

ASME B16.22-2021
(Revision of ASME B16.22-2018)

Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

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AN AMERICAN NATIONAL STANDARD



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Mechanical Engineers**

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FOREWORD

Standardization of cast and wrought solder-joint fittings was initiated in Subcommittee 11 of American Standards Association (ASA) Sectional Committee A40 on Plumbing Requirements and Equipment. Development work culminated in the publication of ASA A40.3-1941. The standard benefited from work done by A. R. Maupin of the National Bureau of Standards, both before and during its development, on the strength of solder joints.

In 1949, work on these fittings was transferred to Sectional Committee B16, which established Subcommittee 9 (now Subcommittee J) with a scope broader than plumbing applications. The first standard developed was approved as ASA B16.18-1950, Cast-Brass Solder Joint Fittings. It was then decided to revise ASA A40.3 as a B16 standard covering only wrought solder-joint fittings. This effort was facilitated by a 1950 draft prepared by joint effort of the Copper and Brass Research Association and the Manufacturers Standardization Society of the Valve and Fittings Industry (MSS). The draft, after review and approval by Subcommittee 9 and the Sectional Committee, was approved as ASA B16.22-1951.

Revisions were published as ASA B16.22-1963 and, after reorganization of ASA as the American National Standards Institute (ANSI), as ANSI B16.22-1973. In these editions, updated practices, new materials, and new types of fittings were incorporated into the standard, as well as editorial improvements and updating of referenced specifications and standards.

In 1979, Subcommittee I (formerly Subcommittee 9, now Subcommittee J) added metric dimensional equivalents and made other minor improvements. This revision was approved by ANSI, after approval by the Committee and secretariat organizations, as ANSI B16.22-1980.

In 1982, American National Standards Committee B16 was reorganized as an ASME Committee operating under procedures accredited by ANSI.

In 1989, Subcommittee J removed metric equivalents and updated referenced standards.

In 1995, Subcommittee J defined bursting strength, defined standard gaging method for threaded ends, revised solder-joint lengths for $\frac{1}{8}$ -in. size external and internal ends, and revised minimum wall-thickness values based on a comprehensive bursting-test study. Following approval by the Standards Committee and ASME, approval as an American National Standard was given by ANSI on July 24, 1995, with the designation ASME B16.22-1995.

In 1998, editorial revisions, which included the addition of a new section on quality systems and a change in the designation of ASTM B32 alloys, were issued as an addendum. This addendum to the 1995 edition of ASME B16.22, after approval by the ASME B16 Committee and ASME, was approved as ASME B16.22a-1998.

In the 2001 edition, Subcommittee J converted the physical requirements to SI (metric) units of measure, added requirements for tube stops, clarified ovalate and alignment requirements, and made numerous editorial revisions. Alloy E and Alloy HB were incorporated into the table listing pressure-temperature ratings for the soldering and brazing materials, plus values for the 95-5 tin-antimony solder were revised. These revisions to pressure-temperature ratings reflected the data from a National Institute of Standards and Technology (NIST) solder-joint testing study, initiated in 1993 to develop stress rupture and strength data on copper tube sleeve joints using various solders. Following approval by the ASME B16 Standards Committee, approval as an American National Standard was given by ANSI on October 11, 2001, with the designation ASME B16.22-2001.

In the 2012 edition, the phrase “pressure-temperature ratings” replaced “working pressure” throughout the text. Following approval by the ASME B16 Standards Committee, approval as an American National Standard was given by ANSI on October 22, 2012, with the designation ASME B16.22-2012.

In the 2013 edition, provisions were included to recognize low lead alloys to comply with the U.S. Safe Drinking Water Act, which took effect in January 2014. Following approval by the ASME B16 Standards Committee, approval as an American National Standard was given by ANSI on July 29, 2013, with the designation ASME B16.22-2013.

In the 2018 edition, the U.S. Customary tables formerly in Mandatory Appendix II were merged with the SI tables in the main text. The tables and figures were redesignated, Mandatory Appendix II was deleted, and the cross-references were updated accordingly. In addition, para. 10.3 was revised to change the requirements for threaded ends to allow a bead with or without ribs to retain consistency with the requirements of ASME B16.18, and all reference standards in what was formerly Mandatory Appendix III were updated. Following approval by the ASME B16 Standards Committee, approval as an American National Standard was given by ANSI on August 3, 2018, with the designation ASME B16.22-2018.

In this 2021 edition, [section 1](#) and [Mandatory Appendix II](#) have been revised. Following approval by the ASME B16 Standards Committee, ASME B16.22-2021 was approved by ANSI on November 12, 2021.

ASME B16 COMMITTEE

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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SUBCOMMITTEE J — COPPER AND COPPER ALLOY FLANGES, FLANGED FITTINGS, AND SOLDER-JOINT FITTINGS

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General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B16 Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
<http://go.asme.org/Inquiry>

Proposing Revisions. Revisions are made periodically to the Standard 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 periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Standard and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Standard to which the proposed Case applies.

Interpretations. Upon request, the B16 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B16 Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at <http://go.asme.org/InterpretationRequest>. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may e-mail the request to the Secretary of the B16 Standards Committee at SecretaryB16@asme.org, or mail it to the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Standard requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not “approve,” “certify,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

Attending Committee Meetings. The B16 Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the B16 Standards Committee.

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ASME B16.22-2021

SUMMARY OF CHANGES

Following approval by the ASME B16 Standards Committee and ASME, and after public review, ASME B16.22-2021 was approved by the American National Standards Institute on November 12, 2021.

ASME B16.22-2021 includes the following changes identified by a margin note, **(21)**. The Record Numbers listed below are explained in more detail in the “List of Changes in Record Number Order” following this Summary of Changes.

<i>Page</i>	<i>Location</i>	<i>Change (Record Number)</i>
1	1	Former first paragraph revised in its entirety (19-1236)
12	Mandatory Appendix II	Updated (20-2564)

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LIST OF CHANGES IN RECORD NUMBER ORDER

Record Number	Change
19-1236	Revised scope in section 1.
20-2564	Updated references in Mandatory Appendix II.

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WROUGHT COPPER AND COPPER ALLOY SOLDER-JOINT PRESSURE FITTINGS

(21) 1 SCOPE

This Standard establishes specifications for wrought copper and copper alloy seamless pressure fittings designed for use by soldering or brazing with seamless copper tube conforming to ASTM B88 (water and general plumbing systems), ASTM B280 (air conditioning and refrigeration service), and ASTM B819 (medical gas systems). Fittings made in accordance with this Standard are intended to be assembled with soldering materials conforming to ASTM B32, brazing materials conforming to AWS A5.8M/A5.8, or tapered pipe thread conforming to ASME B1.20.1.

This Standard is allied with ASME B16.18, which covers cast copper alloy pressure fittings, and ASME B16.50, which covers wrought pressure fittings for brazing only.

This Standard provides requirements for fitting ends of suitable depths to achieve required pressure ratings when joined by either soldering or brazing. This Standard covers the following:

- (a) pressure-temperature ratings
- (b) abbreviations for end connections
- (c) size and method of designating openings of fittings
- (d) marking
- (e) material
- (f) dimensions and tolerances
- (g) tests

2 GENERAL

2.1 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.

2.2 References

Standards and specifications adopted by reference in this Standard are shown in [Mandatory Appendix II](#). It is not considered practical to identify in the text the specific edition of each referenced standard and specification.

Instead, the specific editions are identified in [Mandatory Appendix II](#).

2.3 Quality Systems

Requirements relating to the product manufacturer's quality system program are described in [Nonmandatory Appendix B](#).

3 PRESSURE-TEMPERATURE RATINGS

3.1 Rating of Fittings and Joints

The internal pressure-temperature rating for a solder-joint system is dependent on not only fitting and tube strength, but also composition of the solder used for the joint and selection of valves and appurtenances.

3.1.1 Solder Joints. Pressure-temperature ratings for solder joints to the dimensions of [Table 3.1.1-1](#), made with typical commercial solders, are given in [Table I-1](#).

The internal pressure-temperature rating of the system with solder joints shall be the lowest of the values shown in [Table 3.1.1-2](#) and [Table I-1](#) and those of the tube, valves, and appurtenances.

3.1.2 Braze Joints. Pressure-temperature ratings for braze joints to the dimensions of [Table 3.1.1-1](#), made with typical commercial brazing materials, shall be considered equal to the values given in [Table 3.1.1-2](#).

The internal pressure-temperature rating of the system with braze joints shall be the lowest of the values shown in [Table 3.1.1-2](#) and those of the tube, valves, and appurtenances.

3.2 Bursting Strength

Fittings manufactured to the Standard shall have an ambient-temperature bursting strength of at least 4 times the 38°C (100°F) internal pressure rating as shown in [Table 3.1.1-2](#).

4 TERMINOLOGY

4.1 Size

The size of the fittings shown in [Table 3.1.1-1](#) corresponds to standard water tube size as shown in ASTM B88. The size of the threaded ends corresponds to nominal pipe size as shown in ASME B1.20.1.

Fittings are designated by the size of the openings in the sequence illustrated in [Figure 4.1-1](#).

4.2 Abbreviations

The following symbols are used to designate the type of fitting end:

- C = solder-joint fitting end made to receive copper tube diameter (female)
- F = internal ANSI standard taper pipe-thread end (female) NPTI
- FTG = solder-joint fitting end made to copper tube diameter (male)
- M = external ANSI standard taper pipe-thread end (male) NPTE

4.3 Definitions

out-of-roundness: maximum measured diameter minus minimum measured diameter.

ovality: elliptical condition associated with out-of-roundness.

5 MARKING

Each fitting shall be permanently marked with the manufacturer's name or trademark in accordance with MSS SP-25. Marking on fittings smaller than size $\frac{1}{2}$ or on any fitting where it damages soldering surfaces is not required.

6 MATERIAL

(a) Fittings shall be made from copper UNS No. C10200, C12000, or C12200 or copper alloy UNS No. C23000, for which allowable stresses are found in ASME B31.1, ASME B31.9, or ASME Boiler and Pressure Vessel Code, Section II, Part D.

(b) Other coppers and copper alloys are permitted, provided they meet the chemical requirements of 84% minimum copper and 16% maximum zinc and provided the fittings produced from the copper alloy meet all the mechanical and corrosion-resistant properties for the end purposes of the fittings. For potable water applications, fittings shall be produced from low-lead (0.25% or less) copper alloys and shall meet all the mechanical and corrosion-resistant properties for the end purposes of the fittings. The composition of the copper alloy shall contain nothing that will inhibit joining to the tube or to other fittings.

7 LAYING LENGTHS

Due to widely varying manufacturing processes, meaningful laying length requirements of fittings cannot be established. Consult the manufacturer for these dimensions.

8 TUBE STOPS

Except for repair couplings, fittings shall be manufactured with a tube stop. Repair couplings shall not require a tube stop. The tube stop shall control joint length, even with an external (FTG) end having the minimum outside diameter shown in [Table 3.1.1-1](#). Examples of various tube stop configurations are shown in [Figure 8-1](#).

9 INSPECTION TOLERANCE

9.1 Convention

For determining conformance with this Standard, the convention for fixing significant digits where limits (maximum or 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.

9.2 Linear Dimensions

An inspection tolerance, as shown in [Table 9.2-1](#), shall be allowed on center-to-shoulder, center-to-center, center-to-threaded-end, and shoulder-to-threaded-end dimensions on all fittings having internal (C) solder ends, as well as on center-to-solder-end and solder-end-to-threaded-end dimensions on all fittings having external (FTG) solder ends.

Coupling inspection limits for shoulder-to-shoulder and shoulder-to-end dimensions shall be double those shown in [Table 9.2-1](#), except that the minus tolerance applied to dimension *L* (see [Figure 4.1-1](#)) shall not result in a dimension smaller than 1.5 mm (0.06 in.).

The largest opening in the fitting shall govern the tolerance to be applied to all openings.

9.3 Ovality of Fitting End (C or FTG)

Maximum ovality of the fitting solder-joint end shall not exceed 1% of the maximum diameters shown in [Table 3.1.1-1](#). The average of the maximum and minimum diameters shall be within the dimensions shown in the Table.

9.4 Inside Diameter of Fitting

The minimum cross-sectional area of the inside diameter through the fitting body shall not be less than the theoretical minimum area defined by diameter *O* in [Table 3.1.1-1](#). The out-of-roundness condition of the cross-sectional area shall not exceed the value shown in [Table 3.1.1-1](#).

For reducer or adapter fittings, the smallest end diameter shall apply, provided that this diameter does not restrict the other outlets.

9.5 Wall Thickness

The minimum wall thickness shall not be less than that shown in [Table 3.1.1-1](#).

10 THREADED ENDS

Fitting threads shall be right-hand, conforming to ASME B1.20.1. They shall be taper threads (NPT).

10.1 Countersink or Chamfer

All internal threads shall be countersunk a distance no less than one-half the pitch of the thread, at an angle of approximately 45 deg with the axis of the thread. All external threads shall be chamfered at an angle of 30 deg to 45 deg from the axis. Countersinking and chamfering shall be concentric with the threads.

The length of threads shall be measured to include the countersink or chamfer.

10.2 Threading Tolerances

Tapered pipe threads (NPT) shall be checked by use of plug or ring gages in either standard or limit types. When gaging internal taper threads, the plug gage shall be screwed hand-tight into the fitting. The reference point for gaging internal product threads depends on the chamfer diameter. When the internal chamfer diameter exceeds the major diameter of the internal thread, the reference point shall be the last thread scratch on the chamfer cone. Otherwise, when the internal chamfer diameter does not exceed the major diameter of the internal thread, the reference point shall be the end of the fitting. In gaging external taper threads, the ring gage shall be screwed hand-tight on the external thread. On the external thread, the ring gage shall be flush with the end of the thread.

Tolerance for an internal threaded end having an internal shoulder shall be from the gage reference point (notch) to one turn small. Tolerance for an internally threaded end without a shoulder, and for an externally threaded end, shall be from one turn small to one turn large.

10.3 Design of Threaded Ends

The wrenching section of internally threaded ends shall be polygonal or bead with or without ribs, and the wrenching section of externally threaded ends shall be furnished with polygon, ribs, or flats, at the manufacturer's option.

11 ALIGNMENT

The maximum allowable deviation in the angular alignment of any end from the specified axis position shall be $\frac{1}{2}$ deg (1 deg total). See [Figure 11-1](#).

12 GAGING

12.1 Preferred Gaging Method of Solder-Joint Ends

The preferred method of gaging the diameter tolerances for external and internal ends shall be by the use of plain plug and ring gages designed to hold the product within the limits established in [Table 3.1.1-1](#). Gage tolerances shall be Class ZM, as defined in ASME B4.4M.

12.2 Optional Gaging Method of Solder-Joint Ends

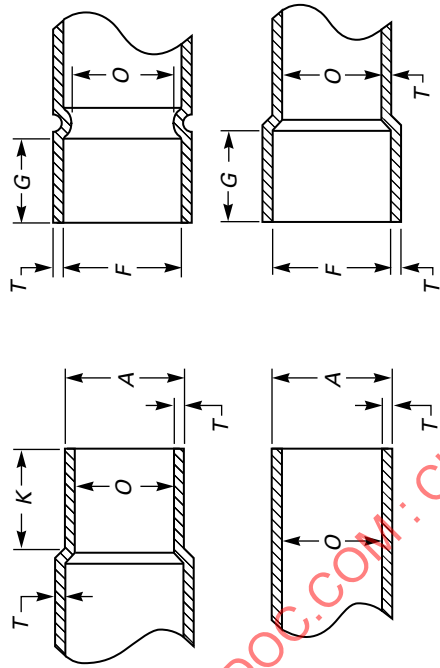
For gaging the diameter tolerance of external and internal ends, the use of direct reading instruments instead of ring and plug gages as specified in [para. 12.1](#) shall be permitted. When gaging the diameters of external and internal ends using direct reading instruments, refer to [para. 9.3](#).

12.3 Standard Gaging Method of Threaded Ends

The standard method of gaging the externally and internally threaded ends shall be in accordance with the requirements of ASME B1.20.1.

NOTE: In gaging pipe threads, it is acceptable and common practice to rap or tap the part to ensure proper seating of the gage. However, it is first necessary to clean both the gage and product threads to ensure that they are free of chips, burrs, abrasives, and other foreign materials.

Table 3.1.1-1
Dimensions of Solder-Joint Ends



Male End (FTG) **Female End (C)**

Standard Water Tube Size [Note (1)]	External End		Internal End				Inside Diameter of Fitting, <i>O</i> , mm (in.)	
	Outside Diameter, <i>A</i> , mm (in.)		Minimum Length, <i>K</i> , mm (in.) [Note (3)]		Inside Diameter, <i>F</i> , mm (in.)		Minimum Wall Thickness, <i>T</i> , mm (in.)	Maximum Out-of- Roundness
	Min.	Max. [Note (2)]	Min.	Max. [Note (2)]	Min.	Max. [Note (2)]		
$\frac{1}{8}$ [Note (5)]	6.30 (0.248)	6.38 (0.251)	7.9 (0.31)	6.40 (0.252)	6.50 (0.256)	6.4 (0.25)	0.48 (0.019)	0.5 (0.02)
$\frac{1}{4}$	9.47 (0.373)	9.55 (0.376)	9.7 (0.38)	9.58 (0.377)	9.68 (0.381)	7.9 (0.31)	0.58 (0.023)	0.8 (0.03)
$\frac{3}{8}$	12.62 (0.497)	12.73 (0.501)	11.2 (0.44)	12.75 (0.502)	12.85 (0.506)	9.7 (0.38)	0.66 (0.026)	1.0 (0.04)
$\frac{1}{2}$	15.80 (0.622)	15.90 (0.626)	14.2 (0.56)	15.93 (0.627)	16.03 (0.631)	12.7 (0.50)	0.74 (0.029)	1.3 (0.05)
$\frac{5}{8}$	18.97 (0.747)	19.08 (0.751)	17.5 (0.69)	19.10 (0.752)	19.20 (0.756)	15.7 (0.62)	0.79 (0.031)	1.6 (0.06)
$\frac{3}{4}$	22.15 (0.872)	22.25 (0.876)	20.6 (0.81)	22.28 (0.877)	22.38 (0.881)	19.1 (0.75)	0.84 (0.033)	1.9 (0.07)
1	28.50 (1.122)	28.63 (1.127)	24.6 (0.97)	28.65 (1.128)	28.75 (1.132)	23.1 (0.91)	1.02 (0.040)	2.5 (0.10)
$1\frac{1}{4}$	34.85 (1.372)	34.98 (1.377)	26.2 (1.03)	35.00 (1.378)	35.10 (1.382)	24.6 (0.97)	1.12 (0.044)	3.1 (0.12)
$1\frac{1}{2}$	41.17 (1.621)	41.33 (1.627)	29.5 (1.16)	41.35 (1.628)	41.48 (1.633)	27.7 (1.09)	1.30 (0.051)	3.7 (0.15)
2	53.87 (2.121)	54.03 (2.127)	35.8 (1.41)	54.05 (2.128)	54.18 (2.133)	34.0 (1.34)	1.50 (0.059)	4.9 (0.19)
$2\frac{1}{2}$	66.57 (2.621)	66.73 (2.627)	38.9 (1.53)	66.75 (2.628)	66.88 (2.633)	37.3 (1.47)	1.70 (0.067)	6.1 (0.24)
3	79.27 (3.121)	79.43 (3.127)	43.7 (1.72)	79.45 (3.128)	79.58 (3.133)	42.2 (1.66)	1.91 (0.075)	7.3 (0.29)
$3\frac{1}{2}$	91.97 (3.621)	92.13 (3.627)	50.0 (1.97)	92.15 (3.628)	92.28 (3.633)	48.5 (1.91)	2.18 (0.086)	8.6 (0.34)

Table 3.1.1-1
Dimensions of Solder-Joint Ends (Cont'd)

Standard Water Tube Size [Note (1)]	External End		Internal End				Inside Diameter of Fitting, <i>O</i> , mm (in.)	
	Outside Diameter, <i>A</i> , mm (in.)		Minimum Length, <i>K</i> , mm (in.)		Inside Diameter, <i>F</i> , mm (in.)		Minimum Wall Thickness, <i>T</i> , mm (in.)	Maximum Out-of- Roundness
	Min.	Max. [Note (2)]	Min. [Note (3)]	Max. [Note (2)]	Min.	Max. [Note (2)]		
4	104.67 (4.121)	104.83 (4.127)	56.4 (2.22)	104.85 (4.128)	104.98 (4.133)	54.9 (2.16)	2.44 (0.096)	9.8 (0.38)
5	130.07 (5.121)	130.23 (5.127)	69.1 (2.72)	130.25 (5.128)	130.38 (5.133)	67.6 (2.66)	2.82 (0.111)	11.9 (0.47)
6	155.47 (6.121)	155.63 (6.127)	81.8 (3.22)	155.65 (6.128)	155.78 (6.133)	78.5 (3.09)	3.15 (0.124)	14.5 (0.57)
8	206.22 (8.119)	206.43 (8.127)	103.9 (4.09)	206.45 (8.128)	206.58 (8.133)	100.8 (3.97)	4.39 (0.173)	19.2 (0.76)

GENERAL NOTE: Drawings and designs of fittings are illustrative only. Dimensions herein shall govern in all cases.

NOTES:

(1) For size designation of fittings, see para. 4.1.

(2) For ovality, see para. 9.3.

(3) The distance from the point of tangency, at the gage I.D. to the gage line, shall be equal to the dimension shown in this column.

(4) The distance from the point of tangency, at the gage O.D. to the gage line, shall be equal to the dimension shown in this column.

(5) Size $\frac{1}{8}$ is $\frac{1}{4}$ O.D. seamless copper tube for refrigeration service, etc., as listed in ASTM B280.

Table 3.1.1-2
Internal Pressure–Temperature Ratings for Copper Fittings, kPa (psi)

Standard Water Tube Size [Note (1)]	–29°C to 38°C (–20°F to 100°F)	66°C (150°F)	93°C (200°F)	121°C (250°F)	149°C (300°F)	177°C (350°F)	204°C (400°F)
1/4	6 280 (910)	5 340 (770)	5 130 (740)	5 020 (725)	4 920 (710)	4 190 (605)	3 140 (455)
3/8	5 360 (775)	4 560 (660)	4 380 (635)	4 290 (620)	4 200 (610)	3 570 (515)	2 680 (385)
1/2	4 970 (720)	4 220 (610)	4 060 (585)	3 980 (575)	3 890 (565)	3 310 (480)	2 480 (360)
5/8	4 350 (630)	3 700 (535)	3 550 (515)	3 480 (505)	3 410 (490)	2 900 (420)	2 170 (315)
3/4	4 010 (580)	3 410 (490)	3 270 (475)	3 210 (465)	3 140 (455)	2 670 (385)	2 000 (290)
1	3 400 (490)	2 890 (420)	2 780 (400)	2 720 (395)	2 660 (385)	2 270 (325)	1 700 (245)
1 1/4	3 020 (435)	2 570 (370)	2 470 (355)	2 420 (350)	2 370 (340)	2 010 (290)	1 510 (215)
1 1/2	2 810 (405)	2 390 (345)	2 300 (330)	2 250 (325)	2 200 (315)	1 870 (270)	1 400 (200)
2	2 500 (360)	2 130 (305)	2 040 (295)	2 000 (290)	1 960 (280)	1 670 (240)	1 250 (180)
2 1/2	2 310 (335)	1 960 (285)	1 890 (270)	1 850 (265)	1 810 (260)	1 540 (220)	1 150 (165)
3	2 180 (315)	1 850 (265)	1 780 (255)	1 740 (250)	1 710 (245)	1 450 (210)	1 090 (155)
3 1/2	2 090 (300)	1 770 (255)	1 700 (245)	1 670 (240)	1 630 (235)	1 390 (200)	1 040 (150)
4	2 020 (290)	1 710 (245)	1 650 (235)	1 610 (230)	1 580 (225)	1 340 (195)	1 010 (145)
5	1 850 (265)	1 570 (225)	1 510 (215)	1 480 (215)	1 450 (210)	1 230 (175)	920 (130)
6	1 720 (250)	1 460 (210)	1 410 (200)	1 380 (200)	1 350 (195)	1 150 (165)	860 (125)
8	1 860 (270)	1 580 (225)	1 520 (220)	1 490 (215)	1 460 (210)	1 240 (180)	930 (135)

GENERAL NOTES:

- (a) The fitting pressure–temperature rating applies to the largest opening of the fitting.
 (b) The fitting pressure–temperature rating is calculated as shown in [Nonmandatory Appendix A](#), then rounded down to the nearest unit of 10.

NOTE: (1) For size designation of fittings, see [para. 4.1](#).

Figure 4.1-1
Method of Designating Laying Lengths of Fittings and Openings of Reducing Fittings

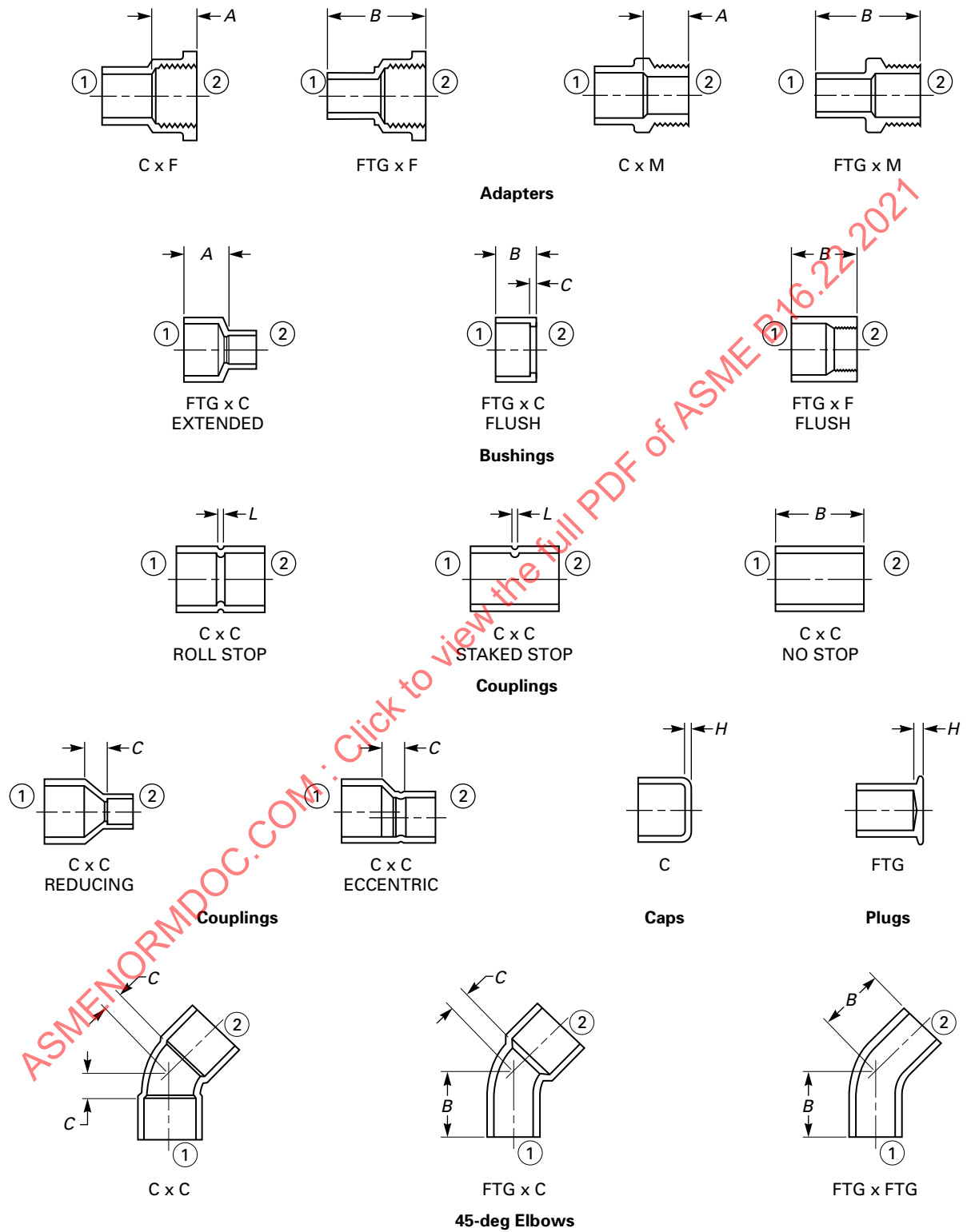
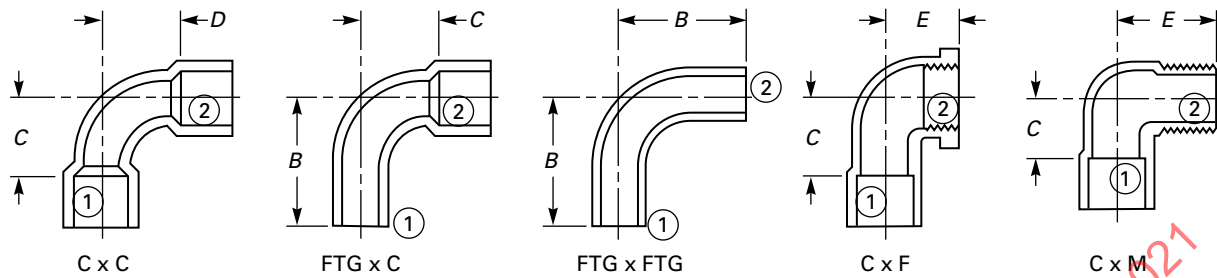
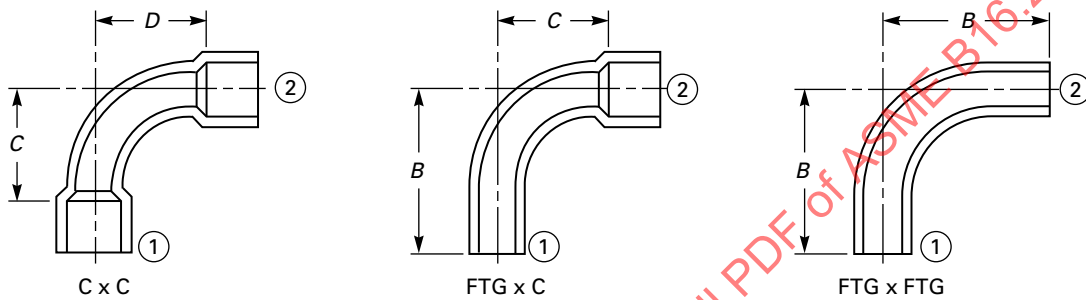


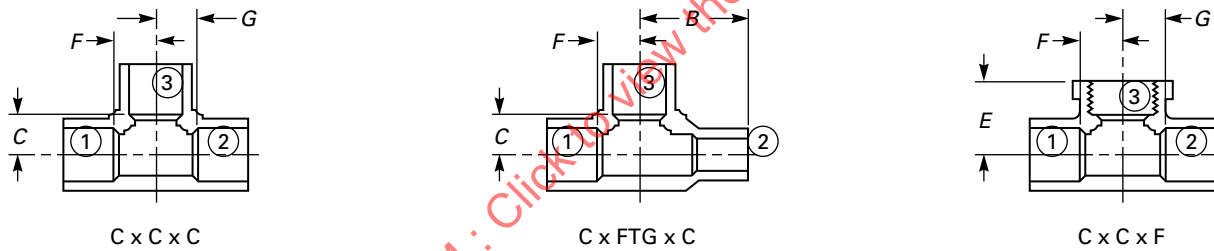
Figure 4.1-1
Method of Designating Laying Lengths of Fittings and Openings of Reducing Fittings (Cont'd)



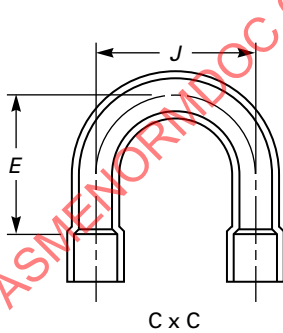
90-deg Elbows, Short Radius



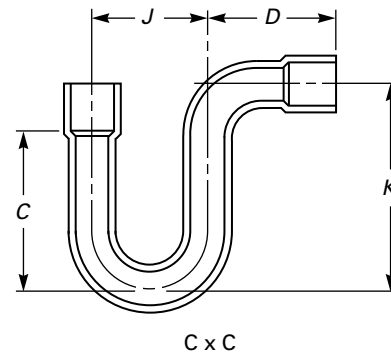
90-deg Elbows, Long Radius



Tees



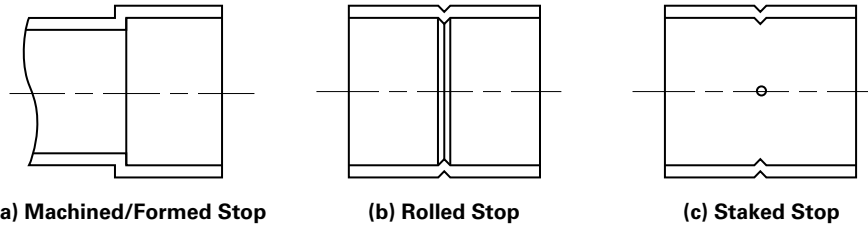
Return Bends



Suction Line P-Traps

GENERAL NOTES:

- (a) Fittings are designated by size in the order: ① x ② x ③.
- (b) Fitting designs and drawings are illustrative only.

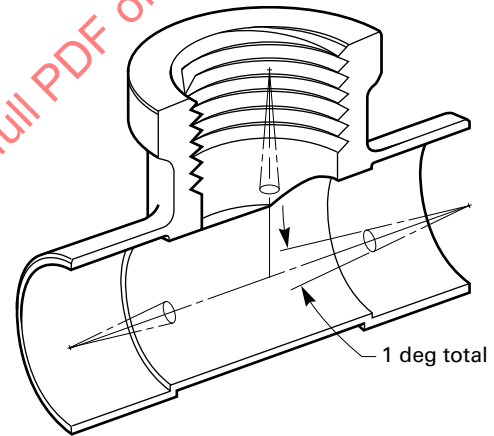
**Figure 8-1
Tube Stops**

GENERAL NOTE: This figure is for illustration only; the shape and number of abutments shall be at the manufacturer's discretion.

**Table 9.2-1
Inspection Tolerance**

Standard Water Tube and Pipe Thread Sizes	Tolerance, Plus or Minus, mm (in.)
$\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$ [Note (1)]	1.3 (0.05)
$\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$	1.5 (0.06)
1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2	2.0 (0.08)
$2\frac{1}{2}$, 3, $3\frac{1}{2}$	2.8 (0.11)
4, 5	3.0 (0.12)
6, 8	4.1 (0.16)

NOTE: (1) Size $\frac{1}{8}$ is $\frac{1}{4}$ O.D. seamless copper tube for refrigeration service, etc., as listed in ASTM B280.

**Figure 11-1
Alignment**

GENERAL NOTE: This figure is for illustration only.

MANDATORY APPENDIX I STRENGTH OF SOLDER JOINTS

The maximum recommended pressure–temperature ratings for solder joints made with copper tube and wrought copper and copper alloy pressure fittings, using representative commercial solders, are listed in

[Table I-1](#). These pressure–temperature ratings are based on solder joints made in accordance with the requirements of ASTM B828.

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Table I-1
Pressure-Temperature Ratings

Joining Material	Temperature, °C (°F)	Maximum Gage Pressure, kPa (psi), for Standard Water Tube Sizes [Note (1)]			
		1/8 Through 1	1 1/4 Through 2	2 1/2 Through 4	5 Through 8
Alloy Sn50	38 (100)	1375 (200)	1205 (175)	1030 (150)	930 (135)
50-50 tin-lead solder	66 (150)	1030 (150)	860 (125)	685 (100)	620 (90)
[Notes (2), (3)]	93 (200)	685 (100)	620 (90)	515 (75)	480 (70)
	121 (250)	585 (85)	515 (75)	340 (50)	310 (45)
Alloy Sb5	38 (100)	7540 (1,090)	5880 (850)	4880 (705)	4555 (660)
95-5 tin-antimony solder	66 (150)	[Note (5)]	[Note (6)]	[Note (6)]	[Note (6)]
[Note (4)]		4315 (625)	3365 (485)	2790 (405)	2605 (375)
	93 (200)	[Note (7)]	[Note (7)]	[Note (7)]	[Note (7)]
		3500 (505)	2730 (395)	2265 (325)	2115 (305)
	121 (250)	[Note (8)]	[Note (7)]	[Note (7)]	[Note (7)]
		1885 (270)	1475 (210)	1220 (175)	1135 (165)
Alloy E	38 (100)	4905 (710)	3825 (555)	3175 (460)	2965 (430)
[Note (9)]		[Note (7)]	[Note (7)]	[Note (7)]	[Note (7)]
	66 (150)	3275 (475)	2550 (370)	2115 (305)	1975 (285)
		[Note (8)]	[Note (7)]	[Note (7)]	[Note (8)]
	93 (200)	2595 (375)	2025 (290)	1680 (240)	1570 (225)
				[Note (8)]	[Note (8)]
	121 (250)	2230 (320)	1735 (250)	1440 (205)	1340 (195)
Alloy HB	38 (100)	7135 (1,035)	5560 (805)	4615 (670)	4305 (625)
[Note (10)]		[Note (5)]	[Note (6)]	[Note (6)]	[Note (5)]
	66 (150)	4905 (710)	3825 (555)	3175 (460)	2965 (430)
		[Note (7)]	[Note (7)]	[Note (7)]	[Note (7)]
	93 (200)	3045 (440)	2375 (345)	1970 (285)	1840 (265)
		[Note (8)]	[Note (8)]	[Note (8)]	[Note (8)]
	121 (250)	2970 (430)	2315 (335)	1920 (275)	1800 (260)
		[Note (8)]	[Note (8)]	[Note (8)]	[Note (8)]
Joining materials melting at or above 593°C (1,100°F) [Note (11)]		Pressure-temperature ratings consistent with the materials and procedures employed			

GENERAL NOTE: For temperatures in the -18°C to -93°C (0°F to -200°F) range, it is recommended that a joint material melting at or above 593°C (1,100°F) be employed [see Note (9)].

NOTES:

- (1) Standard water tube sizes per ASTM B88.
- (2) ASTM B32 Alloy Grade Sn50.
- (3) The Safe Drinking Water Act Amendments of 1986 prohibit the use of any solder having a lead content in excess of 0.2% in potable water systems.
- (4) ASTM B32 Alloy Grade Sb5.
- (5) The solder joint exceeds the strength of Types L and M tube in drawn temper and Type K tube in annealed temper.
- (6) The solder joint exceeds the strength of Types K, L, and M tube in drawn and annealed tempers.
- (7) The solder joint exceeds the strength of Type M tube in drawn temper and Types K and L tube in annealed temper.
- (8) The solder joint exceeds the strength of Type L tube in annealed temper.
- (9) ASTM B32 Alloy Grade E.
- (10) ASTM B32 Alloy Grade HB.
- (11) These joining materials are defined as "brazing alloys" by the American Welding Society.