LeKe Piping

COMPLETE TECHNICAL REFERENCE

FACTORY-MADE BUTTWELDING FITTINGS

ASME B16.9-2018

NPS 1/2-NPS 48 | DN 15-DN 1200

ELBOWS / RETURNS

TEES / CROSSES

STUB ENDS / CAPS

REDUCERS

Dimensions, tolerances, materials, welding ends, testing and marking requirements.

Original source values are retained without numerical alteration.

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Core requirements and fitting families

Clear entry points for source contents, requirements and the principal fitting tables.

01 Original contents and complete table index PAGE 04

Source contents pages listing sections, Tables 5-1 through 11-1, figures and appendices

02 Scope, pressure ratings, size and marking PAGE 06

Sections 1-4: NPS 1/2-NPS 48 coverage, special fittings, design ratings and identification

03 Materials, dimensions and manufacturing rules PAGE 08

Sections 5-8: approved ASTM material groups, dimensional basis, surface contours and welding ends

04 Design qualification and proof testing PAGE 09

Section 9: test assemblies, pressure calculation, acceptance and qualification ranges

05 Material groups, elbows and returns PAGE 11

Table 5-1 and Tables 6.1-1 through 6.1-6: LR, reducing LR, returns, SR and 3D elbows

06 Straight and reducing tees / crosses PAGE 17

Tables 6.1-7 and 6.1-8: run/outlet dimensions and all NPS combinations

Remaining dimensions and quality references

Product tables, welding details, proof-test coverage, tolerances and supporting appendices.

07 Lap-joint stub ends and pipe caps PAGE 24

Tables 6.1-9 and 6.1-10: barrel/lap dimensions, cap lengths E/E1 and limiting wall thickness

08 Concentric and eccentric reducers PAGE 26

Table 6.1-11 and continuation: large/small bevel diameters and end-to-end length H

09 Welding bevels and end-transition envelope PAGE 28

Table 8-1 and Figure 8-1: end preparation by wall thickness and transition limits

10 Proof-test coverage and qualification PAGE 30

Table 9.2.1-1: fitting configurations qualified by each representative proof test

11 Dimensional and angularity tolerances PAGE 31

Landscape Table 11-1: diameters, center-to-end, overall dimensions, returns and angularity

12 References and quality-system program PAGE 33

Mandatory Appendix I and Nonmandatory Appendix A with cited standards and ISO 9000 principles

CONTENTS

Foreword v
Committee Roster vi
Correspondence With the B16 Committee vii
Summary of Changes ix
List of Changes in Record Number Order x

1 Scope 1
2 Pressure Ratings 1
3 Size 2
4 Marking 2
5 Material 3
6 Fitting Dimensions 3
7 Surface Contours 3
8 End Preparation 3
9 Design Proof Test 3
10 Production Tests 5
11 Tolerances 5

Mandatory Appendix
I References 28

Nonmandatory Appendix
A Quality System Program 29

Figure
8-1 Maximum Envelope for Welding End Transitions 24

Tables
5-1 Material Groupings 6
6.1-1 Dimensions of Long Radius Elbows 7
6.1-2 Dimensions of Long Radius Reducing Elbows 8
6.1-3 Dimensions of Long Radius Returns 9
6.1-4 Dimensions of Short Radius Elbows 9
6.1-5 Dimensions of Short Radius 180-deg Returns 10
6.1-6 Dimensions of 3D Radius Elbows 11
6.1-7 Dimensions of Straight Tees and Crosses 12
6.1-8 Dimensions of Reducing Outlet Tees and Reducing Outlet Crosses 13
6.1-9 Dimensions of Lap Joint Stub Ends 19
6.1-10 Dimensions of Caps 20

6.1-11 Dimensions of Reducers 21
8-1 Welding Bevels and Root Face 23
9.2.1-1 Testing Coverage 25
9.3.1-1 Test Factor, *f*, Determination 25
11-1 Tolerances 26

ASME B16.9-2018

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.

(18) ### 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. Within the text and tables, 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

(18) **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.

(18) **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

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) schedule number[1] or nominal wall thickness in mm

(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.

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, and ASTM A420.

(b) "S8" applies for fittings in accordance with ASTM A815.

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

[1] Schedule number is a dimensionless number that is widely used as a convenient designation for use in ordering pipe and fittings. It is normally associated with a group of standardized pipe wall thicknesses. Refer to ASME B36.10M and ASME B36.19M for complete details on pipe schedule numbers.

(18) **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.

6.2 Special 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 General Note (b) in Table 6.1-9.]

(18) **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 special 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 (18)

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 temperature(s) 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.

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.

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, 9.4.2, and 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

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 criteria for the type tested can be determined.

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

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

(a) description of the test, including the 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) pressure design thickness required 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

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.

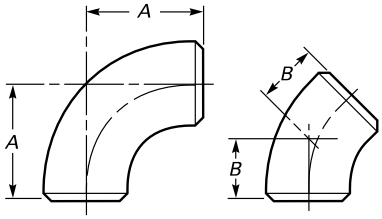
11 TOLERANCES

Tolerances for fittings are shown in Table 11-1 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.

(18) **Table 5-1 Material Groupings**

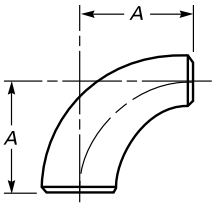
Group No.	Material	Standards
1	Carbon and low-alloy steels	ASTM A234/A234M and ASTM A420/A420M
2	Austenitic and duplex stainless steels	ASTM A403/A403M and ASTM A815/A815M
3	Nickel alloys	ASTM B366/B366M
4	Aluminum alloys	ASTM B361
5	Titanium alloys	ASTM B363

Table 6.1-1 Dimensions of Long Radius Elbows



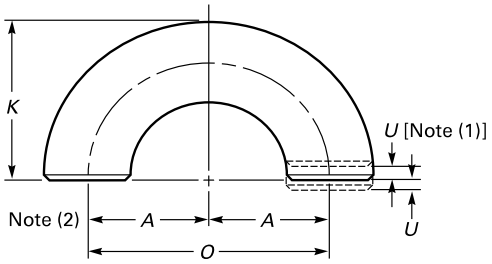
Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-End, mm (in.)	
		90-deg Elbows, *A*	45-deg Elbows, *B*
½	21.3 (0.84)	38 (1.50)	16 (0.62)
¾	26.7 (1.05)	38 (1.50)	19 (0.75)
1	33.4 (1.32)	38 (1.50)	22 (0.88)
1¼	42.2 (1.66)	48 (1.88)	25 (1.00)
1½	48.3 (1.90)	57 (2.25)	29 (1.12)
2	60.3 (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)

(18) **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)	...	...	...	...

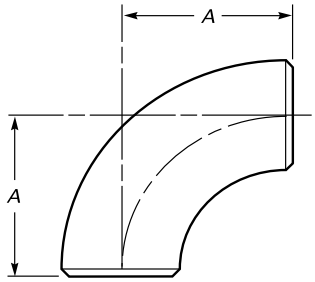
Table 6.1-3 Dimensions of Long Radius Returns



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)

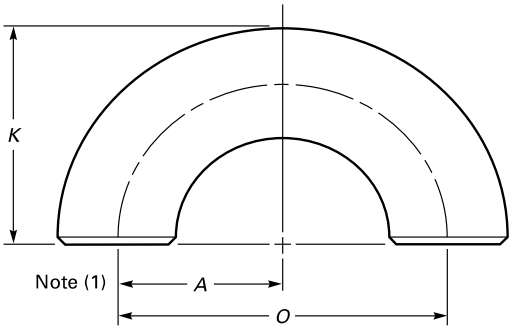
NOTES:
(1) See Table 11-1 for tolerance for alignment of ends *U*.
(2) Dimension *A* is equal to one-half of dimension *O*.

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)

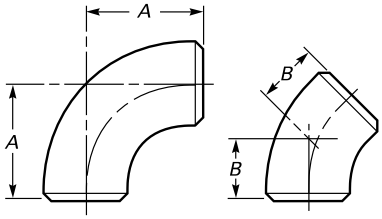
(18) **Table 6.1-5 Dimensions of Short Radius 180-deg Returns**



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)

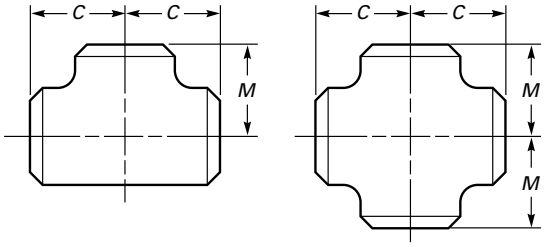
NOTE: (1) Dimension *A* is equal to one-half of dimension *O*.

(18) **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*
¾	26.7 (1.05)	57 (2.25)	24 (0.94)
1	33.4 (1.32)	76 (3.00)	31 (1.25)
1¼	42.2 (1.66)	95 (3.75)	39 (1.56)
1½	48.3 (1.90)	114 (4.50)	47 (1.88)
2	60.3 (2.38)	152 (6.00)	63 (2.50)
2½	73.0 (2.88)	190 (7.50)	79 (3.12)
3	88.9 (3.50)	229 (9.00)	95 (3.75)
3½	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)

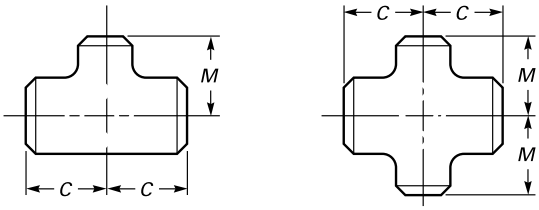
Table 6.1-7 Dimensions of Straight Tees and Crosses



Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Center-to-End, mm (in.)	
		Run, *C*	Outlet, *M* [Notes (1) and (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)
4 × 4 × 1½	114.3 (4.50)	48.3 (1.90)	105 (4.12)	86 (3.38)

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)]
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)
20 × 20 × 14	508 (20.00)	355.6 (14.00)	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 × 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)
30 × 30 × 14	762 (30.00)	355.6 (14.00)	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 × 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)
38 × 38 × 18	965 (38.00)	457.0 (18.00)	711 (28.00)	597 (23.50)

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

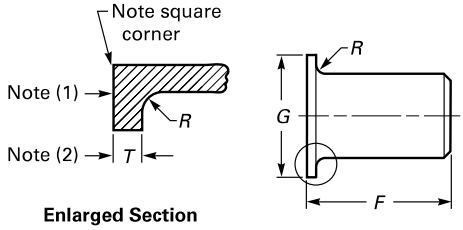
Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)		Center-to-End, mm (in.)	
	Run	Outlet	Run, *C*	Outlet, *M* [Note (1)]
40 × 40 × 38	1 016 (40.00)	965.0 (38.00)	749 (29.50)	749 (29.50)
40 × 40 × 36	1 016 (40.00)	914.0 (36.00)	749 (29.50)	737 (29.00)
40 × 40 × 34	1 016 (40.00)	864.0 (34.00)	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)
46 × 46 × 38	1 168 (46.00)	965.0 (38.00)	851 (33.50)	762 (30.00)

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)]
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



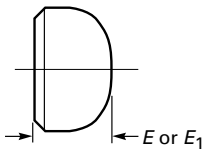
Enlarged Section of Lap

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 11-1 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 11-1 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.

Table 6.1-10 Dimensions of Caps

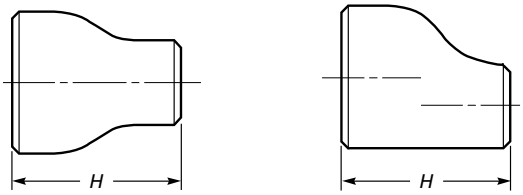


Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.)	Length, E, mm (in.) [Note (1)]	Limiting Wall Thickness for Length, E, mm (in.)	Length, E_1, mm (in.) [Note (2)]
½	21.3 (0.84)	25 (1.00)	4.57 (0.18)	25 (1.00)
¾	26.7 (1.05)	25 (1.00)	3.81 (0.15)	25 (1.00)
1	33.4 (1.32)	38 (1.50)	4.57 (0.18)	38 (1.50)
1¼	42.2 (1.66)	38 (1.50)	4.83 (0.19)	38 (1.50)
1½	48.3 (1.90)	38 (1.50)	5.08 (0.20)	38 (1.50)
2	60.3 (2.38)	38 (1.50)	5.59 (0.22)	44 (1.75)
2½	73.0 (2.88)	38 (1.50)	7.11 (0.28)	51 (2.00)
3	88.9 (3.50)	51 (2.00)	7.62 (0.30)	64 (2.50)
3½	101.6 (4.00)	64 (2.50)	8.13 (0.32)	76 (3.00)
4	114.3 (4.50)	64 (2.50)	8.64 (0.34)	76 (3.00)
5	141.3 (5.56)	76 (3.00)	9.65 (0.38)	89 (3.50)
6	168.3 (6.62)	89 (3.50)	10.92 (0.43)	102 (4.00)
8	219.1 (8.62)	102 (4.00)	12.70 (0.50)	127 (5.00)
10	273.0 (10.75)	127 (5.00)	12.70 (0.50)	152 (6.00)
12	323.8 (12.75)	152 (6.00)	12.70 (0.50)	178 (7.00)
14	355.6 (14.00)	165 (6.50)	12.70 (0.50)	191 (7.50)
16	406.4 (16.00)	178 (7.00)	12.70 (0.50)	203 (8.00)
18	457.0 (18.00)	203 (8.00)	12.70 (0.50)	229 (9.00)
20	508.0 (20.00)	229 (9.00)	12.70 (0.50)	254 (10.00)
22	559.0 (22.00)	254 (10.00)	12.70 (0.50)	254 (10.00)
24	610.0 (24.00)	267 (10.50)	12.70 (0.50)	305 (12.00)
26	660.0 (26.00)	267 (10.50)	...	...
28	711.0 (28.00)	267 (10.50)	...	...
30	762.0 (30.00)	267 (10.50)	...	...
32	813.0 (32.00)	267 (10.50)	...	...
34	864.0 (34.00)	267 (10.50)	...	...
36	914.0 (36.00)	267 (10.50)	...	...
38	965.0 (38.00)	305 (12.00)	...	...
40	1 016.0 (40.00)	305 (12.00)	...	...
42	1 067.0 (42.00)	305 (12.00)	...	...
44	1 118.0 (44.00)	343 (13.50)	...	...
46	1 168.0 (46.00)	343 (13.50)	...	...
48	1 219.0 (48.00)	343 (13.50)	...	...

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) Length E applies for thickness not exceeding that given in column "Limiting Wall Thickness for Length, E."
(2) Length E_1 applies for thickness greater than that given in column "Limiting Wall Thickness for Length, E" for NPS 24 and smaller. For NPS 26 and larger, length E_1 shall be by agreement between the manufacturer and purchaser.

Table 6.1-11 Dimensions of Reducers



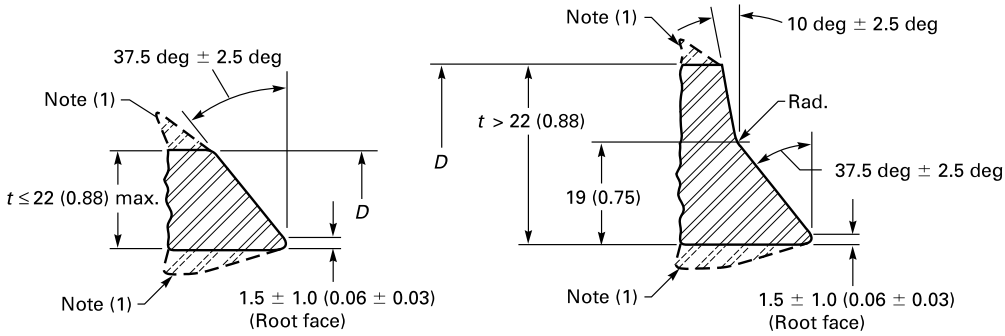
Nominal Pipe Size (NPS)	Outside Diameter at Bevel, mm (in.) Large End	Small End	End-to-End, *H*, mm (in.)
3/4 × 1/2	26.7 (1.05)	21.3 (0.84)	38 (1.50)
3/4 × 3/8	26.7 (1.05)	17.3 (0.68)	38 (1.50)
1 × 3/4	33.4 (1.32)	26.7 (1.05)	51 (2.00)
1 × 1/2	33.4 (1.32)	21.3 (0.84)	51 (2.00)
1 1/4 × 1	42.2 (1.66)	33.4 (1.32)	51 (2.00)
1 1/4 × 3/4	42.2 (1.66)	26.7 (1.05)	51 (2.00)
1 1/4 × 1/2	42.2 (1.66)	21.3 (0.84)	51 (2.00)
1 1/2 × 1 1/4	48.3 (1.90)	42.2 (1.66)	64 (2.50)
1 1/2 × 1	48.3 (1.90)	33.4 (1.32)	64 (2.50)
1 1/2 × 3/4	48.3 (1.90)	26.7 (1.05)	64 (2.50)
1 1/2 × 1/2	48.3 (1.90)	21.3 (0.84)	64 (2.50)
2 × 1 1/2	60.3 (2.38)	48.3 (1.90)	76 (3.00)
2 × 1 1/4	60.3 (2.38)	42.2 (1.66)	76 (3.00)
2 × 1	60.3 (2.38)	33.4 (1.32)	76 (3.00)
2 × 3/4	60.3 (2.38)	26.7 (1.05)	76 (3.00)
2 1/2 × 2	73.0 (2.88)	60.3 (2.38)	89 (3.50)
2 1/2 × 1 1/2	73.0 (2.88)	48.3 (1.90)	89 (3.50)
2 1/2 × 1 1/4	73.0 (2.88)	42.2 (1.66)	89 (3.50)
2 1/2 × 1	73.0 (2.88)	33.4 (1.32)	89 (3.50)
3 × 2 1/2	88.9 (3.50)	73.0 (2.88)	89 (3.50)
3 × 2	88.9 (3.50)	60.3 (2.38)	89 (3.50)
3 × 1 1/2	88.9 (3.50)	48.3 (1.90)	89 (3.50)
3 × 1 1/4	88.9 (3.50)	42.2 (1.66)	89 (3.50)
3 1/2 × 3	101.6 (4.00)	88.9 (3.50)	102 (4.00)
3 1/2 × 2 1/2	101.6 (4.00)	73.0 (2.88)	102 (4.00)
3 1/2 × 2	101.6 (4.00)	60.3 (2.38)	102 (4.00)
3 1/2 × 1 1/2	101.6 (4.00)	48.3 (1.90)	102 (4.00)
3 1/2 × 1 1/4	101.6 (4.00)	42.2 (1.66)	102 (4.00)
4 × 3 1/2	114.3 (4.50)	101.6 (4.00)	102 (4.00)
4 × 3	114.3 (4.50)	88.9 (3.50)	102 (4.00)
4 × 2 1/2	114.3 (4.50)	73.0 (2.88)	102 (4.00)
4 × 2	114.3 (4.50)	60.3 (2.38)	102 (4.00)
4 × 1 1/2	114.3 (4.50)	48.3 (1.90)	102 (4.00)
5 × 4	141.3 (5.56)	114.3 (4.50)	127 (5.00)
5 × 3 1/2	141.3 (5.56)	101.6 (4.00)	127 (5.00)
5 × 3	141.3 (5.56)	88.9 (3.50)	127 (5.00)
5 × 2 1/2	141.3 (5.56)	73.0 (2.88)	127 (5.00)
5 × 2	141.3 (5.56)	60.3 (2.38)	127 (5.00)
6 × 5	168.3 (6.62)	141.3 (5.56)	140 (5.50)
6 × 4	168.3 (6.62)	114.3 (4.50)	140 (5.50)
6 × 3 1/2	168.3 (6.62)	101.6 (4.00)	140 (5.50)
6 × 3	168.3 (6.62)	88.9 (3.50)	140 (5.50)
6 × 2 1/2	168.3 (6.62)	73.0 (2.88)	140 (5.50)
8 × 6	219.1 (8.62)	168.3 (6.62)	152 (6.00)
8 × 5	219.1 (8.62)	141.3 (5.56)	152 (6.00)
8 × 4	219.1 (8.62)	114.3 (4.50)	152 (6.00)
8 × 3 1/2	219.1 (8.62)	101.6 (4.00)	152 (6.00)
10 × 8	273.0 (10.75)	219.1 (8.62)	178 (7.00)
10 × 6	273.0 (10.75)	168.3 (6.62)	178 (7.00)
10 × 5	273.0 (10.75)	141.3 (5.56)	178 (7.00)
10 × 4	273.0 (10.75)	114.3 (4.50)	178 (7.00)
12 × 10	323.8 (12.75)	273.0 (10.75)	203 (8.00)
12 × 8	323.8 (12.75)	219.1 (8.62)	203 (8.00)
12 × 6	323.8 (12.75)	168.3 (6.62)	203 (8.00)
12 × 5	323.8 (12.75)	141.3 (5.56)	203 (8.00)
14 × 12	355.6 (14.00)	323.8 (12.75)	330 (13.00)
14 × 10	355.6 (14.00)	273.0 (10.75)	330 (13.00)
14 × 8	355.6 (14.00)	219.1 (8.62)	330 (13.00)
14 × 6	355.6 (14.00)	168.3 (6.62)	330 (13.00)
16 × 14	406.4 (16.00)	355.6 (14.00)	356 (14.00)
16 × 12	406.4 (16.00)	323.8 (12.75)	356 (14.00)
16 × 10	406.4 (16.00)	273.0 (10.75)	356 (14.00)
16 × 8	406.4 (16.00)	219.1 (8.62)	356 (14.00)
18 × 16	457 (18.00)	406.4 (16.00)	381 (15.00)
18 × 14	457 (18.00)	355.6 (14.00)	381 (15.00)

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

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

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

(18) **Table 8-1 Welding Bevels and Root Face**



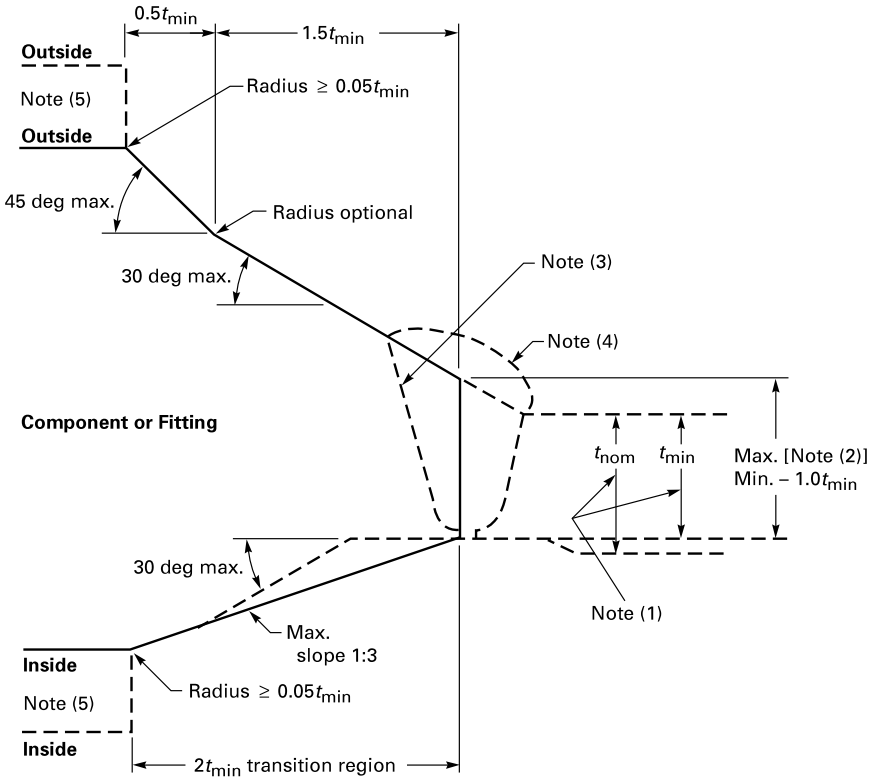
(a) Plain Bevel **(b) Compound Bevel**

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.

(18) **Figure 8-1 Maximum Envelope for Welding End Transitions**



NOTES:

(1) The value of t_{min} is whichever of the following is applicable:

(a) the minimum ordered wall thickness of the pipe, to include pipe that is purchased to a nominal wall thickness with an undertolerance other than 12.5%

(b) 0.875 times the nominal wall thickness of pipe ordered to a pipe schedule wall thickness that has an undertolerance of 12.5%

(2) The maximum thickness at the end of the component is as follows:

(a) the greater of [t_{min} + 4 mm (0.16 in.)] or 1.15t_{min} when ordered on a minimum wall basis

(b) the greater of [t_{min} + 4 mm (0.16 in.)] or 1.10t_{nom} when ordered on a nominal wall basis

(3) Weld bevel shown is for illustration only.

(4) The weld reinforcement permitted by applicable code may lie outside the maximum envelope.

(5) Where transitions using maximum slope do not intersect the inside or outside surfaces within the transition region, as shown by the phantom outline, maximum slopes shall be used. Alternatively, radii lying within the envelope may be used.

Table 9.2.1-1 Testing Coverage

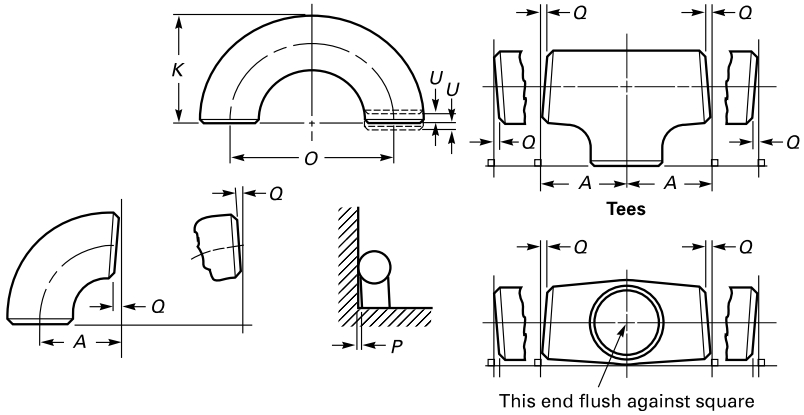
Type of Fitting Tested [Note (1)]	Qualifies the Following If the Same Design Thickness Is Used
Short radius elbow [Note (2)]	Short radius, long radius, reducing long radius, or 3D radius elbow
Long radius elbow [Note (2)]	Long radius, reducing long radius, or 3D radius elbow
3D radius elbow [Note (2)]	3D radius elbow
Straight tee	Straight or reducing tees of any reduction
Reducing tee	Reducing tees with the same or more reduction in outlet size
Straight cross	Straight or reducing crosses of any reduction
Reducing cross	Reducing crosses with the same or more reduction in outlet size
Cap	Caps of the same configuration
Eccentric reducer [Note (3)]	Eccentric or concentric reducers with the same or lesser included transition angle
Concentric reducer [Note (3)]	Concentric reducers with the same or lesser included transition angle [Note (4)]
Lap joint stub ends	Lap joint stub ends are exempt from proof

NOTES:
(1) Paragraph 9.4 applies to as-tested and qualified fittings.
(2) A test of any angle elbow covered in Tables 6.1-1 through 6.1-6 will qualify any other angle. A factory-made segment elbow that has a proof test on a geometrically similar 45-deg or 90-deg elbow need not be tested separately.
(3) Straight conical (no tangent) and bell-shaped reducers are considered different design configurations and require separate testing.
(4) "Transition angle" is defined as the angle of the conical section and is calculated as the [arc tan (difference of diameters/twice the length)] for concentric reducers or [arc tan (difference of diameters/length)] for eccentric reducers.

Table 9.3.1-1 Test Factor, *f*, Determination

Number of Tests Performed, or Number of Geometrically Similar Fittings Tested	Test Factor, *f*
One	1.10
Two	1.05
Three or more	1.0

Table 11-1 Tolerances



All Fittings [Notes (1) and (2)]				Center-to-End Dimensions, mm (in.)		Overall Length of Reducers and Lap Joint Stub Ends, *F*, *H*, mm (in.)	Overall Length of Caps, *E*, mm (in.)	180-deg Returns		
Nominal Pipe Size (NPS)	DN	Outside Diameter at Bevel, *D*, mm (in.) [Notes (3) and (4)]	Inside Diameter at End, mm (in.) [Notes (3) and (5)]	90-deg and 45-deg Long and Short Radius Elbows and Tees, *A*, *B*, *C*, *M*	3D Radius Elbows, *A*, *B*			Center-to-Center Dimension, *O*, mm (in.)	Back-to-Face Dimension, *K*, mm (in.)	Alignment of Ends, *U*, mm (in.)
½ to 2½	15 to 65	+1.6, −0.8 (+0.06, −0.03)	0.8 (0.03)	2 (0.06)	3 (0.09)	2 (0.06)	3 (0.12)	6 (0.25)	6 (0.25)	1 (0.03)
3 to 3½	80 to 90	1.6 (0.06)	1.6 (0.06)	2 (0.06)	3 (0.09)	2 (0.06)	3 (0.12)	6 (0.25)	6 (0.25)	1 (0.03)
4	100	1.6 (0.06)	1.6 (0.06)	2 (0.06)	3 (0.09)	2 (0.06)	3 (0.12)	6 (0.25)	6 (0.25)	1 (0.03)
5 to 8	125 to 200	+2.4, −1.6 (+0.09, −0.06)	1.6 (0.06)	2 (0.06)	3 (0.09)	2 (0.06)	6 (0.25)	6 (0.25)	6 (0.25)	1 (0.03)
10 to 18	250 to 450	+4.0, −3.2 (+0.16, −0.12)	3.2 (0.12)	2 (0.09)	3 (0.12)	2 (0.09)	6 (0.25)	10 (0.38)	6 (0.25)	2 (0.06)
20 to 24	500 to 600	+6.4, −4.8 (+0.25, −0.19)	4.8 (0.19)	2 (0.09)	3 (0.12)	2 (0.09)	6 (0.25)	10 (0.38)	6 (0.25)	2 (0.06)
26 to 30	650 to 750	+6.4, −4.8 (+0.25, −0.19)	4.8 (0.19)	3 (0.12)	6 (0.25)	5 (0.19)	10 (0.38)	...	...	...
32 to 48	800 to 1 200	+6.4, −4.8 (+0.25, −0.19)	4.8 (0.19)	5 (0.19)	6 (0.38)	5 (0.19)	10 (0.38)	...	...	...

Lap Joint Stub Ends [Note (6)]							Angularity Tolerances, mm (in.)	
Nominal Pipe Size (NPS)	DN	Outside Diameter of Lap, *G*, mm (in.)	Fillet Radius of Lap, *R*, mm (in.)	Lap Thickness, mm (in.)	Nominal Pipe Size (NPS)	DN	Off Angle, *Q*	Off Plane, *P*
½ to 2½	15 to 65	+0, −1 (+0, −0.03)	+0, −1 (+0, −0.03)	+1.6, −0 (+0.06, −0)	½ to 4	15 to 100	1 (0.03)	2 (0.06)
3 to 3½	80 to 90	+0, −1 (+0, −0.03)	+0, −1 (+0, −0.03)	+1.6, −0 (+0.06, −0)	5 to 8	125 to 200	2 (0.06)	4 (0.12)
4	100	+0, −1 (+0, −0.03)	+0, −2 (+0, −0.06)	+1.6, −0 (+0.06, −0)	10 to 12	250 to 300	3 (0.09)	5 (0.19)
5 to 8	125 to 200	+0, −1 (+0, −0.03)	+0, −2 (+0, −0.06)	+1.6, −0 (+0.06, −0)	14 to 16	350 to 400	3 (0.09)	6 (0.25)

Table 11-1 Tolerances (Cont'd)

		Lap Joint Stub Ends [Note (6)]					Angularity Tolerances, mm (in.)	
Nominal Pipe Size (NPS)	DN	Outside Diameter of Lap, *G*, mm (in.)	Fillet Radius of Lap, *R*, mm (in.)	Lap Thickness, mm (in.)	Nominal Pipe Size (NPS)	DN	Off Angle, *Q*	Off Plane, *P*
10 to 18	250 to 450	+0, −2 (+0, −0.06)	+0, −2 (+0, −0.06)	+3.2, −0 (+0.12, −0)	18 to 24	450 to 600	4 (0.12)	10 (0.38)
20 to 24	500 to 600	+0, −2 (+0, −0.06)	+0, −2 (+0, −0.06)	+3.2, −0 (+0.12, −0)	26 to 30	650 to 750	5 (0.19)	10 (0.38)
26 to 30	650 to 750	...	...	...	32 to 42	800 to 1 050	5 (0.19)	13 (0.50)
32 to 48	800 to 1 200	...	...	...	44 to 48	1 100 to 1 200	5 (0.19)	19 (0.75)

GENERAL NOTE: Tolerances are equal plus and minus except as noted.

NOTES:

) The inside diameter and the nominal wall thicknesses at ends are to be specified by the purchaser.

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

) Out-of-round is the sum of absolute values of plus and minus tolerances.

) This tolerance may not apply in localized areas of formed fittings where increased wall thickness is required to meet design requirements of para. 2.2.

) Unless otherwise specified by the purchaser, these tolerances apply to the nominal inside diameter, which equals the difference between the nominal outside diameter and twice the nominal wall thickness.

) See Table 6.1-9 for limiting dimensions of outside diameter of barrel.

MANDATORY APPENDIX I
REFERENCES

(18)

The following is a list of standards and specifications referenced in this Standard. Unless otherwise specified, the latest edition of ASME publications shall apply.

ASME B16.5, Pipe Flanges and Flanged Fittings: NPS ½ Through NPS 24 Metric/Inch Standard
ASME B16.25, Buttwelding Ends
ASME B31, Code for Pressure Piping
ASME B31.3, Process Piping
ASME B36.10M, Welded and Seamless Wrought Steel Pipe
ASME B36.19M, Stainless Steel Pipe
ASME Boiler and Pressure Vessel Code
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

ASTM A234/A234M-17, Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A403/A403M-16, Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM A420/A420M-16, Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service
ASTM A815/A815M-14e1, Specification for Wrought Ferritic, Ferritic/Austenitic and Martensitic Stainless Steel Piping Fittings
ASTM A960/A960M-16a, Specification for Common Requirements for Wrought Steel Piping Fittings
ASTM B361-16, Specification for Factory-Made Wrought Aluminum and Aluminum-Alloy Welding Fittings
ASTM B363-14, Specification for Seamless and Welded Unalloyed Titanium and Titanium Alloy Welding Fittings
ASTM B366/B366M-17, Specification for Factory-Made Wrought Nickel and Nickel Alloy Fittings
ASTM E29-13, Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications
Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org)

ISO 6708:1995, Pipework components — Definition and selection of DN (nominal size)
ISO 9000:2015, Quality management systems — Fundamentals and vocabulary[1]
ISO 9001:2015, Quality management systems — Requirements[1]
ISO 9004:2009, Managing for the sustained success of an organization — A quality management approach[1]
Publisher: International Organization for Standardization (ISO), Central Secretariat, Chemin de Blandonnet 8, Case Postale 401, 1214 Vernier, Geneva, Switzerland (www.iso.org)

[1] May also be obtained from the American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036.

NONMANDATORY APPENDIX A
QUALITY SYSTEM PROGRAM

The products manufactured in accordance with this Standard shall be produced under a Quality System Program following the principles of an appropriate standard from the ISO 9000 series.[1] A determination of the need for registration and/or certification of the product manufacturer's quality system by an independent organization shall be the responsibility of the manufacturer. The detailed documentation demonstrating program compliance shall be available to the purchaser at the manufacturer's facility. A written summary description of the program used by the product manufacturer shall be available to the purchaser upon request. The "product manufacturer" is defined as the entity whose name or trademark appears on the product in accordance with the marking or identification requirements of this Standard.

[1] The series is also available from the American National Standards Institute (ANSI) and the American Society for Quality (ASQ) as American National Standards that are identified by the prefix "Q," replacing the prefix "ISO." Each standard of the series is listed under References in Mandatory Appendix I.

Send your requirement

We can review the product list, drawings and documentation requirements.

- Fitting type and configuration
- NPS / DN and schedule or wall thickness
- Material grade and quantity
- Required dimensions, end preparation and tolerances
- Inspection and project-document requirements

SEND RFQ BY EMAIL

CONTACT ON WHATSAPP

DIRECT CONTACT

Email
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