



# Standard Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing<sup>1</sup>

This standard is issued under the fixed designation F2159; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification establishes requirements for sulfone plastic insert fittings and copper crimp rings, or alternate stainless steel clamps for four sizes Nominal Tubing Sizes (NTS) ( $\frac{3}{8}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$ , and 1) of cross-linked polyethylene (PEX) tubing that meet the requirements for Specification **F876** or Specification **F3253**, or polyethylene of raised temperature (PE-RT) tubing that meet the requirements of Specification **F2623** or Specification **F2769**. These fittings are intended for use in 100 psi (690 kPa) cold- and hot-water distribution systems operating at temperatures up to and including 180 °F (82 °C). Included are the requirements for material, molded part properties, performance, workmanship, dimensions, and markings to be used on the fittings and rings.

1.1.1 When used with PEX tubing in accordance with Specification **F876**, the fittings covered by this specification are intended for use in, but not limited to, residential and commercial, hot- and cold-potable water distribution systems, reclaimed water, fire protection, municipal water service lines, radiant heating and cooling systems, hydronic distribution systems, snow and ice melting systems, geothermal ground loops, district heating, turf conditioning, compressed air distribution, and building services pipe.

1.1.2 When used with PEX tubing in accordance with Specification **F3253**, the fittings covered by this specification are intended for use in residential and commercial hydronic heating and cooling systems.

1.1.3 When used with PE-RT tubing in accordance with Specification **F2769**, the fittings covered by this specification are intended for use in residential and commercial, hot- and cold-potable water distribution systems.

1.1.4 When used with PE-RT tubing in accordance with Specification **F2623**, the fittings covered by this specification are intended for use in general fluid transport, including hydronics and irrigations systems.

1.2 Included are the requirements for material, molded part properties, performance, workmanship, dimensions, and markings to be used on the fittings and rings.

1.3 The following is an index of the appendix in this specification:

GO/NO-GO Crimp Gauges

Appendix X1

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee **F17** on Plastic Piping Systems and is the direct responsibility of Subcommittee **F17.10** on Fittings. Current edition approved Nov. 1, 2020/May 1, 2021. Published November 2020/May 2021. Originally approved 2001. Last previous edition approved in 2019/2020 as F2159-19a-20. DOI: 10.1520/F2159-20.10.1520/F2159-21.

\*A Summary of Changes section appears at the end of this standard

1.4 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 The following precautionary caveat pertains only to the test method portions, Sections 11 and 12, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- D618 Practice for Conditioning Plastics for Testing
- D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
- D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings
- D1600 Terminology for Abbreviated Terms Relating to Plastics
- D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
- D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
- D6394 Classification System for and Basis for Specification for Sulfone Plastics (SP)
- F412 Terminology Relating to Plastic Piping Systems
- F876 Specification for Crosslinked Polyethylene (PEX) Tubing
- F1498 Specification for Taper Pipe Threads 60° for Thermoplastic Pipe and Fittings
- F1807 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing
- F2098 Specification for Stainless Steel Clamps for Securing SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) to Metal Insert and Plastic Insert Fittings
- F2623 Specification for Polyethylene of Raised Temperature (PE-RT) Systems for Non-Potable Water Applications
- F2769 Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems
- F3253 Specification for Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems

### 2.2 ASME Standard:

- B 1.20.1 Pipe Threads General Purpose Inch<sup>3</sup>

### 2.3 NSF International Standard:

- ANSI/NSF Standard No. 14 for Plastic Piping Components and Related Materials<sup>4</sup>
- ANSI/NSF Standard No. 61 for Drinking Water System Components-Health Effects<sup>4</sup>

### 2.4 ISO Standards:<sup>5</sup>

- ISO 9080 Plastics piping and ducting systems -- Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation
- ISO 12162 Thermoplastics materials for pipes and fittings for pressure applications –Classification, designation and design coefficient

## 3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>4</sup> Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, <http://www.nsf.org>.

<sup>5</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

#### 4. Classification

4.1 This specification governs one class of fittings and copper crimp rings or alternate stainless steel clamps suitable for use with nominal size  $\frac{3}{8}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$  and 1 size PEX tubing that meets the requirements of Specification **F876** or Specification **F3253** and PE-RT tubing that meets the requirements of Specification **F2623** or Specification **F2769**.

#### 5. Materials and Manufacture

5.1 *Material*—Fittings shall be molded from sulfone plastic (SP) as specified in Specification **D6394**. The material shall be unreinforced polysulfone (group 01, class 1, grades 1 or 2) or polyphenylsulfone (group 03, class 1, grade 1 or 2) or unreinforced polyphenylsulfone/polysulfone blends (group 04, Class 1, grade 2) or reworked plastic in accordance with **5.1.1**.

NOTE 1—Since fittings specified by this standard will be used in hot-and-cold water plumbing systems, a material used to manufacture fittings in accordance with this specification must demonstrate qualities consistent with that application in addition to the performance requirements of this specification. Those qualifying characteristics include, but are not limited to, an established ~~stress~~hydrostatic design basis (~~SDB~~)(HDB) in accordance with Test Method **D2837** ~~pressure design basis (PDB)~~ or ISO 9080/ ISO 12162 minimum required strength (MRS) and a demonstration of resistance to the long-term effects of those chemicals normally found in potable water at the maximum temperature stated in this specification.

5.1.1 *Rework Material*—Clean rework material of the same commercial designation, generated from the manufacturer’s own production may be used by the same manufacturer, provided the fittings meet all of the requirements of this specification. Reworked material shall not be introduced at a ratio exceeding 25 %.

5.2 *Potable Water Requirements*—Products intended for the transport of potable water shall be evaluated, tested and certified for conformance with ANSI/NSF Standard No. 61 or the health effects portion of ANSI/NSF Standard No. 14 by an acceptable certifying organization when required by the regulatory authority having jurisdiction.

5.3 *Crimp Rings*—Crimp rings shall be manufactured and marked in accordance with the requirements of Specification **F1807**.

5.4 *Alternate Stainless Steel Clamps*—Clamps shall be made from stainless steel in conformance with all requirements of Specification **F2098**.

#### 6. Molded Part Properties

6.1 *Insert Crush*—The fitting insert shall not crack, split, or shatter when tested in accordance with **12.1**.

6.2 *Splay*—The molded part shall be free of visible splay excepting some slight blushing at the gate location.

#### 7. Performance Requirements

7.1 *General*—All performance tests shall be performed on assemblies of fittings, crimp rings, or alternate stainless steel clamps, and PEX tubing or PE-RT tubing, or both. Fittings and crimp rings shall meet the material and dimensional requirements of this standard. PEX tubing shall meet the requirements of Specification **F876** or Specification **F3253**. PE-RT tubing shall meet the requirements of Specification **F2623** or Specification **F2769**. Assembly of test specimens shall be in accordance with Section **10**. Use separate sets of assemblies for each performance test requirement.

7.2 *Hydrostatic Burst*—Assemblies shall meet the minimum hydrostatic burst requirements shown in **Table 1**, when tested in accordance with **11.5**.

7.3 *Hydrostatic Sustained Pressure Strength*—Assemblies shall meet the hydrostatic sustained pressure requirements shown in **Table 2** when tested in accordance with **11.6**.

7.4 *Thermocycling*—Assemblies shall not leak or separate when thermocycled 1000 cycles between the temperatures of 60 °F (16 °C) and 180 °F (82 °C) when tested in accordance with **11.7**.

7.5 *Excessive Temperature-Pressure Capability:*

**TABLE 1 Minimum Hydrostatic Burst Strength Requirements for Fitting, Crimp Ring, or Alternate Stainless Steel Clamps, and PEX Tubing or PE-RT Tubing Assemblies**

Nominal Tubing Size	Minimum Burst Pressures at Different Temperatures			
	psig <sup>A</sup> at 73.4°F	(kPa) at (23°C)	psig <sup>A</sup> at 180°F	(kPa) at (82.2°C)
in.				
3/8	620	(4275)	275	(1896)
1/2	480	(3309)	215	(1482)
3/4 and larger	475	(3275)	210	(1448)

<sup>A</sup> The fiber stress to derive this test pressure is: at 73.4 °F (23.0 °C) 1900 psi (13.10 MPa) at 180 °F (82.2 °C) 850 psi (5.86 MPa).

**TABLE 2 Minimum Hydrostatic Sustained Pressure Requirements for Fitting, Crimp Ring, or Alternate Stainless Steel Clamps, and PEX or PE-RT Tubing Assemblies<sup>A, B</sup>**

Nominal Tubing Size	Pressure Required for Test, psig (kPa)	
	180 °F	(82.2 °C)
in.		
3/8	250	(1724)
1/2	195	(1344)
3/4 and larger	190	(1310)

<sup>A</sup> The fiber stress to derive this test pressure is: 770 psi (5.31 MPa) at 180 ° F (82.2 °C).

<sup>B</sup> Test duration is 1000 h.

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7.5.1 *General*—Assemblies shall have adequate strength to accommodate short-term conditions, 30 days (720 h) of 210 ° F (99 °C) and 150 psi (1034 kPa) when tested in accordance with 11.8.

## 8. Dimensions

8.1 *Dimensions and Tolerances*—The dimensions and tolerances of fittings shall be as shown in Fig. 1, when measured in accordance with 11.4. When used, alternate stainless steel clamps shall conform to the dimensional specifications of F2098.

8.1.1 *Alignment*—The maximum angular variation of any opening shall not exceed 1° off the true centerline axis.

8.1.2 *Tapered Threads*—Fitting threads shall be American National Standard Taper Pipe Thread Form conforming to Specification F1498.

8.1.3 *Straight Threads*—Straight pipe threads, intended for the making of a gasketed seal with taper pipe threads, shall be NPSM and conform to ASME B 1.20.1.

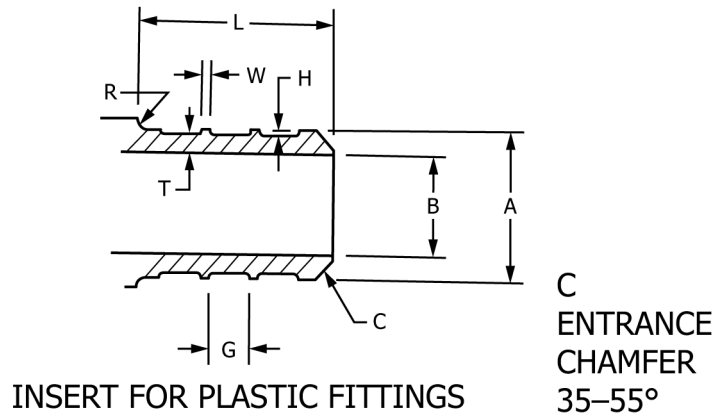
## 9. Workmanship, Finish, and Appearance

9.1 The sealing surfaces of the insert shall be smooth and free of foreign material. The fitting walls shall be free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the unaided eye and that affect the wall integrity.

9.2 Except for the insert, the molded part shall be free of flash in excess of 0.005 in. Flash, mismatch, and witness mark requirements for the insert shall be in accordance with Fig. 1.

## 10. Assembly

10.1 *Crimp Joints*—Insert fittings shall be joined to PEX tubing or PE-RT tubing by the compression of a copper crimp ring around the outer circumference of the tubing forcing the tubing material into annular spaces formed by ribs on the fitting. Insert fittings and crimp rings shall meet the dimensional and material requirements of this standard. PEX tubing shall meet the requirements of Specification F876 or Specification F3253. PE-RT tubing shall meet the requirements of Specification F2623 or Specification F2769. The dimensions and out-of-roundness of the crimp ring after it has been crimped shall be in accordance with Table 3.



SIZE	A OUTSIDE DIAMETER	B MINIMUM ID	L INSERT LENGTH <sup>B</sup>	H MINIMUM RIB HEIGHT	NUMBER OF RIBS <sup>E</sup>	W RIB WIDTH TYP	G GAP WIDTH TYP	T MINIMUM WALL <sup>A</sup>	R MINIMUM RADIUS	MAXIMUM FLASH AND MISMATCH TOTAL ON CREST DIAMETER <sup>D,F</sup>
3/8"	0.347±.003	0.197	0.70+.020	0.015	2	0.03-0.05	0.135- 0.152	0.050	0.03	0.005
1/2"	0.473±.003	0.315	0.70+.020	0.015	2	0.03-0.05	0.135- 0.152	0.056	0.03	0.005
3/4"	0.668±.003	0.460	0.70+.020	0.015	2	0.03-0.05	0.135- 0.152	0.082	0.03	0.005
1"	0.856±.003	0.610	0.85+.020	0.015	3	0.03-0.05	0.135- 0.152	0.100	0.03	0.005

<sup>A</sup> APPLIES TO ENTIRE FITTING NOT JUST INSERT AREA.

<sup>B</sup> FITTING SHALL BE DESIGNED WITH SUFFICIENT OVERALL DIMENSIONS TO ALLOW PROPER USE OF CRIMP TOOL WITHOUT INTERFERENCE WITH PREVIOUSLY COMPLETED CRIMPS ON THE SAME FITTING.

<sup>C</sup> THE MAXIMUM FLASH AND MISMATCH AT THE ROOT DIAMETER BETWEEN THE RIBS MAY NOT EXCEED 30% OF THE RIB HEIGHT.

<sup>D</sup> THE TOTAL FLASH AND MISMATCH IS ASSUMED TO BE THE DIFFERENCE BETWEEN THE DIMENSIONS X AND Y (SEE FIG. 1A). THESE DIMENSIONS MAY BE MEASURED WITH APPROPRIATE CALIPERS OR MICROMETERS. SEE FIG. 1B FOR A GRAPHIC DEFINITION OF FLASH AND MISMATCH CREATED BY IMPERFECTION IN DIE HALF INTERFACES.

<sup>E</sup> LEAD CHAMFER AREA IS NOT CONSIDERED A RIB.

<sup>F</sup> THE MINIMUM ID SHALL BE MAINTAINED THROUGH THE INSERT LENGTH AND INTO THE FITTING, INTERSECTING THE MINIMUM ID OF THE OTHER FITTING INSERT(S).

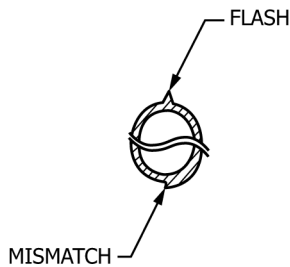


FIG. 1A FLASH AND MISMATCH CREATED BY IMPERFECTION IN DIE HALF INTERFACES.

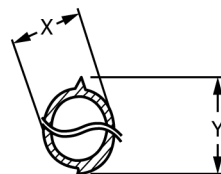


FIG. 1B TOTAL FLASH AND MISMATCH

**FIG. 1 Fitting Insert Dimensions and Tolerances**

**TABLE 3 Crimp Ring Dimensions After Crimping on Tube/Fitting Assembly**

Nominal Tube Size Insert End	Final Crimped Outside Diameter <sup>A,B</sup>	
	Minimum, in. (mm)	Maximum, in. (mm)
3/8	0.580 (14.7)	0.595 (15.1)
1/2	0.700 (17.8)	0.715 (18.2)
3/4	0.945 (24.0)	0.960 (24.4)
1	1.175 (29.8)	1.190 (30.2)

<sup>A</sup> For all diameters except for the area of scoring caused by the crimping tool.

<sup>B</sup> The maximum out-of-roundness as measured by the difference between the minimum crimped outside diameter and the maximum crimped outside diameter shall not exceed 0.006 in. (0.150 mm).

10.1.1 *Crimping Procedure*—To affix the insert fitting to the tubing with the crimp ring, the crimping procedure shall be as follows: slide the crimp ring onto the tubing, insert the ribbed end of the fitting into the end of the tubing until the tubing contacts the shoulder of the fitting or tube stop. The crimp ring shall then be positioned on the tubing so the edge of the crimp ring is 1/8 in. to 1/4 in. (3.2 to 6.4 mm) from the end of the tube. The jaws of the crimping tool shall be centered over the crimp ring and the tool shall be held so that the crimping jaws are approximately perpendicular to the axis of the barb. The jaws of the crimping tool shall be closed around the crimp ring, compressing the crimp ring onto the tubing. The crimp ring shall not be crimped more than once. Each crimp shall be checked to determine conformance to the after crimped dimensional requirements of **Table 3**.

10.2 *Clamp Joints*—Insert fittings shall be joined to PEX tubing by deforming and locking a stainless steel clamp around the outer circumference of the tubing, forcing the tubing material into annular spaces formed by the ribs on the fitting. Plastic insert fittings shall meet the material and dimensional requirements of this specification. PEX tubing shall meet the requirements of Specification **F876**. PE-RT tubing shall meet the requirements Specifications **F2623** and **F2769**. Clamps shall meet the dimensional and material requirements of Specification **F2098**.

10.2.1 *Clamping Procedure*—The clamping procedure shall be as follows: slide the clamp onto the tubing, insert the ribbed end of the fitting into the end of the tubing until the tubing contacts the shoulder of the fitting or tube stop. The clamp shall then be positioned on the tubing so the edge of the clamp is 1/8 to 1/4 in. (3.2 to 6.4 mm) from the end of the tube. The ratcheting clamping tool shall be used to close the clamp. The tool shall not release until the clamp is properly closed.

10.2.2 *Clamping Tools*—Clamps and ratcheting hand tools from different manufacturers have similar appearances. Clamps shall be installed using the tools and calibration methods recommended by the clamp manufacturer.

## 11. Test Methods

11.1 *Conditioning*—Condition specimens at 73 ± 4 °F (23 ± 2 °C) and 50 ± 5 % relative humidity for not less than 4 h prior to testing. Test Method **D618** shall be used to the extent possible as a guide to other conditions.

11.2 *Test Conditions*—Conduct the tests in the standard laboratory atmosphere at 73 ± 4 °F (23 ± 2 °C) and 50 ± 5 % relative humidity unless otherwise specified in the test methods or in this specification.

11.3 *Sampling*—A sample of the fittings, crimp rings, or alternate stainless steel clamps, and PEX tubing sufficient to determine conformance with this specification shall be taken at random.

11.4 *Dimensions*—Any randomly selected fitting or fittings and crimp ring or crimp rings shall be used to determine dimensions. Measurements shall be made in accordance with Test Method **D2122**. Determine the diameters by making measurements at four locations spaced at approximately 45° apart around the circumference.

11.5 *Burst Pressure*—Determine the minimum burst pressure in accordance with Test Method **D1599** on at least six assemblies for each temperature in **Table 1**. Leakage or separation at any of the joints tested, or from the fitting itself, at less than the minimum burst requirements for the temperatures specified in **Table 1** shall constitute a failure in this test.

11.6 *Sustained Hydrostatic Pressure*—Perform the test on at least six assemblies in accordance with Test Method **D1598**, except for the following:

11.6.1 Test temperature shall be  $180 \pm 4$  °F ( $82 \pm 2$  °C).

11.6.2 The external test environment shall be air or water.

11.6.3 Condition the specimens in accordance with Test Method **D1598**

11.6.4 Leakage or separation at any joint tested at less than 1000 h at the sustained pressure as given in **Table 2** shall constitute failure in this test.

11.7 *Thermocycling:*

11.7.1 *Summary of Test Method*—This test method describes a pass-fail test for thermally cycling assemblies comprised of insert fitting, crimp ring, or alternate stainless steel clamps, and PEX tubing over a critical temperature range for a selected number of cycles while subjected to an internal pressure. The test provides a measure of resistance to failure due to the combined effects of differential thermal expansion and creep of connections intended for use up to and including 180 °F (82 °C).

11.7.2 *Apparatus*—A pressure source capable of maintaining an internal pressure of  $100 \pm 10$  psi ( $690 \pm 69$  kPa) on the specimens is required. An immersion system shall consist of two water reservoirs controlled at  $60 \pm 4$  °F ( $16 \pm 2$  °C) and  $180 \pm 4$  °F ( $82 \pm 2$  °C) into which the pressurized specimens will be immersed. Either samples are cycled manually using flexible connectors or alternately the hot and cold water is cycled over the test specimens automatically and returned to the proper reservoir (**Note 2**).

NOTE 2—Automatic recycling may be accomplished by pumping from each reservoir through a delivery system having timer-actuated valves to specimen troughs having synchronized, timer-actuated return drains. Any automatic apparatus shall provide for complete immersion of the test specimen in the water.

11.7.3 *Specimen Assembly*—Test six assemblies. Attach the assemblies to a common manifold in such a way to allow free-end movement of the tubing. Close this specimen assembly with any suitable end closure that will allow free-end mounting and will not leak under the thermocycle conditions, and connect the specimen assembly to the pressure source.

11.7.4 *Procedure*—Pressurize the specimen assembly with air to  $100 \pm 10$  psi ( $690 \pm 69$  kPa) and check for leaks. Eliminate any leaks before the thermocycle test is started. Thermally cycle the specimen assembly either manually or automatically and under a constant internal pressure of  $100 \pm 10$  psi ( $690 \pm 69$  kPa), alternately between  $60 \pm 4$  °F ( $16 \pm 2$  °C) and  $180 \pm 4$  °F ( $82 \pm 2$  °C) by means of immersion in water using the following test cycle (**Note 3**):

Water immersion at 180 °F	2 min minimum
Air immersion at ambient	2 min maximum
Water immersion at 60 °F	2 min minimum
Air immersion at ambient	2 min maximum

NOTE 3—If the test must be interrupted before completion, samples are to be kept at room temperature until the test is restarted.

11.7.4.1 Upon completion of 1000 cycles, visually inspect for leaks while under the test pressure. Any evidence of leakage at the fittings or separation of the fittings from the tubing constitutes failure.

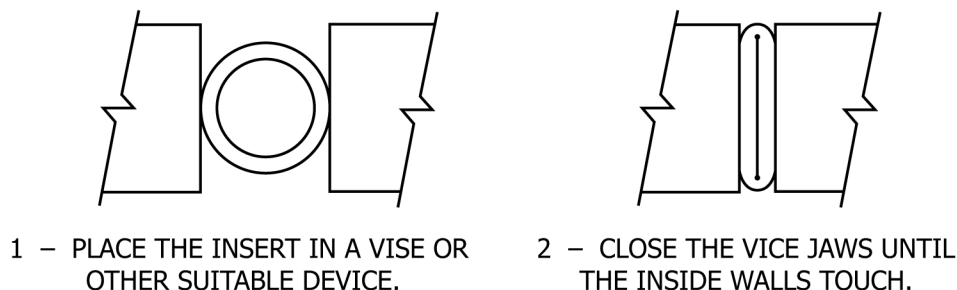


FIG. 2 Insert Crush Test