Steel pipe

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Preface

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

This edition differs from the previous edition as follows:

(a) For other than sour service, this edition covers pipe from Grade 241 to Grade 825. For sour service, this edition covers pipe from Grade 241 to Grade 483.
(b) New definitions of "Flattening test", "Guided-bend test", "Hooked fibre", "Ingot casting", "Pressure casting", "Radiographic inspection", "Sensitivity check", "Standardization", and "Strand casting" have been added.
(c) The definition of "Heat-affected zone" has been revised.
(d) Yield strength requirements for grades higher than Grade 690 have been revised.
(e) For pipe weld tests, the test specimen orientation has been added.
(f) Retest procedures for pipe weld have been added.
(g) Hardness test requirements have been revised.
(h) Requirements for notch-toughness tests — weld have been revised.
(i) Tolerances on out-of-roundness have been revised.
(j) Work quality requirements have been revised.
(k) A new clause on residual magnetism has been added.
(l) The procedure for welded mill-jointers has been revised.
(m) The pipe marking requirements have been revised.
(n) Tables 1, 15, and 16 have been simplified.

This Standard covers the requirements for steel pipe intended to be used for transporting fluids as specified in CSA Z662, *Oil and gas pipeline systems.*

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.

April 2007

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 publication 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 publication.*

(4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*

Requests for interpretation should

(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) be phrased where possible to permit a specific "yes" or "no" answer.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update, *which is available on the CSA Web site at www.csa.ca.*

Z245.1-07
Steel pipe

1 Scope

1.1 General

This Standard covers seamless pipe, electric-welded pipe (flash-welded pipe 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* 1 kHz.

1.2 Size, 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 and wall thickness

This Standard covers pipe having specified outside diameters from 21.3 to 2032 mm.

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 are also permitted.*

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 CSA Standards, "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; "may" is used to express an option or that which is permissible within the limits of the standard; and "can" is used to express possibility or capability. 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 editions listed below, unless the user finds it more appropriate to use newer or amended editions of such publications. Some reference publications are supplemented, qualified, or both by specific requirements elsewhere in this Standard; reference publications should therefore be applied only in the context of this Standard.

CSA (Canadian Standards Association)
CAN/CSA-ISO 9001-00 (R2005)
Quality management systems — Requirements

Z662-07
Oil and gas pipeline systems

API (American Petroleum Institute)
RP 5L3 (1996)
Conducting Drop-Weight Tear Tests on Line Pipe

SPEC Q1 (2003)
Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry

ASME International (American Society of Mechanical Engineers)
Boiler and Pressure Vessel Code, 2004
Section IX — Welding and Brazing Qualifications

B1.20.1-1983 (R2006)
Pipe Threads, General Purpose, Inch

ASTM International (American Society for Testing and Materials)
A 370-05
Standard Test Methods and Definitions for Mechanical Testing of Steel Products

A 751-01 (2006)
Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

E 18-05 e1
Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

E 29-04
Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 92-82 (2003) e2
Standard Test Method for Vickers Hardness of Metallic Materials

E 94-04
Standard Guide for Radiographic Examination

E 140-05 e1
Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness

E 165-02
Standard Test Method for Liquid Penetrant Examination

E 384-05a
Standard Test Method for Microindentation Hardness of Materials

E 709-01
Standard Guide for Magnetic Particle Examination

E 747-04
Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E 1025-05
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 48.9712-2006
Non-destructive Testing — Qualification and Certification of Personnel

ISO (International Organization for Standardization)
2566-1:1984
Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels

5579:1998
Non-destructive testing — Radiographic examination of metallic materials by X- and gamma rays — Basic rules

9001:2000
Quality management systems — Requirements

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

NACE International (National Association of Corrosion Engineers)
TM0284-2003
Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking

3 Definitions

The following definitions apply in this Standard:

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

Analysis, 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.

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.

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.

Pipe, 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.

Pipe, seamless — pipe manufactured without a welded seam.

Pipe, 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.*

Welding, 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.

Welding, 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.*

Welding, 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) CSA Standard designation and year of publication;
(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 outside diameter (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, 7.6.5, 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 Clause 8.4.4.2);
(g) increased absorbed energy acceptance criterion for Category III pipe (see Clause 8.4.5.2);
(h) increased hydrostatic test pressure (see Clause 9.1);
(i) special or alternative tolerances on length (see Clause 11.4.6 and Table 2);
(j) supply of mill-jointers (see Clause 10.6.1);
(k) alternative values for maximum number of jointers on an order item (see Clauses 10.6.2 and 10.6.4);
(l) pipe end bevel (see Clause 10.7.1.2);
(m) removal of outside weld reinforcement (see Clause 10.7.1.6);
(n) threaded and coupling details (see Clause 10.7.2.2);
(o) alternative pipe end outside diameter measurement technique (see Clause 11.4.2.5);
(p) plant inspection by the purchaser (see Clause 11.2);
(q) alternative tolerances on wall thickness (see Table 3);
(r) alternative tolerances on mass (see Table 4);
(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 17.2);
(x) report of type of skelp rolling mill used (see Clause 17.3); and
(y) pipe to be installed in oilfield steam distribution pipelines (see Table 8).

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 E 29.

4.4 Quality program

The manufacturer shall comply with the requirements of

(a) CAN/CSA-ISO 9001;
(b) ISO 9001; or
(c) API SPEC Q1.

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

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

5.4 Pipe manufacture

5.4.1

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 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

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

5.4.4

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 heat-affected zone approximate those of the parent metal. The macrohardness of the heat-affected zone shall not exceed 24 HRC or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E 140. (For sour service, see also Clause 16.)

5.4.5

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

5.4.6

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 6.3.5.4, the methods, practices, and definitions pertaining to chemical analysis shall be in accordance with the requirements of ASTM A 751.

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 once per heat.

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 representing a lot fails 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.

6.3.5.2

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 retests conform to the specified requirements, the lot shall be accepted, except for the length represented by the initial analysis that failed.

6.3.5.4

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 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 A 370. 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 690 , the yield strength shall be the tensile stress required to produce a total extension under load of 0.5% of the gauge length, as determined by an extensometer or by multiplying dividers. For grades higher than Grade 690, 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.

7.2.5 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
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
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 weld shall occur before the distance between the plates is one-half of the specified outside diameter of the pipe. Evidence of defective material shall not develop during the entire flattening operation. 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 outside diameter 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 longer 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 in accordance with the requirements of ASTM A 370, 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 average of the three test results shall be rounded to the nearest per cent or joule, whichever is applicable. The test results shall conform to the applicable requirements of Clauses 8.4 and 8.5 and ASTM A 370.

7.6.1.2

For pipe having a specified outside diameter 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 in order 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 zone tests of electric-welded pipe, the notch shall be located in the heat-treated area 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 required size is expected to exceed 80% of the capacity of the impact testing machine, appropriate smaller test specimens may be substituted.
Note: *As an alternative to the use of smaller test specimens, lower test temperatures may be used. (See Clause 8.4.2.2.)*

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
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.

7.6.5.2
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.

7.6.5.3
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.

7.7 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 4.
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 E 18 or ASTM E 92 for macrohardness tests; and
(b) ASTM E 384 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 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 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
For Categories II and III pipe, where specified in the purchase order, Charpy V-notch impact tests shall be conducted on test specimens taken from the weld zone of electric-welded pipe. Test temperatures, testing frequencies, and acceptance criteria shall be as specified in the purchase order.

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

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:

$P = 2(St/D)$

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 outside diameter, 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.*

10 Dimensions, masses, and lengths

10.1 General

10.1.1

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

Note: *Pipe outside diameters, 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:

$M_\ell = 0.024\ 66\ (D - t)t$

where

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

D = specified outside diameter, mm

t = specified wall thickness, mm

10.2 Outside diameter

Outside diameters 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 it shall be permissible to weigh the individual lengths comprising the jointer or the jointer itself. 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 outside diameter shall be as given in Table 11.

11.4.1.2

For pipe 114.3 mm OD or larger, the outside diameter 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 outside diameter 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 outside diameter 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 0.8 mm smaller than the specified outside diameter for a distance of 100 mm from the ends of the pipe and shall permit passage over the ends, for a distance of 100 mm, of a ring gauge that has a bore 2.4 mm larger than the specified outside diameter of the pipe.

11.4.2.3
For pipe 457 mm OD or smaller, the manufacturer shall have the option of measuring the minimum outside diameter with a diameter tape or a device that measures outside diameter 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 less than 0.8 mm smaller or more than 2.4 mm larger than the specified outside diameter 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 outside diameter 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 outside diameter shall be not more than 1% larger than the specified outside diameter, and the minimum outside diameter shall be not more than 1% smaller than the specified outside diameter.

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 outside diameter; and

(b) 15.9 mm for pipe greater than 1067 mm specified outside diameter.

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.

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 E 140; 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 E 140, 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

It shall not be permissible for skelp end welds to be present in finished longitudinal seam pipe.

11.5.8.1.2

It shall be permissible for skelp end welds to 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., 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 — Dents deeper than 6 mm or having a length in any direction exceeding one-half of the pipe outside diameter, 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 — Leaks shall be considered defects and shall be cut out as cylinders and rejected, or the pipe shall be rejected.

(c) Arc burns — 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 10% solution of ammonium persulphate or a 5% 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.*

(d) Surface cracks — 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 — 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 — 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 may 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 12.7 and 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 16.6.9 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 directly involved in fluoroscopic, ultrasonic, or radiographic inspection shall be approved by the manufacturer. 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, or its 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 E 94. 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

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.

Hole-type image quality indicators shall be in accordance with the requirements of ASTM E 1025. Wire-type image quality indicators shall be in accordance with the requirements of ASTM E 747 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.

12.4.4.2
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.

12.4.4.3
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
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
The image quality indicator shall be used to check the sensitivity of the equipment on
(a) one pipe in every lot of 50 pipes, where fluoroscopic inspection is used;
(b) each film, where film is used; and
(c) each image, where nonfilm radiographic imaging is used.

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 5 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 outside diameter 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 6; 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 6.

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 rejected or inspected in the static mode.

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 outside diameter 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 7:
(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 outside diameter 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 7, 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 7, 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 E 709.

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 E 165.

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 shall be permitted 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 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 8. (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 9. 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 10. 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 11, 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.)

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 shall be permitted. Except as allowed by Clause 15.5, die-stamping marks shall not be permitted on pipe.

Note: *Additional markings may 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 — Z245.1-07;
(c) the specified outside diameter 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 oilfield steam distribution pipe, the symbol SD;
(l) 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;

(m) for pipe 60.3 mm OD or larger, where the specified hydrostatic test pressure is higher than the minimum required by Clause 9.4, such specified hydrostatic test pressure in kilopascals or megapascals; and
(n) 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, the required markings shall be painted on the inside surface of each length of pipe or printed on an adhesive weather-resistant label attached to the inside 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 outside surface.

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 — Z245.1-07 (see Clause 15.2(b));
(c) outside diameter (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) steam distribution (if applicable) (see Clause 15.2(k));
(l) length (see Clause 15.2(l));
(m) hydrostatic test pressure (if applicable) (see Clause 15.2(m)); and
(n) heat number or code (see Clause 15.2(n)).

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 2007 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 Z245.1-07 355.6 9.5 359 SS E 11.70 26374

(b) Electric-welded, quench and tempered pipe, produced by AB Company, to the 2007 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 Z245.1-07 355.6 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.

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 E 140.

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 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 Certification

17.1
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.*

17.2
Where specified in the purchase order, the manufacturer shall furnish a report of the steelmaking process and casting method used.

17.3
Where specified in the purchase order, the manufacturer shall furnish a report of the type of skelp rolling mill used.

17.4
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.

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%.

17.5
Where sour service is specified in the purchase order, the inclusion shape control method used shall be reported, if applicable.

17.6
For each lot supplied, the manufacturer shall furnish a report of the applicable tensile properties.

17.7
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 or pipe weld);
(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) 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.

Table 1
Minimum hydrostatic test pressure

(See Clauses 4.1.1, 9.4, and 10.1.1 and Table 4.)

Specified outside diameter, mm	Specified wall thickness, mm	Minimum hydrostatic test pressure, MPa	
		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
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 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.

(Continued)

Table 1 (Concluded)

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

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 outside diameter, 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, and 7.6.3.1.)

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

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

Table 8
Tensile requirements

(See Clauses 4.1.2, 8.2.1.1, and 8.2.2.4.)

	Yield strength (*Y*), MPa		Tensile strength (*T*), MPa		*Y*/*T*, Maximum*		
Grade	Minimum	Maximum†‡	Minimum	Maximum†‡	Flattened strap specimen	Other than flattened strap specimen	Body elongation in 50 mm, minimum, %
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 mm^2, 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.*

‡*Limits are not applicable to seamless pipe to be installed in oilfield steam distribution pipelines.*

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, mm^2	Specified wall thickness range, mm			Body elongation in 50 mm, minimum, %										
				Grade										
Full-section tension test specimen	19 mm tension test specimen	25 mm tension test specimen	38 mm tension test specimen	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
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

(Continued)

Table 9 (Concluded)

Cross-sectional area range, mm^2	Specified wall thickness range, mm			Body elongation in 50 mm, minimum, %										
				Grade										
Full-section tension test specimen	19 mm tension test specimen	25 mm tension test specimen	38 mm tension test specimen	241	290	359	386	414	448	483	550	620	690	825
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
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, and 8.5.1.1.)

Specified outside diameter, mm	Frequency per size per heat 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 outside diameter, mm	Outside diameter 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	+0.75%*, –0.25%*

**Calculated values are percentages of the specified outside diameter, 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	0.10*t*
4.1 to 8.0	0.40
8.1 or greater	0.05*t*

**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 12.4.4.1.)

	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, outside diameter, 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:*

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

where

A = *width of male member,* mm
D = *specified outside diameter of pipe,* mm
t = *specified wall thickness of pipe,* mm
e = *strain,* mm/mm *(per Table 16)*
1.15 = *peaking factor*

(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 11.)

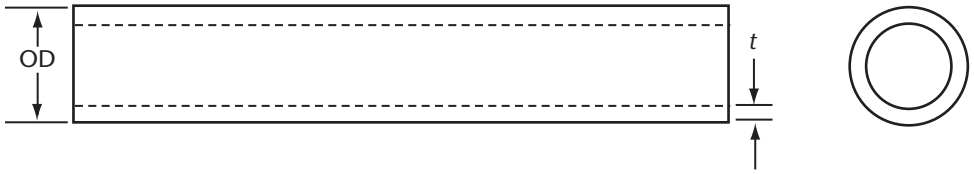
	Dimensions, mm							
Item	Grades 241 and 290	Grades 359 and 386	Grades 414 and 448	Grade 483	Grade 550	Grade 620	Grade 690	Grade 825
Width of male member, A	$6t$	$8t$	$9t$	$10t$	$11t$	$12t$	$13t$	$14t$
Radius of male member, R_A	$3t$	$4t$	$4.5t$	$5t$	$5.5t$	$6t$	$6.5t$	$7t$
Width of groove in female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

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.*

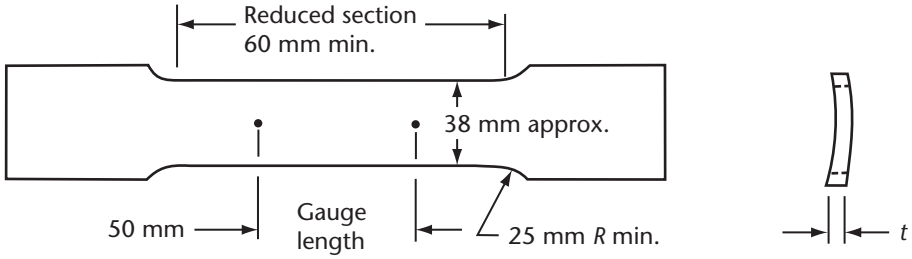
Table 18
Transverse tension tests — Nominal diameter for round specimens

(See Clause 7.2.4.7.)

Specified outside diameter, mm	Specified wall thickness, mm Nominal diameter of test specimen, 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



Full-section test specimen



Longitudinal body strip test specimen

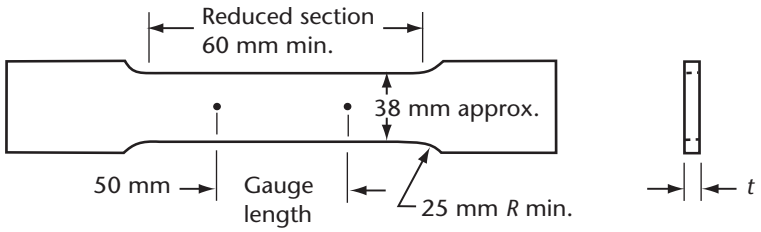
Ring expansion test specimen

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

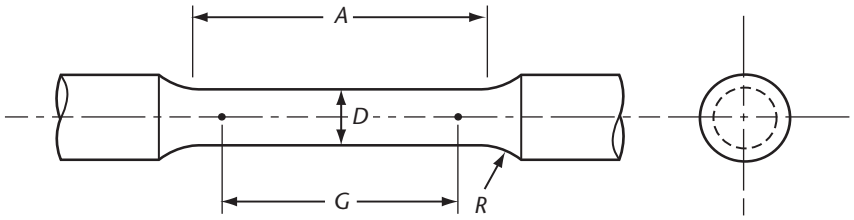
(Continued)

Figure 1
Tension test specimens

(See Clauses 7.2.3.2, 7.2.4.2, and 7.2.5.2.)

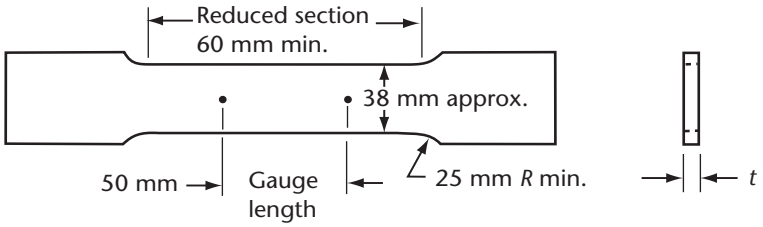


Transverse body strip test specimen



	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

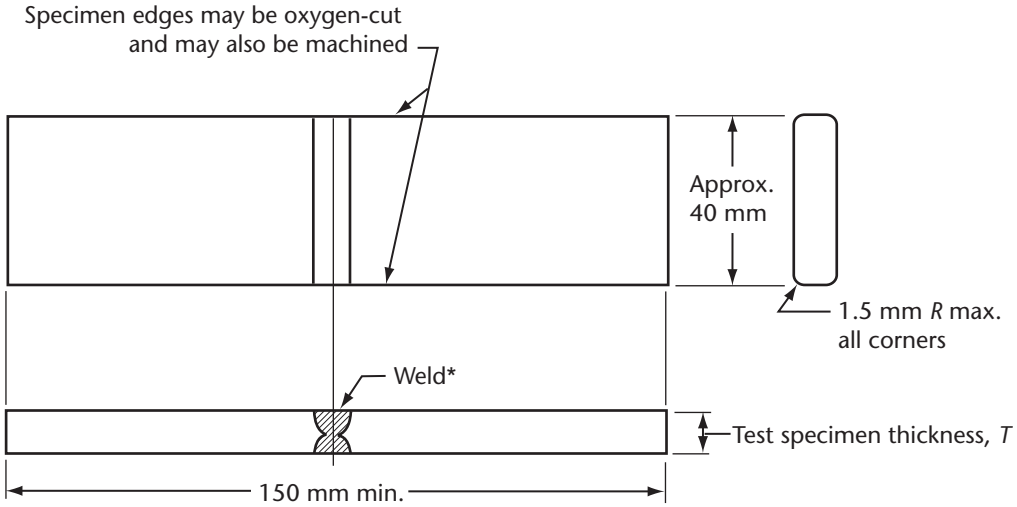
Round tension test specimen



Transverse weld strip test specimen

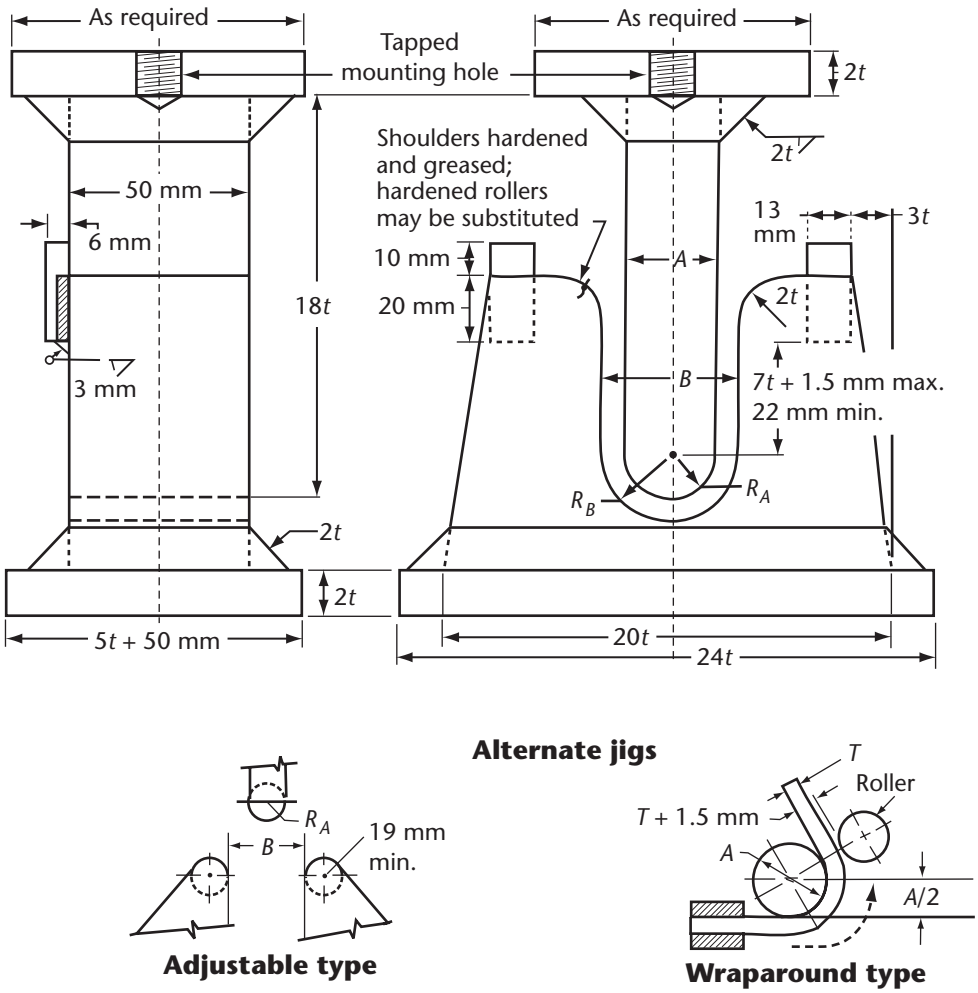
Legend:
t = pipe wall thickness, mm

Figure 1 (Concluded)



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

Figure 2
Guided-bend test specimen
(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, RA, and *RB* are as given in Table 15.

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

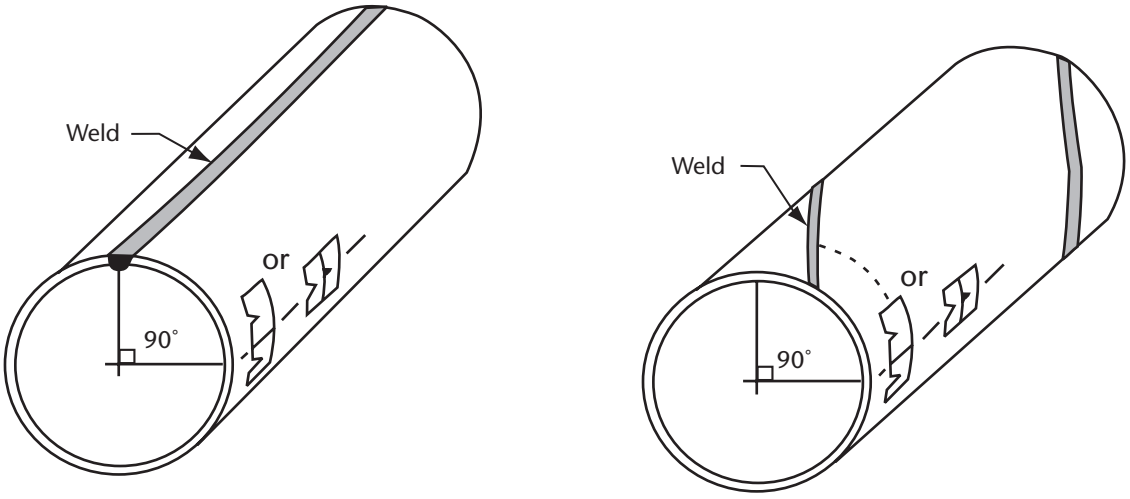


Figure 4
Drop-weight tear test — Specimen orientation and location
(See Clause 7.7.2.)

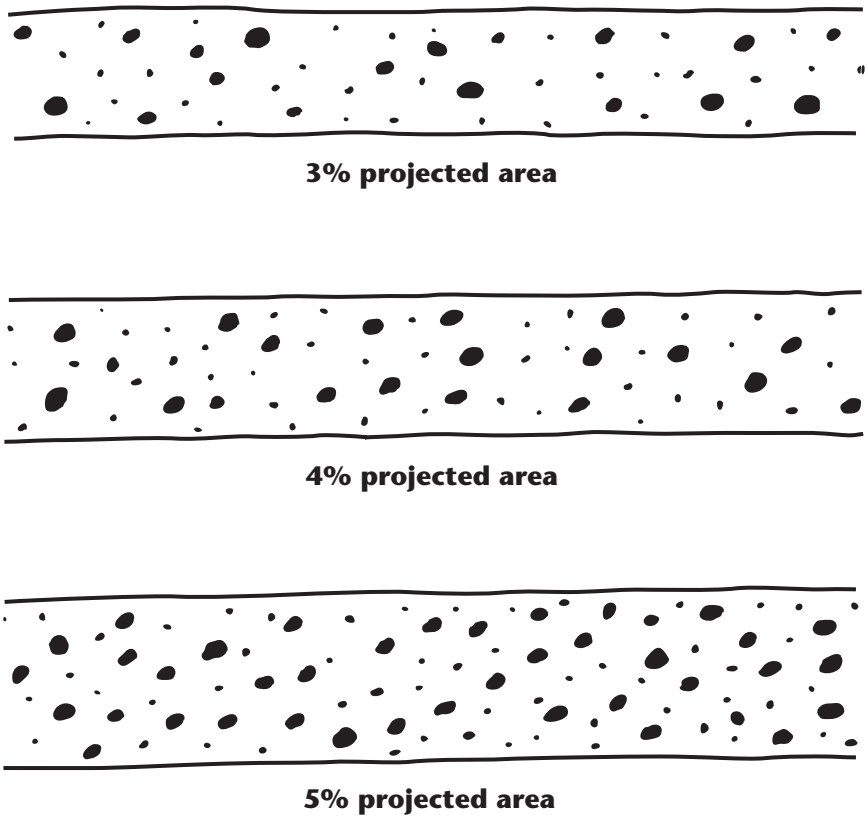
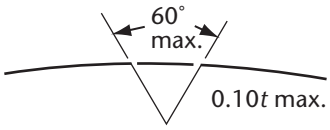
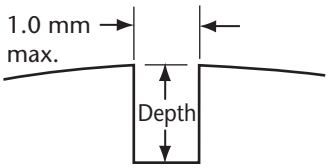


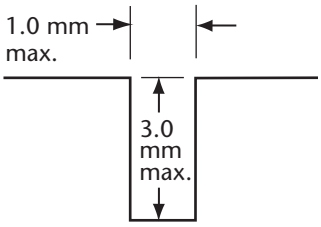
Figure 5
Examples of circular slag inclusions and gas pockets
(See Clause 12.4.5.2.)



V10 notch

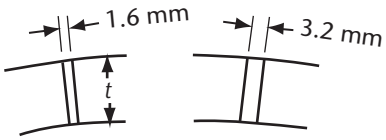


N5 and N10 notch



The notch is oriented transversely to the weld bead

T notch

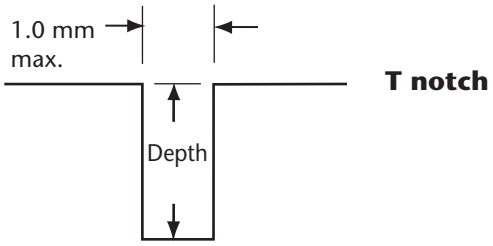


Drilled hole

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

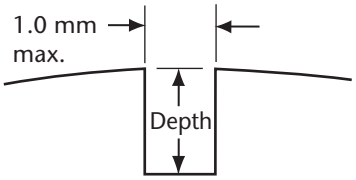
Legend:
t = specified wall thickness of the pipe, mm

Figure 6
Reference indicators — Ultrasonic inspection
(See Clause 12.5.2.2.)



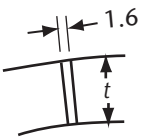
T notch

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



N10 notch

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



Drilled hole

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

Figure 7
Reference indicators — Electromagnetic inspection
(See Clauses 12.6.1.2.2 and 12.6.2.3.2.)

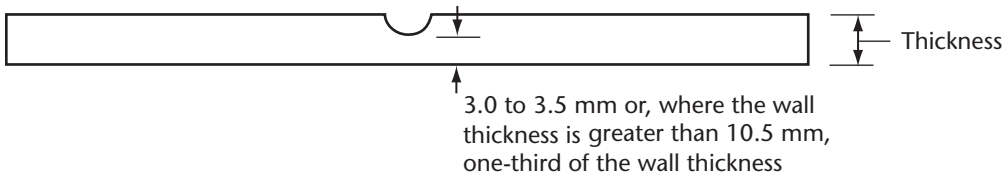
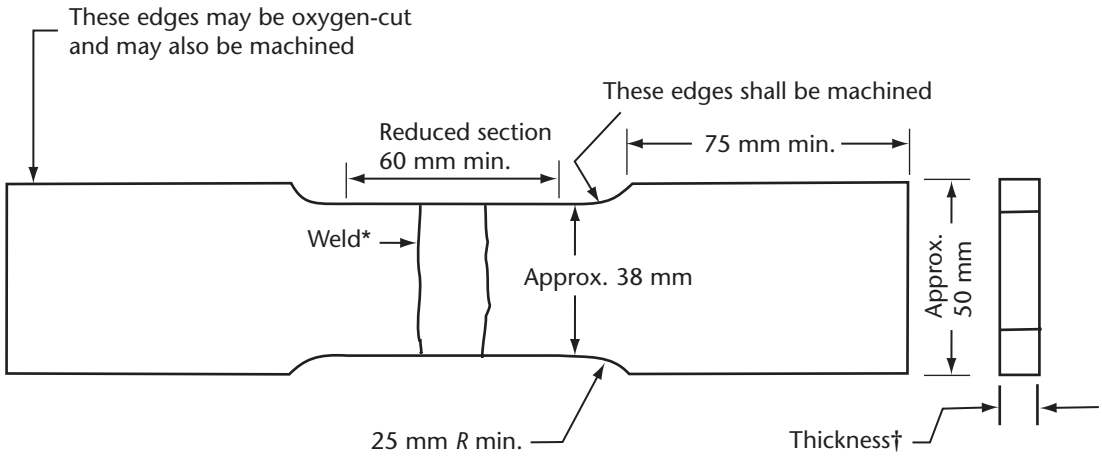
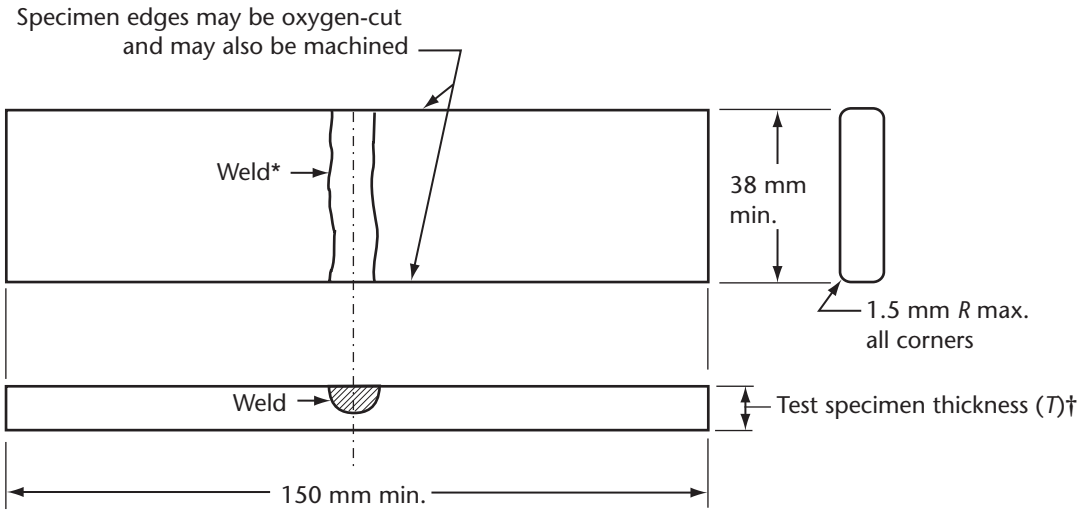


Figure 8
Groove configuration
(See Clause 13.5.1.)



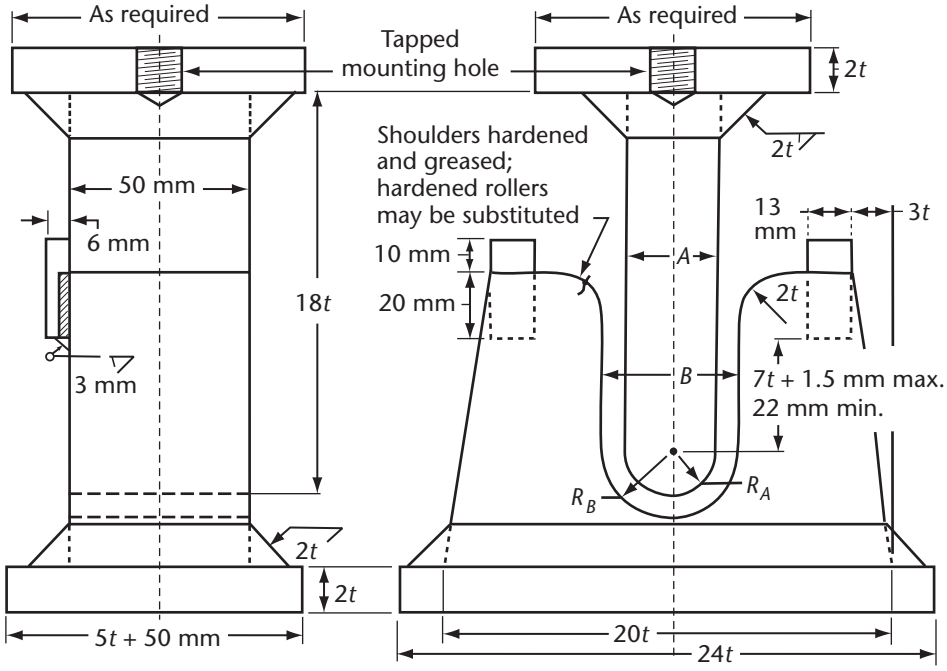
**Weld reinforcement shall be removed.*
†*See Clause 13.5.1.*

Figure 9
Transverse weld tension test specimen
(See Clause 13.5.3.)

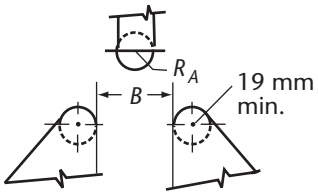


*Weld reinforcement shall be removed.
†See Clause 13.5.1 or 13.6.2, whichever is applicable.

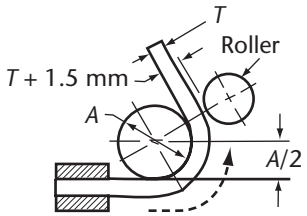
Figure 10
Guided-bend test specimen
(See Clause 13.5.4.)



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, RA, and *RB* are as given in Table 17.

Figure 11
Jig for guided-bend test for repair welds
(See Clause 13.5.4.)

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

Note: *This Annex is not a mandatory part of this Standard.*

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

Nominal size, in	Outside diameter		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
			0.438	11.1	—	160
			0.600	15.2	XXS	—

(Continued)

Table A.1 (Concluded)

Nominal size, in	Outside diameter		Wall thickness		Weight class	Schedule number
	in	mm	in	mm		
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
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

Note: *This Annex is not a mandatory part of this Standard.*

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 outside diameter that differs slightly from the pipe OD size listed.*

Annex C (informative)
Summary of destructive testing requirements

Note: *This Annex is not a mandatory part of this Standard.*

Table C.1
Summary of destructive testing requirements

Test or testing condition	Mandatory	Purchaser's option
Heat analysis	X	
Product analysis	X	
Pipe body tension tests for tensile strength, yield strength, and per cent elongation		
Welded pipe ≥ 219.1 mm OD — transverse	X	
Seamless pipe ≥ 219.1 mm OD — transverse or longitudinal	X	
All pipe < 219.1 mm OD — longitudinal	X	
Transverse weld tension tests for tensile strength	X	
Transverse weld tension tests for per cent elongation for submerged-arc-welded pipe	X	
Flattening tests for electric-welded pipe ≥ 60.3 mm OD	X	
Bend tests for electric-welded pipe < 60.3 mm OD	X	
Guided-bend tests		
Face and root guided-bend tests of all welds in submerged-arc-welded pipe	X	
Root guided-bend tests of electric-welded pipe ≥ 60.3 mm for other than sour service		X
Root guided-bend tests of electric-welded pipe ≥ 60.3 mm OD for sour service	X	
Charpy V-notch impact tests of pipe body for absorbed energy — Category II and Category III pipe	X	
For specified pipe test temperatures lower than –5 °C, Charpy V-notch impact tests of pipe welds and heat-affected zone for absorbed energy — Category II and Category III pipe	X	
For specified pipe test temperatures –5 °C and higher, Charpy V-notch impact tests of pipe welds and heat-affected zone for absorbed energy — Category II and Category III pipe		X
Shear area determination by drop-weight tear tests or Charpy specimens — Category II pipe	X	
Hardness tests for electric-welded pipe	X	
Hydrogen-induced cracking tests		X

Proposition de modification

N'hésitez pas à nous faire part de vos suggestions et de vos commentaires. Au moment de soumettre des propositions de modification aux normes CSA et autres publications CSA prière de fournir les renseignements demandés ci-dessous et de formuler les propositions sur une feuille volante. Il est recommandé d'inclure

- le numéro de la norme/publication
- le numéro de l'article, du tableau ou de la figure visé
- la formulation proposée
- la raison de cette modification.

Proposal for change

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- Standard/publication number
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