

Steel fittings

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Preface

This is the fifth edition of CSA Z245.11, *Steel fittings*. It supersedes the previous editions published in 2001, 1996, 1991, and 1985.

This Standard covers the requirements for steel fittings intended to be used for transporting fluids as specified in CAN/CSA-Z662, *Oil and Gas Pipeline Systems*.

The main differences from the previous edition are as follows:

- (a) a new [Table 8](#) specifying Charpy test specimen sizes and types has been introduced;
- (b) the Charpy test specimen selection has been modified; and
- (c) the sour service requirements have been modified.

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.

September 2005

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.

Z245.11-05

Steel fittings

1 Scope

1.1 General

This Standard covers wrought steel butt welding fittings, including extruded headers and factory-produced bends, primarily intended for use in oil or gas pipeline systems.

1.2 Size, grade, and category

1.2.1 Size

This Standard covers fittings in sizes from NPS 1/2 to NPS 60. (Refer to [Table A.1](#).)

1.2.2 Grade

For other than sour service, this Standard covers fittings from Grade 207 to Grade 550. For sour service, this Standard covers fittings from Grade 207 to Grade 483.

Note: The standard grades are Grades 207, 241, 290, 317, 359, 386, 414, 448, 483, and 550 (see [Table 1](#)); however, intermediate grades are also permitted.

1.2.3 Category

This Standard covers fittings in the following categories:

- (a) Category I: fittings without requirements for proven notch-toughness properties; and
- (b) Category II: fittings with requirements for proven notch-toughness properties.

1.3 Assemblies

This Standard does not cover assemblies.

Note: An assembly means a grouping of fittings or flanges, or both, joined by one or more circumferential welds.

1.4 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 edition listed below, unless the user finds it more appropriate to use newer or amended editions of such publications.

CSA (Canadian Standards Association)

CAN/CSA-ISO 9001-00

Quality management systems — Requirements

CAN/CSA-Z662-03

Oil and gas pipeline systems

ASME International (American Society of Mechanical Engineers)

Boiler and Pressure Vessel Code, 2004

Section VIII — Pressure Vessels, Division 1

Section IX — Welding and Brazing Qualifications

B31.1-2004

Power Piping

B31.3-2002

Process Piping

B31.4-2004

Pipeline Transportation Systems for Liquid Hydrocarbons and other Liquids

B31.5-2001

Refrigeration Piping and Heat Transfer Components

B31.8-2004

Gas Transmission and Distribution Piping Systems

B31.9-1996

Building Services Piping

ASTM International (American Society for Testing and Materials)

A 370-03a

Standard Test Methods and Definitions for Mechanical Testing of Steel Products

A 751-01

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

E 18-03 e1

Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

E 29-02 e1

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 140-02

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 709-01

Standard Guide for Magnetic Particle Examination

ISO (International Organization for Standardization)

9001:2000

Quality management systems — Requirements

15156-2:2003

*Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons***NACE International (National Association of Corrosion Engineers)**

MR0175/ISO 15156-2:2003

Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons

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 fitting or from material representative of the finished fitting.

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

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

Extruded header — a fitting that contains one or more extruded branch outlets.

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

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

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

Strength, tensile — the stress obtained by dividing the maximum load applied in a conventional tensile test by the original cross-sectional area of the test sample.

Strength, yield — the stress at which the steel exhibits either 0.2% offset deviation from the proportionality of stress to strain or 0.5% total elongation under load in a tensile test.

Stress — the internal force per unit area that resists change in the size or shape of a body acted on by a force or forces external to the body.

Stress, hoop — the tensile stress that is produced by the pressure of the fluid in the pipeline and that acts in the circumferential direction.

4 General requirements

4.1 Product ordering requirements

4.1.1 Standard requirements

4.1.1.1

The following information shall be included in the purchase order for fittings:

- (a) CSA Standard designation and year of publication (Z245.11-05);
- (b) quantity, size, and description;
- (c) grade;
- (d) matching pipe specified wall thickness;
- (e) matching pipe grade, if different from the fitting grade;
- (f) pipeline design pressure, design temperatures, and design factor (if pertinent);
- (g) category (see [Clause 1.2.3](#));
- (h) test temperature for Category II (see [Clause 9.3.1.2](#));
- (i) packaging and shipping instructions; and
- (j) required delivery date.

4.1.1.2

For bends, in addition to the requirements of [Clause 4.1.1.1](#), the following information shall be included in the purchase order:

- (a) bend angle, centreline radius, and tangent lengths; and
- (b) the dimensions and grade of any straight pipe supplied by the purchaser for bending.

4.1.2 Optional requirements

Where applicable, the purchase order shall include information concerning the following items, which are optional for the purchaser:

- (a) higher field test pressure (see [Clause 4.3.2](#));
- (b) scraper bars (see [Clause 6.5.1](#));
- (c) increased absorbed energy values (see [Clauses 9.3.4.1](#) and [9.3.4.2](#));
- (d) guided-bend tests (see [Clause 9.5](#));
- (e) plant inspection by the purchaser (see [Clause 11.2](#));
- (f) liquid penetrant or magnetic particle inspection of welds (see [Clause 12.1.3](#));
- (g) liquid penetrant or magnetic particle inspection of bends (see [Clause 12.2.2](#));
- (h) sour service (see [Clause 13](#));
- (i) report of heat analysis (see [Clause 15.2](#));
- (j) report of product analysis and carbon equivalent (see [Clause 15.3](#));
- (k) report of specific mechanical tests (see [Clause 15.4](#));
- (l) report of specific sour service items (see [Clause 15.5](#)); and
- (m) other special requirements.

4.1.3 Additional requirements

Where applicable, the purchase order shall include information concerning the following items, which are subject to agreement between the purchaser and the manufacturer:

- (a) additional test requirements for the design proof test (see [Clause 5.1](#));
- (b) test frequency for hardness tests (see [Clause 9.4.2](#));
- (c) dimensions and tolerances of non-standard fittings (see [Clause 10.2](#));
- (d) ultrasonic inspection of repair welds (see [Clause 11.5.3\(i\)](#));
- (e) ultrasonic inspection of seam welds (see [Clause 12.1.2](#)); and
- (f) alternative requirements for markings (see [Clause 14.1](#)).

4.2 Weldability

Fittings shall be capable of being welded in accordance with CAN/CSA-Z662 when using welding procedure specifications that comply with that Standard.

4.3 Pressure rating

4.3.1

The pressure rating for fittings shall be calculated in accordance with the rules established in the applicable ASME Standard (B31.1, B31.3, B31.4, B31.5, B31.8, or B31.9) and in the applicable clauses of CAN/CSA-Z662.

4.3.2

After installation, fittings shall be capable of withstanding the pressure test at a pressure level required to develop a hoop stress equal to the specified minimum yield strength for pipe of equivalent grade and wall thickness attached to the fitting, or at a higher pressure level specified in the purchase order, without failure, leakage, or impairment of serviceability or mechanical properties.

4.3.3

The design of fittings shall include design wall thicknesses and other geometric details as dictated by the shape of the part. The design shall be derived by mathematical analyses contained in nationally recognized pressure vessel or piping codes, or shall be confirmed by proof testing in accordance with the requirements of [Clause 5](#).

4.4 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.

4.5 Quality program

The manufacturer shall comply with the requirements of CAN/CSA-ISO 9001 or ISO 9001.

5 Design proof test

5.1

Where required by [Clause 4.3.3](#), proof tests shall be performed to provide evidence of the adequacy of the design. Records of design or successful proof tests shall be available at the manufacturer's facility for inspection by the purchaser. Unless otherwise agreed upon by the purchaser and the manufacturer, the only required proof test shall be a bursting strength test.

5.2

Fittings selected for test shall be representative of production; identified as to material, grade, lot, and heat-treatment state; and inspected for dimensional compliance with this Standard.

5.3

Straight sections of seamless or welded pipe, whose calculated bursting strength is at least as great as the adjusted proof test pressure calculated as specified in [Clause 5.4](#), shall be welded to each end of the fitting to be tested. Any internal misalignment greater than 1.6 mm shall be reduced by taper boring at a slope not over 1:3. The length of the pipe sections for closures shall be at least twice the outside diameter of the pipe, except that shorter lengths may be used as follows:

- (a) each part of the assembly shall withstand at least 110% of the adjusted proof test pressure calculated as specified in [Clause 5.4](#); and
- (b) the minimum length of pipe shall be one pipe diameter for sizes NPS 14 and smaller, or one-half pipe diameter for sizes larger than NPS 14.

5.4

The test fluid for the hydrostatic proof test shall be water or another appropriate liquid. Except as required by [Clause 5.3\(a\)](#), the hydrostatic pressure shall be applied until the fitting ruptures or until the pressure in each part of the assembly is at least 105% of the adjusted proof test pressure. The actual test pressure prior to rupture shall at least equal the adjusted proof test pressure, as follows:

$$P_a = \frac{2000 \times t \times S}{D}$$

where

- P_a = the adjusted proof test pressure, kPa
- t = the nominal wall thickness of the matching pipe of equivalent grade, mm
- S = the tensile strength of the material in the test fitting, as determined from a test specimen representative of the test fitting, MPa
- D = the specified outside diameter of the matching pipe, mm

5.5

It shall not be necessary to conduct an individual test of fittings with all combinations of size, wall thickness, and grade. Provided that the untested fitting has a t/D ratio from 0.5 to 3.0 times the t/D ratio of the test fitting, a successful proof test on one fitting shall be allowed to represent other fittings, as follows:

- (a) fittings of similar design that are not smaller than one-half or larger than twice the size of the test fitting, provided that for tees and crosses the dimensions and tolerances are as specified in [Tables 2 to 5](#);
- (b) reducing fittings that are of the same pattern as the non-reducing test fitting; and
- (c) elbows that are not smaller than one-half or larger than twice the size of the test fitting but have a longer radius than the test fitting.

Note: The pressure-retaining capacity of a fitting made to one grade will be essentially directly proportional to the tensile properties of a fitting made to a different grade; hence, prototypes need only be tested in a single grade to prove the geometric design of the fitting.

6 Materials and manufacture

6.1 Steelmaking process

Fittings shall be made from open hearth, electric furnace, or basic oxygen-process steel.

6.2 Deoxidation practice

The steel shall be semi-killed or killed.

6.3 Fittings containing welds

6.3.1

Fittings shall be made

- (a) using welding procedure specifications qualified in accordance with the ASME *Boiler and Pressure Vessel Code*, Section IX; and
- (b) by welders or welding operators qualified in accordance with the ASME *Boiler and Pressure Vessel Code*, Section IX.

6.3.2

For Category II fittings, the welding procedure qualification tests shall include Charpy V-notch impact tests of both the weld metal and the heat-affected zone. Specimen location and orientation shall be as specified in Paragraph UG 84 of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1. The absorbed energy value shall be as specified in [Clause 9.3.4.2](#).

6.4 Forming and heat-treating processes

6.4.1 Fittings other than bends

Fittings formed below 620 °C, welded fittings of all grades, and seamless fittings of Grades 290 and higher shall be furnished in the heat-treated condition. Hot-formed fittings shall be cooled below the lower critical temperature prior to heat treatment. Where heat treatment is required, fittings other than bends shall be heat treated in accordance with one or more of the procedures specified in [Clause 8](#).

6.4.2 Bends

6.4.2.1

Hot bends shall be manufactured using any suitable thermal process. Hot bends of Grades 290 and higher shall be post-bend heat treated, except that induction bends may be furnished without such heat treatment, provided that the bending process is controlled within a temperature range of ± 30 °C and processing is such as to ensure proper cooling. Where post-bend heat treatment is required, bends shall be heat treated in accordance with one or more of the procedures specified in [Clause 8](#).

6.4.2.2

Bends formed below 620 °C shall be heat treated in accordance with one or more of the procedures specified in [Clause 8](#) if the wall thinning due to bending exceeds 10%.

6.5 Installation of scraper bars

6.5.1

Where specified in the purchase order, scraper bars shall be installed. The design, material selection, location, and attachment of the scraper bars shall be as specified in the purchase order.

Note: *Scraper bars are also known as pig bars.*

6.5.2

The welding procedure specifications and welders or welding operators used for the installation of the scraper bars shall be as specified in [Clause 6.3.1](#).

6.5.3

For Category II fittings, the welding procedure qualification tests shall include Charpy V-notch impact tests of both the weld metal and the heat-affected zone of the fitting material. The absorbed energy level specified in [Clause 9.3.4.2](#) shall be met.

6.5.4

Scraper bars shall be installed after any cold sizing and any heat treatment required by [Clause 8.3](#), [8.4](#), or [8.5](#). After installation of the scraper bars, the fitting containing the scraper bars shall be stress relieved as specified in [Clause 8.2](#).

6.5.5

After stress relieving of the fittings containing scraper bars, the scraper bar welds shall be inspected by liquid penetrant inspection or magnetic particle inspection.

7 Chemical test requirements

7.1 General

Except as otherwise required by this Standard, the methods, practices, and definitions pertaining to chemical analysis shall be as specified in ASTM A 751.

7.2 Heat analysis

The requirements for heat analysis shall be as specified in [Table 6](#).

7.3 Product analysis

For Grades 290 and higher, at a frequency of one test per heat, a product analysis shall be determined by the fitting manufacturer or the steel manufacturer. The requirements for product analysis shall be as specified in [Table 6](#).

8 Heat-treatment procedures

8.1 General

Where required by [Clause 6.4](#), the fittings shall be heat treated using one or more of the procedures specified in [Clauses 8.2](#) to [8.5](#).

Note: A recommended practice for the calibration and survey of heat-treating equipment is provided in [Annex B](#).

8.2 Stress relieving

Fittings shall be heated to a suitable temperature below the transformation range, but not less than 540 °C; held at this temperature for a minimum of 1 h per 25 mm of maximum thickness, but not less than 0.5 h; and cooled in the furnace or in air.

8.3 Normalizing

Fittings shall be uniformly heated above the transformation range, held at this temperature for a sufficient time to achieve uniform temperature throughout the mass, and cooled in air.

8.4 Normalizing and tempering

Fittings shall be normalized as specified in [Clause 8.3](#); tempered by reheating to a temperature below the transformation range, but not less than 540 °C; held at this temperature for a minimum of 1 h per 25 mm of maximum thickness, but not less than 0.5 h; and cooled in the furnace or in air.

8.5 Quenching and tempering

Fittings shall be uniformly heated above the transformation range; held at this temperature for a sufficient time to achieve uniform temperature throughout the mass; immediately immersion-quenched in a suitable liquid medium; and tempered as specified in [Clause 8.4](#). Quenching facilities shall be of sufficient size and equipped to ensure proper cooling.

9 Mechanical test requirements

9.1 General

9.1.1 Selection of test specimens

9.1.1.1

Test specimens for mechanical tests shall be representative of the finished fitting.

9.1.1.2

Except where allowed by [Clause 9.1.1.3](#), test specimens shall be in the same heat-treated condition as the fittings they represent.

9.1.1.3

Fittings stress relieved at or below a previous stress-relieving or tempering temperature need not be retested.

9.1.2 Defective test specimens

For any of the mechanical tests specified in [Clauses 9.2 to 9.5](#), 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 original specimens.

9.1.3 Fittings other than bends

9.1.3.1

Tests shall be performed at a frequency of one set of tests per lot. For Category I fittings, a set shall consist of one or more tension tests. For Category II fittings, a set shall consist of one or more tension tests and one or more notch-toughness tests. Where guided-bend tests are specified in the purchase order, a set shall also include one root guided-bend test and one face guided-bend test.

9.1.3.2

For quenched and tempered fittings of Grades 290 and higher, the test coupons shall be attached to a fitting from the same lot as the production fittings.

9.1.3.3

For Grades 290 and higher, a lot shall consist of all fittings from one heat of material of the same starting thickness that are

- (a) heat treated in the same charge as the test coupons; or
- (b) heat treated in the same manner as the test coupons in one or more furnaces that are surveyed at least annually, controlled within a range of 30 °C, and equipped with recording sensors that are calibrated at least quarterly.

9.1.3.4

For grades less than Grade 290, a lot shall consist of all fittings from one heat of material of the same starting thickness that are

- (a) heat treated in the same charge as the test coupons; or
- (b) heat treated in the same manner as the test coupons in one or more furnaces that are controlled within a range of 30 °C and equipped with recording sensors.

9.1.4 Bends

One set of tests shall be performed on a bend that is made using the same bending procedure that is used for the production bends. For Category I bends, a set shall consist of one or more tension tests. For Category II bends, a set shall consist of one or more tension tests and one or more notch-toughness tests. Where specified in the purchase order, a set shall also consist of one or more guided-bend tests. The location of the test coupons and the frequency of testing shall be as specified in [Table 7](#).

9.2 Tension tests

9.2.1 General

Except as otherwise required by this Standard, test specimens and testing procedures shall be as specified in 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.

9.2.2 Requirements

The tensile properties of test specimens representing the body of fittings shall be as specified in [Table 1](#), and for NPS 8 and larger welded fittings the tensile strength of test specimens across welds shall be as specified in [Table 1](#). The longitudinal axis of transverse weld specimens shall be perpendicular to the weld axis.

9.3 Notch-toughness tests — Category II fittings

9.3.1 General

9.3.1.1

Charpy V-notch impact tests shall be conducted and evaluated as specified in ASTM A 370. An impact test shall consist of testing three adjacent specimens taken from a single test coupon. The result shall be the average of the results of the three test specimens.

9.3.1.2

The test temperature shall be as specified in the purchase order, except that a lower test temperature may be used if the specified absorbed energy requirements are met.

9.3.2 Test specimen orientation

9.3.2.1

For body tests, the notch shall be perpendicular to the surface of the fitting. For Grades 290 and higher, the test specimen orientation shall be transverse to the axis of the matching pipe, and the test specimen size and type shall be as specified in [Table 8](#). For grades less than Grade 290, the test specimen orientation shall be either transverse or parallel to the direction of maximum work, at the option of the manufacturer.

9.3.2.2

For weld tests, Charpy V-notch test specimens shall be transverse to the axis of the weld, and the root of the notch shall be located along the deposited weld metal centreline.

9.3.3 Test specimen size

The test specimens shall be full-size specimens unless the fitting dimensions or the testing machine energy capacity dictate the use of subsize specimens. For longitudinal test specimens, the largest obtainable subsize test specimen from those specified in [Clause 9.3.4.3](#) shall be used.

9.3.4 Requirements

9.3.4.1

For body tests, the absorbed energy (based upon full-size test specimens) for each Charpy V-notch impact test shall be greater than or equal to

- (a) 18 J, for fittings that are lower than Grade 359;
- (b) 27 J, for fittings that are Grade 359 or higher; or
- (c) a higher value, if specified in the purchase order.

9.3.4.2

For weld tests, the absorbed energy (based upon full-size test specimens) for each Charpy V-notch impact test shall be equal to or greater than

- (a) 18 J; or
- (b) a higher value, if specified in the purchase order.

Note: A lower toughness value is permitted for weld tests because welds are 100% non-destructively inspected; accordingly, imperfections in the weld should generally be smaller than imperfections in the body of the fitting.

9.3.4.3

Where subsize test specimens are used, the minimum energy absorption value requirement shall be that specified for full-size test specimens multiplied by the applicable reduction ratio, as follows:

Specimen size	Dimensions, mm	Reduction ratio
3/4	10 × 7.5	0.75
2/3	10 × 6.7	0.67
1/2	10 × 5.0	0.50

9.4 Macrohardness tests

9.4.1

The macro hardness at any location shall not exceed 30 HRC, as specified in ASTM E 18 or as converted from another scale as specified in ASTM A 370.

9.4.2

If hardness testing is required, the fittings shall be tested at the frequency specified in the purchase order.

9.5 Guided-bend tests

9.5.1

Where guided-bend tests are specified in the purchase order, welds shall be subjected to such tests as specified in [Clauses 9.5.2](#) and [9.5.3](#).

9.5.2

Transverse weld test specimens shall be subjected to face and root guided-bend tests. The specimens shall be as specified in [Figure 1](#), and shall be bent using a plunger that is as shown in [Figure 2](#) and a jig that is substantially as shown in [Figure 2](#).

9.5.3

Bend tests shall be acceptable if no cracks or other defects exceeding 3 mm in any direction are present in the weld metal or the heat-affected zone after bending. Cracks that originate at the edges of the specimen and are less than 6 mm long shall not be cause for rejection.

10 Dimensions and tolerances

10.1 Dimensions and tolerances of standard fittings

The dimensions of standard fittings shall be as specified in [Tables 2, 3, and 9 to 13](#). The tolerances of standard fittings shall be as specified in [Tables 4 and 5](#).

10.2 Dimensions and tolerances of non-standard fittings

The dimensions and tolerances of non-standard fittings shall be as agreed upon by the purchaser and the manufacturer.

10.3 Wall thickness tolerances

For sizes NPS 18 and smaller, the minimum acceptable wall thickness shall be 87.5% of the design wall thickness of the applicable portions of the fitting. For sizes larger than NPS 18, the minimum acceptable wall thickness shall be 92% of the design wall thickness of the applicable portions of the fitting.

10.4 Pipe bend tolerances

The tolerances of factory-produced bends shall be as specified in [Table 14](#).

10.5 Recommended end preparations

The recommended end preparations are shown in [Figure 3](#). The land shall be machined flat within 0.8 mm.

10.6 Design of ends for unequal grades

Weld end configurations for fittings with a lower grade than the matching pipe shall be designed as shown in [Figure 4](#).

11 Inspection, work quality, and repair of fittings containing defects

11.1 Plant inspection

The finished fitting shall be free, both internally and externally, of loose mill scale, foreign matter, oil, and grease, and shall be clean and dry for final inspection. Each fitting shall be visually inspected to detect defects and to determine compliance with the dimensional and work quality requirements.

11.2 Inspection notice

Where it is specified in the purchase order that the inspector representing the purchaser intends to inspect the fittings 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 concerned with the manufacture of the ordered fittings. The manufacturer shall afford the inspector all reasonable facilities to allow the inspector to be satisfied that the fittings are being manufactured, sampled, tested, and inspected as specified in this Standard and the purchase order. Inspections shall be conducted without unnecessary interference with normal plant operation.

11.4 Work quality

11.4.1

Fittings shall be free of defects and shall have a competently produced finish. Bends shall be smooth and continuous.

11.4.2

Defects shall be defined as sharp notches, scratches, scabs, seams, laps, tears, slivers, and cracks; other imperfections, excluding dents, that result in a wall thickness less than that allowed by [Clause 10.3](#); and dents described by one or more of the following criteria:

- (a) dents that are deeper than 1.5 mm, are located in the body of the fitting, and contain a stress concentrator such as a gouge, groove, or arc burn;
- (b) dents that are located on a weld and are deeper than 1.5 mm;
- (c) for NPS 12 and smaller fittings, plain dents that are deeper than 6.3 mm; and
- (d) for fittings larger than NPS 12, plain dents that are deeper than 2% of the nominal fitting size.

The depth of a dent shall be measured as the gap between the lowest point of the dent and the prolongation of the original contour of the fitting in any direction. Pounding out or welding of dents shall be prohibited.

11.4.3

Butt welds shall have full penetration. Backing rings shall not be used. For submerged arc welds, welding shall be done with at least one pass from the inside. However, where inaccessibility makes such welding impracticable, a manual or machine root bead shall be employed, provided that a visual inspection of the root bead is performed where practicable.

11.4.4

Welded-on braces, if used, should be removed before heat treatment and the remaining weldment ground flush and smooth, except that where braces are required during heat treatment, they shall be removed and the remaining weldment ground flush and smooth after heat treatment. No welding shall be permitted after final heat treatment.

11.4.5

For bends, the seam weld of longitudinally welded pipe shall be located at the neutral axis of the finished bend where practicable.

11.5 Repair of fittings containing defects

11.5.1

Fittings containing 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 the limits specified in [Clause 10.3](#);
- (b) the defect shall be removed by grinding and the fitting repaired by welding; or
- (c) the fitting shall be rejected.

11.5.2

Where grinding is performed, it shall be done in a competent manner.

11.5.3

The repair of fittings by welding shall comply with the following requirements:

- (a) The defect shall be removed and the resultant cavity shall be thoroughly cleaned and suitably prepared for magnetic particle or liquid penetrant inspection, which shall be used to verify the complete removal of the defect.
Note: *Surface preparation can affect the adequacy of the inspection.*
- (b) For repairs to the parent metal, the depth of the cavity shall not exceed one-third of the actual thickness at the area to be repaired.
- (c) The maximum length of repair shall be 25% of the nominal diameter.
- (d) The repair shall be made by submerged arc welding, gas tungsten arc welding, gas metal arc welding, or shielded metal arc welding using low-hydrogen electrodes.
- (e) The repaired area shall be heat treated in accordance with one or more of the procedures specified in [Clause 8](#).
- (f) The repair shall be ground flush with the surface.
- (g) The welders, welding operators, and welding procedure specifications shall be qualified as specified in [Clauses 6.3.1](#) and [6.3.2](#).
- (h) Except as allowed by Item (i), repairs made by welding shall be film radiographed and shall comply with Paragraph UW 51 of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.
- (i) Where approved by the purchaser, welds may be ultrasonically inspected. Welds so inspected shall comply with Appendix 12 of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

12 Non-destructive inspection

12.1 Fittings other than bends

12.1.1 Radiographic inspection

Except as allowed by [Clause 12.1.2](#), all seam welds shall be radiographically inspected throughout their entire length and shall comply with Paragraph UW 51 of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

12.1.2 Ultrasonic inspection

Where approved by the purchaser, welds may be ultrasonically inspected. Welds so inspected shall comply with Appendix 12 of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

12.1.3 Liquid penetrant or magnetic particle inspection

Where specified in the purchase order, liquid penetrant or magnetic particle inspection of all accessible weld surfaces shall be performed after final heat treatment.

12.1.4 Inspection of cold-formed tees

12.1.4.1

Tees manufactured by cold-forming methods shall be liquid penetrant or magnetic particle inspected using methods specified in ASTM E 165 or ASTM E 709, respectively. Such inspection shall be performed after the final heat treatment.

12.1.4.2

The side wall on both sides of the tee shall be inspected in a circular area, as shown in [Figure 5](#). Internal and external surfaces shall be inspected where size permits accessibility.

12.1.4.3

Cracks shall not be permitted.

12.2 Bends

12.2.1

Welds that have not been radiographically or ultrasonically inspected by the pipe manufacturer shall be inspected throughout their entire length after bending and shall comply with Paragraph UW 51 or Appendix 12, whichever is applicable, of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

12.2.2

Where specified in the purchase order, liquid penetrant or magnetic particle inspection shall be performed on both the inside and outside bend radii. The mill scale shall be removed from the areas to be inspected.

13 Sour service

13.1

Where sour service is specified in the purchase order, the requirements of [Clauses 1 to 12](#) and [14](#) and [15](#) shall apply, except as such requirements are modified by [Clauses 13.2](#) and [13.3](#).

Note: *Materials, including welding consumables, and manufacturing procedures should be selected in order to avoid microstructures in the weld metal, heat-affected zones, and parent metal that are detrimental to sour service.*

13.2

Except as allowed by [Clause 13.3](#), fittings shall comply with the requirements specified for SSC Region 3 sour service in ISO 15156-2 or NACE MR0175/ISO 15156-2.

13.3

Macrohardness surveys on a cross-section of the welding procedure qualification weld required by [Clauses 6.3](#), [6.5.2](#), and [11.5.3\(g\)](#) may be performed as specified in ASTM E 18 or ASTM E 92. Hardness values shall be converted as specified in ASTM E 140. The location and minimum number of hardness impressions shall be as shown in [Figure 6](#). The macrohardness results at any location shall not exceed HRC 22.

14 Markings

14.1 General

Unless otherwise agreed upon by the purchaser and the manufacturer, the manufacturer or the manufacturer's delegate authorized in writing shall mark the fittings as specified in [Clause 14.2](#). Additional markings desired by the manufacturer or requested by the purchaser may be used. Where used, die-stamping shall be performed with low-stress steel stamps.

14.2 Required markings

14.2.1

Except as allowed by [Clause 14.3](#), the following markings shall be marked on the fitting in the following sequence and separated by dashes or adequate spaces:

- (a) manufacturer's name or mark;
- (b) CSA designation: "CSA" or "C";
- (c) grade: the numerical portion of the fitting grade designation;
- (d) test temperature for Category II: the notch-toughness test 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 test temperature in degrees Celsius (e.g., "M45C" for -45 °C);
- (e) "SS" for sour service, if applicable;

- (f) identification designation: a manufacturer's identification designation shall be used on fittings and shall be traceable to pertinent material certificates, test reports, and inspection reports;
- (g) matching pipe grade, where different from the fitting grade;
- (h) size: the numerical portion of the NPS designation;
- (i) matching pipe wall thickness; and
- (j) "W" for fittings that contain weld repairs to the parent metal.

14.2.2

Examples of the markings specified in [Clause 14.2.1](#) are as follows:

- (a) NPS 10 × 8 reducer, manufactured by XYZ Company, Grade 207, Category I, sour service, to match 8.3 mm thick Grade 241 pipe, with an identification designation of 3261, and with a weld repair to the parent metal shall be marked as follows: XYZ CSA 207 SS 3261 241 10 × 8 8.3 W.
- (b) NPS 36 elbow, manufactured by ABCD Company, whose mark is A, Grade 414, Category II, with a test temperature of -20 °C, to match 7.6 mm thick Grade 414 pipe, with an identification designation of 167AC, shall be marked as follows: A CSA 414 M20C 167AC 36 7.6.

14.3 Omission of markings

Where the size or shape of the fitting does not permit all of the markings specified in [Clause 14.2.1](#) to be marked on the fitting, one or more of such markings may be omitted as needed, in the reverse order to that specified in Items (g) to (j).

15 Certification

15.1

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.

15.2

Where specified in the purchase order, for grades lower than Grade 290, the manufacturer shall furnish a report of the heat analysis for each heat of steel supplied. For each heat analysis, the elements reported shall include carbon, manganese, phosphorus, sulphur, and silicon.

15.3

Where specified in the purchase order, for Grades 290 and higher, the manufacturer shall furnish a report of the product analysis and the carbon equivalent value for each heat of steel supplied. For each product analysis, the elements reported shall include each of the elements specified in [Table 6](#).

15.4

Where specified in the purchase order, the manufacturer shall furnish a report of the results of any of the mechanical tests (see [Clauses 9.2](#) to [9.5](#)) specified by the purchaser to be reported.

15.5

Where specified in the purchase order, the manufacturer shall furnish a report of any sour service items specified by the purchaser to be reported.

15.6

Reports of Charpy V-notch tests shall include the following:

- (a) the test specimen size;
- (b) the test specimen orientation;
- (c) the test temperature;
- (d) the actual test results for each test specimen; and

- (e) where the required absorbed energy is higher than the applicable minimum specified in [Clause 9.3.4](#), the absorbed energy acceptance criterion.

15.7

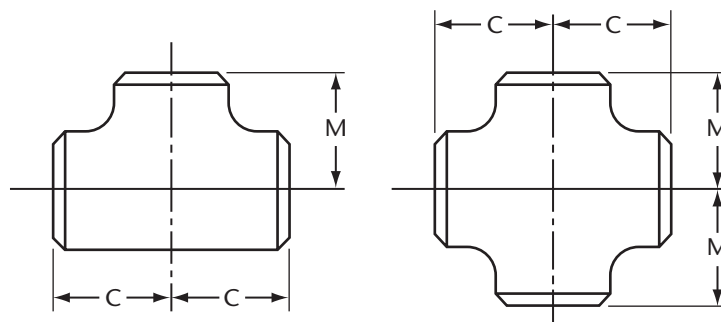
Reports of hardness tests shall include the test method used and the test results.

Table 1
Tensile requirements
(See [Clauses 1.2.2](#) and [9.2.2](#).)

Grade	Minimum yield strength, MPa	Minimum tensile strength, MPa	Minimum elongation in 50 mm, %
207	207	331	20
241	241	414	20
290	290	414	20
317	317	434	20
359	359	455	20
386	386	490	20
414	414	517	20
448	448	531	18
483	483	565	16
550	550	620	16

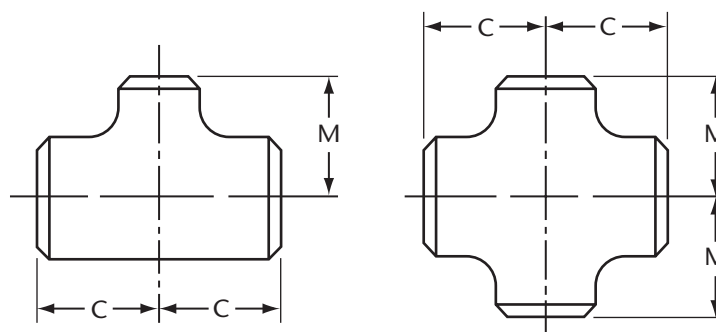
Note: The tensile requirements for intermediate grades shall be obtained by interpolation between those specified for standard grades.

Table 2
Dimensions of straight tees and crosses
 (See [Clauses 5.5](#) and [10.1](#).)



Size	Nominal outside diameter at bevel, mm	Centre-to-end dimension, mm		
		Run, C	Outlet, M	
			Tees	Crosses
NPS 1/2	21.3	25	25	25
NPS 3/4	26.7	29	29	29
NPS 1	33.4	38	38	38
NPS 1-1/4	42.2	48	48	48
NPS 1-1/2	48.3	57	57	57
NPS 2	60.3	64	64	64
NPS 2-1/2	73.0	76	76	76
NPS 3	88.9	86	86	86
NPS 3-1/2	101.6	95	95	95
NPS 4	114.3	105	105	105
NPS 5	141.3	124	124	124
NPS 6	168.3	143	143	143
NPS 8	219.1	178	178	178
NPS 10	273.1	216	216	216
NPS 12	323.9	254	254	254
NPS 14	355.6	279	279	279
NPS 16	406.4	305	305	305
NPS 18	457	343	343	343
NPS 20	508	381	381	381
NPS 22	559	419	419	419
NPS 24	610	432	432	432
NPS 26	660	495	495	—
NPS 28	711	521	521	—
NPS 30	762	559	559	—
NPS 32	813	597	597	—
NPS 34	864	635	635	—
NPS 36	914	673	673	—
NPS 38	965	711	711	—
NPS 40	1016	749	749	—
NPS 42	1067	762	711	—
NPS 44	1118	813	762	—
NPS 46	1168	851	800	—
NPS 48	1219	889	838	—

Table 3
Dimensions of reducing outlet tees and reducing outlet crosses
 (See [Clauses 5.5](#) and [10.1](#).)



Size	Nominal outside diameter at bevel, mm		Centre-to-end dimension, mm	
	Run	Outlet	Run, C	Outlet, M
NPS 1/2 × 1/2 × 3/8	21.3	17.1	25	25
NPS 1/2 × 1/2 × 1/4	21.3	13.7	25	25
NPS 3/4 × 3/4 × 1/2	26.7	21.3	29	29
NPS 3/4 × 3/4 × 3/8	26.7	17.1	29	29
NPS 1 × 1 × 3/4	33.4	26.7	38	38
NPS 1 × 1 × 1/2	33.4	21.3	38	38
NPS 1-1/4 × 1-1/4 × 1	42.2	33.4	48	48
NPS 1-1/4 × 1-1/4 × 3/4	42.2	26.7	48	48
NPS 1-1/4 × 1-1/4 × 1/2	42.2	21.3	48	48
NPS 1-1/2 × 1-1/2 × 1-1/4	48.3	42.2	57	57
NPS 1-1/2 × 1-1/2 × 1	48.3	33.4	57	57
NPS 1-1/2 × 1-1/2 × 3/4	48.3	26.7	57	57
NPS 1-1/2 × 1-1/2 × 1/2	48.3	21.3	57	57
NPS 2 × 2 × 1-1/2	60.3	48.3	64	60
NPS 2 × 2 × 1-1/4	60.3	42.2	64	57
NPS 2 × 2 × 1	60.3	33.4	64	51
NPS 2 × 2 × 3/4	60.3	26.7	64	44
NPS 2-1/2 × 2-1/2 × 2	73.0	60.3	76	70
NPS 2-1/2 × 2-1/2 × 1-1/2	73.0	48.3	76	67
NPS 2-1/2 × 2-1/2 × 1-1/4	73.0	42.2	76	64
NPS 2-1/2 × 2-1/2 × 1	73.0	33.4	76	57
NPS 3 × 3 × 2-1/2	88.9	73.0	86	83
NPS 3 × 3 × 2	88.9	60.3	86	76
NPS 3 × 3 × 1-1/2	88.9	48.3	86	73
NPS 3 × 3 × 1-1/4	88.9	42.2	86	70
NPS 3-1/2 × 3-1/2 × 3	101.6	88.9	95	92
NPS 3-1/2 × 3-1/2 × 2-1/2	101.6	73.0	95	89
NPS 3-1/2 × 3-1/2 × 2	101.6	60.3	95	83
NPS 3-1/2 × 3-1/2 × 1-1/2	101.6	48.3	95	79
NPS 4 × 4 × 3-1/2	114.3	101.6	105	102
NPS 4 × 4 × 3	114.3	88.9	105	98
NPS 4 × 4 × 2-1/2	114.3	73.0	105	95
NPS 4 × 4 × 2	114.3	60.3	105	89
NPS 4 × 4 × 1-1/2	114.3	48.3	105	86

(Continued)

Table 3 (Continued)

Size	Nominal outside diameter at bevel, mm		Centre-to-end dimension, mm	
	Run	Outlet	Run, C	Outlet, M
NPS 5 × 5 × 4	141.3	114.3	124	117
NPS 5 × 5 × 3-1/2	141.3	101.6	124	114
NPS 5 × 5 × 3	141.3	88.9	124	111
NPS 5 × 5 × 2-1/2	141.3	73.0	124	108
NPS 5 × 5 × 2	141.3	60.3	124	105
NPS 6 × 6 × 5	168.3	141.3	143	137
NPS 6 × 6 × 4	168.3	114.3	143	130
NPS 6 × 6 × 3-1/2	168.3	101.6	143	127
NPS 6 × 6 × 3	168.3	88.9	143	124
NPS 6 × 6 × 2-1/2	168.3	73.0	143	121
NPS 8 × 8 × 6	219.1	168.3	178	168
NPS 8 × 8 × 5	219.1	141.3	178	162
NPS 8 × 8 × 4	219.1	114.3	178	156
NPS 8 × 8 × 3-1/2	219.1	101.6	178	152
NPS 10 × 10 × 8	273.1	219.1	216	203
NPS 10 × 10 × 6	273.1	168.3	216	194
NPS 10 × 10 × 5	273.1	141.3	216	191
NPS 10 × 10 × 4	273.1	114.3	216	184
NPS 12 × 12 × 10	323.9	273.1	254	241
NPS 12 × 12 × 8	323.9	219.1	254	229
NPS 12 × 12 × 6	323.9	168.3	254	219
NPS 12 × 12 × 5	323.9	141.3	254	216
NPS 14 × 14 × 12	355.6	323.9	279	270
NPS 14 × 14 × 10	355.6	273.1	279	257
NPS 14 × 14 × 8	355.6	219.1	279	248
NPS 14 × 14 × 6	355.6	168.3	279	238
NPS 16 × 16 × 14	406.4	355.8	305	305
NPS 16 × 16 × 12	406.4	323.9	305	295
NPS 16 × 16 × 10	406.4	273.1	305	283
NPS 16 × 16 × 8	406.4	219.1	305	273
NPS 16 × 16 × 6	406.4	168.3	305	264
NPS 18 × 18 × 16	457	406.4	343	330
NPS 18 × 18 × 14	457	355.6	343	330
NPS 18 × 18 × 12	457	323.9	343	321
NPS 18 × 18 × 10	457	273.1	343	308
NPS 18 × 18 × 8	457	219.1	343	298
NPS 20 × 20 × 18	508	457	381	368
NPS 20 × 20 × 16	508	406.4	381	356
NPS 20 × 20 × 14	508	355.6	381	356
NPS 20 × 20 × 12	508	323.9	381	346
NPS 20 × 20 × 10	508	273.1	381	333
NPS 20 × 20 × 8	508	219.1	381	324
NPS 22 × 22 × 20	559	508	419	406
NPS 22 × 22 × 18	559	457	419	394
NPS 22 × 22 × 16	559	406.4	419	381
NPS 22 × 22 × 14	559	355.6	419	381
NPS 22 × 22 × 12	559	323.9	419	371
NPS 22 × 22 × 10	559	273.1	419	359

(Continued)

Table 3 (Continued)

Size	Nominal outside diameter at bevel, mm		Centre-to-end dimension, mm	
	Run	Outlet	Run, C	Outlet, M
NPS 24 × 24 × 22	610	559	432	432
NPS 24 × 24 × 20	610	508	432	432
NPS 24 × 24 × 18	610	457	432	419
NPS 24 × 24 × 16	610	406.4	432	406
NPS 24 × 24 × 14	610	355.6	432	406
NPS 24 × 24 × 12	610	323.9	432	397
NPS 24 × 24 × 10	610	273.1	432	384
NPS 26 × 26 × 24	660	610	495	483
NPS 26 × 26 × 22	660	559	495	470
NPS 26 × 26 × 20	660	508	495	457
NPS 26 × 26 × 18	660	457	495	444
NPS 26 × 26 × 16	660	406.4	495	432
NPS 26 × 26 × 14	660	355.6	495	432
NPS 26 × 26 × 12	660	323.9	495	422
NPS 28 × 28 × 26	711	660	521	521
NPS 28 × 28 × 24	711	610	521	508
NPS 28 × 28 × 22	711	559	521	495
NPS 28 × 28 × 20	711	508	521	483
NPS 28 × 28 × 18	711	457	521	470
NPS 28 × 28 × 16	711	406.4	521	457
NPS 28 × 28 × 14	711	355.6	521	457
NPS 28 × 28 × 12	711	323.9	521	448
NPS 30 × 30 × 28	762	711	559	546
NPS 30 × 30 × 26	762	660	559	546
NPS 30 × 30 × 24	762	610	559	533
NPS 30 × 30 × 22	762	559	559	521
NPS 30 × 30 × 20	762	508	559	508
NPS 30 × 30 × 18	762	457	559	495
NPS 30 × 30 × 16	762	406.4	559	483
NPS 30 × 30 × 14	762	355.6	559	483
NPS 30 × 30 × 12	762	323.9	559	473
NPS 30 × 30 × 10	762	273.1	559	460
NPS 32 × 32 × 30	813	762	597	584
NPS 32 × 32 × 28	813	711	597	572
NPS 32 × 32 × 26	813	660	597	572
NPS 32 × 32 × 24	813	610	597	559
NPS 32 × 32 × 22	813	559	597	546
NPS 32 × 32 × 20	813	508	597	533
NPS 32 × 32 × 18	813	457	597	521
NPS 32 × 32 × 16	813	406.4	597	508
NPS 32 × 32 × 14	813	355.6	597	508
NPS 34 × 34 × 32	864	813	635	622
NPS 34 × 34 × 30	864	762	635	610
NPS 34 × 34 × 28	864	711	635	597
NPS 34 × 34 × 26	864	660	635	597
NPS 34 × 34 × 24	864	610	635	584
NPS 34 × 34 × 22	864	559	635	572
NPS 34 × 34 × 20	864	508	635	559
NPS 34 × 34 × 18	864	457	635	546
NPS 34 × 34 × 16	864	406.4	635	533

(Continued)

Table 3 (Continued)

Size	Nominal outside diameter at bevel, mm		Centre-to-end dimension, mm	
	Run	Outlet	Run, C	Outlet, M
NPS 36 × 36 × 34	914	864	673	660
NPS 36 × 36 × 32	914	813	673	648
NPS 36 × 36 × 30	914	762	673	635
NPS 36 × 36 × 28	914	711	673	622
NPS 36 × 36 × 26	914	660	673	622
NPS 36 × 36 × 24	914	610	673	610
NPS 36 × 36 × 22	914	559	673	597
NPS 36 × 36 × 20	914	508	673	584
NPS 36 × 36 × 18	914	457	673	572
NPS 36 × 36 × 16	914	406.4	673	559
NPS 38 × 38 × 36	965	914	711	711
NPS 38 × 38 × 34	965	864	711	698
NPS 38 × 38 × 32	965	813	711	686
NPS 38 × 38 × 30	965	762	711	673
NPS 38 × 38 × 28	965	711	711	648
NPS 38 × 38 × 26	965	660	711	648
NPS 38 × 38 × 24	965	610	711	635
NPS 38 × 38 × 22	965	559	711	622
NPS 38 × 38 × 20	965	508	711	610
NPS 38 × 38 × 18	965	457	711	597
NPS 40 × 40 × 38	1016	965	749	749
NPS 40 × 40 × 36	1016	914	749	737
NPS 40 × 40 × 34	1016	864	749	724
NPS 40 × 40 × 32	1016	813	749	711
NPS 40 × 40 × 30	1016	762	749	698
NPS 40 × 40 × 28	1016	711	749	673
NPS 40 × 40 × 26	1016	660	749	673
NPS 40 × 40 × 24	1016	610	749	660
NPS 40 × 40 × 22	1016	559	749	648
NPS 40 × 40 × 20	1016	508	749	635
NPS 40 × 40 × 18	1016	457	749	622
NPS 42 × 42 × 40	1067	1016	762	711
NPS 42 × 42 × 38	1067	965	762	711
NPS 42 × 42 × 36	1067	914	762	711
NPS 42 × 42 × 34	1067	864	762	711
NPS 42 × 42 × 32	1067	813	762	711
NPS 42 × 42 × 30	1067	762	762	711
NPS 42 × 42 × 28	1067	711	762	698
NPS 42 × 42 × 26	1067	660	762	698
NPS 42 × 42 × 24	1067	610	762	660
NPS 42 × 42 × 22	1067	559	762	660
NPS 42 × 42 × 20	1067	508	762	660
NPS 42 × 42 × 18	1067	457	762	648
NPS 42 × 42 × 16	1067	406.4	762	635

(Continued)

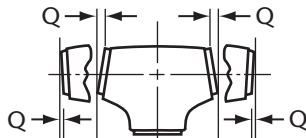
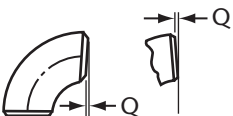
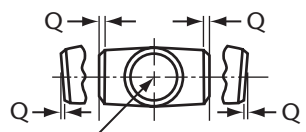
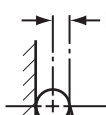
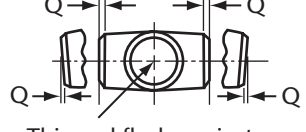
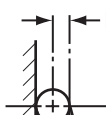
Table 3 (Concluded)

Size	Nominal outside diameter at bevel, mm		Centre-to-end dimension, mm	
	Run	Outlet	Run, C	Outlet, M
NPS 44 × 44 × 42	1118	1067	813	762
NPS 44 × 44 × 40	1118	1016	813	749
NPS 44 × 44 × 38	1118	965	813	737
NPS 44 × 44 × 36	1118	914	813	724
NPS 44 × 44 × 34	1118	864	813	724
NPS 44 × 44 × 32	1118	813	813	711
NPS 44 × 44 × 30	1118	762	813	711
NPS 44 × 44 × 28	1118	711	813	698
NPS 44 × 44 × 26	1118	660	813	698
NPS 44 × 44 × 24	1118	610	813	698
NPS 44 × 44 × 22	1118	559	813	686
NPS 44 × 44 × 20	1118	508	813	686
NPS 46 × 46 × 44	1168	1118	851	800
NPS 46 × 46 × 42	1168	1067	851	787
NPS 46 × 46 × 40	1168	1016	851	775
NPS 46 × 46 × 38	1168	965	851	762
NPS 46 × 46 × 36	1168	914	851	762
NPS 46 × 46 × 34	1168	864	851	749
NPS 46 × 46 × 32	1168	813	851	749
NPS 46 × 46 × 30	1168	762	851	737
NPS 46 × 46 × 28	1168	711	851	737
NPS 46 × 46 × 26	1168	660	851	737
NPS 46 × 46 × 24	1168	610	851	724
NPS 46 × 46 × 22	1168	559	851	724
NSP 48 × 48 × 46	1219	1168	889	838
NSP 48 × 48 × 44	1219	1118	889	838
NSP 48 × 48 × 42	1219	1067	889	813
NSP 48 × 48 × 40	1219	1016	889	813
NSP 48 × 48 × 38	1219	965	889	813
NSP 48 × 48 × 36	1219	914	889	787
NSP 48 × 48 × 34	1219	864	889	787
NSP 48 × 48 × 32	1219	813	889	787
NSP 48 × 48 × 30	1219	762	889	762
NSP 48 × 48 × 28	1219	711	889	762
NSP 48 × 48 × 26	1219	660	889	762
NSP 48 × 48 × 24	1219	610	889	737
NSP 48 × 48 × 22	1219	559	889	737

Table 4
Tolerances for standard fittings Grades 290 and higher

(See [Clauses 5.5](#) and [10.1.](#))

Size	Inside diameter at end	Out-of-roundness		Centre-to-end dimension (A, B, C, M), SR and LR elbows, tees	Centre-to-end dimension, 3R elbows	Reducers overall length, H	Caps overall length, E
		Elbows	Other				
NPS 1/2 to NPS 24 inclusive	± 2	5	3	± 2	± 3	± 2	± 7
NPS 26 to NPS 36 inclusive	± 2	1%	3	± 3	± 6	± 5	± 10
NPS 38 to NPS 48 inclusive	± 3	1%	3	± 5	± 10	± 10	± 10

Size	Angularity tolerance, elbows, tees, reducers off angle, Q	Elbows off plane, P	Reducers centreline offset		
NPS 1/2 to NPS 24 inclusive	2	6	3%		
NPS 26 to NPS 36 inclusive	2	13	3%		
NPS 38 to NPS 48 inclusive	3	19	3%		

This end flush against square

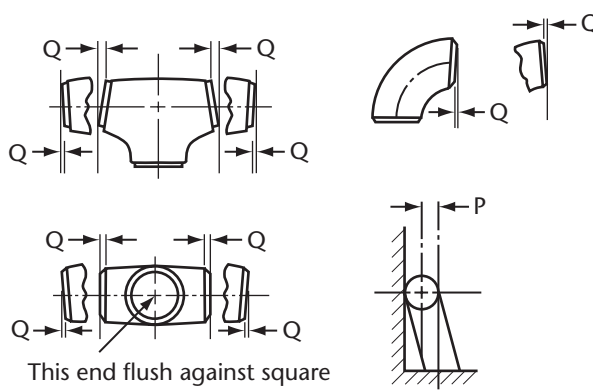
Notes:

- (1) The out-of-roundness tolerance shall be the difference between the maximum and minimum inside diameters measured on any radial cross-section at the end of the fitting. In addition, NPS 18 and larger elbows shall be not more than 3% out-of-round throughout their length.
- (2) Where tolerances are given in percentages, the tolerance applies to the nominal diameter expressed in millimetres.
- (3) For reducing tees, the run size shall be used to determine the tolerance of the centre-to-end dimension of the outlet.
- (4) For reducers, the larger dimension shall be used to determine the length tolerance.
- (5) All tolerances, except as noted, are in millimetres.

Table 5
Tolerances for standard fittings less than Grade 290

(See [Clauses 5.5](#) and [10.1.](#))

Size	Inside diameter at end	Out-of-roundness	Centre-to-end dimension (A, B, C, M), SR and LR elbows, tees	Reducers overall length, H	Caps overall length, E
NPS 1/2 to NPS 2-1/2 inclusive	± 1	2	± 2	± 2	± 4
NPS 3 to NPS 3-1/2 inclusive	± 2	2	± 2	± 2	± 4
NPS 4	± 2	3	± 2	± 2	± 4
NPS 5 to NPS 6 inclusive	± 2	4	± 2	± 2	± 7
NPS 8	± 2	4	± 2	± 2	± 7
NPS 10	± 3	7	± 2	± 2	± 7
NPS 12 to NPS 18 inclusive	± 3	7	± 3	± 3	± 7
NPS 20 to NPS 24 inclusive	± 5	11	± 3	± 3	± 7
NPS 26 to NPS 30 inclusive	± 5	12	± 3	± 3	± 10
NPS 32 to NPS 48 inclusive	± 5	12	± 5	± 5	± 10

Size	Angularity tolerance, elbows, tees, reducers off angle, Q	Elbows off plane, P	Reducers centreline offset		
NPS 1/2 to NPS 4 inclusive	1	2	3%		
NPS 5 to NPS 8 inclusive	2	4	3%		
NPS 10 to NPS 12 inclusive	3	5	3%		
NPS 14 to NPS 16 inclusive	3	7	3%		
NPS 18 to NPS 24 inclusive	4	10	3%		
NPS 26 to NPS 30 inclusive	5	10	3%		
NPS 32 to NPS 42 inclusive	5	13	3%		
NPS 44 to NPS 48 inclusive	5	20	3%		

Notes:

- (1) The out-of-roundness tolerance shall be the difference between the maximum and minimum inside diameters measured on any radial cross-section at the end of the fitting.
- (2) Where tolerances are given in percentages, the tolerance applies to the nominal diameter expressed in millimetres.
- (3) For reducing tees, the run size shall be used to determine the tolerance of the centre-to-end dimension of the outlet.
- (4) For reducers, the larger dimension shall be used to determine the length tolerance.
- (5) All tolerances, except as noted, are in millimetres.

Table 6
Chemical composition limits for heat and product analyses
 (See [Clauses 7.2](#), [7.3](#), and [15.3](#).)

Grades	Maximum carbon equivalent, %*	
Grades 290 and higher	0.50	
Element	Maximum permitted, %	
	Lower than Grade 290, by heat analysis	Grades 290 and higher, by product analysis
Carbon	0.35	0.30
Manganese	1.35	1.60
Phosphorus	0.05	0.05
Sulphur	0.06	0.06
Silicon	0.35	0.50
Copper	—	1.50
Nickel	—	1.00
Chromium	—	0.25
Molybdenum	—	0.25
Vanadium	—	0.13
Niobium	—	0.10
Boron	—	0.001

*The carbon equivalent shall be determined from the product analysis using the following formula:

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

where

F = a compliance factor that is dependent upon carbon content and is as specified in the following table:

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

Notes:

- (1) The chemical requirements specified in [Table 6](#) are not intended to represent the composition of any heat of steel but to record the maximum permissible amounts of individual elements.
- (2) Niobium is also known as columbium.

Table 7
Location of test samples and frequency of testing for bends
 (See [Clause 9.1.4.](#))

Manufacturing procedure	Test locations
Cold bends	Outer radius, weld seam, tangent
Hot bends, lower than Grade 290	Outer radius, weld seam, tangent
Hot bends, Grade 290 or higher	Outer radius, inner radius, weld seam, neutral axis, tangent

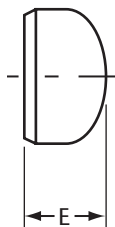
Notes:

- (1) New sets of tests, as described in [Clause 9.1.4](#), shall be required for changes in grade, wall thickness, outside diameter, or heat number.
- (2) Where a post-bend heat treatment is performed, the bends represented by a set of tests shall be
 - (a) heat treated in the same charge as the test coupons; or
 - (b) heat treated in the same manner as the test coupons in one or more furnaces that are surveyed at least annually, controlled within a range of 30 °C, and equipped with recording sensors that are calibrated at least quarterly.
- (3) Testing of tangents shall not be required if a post-bend heat treatment is not performed.
- (4) Testing of weld seams shall not be required for welds made without the addition of extraneous metal.
- (5) The weld seam test location shall include Charpy V-notch impact tests of both the weld metal and the heat-affected zone. The absorbed energy level in [Clause 9.3.4.2](#) shall be met.

Table 8
Charpy test specimens — Body
 (See [Clause 9.3.2.1.](#))

Fitting size	Material wall thickness, mm			
	Charpy specimen size and type			
	Full non-flattened	2/3 non-flattened	1/2 non-flattened	1/2 flattened
NPS 4	>12.5	10.9 to 12.5	10.1 to 10.8	6.0 to 10.0
NPS 5	>11.8	9.4 to 11.8	8.6 to 9.3	6.0 to 8.5
NPS 6	>11.6	8.5 to 11.6	7.6 to 8.4	6.0 to 7.5
NPS 8	>11.3	8.1 to 11.3	6.5 to 8.0	6.0 to 6.4
NPS 10	>11.2	7.9 to 11.2	6.2 to 7.8	6.0 to 6.1
NPS 12	>11.0	7.8 to 11.0	6.1 to 7.7	6.0
NPS 14	>11.0	7.7 to 11.0	6.1 to 7.6	6.0
NPS 16 to NPS 60	>10.9	7.7 to 10.9	6.0 to 7.6	—

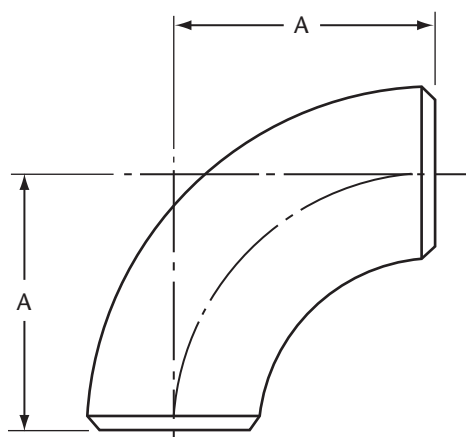
Table 9
Dimensions of caps
 (See [Clause 10.1.](#))



Size	Nominal outside diameter at bevel, mm	Length E, mm
NPS 1/2	21.3	25
NPS 3/4	26.7	25
NPS 1	33.4	38
NPS 1-1/4	42.2	38
NPS 1-1/2	48.3	38
NPS 2	60.3	38
NPS 2-1/2	73.0	38
NPS 3	88.9	51
NPS 3-1/2	101.6	64
NPS 4	114.3	64
NPS 5	141.3	76
NPS 6	168.3	89
NPS 8	219.1	102
NPS 10	273.1	127
NPS 12	323.9	152
NPS 14	355.6	165
NPS 16	406.4	178
NPS 18	457	203
NPS 20	508	229
NPS 22	559	254
NPS 24	610	267
NPS 26	660	267
NPS 28	711	267
NPS 30	762	267
NPS 32	813	267
NPS 34	864	267
NPS 36	914	267
NPS 38	965	305
NPS 40	1016	305
NPS 42	1067	305
NPS 44	1118	343
NPS 46	1168	343
NPS 48	1219	343

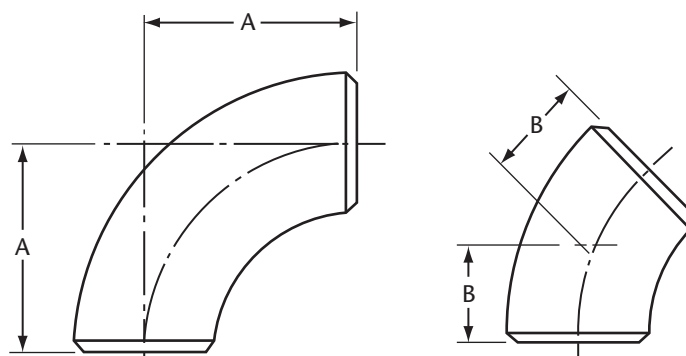
Note: The shape of caps shall be ellipsoidal in accordance with the requirements of Paragraph UG 32 of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

Table 10
Dimensions of short radius elbows
 (See [Clause 10.1.](#))



Size	Nominal outside diameter at bevel, mm	Centre-to-end dimension, mm
		90° elbows, A
NPS 1	33.4	25
NPS 1-1/4	42.2	32
NPS 1-1/2	48.3	38
NPS 2	60.3	51
NPS 2-1/2	73.0	64
NPS 3	88.9	76
NPS 3-1/2	101.6	89
NPS 4	114.3	102
NPS 5	141.3	127
NPS 6	168.3	152
NPS 8	219.1	203
NPS 10	273.1	254
NPS 12	323.9	305
NPS 14	355.6	356
NPS 16	406.4	406
NPS 18	457	457
NPS 20	508	508
NPS 22	559	559
NPS 24	610	610

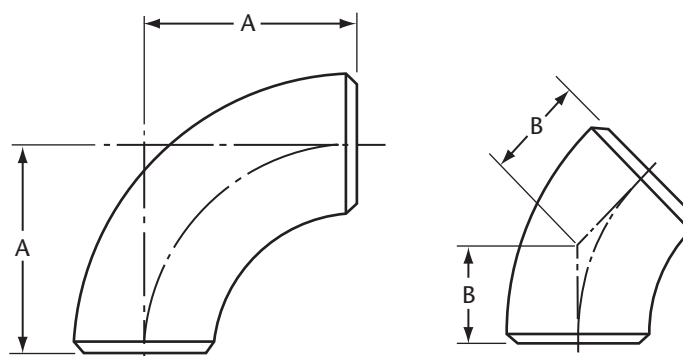
Table 11
Dimensions of long radius elbows
 (See [Clause 10.1.](#))



Size	Nominal outside diameter at bevel, mm	Centre-to-end dimension, mm	
		90° elbows, A	45° elbows, B
NPS 1/2	21.3	38	16
NPS 3/4	26.7	29*	11*
NPS 1	33.4	38	22
NPS 1-1/4	42.2	48	25
NPS 1-1/2	48.3	57	29
NPS 2	60.3	76	35
NPS 2-1/2	73.0	95	44
NPS 3	88.9	114	51
NPS 3-1/2	101.6	133	57
NPS 4	114.3	152	64
NPS 5	141.3	190	79
NPS 6	168.3	229	95
NPS 8	219.1	305	127
NPS 10	273.1	381	159
NPS 12	323.9	457	190
NPS 14	355.6	533	222
NPS 16	406.4	610	254
NPS 18	457	686	286
NPS 20	508	762	318
NPS 22	559	838	343
NPS 24	610	914	381
NPS 26	660	991	406
NPS 28	711	1067	438
NPS 30	762	1143	470
NPS 32	813	1219	502
NPS 34	864	1295	533
NPS 36	914	1372	565
NPS 38	965	1448	600
NPS 40	1016	1524	632
NPS 42	1067	1600	660
NPS 44	1118	1676	695
NPS 46	1168	1753	727
NPS 48	1219	1829	759

*At the option of the manufacturer, A may be 38 mm and B may be 19 mm.

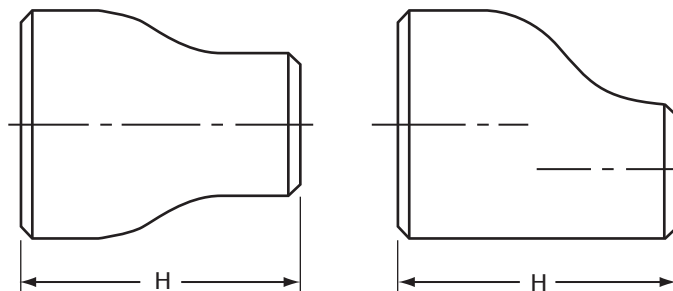
Table 12
Dimensions of 3R* elbows
 (See [Clause 10.1.](#))



Size	Nominal outside diameter at bevel, mm	Centre-to-end dimension, mm			
		90° elbows, A	60° elbows, B	45° elbows, B	30° elbows, B
NPS 16	406.4	1219	703	505	327
NPS 18	457	1372	789	568	367
NPS 20	508	1524	879	632	408
NPS 22	559	1676	968	694	449
NPS 24	610	1829	1057	757	490
NPS 26	660	1981	1143	821	519
NPS 30	762	2286	1321	946	611
NPS 34	864	2591	1497	1073	695
NPS 36	914	2743	1586	1137	735
NPS 38	965	2896	1673	1200	776
NPS 40	1016	3048	1759	1264	818
NPS 42	1067	3200	1848	1326	857
NPS 44	1118	3353	1937	1389	899
NPS 46	1168	3505	2024	1453	940
NPS 48	1219	3658	2113	1516	981

*R = nominal outside diameter.

Table 13
Dimensions of reducers
 (See [Clause 10.1.](#))



Size	Nominal outside diameter at bevel, mm		End-to-end length H, mm
	Large end	Small end	
NPS 3/4 × 1/2	26.7	21.3	38
NPS 3/4 × 3/8	26.7	17.1	38
NPS 1 × 3/4	33.4	26.7	51
NPS 1 × 1/2	33.4	21.3	51
NPS 1-1/4 × 1	42.2	33.4	51
NPS 1-1/4 × 3/4	42.2	26.7	51
NPS 1-1/4 × 1/2	42.2	21.3	51
NPS 1-1/2 × 1-1/4	48.3	42.2	64
NPS 1-1/2 × 1	48.3	33.4	64
NPS 1-1/2 × 3/4	48.3	26.7	64
NPS 1-1/2 × 1/2	48.3	21.3	64
NPS 2 × 1-1/2	60.3	48.3	76
NPS 2 × 1-1/4	60.3	42.2	76
NPS 2 × 1	60.3	33.4	76
NPS 2 × 3/4	60.3	26.7	76
NPS 2-1/2 × 2	73.0	60.3	89
NPS 2-1/2 × 1-1/2	73.0	48.3	89
NPS 2-1/2 × 1-1/4	73.0	42.2	89
NPS 2-1/2 × 1	73.0	33.4	89
NPS 3 × 2-1/2	89.9	73.0	89
NPS 3 × 2	89.9	60.3	89
NPS 3 × 1-1/2	89.9	48.3	89
NPS 3 × 1-1/4	89.9	42.2	89
NPS 3-1/2 × 3	101.6	88.9	102
NPS 3-1/2 × 2-1/2	101.6	73.0	102
NPS 3-1/2 × 2	101.6	60.3	102
NPS 3-1/2 × 1-1/2	101.6	48.3	102
NPS 3-1/2 × 1-1/4	101.6	42.2	102
NPS 4 × 3-1/2	114.3	101.6	102
NPS 4 × 3	114.3	88.9	102
NPS 4 × 2-1/2	114.3	73.0	102
NPS 4 × 2	114.3	60.3	102
NPS 4 × 1-1/2	114.3	48.3	102

(Continued)

Table 13 (Continued)

Size	Nominal outside diameter at bevel, mm		End-to-end length H, mm
	Large end	Small end	
NPS 5 × 4	141.3	114.3	127
NPS 5 × 3-1/2	141.3	101.6	127
NPS 5 × 3	141.3	88.9	127
NPS 5 × 2-1/2	141.3	73.0	127
NPS 5 × 2	141.3	60.3	127
NPS 6 × 5	168.3	141.3	140
NPS 6 × 4	168.3	114.3	140
NPS 6 × 3-1/2	168.3	101.6	140
NPS 6 × 3	168.3	88.9	140
NPS 6 × 2-1/2	168.3	73.0	140
NPS 8 × 6	219.1	168.3	152
NPS 8 × 5	219.1	141.3	152
NPS 8 × 4	219.1	114.3	152
NPS 8 × 3-1/2	219.1	101.6	152
NPS 10 × 8	273.1	219.1	178
NPS 10 × 6	273.1	168.3	178
NPS 10 × 5	273.1	141.3	178
NPS 10 × 4	273.1	114.3	178
NPS 12 × 10	323.9	273.1	203
NPS 12 × 8	323.9	219.1	203
NPS 12 × 6	323.9	168.3	203
NPS 12 × 5	323.9	141.4	203
NPS 14 × 12	355.6	323.9	330
NPS 14 × 10	355.6	273.1	330
NPS 14 × 8	355.6	219.1	330
NPS 14 × 6	355.6	168.3	330
NPS 16 × 14	406.4	355.6	356
NPS 16 × 12	406.4	323.9	356
NPS 16 × 10	406.4	273.1	356
NPS 16 × 8	406.4	219.1	356
NPS 18 × 16	457	406.4	381
NPS 18 × 14	457	355.6	381
NPS 18 × 12	457	323.9	381
NPS 18 × 10	457	273.1	381
NPS 20 × 18	508	457	508
NPS 20 × 16	508	406.4	508
NPS 20 × 14	508	355.6	508
NPS 20 × 12	508	323.9	508
NPS 22 × 20	559	508	508
NPS 22 × 18	559	457	508
NPS 22 × 16	559	406.4	508
NPS 22 × 14	559	355.6	508
NPS 24 × 22	610	559	508
NPS 24 × 20	610	508	508
NPS 24 × 18	610	457	508
NPS 24 × 16	610	406.4	508

(Continued)

Table 13 (Continued)

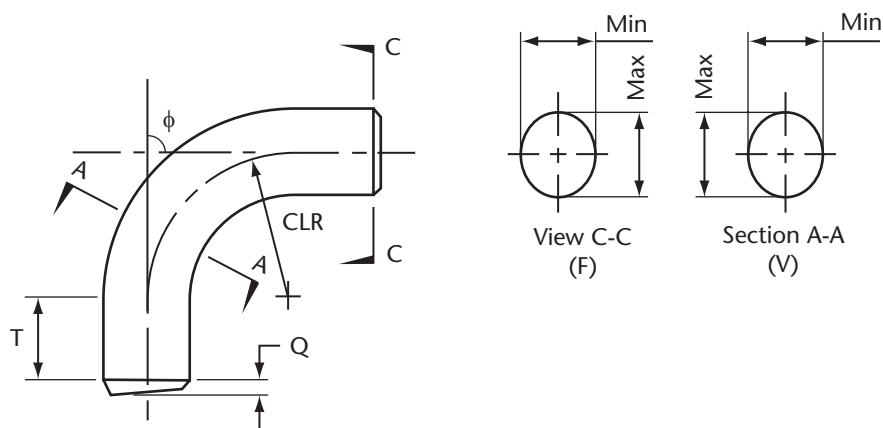
Size	Nominal outside diameter at bevel, mm		End-to-end length H, mm
	Large end	Small end	
NPS 26 × 24	660	610	610
NPS 26 × 22	660	559	610
NPS 26 × 20	660	508	610
NPS 26 × 18	660	457	610
NPS 28 × 26	711	660	610
NPS 28 × 24	711	610	610
NPS 28 × 20	711	508	610
NPS 28 × 18	711	457	610
NPS 30 × 28	762	711	610
NPS 30 × 26	762	660	610
NPS 30 × 24	762	610	610
NPS 30 × 20	762	508	610
NPS 32 × 30	813	762	610
NPS 32 × 28	813	711	610
NPS 32 × 26	813	660	610
NPS 32 × 24	813	610	610
NPS 34 × 32	864	813	610
NPS 34 × 30	864	762	610
NPS 34 × 26	864	660	610
NPS 34 × 24	864	610	610
NPS 36 × 34	914	864	610
NPS 36 × 32	914	813	610
NPS 36 × 30	914	762	610
NPS 36 × 26	914	660	610
NPS 36 × 24	914	610	610
NPS 38 × 36	965	914	610
NPS 38 × 34	965	864	610
NPS 38 × 32	965	813	610
NPS 38 × 30	965	762	610
NPS 38 × 28	965	711	610
NPS 38 × 26	965	660	610
NPS 40 × 38	1016	965	610
NPS 40 × 36	1016	914	610
NPS 40 × 34	1016	864	610
NPS 40 × 32	1016	813	610
NPS 40 × 30	1016	762	610
NPS 42 × 40	1067	1016	610
NPS 42 × 38	1067	965	610
NPS 42 × 36	1067	914	610
NPS 42 × 34	1067	864	610
NPS 42 × 32	1067	813	610
NPS 42 × 30	1067	762	610
NPS 44 × 42	1118	1067	610
NPS 44 × 40	1118	1016	610
NPS 44 × 38	1118	965	610
NPS 44 × 36	1118	914	610

(Continued)

Table 13 (Concluded)

Size	Nominal outside diameter at bevel, mm		End-to-end length H, mm
	Large end	Small end	
NPS 46 × 44	1168	1118	711
NPS 46 × 42	1168	1067	711
NPS 46 × 40	1168	1016	711
NPS 46 × 38	1168	965	711
NPS 48 × 46	1219	1168	711
NPS 48 × 44	1219	1118	711
NPS 48 × 42	1219	1067	711
NPS 48 × 40	1219	1016	711

Table 14
Pipe bend tolerances
 (See [Clause 10.4.](#))



$$F = \frac{\text{Max} - \text{Min}}{\text{NOD}} \times 100$$

$$V = \frac{\text{Max} - \text{Min}}{\text{NOD}} \times 100$$

F = end out-of-roundness

Q = end squareness

CLR = centreline radius

T = tangent

V = bend zone out-of-roundness

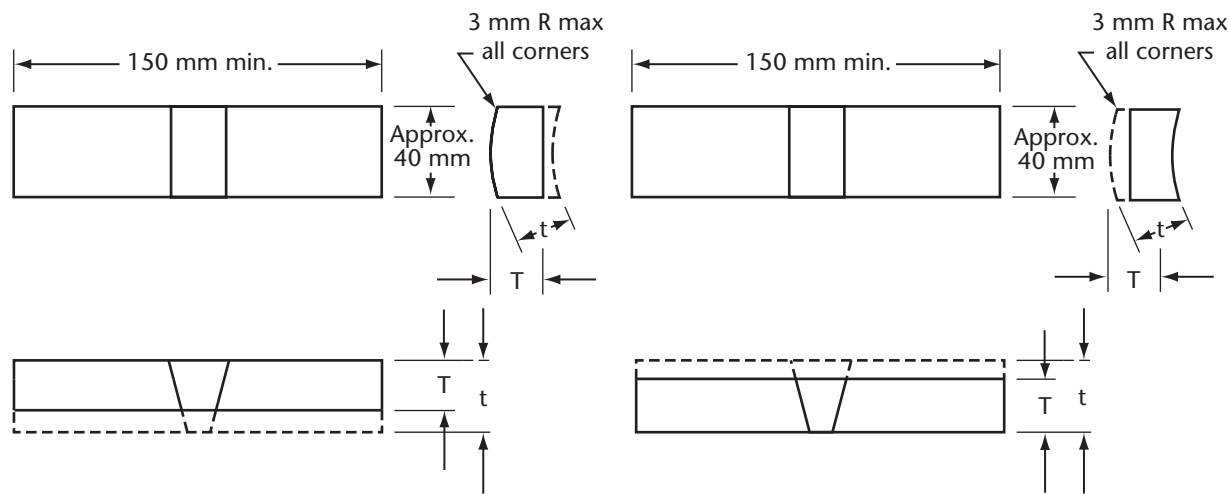
ϕ = bend angle

NOD = nominal outside diameter

NID = nominal inside diameter

Note: Material upsets or wrinkles at the start to stop of the intrados are acceptable provided that the differences between the peaks and valleys of such imperfections are not greater than 1% of the nominal outside diameter.

Item	Tolerances	
Bend angle (ϕ)	$\pm 1^\circ$ for $\text{CLR} \leq 4500 \text{ mm}$	$\pm 2^\circ$ for $\text{CLR} > 4500 \text{ mm}$
Centreline radius (CLR)	$\pm 1\%$	
Bend zone out-of-roundness (V)	8% max for $\text{CLR} \leq 5 \times \text{NOD}$	5% max for $\text{CLR} > 5 \times \text{NOD}$
End out-of-roundness (F)	2% max for $T \geq 1.5 \times \text{NOD}$	Tolerance to be specified by purchaser for $T < 1.5 \times \text{NOD}$
End squareness (Q)	3 mm max	
Minimum internal diameter	95% min for $\text{CLR} \leq 5 \times \text{NID}$	97% min for $\text{CLR} > 5 \times \text{NID}$



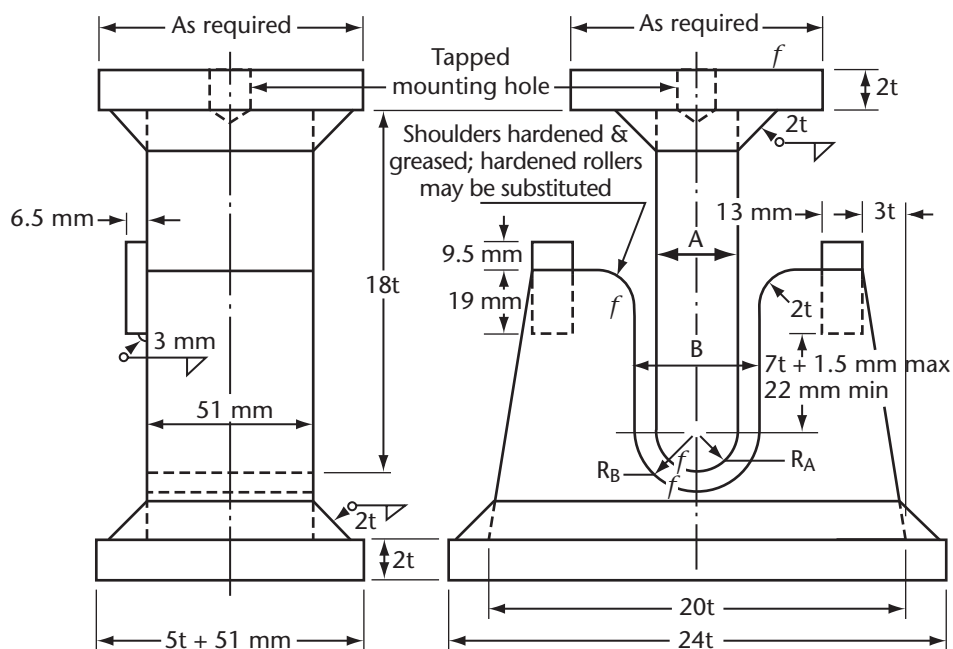
Face guided-bend test specimen

Root guided-bend test specimen

Fitting wall thickness t , mm	Test specimen thickness T , mm
Up to 9.5	t
Over 9.5	9.5

- Notes:**
- (1) Weld reinforcement shall be removed from both faces.
 - (2) Specimen edges may be oxygen-cut and may also be machined.

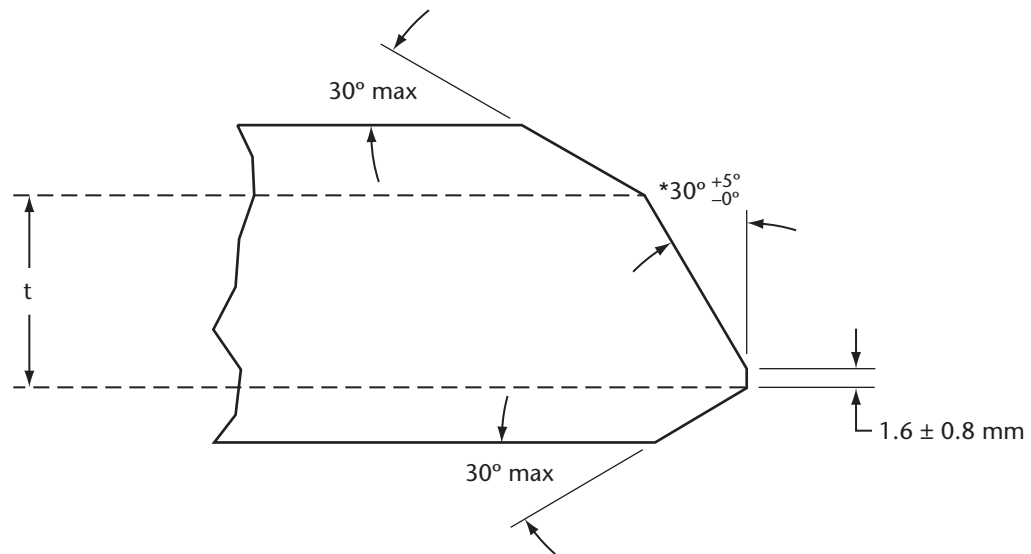
Figure 1
Guided-bend test specimen
(See [Clause 9.5.2.](#))



	Test jig dimension, mm			
	Grade 290 or lower	Over Grade 290 to less than Grade 331	Grade 331 to less than Grade 414	Grade 414 or higher
Radius of male member, R_A	$3t$	$3.5t$	$4t$	$4.5t$
Radius of female member, R_B	$4t + 1.6$	$4.5t + 1.6$	$5t + 1.6$	$5.5t + 1.6$
Width of male member, A	$6t$	$7t$	$8t$	$9t$
Width of groove in female member, B	$8t + 3.2$	$9t + 3.2$	$10t + 3.2$	$11t + 3.2$

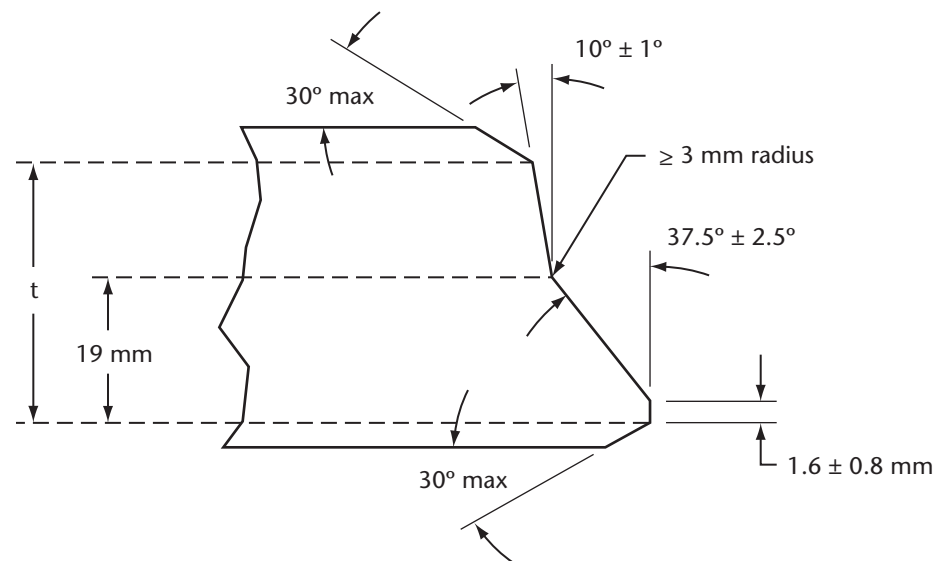
Note: t = test specimen thickness.

Figure 2
Guided-bend test jig dimensions
 (See [Clause 9.5.2.](#))



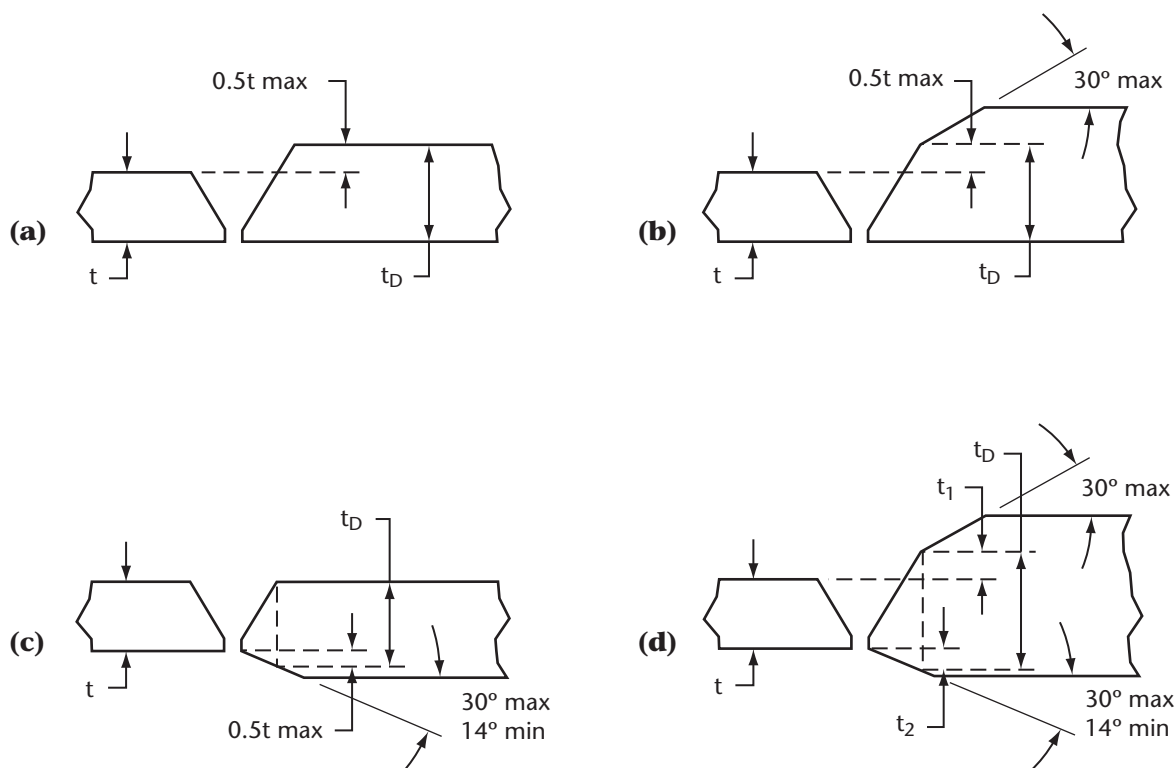
*At the option of the manufacturer, NPS 24 and smaller fittings may be furnished with a $37.5^\circ \pm 2.5^\circ$ bevel.

**(a) Recommended end preparation for wall thickness
at end of fitting ($t \leq 22$ mm)**



**(b) Recommended end preparation for wall thickness
at end of fitting ($t > 22$ mm)**

Figure 3
Recommended end preparations
(See [Clause 10.5](#) and [Figure 4](#).)

**Notes:**

- (1) t = specified wall thickness of the matching pipe.
 t_D = design thickness of the fitting.
- (2) t_D shall be at least equal to t times the ratio of the specified minimum yield strength of the matching pipe to that of the fitting.
- (3) Neither t_1 , t_2 , nor their sum shall exceed $0.5t$.
- (4) Any internal taper on (a) and (b) shall not exceed 30° .
- (5) t_D shall not be less than t .
- (6) Angles and dimensions not shown shall be as shown in [Figure 3](#).

Figure 4
Design of ends for unequal grades
 (See [Clause 10.6](#).)

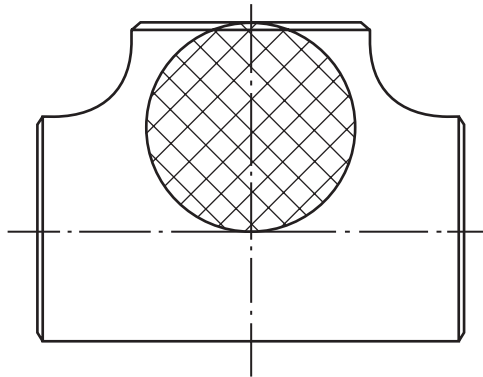


Figure 5
Extent of non-destructive inspection on cold-formed tees
(See [Clause 12.1.4.2.](#))

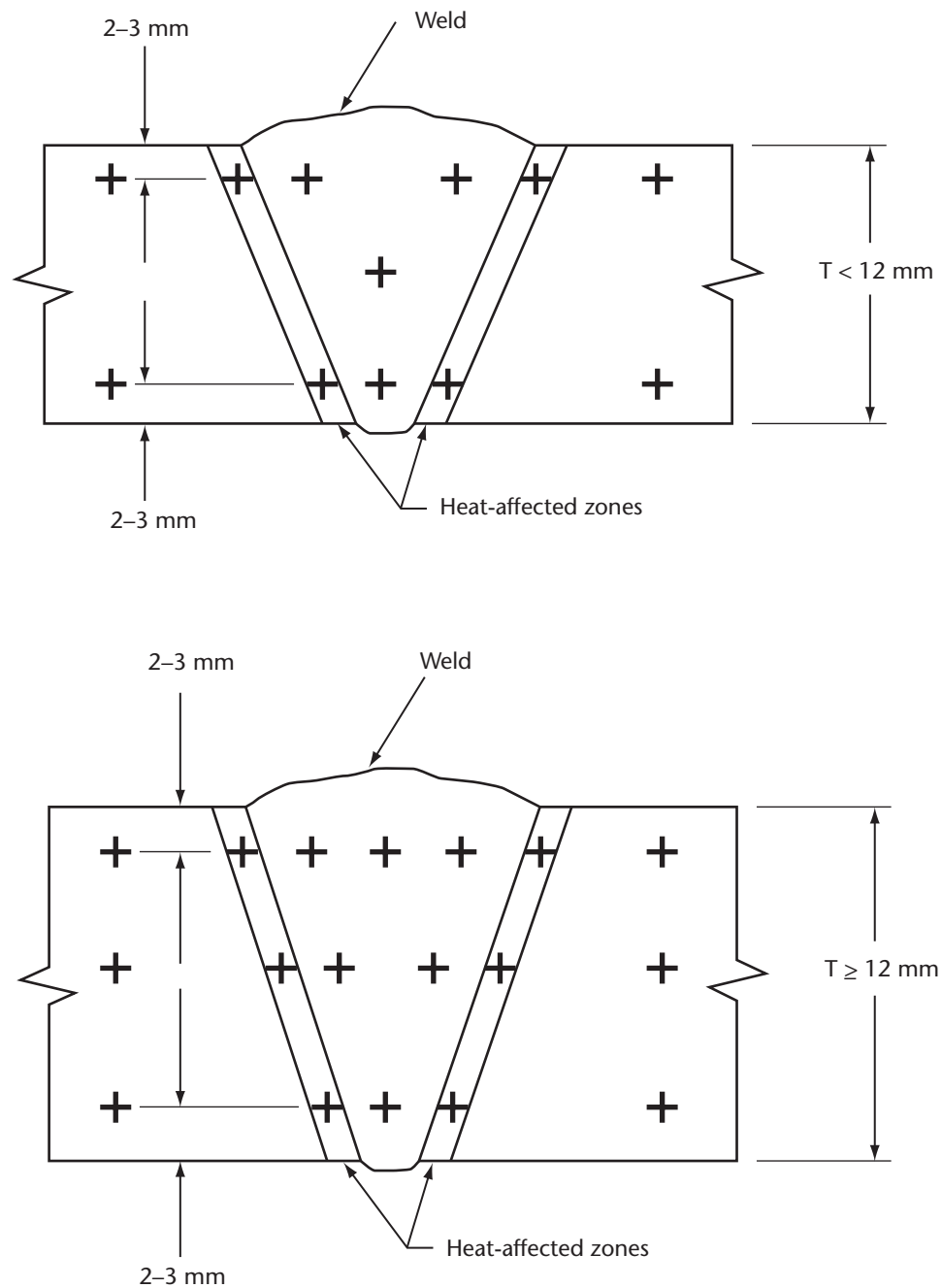


Figure 6
Welding procedure qualification macrohardness test locations
(See [Clause 13.3.](#))

Annex A (informative)

Pipeline component size nomenclature

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

Table A.1
Pipeline component size nomenclature
(See [Clause 1.2.1.](#))

Nominal fitting size		Matching steel line pipe size OD, mm
NPS 1/8	DN 6	10.3
NPS 1/4	DN 8	13.7
NPS 3/8	DN 10	17.1
NPS 1/2	DN 15	21.3
NPS 3/4	DN 20	26.7
NPS 1	DN 25	33.4
NPS 1-1/4	DN 32	42.2
NPS 1-1/2	DN 40	48.3
NPS 2	DN 50	60.3
NPS 2-1/2	DN 65	73.0
NPS 3	DN 80	88.9
NPS 3-1/2	DN 90	101.6
NPS 4	DN 100	114.3
NPS 5	DN 125	141.3
NPS 6	DN 150	168.3
NPS 8	DN 200	219.1
NPS 10	DN 250	273.1
NPS 12	DN 300	323.9
NPS 14	DN 350	355.6
NPS 16	DN 400	406.4
NPS 18	DN 450	457
NPS 20	DN 500	508
NPS 22	DN 550	559
NPS 24	DN 600	610
NPS 26	DN 650	660
NPS 28	DN 700	711
NPS 30	DN 750	762
NPS 32	DN 800	813
NPS 34	DN 850	864
NPS 36	DN 900	914
NPS 38	DN 950	965
NPS 40	DN 1000	1016
NPS 42	DN 1050	1067
NPS 44	DN 1100	1118
NPS 46	DN 1150	1168
NPS 48	DN 1200	1219

(Continued)

Table A.1 (Concluded)

Nominal size of fitting		Matching steel line pipe size OD, mm
NPS 50	DN 1250	1270.0
NPS 52	DN 1300	1321.0
NPS 54	DN 1350	1372.0
NPS 56	DN 1400	1422.0
NPS 58	DN 1450	1473.0
NPS 60	DN 1500	1524.0

Notes:

- (1) "NPS" means "nominal pipe size", and the NPS system of nominal size designation is contained in Standards prepared by the American Society of Mechanical Engineers. The NPS size is dimensionless, and the numerical portion of the designation is identical to the numerical portion of the previously used inch nominal size designation.
- (2) "DN" means "diamètre nominal", and the DN system of nominal size designation is contained 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 B (informative)

Recommended practice for the calibration and survey of heat-treating equipment

Note: This Annex is not a mandatory part of this Standard. However, it has been written in mandatory terms to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

B.1 Furnace survey and calibration

B.1.1

A temperature survey within each furnace working zone shall be performed on each furnace at the maximum and minimum temperatures of the range for which the furnace is qualified for use.

B.1.2

The total number of thermocouple test locations in the working zone of a furnace shall be not fewer than four for furnace working zones of 2 m³ or less. The location of the thermocouples shall be at the manufacturer's discretion.

B.1.3

Furnace working zones greater than 2 m³ and equal to or less than 10 m³ shall use not fewer than nine thermocouples. The location of the thermocouples shall be as shown in [Figure B.1](#).

B.1.4

Furnace working zones greater than 10 m³ shall use a minimum of nine thermocouples, plus one additional thermocouple for each 3 m³ of working zone exceeding 10 m³, to a maximum of 20 thermocouples. It shall be permissible to use additional thermocouples. The location of the first nine thermocouples shall be as shown in [Figure B.1](#). The placement of additional thermocouples shall be at the manufacturer's discretion and shall be recorded on the survey records.

B.1.5

After the thermocouples have been installed, readings shall be taken at least once every 3 min to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

B.1.6

Once the furnace temperature has reached the set point temperature, the temperature of each thermocouple shall be recorded at maximum intervals of 2 min, for at least 10 min. Then, readings shall be taken at maximum intervals of 5 min for a sufficient time to determine the recurrent temperature pattern of the working zone for at least 30 min.

B.1.7

After the furnace control set point temperature is reached, the temperature at any point in the working zone shall not vary by more than 15 °C from the set point temperature.

B.1.8

Furnaces that have been subjected to a change in burner quantity or location, or both, shall be surveyed, and the requirements of [Clause B.1.7](#) shall be met.

B.1.9

Furnaces that have been subjected to a change in the type of lining shall be surveyed, and the requirements of [Clause B.1.7](#) shall be met.

Note: *An example of a change in the type of lining is from brick to fibre.*

B.1.10

Except as required by [Clauses B.1.8](#) and [B.1.9](#), furnaces that have been repaired or rebuilt shall be surveyed if deemed necessary by the manufacturer. For any such surveys, the requirements of [Clause B.1.7](#) shall be met.

B.2 Instruments**B.2.1 Accuracy of production instruments**

The production instruments (thermocouples, controllers, and recorders) used for the heat-treatment process shall be accurate to within $\pm 1\%$ over the heat-treatment range.

B.2.2 Calibration of production instruments

Equipment used to calibrate production instruments shall be accurate to within $\pm 0.25\%$ of their full-scale range.

B.3 Records

Records of furnace calibration and surveys shall be maintained for at least five years.

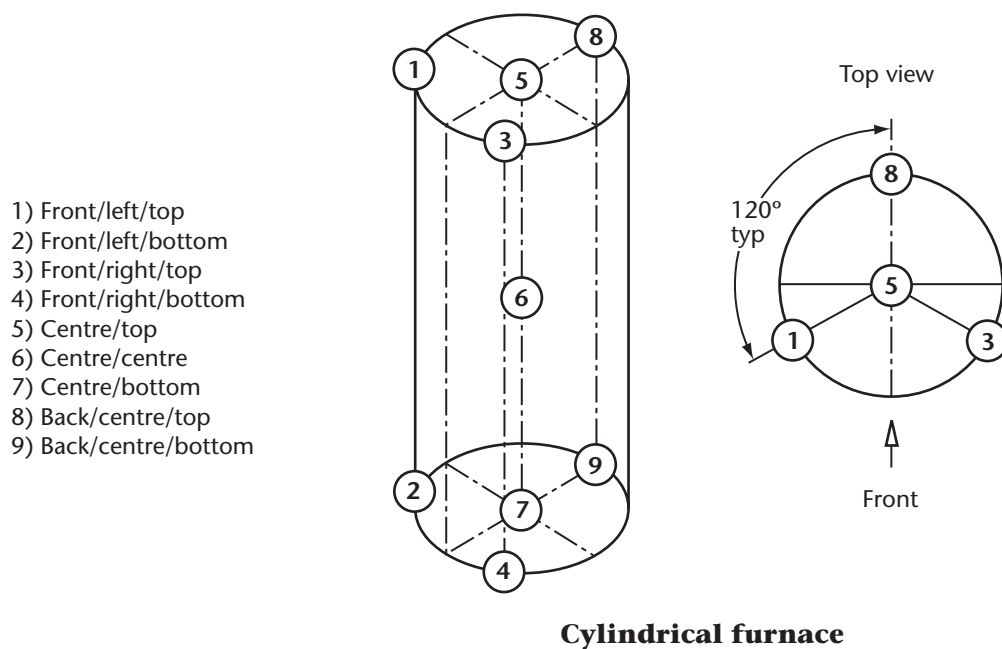
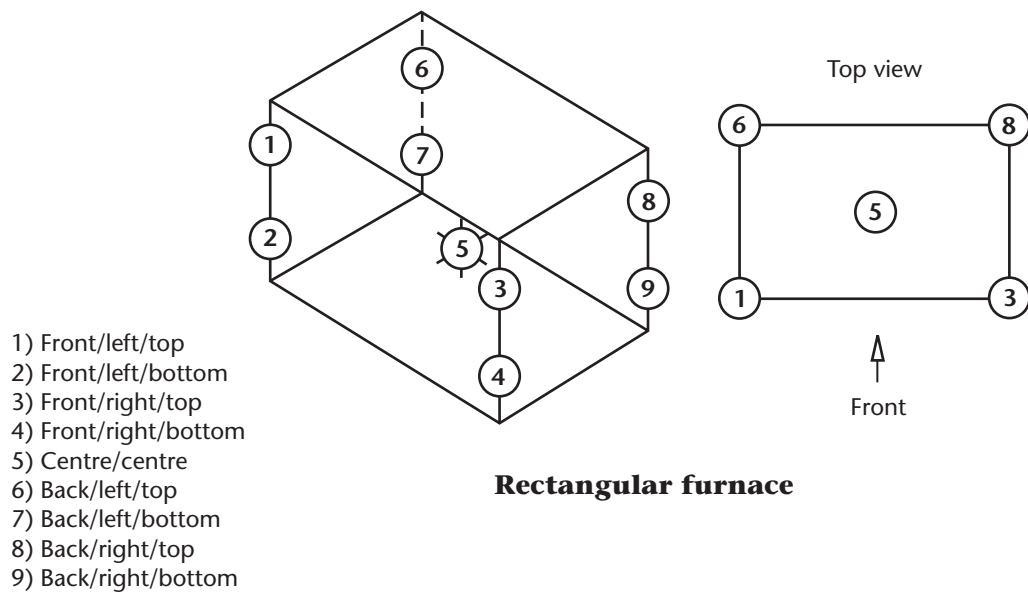


Figure B.1
Thermocouple locations
(See [Clauses B.1.3](#) and [B.1.4.](#))

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.

Nom/Name: _____

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