ASME B16.51-2013
(Revision of ASME B16.51-2011)

Copper and Copper Alloy Press-Connect Pressure Fittings

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: December 6, 2013

The next edition of this Standard is scheduled for publication in 2018.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Periodically certain actions of the ASME B16 Committee may be published as Cases. Cases and interpretations are published on the ASME Web site under the Committee Pages at http://cstools.asme.org/ as they are issued, and will be published within the next edition of the standard.

Errata to codes and standards may be posted on the ASME Web site under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

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The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

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FOREWORD

Standardization of cast and wrought press-connect pressure fittings was initiated by Subcommittee J of the ASME B16 Committee in 2000. The first draft of the Standard was based on International Association of Plumbing and Mechanical Officials (IAPMO) Interim Guide Criteria IGC 137-2000. The general requirements of ASME B16.22-2000 and ASME B16.24-1998 were added to the first draft. The development of the Standard was necessary to regulate the strength of the joint in copper press-connect fittings. The performance test requirements of this Standard are an important aspect for determining the quality of the fittings.

Following approval by the Standards Committee and the ASME Board on PTCS, approval as an American National Standard was given by the American National Standards Institute (ANSI) on December 21, 2011 with the designation ASME B16.51-2011.

In this 2013 edition, provisions have been included to recognize low lead alloys to comply with the U.S. Safe Drinking Water Act, which will be effective 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 new designation ASME B16.51-2013.

Requests for interpretation or suggestions for revision should be sent to the Secretary, B16 Committee, The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

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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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, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B16 Standards Committee
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Two Park Avenue
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As an alternative, inquiries may be submitted via email to: SecretaryB16@asme.org.

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 for the purpose of providing 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, 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 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.

The request for 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.
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. 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 this format will be rewritten in this format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

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, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B16 Standards Committee.

ASME B16.51-2013
SUMMARY OF CHANGES

Following approval by the ASME B16 Committee and ASME, and after public review, ASME B16.51-2013 was approved by the American National Standards Institute on July 29, 2013.

ASME B16.51-2013 includes the following changes identified by a margin note, **(13)**.

Page	*Location*	*Change*
4	6.1	Subparagraph (b) revised
	6.2	Revised

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COPPER AND COPPER ALLOY PRESS-CONNECT PRESSURE FITTINGS

1 SCOPE

This Standard establishes requirements for cast copper alloy, wrought copper, and wrought copper alloy, press-connect pressure fittings for use with hard drawn seamless copper water tube conforming to ASTM B88 for piping systems conveying water. The press-connect system (tube, fitting, and joint) conforming to this Standard is for use at a maximum pressure of 1 380 kPa (200 psi) over the temperature range from 0°C to 93°C (32°F to 200°F).

This Standard provides requirements for fittings suitable for press-connect joining and covers the following:

(a) size designations
(b) pressure–temperature ratings
(c) terminology
(d) dimensions and tolerances
(e) materials
(f) design qualification
(g) required installation instructions
(h) markings

2 GENERAL

2.1 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.

2.2 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, the U.S. Customary units are shown in parentheses or in separate tables that appear in Mandatory Appendix I. 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.

2.3 References

Codes, standards, and specifications, containing provisions to the extent referenced herein, constitute requirements of this Standard. These referenced documents are listed in Mandatory Appendix II.

2.4 Quality Systems

Requirements relating to the product manufacturer's Quality System Programs are described in Nonmandatory Appendix A.

3 TERMINOLOGY

3.1 Abbreviations

The following abbreviations are used to designate the type of fitting end as shown in Fig. 1:

F = internal ASME B1.20.1 taper pipe-thread end (NPTI)
FTG = solder-joint fitting end made to copper tube outside diameter
M = external ASME B1.20.1 taper pipe-thread end (NPTE)
P = internal press-connect joint end made to receive copper tube diameter

3.2 Definitions

This paragraph defines the terms used in this Standard.

joining, press-connect: the act of joining a fitting or piping component to a tube by use of a tool that mechanically compresses the wall of the fitting end over the tubing, encasing an elastomeric seal between the mating surfaces.

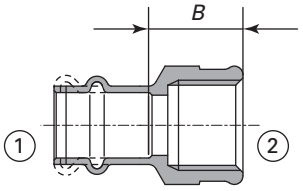
out-of-roundness: the maximum measured diameter minus the minimum measured diameter.

press-connect fitting: a type of piping component (e.g., coupling, tee, elbow) used to connect tubing or other accessories by mechanically compressing the wall of the fitting end over the tube, using an elastomeric material to provide a seal between the inside surface of the fitting and the outside surface of the tube.

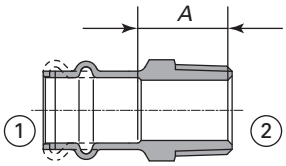
4 SIZE

The size designations of the fittings shown in the tables of this Standard correspond to standard water tube size as shown in ASTM B88, Specification for

Fig. 1 Method of Designating Laying Lengths of Fittings and Openings of Reducing Fittings

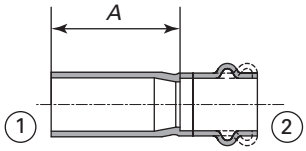


P × F



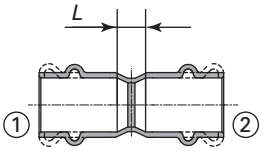
P × M

(a) Adapters



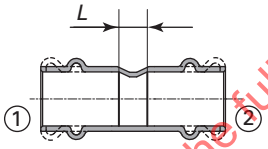
FTG × P

(b) Extended Bushings



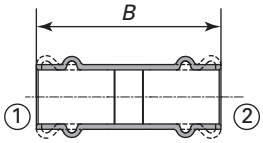
P × P

Roll Stop



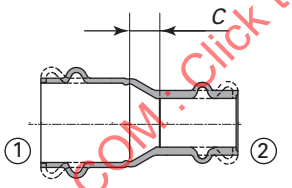
P × P

Staked Stop



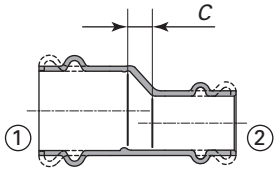
P

No Stop



P × P

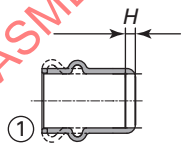
Reducing



P × P

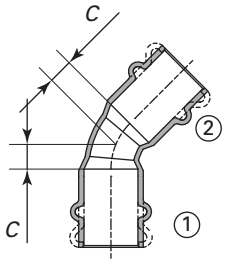
Eccentric

(c) Couplings

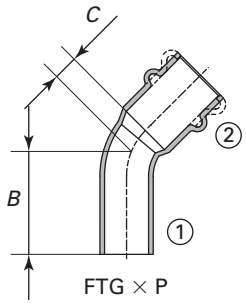


P

(d) Caps



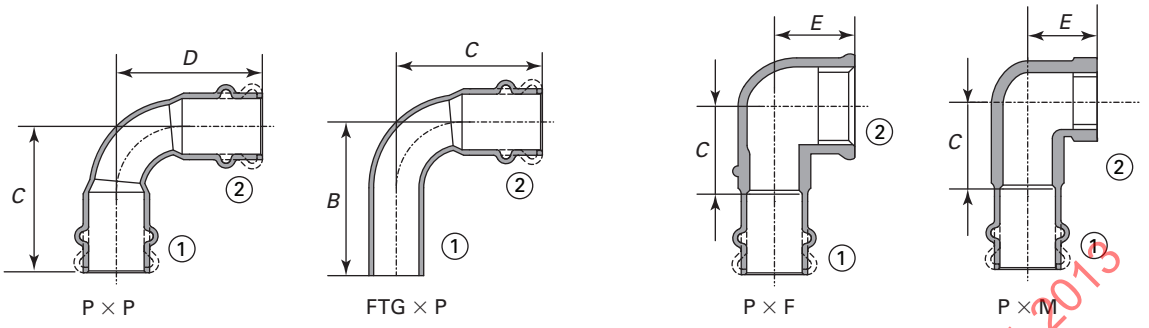
P × P



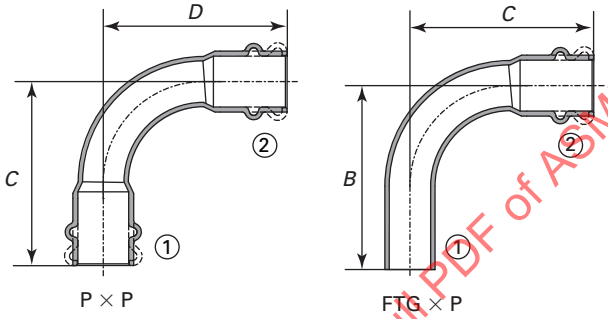
FTG × P

(e) 45 deg Elbows

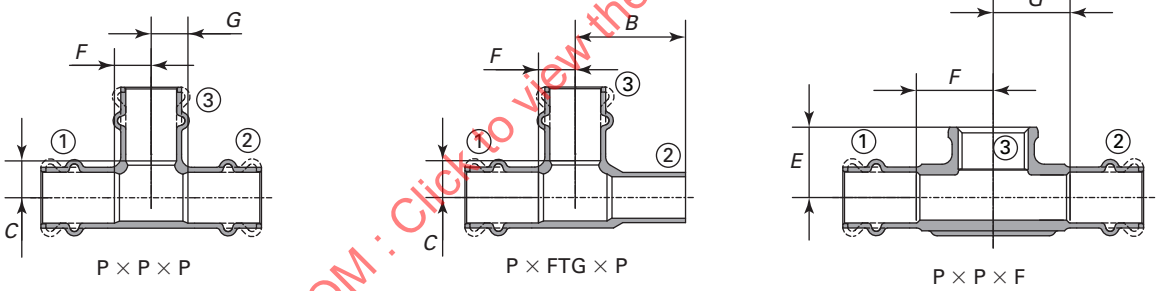
Fig. 1 Method of Designating Laying Lengths of Fittings and Openings of Reducing Fittings (Cont'd)



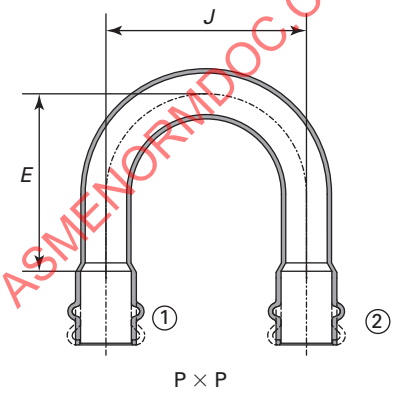
(f) 90 deg Elbows, Short Radius



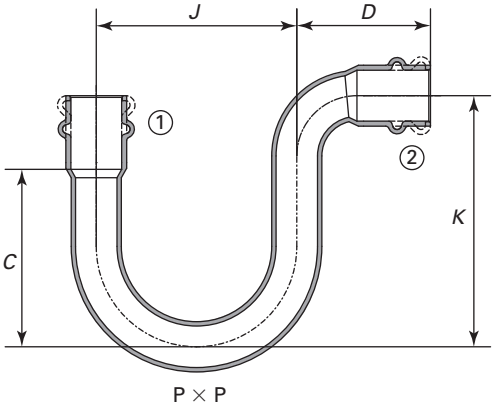
(g) 90 deg Elbows, Long Radius



(h) Tees



(i) Return Bends



(j) Suction Line P-Traps

GENERAL NOTES:

(a) Fittings are designated by size in the following order: 1 × 2 × 3 (designated in circles above).

(b) Fitting designs and drawings are illustrative only.

(c) Number of O-rings and locations shall be specified by the manufacturer and is shown for two typical locations.

(d) Dimensions *A* through *L* shall be specified by the manufacturer.

Seamless Copper Water Tube. The size designations of the threaded ends correspond to nominal pipe size as shown in ASME B1.20.1.

Fittings shall be designated by the size of the openings in the sequence illustrated in Fig. 1.

5 MARKING

Each fitting shall be permanently marked with the manufacturer's name or trademark in accordance with MSS SP-25. Marking on fittings less than nominal size ½ or on any fitting where it damages joining surfaces is not required.

6 MATERIAL

(13) 6.1 Wrought Copper Alloys

(a) Fittings shall be made from copper UNS alloy number C10200, C12000, C12200, or C23000.

(b) Other coppers and copper alloys shall be permitted, provided their chemical composition contains a minimum of 84% copper and a maximum of 16% 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 not inhibit joining to the tube or to other fittings.

(13) 6.2 Cast Copper Alloys

(a) Castings intended for use in applications up to 204°C (400°F) shall be of a copper alloy produced to meet

(1) the requirements of ASTM B62 UNS alloy number C83600, or

(2) the chemical and tensile requirements of ASTM B584 UNS alloy number C83800 or C84400 and in all other respects the requirements of ASTM B62

(b) Castings intended for use in potable water applications up to 93°C (200°F) shall be low lead (0.25% or less) and shall be

(1) of a copper alloy produced to meet the requirements of ASTM B584 UNS alloy number C87850 or C89833, or

(2) of other cast copper alloys, provided the fittings produced meet mechanical and corrosion-resistant properties needed for potable water application

6.3 Elastomers (Seals)

Elastomeric components shall be resistant to microbiological attack and ozone attack, and shall contain inhibitors to prevent copper degradation. The elastomer shall be an ethylene propylene diene monomer (EPDM) and shall meet the minimum property and test requirements, as defined by ASTM D2000, shown in the following table:

Material	EPDM
Minimum nominal durometer hardness, ±5 points	60
Minimum tensile strength, MPa (psi)	10 (1,450)
Heat resistance	A25
Compression set	B35
Water resistance	EA14
Low-temperature resistance	F17
Tear resistance	G21
Special requirements	Z1, Z2, Z3, Z4

The special requirements shall be as follows:

(a) Z1 designates compliance with NSF/ANSI 61.

(b) Z2 designates the compression set. The maximum compression set shall be 45% when compressed 2.62 mm (0.103 in.), 40% when compressed 3.53 mm (0.139 in.), and 35% when compressed 5.33 mm (0.210 in.).

(c) Z3 designates chloramine resistance that is determined by testing for 1 008 h at 70°C (158°F) per ASTM D6284 a solution containing 50 ppm total chlorine; this shall be checked and refreshed daily. Upon completion of the test, the change in volume shall be less than 30%, and the change in durometer hardness shall be a maximum of 6. There shall be no visual degradation of the elastomeric material.

(d) Z4 designates resistance of the elastomer to copper degradation. The test shall be conducted in accordance with para. 14.9.1 of this Standard. Upon completion of the test, the change in volume shall be less than 30%, and the change in durometer hardness shall be a maximum of 6. There shall be no visual degradation of the elastomeric material.

6.4 Seal Lubricant

The only seal lubricant that shall be used is that specified by the manufacturer.

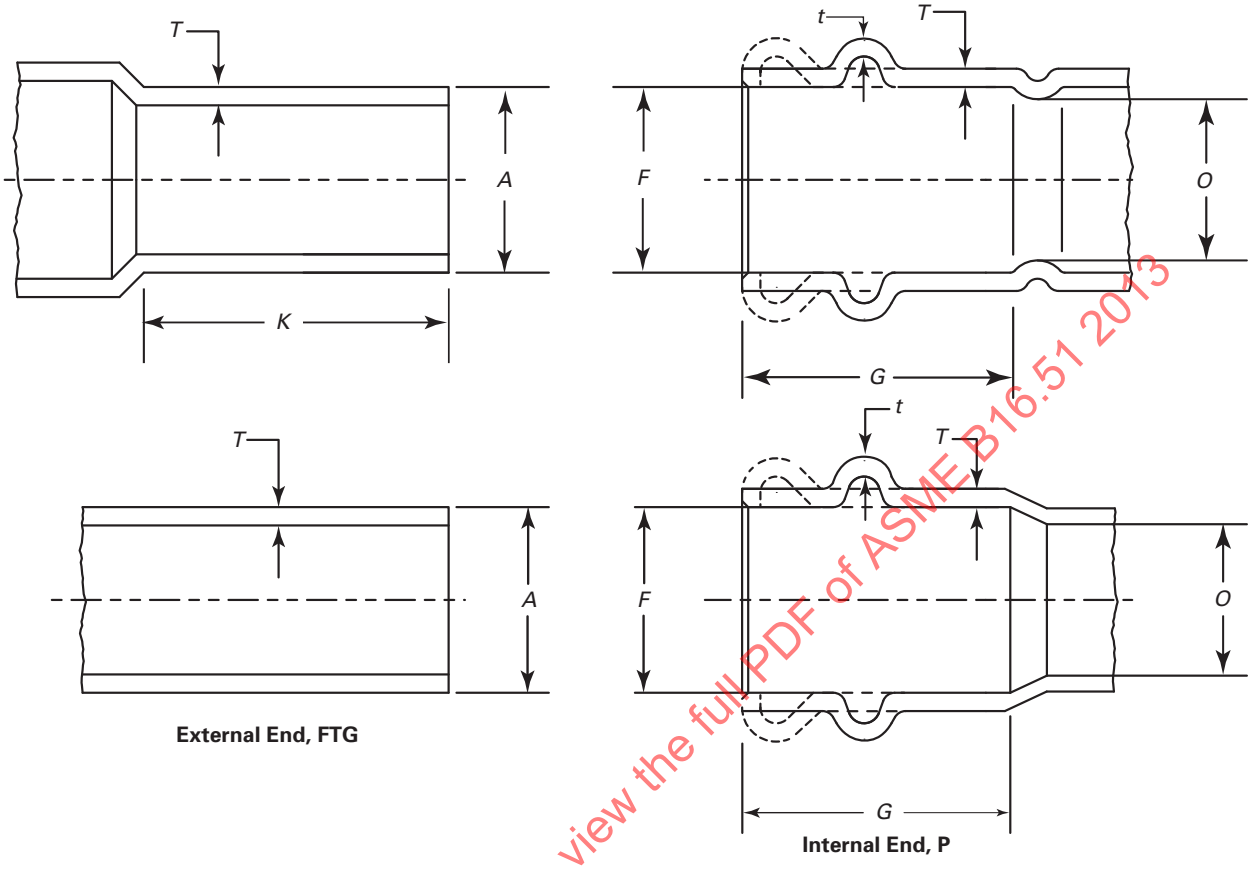
7 LAYING LENGTHS

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 (abutment) to limit tube insertion. 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 1 (Table I-1). Examples of various tube stop configurations are shown in Fig. 2.

Table 1 Dimensions of Press-Connect Ends



Standard Water Tube Size [Note (1)]	External End			Internal End			Wall Thickness				Minimum Inside Diameter of Fitting, *O*
	Outside Diameter, *A*		Minimum Length, *K* [Note (2)]	Inside Diameter, *F*		Depth, *G* [Note (3)]	Minimum Wrought		Minimum Cast		
	Min.	Max.		Min.	Max. [Note (3)]		*T*	*t*	*T*	*t*	
3/8	12.62	12.73	11.2	12.75	...	...	0.66	0.46	1.27	1.27	9.9
1/2	15.80	15.90	14.2	15.93	...	...	0.74	0.52	1.27	1.27	13.2
3/4	22.15	22.25	20.6	22.28	...	...	0.84	0.59	1.27	1.27	18.8
1	28.50	28.63	24.6	28.65	...	...	1.02	0.71	1.27	1.27	24.9
1 1/4	34.85	34.98	26.2	35.00	...	...	1.12	0.78	1.27	1.27	31.2
1 1/2	41.17	41.33	29.5	41.35	...	...	1.30	0.91	1.78	1.78	37.3
2	53.87	54.03	35.8	54.05	...	...	1.50	1.05	1.78	1.78	49.3
2 1/2	66.57	66.73	38.9	66.75	...	...	1.70	1.19	3.00	3.00	61.5
3	79.27	79.43	43.7	79.45	...	...	1.91	1.34	3.00	3.00	73.4
3 1/2	91.97	92.13	50.0	92.15	...	...	2.18	1.53	3.00	3.00	85.6
4	104.67	104.83	56.4	104.85	...	...	2.44	1.71	3.00	3.00	97.5

GENERAL NOTES:

(a) Dimensions are in millimeters.

(b) Drawings and designs of fittings are illustrative only.

(c) Number of O-rings and locations shall be specified by the manufacturer and is shown for two typical locations.

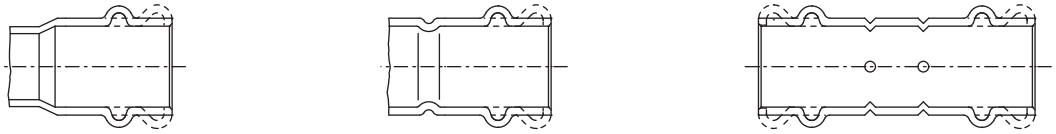
NOTES:

(1) For size designation of fittings, see section 4.

(2) The distance from the point of tangency, at the gage inside diameter to the gage line, shall be equal to the dimension shown under the column titled External End, Minimum Length, *K*.

(3) The maximum inside diameter and depth of the internal end shall be at the option of the manufacturer.

Fig. 2 Tube Stops



(a) Machine/Formed Stop (b) Rolled Stop (c) Staked Stop

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

9 DESIGN

9.1 General

As a minimum, the fitting shall be designed to withstand the tests specified in section 14 without leakage. The press-connect ends shall be assembled in accordance with the fitting manufacturer's installation instructions. The dimensions and tolerances of the press-connect ends shall be as shown in Table 1 (Table I-1).

9.2 Out-of-Roundness of Fitting End (P or FTG)

Maximum out-of-roundness of the press-connect fitting ends, dimensions *A* and *F*, shall not exceed 1% of the maximum corresponding diameters shown in Table 1 (Table I-1). The average of the maximum and minimum diameters shall be within the dimensions shown in Table 1 (Table I-1).

9.3 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 1 (Table I-1). The out-of-roundness condition of the cross-sectional area shall not exceed 10% of the minimum diameter shown in Table 1 (Table I-1).

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

9.4 Wall Thickness

The minimum wall thickness taken at any location of the fitting shall not be less than shown in Table 1 (Table I-1).

10 THREADED ENDS

The threaded ends shall have right-hand nominal pipe taper (NPT) threads conforming to ASME B1.20.1.

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

NPT threads shall be checked by use of a plug or ring gage 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, and the wrenching section of externally threaded ends shall be furnished with either polygon or flats, at the manufacturer's option.

11 ALIGNMENT

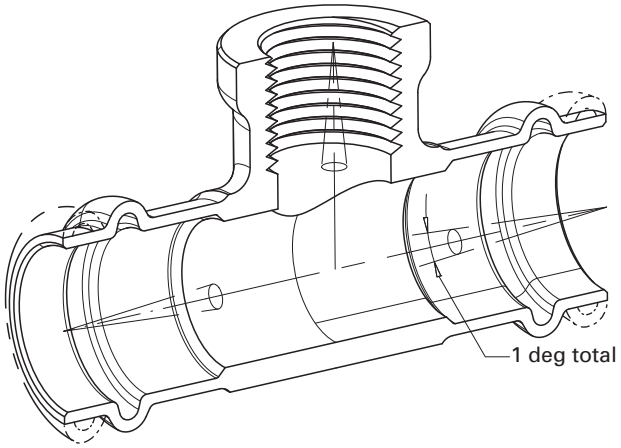
The maximum allowable deviation in the angular alignment of any end from the specified axis position shall be ½ deg (1 deg total). See Fig. 3.

12 GAGING

12.1 Preferred Gaging Method of Press-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 1 (Table I-1). Gage tolerances shall be Class ZM, as defined in ASME B4.4M.

Fig. 3 Alignment



GENERAL NOTE: This figure is for illustration only.

12.2 Optional Gaging Method of Press-Connect Pressure Fittings

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. 9.2.

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 the product threads to ensure that they are free of chips, burrs, abrasives, or other foreign materials.

13 INSTALLATION INSTRUCTIONS

The manufacturer of press connection fittings shall provide instructions for the installation of the fittings. The instructions shall provide a minimum of

(a) end preparation of the tube

(b) assembly of copper tube to the fitting

(c) requirements for the tool used to form the press-connect joint

(d) pressing procedure

Installation instructions shall include details to enable assemblers to install fittings with performance consistent with that demonstrated by the design qualification testing described in section 14.

The pressure–temperature ratings are only applicable to fittings that are installed in accordance with the manufacturer's instructions.

14 DESIGN QUALIFICATION

14.1 General

Press-connection fitting shall be qualified with the performance tests defined herein. The fittings shall be tested with both ASTM Type K and Type M hard drawn tube, so two sets of tests are required, except for the thermocycle test described in para. 14.9.

Manufacturers shall retain test reports demonstrating compliance with this Standard. For any design change, the performance tests shall be repeated.

Press-connection of the test assemblies shall be done according to the fitting manufacturer's installation instructions. Each test shall be performed on a new test assembly.

14.2 Hydrostatic Pressure Test at 20°C (68°F)

14.2.1 Test Assembly. The test assembly shall contain a press-connection fitting located between two sections of copper tube as shown in Fig. 4. The sample shall not be restrained in the test assembly. The sample shall be filled with water to a pressure of 4 140 kPa ± 50 kPa (600 psi ± 7 psi) at a temperature of 20°C ± 5°C (68°F ± 9°F) for a period of 48 h.

14.2.2 Acceptance Criteria. During the first hour, the maximum slippage of each joint shall be as specified in Table 2 (Table I-2). Once the 1-h slippage is recorded, the maximum additional slippage after the first hour shall not exceed the distance specified in Table 2 (Table I-2). During the test, there shall be no visible leakage of the joint.

Fig. 4 Test Setup for Pressure Test

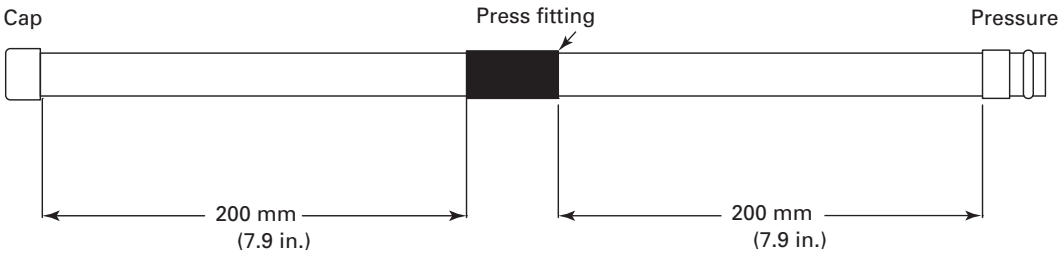


Table 2 Maximum Slippage

Standard Water Tube Size	Maximum Slippage (mm) per Joint After 1 h	Maximum Additional Slippage (mm) per Joint After First Hour
3/8	0.3	0.05
1/2	0.3	0.05
3/4	0.3	0.05
1	0.8	0.05
1 1/4	1.0	0.05
1 1/2	1.5	0.05
2	2.0	0.05
2 1/2	2.5	0.1
3	3.0	0.1
3 1/2	3.5	0.1
4	4.0	0.1

14.3 Unrestrained Hydrostatic Pressure Test At 93°C (200°F)

14.3.1 Test Assembly. The test assembly shall contain a press-connect fitting located between two sections of copper tube as shown in Fig. 4. The sample shall not be restrained in the test assembly. The sample shall be filled with water to a pressure of 4 140 kPa ± 50 kPa (600 psi ± 7 psi) and held at a temperature of 93°C ± 2°C (200°F ± 5°F) for a period of 48 h.

14.3.2 Acceptance Criteria. The acceptance criteria shall be as defined in para. 14.2.2.

14.4 Static Torque Test

14.4.1 Test Assembly. Prepare samples with a copper press-connect coupling joining two equal lengths hard drawn copper tube. One end of the test assembly shall be fixed and the other end fabricated to accommodate a moment arm, as shown in Fig. 5. Each test assembly with a press-connect fitting shall have a minimum torque applied as specified in Table 3 (Table I-3).

After applying the torque, release the force and subject the sample to a water pressure test of 2 760 kPa ± 50 kPa (400 psi ± 7 psi) gage pressure for a period of 48 h at a temperature of 20°C ± 5°C (68°F ± 9°F).

14.4.2 Acceptance Criteria. The press-connect fitting shall withstand the minimum torque listed in Table 3 (Table I-3). During the test, there shall be no visible leakage of the joint.

14.5 Bending Test

14.5.1 Test Assembly. A test assembly shall have two 1 020 mm (40 in.) lengths of (hard) copper tube joined with a coupling with an internal stop. The sample shall be centered between supports spaced 1 829 mm (6.0 ft) apart as shown in Fig. 6. A concentrated load shall be applied to the center of the span at the center of the coupling. The concentrated load shall be in accordance with Table 4 (Table I-4). A hydrostatic internal pressure of 4 140 kPa ± 50 kPa (600 psi ± 7 psi) shall be applied and maintained for a period of 1 h at a temperature of 20°C ± 5°C (68°F ± 9°F).

14.5.2 Acceptance Criteria. During the test, there shall be no visible leakage of the joint.

14.6 Vacuum Test

14.6.1 Test Assembly. A test assembly shall have a press-connect fitting.

The sample shall be subjected to a vacuum of −83 kPa ± 2 kPa (−24.5 in. of mercury ± 0.5 in. of mercury)

Fig. 5 Test Setup for Static Torque Test

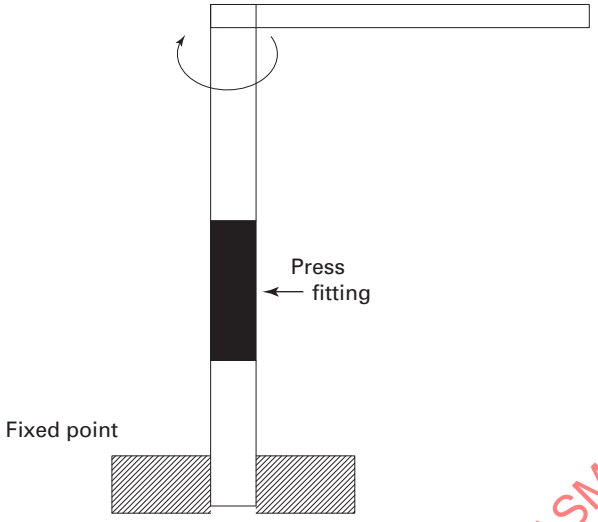


Table 3 Torque

Standard Water Tube Size	Torque, N·m
3/8	11
1/2	20
3/4	25
1	40
1 1/4	55
1 1/2	70
2	100
2 1/2	130
3	165
3 1/2	200
4	240

Fig. 6 Test Setup for Bending Test

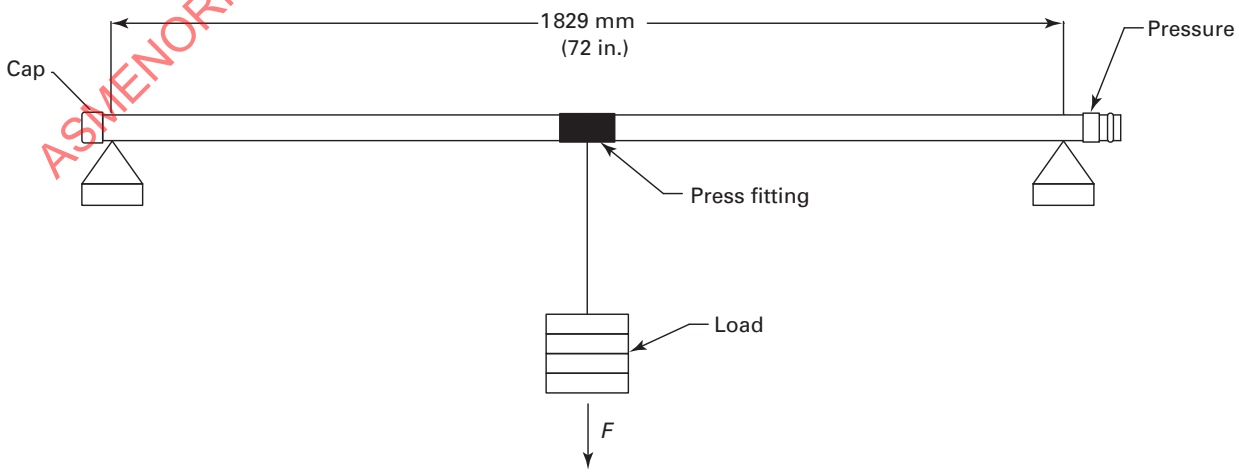


Table 4 Concentrated Load

Standard Water Tube Size	Static Load, N
3/8	40
1/2	110
3/4	180
1	240
1 1/4	310
1 1/2	380
2	500
2 1/2	630
3	770
3 1/2	920
4	1 090

at a temperature of 20°C ± 5°C (68°F ± 9°F). Once the vacuum is established, the sample shall be isolated. The vacuum shall be maintained for a period of 1 h.

14.6.2 Acceptance Criteria. The maximum change in vacuum shall not exceed 3.4 kPa (1.0 in. of mercury) within the 1-h test period.

14.7 Cyclic Pressure Test

14.7.1 Test Assembly. The test assembly shall have a minimum of one press-connect fitting. The sample shall be installed in a system filled with water at a temperature of 20°C ± 5°C (68°F ± 9°F) pressurized to 100 kPa ± 10 kPa (14.7 psi ± 1.5 psi). The specimen shall be subjected to a hydraulic shock of 2 760 kPa ± 200 kPa (400 psi ± 29 psi) for 10 000 cycles at a sinusoidal procedure with a frequency of 0.5 Hz.

14.7.2 Acceptance Criteria. During the test, there shall be no visible leakage of the joint.

14.8 Vibration Test

14.8.1 Test Assembly. A test assembly shall be fabricated using five lengths of copper tube, two couplings, and two elbows as shown in Fig. 7. Two lengths of tube shall be connected with press-connect couplings. Press-connect elbows shall join the three remaining lengths. The sample shall be installed in a test assembly that subjects the system to a vibration while pressurized to 2 760 kPa ± 50 kPa (400 psi ± 7 psi). The test assembly shall be subjected to 1 000 000 vibration cycles. A vibration cycle shall be a forward and reverse movement of 1 mm (0.04 in.) at a frequency of 20 Hz ± 2 Hz. After the vibration cycling, the sample shall be hydrostatically tested to a pressure of 4 140 kPa ± 50 kPa (600 psi ± 7 psi) for a period of 30 min at a temperature of 20°C ± 5°C (68°F ± 9°F).

14.8.2 Acceptance Criteria. During the test, there shall be no visible leakage of the joint.

14.9 Thermocycling Test

14.9.1 Test Assembly. A test assembly shall be constructed using Type L copper tube and press-connect fittings in accordance with Fig. 8. The specimen shall be installed in a test assembly that permits the flow of oxygenated water at a pressure of 1 000 kPa ± 50 kPa (145 psi ± 7 psi). Flow water at a temperature of 20°C ± 5°C (68°F ± 9°F) through the specimen for a period of 15 min for nominal size 2 and smaller, and 30 min for nominal size 2 1/2 and larger. Change the flow to hot water at a temperature of 93°C ± 5°C (200°F ± 9°F) for a period of 15 min for nominal size 2 and smaller, and 30 min for nominal size 2 1/2 and larger. Continue this cycling for 5 000 cycles for nominal size 2 and smaller, and 2 500 cycles for nominal size 2 1/2 and larger. The water temperature in the piping shall reach the change in temperature within a period of 2 min.

14.9.2 Acceptance Criteria

(a) During the test, there shall be no visible leakage of the joint.

(b) The elastomeric material shall conform to para. 6.3(d).

14.10 Dynamic Torque Test

14.10.1 Test Assembly. Prepare two samples with a copper press-connect coupling joining two lengths of copper tube. Install one test assembly in a dynamic torque test assembly that twists the tube, at the non-fixed end, with respect to the coupling, ±5 deg ± 0.5 deg, as shown in Fig. 9. At a temperature of 20°C ± 5°C (68°F ± 9°F), cycle the specimen 10 000 times (a cycle is twisting one direction, reversing and twisting in the other direction). Repeat the test with the second sample at a temperature of 93°C ± 2°C (200°F ± 5°F). After completing the twisting cycles, the samples shall be hydrostatically tested to a pressure of 2 760 kPa ± 50 kPa (400 psi ± 7 psi) for a period of 1 h at a temperature of 20°C ± 5°C (68°F ± 9°F).

14.10.2 Acceptance Criteria. During the test, there shall be no visible leakage of the joint.

Fig. 7 Test Setup for Vibration Test

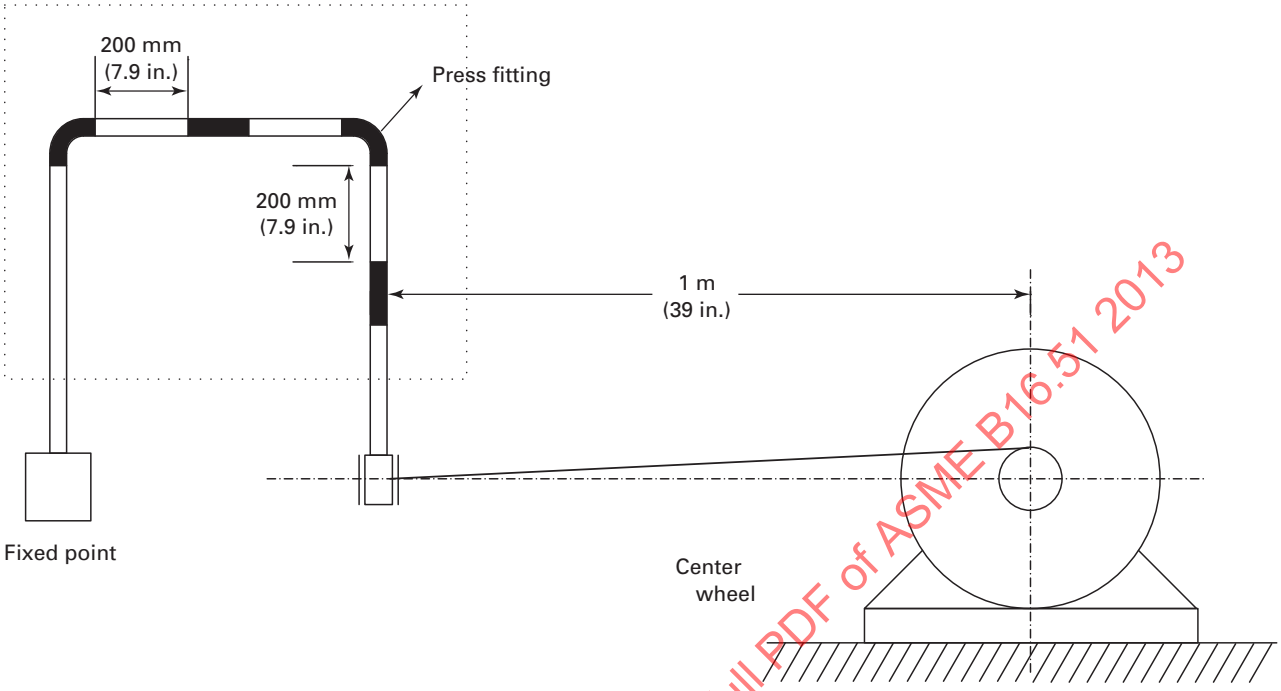


Fig. 8 Test Setup for Thermocycling Test

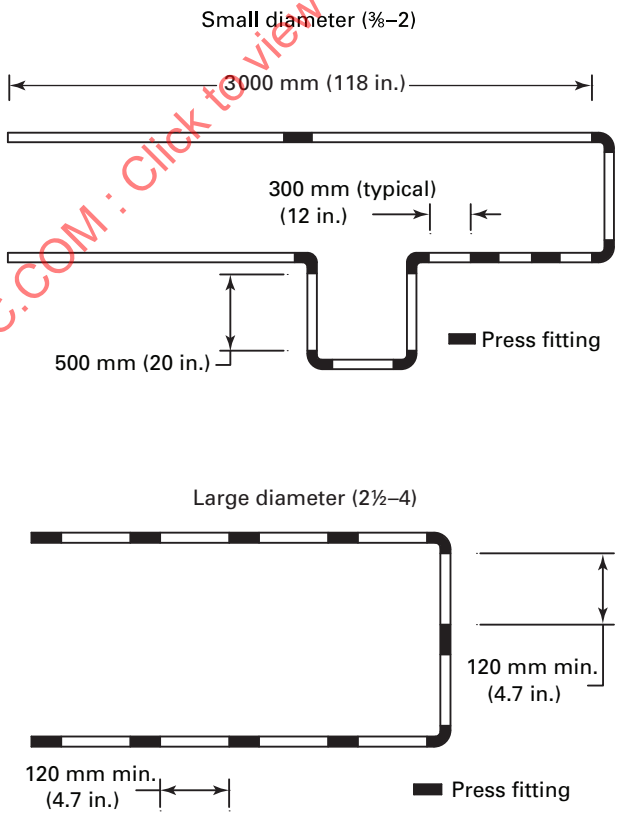
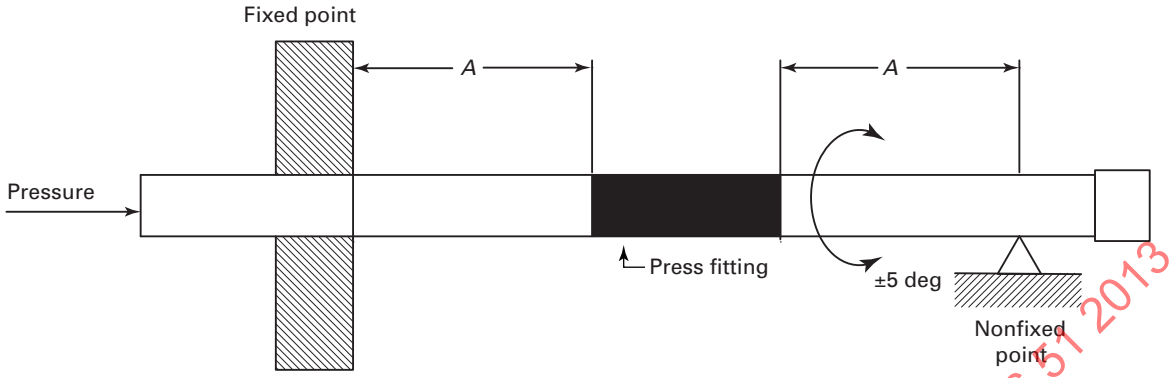


Fig. 9 Test Setup for Dynamic Torque Test

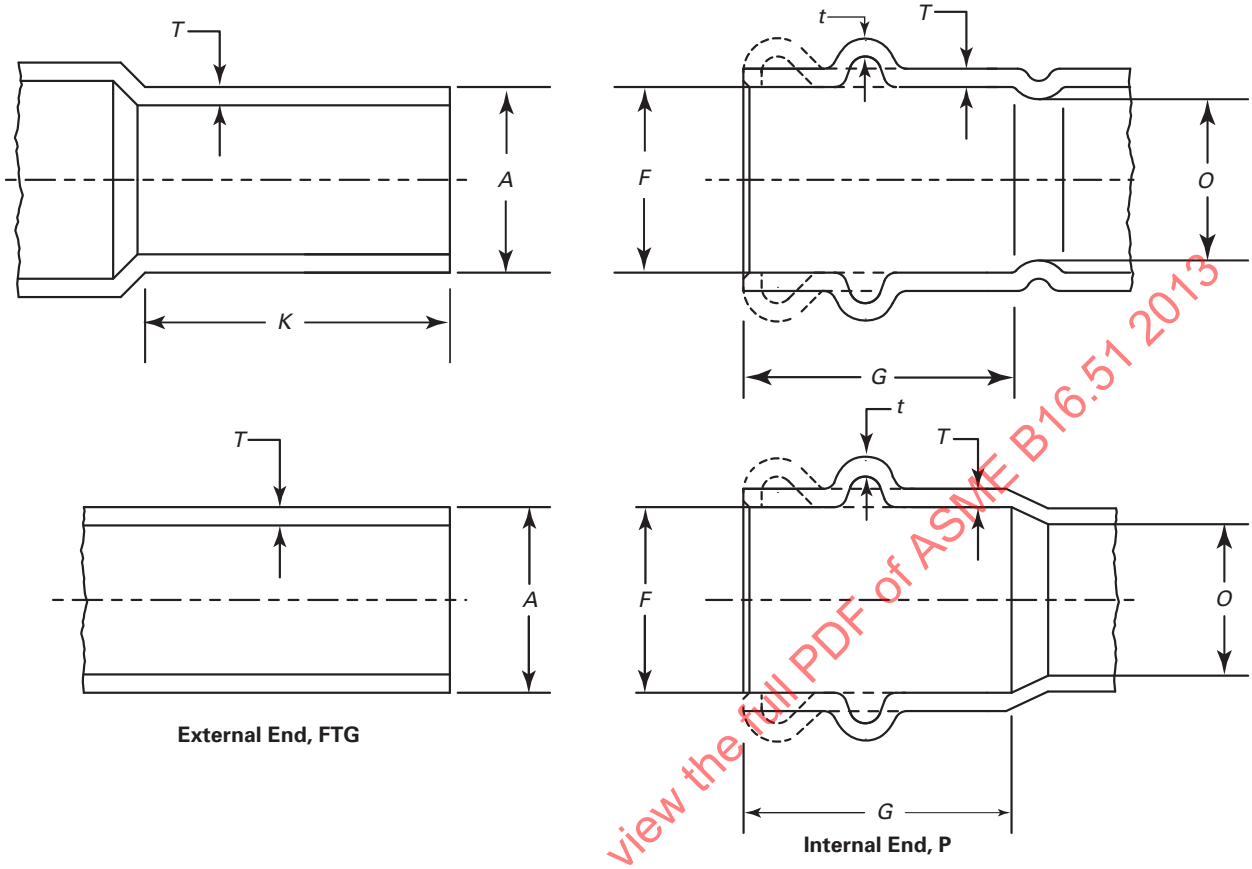


Tubing Size	Distance *A*, mm (in.)
⅜–2½	400 (15.7 in.)
3–4	600 (23.6 in.)

MANDATORY APPENDIX I
U.S. CUSTOMARY EQUIVALENTS

U.S. Customary equivalents are given in Tables I-1 through I-4.

Table I-1 Dimensions of Press-Connect Ends



Standard Water Tube Size [Note (1)]	External End			Internal End			Wall Thickness				Minimum Inside Diameter of Fitting, *O*
	Outside Diameter, *A*		Minimum Length, *K* [Note (2)]	Inside Diameter, *F*		Depth, *G* [Note (3)]	Minimum Wrought		Minimum Cast		
	Min.	Max.		Min.	Max. [Note (3)]		*T*	*t*	*T*	*t*	
3/8	0.497	0.501	0.44	0.502	...	...	0.026	0.018	0.05	0.05	0.39
1/2	0.622	0.626	0.56	0.627	...	...	0.029	0.020	0.05	0.05	0.52
3/4	0.872	0.876	0.81	0.877	...	...	0.033	0.023	0.05	0.05	0.74
1	1.122	1.127	0.97	1.128	...	...	0.040	0.028	0.05	0.05	0.98
1 1/4	1.372	1.377	1.03	1.378	...	...	0.044	0.031	0.05	0.05	1.23
1 1/2	1.621	1.627	1.16	1.628	...	...	0.051	0.036	0.07	0.07	1.47
2	2.121	2.127	1.41	2.128	...	...	0.059	0.041	0.07	0.07	1.94
2 1/2	2.621	2.627	1.53	2.628	...	...	0.067	0.047	0.12	0.12	2.42
3	3.121	3.127	1.72	3.128	...	...	0.075	0.053	0.12	0.12	2.89
3 1/2	3.621	3.627	1.97	3.628	...	...	0.086	0.060	0.12	0.12	3.37
4	4.121	4.127	2.22	4.128	...	...	0.096	0.067	0.12	0.12	3.84

GENERAL NOTES:

(a) Dimensions are in inches.

(b) Drawings and designs of fittings are illustrative only.

(c) Number of O-rings and locations shall be specified by the manufacturer and is shown for two typical locations.

NOTES:

(1) For size designation of fittings, see section 4.

(2) The distance from the point of tangency, at the gage inside diameter to the gage line, shall be equal to the dimension shown under the column titled External End, Minimum Length, *K*.

(3) The maximum inside diameter and depth of the internal end shall be at the option of the manufacturer.

Table I-2 Maximum Slippage

Standard Water Tube Size	Maximum Slippage (in.) per Joint After 1 hr	Maximum Additional Slippage (in.) per Joint After First Hour
3/8	0.012	0.002
1/2	0.012	0.002
3/4	0.012	0.002
1	0.032	0.002
1 1/4	0.039	0.002
1 1/2	0.059	0.002
2	0.079	0.002
2 1/2	0.098	0.004
3	0.118	0.004
3 1/2	0.138	0.004
4	0.157	0.004

Table I-3 Torque

Standard Water Tube Size	Torque, lb-ft
3/8	8
1/2	15
3/4	18
1	29
1 1/4	41
1 1/2	52
2	74
2 1/2	96
3	122
3 1/2	147
4	177

Table I-4 Concentrated Load

Standard Water Tube Size	Static Load, lb
3/8	9
1/2	25
3/4	40
1	53
1 1/4	68
1 1/2	84
2	110
2 1/2	138
3	170
3 1/2	204
4	240