



Standard Specification for Multilayer Pipe Type 2, Compression Fittings, and Compression Joints for Hydronic Heating Systems¹

This standard is issued under the fixed designation F 1987; 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 (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers requirements for multilayer pipe type 2 and compression fittings for hydronic heating systems, with a maximum pressure/temperature range of 1000 kPa (145 psi), at 82°C (180°F).

NOTE 1—*Multilayer Pipe Type 2*—Construction-based pressure rated pipe comprising more than one layer in which at least 60 % of the wall thickness is polymeric material.

1.2 Multilayer pipe type 2 is produced using a butt-welded aluminum pipe as a core, with an extruded inside layer of crosslinked polyethylene (PEX). An adhesive layer is used to bond the inside layer to the wall of the aluminum pipe. An outer layer of polyethylene (PE) and an adhesive layer are extruded to the outer wall of the aluminum pipe.

1.3 Multilayer pipe type 2 is produced in Configurations 1 and 2, as shown in Fig. 1.

1.4 This specification includes compression fittings, which are referenced in Fig. 2.

1.5 The following safety hazards caveat pertains only to the test method portion 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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

NOTE 2—Multilayer pipe type 2, configurations 1 and 2, for hydronic heating systems are not compatible for drinking water use.

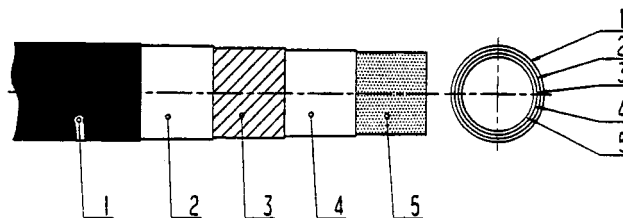
2. Referenced Documents

2.1 ASTM Standards:

¹ This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.11 on Composite.

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Layer:	1	2	3	4	5
Configuration 1	HDPE	Adhesive Layer	Al - Alloy	Adhesive Layer	PEX ⁽¹⁾ crosslinkable
Configuration 2	MDPE	Adhesive Layer	Al - Alloy	Adhesive Layer	PEX ⁽¹⁾ crosslinkable

PEX ⁽¹⁾: Material is being crosslinked partially during manufacturing process. Final crosslinking takes place during use.

FIG. 1 Multilayer Pipe Sample for Configurations 1 and 2

B 283 Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)²

B 455 Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes²

B 547/B 547M Specification for Aluminum and Aluminum-Alloy Formed and Arc-Welded Round Tube³

B 584 Specification for Copper Alloy Sand Castings for General Applications²

² Annual Book of ASTM Standards, Vol 02.01.

³ Annual Book of ASTM Standards, Vol 02.02.

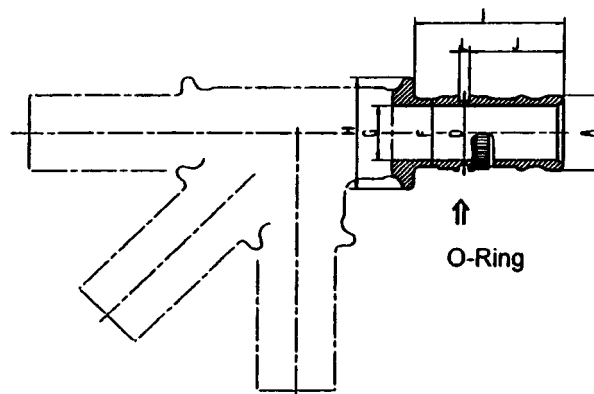


FIG. 2 Compression Fittings and O-Rings for Multilayer Pipe

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing⁴
- D 1505 Test Method for Density of Plastics by the Density-Gradient Technique⁴
- D 1525 Test Method for Vicat Softening Temperature of Plastics⁴
- D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure⁵
- D 1600 Terminology for Abbreviated Terms Relating to Plastics⁴
- D 1898 Practice for Sampling of Plastics⁴
- D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings⁵
- D 3222 Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials⁶
- D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials⁶
- D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics⁷
- F 412 Terminology Relating to Plastic Piping Systems⁵
- F 477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe⁵
- 2.2 *ISO Standard*:⁸
- ISO 10508 Thermoplastics Pipe and Fittings for Hot and Cold Water Systems
- 2.3 *ARP Standard*:⁹
- AS 568 A Aerospace Size Standard for O-Rings

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600, unless otherwise specified.

3.1.1 *crosslinkable polyethylene, n*—plastic prepared by crosslinking (curing) of PE compound partially during manufacturing process and final crosslinking during use.

3.1.2 *crosslinked polyethylene (PEX), n*—plastic prepared by crosslinking (curing) of polyethylene compound.

3.1.3 *multilayer pipe type 2, n*—pipe consisting of different materials with specific functional purpose to serve as pipe.

3.1.4 *pressure ratings, PR, n*—the maximum, continuous water pressure at a specified temperature that is capable of withstanding without failure.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *adhesive, n*—a low-molecular-weight PE that functions as an adhesive layer and bonds the PEX to aluminum pipe.

3.2.2 *compression fittings for multilayer pipe, n*—fittings developed specially for multilayer pipe in which the aluminum core is used as compression sleeve to develop sufficient mechanical strength for the connection (see Fig. 2).

3.2.3 *lot, n*—all pipe of the same size produced from one extrusion line during one designated period.

3.2.4 *multilayer pipe*—abbreviation used in this specification for multilayer pipe type 2.

4. Classification

4.1 Multilayer pipe and compression fittings produced under this specification shall be suitable for hydronic heating systems at specified pressure ratings and temperatures.

5. Materials and Manufacture

5.1 *Specification for Material and Manufacture of Multilayer Pipe Configurations 1 and 2*:

5.1.1 *Polyethylene (PE)*, shall meet the requirement provided in Specification D 3350 and shall equal or exceed a minimum cell classification of 234233 B or 345442 B. Color and form of the material shall be in accordance with the agreement between purchaser and supplier under Specification D 3350.

5.1.2 *Crosslinked Polyethylene (PEX)*, shall equal or exceed a minimum cell classification 344543 A. Form of the material shall be in accordance with the agreement between purchaser and supplier under Specification D 3350.

5.1.3 *Adhesive Polymers*, shall be modified low molecular weight PE with a minimum density of 0.915 g/cm³ and different levels of comonomer for adhesion to aluminum and other substrates. The melting point shall not be less than 120°C (248°F). Density shall be determined in accordance with Test Method D 1505 and melting point in accordance with Test Method D 1525.

5.1.4 *Aluminum Pipe—Mechanical Properties*—Minimum tensile strength shall be 80 MPa (11 600 psi), minimum elongation shall be 22 % A5, in accordance with Test Method B 547/B 547M.

5.1.5 *Reusable Material*—Reusable material as defined in Guide D 5033 issued from the multilayer pipe manufacturer shall be used for the outside coating of the multilayer pipe.

5.2 *Specification for Material and Manufacture of Compression Fittings for Multilayer Pipe*:

5.2.1 Compression fittings made from cast bronze shall meet the requirements of Specification B 584 UNS copper alloy C 83600.

5.2.2 Compression fittings made from brass shall meet the requirements of Specification B 455, copper alloy C 38500 or Specification B 283 copper alloy C 37700.

5.2.3 Compression fittings made from plastic shall be injection molded from virgin material and meet the requirements of Specification D 3222, Type II.

5.3 *Material Specification for O-Rings*—The O-ring material shall be EPDM, with a hardness of 70° IRHD, in accordance with Specification F 477. O-ring dimensions shall be in accordance with AS 568 A.

6. Requirements

6.1 *Multilayer Pipe Dimensions*:

6.1.1 *Outside Diameter*—The outside diameter shall meet the requirements of Table 1, when measured in accordance with Test Method D 2122.

6.1.2 *Wall Thickness*—The wall thickness of composite pipe

⁴ Annual Book of ASTM Standards, Vol 08.01.

⁵ Annual Book of ASTM Standards, Vol 08.04.

⁶ Annual Book of ASTM Standards, Vol 08.02.

⁷ Annual Book of ASTM Standards, Vol 08.03.

⁸ Available from American National Standards Institute, 11 West 42nd Street, 13th floor, New York, NY, 10036.

⁹ Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

TABLE 1 Composite Pipe Dimensions

Config-uration	Outside Diameter, mm (in.)	Inside Diameter, mm (in.)	Wall Thickness, mm (in.)	Thickness of Inside PEX Layer, mm (in.)	Thickness of Inside Adhesive Layer, mm (in.)	Aluminum Thickness, mm (in.)	Thickness of Outside Adhesive Layer, mm (in.)	Thickness of Outside HDPE Layer, mm (in.)	Out-of-Roundness Minimum Inside Diameter, mm (in.)
1	26 ± 0.2 (1.024 ± 0.008)	20 ± 0.2 (0.787 ± 0.008)	3.00 +0.25 -0.1 (0.118 +0.010 -0.004)	1.25 ± 0.15 (0.049 ± 0.006)	0.15 (0.006)	0.70 +0.06 -0.02 (0.028 +0.002 -0.001)	0.15 (0.006)	0.75 ± 0.15 (0.030 ± 0.006)	19.3 (0.760)
	16 ± 0.2 (0.630 ± 0.008)	11.5 ± 0.2 (0.453 ± 0.008)	2.25 +0.2 -0.1 (0.089 +0.008 -0.004)	0.60 +0.15 -0.1 (0.024 +0.006 -0.004)	0.15 (0.006)	0.40 +0.01 -0.03 (0.016 +0.000 -0.001)	0.15 (0.006)	0.95 +0.2 -0.1 (0.037 +0.008 -0.004)	10.8 (0.425)
2	20 ± 0.2 (0.787 ± 0.008)	15 ± 0.2 (0.591 ± 0.008)	2.50 +0.2 -0.1 (0.098 +0.008 -0.004)	0.70 +0.2 -0.1 (0.028 +0.008 -0.004)	0.15 (0.006)	0.47 +0.01 -0.03 (0.019 +0.000 -0.001)	0.15 (0.006)	1.03 +0.2 -0.1 (0.041 +0.008 -0.004)	14.3 (0.563)

shall meet the requirements of Table 1 when measured in accordance with Test Method D 2122. The wall thickness and the outside diameter of the aluminum pipe shall be determined prior to the next manufacturing steps.

6.1.3 *Average Thickness of Inner and Outer Layers*—The average thickness of the inner and outer layers of the multilayer pipe will be calculated as follows:

6.1.3.1 *Average Thickness of the Outer Layer*—The average outside diameter of the multilayer pipe minus the average outside diameter of the aluminum pipe multiplied by 0.5.

6.1.3.2 *Average Thickness of the Inner Layer*—The average wall thickness of the multilayer pipe minus the average wall thickness of the aluminum pipe minus the average wall thickness of the outer layer.

6.1.4 *Length*—The pipe shall be supplied in coils or in straight lengths in accordance with the agreement between purchaser and seller. The tolerance shall be +100 mm for coiled lengths, and +10 mm for straight lengths.

6.2 *Compression Fitting/Dimensions*—Compression fittings shall meet the requirements of Table 2 when measured in accordance with Test Method D 2122.

6.2.1 *Compression Tool*—The compression tool shall meet the requirements of Table 3 when measured in accordance with Test Method D 2122.

6.3 *Minimum Burst Pressure*—The minimum burst pressure for multilayer pipe and compression fittings for hydronic heating systems shall be as given in Table 5.

6.4 *Sustained Pressure*—The multilayer pipe and fittings shall not fail at the test pressure and temperature given in Table 6 when tested in accordance with 8.1.

6.5 *Thermal Cycling Test*—The multilayer pipe and fittings shall not fail when tested in accordance with 8.2.

6.6 *Excessive Temperature/Pressure Capability*—In the event of a waterheating systems malfunction, the multilayer

TABLE 3

Ø Pipes mm (in.)	16 (0.630)	20 (0.787)	26 (1.024)
a	27.3 (1.075)	30 (1.181)	34.4 (1.354)
b	10.75 (0.423)	12 (0.472)	14.35 (0.565)
c	5.8 (0.228)	6 (0.236)	5.7 (0.224)
d	8.6 (0.339)	9.5 (0.374)	10.9 (0.429)
e	6.85 (0.270)	7.2 (0.283)	8 (0.315)
f	5.8 (0.228)	6 (0.236)	6.4 (0.252)
g	18.2 (0.717)	22.2 (0.874)	28.8 (1.134)
h	14.4 (0.567)	18.3 (0.720)	23.9 (0.941)
j	14.9 (0.587)	18.9 (0.744)	24.7 (0.972)
k	16.2 (0.638)	20.2 (0.795)	26.2 (1.031)

TABLE 4

Pipe Nominal Size, mm (in.)	Tooling Measurements, mm (in.)		
	A ± 0.20 (±0.008)	B ± 0.20 (±0.008)	C ± 0.20 (±0.008)
16 (¾)	11.0 (0.433)	13.6 (0.535)	15.3 (0.602)
20 (¾)	14.5 (0.571)	17.6 (0.693)	20.0 (0.787)
26 (1)	19.5 (0.768)	23.3 (0.917)	25.7 (1.012)

pipe and fittings shall have adequate strength to accommodate short-term conditions, 30 days at 100°C (212°F), 1200 kPa (175 psi) until repairs can be made. Tests will be made in accordance with 8.6.

7. Workmanship, Finish and Appearance

7.1 *Workmanship for Multilayer Pipe*—Multilayer pipe

TABLE 2 Compression Fittings and O-Rings for Multilayer Pipe Dimensions

Ø Pipes mm (in.)	16 (0.630)	20 (0.787)	26 (1.024)
Ø A	11.3 - 0.1 (0.445 - 0.004)	14.8 - 0.1 (0.583 - 0.004)	19.8 - 0.1 (0.780 - 0.004)
Ø D -0.1 (-0.004)	9.2 (0.362)	12.7 (0.500)	17.3 (0.681)
Ø F	10 ± 0.1 (0.394 ± 0.004)	13.4 ± 0.1 (0.134 ± 0.004)	18 ± 0.1 (0.709 ± 0.004)
Ø G	7.4 - 0.3 (0.291 - 0.012)	10.7 - 0.3 (0.421 - 0.012)	15 - 0.3 (0.591 - 0.012)
Ø H -0.2 (-0.008)	17.9 (0.705)	21.9 (0.862)	28.5 (1.122)
I	26 ± 0.2 (1.024 ± 0.008)	28.5 ± 0.2 (1.122 ± 0.008)	33 ± 0.3 (1.299 ± 0.012)
J ± 0.2 (± 0.008)	16.7 (0.657)	18 (0.709)	20.5 (0.807)
L ± 0.1 (± 0.004)	2 (0.079)	2 (0.079)	2.4 (0.094)
O-Ring	8.5×1.5 (0.335×0.059)	12×1.5 (0.472×0.059)	15.6×1.78 (0.614×0.070)

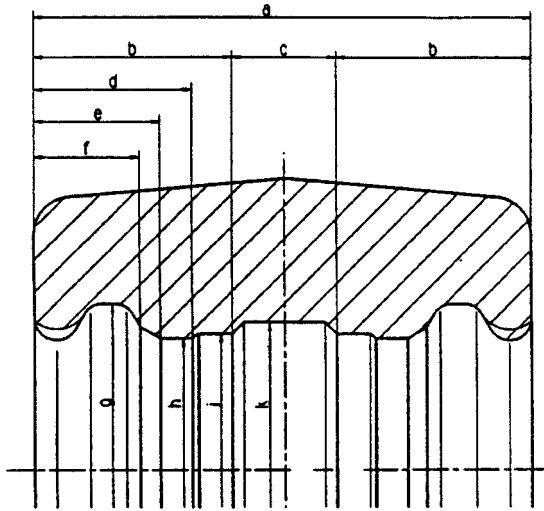


FIG. 3 Compression Tools for Multilayer Pipes

TABLE 5 Burst Pressure Test for Multilayer Pipe and Compression Fittings

Pipe Ø, mm (in.)	Minimum Burst Pressure at 20°C (68°F)
16 (5/8)	8000 kPa (1160 psi)
20 (3/4)	7000 kPa (1015 psi)
26 (1)	7000 kPa (1015 psi)

TABLE 6 Sustained Hydrostatic Pressure Test for Multilayer Pipe and Compression Fittings^A

Length of Time, h	Temperature	Pressure
1	20°C (68°F)	2400 kPa (350 psi)
1	70°C (158°F)	2200 kPa (320 psi)
1	90°C (194°F)	2100 kPa (305 psi)
1000	20°C (68°F)	2300 kPa (335 psi)
1000	70°C (158°F)	2100 kPa (305 psi)
1000	90°C (194°F)	1900 kPa (275 psi)

^APipe dimensions, Ø, are 16, 20, and 26 mm (5/8, 3/4, and 1).

must have a smooth inner and outer surface, free from irregularities such as cracks, bubbles, pin holes or other imperfections. There shall be no evidence of delamination during testing or assembling of multilayer pipe and the selected fittings.

7.2 Workmanship for Compression Fittings—Compression fittings for multilayer pipe shall be suitable for the intended application and free from defects. The selected fittings shall be smooth and free of any sharp-edged grooves, which could damage the pipe.

8. Test Methods

8.1 Sustained-Hydrostatic-Pressure Test—Multilayer pipe and fittings shall be tested in accordance with Test Method D 1598. Tests shall be performed at 1 h and 1000 h in accordance with Table 6. No failure shall occur for the duration of the tests.

8.2 Thermal Cycling Test—The multilayer pipe and fittings shall be tested in accordance with ISO 10508, referring to Fig. 4. There shall be no leakage from pipes, fittings, or joints after completion of 5000 cycles, each with a duration of 30 ± 2 min at a constant internal pressure of 1000 ± 50 kPa (145 ± 7.25

psi). Each cycle shall comprise 15 min of cold water at $20 \pm 2^\circ\text{C}$ ($68 \pm 3.6^\circ\text{F}$) and 15 min of hot water at $90 \pm 2^\circ\text{C}$ ($194 \pm 3.6^\circ\text{F}$).

8.3 Water Hammer Test—Multilayer pipe and fittings shall not fail when subjected to 10 000 cycles. Tests shall be performed at room temperature, pressure cycles alternating between 100 ± 50 kPa (14.51 ± 7.25 psi) and 1500 ± 50 kPa (220 ± 7.25 psi) at a rate of 30 ± 5 per min. Test in accordance with ISO 10508, referring to Fig. 5.

8.4 Delamination—Multilayer pipe shall not delaminate when tested with the adapter tool, as described in Fig. 6. The depth to which the adapter tool is to be inserted shall be marked. No delamination of bond shall occur.

8.5 Fusion Line Test—The adapter tool has to be inserted into the multilayer pipe to the indicated depth (see Fig. 6). No visible damage shall occur on the fusion line or at any place of the aluminum section.

8.6 Excessive Temperature/Pressure Capability—Test six assemblies of multilayer pipe and fittings selected at random in accordance with Test Method D 1598, except the test temperature shall be $100 \pm 2^\circ\text{C}$ ($212 \pm 3.6^\circ\text{F}$), the test pressure shall be 1200 kPa (175 psi), the external test environment shall be air, and the specimens shall be filled with water at a temperature of at least 50°C (122°F). Leakage or separation at any joint tested at less than 30 days (720 h) at the test pressure shall constitute failure.

9. Quality Control

9.1 Quality control tests are valid for the whole range of diameters, but only specified test methods are accepted. A quality program shall include tests described in Section 8, 8.1, 8.4, and 8.5.

10. Sampling and Conditioning

10.1 Sampling—Specimens for each test shall be taken from pipe selected at random from each lot and the random sampling plan of Practice D 1898.

10.2 Conditioning—Each specimen shall be conditioned at room temperature and $50 \pm 5\%$ relative humidity of the manufacturer's facility for not less than 1 h, or until the temperature of the specimen is at room temperature.

10.3 Frequency and Number of the Tests for Quality Control—The frequency and number of tests shall be in accordance with the manufacturer's established quality control program.

10.4 Referee Testing:

10.4.1 Sampling—Specimens shall be collected as per 10.1. The number of specimens shall be sufficient to obtain test results as required for those properties tested. Specimens shall be prepared in accordance with the appropriate ASTM test method, unless otherwise stated.

10.4.2 Conditioning for Referee Testing—Specimens shall be conditioned at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and $50 \pm 5\%$ relative humidity for not less than 40 h before testing in accordance with Practice D 618 Procedure A.

10.5 Referee/Test Conditions—Tests at room temperature shall be conducted at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and $50 \pm 5\%$ relative humidity.

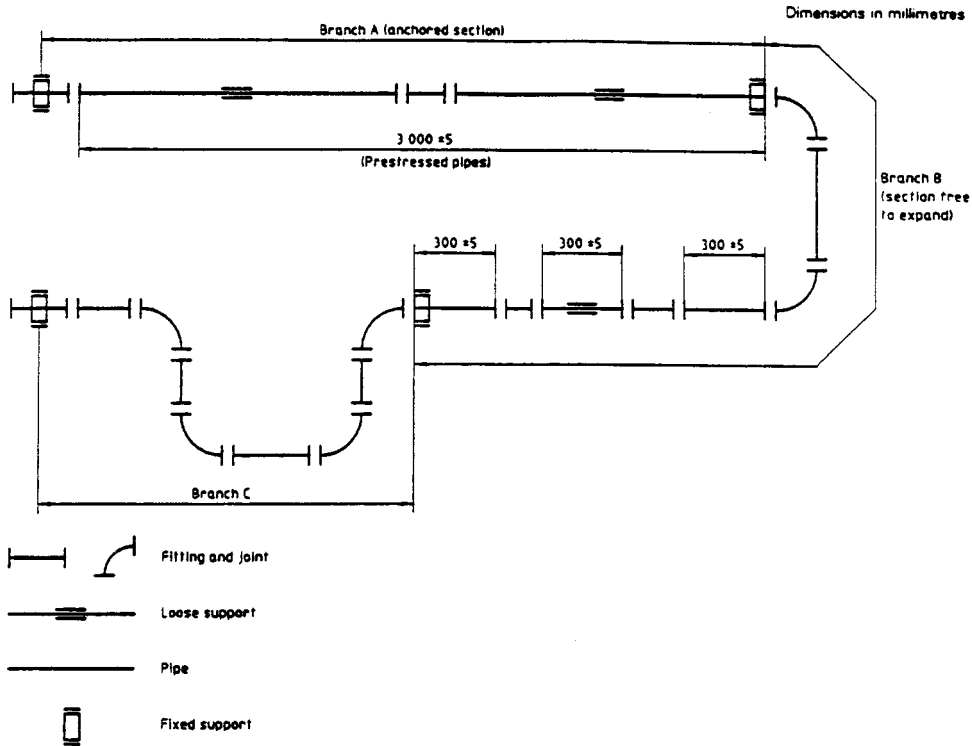


FIG. 4 Thermal Cycling Test

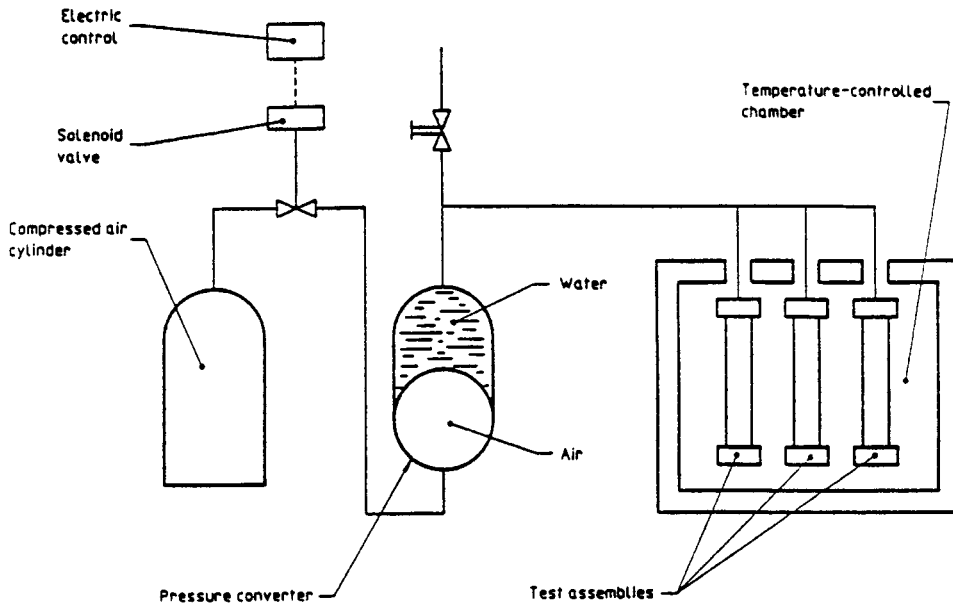


FIG. 5 Water Hammer Test

10.6 *Test Methods*—Test methods specified herein shall be used.

11. Rejection and Rehearing

11.1 *Rejection*—If the results of any test(s) does not meet the requirements of this specification, all tests shall be repeated. In retesting, the product requirements of this specification shall be met. If failure occurs on retest of a lot, the lot fails this specification.

11.2 *Certification*—Certification shall be provided in writing and signed by an authorized agent of the manufacturer

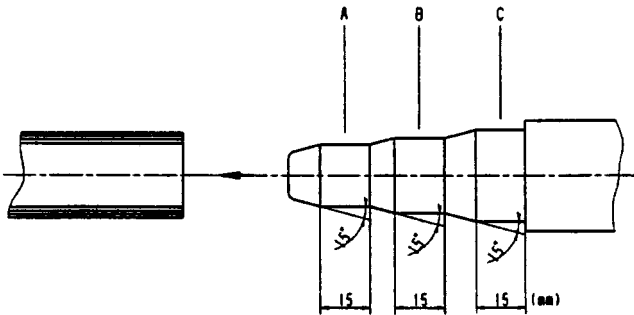
indicating compliance with the provisions of this specification.

12. Product Marking

12.1 *Quality of Marking*—The marking shall be applied to the pipe for end-use application in such manner that it is not removable.

12.2 *Content of Marking for Multilayer Pipe*—Marking on pipe shall include the following information, spaced at intervals of not more than 2 m:

- 12.2.1 Nominal pipe size and wall thickness,
- 12.2.2 ASTM designation F 1987,



A = inside pipe diameter guide
 B = diameter increase for bond strength test
 C = diameter increase for fusion line inspection test

FIG. 6 Delamination and Fusion Line Test

- 12.2.3 Manufacturer's name or trademark,
- 12.2.4 The material designation:
 - 12.2.4.1 Configuration 1: *PEX/AL/HDPE*, or
 - 12.2.4.2 Configuration 2: *PEX/AL/MDPE*, and

- 12.2.5 Production code and type of configuration.
- 12.3 *Content of Marking for Fittings*—Marking on the compression fittings for multilayer pipe shall include:
 - 12.3.1 Nominal size,
 - 12.3.2 Manufacturer's name or trademark, and
 - 12.3.3 ASTM designation F 1987.
 - 12.3.4 Information that cannot be placed on the fitting shall be placed on the packing.

13. Quality Assurance

13.1 When the product is marked with the designation F 1987, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

14. Keywords

14.1 butt-welded aluminum pipe; compression fittings; crosslinkable; hydronic heating system; multilayer pipe; pipe; pressure

APPENDIXES

(Nonmandatory Information)

X1. CONSTRUCTION

X1.1 The multilayer pipe is made by a continuous-extrusion process with five layers of different materials. A butt-welded aluminum tube with the weld laying parallel to the pipe axis is situated between two polymeric layers. Extruded adhesive coats allow adhesion between the components.

X1.2 The pipe section is perfectly homogeneous in the circumference, and this process allows unlimited lengths.

X2. PRESSURE RATING

X2.1 The methodology used to define long-term hydrostatic pressure is based on ISO 10508, Test Method TR 9080.

specification is 1500 kPa (220 psi) at 82°C (180°F), using a designated factor of 1.5. The pressure rating at 82°C (180°F) is 1000 kPa (145 psi).

X2.2 In accordance with ISO 10508, Test Method TR 9080, the MRP for multilayer pipe made in conformity with this

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