ASME B16.9-2024

(Revision of ASME B16.9-2018)

Factory-Made Wrought Buttwelding Fittings

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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The American Society of Mechanical Engineers
150 Clove Road • Little Falls, NJ • 07424 USA

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FOREWORD

In 1921, the American Engineering Standards Committee, later the American Standards Association (ASA), organized Sectional Committee B16 to unify and further develop national standards for pipe flanges and fittings (and later, for valves, gaskets, and valve actuators). Cosponsors of the B16 Committee were The American Society of Mechanical Engineers (ASME), the Heating and Piping Contractors National Association [now the Mechanical Contractors Association of America (MCAA)], and the Manufacturers Standardization Society of the Valve and Fittings Industry (MSS). Cosponsors were later designated as cosecretariat organizations.

Standardization of welding fittings was initiated in 1937 by a subgroup (designated Subgroup G) of Subcommittee 3. After consideration of several drafts, a standard was approved by the committee, cosponsors, and ASA, and published with the designation ASA B16.9-1940.

Revisions were made in 1950 and 1955 to add sizes up to NPS 24 and to complete coverage of fittings in some sizes. These revisions were approved and published as ASA B16.9-1951 and ASA B16.9-1958. With the subgroup now designated Subcommittee 6 (later Subcommittee F), further revisions were begun to clarify the intent of the Standard, to add angularity tolerances, and to include fittings of different types (long radius reducing elbows and crosses) and smaller sizes (NPS $^{1}/_{4}$ and NPS $^{1}/_{2}$). This revision was published as ASA B16.9-1964 after ASA approval.

After reorganization of ASA, first as the United States of America Standards Institute (USASI), then as the American National Standards Institute (ANSI), with the Sectional Committee being redesignated as an American National Standards Committee, another revision increasing the size range to NPS 48 and revising the text for clarity was approved and published as ANSI B16.9-1971.

In 1975, Subcommittee F began a major revision to bring the standard up to date with current practice and usage. Common fractions were expressed as decimals (but without intending higher precision) and metric dimensional equivalents were added. Provisions for step-wise change of radius for NPS $^{3}/_{4}$ long radius elbows and 180-deg returns were introduced. Following Standards Committee, cosecretariat, and ANSI approval, the revision was published as ANSI B16.9-1978. It was updated by a corrective addendum, B16.9a-1981, issued in February 1982.

In 1982, American National Standards Committee B16 was reorganized as an ASME committee operating under procedures accredited by ANSI. In ASME/ANSI B16.9-1986, the text was revised and inch dimensions were established as the standard.

In 1991, the subcommittee reviewed the Standard and made a number of revisions that were included in ASME B16.9-1993. Dimensions for short pattern lap joints were also added.

In ASME B16.9-2001, short radius elbows and returns were added, which included all dimensions and tolerances of ASME B16.28-1994. Metric units were provided as an independent but parallel alternative standard to U.S. Customary units. U.S. Customary units were moved into parentheses or separate tables in Mandatory Appendix I. In addition, a Quality System Program appendix was added.

In 2003, the subcommittee reviewed the Standard and made a number of revisions. The scope of the Standard was changed to permit fabricated lap joint stub ends employing circumferential or intersection welds.

In 2006, the subcommittee reviewed the Standard and made a number of additions and revisions. Segmental elbow requirements were added, as were 3D radius elbow dimensions. Reference documents were updated.

In 2012, the subcommittee reviewed the Standard and made numerous revisions to the design proof test in section 9 and updated the references in Mandatory Appendix II.

The 2018 edition added more specific descriptions of acceptable design methods, revised the requirements for the design proof test, and updated the references. In addition, the U.S. Customary tables in Mandatory Appendix I were merged with the metric tables and all tables were redesignated. Following the approval of the ASME B16 Standards Committee, ANSI approved ASME B16.9-2018 as an American National Standard on September 25, 2018.

In 2024, the subcommittee reviewed the Standard and made a number of revisions. This edition adds sample reports for pressure testing and defines minimum requirements for determining design thickness for design proof testing. In addition, Tables 6.1-10 and 11.2-1 have been revised, and options for marking nominal wall thickness have been added. Material grade, material group, and method of manufacture have been added as required content for new proof test reports, and the requirements for proof test reports prepared under previous editions have been revised. Following approval by the ASME B16 Standards Committee, ASME B16.9-2024 was approved by ANSI on September 5, 2024.

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Standardization of Valves, Flanges, Fittings, and Gaskets

(The following is the roster of the committee at the time of approval of this Standard.)

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Revisions and Errata. The committee processes revisions to this Standard on a continuous basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published in the next edition of the Standard.

In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive e-mail notifications of posted errata.

This Standard is always open for comment, and the committee welcomes proposals for revisions. Such proposals should be as specific as possible, citing the paragraph number, the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent background information and supporting documentation.

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(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Standard

(4) to permit the use of a new material or process

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(c) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Standard and the paragraph, figure, or table number

(4) the editions of the Standard to which the proposed case applies

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ASME B16.9-2024
SUMMARY OF CHANGES

Following approval by the ASME B16.9 Standards Committee and ASME, and after public review, ASME B16.9-2024 was approved by the American National Standards Institute on September 5, 2024.

ASME B16.9-2024 includes the following changes identified by a margin note, **(24)**. The Record Numbers listed below are explained in more detail in the "List of Changes in Record Number Order" following this Summary of Changes.

Page	*Location*	*Change (Record Number)*
2	4.1	Subparagraph (c) and footnote 1 revised *(22-678)*
3	4.4.2	Subparagraph (a) revised and subpara. (b) deleted; subsequent paragraph redesignated *(22-678)*
3	6.2	Title revised *(22-678)*
3	6.2.4	In last paragraph, first sentence revised *(22-678)*
5	9.3.7	Last two paragraphs added *(18-811)*
5	9.5	Revised *(22-623)*
5	9.6	Subparagraph (a) revised; last two paragraphs added *(18-811, 18-812, and 22-623)*
6	11	Revised in its entirety *(18-811)*
21	Table 6.1-10	Revised in its entirety *(18-813)*
28	Table 11.2-1	(1) Former Table 11-1 editorially redesignated as Table 11.2-1 (2) Notes (2) and (5) revised *(17-503, 18-811)*
32	Nonmandatory Appendix B	Added *(18-812)*

LIST OF CHANGES IN RECORD NUMBER ORDER

Record Number	Change
17-503	Revised Note (5) in Table 11.2-1.
18-811	Clarified establishment of “design thickness” in case of design proof testing by defining minimum requirements for its determination.
18-812	Added sample reports for pressure testing.
18-813	Revised Table 6.1-10, Dimensions of Caps.
22-623	Added material grade and material group as well as the method of manufacture to the required content of new proof test reports and added requirements for proof test reports prepared under previous editions.
22-678	Added options of marking nominal wall thickness in para. 4.1; updated marking of special fittings in para 4.4.2; and revised para. 6.2 to avoid confusion with special fittings as per para. 4.4.2.

FACTORY-MADE WROUGHT BUTTWELDING FITTINGS

1 SCOPE

1.1 General

This Standard covers overall dimensions, tolerances, ratings, testing, and markings for factory-made wrought buttwelding fittings in sizes NPS ½ through NPS 48 (DN 15 through DN 1200).

1.2 Special Fittings

Fittings may be made to special dimensions, sizes, shapes, and tolerances by agreement between the manufacturer and the purchaser.

1.3 Fabricated Fittings

Fabricated laterals and other fittings employing circumferential or intersection welds are considered pipe fabrication and are not within the scope of this Standard.

Fabricated lap joint stub ends are exempt from the above restrictions, provided they meet all the requirements of the applicable ASTM material specification listed in section 5.

1.4 Relevant Units

This Standard states values in both SI (metric) and U.S. Customary units. These systems of units are to be regarded separately as standard. In this Standard, the U.S. Customary units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, it is required that each system of units be used independently of the other. Combining values from the two systems constitutes nonconformance with the Standard.

The designation for size is NPS for both metric- and Customary-dimensioned fittings. Fitting pressure rating is associated with the connecting wall thickness of pipe of equivalent size and material.

1.5 References

1.5.1 Referenced Standards. Standards and specifications adopted by reference in this Standard are shown in Mandatory Appendix I. It is not considered practical to identify the specific edition of each standard and specification in the individual references. Instead, the specific edition reference is identified in Mandatory Appendix I. A product made in conformance with a prior edition of referenced standards and in all other respects conforming to this Standard will be considered to be in conformance.

1.5.2 Codes and Regulations. A fitting used under the jurisdiction of the ASME Boiler and Pressure Vessel Code (BPVC), the ASME Code for Pressure Piping, or a governmental regulation is subject to any limitation of that code or regulation. This includes any maximum temperature limitation or rule governing the use of a material at low temperature.

1.6 Service Conditions

Criteria for selection of fitting types and materials suitable for particular fluid service are not within the scope of this Standard.

1.7 Welding

Installation welding requirements are outside the scope of this Standard.

1.8 Quality Systems

Nonmandatory requirements relating to the fitting manufacturer's Quality System Program are described in Nonmandatory Appendix A.

1.9 Convention

For determining conformance with this Standard, the convention for fixing significant digits where limits (maximum and minimum values) are specified shall be as defined in ASTM E29. This requires that an observed or calculated value be rounded off to the nearest unit in the last right-hand digit used for expressing the limit. Decimal values and tolerances do not imply a particular method of measurement.

1.10 Pressure Rating Designation

Class followed by a dimensionless number is the designation for pressure–temperature ratings. Standardized designations for flanges per ASME B16.5 referenced in this Standard are Classes 150, 300, 600, 900, 1500, and 2500.

2 PRESSURE RATINGS

2.1 Basis of Ratings

The allowable pressure ratings for fittings designed in accordance with this Standard may be calculated as for straight seamless pipe of equivalent material (as shown by comparison of composition and mechanical properties in the respective material specifications) in accordance with the rules established in the applicable sections of ASME B31, Code for Pressure Piping. For the calculation, applicable data for the pipe size, wall thickness, and material that are equivalent to that of the fitting shall be used. Pipe size, wall thickness (or schedule number), and material identity on the fittings are in lieu of pressure rating markings.

2.2 Design of Fittings

2.2.1 Acceptable Design Methods. The design of fittings shall be established by one of the following methods:

(a) mathematical analyses contained in nationally recognized pressure vessel or piping codes (e.g., ASME B31.3 para. 304.2 for elbows and para. 304.3 for tees).

(b) proof testing in accordance with section 9 of this Standard.

(c) experimental stress analysis, such as described in ASME BPVC, Section VIII, Division 2, Annex 5.F with validation of results. Hydrostatic testing can be used to validate experimental results.

(d) detailed stress analysis (e.g., finite element method) with results evaluated as described in ASME BPVC, Section VIII, Division 2, Part 5 with validation of results. Strain measurement, photoelastic testing, or hydrostatic testing can be used to validate calculated results.

2.2.2 Design Thickness. To meet design or manufacturing requirements, it is expected that some portion of formed fittings may have to be thicker than the pipe wall with which the fitting is intended to be used. The mathematical analyses, if used, may take into account such thicker sections.

2.2.3 Records. Copies of English-language records of the mathematical analysis, the successful proof test, or both shall be made available to the purchaser or regulatory authority upon request.

3 SIZE

NPS, followed by a dimensionless number, is the designation for nominal fitting size. NPS is related to the reference nominal diameter, DN, used in international standards. The relationship is, typically, as follows:

DN	NPS
15	½
20	¾
25	1
32	1¼
40	1½
50	2
65	2½
80	3
100	4

NOTE: For NPS > 4, the equivalence is DN = 25 × NPS.

4 MARKING

4.1 Standard Marking (24)

Each fitting shall be permanently marked to show the following:

(a) manufacturer's name or trademark

(b) material identification, either the ASTM or ASME grade designation

(c) wall-thickness identification,[1] schedule number,[1] or nominal wall thickness, mm (in.)

(d) size — the nominal pipe size (NPS) identification number related to the end connections shall be used

(e) compliance — see para. 4.4 for standard and special fitting marking

A manufacturer may supplement these mandatory markings with others, including a DN size designation, but confusion with the required marking shall be avoided.

4.2 Exceptions

Where the size of the fitting does not permit complete marking, the identification marks may be omitted in reverse of the order presented in para. 4.1.

4.3 Depth of Stamping

Where steel stamps are used, care shall be taken so that the marking is not deep enough or sharp enough to cause cracks or to reduce the wall thickness of the fitting below the minimum allowed.

4.4 Compliance

4.4.1 Standard Fittings. That the fitting was manufactured in conformance with this Standard, including all dimensional requirements, is certified by a prefix "WP" in the material grade designation marking.

[1] The wall-thickness identifications standard (STD), extra-strong (XS), and double extra-strong (XXS), or schedule number are as described in ASME B36.10 and ASME B36.19.

(24) **4.4.2 Special Fittings.** That the fitting was manufactured in conformance with this Standard, except that dimensional requirements are as agreed between the purchaser and the manufacturer, is certified by a supplementary suffix to the material grade designation marking as follows:

(a) "S58" of ASTM A960 applies for fittings in accordance with ASTM A234, ASTM A403, ASTM A420, and ASTM A815.

(b) "SPLD" applies for fittings in accordance with ASTM B361, ASTM B363, and ASTM B366.

5 MATERIAL

Wrought fittings covered by this Standard shall be in accordance with ASTM A234, ASTM A403, ASTM A420, ASTM A815, ASTM B361, ASTM B363, ASTM B366, or the corresponding specification listed in ASME BPVC, Section II. The term "wrought" denotes fittings made of pipe, tubing, plate, or forgings. For purposes of determining proof testing requirements of section 9, the materials are grouped by similar properties as shown in Table 5-1.

Fittings made from block forgings may only be supplied subject to agreement between the manufacturer and purchaser. Such fittings need not meet the requirements of section 7.

6 FITTING DIMENSIONS

6.1 General

This Standard provides for a fixed position for the welding ends with reference to either the centerline of the fittings or the overall dimensions. Dimensional requirements for these fittings are in Tables 6.1-1 through 6.1-11.

(24) ### 6.2 Optional Dimensions

6.2.1 Fatigue Loading. For applications where fatigue loading is a concern, required minimum dimensions shall be furnished by the purchaser.

6.2.2 Bore Diameter. Bore diameters away from the ends are not specified. If special flow path requirements are needed, the bore dimensions shall be specified by the purchaser.

6.2.3 Stub Ends. Service conditions and joint construction often dictate stub end length requirements. Therefore, the purchaser must specify long or short pattern fitting when ordering. [See Table 6.1-9, General Note (b).]

(24) **6.2.4 Segmental Elbows.** Factory-made segments of short radius, long radius, and 3D radius elbows may be made to meet customer angle requirements. With the exception of the *B* dimension, factory-made segments of elbows shall meet all other requirements of this Standard. The *B* dimension for segmented elbows can be calculated as follows:

For segments of 90-deg elbows

$$B_s = A \times \tan(\theta/2)$$

where

A = dimension A for appropriate 90-deg elbow being segmented from
- *(a)* Table 6.1-1 for long radius elbow, mm (in.)
- *(b)* Table 6.1-4 for short radius elbow, mm (in.)
- *(c)* Table 6.1-6 for 3D radius elbow, mm (in.)

B_s = center-to-end dimension for segmented elbow

θ = angle of segmented elbow — 30 deg, 60 deg, 75 deg, etc.

When elbows are intended for field segmenting, the outside or inside diameter tolerance shall be furnished throughout the fitting by agreement between the manufacturer and the purchaser. Any mismatch on the outside or inside diameter needs to be corrected in the field by grinding, back-welding, or bridging of weld to meet the applicable piping code requirements. Although the elbow intended for field segmenting must meet the requirements of this Standard, once the field-segmented elbow is cut, it is not a B16.9 product.

7 SURFACE CONTOURS

Where adjacent openings in fittings are not in parallel planes, they shall be joined by a circular arc or radius on the external surfaces. The arc or radius may be terminated in tangents. Except as provided for block forgings (see section 5), the projected profile of external surfaces of fittings shall not have sharp intersections (corners) and/or collapsed arcs.

8 END PREPARATION

Unless otherwise specified, the details of the welding end preparation shall be in accordance with Table 8-1. Transitions from the welding bevel to the outside surface of the fitting and from the root face to the inside surface of the fitting lying within the maximum envelope shown in Figure 8-1 are at the manufacturer's option, except as covered in Note (5) of Figure 8-1 or unless otherwise specifically ordered.

9 DESIGN PROOF TEST

9.1 Required Tests

Proof tests shall be made as set forth in this Standard when the manufacturer chooses proof testing to qualify the fitting design. The pressure design thickness for critical areas of each type of fitting shall be determined and recorded. The design thickness for other sizes or wall thicknesses covered in para. 9.4 shall require a similar

percentage of reinforcement proportional by size or thickness. Critical areas are normally the inner radius of elbows, the crotch of tees and crosses, the knuckle radius of caps, and the large ends of reducers. Proof test shall be based on the computed burst pressure of the fitting and its connecting piping as defined in para. 9.3.

9.2 Test Assembly

9.2.1 Representative Components. Each fitting type shall be tested, except that testing of certain types of fittings can qualify other fittings as described in Table 9.2.1-1. Fittings from the same material group that have the same basic design configuration and method of manufacture shall be selected from production for testing and shall be identified as to material, grade, and lot, including heat treatment.

(a) Examples of different basic configurations include the following:

(1) elbows of different centerline radius (short versus long versus 3D radius)

(2) tees or crosses formed in full encircling dies versus cold or hot extrusion using a pad die

(3) concentric versus eccentric shaped reducers

(4) caps of different configurations

(b) Examples of different methods of manufacture include the following:

(1) mandrel-formed elbows versus elbows welded from two half-shells versus bent pipe

(2) cold-formed tees or crosses versus extruded tees versus machined from solid forgings

(3) conical reducers versus bell-shaped (integral tangents) reducers

(4) caps formed by extruding through a draw ring versus ends cut off cold-formed tees versus machined from solids

(5) hot forming versus cold forming or using differential heating

9.2.2 Other Components. Straight seamless or welded pipe whose calculated bursting strength is at least as great as the proof test pressure as calculated in para. 9.3 shall be welded to each end of the fitting to be tested. Pipe sections may have the nominal wall greater than the thickness indicated by the fitting markings. That greater thickness shall not exceed 1.5 times the fitting markings wall. Any internal misalignment greater than 1.5 mm (0.06 in.) shall be reduced by taper boring at a slope not greater than 1:3. Any other unequal wall welding preparation shall be in accordance with ASME B16.25. Length of pipe sections for closures shall be as follows:

(a) Minimum length of pipe shall be one pipe O.D. for NPS 14 (DN 350) and smaller.

(b) Minimum length of pipe shall be one-half pipe O.D. for NPS greater than 14 (DN 350).

9.3 Test Procedure

To qualify a fitting by proof testing, the fitting shall be tested as described herein and shall withstand the minimum calculated pressure for at least 180 s (3 min).

9.3.1 Number of Tests. At least three specimen tests for each fitting, joint size, or configuration are recommended. The test factor, f, is based on the number of specimen tests performed. The test factor, f, described in Table 9.3.1-1, is used in the computed proof test pressure equation.

NOTE: Tests of geometrically identical fittings of different sizes and wall thicknesses that have overlapping ranges as described in para. 9.4 may be combined to establish the test factor applied to a set of fittings. For example, testing an NPS 2, NPS 8, and NPS 24 of the same basic design configuration and method of manufacture would qualify for a test factor of 1.0 and would qualify fittings of that type from NPS 1 to NPS 48 and thickness ranges in accordance with para. 9.4.2.

9.3.2 Computed Test Pressure. The minimum proof test pressure shall be at least equal to the value computed by the following equation and rounded to the nearest 0.2 MPa (25 psi):

$$P = \frac{2Sft}{D}$$

where

D = specified outside diameter of pipe
f = test factor from Table 9.3.1-1
P = computed minimum proof test pressure for fitting
S = actual tensile strength of the test fitting, determined on a specimen representative of the test fitting, which shall meet the tensile strength requirements of the applicable material of section 5
t = nominal pipe wall thickness of the pipe that the fitting marking identifies

NOTE: Any dimensionally consistent system of units may be used.

9.3.3 Test Media. The test shall be conducted with water. Trapped air in the assembly shall be purged prior to the start of the test.

9.3.4 Application of Test Pressure. A pump with suitable pressure capacity shall be used to uniformly increase the test pressure through yield. Any gauges attached directly to the assembly may be removed and the pressure again uniformly increased at a suitable rate until either failure or the required test pressure has been achieved and held for 180 s. It is acceptable to increase pressure in the test assembly to accommodate reductions in test pressure caused by yielding in the test assembly.

9.3.5 Recording Pressure–Time Readings. Test pressure versus time readings shall be recorded periodically. This may be achieved through electronic means or instrumentation with appropriate resolution and range that has been calibrated prior to the test.

9.3.6 Test Temperature. The temperatures of the test fluid and components of the test assembly may not intentionally be increased or decreased if doing so would significantly affect a mechanical property or response of any component of the test assembly while it is under test.

(24) **9.3.7 Test Results.** The test may be terminated if any component (e.g., fitting, pipe segment, fabrication weld) of the test assembly loses containment. The test of the fitting shall be considered unsuccessful if there is any loss of containment from the tested fitting before or during the time it is to be held at or above the computed pressure. A proof test is successful only when the fitting being tested withstands for at least 180 s a continuous proof test pressure of at least the computed minimum (see para. 9.3.2) without exhibiting loss of containment or evidence of cracking, fissuring, tearing, etc. in the fitting under test.

If the actual final test pressure is equal to the computed test pressure, the design thickness in critical areas shall be at least the actual measured thickness. If the actual final test pressure is higher than the computed test pressure, the design thickness in critical areas may be reduced inverse proportionally, but not more than 15% nor below the nominal wall thickness.

If more than one test is used to establish the test factor f, all of these tests shall be considered for the determination of the pressure design thickness.

9.4 Applicability of Test Results

It is not necessary to conduct an individual test of fittings with all combinations of sizes, wall thicknesses, and materials. A successful proof test on one representative fitting may qualify others to the extent described in paras. 9.4.1 through 9.4.3.

9.4.1 Size Range. One test fitting may be used to qualify similarly proportioned fittings as defined in para. 9.2.1 with a size range from one-half to twice that for the tested fitting.

9.4.2 Thickness Range. One test fitting may be used to qualify similarly proportioned fittings as defined in para. 9.2.1 with t/D ranges from one-half to three times that for the tested fitting.

9.4.3 Material Grades. The pressure-retaining capacity of a fitting of the same basic design configuration and method of manufacture made from material in a material group as listed in Table 5-1 will be directly proportional to the tensile properties of the materials. Therefore, it is necessary to test only a representative fitting to prove the design of a fitting for all materials in a group.

9.5 Maintenance of Results (24)

The manufacturer shall have a quality control (QC) program that verifies the manufacturing process and material used and ensures that the resulting geometry and design thickness of the fittings or joints manufactured reasonably conform to the geometries tested. The QC program shall control the manufacturing drawings and maintain the QC records showing conformance to these drawings.

Tests made in accordance with and at the time of previous editions of this Standard are not intended to be nullified by the changes made in this edition's test procedure and requirements, provided the design conformity and criteria for the type tested can be determined and the test report or an attachment includes the following:

(a) critical areas of design
(b) material grade or material group
(c) method of manufacture
(d) actual thickness of test part critical areas.

The pressure design thickness in critical areas shall be determined according to this edition of this Standard.

Whenever a significant change is made in the geometry or method of manufacture, the manufacturer shall either retest the new production or show by analysis that the change would not affect the results of prior tests. Examples of changes in geometry that require retests are a change in starting thickness or revised tooling configuration.

9.6 Proof Test Report (24)

A report of the testing for each joint configuration shall be prepared and shall include

(a) description of the test, including the material grade, material group, method of manufacture, number of tests, and f factor used to establish the target proof test
(b) instrumentation and methods of calibration used
(c) material test reports for the assembly's materials (fitting, pipe, and end caps, if used)
(d) actual final test pressures achieved for each test
(e) length of time at or above the required test pressure (see para. 9.3.4)
(f) calculations performed
(g) location of rupture, if any, including a sketch or photographs of the assembly
(h) actual measured thickness in critical areas
(i) certification by the manufacturer and by a licensed Authorized Inspector or other third party having experience in pressure component design and testing

The pressure design thickness in critical areas shall be reported either on the reports for the individual tests or on a separate report covering multiple tests.

Nonmandatory Appendix B shows sample forms for a proof test report and determination of the pressure design thickness in critical areas.

10 PRODUCTION TESTS

Hydrostatic testing of wrought fittings is not required by this Standard. All fittings shall be capable of withstanding, without leakage or impairment of serviceability, a hydrostatic test pressure required by the applicable piping code for seamless pipe of material equivalent to the fitting material, and of the size and wall thickness the fitting marking identifies.

(24) ## 11 TOLERANCES

11.1 Wall Thickness

At the bevel a minimum wall thickness of 87.5% of the nominal thickness applies unless the purchaser specifies a different wall thickness tolerance. See Figure 8-1, Note (1)(a).

NOTE: Meeting minimum outside diameter and maximum inside diameter requirements may require a thicker wall at the ends.

Except for necessary transitions in weld ends, the following apply:

(a) In a nonreducing fitting, at no point shall the wall thickness be thinner than 87.5% of the marked nominal thickness. In addition, in critical areas the wall thickness shall not be thinner than 87.5% of the design thickness.

(b) In a reducing fitting, in the proximity of the ends the wall thickness shall not be thinner than 87.5% of the marked nominal thickness at that end. In between, the wall thickness shall not be thinner than 87.5% of the smaller of the marked nominal thicknesses. In addition, in critical areas the wall thickness shall not be thinner than 87.5% of the design thickness.

(c) When an undertolerance other than 12.5% is specified, this other undertolerance shall be applied in the requirements in (a) and (b).

(d) When a minimum thickness is specified, at no point shall the wall thickness be thinner than the specified minimum thickness. In addition, in critical areas the wall thickness shall not be thinner than the design thickness.

(e) The wall thickness distribution shall be not markedly abrupt but shall be smooth.

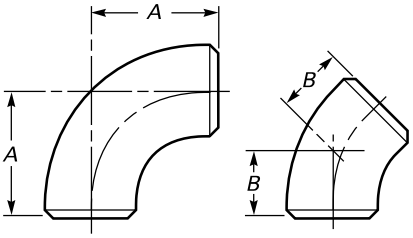
11.2 Fitting Dimensions

Tolerances for fittings are shown in Table 11.2-1 and apply to the nominal dimensions given in Tables 6.1-1 through 6.1-11. Where given in the tables, the minimum and maximum dimensions are based on these tolerances. The listings with decimals do not imply precision measurement, such as use of vernier, micrometer, or electronic readout equipment.

Table 5-1
Material Groupings

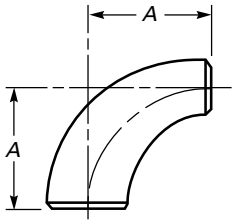
Group No.	Material	Standards
1	Carbon and low-alloy steels	ASTM A234/A234M and ASTM A420/A420M
2	Austenitic and duplex stainless steels	ASTM A403/A403M and ASTM A815/A815M
3	Nickel alloys	ASTM B366/B366M
4	Aluminum alloys	ASTM B361
5	Titanium alloys	ASTM B363

Table 6.1-1
Dimensions of Long Radius Elbows



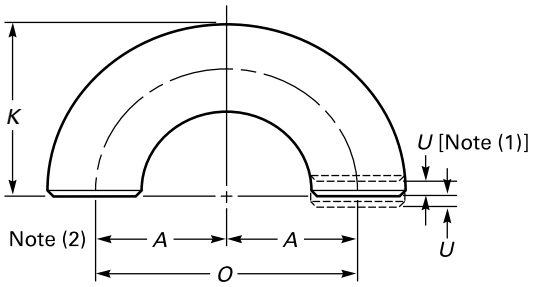
Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-End, mm (in.)	
		90-deg Elbows, *A*	45-deg Elbows, *B*
½	21.3 (0.84)	38 (1.50)	16 (0.62)
¾	26.7 (1.05)	38 (1.50)	19 (0.75)
1	33.4 (1.32)	38 (1.50)	22 (0.88)
1¼	42.2 (1.66)	48 (1.88)	25 (1.00)
1½	48.3 (1.90)	57 (2.25)	29 (1.12)
2	60.3 (2.38)	76 (3.00)	35 (1.38)
2½	73.0 (2.88)	95 (3.75)	44 (1.75)
3	88.9 (3.50)	114 (4.50)	51 (2.00)
3½	101.6 (4.00)	133 (5.25)	57 (2.25)
4	114.3 (4.50)	152 (6.00)	64 (2.50)
5	141.3 (5.56)	190 (7.50)	79 (3.12)
6	168.3 (6.62)	229 (9.00)	95 (3.75)
8	219.1 (8.62)	305 (12.00)	127 (5.00)
10	273.0 (10.75)	381 (15.00)	159 (6.25)
12	323.8 (12.75)	457 (18.00)	190 (7.50)
14	355.6 (14.00)	533 (21.00)	222 (8.75)
16	406.4 (16.00)	610 (24.00)	254 (10.00)
18	457.0 (18.00)	686 (27.00)	286 (11.25)
20	508.0 (20.00)	762 (30.00)	318 (12.50)
22	559.0 (22.00)	838 (33.00)	343 (13.50)
24	610.0 (24.00)	914 (36.00)	381 (15.00)
26	660.0 (26.00)	991 (39.00)	406 (16.00)
28	711.0 (28.00)	1 067 (42.00)	438 (17.25)
30	762.0 (30.00)	1 143 (45.00)	470 (18.50)
32	813.0 (32.00)	1 219 (48.00)	502 (19.75)
34	864.0 (34.00)	1 295 (51.00)	533 (21.00)
36	914.0 (36.00)	1 372 (54.00)	565 (22.25)
38	965.0 (38.00)	1 448 (57.00)	600 (23.62)
40	1 016.0 (40.00)	1 524 (60.00)	632 (24.88)
42	1 067.0 (42.00)	1 600 (63.00)	660 (26.00)
44	1 118.0 (44.00)	1 676 (66.00)	695 (27.38)
46	1 168.0 (46.00)	1 753 (69.00)	727 (28.62)
48	1 219.0 (48.00)	1 829 (72.00)	759 (29.88)

Table 6.1-2
Dimensions of Long Radius Reducing Elbows



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, *A*, mm (in.)	Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, *A*, mm (in.)
	Large End	Small End			Large End	Small End	
2 × 1½	60.3 (2.38)	48.3 (1.90)	76 (3.00)	10 × 8	273.0 (10.75)	219.1 (8.62)	381 (15.00)
2 × 1¼	60.3 (2.38)	42.2 (1.66)	76 (3.00)	10 × 6	273.0 (10.75)	168.3 (6.62)	381 (15.00)
2 × 1	60.3 (2.38)	33.4 (1.32)	76 (3.00)	10 × 5	273.0 (10.75)	141.3 (5.56)	381 (15.00)
2½ × 2	73.0 (2.88)	60.3 (2.38)	95 (3.75)	12 × 10	323.8 (12.75)	273.0 (10.75)	457 (18.00)
2½ × 1½	73.0 (2.88)	48.3 (1.90)	95 (3.75)	12 × 8	323.8 (12.75)	219.1 (8.62)	457 (18.00)
2½ × 1¼	73.0 (2.88)	42.2 (1.66)	95 (3.75)	12 × 6	323.8 (12.75)	168.3 (6.62)	457 (18.00)
3 × 2½	88.9 (3.50)	73.0 (2.88)	114 (4.50)	14 × 12	355.6 (14.00)	323.8 (12.75)	533 (21.00)
3 × 2	88.9 (3.50)	60.3 (2.38)	114 (4.50)	14 × 10	355.6 (14.00)	273.0 (10.75)	533 (21.00)
3 × 1½	88.9 (3.50)	48.3 (1.90)	114 (4.50)	14 × 8	355.6 (14.00)	219.1 (8.62)	533 (21.00)
3½ × 3	101.6 (4.00)	88.9 (3.50)	133 (5.25)	16 × 14	406.4 (16.00)	355.6 (14.00)	610 (24.00)
3½ × 2½	101.6 (4.00)	73.0 (2.88)	133 (5.25)	16 × 12	406.4 (16.00)	323.8 (12.75)	610 (24.00)
3½ × 2	101.6 (4.00)	60.3 (2.38)	133 (5.25)	16 × 10	406.4 (16.00)	273.0 (10.75)	610 (24.00)
4 × 3½	114.3 (4.50)	101.6 (4.00)	152 (6.00)	18 × 16	457.0 (18.00)	406.4 (16.00)	686 (27.00)
4 × 3	114.3 (4.50)	88.9 (3.50)	152 (6.00)	18 × 14	457.0 (18.00)	355.6 (14.00)	686 (27.00)
4 × 2½	114.3 (4.50)	73.0 (2.88)	152 (6.00)	18 × 12	457.0 (18.00)	323.8 (12.75)	686 (27.00)
4 × 2	114.3 (4.50)	60.3 (2.38)	152 (6.00)	18 × 10	457.0 (18.00)	273.0 (10.75)	686 (27.00)
5 × 4	141.3 (5.56)	114.3 (4.50)	190 (7.50)	20 × 18	508.0 (20.00)	457.0 (18.00)	762 (30.00)
5 × 3½	141.3 (5.56)	101.6 (4.00)	190 (7.50)	20 × 16	508.0 (20.00)	406.4 (16.00)	762 (30.00)
5 × 3	141.3 (5.56)	88.9 (3.50)	190 (7.50)	20 × 14	508.0 (20.00)	355.6 (14.00)	762 (30.00)
5 × 2½	141.3 (5.56)	73.0 (2.88)	190 (7.50)	20 × 12	508.0 (20.00)	323.8 (12.75)	762 (30.00)
				20 × 10	508.0 (20.00)	273.0 (10.75)	762 (30.00)
6 × 5	168.3 (6.62)	141.3 (5.56)	229 (9.00)				
6 × 4	168.3 (6.62)	114.3 (4.50)	229 (9.00)	24 × 22	610.0 (24.00)	559.0 (22.00)	914 (36.00)
6 × 3½	168.3 (6.62)	101.6 (4.00)	229 (9.00)	24 × 20	610.0 (24.00)	508.0 (20.00)	914 (36.00)
6 × 3	168.3 (6.62)	88.9 (3.50)	229 (9.00)	24 × 18	610.0 (24.00)	457.0 (18.00)	914 (36.00)
				24 × 16	610.0 (24.00)	406.4 (16.00)	914 (36.00)
8 × 6	219.1 (8.62)	168.3 (6.62)	305 (12.00)	24 × 14	610.0 (24.00)	355.6 (14.00)	914 (36.00)
8 × 5	219.1 (8.62)	141.3 (5.56)	305 (12.00)	24 × 12	610.0 (24.00)	323.8 (12.75)	914 (36.00)
8 × 4	219.1 (8.62)	114.3 (4.50)	305 (12.00)	...	...	...	...

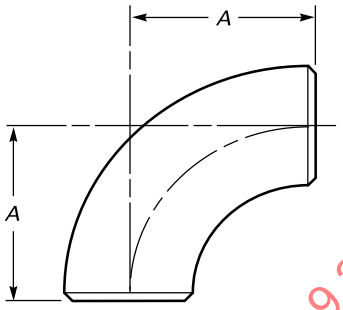
Table 6.1-3
Dimensions of Long Radius Returns



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-Center, *O*, mm (in.)	Back-to-Face, *K*, mm (in.)
½	21.3 (0.84)	76 (3.00)	48 (1.88)
¾	26.7 (1.05)	76 (3.00)	51 (2.00)
1	33.4 (1.32)	76 (3.00)	56 (2.19)
1¼	42.2 (1.66)	95 (3.75)	70 (2.75)
1½	48.3 (1.90)	114 (4.50)	83 (3.25)
2	60.3 (2.38)	152 (6.00)	106 (4.19)
2½	73.0 (2.88)	190 (7.50)	132 (5.19)
3	88.9 (3.50)	229 (9.00)	159 (6.25)
3½	101.6 (4.00)	267 (10.50)	184 (7.25)
4	114.3 (4.50)	305 (12.00)	210 (8.25)
5	141.3 (5.56)	381 (15.00)	262 (10.31)
6	168.3 (6.62)	457 (18.00)	313 (12.31)
8	219.1 (8.62)	610 (24.00)	414 (16.31)
10	273.0 (10.75)	762 (30.00)	518 (20.38)
12	323.8 (12.75)	914 (36.00)	619 (24.38)
14	355.6 (14.00)	1 067 (42.00)	711 (28.00)
16	406.4 (16.00)	1 219 (48.00)	813 (32.00)
18	457.0 (18.00)	1 372 (54.00)	914 (36.00)
20	508.0 (20.00)	1 524 (60.00)	1 016 (40.00)
22	559.0 (22.00)	1 676 (66.00)	1 118 (44.00)
24	610.0 (24.00)	1 829 (72.00)	1 219 (48.00)

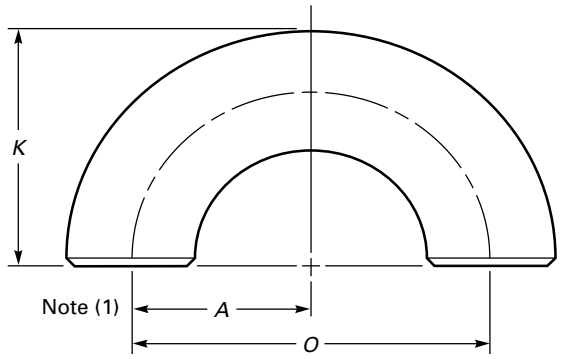
NOTES:
(1) See Table 11.2-1 for tolerance for alignment of ends *U*.
(2) Dimension *A* is equal to one-half of dimension *O*.

Table 6.1-4
Dimensions of Short Radius Elbows



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-End, *A*, mm (in.)
1	33.4 (1.32)	25 (1.00)
1¼	42.2 (1.66)	32 (1.25)
1½	48.3 (1.90)	38 (1.50)
2	60.3 (2.38)	51 (2.00)
2½	73.0 (2.88)	64 (2.50)
3	88.9 (3.50)	76 (3.00)
3½	101.6 (4.00)	89 (3.50)
4	114.3 (4.50)	102 (4.00)
5	141.3 (5.56)	127 (5.00)
6	168.3 (6.62)	152 (6.00)
8	219.1 (8.62)	203 (8.00)
10	273.0 (10.75)	254 (10.00)
12	323.8 (12.75)	305 (12.00)
14	355.6 (14.00)	356 (14.00)
16	406.4 (16.00)	406 (16.00)
18	457.0 (18.00)	457 (18.00)
20	508.0 (20.00)	508 (20.00)
22	559.0 (22.00)	559 (22.00)
24	610.0 (24.00)	610 (24.00)

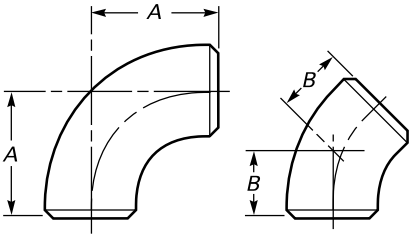
Table 6.1-5
Dimensions of Short Radius 180-deg Returns



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-Center, *O*, mm (in.)	Back-to-Face, *K*, mm (in.)
1	33.4 (1.32)	51 (2.00)	41 (1.62)
1¼	42.2 (1.66)	64 (2.50)	52 (2.06)
1½	48.3 (1.90)	76 (3.00)	62 (2.44)
2	60.3 (2.38)	102 (4.00)	81 (3.19)
2½	73.0 (2.88)	127 (5.00)	100 (3.94)
3	88.9 (3.50)	152 (6.00)	121 (4.75)
3½	101.6 (4.00)	178 (7.00)	140 (5.50)
4	114.3 (4.50)	203 (8.00)	159 (6.25)
5	141.3 (5.56)	254 (10.00)	197 (7.75)
6	168.3 (6.62)	305 (12.00)	237 (9.31)
8	219.1 (8.62)	406 (16.00)	313 (12.31)
10	273.0 (10.75)	508 (20.00)	391 (15.38)
12	323.8 (12.75)	610 (24.00)	467 (18.38)
14	355.6 (14.00)	711 (28.00)	533 (21.00)
16	406.4 (16.00)	813 (32.00)	610 (24.00)
18	457.0 (18.00)	914 (36.00)	686 (27.00)
20	508.0 (20.00)	1 016 (40.00)	762 (30.00)
22	559.0 (22.00)	1 118 (44.00)	838 (33.00)
24	610.0 (24.00)	1 219 (48.00)	914 (36.00)

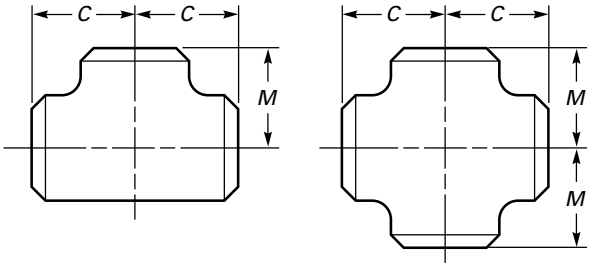
NOTE: (1) Dimension *A* is equal to one-half of dimension *O*.

Table 6.1-6
Dimensions of 3D Radius Elbows



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-End, mm (in.)	
		90-deg Elbows, *A*	45-deg Elbows, *B*
3/4	26.7 (1.05)	57 (2.25)	24 (0.94)
1	33.4 (1.32)	76 (3.00)	31 (1.25)
1 1/4	42.2 (1.66)	95 (3.75)	39 (1.56)
1 1/2	48.3 (1.90)	114 (4.50)	47 (1.88)
2	60.3 (2.38)	152 (6.00)	63 (2.50)
2 1/2	73.0 (2.88)	190 (7.50)	79 (3.12)
3	88.9 (3.50)	229 (9.00)	95 (3.75)
3 1/2	101.6 (4.00)	267 (10.50)	111 (4.38)
4	114.3 (4.50)	305 (12.00)	127 (5.00)
5	141.3 (5.56)	381 (15.00)	157 (6.19)
6	168.3 (6.62)	457 (18.00)	189 (7.44)
8	219.1 (8.62)	610 (24.00)	252 (9.94)
10	273.0 (10.75)	762 (30.00)	316 (12.44)
12	323.8 (12.75)	914 (36.00)	378 (14.88)
14	355.6 (14.00)	1 067 (42.00)	441 (17.38)
16	406.4 (16.00)	1 219 (48.00)	505 (19.88)
18	457.0 (18.00)	1 372 (54.00)	568 (22.38)
20	508.0 (20.00)	1 524 (60.00)	632 (24.88)
22	559.0 (22.00)	1 676 (66.00)	694 (27.31)
24	610.0 (24.00)	1 829 (72.00)	757 (29.81)
26	660.0 (26.00)	1 981 (78.00)	821 (32.31)
28	711.0 (28.00)	2 134 (84.00)	883 (34.75)
30	762.0 (30.00)	2 286 (90.00)	946 (37.25)
32	813.0 (32.00)	2 438 (96.00)	1 010 (39.75)
34	864.0 (34.00)	2 591 (102.00)	1 073 (42.25)
36	914.0 (36.00)	2 743 (108.00)	1 135 (44.69)
38	965.0 (38.00)	2 896 (114.00)	1 200 (47.25)
40	1 016.0 (40.00)	3 048 (120.00)	1 264 (49.75)
42	1 067.0 (42.00)	3 200 (126.00)	1 326 (52.19)
44	1 118.0 (44.00)	3 353 (132.00)	1 389 (54.69)
46	1 168.0 (46.00)	3 505 (138.00)	1 453 (57.19)
48	1 219.0 (48.00)	3 658 (144.00)	1 516 (59.69)

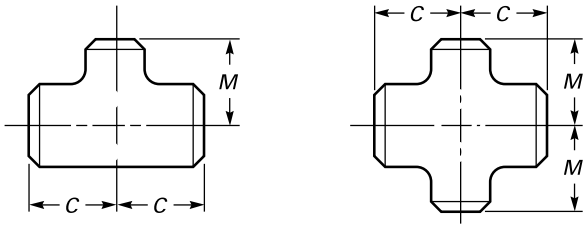
Table 6.1-7
Dimensions of Straight Tees and Crosses



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-End, mm (in.)	
		Run, *C*	Outlet, *M* [Notes (1), (2)]
½	21.3 (0.84)	25 (1.00)	25 (1.00)
¾	26.7 (1.05)	29 (1.12)	29 (1.12)
1	33.4 (1.32)	38 (1.50)	38 (1.50)
1¼	42.2 (1.66)	48 (1.88)	48 (1.88)
1½	48.3 (1.90)	57 (2.25)	57 (2.25)
2	60.3 (2.38)	64 (2.50)	64 (2.50)
2½	73.0 (2.88)	76 (3.00)	76 (3.00)
3	88.9 (3.50)	86 (3.38)	86 (3.38)
3½	101.6 (4.00)	95 (3.75)	95 (3.75)
4	114.3 (4.50)	105 (4.12)	105 (4.12)
5	141.3 (5.56)	124 (4.88)	124 (4.88)
6	168.3 (6.62)	143 (5.62)	143 (5.62)
8	219.1 (8.62)	178 (7.00)	178 (7.00)
10	273.0 (10.75)	216 (8.50)	216 (8.50)
12	323.8 (12.75)	254 (10.00)	254 (10.00)
14	355.6 (14.00)	279 (11.00)	279 (11.00)
16	406.4 (16.00)	305 (12.00)	305 (12.00)
18	457.0 (18.00)	343 (13.50)	343 (13.50)
20	508.0 (20.00)	381 (15.00)	381 (15.00)
22	559.0 (22.00)	419 (16.50)	419 (16.50)
24	610.0 (24.00)	432 (17.00)	432 (17.00)
26	660.0 (26.00)	495 (19.50)	495 (19.50)
28	711.0 (28.00)	521 (20.50)	521 (20.50)
30	762.0 (30.00)	559 (22.00)	559 (22.00)
32	813.0 (32.00)	597 (23.50)	597 (23.50)
34	864.0 (34.00)	635 (25.00)	635 (25.00)
36	914.0 (36.00)	673 (26.50)	673 (26.50)
38	965.0 (38.00)	711 (28.00)	711 (28.00)
40	1 016.0 (40.00)	749 (29.50)	749 (29.50)
42	1 067.0 (42.00)	762 (30.00)	711 (28.00)
44	1 118.0 (44.00)	813 (32.00)	762 (30.00)
46	1 168.0 (46.00)	851 (33.50)	800 (31.50)
48	1 219.0 (48.00)	889 (35.00)	838 (33.00)

NOTES:
(1) Outlet dimension *M* for NPS 26 and larger is recommended but not required.
(2) Dimensions applicable to crosses NPS 24 and smaller.

Table 6.1-8
Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
½ × ½ × ⅜	21.3 (0.84)	17.3 (0.68)	25 (1.00)	25 (1.00)
½ × ½ × ¼	21.3 (0.84)	13.7 (0.54)	25 (1.00)	25 (1.00)
¾ × ¾ × ½	26.7 (1.05)	21.3 (0.84)	29 (1.12)	29 (1.12)
¾ × ¾ × ⅜	26.7 (1.05)	17.3 (0.68)	29 (1.12)	29 (1.12)
1 × 1 × ¾	33.4 (1.32)	26.7 (1.05)	38 (1.50)	38 (1.50)
1 × 1 × ½	33.4 (1.32)	21.3 (0.84)	38 (1.50)	38 (1.50)
1¼ × 1¼ × 1	42.2 (1.66)	33.4 (1.32)	48 (1.88)	48 (1.88)
1¼ × 1¼ × ¾	42.2 (1.66)	26.7 (1.05)	48 (1.88)	48 (1.88)
1¼ × 1¼ × ½	42.2 (1.66)	21.3 (0.84)	48 (1.88)	48 (1.88)
1½ × 1½ × 1¼	48.3 (1.90)	42.2 (1.66)	57 (2.25)	57 (2.25)
1½ × 1½ × 1	48.3 (1.90)	33.4 (1.32)	57 (2.25)	57 (2.25)
1½ × 1½ × ¾	48.3 (1.90)	26.7 (1.05)	57 (2.25)	57 (2.25)
1½ × 1½ × ½	48.3 (1.90)	21.3 (0.84)	57 (2.25)	57 (2.25)
2 × 2 × 1½	60.3 (2.38)	48.3 (1.90)	64 (2.50)	60 (2.38)
2 × 2 × 1¼	60.3 (2.38)	42.2 (1.66)	64 (2.50)	57 (2.25)
2 × 2 × 1	60.3 (2.38)	33.4 (1.32)	64 (2.50)	51 (2.00)
2 × 2 × ¾	60.3 (2.38)	26.7 (1.05)	64 (2.50)	44 (1.75)
2½ × 2½ × 2	73.0 (2.88)	60.3 (2.38)	76 (3.00)	70 (2.75)
2½ × 2½ × 1½	73.0 (2.88)	48.3 (1.90)	76 (3.00)	67 (2.62)
2½ × 2½ × 1¼	73.0 (2.88)	42.2 (1.66)	76 (3.00)	64 (2.50)
2½ × 2½ × 1	73.0 (2.88)	33.4 (1.32)	76 (3.00)	57 (2.25)
3 × 3 × 2½	88.9 (3.50)	73.0 (2.88)	86 (3.38)	83 (3.25)
3 × 3 × 2	88.9 (3.50)	60.3 (2.38)	86 (3.38)	76 (3.00)
3 × 3 × 1½	88.9 (3.50)	48.3 (1.90)	86 (3.38)	73 (2.88)
3 × 3 × 1¼	88.9 (3.50)	42.2 (1.66)	86 (3.38)	70 (2.75)
3½ × 3½ × 3	101.6 (4.00)	88.9 (3.50)	95 (3.75)	92 (3.62)
3½ × 3½ × 2½	101.6 (4.00)	73.0 (2.88)	95 (3.75)	89 (3.50)
3½ × 3½ × 2	101.6 (4.00)	60.3 (2.38)	95 (3.75)	83 (3.25)
3½ × 3½ × 1½	101.6 (4.00)	48.3 (1.90)	95 (3.75)	79 (3.12)
4 × 4 × 3½	114.3 (4.50)	101.6 (4.00)	105 (4.12)	102 (4.00)
4 × 4 × 3	114.3 (4.50)	88.9 (3.50)	105 (4.12)	98 (3.88)
4 × 4 × 2½	114.3 (4.50)	73.0 (2.88)	105 (4.12)	95 (3.75)
4 × 4 × 2	114.3 (4.50)	60.3 (2.38)	105 (4.12)	89 (3.50)

Table 6.1-8
Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses (Cont'd)

Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
4 × 4 × 1½	114.3 (4.50)	48.3 (1.90)	105 (4.12)	86 (3.38)
5 × 5 × 4	141.3 (5.56)	114.3 (4.50)	124 (4.88)	117 (4.62)
5 × 5 × 3½	141.3 (5.56)	101.6 (4.00)	124 (4.88)	114 (4.50)
5 × 5 × 3	141.3 (5.56)	88.9 (3.50)	124 (4.88)	111 (4.38)
5 × 5 × 2½	141.3 (5.56)	73.0 (2.88)	124 (4.88)	108 (4.25)
5 × 5 × 2	141.3 (5.56)	60.3 (2.38)	124 (4.88)	105 (4.12)
6 × 6 × 5	168.3 (6.62)	141.3 (5.56)	143 (5.62)	137 (5.38)
6 × 6 × 4	168.3 (6.62)	114.3 (4.50)	143 (5.62)	130 (5.12)
6 × 6 × 3½	168.3 (6.62)	101.6 (4.00)	143 (5.62)	127 (5.00)
6 × 6 × 3	168.3 (6.62)	88.9 (3.50)	143 (5.62)	124 (4.88)
6 × 6 × 2½	168.3 (6.62)	73.0 (2.88)	143 (5.62)	121 (4.75)
8 × 8 × 6	219.1 (8.62)	168.3 (6.62)	178 (7.00)	168 (6.62)
8 × 8 × 5	219.1 (8.62)	141.3 (5.56)	178 (7.00)	162 (6.38)
8 × 8 × 4	219.1 (8.62)	114.3 (4.50)	178 (7.00)	156 (6.12)
8 × 8 × 3½	219.1 (8.62)	101.6 (4.00)	178 (7.00)	152 (6.00)
10 × 10 × 8	273.0 (10.75)	219.1 (8.62)	216 (8.50)	203 (8.00)
10 × 10 × 6	273.0 (10.75)	168.3 (6.62)	216 (8.50)	194 (7.62)
10 × 10 × 5	273.0 (10.75)	141.3 (5.56)	216 (8.50)	191 (7.50)
10 × 10 × 4	273.0 (10.75)	114.3 (4.50)	216 (8.50)	184 (7.25)
12 × 12 × 10	323.8 (12.75)	273.0 (10.75)	254 (10.00)	241 (9.50)
12 × 12 × 8	323.8 (12.75)	219.1 (8.62)	254 (10.00)	229 (9.00)
12 × 12 × 6	323.8 (12.75)	168.3 (6.62)	254 (10.00)	219 (8.62)
12 × 12 × 5	323.8 (12.75)	141.3 (5.56)	254 (10.00)	216 (8.50)
14 × 14 × 12	355.6 (14.00)	323.8 (12.75)	279 (11.00)	270 (10.62)
14 × 14 × 10	355.6 (14.00)	273.0 (10.75)	279 (11.00)	257 (10.12)
14 × 14 × 8	355.6 (14.00)	219.1 (8.62)	279 (11.00)	248 (9.75)
14 × 14 × 6	355.6 (14.00)	168.3 (6.62)	279 (11.00)	238 (9.38)
16 × 16 × 14	406.4 (16.00)	355.6 (14.00)	305 (12.00)	305 (12.00)
16 × 16 × 12	406.4 (16.00)	323.8 (12.75)	305 (12.00)	295 (11.62)
16 × 16 × 10	406.4 (16.00)	273.0 (10.75)	305 (12.00)	283 (11.12)
16 × 16 × 8	406.4 (16.00)	219.1 (8.62)	305 (12.00)	273 (10.75)
16 × 16 × 6	406.4 (16.00)	168.3 (6.62)	305 (12.00)	264 (10.38)
18 × 18 × 16	457 (18.00)	406.4 (16.00)	343 (13.50)	330 (13.00)
18 × 18 × 14	457 (18.00)	355.6 (14.00)	343 (13.50)	330 (13.00)
18 × 18 × 12	457 (18.00)	323.8 (12.75)	343 (13.50)	321 (12.62)
18 × 18 × 10	457 (18.00)	273.0 (10.75)	343 (13.50)	308 (12.12)
18 × 18 × 8	457 (18.00)	219.1 (8.62)	343 (13.50)	298 (11.75)
20 × 20 × 18	508 (20.00)	457.0 (18.00)	381 (15.00)	368 (14.50)
20 × 20 × 16	508 (20.00)	406.4 (16.00)	381 (15.00)	356 (14.00)

Table 6.1-8
Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses (Cont'd)

Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
20 × 20 × 14	508 (20.00)	355.6 (14.00)	381 (15.00)	356 (14.00)
20 × 20 × 12	508 (20.00)	323.8 (12.75)	381 (15.00)	346 (13.62)
20 × 20 × 10	508 (20.00)	273.0 (10.75)	381 (15.00)	333 (13.12)
20 × 20 × 8	508 (20.00)	219.1 (8.62)	381 (15.00)	324 (12.75)
22 × 22 × 20	559 (22.00)	508.0 (20.00)	419 (16.50)	406 (16.00)
22 × 22 × 18	559 (22.00)	457.0 (18.00)	419 (16.50)	394 (15.50)
22 × 22 × 16	559 (22.00)	406.4 (16.00)	419 (16.50)	381 (15.00)
22 × 22 × 14	559 (22.00)	355.6 (14.00)	419 (16.50)	381 (15.00)
22 × 22 × 12	559 (22.00)	323.8 (12.75)	419 (16.50)	371 (14.62)
22 × 22 × 10	559 (22.00)	273.0 (10.75)	419 (16.50)	359 (14.12)
24 × 24 × 22	610 (24.00)	559.0 (22.00)	432 (17.00)	432 (17.00)
24 × 24 × 20	610 (24.00)	508.0 (20.00)	432 (17.00)	432 (17.00)
24 × 24 × 18	610 (24.00)	457.0 (18.00)	432 (17.00)	419 (16.50)
24 × 24 × 16	610 (24.00)	406.4 (16.00)	432 (17.00)	406 (16.00)
24 × 24 × 14	610 (24.00)	355.6 (14.00)	432 (17.00)	406 (16.00)
24 × 24 × 12	610 (24.00)	323.8 (12.75)	432 (17.00)	397 (15.62)
24 × 24 × 10	610 (24.00)	273.0 (10.75)	432 (17.00)	384 (15.12)
26 × 26 × 24	660 (26.00)	610.0 (24.00)	495 (19.50)	483 (19.00)
26 × 26 × 22	660 (26.00)	559.0 (22.00)	495 (19.50)	470 (18.50)
26 × 26 × 20	660 (26.00)	508.0 (20.00)	495 (19.50)	457 (18.00)
26 × 26 × 18	660 (26.00)	457.0 (18.00)	495 (19.50)	444 (17.50)
26 × 26 × 16	660 (26.00)	406.4 (16.00)	495 (19.50)	432 (17.00)
26 × 26 × 14	660 (26.00)	355.6 (14.00)	495 (19.50)	432 (17.00)
26 × 26 × 12	660 (26.00)	323.8 (12.75)	495 (19.50)	422 (16.62)
28 × 28 × 26	711 (28.00)	660.0 (26.00)	521 (20.50)	521 (20.50)
28 × 28 × 24	711 (28.00)	610.0 (24.00)	521 (20.50)	508 (20.00)
28 × 28 × 22	711 (28.00)	559.0 (22.00)	521 (20.50)	495 (19.50)
28 × 28 × 20	711 (28.00)	508.0 (20.00)	521 (20.50)	483 (19.00)
28 × 28 × 18	711 (28.00)	457.0 (18.00)	521 (20.50)	470 (18.50)
28 × 28 × 16	711 (28.00)	406.4 (16.00)	521 (20.50)	457 (18.00)
28 × 28 × 14	711 (28.00)	355.6 (14.00)	521 (20.50)	457 (18.00)
28 × 28 × 12	711 (28.00)	323.8 (12.75)	521 (20.50)	448 (17.62)
30 × 30 × 28	762 (30.00)	711.0 (28.00)	559 (22.00)	546 (21.50)
30 × 30 × 26	762 (30.00)	660.0 (26.00)	559 (22.00)	546 (21.50)
30 × 30 × 24	762 (30.00)	610.0 (24.00)	559 (22.00)	533 (21.00)
30 × 30 × 22	762 (30.00)	559.0 (22.00)	559 (22.00)	521 (20.50)
30 × 30 × 20	762 (30.00)	508.0 (20.00)	559 (22.00)	508 (20.00)
30 × 30 × 18	762 (30.00)	457.0 (18.00)	559 (22.00)	495 (19.50)
30 × 30 × 16	762 (30.00)	406.4 (16.00)	559 (22.00)	483 (19.00)

Table 6.1-8
Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses (Cont'd)

Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
30 × 30 × 14	762 (30.00)	355.6 (14.00)	559 (22.00)	483 (19.00)
30 × 30 × 12	762 (30.00)	323.8 (12.75)	559 (22.00)	473 (18.62)
30 × 30 × 10	762 (30.00)	273.0 (10.75)	559 (22.00)	460 (18.12)
32 × 32 × 30	813 (32.00)	762.0 (30.00)	597 (23.50)	584 (23.00)
32 × 32 × 28	813 (32.00)	711.0 (28.00)	597 (23.50)	572 (22.5)
32 × 32 × 26	813 (32.00)	660.0 (26.00)	597 (23.50)	572 (22.50)
32 × 32 × 24	813 (32.00)	610.0 (24.00)	597 (23.50)	559 (22.00)
32 × 32 × 22	813 (32.00)	559.0 (22.00)	597 (23.50)	546 (21.50)
32 × 32 × 20	813 (32.00)	508.0 (20.00)	597 (23.50)	533 (21.00)
32 × 32 × 18	813 (32.00)	457.0 (18.00)	597 (23.50)	521 (20.50)
32 × 32 × 16	813 (32.00)	406.4 (16.00)	597 (23.50)	508 (20.00)
32 × 32 × 14	813 (32.00)	355.6 (14.00)	597 (23.50)	508 (20.00)
34 × 34 × 32	864 (34.00)	813.0 (32.00)	635 (25.00)	622 (24.50)
34 × 34 × 30	864 (34.00)	762.0 (30.00)	635 (25.00)	610 (24.00)
34 × 34 × 28	864 (34.00)	711.0 (28.00)	635 (25.00)	597 (23.50)
34 × 34 × 26	864 (34.00)	660.0 (26.00)	635 (25.00)	597 (23.50)
34 × 34 × 24	864 (34.00)	610.0 (24.00)	635 (25.00)	584 (23.00)
34 × 34 × 22	864 (34.00)	559.0 (22.00)	635 (25.00)	572 (22.50)
34 × 34 × 20	864 (34.00)	508.0 (20.00)	635 (25.00)	559 (22.00)
34 × 34 × 18	864 (34.00)	457.0 (18.00)	635 (25.00)	546 (21.50)
34 × 34 × 16	864 (34.00)	406.4 (16.00)	635 (25.00)	533 (21.00)
36 × 36 × 34	914 (36.00)	864.0 (34.00)	673 (26.50)	660 (26.00)
36 × 36 × 32	914 (36.00)	813.0 (32.00)	673 (26.50)	648 (25.50)
36 × 36 × 30	914 (36.00)	762.0 (30.00)	673 (26.50)	635 (25.00)
36 × 36 × 28	914 (36.00)	711.0 (28.00)	673 (26.50)	622 (24.50)
36 × 36 × 26	914 (36.00)	660.0 (26.00)	673 (26.50)	622 (24.50)
36 × 36 × 24	914 (36.00)	610.0 (24.00)	673 (26.50)	610 (24.00)
36 × 36 × 22	914 (36.00)	559.0 (22.00)	673 (26.50)	597 (23.50)
36 × 36 × 20	914 (36.00)	508.0 (20.00)	673 (26.50)	584 (23.00)
36 × 36 × 18	914 (36.00)	457.0 (18.00)	673 (26.50)	572 (22.50)
36 × 36 × 16	914 (36.00)	406.4 (16.00)	673 (26.50)	559 (22.00)
38 × 38 × 36	965 (38.00)	914.0 (36.00)	711 (28.00)	711 (28.00)
38 × 38 × 34	965 (38.00)	864.0 (34.00)	711 (28.00)	698 (27.50)
38 × 38 × 32	965 (38.00)	813.0 (32.00)	711 (28.00)	686 (27.00)
38 × 38 × 30	965 (38.00)	762.0 (30.00)	711 (28.00)	673 (26.50)
38 × 38 × 28	965 (38.00)	711.0 (28.00)	711 (28.00)	648 (25.50)
38 × 38 × 26	965 (38.00)	660.0 (26.00)	711 (28.00)	648 (25.50)
38 × 38 × 24	965 (38.00)	610.0 (24.00)	711 (28.00)	635 (25.00)
38 × 38 × 22	965 (38.00)	559.0 (22.00)	711 (28.00)	622 (24.50)
38 × 38 × 20	965 (38.00)	508.0 (20.00)	711 (28.00)	610 (24.00)

Table 6.1-8
Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses (Cont'd)

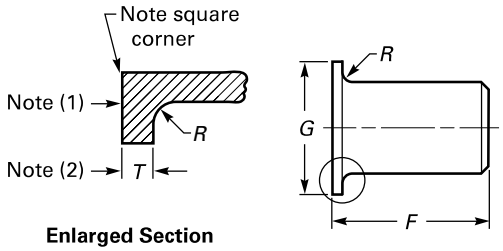
Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
38 × 38 × 18	965 (38.00)	457.0 (18.00)	711 (28.00)	597 (23.50)
40 × 40 × 38	1 016 (40.00)	965.0 (38.00)	749 (29.50)	749 (29.50)
40 × 40 × 36	1 016 (40.00)	914.0 (36.00)	749 (29.50)	737 (29.00)
40 × 40 × 34	1 016 (40.00)	864.0 (34.00)	749 (29.50)	724 (28.50)
40 × 40 × 32	1 016 (40.00)	813.0 (32.00)	749 (29.50)	711 (28.00)
40 × 40 × 30	1 016 (40.00)	762.0 (30.00)	749 (29.50)	698 (27.50)
40 × 40 × 28	1 016 (40.00)	711.0 (28.00)	749 (29.50)	673 (26.50)
40 × 40 × 26	1 016 (40.00)	660.0 (26.00)	749 (29.50)	673 (26.50)
40 × 40 × 24	1 016 (40.00)	610.0 (24.00)	749 (29.50)	660 (26.00)
40 × 40 × 22	1 016 (40.00)	559.0 (22.00)	749 (29.50)	648 (25.50)
40 × 40 × 20	1 016 (40.00)	508.0 (20.00)	749 (29.50)	635 (25.00)
40 × 40 × 18	1 016 (40.00)	457.0 (18.00)	749 (29.50)	622 (24.50)
42 × 42 × 40	1 067 (42.00)	1 016.0 (40.00)	762 (30.00)	711 (28.00)
42 × 42 × 38	1 067 (42.00)	965.0 (38.00)	762 (30.00)	711 (28.00)
42 × 42 × 36	1 067 (42.00)	914.0 (36.00)	762 (30.00)	711 (28.00)
42 × 42 × 34	1 067 (42.00)	864.0 (34.00)	762 (30.00)	711 (28.00)
42 × 42 × 32	1 067 (42.00)	813.0 (32.00)	762 (30.00)	711 (28.00)
42 × 42 × 30	1 067 (42.00)	762.0 (30.00)	762 (30.00)	711 (28.00)
42 × 42 × 28	1 067 (42.00)	711.0 (28.00)	762 (30.00)	698 (27.50)
42 × 42 × 26	1 067 (42.00)	660.0 (26.00)	762 (30.00)	698 (27.50)
42 × 42 × 24	1 067 (42.00)	610.0 (24.00)	762 (30.00)	660 (26.00)
42 × 42 × 22	1 067 (42.00)	559.0 (22.00)	762 (30.00)	660 (26.00)
42 × 42 × 20	1 067 (42.00)	508.0 (20.00)	762 (30.00)	660 (26.00)
42 × 42 × 18	1 067 (42.00)	457.0 (18.00)	762 (30.00)	648 (25.50)
42 × 42 × 16	1 067 (42.00)	406.4 (16.00)	762 (30.00)	635 (25.00)
44 × 44 × 42	1 118 (44.00)	1 067.0 (42.00)	813 (32.00)	762 (30.00)
44 × 44 × 40	1 118 (44.00)	1 016.0 (40.00)	813 (32.00)	749 (29.50)
44 × 44 × 38	1 118 (44.00)	965.0 (38.00)	813 (32.00)	737 (29.00)
44 × 44 × 36	1 118 (44.00)	914.0 (36.00)	813 (32.00)	724 (28.50)
44 × 44 × 34	1 118 (44.00)	864.0 (34.00)	813 (32.00)	724 (28.50)
44 × 44 × 32	1 118 (44.00)	813.0 (32.00)	813 (32.00)	711 (28.00)
44 × 44 × 30	1 118 (44.00)	762.0 (30.00)	813 (32.00)	711 (28.00)
44 × 44 × 28	1 118 (44.00)	711.0 (28.00)	813 (32.00)	698 (27.50)
44 × 44 × 26	1 118 (44.00)	660.0 (26.00)	813 (32.00)	698 (27.50)
44 × 44 × 24	1 118 (44.00)	610.0 (24.00)	813 (32.00)	698 (27.50)
44 × 44 × 22	1 118 (44.00)	559.0 (22.00)	813 (32.00)	686 (27.00)
44 × 44 × 20	1 118 (44.00)	508.0 (20.00)	813 (32.00)	686 (27.00)
46 × 46 × 44	1 168 (46.00)	1 118.0 (44.00)	851 (33.50)	800 (31.50)
46 × 46 × 42	1 168 (46.00)	1 067.0 (42.00)	851 (33.50)	787 (31.00)
46 × 46 × 40	1 168 (46.00)	1 016.0 (40.00)	851 (33.50)	775 (30.50)

Table 6.1-8
Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses (Cont'd)

Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
46 × 46 × 38	1 168 (46.00)	965.0 (38.00)	851 (33.50)	762 (30.00)
46 × 46 × 36	1 168 (46.00)	914.0 (36.00)	851 (33.50)	762 (30.00)
46 × 46 × 34	1 168 (46.00)	864.0 (34.00)	851 (33.50)	749 (29.50)
46 × 46 × 32	1 168 (46.00)	813.0 (32.00)	851 (33.50)	749 (29.50)
46 × 46 × 30	1 168 (46.00)	762.0 (30.00)	851 (33.50)	737 (29.00)
46 × 46 × 28	1 168 (46.00)	711.0 (28.00)	851 (33.50)	737 (29.00)
46 × 46 × 26	1 168 (46.00)	660.0 (26.00)	851 (33.50)	737 (29.00)
46 × 46 × 24	1 168 (46.00)	610.0 (24.00)	851 (33.50)	724 (28.50)
46 × 46 × 22	1 168 (46.00)	559.0 (22.00)	851 (33.50)	724 (28.50)
48 × 48 × 46	1 219 (48.00)	1 168.0 (46.00)	889 (35.00)	838 (33.00)
48 × 48 × 44	1 219 (48.00)	1 118.0 (44.00)	889 (35.00)	838 (33.00)
48 × 48 × 42	1 219 (48.00)	1 067.0 (42.00)	889 (35.00)	813 (32.00)
48 × 48 × 40	1 219 (48.00)	1 016.0 (40.00)	889 (35.00)	813 (32.00)
48 × 48 × 38	1 219 (48.00)	965.0 (38.00)	889 (35.00)	813 (32.00)
48 × 48 × 36	1 219 (48.00)	914.0 (36.00)	889 (35.00)	787 (31.00)
48 × 48 × 34	1 219 (48.00)	864.0 (34.00)	889 (35.00)	787 (31.00)
48 × 48 × 32	1 219 (48.00)	813.0 (32.00)	889 (35.00)	787 (31.00)
48 × 48 × 30	1 219 (48.00)	762.0 (30.00)	889 (35.00)	762 (30.00)
48 × 48 × 28	1 219 (48.00)	711.0 (28.00)	889 (35.00)	762 (30.00)
48 × 48 × 26	1 219 (48.00)	660.0 (26.00)	889 (35.00)	762 (30.00)
48 × 48 × 24	1 219 (48.00)	610.0 (24.00)	889 (35.00)	737 (29.00)
48 × 48 × 22	1 219 (48.00)	559.0 (22.00)	889 (35.00)	737 (29.00)

NOTE: (1) Outlet dimension *M* for run sizes NPS 14 and larger is recommended but not required.

Table 6.1-9
Dimensions of Lap Joint Stub Ends



Enlarged Section of Lap

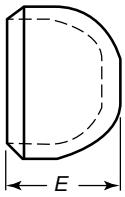
Nominal Pipe Size (NPS)	Outside Diameter of Barrel, mm (in.)		Long Pattern Length, *F*, mm (in.) [Notes (3), (4)]	Short Pattern Length, *F*, mm (in.) [Notes (3), (4)]	Radius of Fillet, *R*, mm (in.) [Note (5)]	Diameter of Lap, *G*, mm (in.) [Note (6)]
	Max.	Min.				
½	22.8 (0.896)	20.5 (0.809)	76 (3.00)	51 (2.00)	3 (0.12)	35 (1.38)
¾	28.1 (1.106)	25.9 (1.019)	76 (3.00)	51 (2.00)	3 (0.12)	43 (1.69)
1	35.0 (1.376)	32.6 (1.284)	102 (4.00)	51 (2.00)	3 (0.12)	51 (2.00)
1¼	43.6 (1.716)	41.4 (1.629)	102 (4.00)	51 (2.00)	5 (0.19)	64 (2.50)
1½	49.9 (1.965)	47.5 (1.869)	102 (4.00)	51 (2.00)	6 (0.25)	73 (2.88)
2	62.4 (2.456)	59.5 (2.344)	152 (6.00)	64 (2.50)	8 (0.31)	92 (3.62)
2½	75.3 (2.966)	72.2 (2.844)	152 (6.00)	64 (2.50)	8 (0.31)	105 (4.12)
3	91.3 (3.596)	88.1 (3.469)	152 (6.00)	64 (2.50)	10 (0.38)	127 (5.00)
3½	104.0 (4.096)	100.8 (3.969)	152 (6.00)	76 (3.00)	10 (0.38)	140 (5.50)
4	116.7 (4.593)	113.5 (4.469)	152 (6.00)	76 (3.00)	11 (0.44)	157 (6.19)
5	144.3 (5.683)	140.5 (5.532)	203 (8.00)	76 (3.00)	11 (0.44)	186 (7.31)
6	171.3 (6.743)	167.5 (6.594)	203 (8.00)	89 (3.50)	13 (0.50)	216 (8.50)
8	222.1 (8.743)	218.3 (8.594)	203 (8.00)	102 (4.00)	13 (0.50)	270 (10.62)
10	277.2 (10.913)	272.3 (10.719)	254 (10.00)	127 (5.00)	13 (0.50)	324 (12.75)
12	328.0 (12.913)	323.1 (12.719)	254 (10.00)	152 (6.00)	13 (0.50)	381 (15.00)
14	359.9 (14.170)	354.8 (13.969)	305 (12.00)	152 (6.00)	13 (0.50)	413 (16.25)
16	411.0 (16.180)	405.6 (15.969)	305 (12.00)	152 (6.00)	13 (0.50)	470 (18.50)
18	462.0 (18.190)	456.0 (17.969)	305 (12.00)	152 (6.00)	13 (0.50)	533 (21.00)
20	514.0 (20.240)	507.0 (19.969)	305 (12.00)	152 (6.00)	13 (0.50)	584 (23.00)
22	565.0 (22.240)	558.0 (21.969)	305 (12.00)	152 (6.00)	13 (0.50)	641 (25.25)
24	616.0 (24.240)	609.0 (23.969)	305 (12.00)	152 (6.00)	13 (0.50)	692 (27.25)

GENERAL NOTES:
(a) See Table 11.2-1 for tolerances.
(b) Service conditions and joint construction often dictate stub end length requirements. Therefore, the purchaser must specify long or short pattern fitting when ordering.

NOTES:
(1) Gasket face finish shall be in accordance with ASME B16.5 for raised-face flanges.
(2) The lap thickness, *T*, shall not be less than nominal pipe wall thickness. See Table 11.2-1 for tolerance.
(3) When short pattern stub ends are used with larger flanges in Classes 300 and 600, with most sizes in Classes 900 and higher, and when long pattern stub ends are used with larger flanges in Classes 1500 and 2500, it may be necessary to increase the length of the stub ends in order to avoid covering the weld with the flange. Such increases in length shall be a matter of agreement between the manufacturer and purchaser.
(4) When special facings such as tongue and groove or male and female are employed, additional lap thickness must be provided and such additional thickness shall be in addition to (not included in) the basic length, *F*.
(5) These dimensions conform to the radius established for lap joint flanges in ASME B16.5.
(6) This dimension conforms to standard machined facings shown in ASME B16.5. The back face of the lap shall be machined to conform to the surface on which it sits. Where ring joint facings are to be applied, use dimension *K* as given in ASME B16.5.

(24)

Table 6.1-10
Dimensions of Caps



Nominal Pipe Size (NPS) [Note (1)]	Outside Diameter at Bevel, mm (in.)	Limiting Wall Thickness for Length, *E*, mm (in.)	Length, *E*, mm (in.) [Note (2)]	Length, *E*, mm (in.) [Note (3)]
½	21.3 (0.84)	4.57 (0.18)	25 (1.00)	25 (1.00)
¾	26.7 (1.05)	3.81 (0.15)	25 (1.00)	25 (1.00)
1	33.4 (1.32)	4.57 (0.18)	38 (1.50)	38 (1.50)
1¼	42.2 (1.66)	4.83 (0.19)	38 (1.50)	38 (1.50)
1½	48.3 (1.90)	5.08 (0.20)	38 (1.50)	38 (1.50)
2	60.3 (2.38)	5.59 (0.22)	38 (1.50)	44 (1.75)
2½	73.0 (2.88)	7.11 (0.28)	38 (1.50)	51 (2.00)
3	88.9 (3.50)	7.62 (0.30)	51 (2.00)	64 (2.50)
3½	101.6 (4.00)	8.13 (0.32)	64 (2.50)	76 (3.00)
4	114.3 (4.50)	8.64 (0.34)	64 (2.50)	76 (3.00)
5	141.3 (5.56)	9.65 (0.38)	76 (3.00)	89 (3.50)
6	168.3 (6.62)	10.92 (0.43)	89 (3.50)	102 (4.00)
8	219.1 (8.62)	12.70 (0.50)	102 (4.00)	127 (5.00)
10	273.0 (10.75)	12.70 (0.50)	127 (5.00)	152 (6.00)
12	323.8 (12.75)	12.70 (0.50)	152 (6.00)	178 (7.00)
14	355.6 (14.00)	12.70 (0.50)	165 (6.50)	191 (7.50)
16	406.4 (16.00)	12.70 (0.50)	178 (7.00)	203 (8.00)
18	457.0 (18.00)	12.70 (0.50)	203 (8.00)	229 (9.00)
20	508.0 (20.00)	12.70 (0.50)	229 (9.00)	254 (10.00)
22	559.0 (22.00)	12.70 (0.50)	254 (10.00)	254 (10.00)
24	610.0 (24.00)	12.70 (0.50)	267 (10.50)	305 (12.00)
26	660.0 (26.00)	12.70 (0.50)	267 (10.50)	[Note (3)]
28	711.0 (28.00)	12.70 (0.50)	267 (10.50)	[Note (3)]
30	762.0 (30.00)	12.70 (0.50)	267 (10.50)	[Note (3)]
32	813.0 (32.00)	12.70 (0.50)	267 (10.50)	[Note (3)]
34	864.0 (34.00)	12.70 (0.50)	267 (10.50)	[Note (3)]
36	914.0 (36.00)	12.70 (0.50)	267 (10.50)	[Note (3)]
38	965.0 (38.00)	12.70 (0.50)	305 (12.00)	[Note (3)]
40	1 016.0 (40.00)	12.70 (0.50)	305 (12.00)	[Note (3)]
42	1 067.0 (42.00)	12.70 (0.50)	305 (12.00)	[Note (3)]
44	1 118.0 (44.00)	12.70 (0.50)	343 (13.50)	[Note (3)]
46	1 168.0 (46.00)	12.70 (0.50)	343 (13.50)	[Note (3)]
48	1 219.0 (48.00)	12.70 (0.50)	343 (13.50)	[Note (3)]

GENERAL NOTE: The shape of these caps shall be ellipsoidal and shall conform to the requirements given in the ASME Boiler and Pressure Vessel Code.

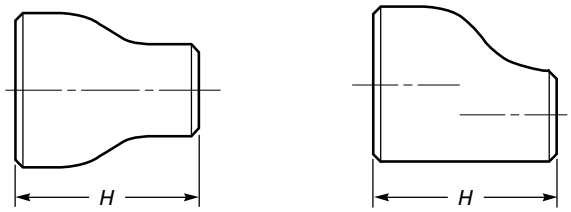
NOTES:

(1) For NPS 26 and larger, with a limiting wall thickness greater than 12.7 mm (0.50 in.), length *E* will be at the manufacturer's option unless otherwise agreed by the manufacturer and purchaser.

Table 6.1-10
Dimensions of Caps (Cont'd)

NOTES: (Cont'd)
(2) This column applies when the nominal wall thickness or schedule as it is marked on the fitting is less than or equal to the limiting wall thickness.
(3) This column applies when the nominal wall thickness or schedule as it is marked on the fitting is greater than the limiting wall thickness.

Table 6.1-11
Dimensions of Reducers



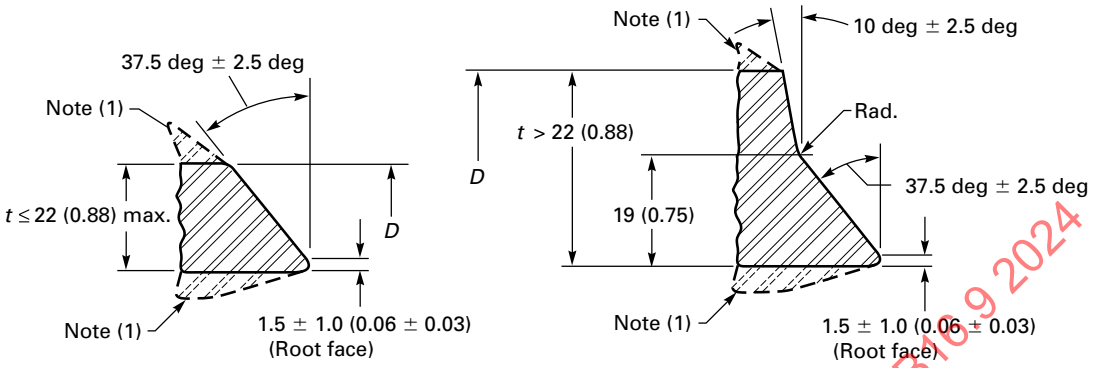
Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		End-to-End, *H*, mm (in.)	Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		End-to-End, *H*, mm (in.)
	Large End	Small End			Large End	Small End	
¾ × ½	26.7 (1.05)	21.3 (0.84)	38 (1.50)	4 × 1½	114.3 (4.50)	48.3 (1.90)	102 (4.00)
¾ × ⅜	26.7 (1.05)	17.3 (0.68)	38 (1.50)				
1 × ¾	33.4 (1.32)	26.7 (1.05)	51 (2.00)	5 × 4	141.3 (5.56)	114.3 (4.50)	127 (5.00)
1 × ½	33.4 (1.32)	21.3 (0.84)	51 (2.00)	5 × 3½	141.3 (5.56)	101.6 (4.00)	127 (5.00)
				5 × 3	141.3 (5.56)	88.9 (3.50)	127 (5.00)
1¼ × 1	42.2 (1.66)	33.4 (1.32)	51 (2.00)	5 × 2½	141.3 (5.56)	73.0 (2.88)	127 (5.00)
1¼ × ¾	42.2 (1.66)	26.7 (1.05)	51 (2.00)	5 × 2	141.3 (5.56)	60.3 (2.38)	127 (5.00)
1¼ × ½	42.2 (1.66)	21.3 (0.84)	51 (2.00)				
				6 × 5	168.3 (6.62)	141.3 (5.56)	140 (5.50)
1½ × 1¼	48.3 (1.90)	42.2 (1.66)	64 (2.50)	6 × 4	168.3 (6.62)	114.3 (4.50)	140 (5.50)
1½ × 1	48.3 (1.90)	33.4 (1.32)	64 (2.50)	6 × 3½	168.3 (6.62)	101.6 (4.00)	140 (5.50)
1½ × ¾	48.3 (1.90)	26.7 (1.05)	64 (2.50)	6 × 3	168.3 (6.62)	88.9 (3.50)	140 (5.50)
1½ × ½	48.3 (1.90)	21.3 (0.84)	64 (2.50)	6 × 2½	168.3 (6.62)	73.0 (2.88)	140 (5.50)
2 × 1½	60.3 (2.38)	48.3 (1.90)	76 (3.00)	8 × 6	219.1 (8.62)	168.3 (6.62)	152 (6.00)
2 × 1¼	60.3 (2.38)	42.2 (1.66)	76 (3.00)	8 × 5	219.1 (8.62)	141.3 (5.56)	152 (6.00)
2 × 1	60.3 (2.38)	33.4 (1.32)	76 (3.00)	8 × 4	219.1 (8.62)	114.3 (4.50)	152 (6.00)
2 × ¾	60.3 (2.38)	26.7 (1.05)	76 (3.00)	8 × 3½	219.1 (8.62)	101.6 (4.00)	152 (6.00)
2½ × 2	73.0 (2.88)	60.3 (2.38)	89 (3.50)	10 × 8	273.0 (10.75)	219.1 (8.62)	178 (7.00)
2½ × 1½	73.0 (2.88)	48.3 (1.90)	89 (3.50)	10 × 6	273.0 (10.75)	168.3 (6.62)	178 (7.00)
2½ × 1¼	73.0 (2.88)	42.2 (1.66)	89 (3.50)	10 × 5	273.0 (10.75)	141.3 (5.56)	178 (7.00)
2½ × 1	73.0 (2.88)	33.4 (1.32)	89 (3.50)	10 × 4	273.0 (10.75)	114.3 (4.50)	178 (7.00)
3 × 2½	88.9 (3.50)	73.0 (2.88)	89 (3.50)	12 × 10	323.8 (12.75)	273.0 (10.75)	203 (8.00)
3 × 2	88.9 (3.50)	60.3 (2.38)	89 (3.50)	12 × 8	323.8 (12.75)	219.1 (8.62)	203 (8.00)
3 × 1½	88.9 (3.50)	48.3 (1.90)	89 (3.50)	12 × 6	323.8 (12.75)	168.3 (6.62)	203 (8.00)
3 × 1¼	88.9 (3.50)	42.2 (1.66)	89 (3.50)	12 × 5	323.8 (12.75)	141.3 (5.56)	203 (8.00)
3½ × 3	101.6 (4.00)	88.9 (3.50)	102 (4.00)	14 × 12	355.6 (14.00)	323.8 (12.75)	330 (13.00)
3½ × 2½	101.6 (4.00)	73.0 (2.88)	102 (4.00)	14 × 10	355.6 (14.00)	273.0 (10.75)	330 (13.00)
3½ × 2	101.6 (4.00)	60.3 (2.38)	102 (4.00)	14 × 8	355.6 (14.00)	219.1 (8.62)	330 (13.00)
3½ × 1½	101.6 (4.00)	48.3 (1.90)	102 (4.00)	14 × 6	355.6 (14.00)	168.3 (6.62)	330 (13.00)
3½ × 1¼	101.6 (4.00)	42.2 (1.66)	102 (4.00)				
				16 × 14	406.4 (16.00)	355.6 (14.00)	356 (14.00)
4 × 3½	114.3 (4.50)	101.6 (4.00)	102 (4.00)	16 × 12	406.4 (16.00)	323.8 (12.75)	356 (14.00)
4 × 3	114.3 (4.50)	88.9 (3.50)	102 (4.00)	16 × 10	406.4 (16.00)	273.0 (10.75)	356 (14.00)
4 × 2½	114.3 (4.50)	73.0 (2.88)	102 (4.00)	16 × 8	406.4 (16.00)	219.1 (8.62)	356 (14.00)
4 × 2	114.3 (4.50)	60.3 (2.38)	102 (4.00)				

Table 6.1-11
Dimensions of Reducers (Cont'd)

Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		End-to-End, *H*, mm (in.)	Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		End-to-End, *H*, mm (in.)
	Large End	Small End			Large End	Small End	
18 × 16	457 (18.00)	406.4 (16.00)	381 (15.00)	34 × 24	864 (34.00)	610.0 (24.00)	610 (24.00)
18 × 14	457 (18.00)	355.6 (14.00)	381 (15.00)				
18 × 12	457 (18.00)	323.8 (12.75)	381 (15.00)	36 × 34	914 (36.00)	864 (34.00)	610 (24.00)
18 × 10	457 (18.00)	273.0 (10.75)	381 (15.00)	36 × 32	914 (36.00)	813 (32.00)	610 (24.00)
				36 × 30	914 (36.00)	762 (30.00)	610 (24.00)
20 × 18	508 (20.00)	457.0 (18.00)	508 (20.00)	36 × 26	914 (36.00)	660 (26.00)	610 (24.00)
20 × 16	508 (20.00)	406.4 (16.00)	508 (20.00)	36 × 24	914 (36.00)	610 (24.00)	610 (24.00)
20 × 14	508 (20.00)	355.6 (14.00)	508 (20.00)				
20 × 12	508 (20.00)	323.8 (12.75)	508 (20.00)	38 × 36	965 (38.00)	914 (36.00)	610 (24.00)
				38 × 34	965 (38.00)	864 (34.00)	610 (24.00)
22 × 20	559 (22.00)	508.0 (20.00)	508 (20.00)	38 × 32	965 (38.00)	813 (32.00)	610 (24.00)
22 × 18	559 (22.00)	457.0 (18.00)	508 (20.00)	38 × 30	965 (38.00)	762 (30.00)	610 (24.00)
22 × 16	559 (22.00)	406.4 (16.00)	508 (20.00)	38 × 28	965 (38.00)	711 (28.00)	610 (24.00)
22 × 14	559 (22.00)	355.4 (14.00)	508 (20.00)	38 × 26	965 (38.00)	660 (26.00)	610 (24.00)
24 × 22	610 (24.00)	559.0 (22.00)	508 (20.00)	40 × 38	1 016 (40.00)	965 (38.00)	610 (24.00)
24 × 20	610 (24.00)	508.0 (20.00)	508 (20.00)	40 × 36	1 016 (40.00)	914 (36.00)	610 (24.00)
24 × 18	610 (24.00)	457.0 (18.00)	508 (20.00)	40 × 34	1 016 (40.00)	864 (34.00)	610 (24.00)
24 × 16	610 (24.00)	406.4 (16.00)	508 (20.00)	40 × 32	1 016 (40.00)	813 (32.00)	610 (24.00)
				40 × 30	1 016 (40.00)	762 (30.00)	610 (24.00)
26 × 24	660 (26.00)	610.0 (24.00)	610 (24.00)				
26 × 22	660 (26.00)	559.0 (22.00)	610 (24.00)	42 × 40	1 067 (42.00)	1 016 (40.00)	610 (24.00)
26 × 20	660 (26.00)	508.0 (20.00)	610 (24.00)	42 × 38	1 067 (42.00)	965 (38.00)	610 (24.00)
26 × 18	660 (26.00)	457.0 (18.00)	610 (24.00)	42 × 36	1 067 (42.00)	914 (36.00)	610 (24.00)
				42 × 34	1 067 (42.00)	864 (34.00)	610 (24.00)
28 × 26	711 (28.00)	660.0 (26.00)	610 (24.00)	42 × 32	1 067 (42.00)	813 (32.00)	610 (24.00)
28 × 24	711 (28.00)	610.0 (24.00)	610 (24.00)	42 × 30	1 067 (42.00)	762 (30.00)	610 (24.00)
28 × 20	711 (28.00)	508.0 (20.00)	610 (24.00)				
28 × 18	711 (28.00)	457.0 (18.00)	610 (24.00)	44 × 42	1 118 (44.00)	1 067 (42.00)	610 (24.00)
				44 × 40	1 118 (44.00)	1 016 (40.00)	610 (24.00)
30 × 28	762 (30.00)	711.0 (28.00)	610 (24.00)	44 × 38	1 118 (44.00)	965 (38.00)	610 (24.00)
30 × 26	762 (30.00)	660.0 (26.00)	610 (24.00)	44 × 36	1 118 (44.00)	914 (36.00)	610 (24.00)
30 × 24	762 (30.00)	610.0 (24.00)	610 (24.00)				
30 × 20	762 (30.00)	508.0 (20.00)	610 (24.00)	46 × 44	1 168 (46.00)	1 118 (44.00)	711 (28.00)
				46 × 42	1 168 (46.00)	1 067 (42.00)	711 (28.00)
32 × 30	813 (32.00)	762.0 (30.00)	610 (24.00)	46 × 40	1 168 (46.00)	1 016 (40.00)	711 (28.00)
32 × 28	813 (32.00)	711.0 (28.00)	610 (24.00)	46 × 38	1 168 (46.00)	965 (38.00)	711 (28.00)
32 × 26	813 (32.00)	660.0 (26.00)	610 (24.00)				
32 × 24	813 (32.00)	610.0 (24.00)	610 (24.00)	48 × 46	1 219 (48.00)	1 168 (46.00)	711 (28.00)
				48 × 44	1 219 (48.00)	1 118 (44.00)	711 (28.00)
34 × 32	864 (34.00)	813.0 (32.00)	610 (24.00)	48 × 42	1 219 (48.00)	1 067 (42.00)	711 (28.00)
34 × 30	864 (34.00)	762.0 (30.00)	610 (24.00)	48 × 40	1 219 (48.00)	1 016 (40.00)	711 (28.00)
34 × 26	864 (34.00)	660.0 (26.00)	610 (24.00)				

GENERAL NOTE: Although the figure illustrates a bell-shaped reducer, the use of a conical reducer is not prohibited.

Table 8-1
Welding Bevels and Root Face



(a) Plain Bevel **(b) Compound Bevel**

Nominal Wall Thickness, *t*, mm (in.)	End Preparation
Less than *x* [Note (2)]	Cut square or slightly chamfer, at manufacturer's option (not illustrated)
x to 22 (0.88), inclusive [Note (2)]	Plain bevel as in illustration (a) above
More than 22 (0.88)	Compound bevel as in illustration (b) above

GENERAL NOTE: In the illustrations, dimensions in parentheses are in inches; other dimensions are in millimeters.

NOTES:
(1) See section 8 and Figure 8-1 for transition contours.
(2) *x* = 5 mm (0.19 in.) for carbon steel or ferritic alloy steel and 3 mm (0.12 in.) for austenitic steel or nonferrous alloys.