacturer to place some or all of the markings on the outside surface of the pipe, the required markings shall be in the sequential order listed in Clause 15.4 and shall be
a) painted on the inside surface of each length of pipe; or
b) printed on an adhesive weather-resistant label attached to the inside surface of each length of pipe.

15.3.4

The required painted length markings on the outside of the pipe shall be between 300 and 600 mm from a pipe end. The location of the required painted heat code markings shall be at the option of the manufacturer. Other required painted markings on the outside surface of the pipe shall be located near, but at least 450 mm from, a pipe end.

15.3.5

The required labels on the outside surface of the pipe shall be near, but at least 450 mm from, a pipe end. The location of the required labels on the inside surface of the pipe shall be at the option of the manufacturer.

15.4 Sequence of required markings

15.4.1 Requirements

Individual required markings on the outside surface of the pipe shall be separated by dashes or spaces. Where each individual description is not clearly obvious, the required markings shall be in the following sequence:

a) manufacturer's name or mark [see Clause 15.2 a)];
b) CSA Standard designation: Z245.1:22 [see Clause 15.2 b)];
c) OD [see Clause 15.2 c)];
d) wall thickness [see Clause 15.2 d)];
e) pipe grade designation [see Clause 15.2 e)];
f) pipe category designation (if applicable) [see Clause 15.2 f)];
g) test temperature (if applicable) [see Clause 15.2 g)];
h) sour service (if applicable) [see Clause 15.2 h)];
i) process of manufacture (if applicable) [see Clause 15.2 i)];
j) heat treatment (if applicable) [see Clause 15.2 j)];
k) elevated temperature service (if applicable) [see Clause 15.2 k)];
l) strain-based design (if applicable) [see Clause 15.2 l)];
m) length [see Clause 15.2 m)];
n) hydrostatic test pressure (if applicable) [see Clause 15.2 n)]; and
o) heat number or code [see Clause 15.2 o)].

15.4.2 Examples

The following examples illustrate the requirements of Clause 15.4.1:

a) Electric-welded pipe for sour service, produced by AB Company, to the 2022 edition of CSA Z245.1, 355.6 mm OD, 9.5 mm wall thickness, Grade 359, Category I, 11.70 m long, hydrostatically tested at 16.3 MPa, heat number 26374, shall be painted as follows or shall have the following printed on a label:
   ABCO Z245.1:22 355.6 9.5 359 SS E 11.70 26374
b) Electric-welded, quench and tempered pipe, produced by AB Company, to the 2022 edition of CSA Z245.1, 355.6 mm OD, 9.5 mm wall thickness, Grade 359, Category II, tested at –5 °C, 11.70 m long, hydrostatically tested at 18.3 MPa, heat number 26374, shall be painted as follows or shall have the following printed on a label:
   ABCO Z245.1:22 355.6 9.5 359 CAT II M5C E HQ 11.70 18.3 26374

15.4.3 Sequence of markings

The sequence of the required markings on the inside surface of the pipe and on tags shall be at the option of the manufacturer.

15.5 Die-stamped markings

For other than required markings, the manufacturer may die-stamp pipe end faces, provided that such markings are applied

a) at least 25 mm from any weld;
b) at temperatures less than 100 °C; and
c) with round, blunt, or low-stress stamps or dies.

15.6 Coating

Unless otherwise stated in the purchase order, pipe shall be supplied with bare metal finish.

Notes:

1) *Where bare metal pipe is to be supplied, the purchase order should state the following:*
   a) *the type of coating intended to be applied;*
   b) *the pipe surfaces intended to be coated; and*
   c) *whether there are special surface finish requirements for the pipe.*
2) *Where coated pipe is to be supplied, the purchase order should state the following:*
   a) *the type of coating;*
   b) *the coating requirements;*
   c) *the pipe surfaces to be coated; and*
   d) *whether the coatings are to be applied along the full length of the pipe or the pipe is to be left bare for a specified distance from the pipe ends.*
3) *With regards to the quality program requirements of Clause 4.4, coating is considered to be out of scope.*

16 Sour service

16.1

Where sour service is specified in the purchase order, the provisions of Clauses 1 to 15 shall apply, except insofar as such provisions are specifically modified by the requirements of Clause 16.

Note: *Materials (including welding consumables) and manufacturing procedures should be selected in a way that avoids microstructures in the weld metal, heat-affected zones, and parent metal that are detrimental for use in sour service.*

16.2

Where an inclusion shape control method is employed, the manufacturer shall report the method.

16.3

The welding procedure qualification test weld [see Clauses 5.4.6, 13.4 g), 13.5, and 14.1] shall be microhardness tested at the hardest-appearing microstructure. The microhardness at any location therein shall not exceed 248 HV 500 gf.

16.4

The macrohardness at any location in the pipe shall not exceed 22 HRC or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E140.

16.5
The microhardness at any location in the weld zone of electric-welded pipe and in the deposited weld metal and heat-affected zones of other welds shall not exceed 248 HV 500 gf.

16.6
Electric-welded pipe 60.3 mm OD or larger shall be subjected to the root guided-bend test in accordance with the applicable requirements of Clause 7.5.2.

16.7
Where hydrogen-induced cracking testing is specified in the purchase order, such testing shall be performed in accordance with the requirements of ANSI/NACE TM0284, with the test solution, test frequency, and acceptance criteria as specified in the purchase order.

16.8
The tensile strength shall not exceed 625 MPa for Grades 386 and lower, 650 MPa for grades higher than Grade 386 but lower than Grade 483, and 665 MPa for Grade 483.

Note: *For sour service, grades higher than Grade 483 are not within the scope of this Standard.*

16.9
Any lamination in the body of the pipe shall be considered a defect if its nondestructively determined dimensions exceed

a) a width of 20 mm; and
b) an area of 500 mm^2.

16.10
The nickel content at any location, including any deposited weld metal, shall not exceed 1.0%.

17 Elevated temperature service

17.1
Where pipe for elevated temperature service is specified in the purchase order, the provisions of Clauses 1 to 15 shall apply, as well as Clause 16 when sour service is applicable and Clause 18 when strain based design is applicable, except where requirements of Clauses 1 to 15 are modified by the requirements of Clause 17.

Note: *Materials (including welding consumables) and manufacturing procedures should be selected so that specified elevated temperature properties are maintained at the elevated test temperature for welds, heat-affected zones, and parent metal.*

17.2
In addition to the requirements specified in Clause 4.1.1, the purchase order shall state

a) elevated test temperature(s); and
b) elevated temperature tension test
    i) frequency;
    ii) specimen type, size, location, and orientation;
    iii) required properties for pipe body and weld seam (if present); and

iv) retesting procedures.

Note: *Elevated temperature tension test requirements and impact property requirements at the minimum design temperature may be derived from CSA Z662, Clause 14, and CSA Z662, Annex I.*

17.3

Elevated temperature tension tests shall be conducted in accordance with the requirements of ASTM E21 at the specified elevated test temperature.

17.4

Elevated temperature tension testing shall be in addition to room temperature tension testing.

Note: *The relationship between tensile properties and test temperatures can be non-linear.*

17.5

When the purchaser specifies submerged-arc-welded pipe, each pipe grade and combination of welding flux and electrode classifications shall be considered essential variables.

17.6

All-weld-metal tension testing shall be conducted at room temperature in accordance with the requirements of ASTM A370 (see also Clause 7.2.1) and at the specified elevated test temperature in accordance with the requirements of ASTM E21 (see also Clause 17.3), as part of each welding procedure qualification record (PQR). Test specimens shall be all-weld-metal standard or subsize round tensile specimen in accordance with the requirement of ASTM A370 or equivalent standards agreed to by the purchaser. The room temperature all-weld-metal yield strength shall be no less than the pipe body specified minimum yield strength at room temperature. The elevated temperature all-weld-metal yield strength shall be no less than the specified minimum body elevated temperature yield strength.

18 Pipe for strain-based design

18.1

Where pipe for strain-based design or other designs requiring longitudinal plastic strain capacity is specified in the purchase order, the provisions of Clauses 1 to 15 shall apply, as well as Clause 16 when sour service is applicable and Clause 17 when elevated temperature service is applicable, except where requirements of Clauses 1 to 15 are modified by the more stringent requirements of Clause 18.

Notes:

1) *This Clause provides guidance for the purchaser to specify the requirements that are known to affect the global longitudinal strain capacity of the pipe. This Clause does not specify acceptance criteria since the requirements will vary and depend on each application and design.*
2) *Raw materials such as hot rolled coil/plate and billets, including welding consumables, and manufacturing procedure are known to affect the mechanical properties of the pipe.*

18.2

In addition to the requirements specified in Clause 4.1.1, the purchase order shall state

a) longitudinal body tension test (see Clause 18.5);
b) all-weld-metal tension test (where applicable) (see Clause 18.9); and
c) cross-weld tension test for mill-jointer welds (see Clause 18.10).

Note: *The purchaser may specify more restrictive provisions and acceptance criteria than in Clauses 1 to 15 (and Clauses 16 and 17 as applicable).*

18.3

Where applicable, in addition to the requirements specified in Clause 4.1.2, the purchase order may include the following as supplementary requirements:

a) strain aging test requirements;
   i) test frequency;
   ii) aging conditions [strain, temperature(s), and duration];
   iii) type of mechanical testing;
   iv) specimen type, size, and location;
   v) required properties; and
   vi) retesting procedure;
b) aging conditions for longitudinal body tension test pieces;
   i) aging temperature(s);
   ii) aging duration(s); and
   iii) method of heating the sample;
c) strain aged and/or aged condition(s) notch-toughness test requirements;
   i) test frequency;
   ii) test temperature(s);
   iii) specimen orientation; and
   iv) absorbed energy and shear area (as applicable) for pipe body, heat-affected zone and deposited weld metal (for submerged-arc-welded pipe), or weld fusion line (for electric-welded pipe);
d) tolerances requirements on pipe body and pipe ends;
   i) OD — pipe body;
   ii) OD — pipe ends;
   iii) out-of-roundness;
   iv) wall thickness; and
   v) straightness;
e) hardness test requirements on pipe body, weld seam, and heat-affected zone (if present); and
   i) test frequency; and
   ii) maximum hardness values (beyond those in Clause 5.4.4 and, where applicable, Clauses 16.4 and 16.5); and
f) nondestructive inspection requirements;
   i) acceptance limits;
   ii) ultrasonic inspection for laminar imperfections on strip and plate for welded pipes; and
   iii) full-body ultrasonic inspection.

Notes:

1) *Strain aging test is intended to assess mechanical properties' change due to the strain and temperature(s) applied during the pipe coating process and field operation.*
2) *Longitudinal body tension test after aging is intended to confirm tensile properties' change due to thermal effects incurred during the pipe coating process and anticipated field operation. Coating and/or operation temperature(s) should be considered for aging temperature(s).*

18.4

Longitudinal body tension tests before and after aging (where applicable) shall be conducted in accordance with the requirements specified in Clauses 7.2.1, 7.2.2, and 7.2.3. The purchase order shall state

a) test frequency;
b) specimen type; and
c) required properties (see Clause 18.5).

18.5

The required mechanical properties for pipe body for longitudinal body tension test before and after aging (where applicable) shall be defined by the purchaser and may include

a) minimum and maximum yield strength;
b) minimum and maximum tensile strength;
c) maximum yield-to-tensile strength ratio;
d) minimum uniform elongation;
e) range of actual longitudinal yield strength (limit on the difference between the maximum and minimum values of actual longitudinal yield strength);
f) stress-strain curve;
    i) full-thickness strip specimen for welded pipe (unless otherwise agreed);
    ii) full-thickness strip specimen or round bar specimen for seamless pipe; and
    iii) full stress-strain curve (unless otherwise agreed); and
g) requirements on stress-strain curve shape and strain hardening behaviour.

18.6

Retesting procedures of longitudinal body tension tests shall be in accordance with the requirements specified in Clause 7.2.6.

18.7

Longitudinal body tension tests shall be conducted in addition to transverse body tension tests where required by Clause 8.2.1.1.

18.8

When the purchaser specifies submerged-arc-welded pipe, each pipe grade and combination of welding flux and electrode classifications shall be considered essential variables.

18.9

Unless otherwise specified, all-weld-metal tension tests shall be conducted in accordance with the requirements of ASTM A370 (see also Clause 7.2.1). Test specimens shall be all-weld-metal standard or subsize round tensile specimen in accordance with the requirements of ASTM A370 or equivalent standards agreed to by the purchaser. The purchase order shall state

a) test frequency (beyond those of Table 10);
b) round tensile specimen size (standard or subsize);
c) required properties; and
d) retesting procedure.

18.10

Cross-weld tension test for mill-jointer welds before and after aging (where applicable) shall be conducted in accordance with the requirements of ASTM A370. The purchase order shall state

a) test frequency;
b) specimen type and size;
c) required properties; and
d) retesting procedure.

Unless otherwise agreed to by the purchaser, the specimens shall not fail in the weld or heat-affected zone.

Note: *The purchaser may specify other acceptance criteria than the failure location of the specimens based on their design requirements.*

19 Certification

19.1 Certificate of compliance

The manufacturer shall furnish a certificate of compliance for each order item.

Note: *A single document containing certificate of compliance information and test report information may be used.*

19.2 Steelmaking and casting

Where specified in the purchase order, the manufacturer shall furnish a report of the steelmaking process and casting method used.

19.3 Rolling mill

Where specified in the purchase order, the manufacturer shall furnish a report of the type of skelp rolling mill used.

19.4 Chemical analysis

For each heat of steel supplied, the manufacturer shall furnish a report of the deoxidation practice, heat analysis, product analysis, and carbon equivalent values. The elements reported shall include carbon, manganese, phosphorus, sulphur, silicon, copper, nickel, chromium, molybdenum, vanadium, niobium, boron, and any alloying element intentionally added for other than inclusion shape control. In addition, the report shall identify the name and location of facilities used for pipe manufacturing, plate/coil rolling and steelmaking.

Note: *The value for an element may be reported as zero, provided that the element is*

a) *other than boron, phosphorus, or sulphur, and the measured concentration is less than 0.003%; or*
b) *boron, and the measured concentration is less than 0.0005%.*

19.5 Inclusion shape control

Where sour service is specified in the purchase order, the inclusion shape control method used shall be reported, if applicable.

19.6 Elevated service

Where elevated temperature service is specified in the purchase order, elevated test temperature and the elevated temperature tension test properties (including yield strength, tensile strength, and elongation) [see Clause 17.2 a), b), and c)] shall be reported, as applicable.

19.7 Strain-based design

Where pipe for strain-based design is specified in the purchase order, the results of longitudinal body tension test, all-weld-metal tension test, and cross-weld tension test for mill-jointer welds [see Clause 18.2 a), b), and c)] shall be reported, as applicable.

19.8 Tensile properties

For each lot supplied, the manufacturer shall furnish a report of the applicable tensile properties.

19.9 Notch toughness

For each lot of Category II and Category III pipe supplied, the manufacturer shall furnish a report of the applicable notch-toughness properties. Such reports shall include the following, as applicable:

a) source (pipe body, EW fusion line, SAW weld, or SAW HAZ);
b) type of Charpy test specimen (flattened or nonflattened);

c) Charpy test specimen size;
d) type of drop-weight tear-test specimen (flattened or nonflattened);
e) type of drop-weight tear-test notch (pressed or chevron);
f) toughness test temperature;
g) actual test results for each test specimen; and
h) where the required absorbed energy is in accordance with the requirements of Clause 8.4.4.2 c), 8.4.5.2, or 8.5, the absorbed energy acceptance criterion.

19.10 Hydrostatic pressure

Where the hydrostatic test pressure is higher than the minimum required by Clause 9.4.1, the manufacturer shall furnish a report identifying the minimum test pressure and minimum test duration. If the hydrostatic test pressure calculation of Clause 9.4.2 is applied, the manufacturer shall also furnish a report identifying the minimum gauge pressure and minimum test pressure calculated in accordance with Clause 9.4.2.

19.11 Records

19.11.1

Material test reports shall be retained by the manufacturer for a period of not less than ten years from the date of manufacture.

19.11.2

Supporting data for the material test report shall be retained by the manufacturer for a period of not less than five years from the date of manufacture, and should include information detailing

a) chemical and mechanical test data;
b) product compliance nondestructive inspection reports;
c) pipe product compliance nondestructive testing and mechanical testing machine calibration reports;
d) pipe product compliance nondestructive testing and mechanical testing machine procedures; and
e) welding procedure specifications (WPS)/procedure qualification records (PQR).

19.11.3

Radiographs shall be kept for a period of not less than two years from the date of manufacture.

Note: *Interpretation reports of radiographs are considered supporting data and retained as described in Clause 19.11.2 b).*

19.11.4

Manufacturers shall take reasonable and prudent care to store records in a manner that prevents loss, damage, or degradation.

Table 1
Minimum hydrostatic test pressure
(See Clauses 4.1.1, 9.4.1, 9.4.2, and 10.1.1.)

Specified OD, mm	Specified wall thickness, mm	Minimum hydrostatic test pressure, MPa (see Note 2)	
		Grade 241	Grades higher than 241
21.3	2.1	4.8	20.7
	2.3	4.8	20.7
	2.8	4.8	20.7
	3.7	5.9	20.7
	4.8	6.2	20.7
	7.5	6.9	20.7
26.7	2.1	4.8	20.7
	2.3	4.8	20.7
	2.9	4.8	20.7
	3.2	5.1	20.7
	3.9	5.9	20.7
	5.6	6.6	20.7
	7.8	6.9	20.7
33.4	2.1	4.8	20.7
	2.3	4.8	20.7
	2.8	4.8	20.7
	3.4	4.8	20.7
	4.5	5.9	20.7
	6.4	6.6	20.7
	9.1	6.9	20.7
42.2	2.1	9.0	See Note 1
	2.3	9.0	See Note 1
	2.8	9.0	20.7
	3.2	9.0	20.7
	3.6	9.0	20.7
	4.9	13.0	20.7
	6.4	14.0	20.7
	9.7	15.9	20.7

(Continued)

Table 1 (Continued)

Specified OD, mm	Specified wall thickness, mm	Minimum hydrostatic test pressure, MPa (see Note 2)	
		Grade 241	Grades higher than 241
48.3	2.1	9.0	See Note 1
	2.3	9.0	See Note 1
	2.8	9.0	See Note 1
	3.2	9.0	20.7
	3.7	9.0	20.7
	5.1	13.1	20.7
	7.1	14.2	20.7
	10.2	15.9	20.7
60.3–2032	All	See Note 1	See Note 1

Notes:

1) *Test pressures shall be calculated using the equation in Clause 9.4.1 and the percentage of specified minimum yield strength specified in the table to this Note. The results shall be rounded to the nearest 0.1 MPa.*

Specified OD, mm	Percentage of specified minimum yield strength
88.9 or smaller	60
>88.9 to <168.3	60
168.3 to <273.1	75
273.1 to <508	85
508 or greater	90

2) *For Grade 241 and pipe diameter 88.9 mm or smaller, the minimum hydrostatic test pressure need not exceed 17.2 MPa. For Grade 241 and pipe diameter larger than 88.9 mm, the minimum hydrostatic test pressure need not exceed 19.3 MPa. For pipe greater than Grade 241, the minimum hydrostatic test pressure need not exceed 20.7 MPa.*

Table 2
Tolerances on length
(See Clauses 4.1.1, 4.1.2, 10.5, and 11.4.6.)

	Specified lengths in entire shipment, m		
Nominal length, m	**Minimum**	**Minimum average**	**Maximum**
6	4.00	5.00	8.00
12	4.00	11.00	16.00
18	4.00	16.00	20.00
24	4.00	21.00	26.00
Special	As specified in the purchase order		

Note: *The limitations specified in the purchase order can be affected by issues such as coating and transportation.*

Table 3
Tolerances on wall thickness
(See Clauses 4.1.2 and 11.4.4 and Table 4.)

Specified OD, mm	Specified wall thickness, mm	Type of pipe	Tolerances on wall thickness, %*
73.0 or smaller	Any	Any	+20.0, –12.5
Larger than 73.0 but smaller than 101.6	Any	Any	+18.0, –12.5
101.6 to 457	Any	Any	+15.0, –12.5
Larger than 457	Any	Seamless	+17.5, –10.0
Larger than 457	9.5 or less	Welded	+17.0, –8.0
Larger than 457	9.6 to 12.6	Welded	+15.0, –8.0
Larger than 457	12.7 or greater	Welded	+12.0, –8.0

* *Calculated values shall be rounded to the nearest 0.1 mm.*

Note: *For orders where the minus tolerance on wall thickness is reduced from the applicable value given in this Table, the corresponding plus tolerance on wall thickness shall be increased by the same number of percentage points unless otherwise specified in the purchase order.*

Table 4
Tolerances on mass
(See Clauses 4.1.2 and 11.4.5 and Table 3.)

Quantity	Tolerances on mass, %
Single lengths, 457 mm OD or smaller, other than special light sizes	+10.0, –3.5
Single lengths, larger than 457 mm OD, other than special light sizes	+10.0, –2.5
Single lengths of special light sizes	+10.0, –5.0
Carload* lots exceeding 20 Mg	–1.75
Order items exceeding 20 Mg	–1.75

** A carload is considered to be a railway carload or a truckload.*

Notes:

1) *For orders where the minus tolerance on wall thickness is reduced from the applicable value given in Table 3, the corresponding plus tolerance on mass shall be increased by the same number of percentage points unless otherwise specified in the purchase order.*
2) *Special light sizes shall be as follows:*

Specified OD, mm	Specified wall thickness*, mm
60.3	2.1–3.9
73.0–168.3	2.1–4.0
219.1	3.2–4.0
273.1	4.0–5.2
323.9	4.4–5.6
355.6–508	4.8–7.1
559–914	5.6–7.1
965–1372	6.4–7.1

** Pipe having specified wall thicknesses intermediate to these values shall also be considered special light sizes.*

Table 5
Chemical composition limits for heat and product analyses
(See Clauses 6.2 and 6.3.1.)

Grades	Carbon equivalent*, maximum
All	**0.40**
Element	**Maximum permitted, %**
Carbon	0.26
Manganese	2.00
Phosphorus	0.030
Sulphur	0.035
Silicon	0.50
Niobium	0.11
Titanium	0.11
Vanadium	0.11
Boron	0.001

* *The carbon equivalent (CE) shall be calculated using the following formula:*

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

where *F* is a compliance factor that depends on carbon content and shall be as given in Table 6.

Notes:

1) *The addition of cerium shall be subject to agreement by the purchaser.*
2) *Niobium (Nb) is also known as columbium (Cb).*

Table 6
Compliance factor (*F*) — Carbon equivalent formula
(See Table 5.)

Carbon content, %	*F*
<0.06	0.53
0.06	0.54
0.07	0.56
0.08	0.58
0.09	0.62
0.10	0.66
0.11	0.70
0.12	0.75
0.13	0.80
0.14	0.85
0.15	0.88
0.16	0.92
0.17	0.94
0.18	0.96
0.19	0.97
0.20	0.98
0.21	0.99
>0.21	1.00

Table 7
Charpy test specimen sizes
(See Clauses 7.6.1.2, 7.6.2.1, 7.6.2.3, and 7.6.3.1.)

	Specified wall thickness, mm				
Specified OD, mm	Full nonflattened	3/4 nonflattened	2/3 nonflattened	1/2 nonflattened	1/2 flattened*
114.3–141.2	>12.5	11.3–12.5	10.9–11.2	10.1–10.8	6.0–10.0
141.3–168.2	>11.8	9.8–11.8	9.4–9.7	8.6–9.3	6.0–8.5
168.3–219.0	>11.6	9.2–11.6	8.5–9.1	7.6–8.4	6.0–7.5
219.1–273.0	>11.3	8.9–11.3	8.1–8.8	6.5–8.0	6.0–6.4
273.1–323.8	>11.2	8.6–11.2	7.9–8.5	6.2–7.8	6.0–6.1
323.9–355.5	>11.0	8.6–11.0	7.8–8.5	6.1–7.7	6.0
355.6–406.3	>11.0	8.6–11.0	7.7–8.5	6.1–7.6	6.0
406.4–2032	>10.9	8.5–10.9	7.7–8.4	6.0–7.6	—

* *This column is not applicable to weld or heat-affected zone Charpy tests.*

Table 8
Tensile requirements
(See Clauses 8.2.1.1 and 8.2.2.4.)

Grade	Yield strength (Y), MPa		Tensile strength (T), MPa		Y/T, Maximum*		Body elongation in 50 mm, minimum, %
	Mini-mum	Maxi-mum†	Minimum	Maxi-mum†	Flattened strip specimen	Other than flattened strip specimen	
241	241	495	414	760	0.93	0.93	The minimum elongation requirement shall be determined by the following formula or by using Table 9: $e = 1940\frac{A^{0.2}}{U^{0.9}}$ where e = minimum elongation in 50 mm, rounded to the nearest per cent; A = based on nominal dimensions, the cross-sectional area of the tensile test specimen, rounded to the nearest square millimetre, or 500 mm², whichever is less; U = specified minimum tensile strength, MPa
290	290	495	414	760	0.93	0.93	
359	359	530	455	760	0.93	0.93	
386	386	540	490	760	0.93	0.93	
414	414	565	517	760	0.93	0.93	
448	448	600	531	760	0.93	0.93	
483	483	620	565	760	0.93	0.93	
550	550	690	620	830	0.93	0.93	
620	620	760	690	900	0.93	0.95	
690	690	825	760	970	0.93	0.97	
825	825	1050	915	1145	0.99	0.99	

* *Limits are not applicable to pipe smaller than 355.6 mm OD.*

† *Limits are not applicable to pipe smaller than 219.1 mm OD.*

Notes:

1) *The yield strength and tensile requirements for intermediate grades shall be obtained by interpolation between the values specified for the standard listed grades, with the results for minimum yield strength rounded to the nearest 1 MPa and the results for maximum yield strength, minimum tensile strength, and maximum tensile strength rounded to the nearest 5 MPa.*

2) *The Y/T for intermediate grades shall be obtained by interpolation, with the results rounded to the nearest 0.01.*

Table 9
Body elongation requirements
(See Table 8.)

Cross-sectional area range, mm²	Specified wall thickness range, mm			Body elongation in 50 mm, minimum, %										
Full-section tension test specimen	19 mm tension test specimen	25 mm tension test specimen	38 mm tension test speci-men	Grade										
				241	290	359	386	414	448	483	550	620	690	825
40–49	2.1–2.6	—	—	19	19	17	16	15	15	14	13	12	11	9
50–59	2.7–3.1	2.1–2.3	—	19	19	18	17	16	15	15	13	12	11	9
60–69	3.2–3.6	2.4–2.7	—	20	20	18	17	16	16	15	14	13	12	10
70–79	3.7–4.1	2.8–3.1	—	21	21	19	18	17	16	16	14	13	12	10
80–89	4.2–4.7	3.2–3.5	—	21	21	19	18	17	17	16	14	13	12	10
90–99	4.8–5.2	3.6–3.9	—	21	21	20	18	18	17	16	15	14	12	11
100–109	5.3–5.7	4.0–4.3	—	22	22	20	19	18	18	17	15	14	13	11
110–119	5.8–6.2	4.4–4.7	—	22	22	20	19	18	18	17	15	14	13	11
120–129	6.3–6.8	4.8–5.1	3.2–3.4	23	23	21	19	19	18	17	16	14	13	11
130–139	6.9–7.3	5.2–5.5	3.5–3.6	23	23	21	20	19	18	17	16	15	13	11
140–149	7.4–7.8	5.6–5.9	3.7–3.9	23	23	21	20	19	19	18	16	15	13	11
150–159	7.9–8.3	6.0–6.3	4.0–4.1	24	24	22	20	19	19	18	16	15	14	12
160–169	8.4–8.9	6.4–6.7	4.2–4.4	24	24	22	21	20	19	18	17	15	14	12
170–179	9.0–9.4	6.8–7.1	4.5–4.7	24	24	22	21	20	19	18	17	15	14	12

(Continued)

Table 9 (Continued)

Cross-sectional area range, mm²	Specified wall thickness range, mm			Body elongation in 50 mm, minimum, %										
Full-section tension test specimen	19 mm tension test specimen	25 mm tension test specimen	38 mm tension test speci-men	Grade										
				241	290	359	386	414	448	483	550	620	690	825
180–189	9.5–9.9	7.2–7.5	4.8–4.9	24	24	22	21	20	20	18	17	15	14	12
190–199	10.0–10.4	7.6–7.9	5.0–5.2	25	25	23	21	20	20	19	17	16	14	12
200–219	10.5–11.5	8.0–8.7	5.3–5.7	25	25	23	22	21	20	19	17	16	15	12
220–239	11.6–12.6	8.8–9.5	5.8–6.3	26	26	24	22	21	20	19	18	16	15	13
240–259	12.7–13.6	9.6–10.3	6.4–6.8	26	26	24	22	21	21	20	18	16	15	13
260–279	13.7–14.7	10.4–11.1	6.9–7.3	26	26	24	23	22	21	20	18	17	15	13
280–299	14.8–15.2	11.2–11.9	7.4–7.8	27	27	25	23	22	21	20	18	17	15	13
300–319	—	12.0–12.7	7.9–8.4	27	27	25	23	22	22	21	19	17	16	13
320–339	—	12.8–13.5	8.5–8.9	27	27	25	24	22	22	21	19	17	16	13
340–359	—	13.6–14.3	9.0–9.4	28	28	26	24	23	22	21	19	18	16	14
360–379	—	14.4–15.1	9.5–9.9	28	28	26	24	23	22	21	19	18	16	14
380–399	—	15.2–15.9	10.0–10.5	28	28	26	24	23	23	21	20	18	16	14
400–419	—	16.0–16.7	10.6–11.0	29	29	26	25	23	23	22	20	18	17	14
420–439	—	16.8–17.5	11.1–11.5	29	29	27	25	24	23	22	20	18	17	14

(Continued)

Table 9 (Concluded)

Cross-sectional area range, mm²	Specified wall thickness range, mm			Body elongation in 50 mm, minimum, %										
Full-section tension test specimen	19 mm tension test specimen	25 mm tension test specimen	38 mm tension test speci-men	Grade										
				241	290	359	386	414	448	483	550	620	690	825
440–459	—	17.6–18.3	11.6–12.0	29	29	27	25	24	23	22	20	18	17	14
460–479	—	18.4–19.1	12.1–12.6	29	29	27	25	24	24	22	20	19	17	14
≥ 480	—	≥ 19.2	≥ 12.7	30	30	27	25	24	24	22	21	19	17	15

Table 10
Testing frequency
(See Clauses 8.2.1.2, 8.2.2.2, 8.4.1, 8.5.1.1, 8.5.2, 17.2, 18.4, and 18.9.)

Specified outside diameter, mm	Frequency per size per heat per hot rolling practice (as applicable to welded pipe) per cold expansion percentage*
141.3 or smaller	1 per lot of 400 lengths
Larger than 141.3 and up to 323.9	1 per lot of 200 lengths
Larger than 323.9	1 per lot of 100 lengths

* *Pipe manufactured with the same nominal percentage of cold expansion (i.e., within ±0.2 of a percentage point) shall be considered to have the same cold expansion percentage.*

Table 11
Tolerances on outside diameter — Pipe body
(See Clause 11.4.1.1.)

Specified OD, mm	OD tolerances
48.3 or smaller	+0.4 mm, –0.8 mm
Larger than 48.3 but smaller than 114.3	±1.00%*
114.3 to 457	±0.75%*
Larger than 457, nonexpanded	±1.00%*
Larger than 457, cold-expanded	±0.50%*

* *Calculated values are percentages of the specified OD, rounded to the nearest 0.1 mm.*

Table 12
Electric-welded pipe — Removal of internal weld flash
(See Clause 11.5.6.2.)

Specified wall thickness (t), mm	Maximum depth of groove, mm*
4.0 or less	0.10t
4.1 to 8.0	0.40
8.1 or greater	0.05t

* *Calculated values shall be rounded to the nearest 0.1 mm.*

Note: *The depth of groove is the positive difference between the wall thickness approximately 40 mm from the weld line and the minimum wall thickness at the trim.*

Table 13
Image quality indicator sizes
(See Clause 12.4.4.2.)

	Image quality indicator thickness or wire diameter, maximum, mm			
	Hole-type		Wire-type	
Weld thickness range, mm	Radiographic inspection	Fluoroscopic inspection	Radiographic inspection	Fluoroscopic inspection
<8	0.25	0.30	0.16	0.33
8–11	0.30	0.38	0.20	0.41
11–14	0.38	0.43	0.25	0.51
14–18	0.43	0.51	0.33	0.64
18–25	0.51	0.64	0.41	0.81
>25	0.64	0.76	0.51	1.02

Table 14
Circular slag inclusions and gas pockets
(See Clause 12.4.5.2.)

Weld thickness, mm	Projected area on radiological image, maximum, %
Less than 14	3
14 to 18	4
Greater than 18	5

Table 15
Guided-bend test jig dimensions
(See Figure 3.)

Item	Dimensions, mm
Width of male member, *A*	See Note 1
Radius of male member, R_A	Equal to 1/2 dimension *A*
Width of groove in female member, *B*	Equal to $A + 2t + 3.2$
Radius of female member, R_B	Equal to 1/2 dimension *B*

Notes:

1) *The calculation of A allows for a peaking effect in the guided-bend test and for the strain introduced by the flattening of the curved test specimens. For any combination of grade, OD, and specified wall thickness, the exact width of male member (A) may be calculated using the following equation, with the results rounded to the nearest 5 mm, provided that they do not exceed the 790 mm maximum specified male member (A) width:*

$$A = \frac{1.15(D - 2t)}{e(D / t) - 2e - 1} - t$$

where

A = width of male member, mm

1.15 = peaking factor

D = specified OD of pipe, mm

t = specified wall thickness of pipe, mm

e = strain, mm/mm (per Table 16)

2) *At the option of the manufacturer, the width of the male member (A) used for testing may be smaller than the value calculated in accordance with Note 1.*

Table 16
Strain values for guided-bend test
(See Table 15.)

Pipe grade	Strain value, *e**
241	0.1375
290	0.1375
359	0.1250
386	0.1175
414	0.1125
448	0.1100
483	0.1050
550	0.0950
620	0.0875
690	0.0800
825	0.0675

** For intermediate grades, the strain values shall be obtained by interpolation based on the specified minimum tensile strength, with the interpolated value rounded to the nearest multiple of 0.0025.*

Table 17
Guided-bend test jig dimensions for repair welds
(See Figure 12.)

	Dimensions, mm							
Item	Grades 241 and 290	Grades 359 and 386	Grades 414 and 448	Grade 483	Grade 550	Grade 620	Grade 690	Grade 825
Width of male member, *A*	6*t*	8*t*	9*t*	10*t*	11*t*	12*t*	13*t*	14*t*
Radius of male member, R_A	3*t*	4*t*	4.5*t*	5*t*	5.5*t*	6*t*	6.5*t*	7*t*
Width of groove in female member, *B*	8*t* + 3.0	10*t* + 3.0	11*t* + 3.0	12*t* + 3.0	13*t* + 3.0	14*t* + 3.0	15*t* + 3.0	16*t* + 3.0
Radius of female member, R_B	4*t* + 1.5	5*t* + 1.5	5.5*t* + 1.5	6*t* + 1.5	6.5*t* + 1.5	7*t* + 1.5	7.5*t* + 1.5	8*t* + 1.5

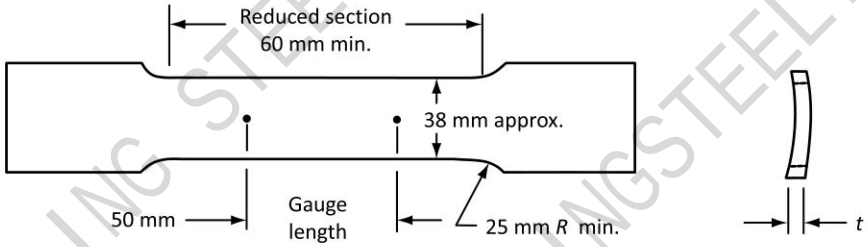
Notes:
1) *t = specified wall thickness of the pipe in millimetres (see Clause 13.5.1).*
2) *For intermediate pipe grades, the test jig dimensions shall be consistent with the values in this Table.*
3) *Jig dimensions smaller than those required by this Table may be used at the option of the manufacturer.*

Table 18
Transverse tension tests — Nominal diameter for round specimens
(See Clause 7.2.4.7.)

	Specified wall thickness, mm		
	Nominal diameter of test specimen, mm		
Specified OD, mm	**12.7**	**8.9**	**6.4**
219.1 to <273.1	—	>28.1	<28.1
273.1 to <323.9	—	>25.5	<25.5
323.9 to <355.6	—	>23.9	<23.9
355.6 to <406.4	—	>23.2	<23.2
406.4 to <457	>30.9	>22.2 to <30.9	<22.2
457 to <508	>29.7	>21.5 to <29.7	<21.5
508 to <559	>28.8	>21.0 to <28.8	<21.0
559 to <610	>28.1	>20.5 to <28.1	<20.5
610 to <660	>27.5	>20.1 to <27.5	<20.1
660 to <711	>27.0	>19.8 to <27.0	<19.8
711 to <762	>26.5	>19.5 to <26.5	<19.5
762 to <813	>26.2	>19.3 to <26.2	<19.3
813 to <864	>25.8	>19.1 to <25.8	<19.1
864 to <914	>25.5	>18.9 to <25.5	<18.9
914 to <965	>25.3	>18.7 to <25.3	<18.7
965 to <1016	>25.1	>18.6 to <25.1	<18.6
1016 to <1067	>24.9	>18.5 to <24.9	<18.5
1067 to <1118	>24.7	>18.3 to <24.7	<18.3
1118 to <1168	>24.5	>18.2 to <24.5	<18.2
1168 to <1219	>24.4	>18.1 to <24.4	<18.1
1219 to <1321	>24.2	>18.1 to <24.2	<18.1
1321 to <1422	>24.0	>17.9 to <24.0	<17.9
1422 to <1524	>23.8	>17.8 to <23.8	<17.8
1524 to <1626	>23.6	>17.6 to <23.6	<17.6
1626 to <1727	>23.4	>17.5 to <23.4	<17.5
1727 to <1829	>23.3	>17.4 to <23.3	<17.4
1829 to <1930	>23.1	>17.4 to <23.1	<17.4
1930 to <2032	>23.0	>17.3 to <23.0	<17.3
>2032	>22.9	>17.2 to <22.9	<17.2

Figure 1
Tension test specimens
(See Clauses 7.2.3.2, 7.2.4.2, and 7.2.5.2.)

Full-section test specimen



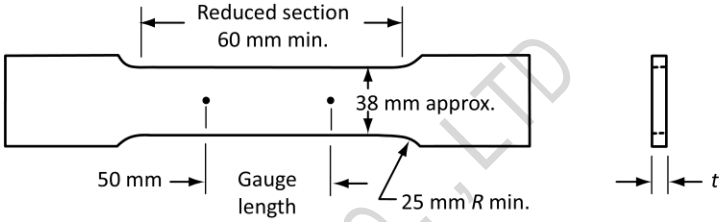
Longitudinal body strip test specimen

Ring expansion test specimen

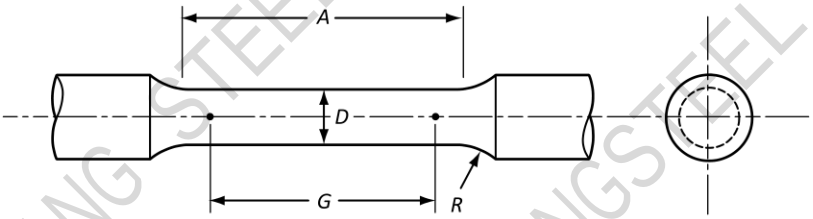
Legend:
OD = outer diameter, mm
t = pipe wall thickness, mm

(Continued)

Figure 1 (Concluded)



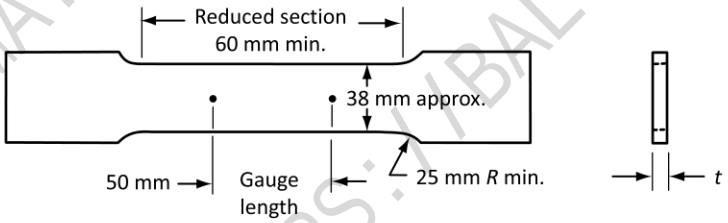
Transverse body strip test specimen



Round tension test specimen

Nominal diameter of round tension test specimen, mm

	12.7	8.9	6.4
G — Gauge length	50.0 ± 0.1	35.0 ± 0.1	25.0 ± 0.1
D — Diameter	12.7 ± 0.2	8.9 ± 0.2	6.4 ± 0.1
R — Radius of fillet, min.	10	6	5
A — Length of reduced section, min.	60	45	32

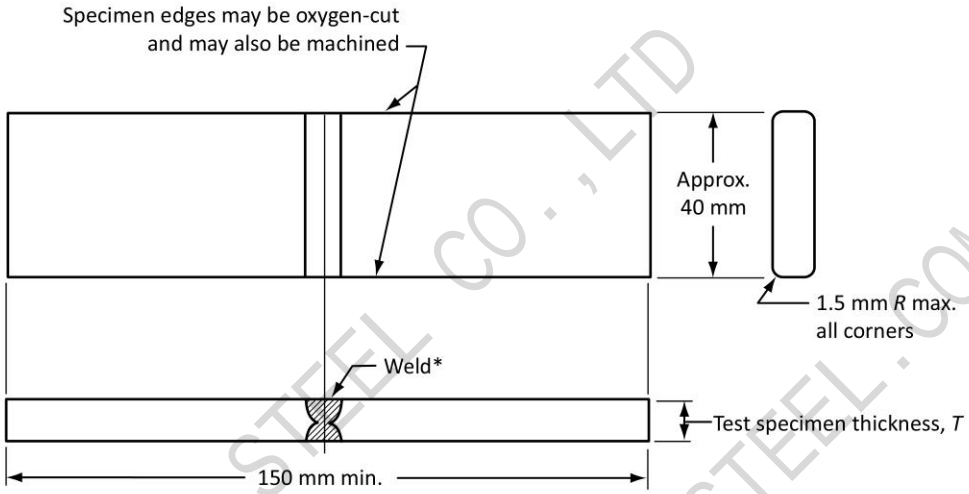


Transverse weld strip test specimen

Legend:

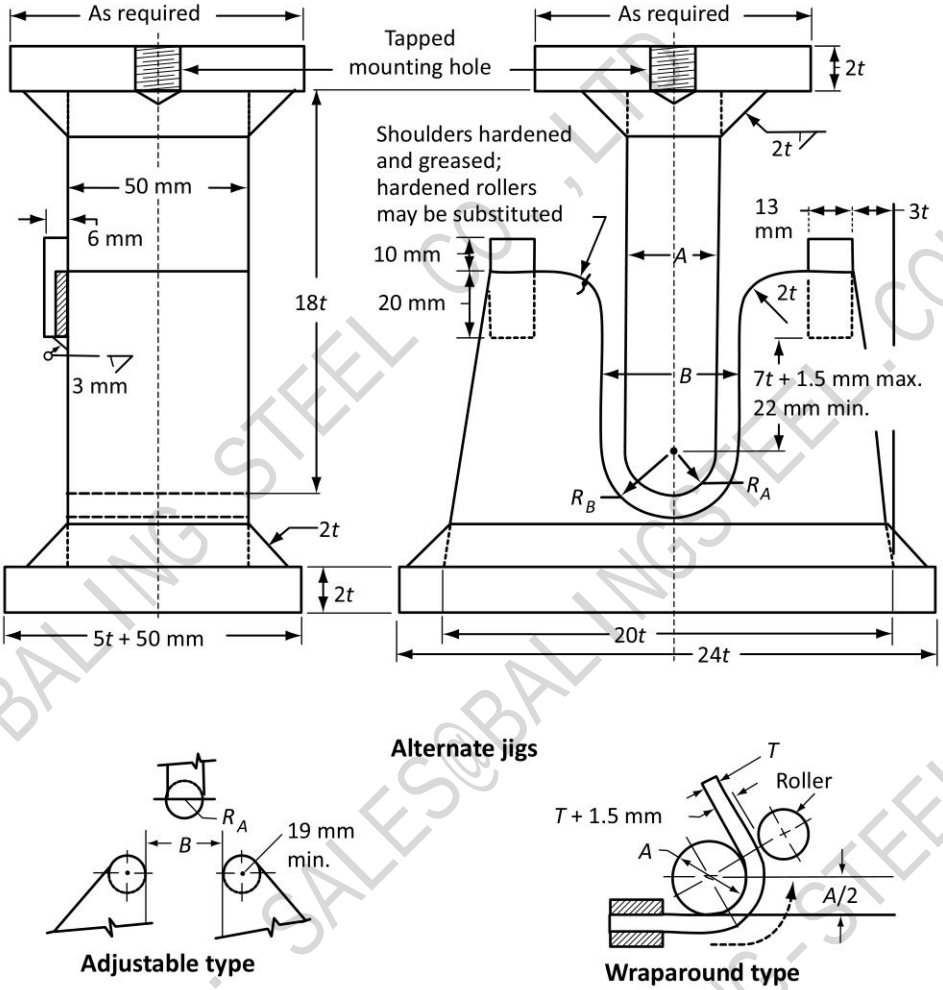
t = pipe wall thickness, mm

Figure 2
Guided-bend test specimen
(See Clauses 7.5.1.1.1 and 7.5.2.1.)



*Weld reinforcement shall be removed from both faces. Test specimens shall not contain repair welds.

Figure 3
Jig for guided-bend test
(See Clauses 7.5.1.1.1 and 7.5.2.1.)



Legend:

T = test specimen thickness, mm

t = specified wall thickness of the pipe, mm

A, *B*, R_A, and R_B are as given in Table 15.

Figure 4
Lot testing
(See Clause 7.6.5.2.)

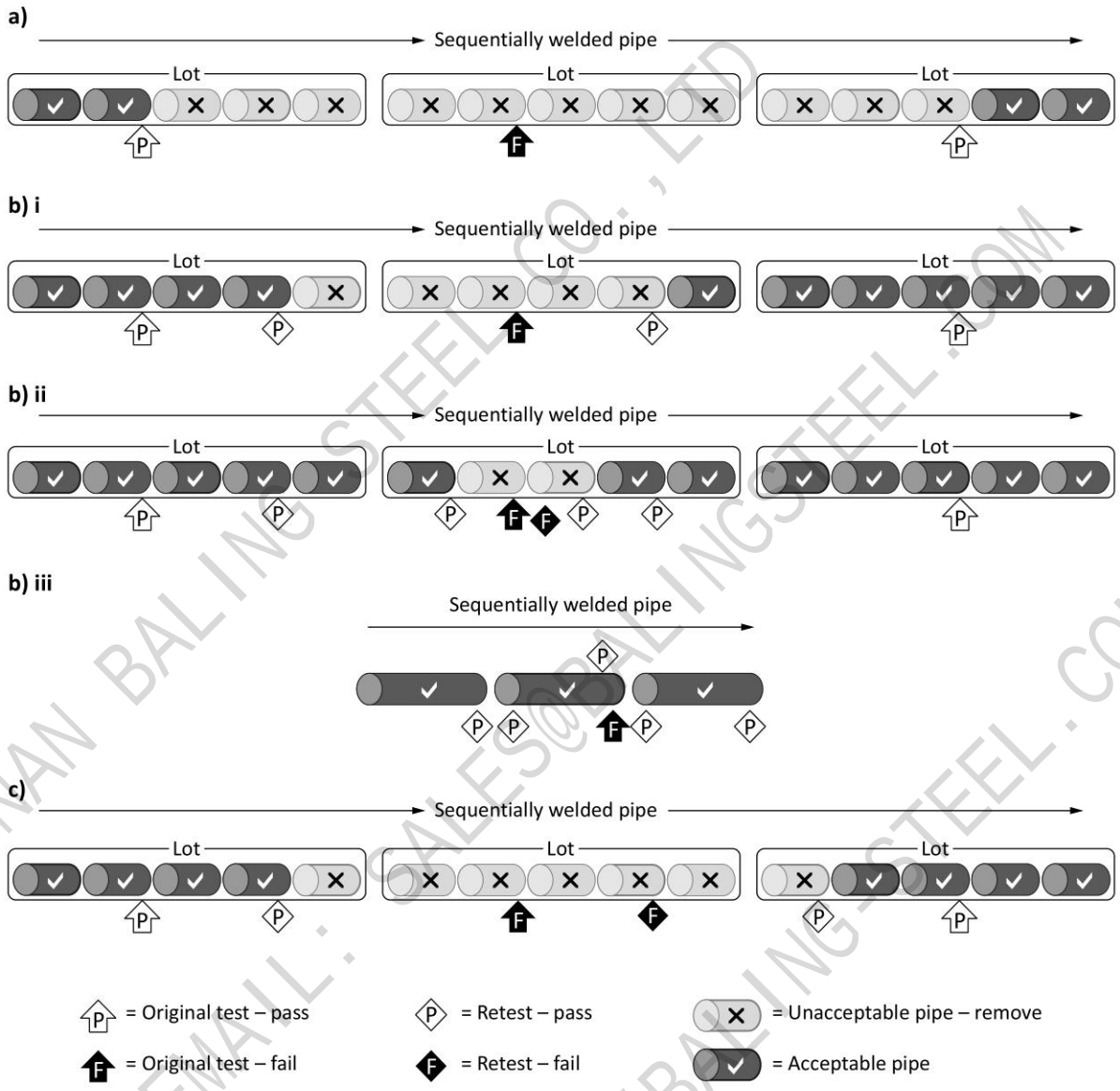
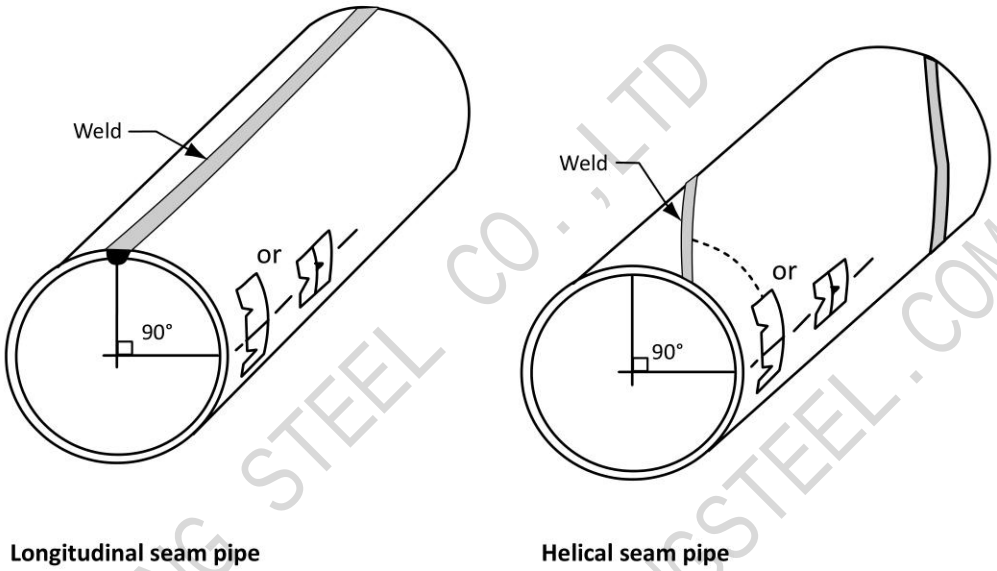


Figure 5
Drop-weight tear test — Specimen orientation and location
(See Clause 7.7.2.)



Longitudinal seam pipe **Helical seam pipe**

Figure 6
Examples of circular slag inclusions and gas pockets
(See Clause 12.4.5.2.)

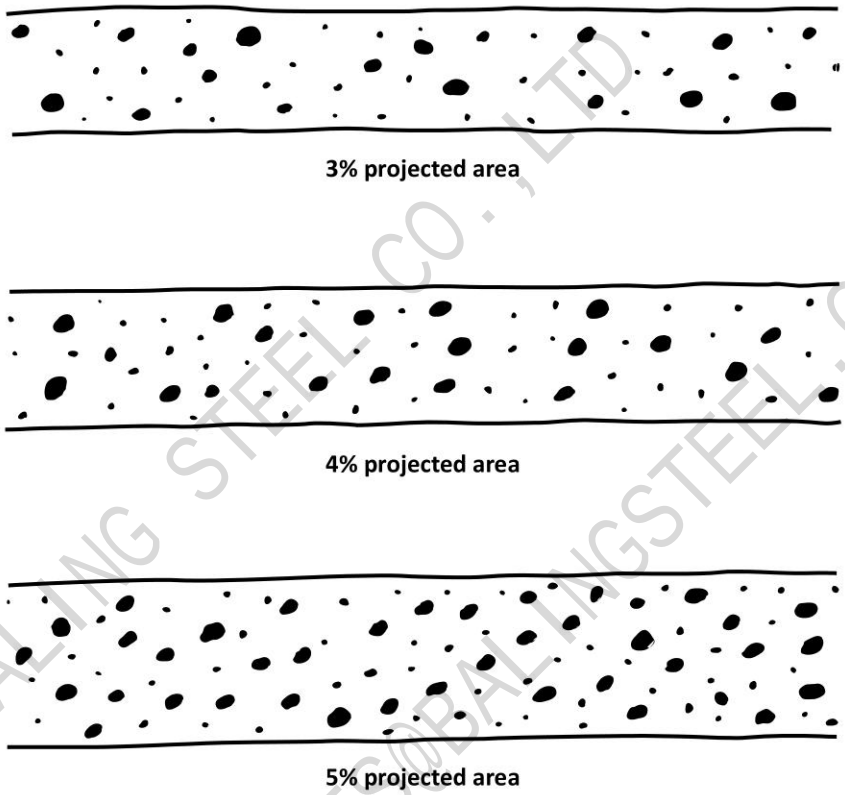
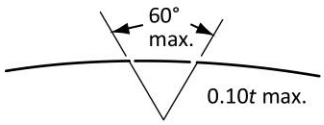
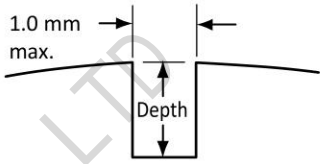


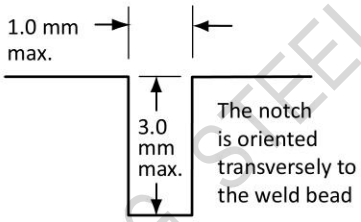
Figure 7
Reference indicators — Ultrasonic inspection
(See Clause 12.5.2.2.)



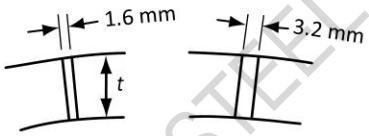
V10 notch



N5 and N10 notch



T notch

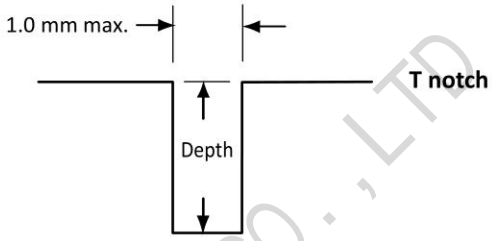


Drilled hole

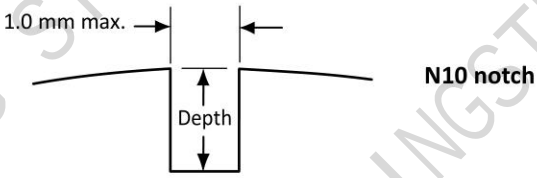
Legend:
t = specified wall thickness of the pipe, mm

N5 depth = greater of 0.05*t* and 0.3 mm
N10 depth = greater of 0.10*t* and 0.3 mm
Depth tolerance = ±15% of specified depth
Notch length = 50 mm maximum

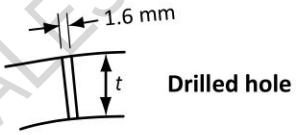
Figure 8
Reference indicators — Electromagnetic inspection
(See Clauses 12.6.1.2.2 and 12.6.2.3.2.)



The notch is oriented transversely to the pipe axis
Specified depth = greater of 0.10 *t* and 0.3 mm
Depth tolerance = ±15% of specified depth
Notch length = 50 mm maximum



The notch is oriented parallel to the pipe axis
Specified depth = greater of 0.10 *t* and 0.3 mm
Depth tolerance = ±15% of specified depth
Notch length = 50 mm maximum



Legend:
t = specified wall thickness of the pipe, mm

Figure 9
Groove configuration
(See Clause 13.5.1.)

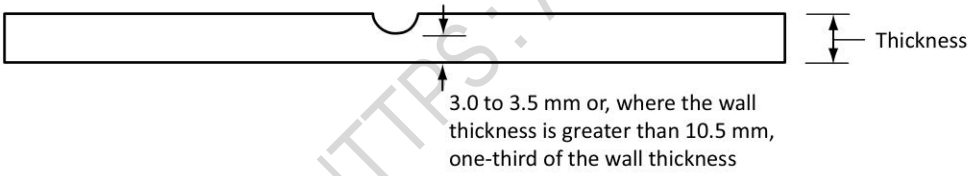
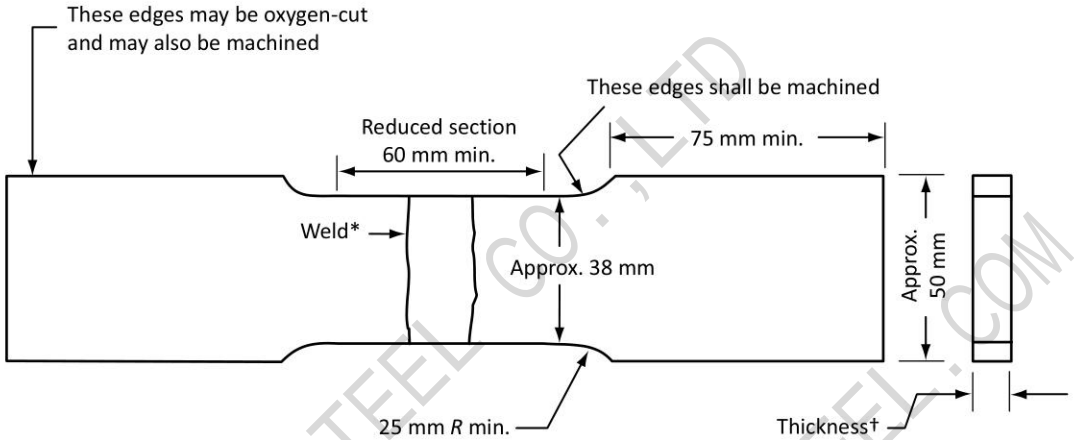
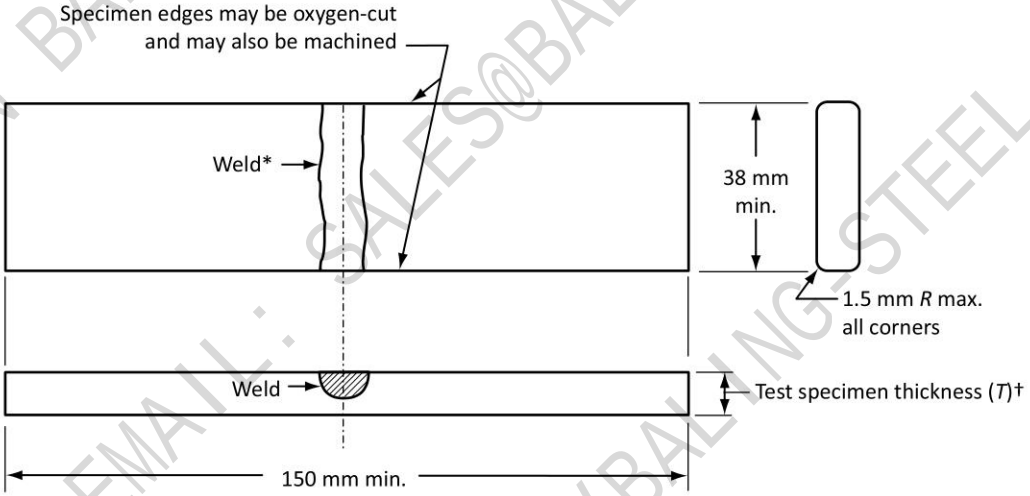


Figure 10
Transverse weld tension test specimen
(See Clause 13.5.3.)



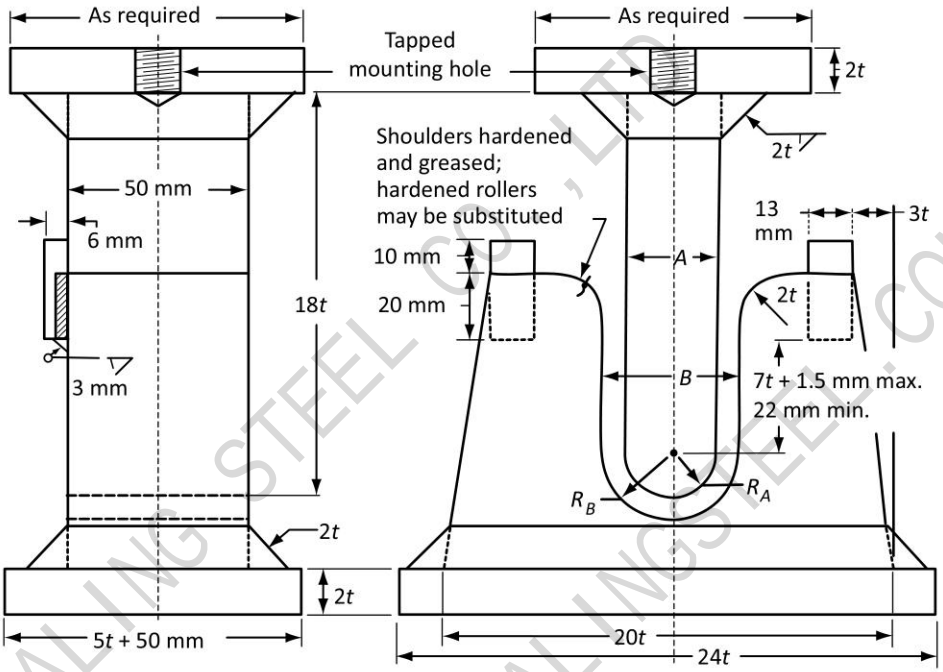
* *Weld reinforcement shall be removed.*
† *See Clause 13.5.1.*

Figure 11
Guided-bend test specimen
(See Clause 13.5.4.)

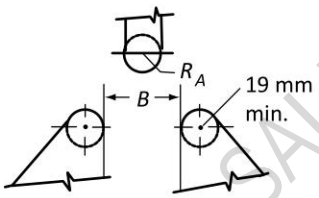


* *Weld reinforcement shall be removed.*
† *See Clause 13.5.1 or 13.6.2, whichever is applicable.*

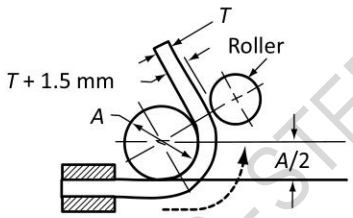
Figure 12
Jig for guided-bend test for repair welds
(See Clause 13.5.4.)



Alternate jigs



Adjustable type



Wraparound type

Legend:

T = test specimen thickness, mm

t = specified wall thickness of the pipe (see Clause 13.5.1), mm

A, *B*, R_A, and R_B are as given in Table 17.

Annex A (informative)
Steel pipe dimensions, weight classes, and schedule numbers

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See Clause 4.1.1.*

Table A.1
Steel pipe dimensions, weight classes, and schedule numbers

Nominal size, in	OD		Wall thickness		Weight class	Schedule number
	in	mm	in	mm		
1/2	0.840	21.3	0.109	2.8	STD	40
			0.147	3.7	XS	80
			0.188	4.8	—	160
			0.294	7.5	XXS	—
3/4	1.050	26.7	0.113	2.9	STD	40
			0.154	3.9	XS	80
			0.219	5.6	—	160
			0.308	7.8	XXS	—
1	1.315	33.4	0.133	3.4	STD	40
			0.179	4.5	XS	80
			0.250	6.4	—	160
			0.358	9.1	XXS	—
1-1/4	1.660	42.2	0.140	3.6	STD	40
			0.191	4.9	XS	80
			0.250	6.4	—	160
			0.382	9.7	XXS	—
1-1/2	1.900	48.3	0.145	3.7	STD	40
			0.200	5.1	XS	80
			0.281	7.1	—	160
			0.400	10.2	XXS	—
2	2.375	60.3	0.154	3.9	STD	40
			0.218	5.5	XS	80
			0.344	8.7	—	160
			0.436	11.1	XXS	—
2-1/2	2.875	73.0	0.203	5.2	STD	40
			0.276	7.0	XS	80
			0.375	9.5	—	160
			0.552	14.0	XXS	—
3	3.500	88.9	0.216	5.5	STD	40
			0.300	7.6	XS	80

(Continued)

Table A.1 (Continued)

Nominal size, in	OD		Wall thickness		Weight class	Schedule number
	in	mm	in	mm		
			0.438	11.1	—	160
			0.600	15.2	XXS	—
3-1/2	4.000	101.6	0.226	5.7	STD	40
			0.318	8.1	XS	80
4	4.500	114.3	0.237	6.0	STD	40
			0.337	8.6	XS	80
			0.438	11.1	—	120
			0.531	13.5	—	160
			0.674	17.1	XXS	—
5	5.563	141.3	0.258	6.6	STD	40
			0.375	9.5	XS	80
			0.500	12.7	—	120
			0.625	15.9	—	160
			0.750	19.1	XXS	—
6	6.625	168.3	0.280	7.1	STD	40
			0.432	11.0	XS	80
			0.562	14.3	—	120
			0.719	18.3	—	160
			0.864	21.9	XXS	—
8	8.625	219.1	0.250	6.4	—	20
			0.277	7.0	—	30
			0.322	8.2	STD	40
			0.406	10.3	—	60
			0.500	12.7	XS	80
			0.594	15.1	—	100
			0.719	18.3	—	120
			0.812	20.6	—	140
			0.875	22.2	XXS	—
			0.906	23.0	—	160

(Continued)

Table A.1 (Concluded)

Nominal size, in	OD		Wall thickness		Weight class	Schedule number
	in	mm	in	mm		
10	10.750	273.1	0.250	6.4	—	20
			0.307	7.8	—	30
			0.365	9.3	STD	40
			0.500	12.7	XS	60
			0.594	15.1	—	80
			0.719	18.3	—	100
			0.844	21.4	—	120
			1.000	25.4	XXS	140
			1.125	28.6	—	160
12	12.750	323.9	0.250	6.4	—	20
			0.330	8.4	—	30
			0.375	9.5	STD	—
			0.406	10.3	—	40
			0.500	12.7	XS	—
			0.562	14.3	—	60
			0.688	17.5	—	80
			0.844	21.4	—	100
			1.000	25.4	XXS	120
			1.125	28.6	—	140
			1.312	33.3	—	160

Annex B (informative)
Steel line pipe and component size nomenclature

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See Clause 4.1.1.*

Table B.1
Steel line pipe and component size nomenclature

Pipe size OD, mm	Nominal size of matching component	
	NPS	DN
21.3	1/2	15
26.7	3/4	20
33.4	1	25
42.2	1-1/4	32
48.3	1-1/2	40
60.3	2	50
73.0	2-1/2	65
88.9	3	80
101.6	3-1/2	90
114.3	4	100
141.3	5	125
168.3	6	150
219.1	8	200
273.1	10	250
323.9	12	300
355.6	14	350
406.4	16	400
457	18	450
508	20	500
559	22	550
610	24	600
660	26	650
711	28	700
762	30	750
813	32	800

(Continued)

Table B.1 (Concluded)

Pipe size OD, mm	Nominal size of matching component	
	NPS	DN
864	34	850
914	36	900
965	38	950
1016	40	1000
1067	42	1050
1118	44	1100
1168	46	1150
1219	48	1200
1270	50	1250
1321	52	1300
1372	54	1350
1422	56	1400
1473	58	1450
1524	60	1500
1575	62	1550
1626	64	1600
1676	66	1650
1727	68	1700
1778	70	1750
1829	72	1800
1880	74	1850
1930	76	1900
1981	78	1950
2032	80	2000

Notes:

1) *The nominal pipe size (NPS) system of nominal size designation is used in standards prepared by the American Society of Mechanical Engineers. The NPS is dimensionless, and the numerical portion of the designation is identical to the numerical portion of the previously used inch nominal size designation.*
2) *The "diamètre nominal" (DN) system of nominal size designation is used in standards prepared by the International Organization for Standardization (ISO).*
3) *The DN nominal sizes listed in this Table have generally been extracted from various ISO standards but, in some cases, have been assigned arbitrarily. Caution should be exercised in the use of this Table because, in many cases, the DN nominal size shown is identical to that used in ISO standards to designate components for pipe having a specified OD that differs slightly from the pipe OD size listed.*

Annex C (informative)
Summary of destructive testing requirements

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See Clause 4.1.1.*

Table C.1
Summary of destructive testing requirements

Clause	Test or testing condition	Mandatory	Purchaser's option
6.2	Heat analysis	X	
6.3	Product analysis	X	
	Pipe body tension tests for tensile strength, yield strength, and per cent elongation		
8.2.1.1 a)	Welded pipe ≥219.1 mm OD — transverse	X	
8.2.1.1 b)	Seamless pipe ≥219.1 mm OD — transverse or longitudinal	X	
8.2.1.1 c)	All pipe <219.1 mm OD — longitudinal	X	
8.2.2.1	Transverse weld tension tests for tensile strength	X	
8.2.2.5	Transverse weld tension tests for percent elongation for submerged-arc-welded pipe	X	
8.3.1.1	Flattening tests for electric-welded pipe ≥60.3 mm OD	X	
8.3.1.1	Bend tests for electric-welded pipe <60.3 mm OD	X	
8.3.3	Guided-bend tests		
8.3.3.1	Face and root guided-bend tests of all welds in submerged-arc-welded pipe	X	
8.3.1.2	Root guided-bend tests of electric-welded pipe ≥60.3 mm for other than sour service		X
16.6	Root guided-bend tests of electric-welded pipe ≥60.3 mm OD for sour service pipe	X	
8.4.4.2 and 8.4.5.2	Charpy V-notch impact tests of pipe body for absorbed energy — Category II and Category III pipe	X	
8.5.1.3 a)	For specified pipe test temperatures lower than –5 °C, Charpy V-notch impact tests of pipe welds	X	

(Continued)

Table C.1 (Concluded)

Clause	Test or testing condition	Mandatory	Purchaser's option
	and heat-affected zone for absorbed energy — Category II and Category III pipe		
8.5.1.3 b)	For specified pipe test temperatures –5 °C or higher, Charpy V-notch impact tests of pipe welds and heat-affected zone for absorbed energy — Category II and Category III pipe		X
8.5.2	Charpy V-notch impact tests of weld fusion line for electric-welded pipe Category II or Category III with a specified test temperature of -5 °C or higher.		X
8.5.2	Charpy V-notch impact tests of weld fusion line for electric-welded pipe Category II or Category III with a specified test temperature of lower than -5 °C.	X	
8.4.4.1.1 and 8.4.4.1.2	Shear area determination by drop-weight tear tests or Charpy specimens — Category II pipe	X	
8.6 and 16.4	Macrohardness tests of weld zone and pipe body for electric-welded pipe	X	
16.5	Microhardness tests of weld zone of electric-welded pipe and in deposited weld metal and heat-affected zones of other welds for sour service pipe	X	
16.7	Hydrogen-induced cracking tests for sour service pipe		X
17.2 b)	Elevated temperature tension tests	X	
17.6	All-weld-metal tension tests at room temperature and at the specified elevated test temperature for submerged-arc-welded pipe	X	
18.2 a) and 18.5	Longitudinal body tension test		X
18.2 b) and 18.9	All-weld-metal tension test for submerged-arc-welded pipe		X
18.2 c) and 18.10	Cross-weld tension test for mill-jointer welds		X
18.3 a)	Strain aging test		X
18.3 b)	Aging conditions for longitudinal body tension test pieces		X
18.3 c)	Notch-toughness test		X
18.3 e)	Hardness test requirements on pipe body, weld seam, and heat-affected zone		X

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