Designation: F 781 – 95

An American National Standard

Standard Specification for Perfluoro (Alkoxyalkane) Copolymer (PFA) Plastic-Lined Ferrous Metal Pipe and Fittings[1]

This standard is issued under the fixed designation F 781; 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 factory-made perfluoro (alkoxyalkane) copolymer (PFA) plastic-lined ferrous metal pipe and fittings, primarily intended for conveying corrosive liquids and gases. Requirements for materials, workmanship, dimensions, design, construction, working pressures and temperatures, test methods, and markings are included.

1.2 The values given in parentheses are provided for information purposes only.

NOTE 1—This specification does not include products coated with PFA nor does it define the suitability of PFA-lined components in chemical environments.

1.3 The ferrous piping products shall meet the requirements of the relevant specification listed in 1.3.1 through 1.4. Nominal sizes from 1 through 12 in. in 150 and 300 psi (1.0 to 2.0 MPa) ratings are covered.

NOTE 2—The PFA sealing faces may prevent achievement of the full pressure rating of the ferrous housings. For pressure limitations, the manufacturer should be consulted.

1.3.1 *For Ferrous Pipe*[2,3]:

Title of Specification	ASTM Designation
Pipe, Steel, Black, and Hot-Dipped, Zinc-Coated Welded and Seamless	A 53
Seamless Carbon Steel Pipe and High-Temperature Service	A 106
Electric-Resistance-Welded Steel Pipe	A 135
Electric-Welded Low-Carbon Steel Pipe for the Chemical Industry	A 587
Seamless and Welded Austenitic Stainless Steel Pipe	A 312

1.3.2 *For Ferrous Flanges*[2,3]:

Title of Specification	ASTM Designation
Forgings, Carbon Steel, for Piping Components	A 105
Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves and Parts for General Service	A 181
Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service	A 182
Carbon-Steel Castings Suitable for Fusion Welding for High-Temperature Service	A 216
Ferritic Ductile Iron for Pressure Retaining Castings for Use at Elevated Temperatures	A 395
Ductile Iron Castings	A 536

1.3.3 *For Ferrous Fittings*[2,3]:

Title of Specification	ASTM Designation
Forgings, Carbon Steel, for Piping Components	A 105
Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service	A 181
Carbon Steel Castings Suitable for Fusion Welding for High-Temperature Service	A 216
Piping Fittings Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures	A 234
Austenitic Steel Castings for High-Temperature Service	A 351
Alloy Steel Castings Specially Heat-Treated for Pressure Containing Parts Suitable for High-Temperature Service	A 389
Ferritic Ductile Iron for Pressure Retaining Castings for Use at Elevated Temperatures	A 395
Ductile Iron Castings	A 536
Ductile Iron for Pressure Containing Castings for Use at Elevated Temperatures	A 403

1.4 The PFA-lined flanged pipe and fitting assemblies are limited to use from −20 to 500°F (−29 to 260°C). For use below −29°C (−20°F) consult the manufacturer.

NOTE 3—The above temperature limitations are based on noncorrosive test conditions. Use in specific aggressive environments may alter the above temperatures, and these limits shall be established by mutual agreement between the purchaser and manufacturer.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1600 Terminology for Abbreviated Terms Relating to Plastics[4]

D 3307 Specification for PFA-Fluorocarbon Molding and Extrusion Materials[5]

F 412 Terminology Relating to Plastic Piping Systems[6]

2.2 *ANSI Standard:*

B 16.5 Steel Pipe Flanges and Flanged Fittings[7]

2.3 *Federal Standard:*

[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.

Current edition approved Sept. 10, 1995. Published November 1995. Originally published as F 781 – 82. Last previous edition F 781 – 93.

[2] *Annual Book of ASTM Standards*, Vol 01.01.

[3] *Annual Book of ASTM Standards*, Vol 01.02.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 08.03.

[6] *Annual Book of ASTM Standards*, Vol 08.04.

[7] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

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Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[8]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[8]

3. Terminology

3.1 The terminology used is in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600 unless otherwise specified.

3.2 The abbreviation for perfluoro (alkoxyalkane) copolymer is PFA.

4. Materials

4.1 *Lining*:

4.1.1 *Material*—The lining shall be made from PFA resins conforming to the requirements of Type II materials as defined in Specification D 3307 except that a maximum of 1 % by weight of additives or colorants, or both, is permissible. Organic colorants, if used, shall be identified in the manufacturer's specification.

4.1.2 *Mechanical Properties*—The minimum tensile strength and minimum elongation at yield when tested in accordance with the requirements of Specification D 3307 shall be 3800 psi (26 MPa) and 300 % respectively.

4.1.3 *Flow Rate*—PFA resins used to manufacture the liner and molded fittings shall have a maximum flow rate of 3.0 g/10 min when tested in accordance with Specification D 3307.

4.2 *Ferrous Pipe and Fittings*:

4.2.1 The mechanical properties of the pipes and fittings shall conform to the requirements of the appropriate specification of 1.3 except as they are influenced by accepted methods of processing in the industry, for example, Van Stone flaring, bending, swagging, and welding. The carbon steel pipe and wrought fittings shall be welded or seamless steel. Schedule 40 or Schedule 80, except that Schedule 30 pipe may be used in 8, 10, and 12-in. nominal size. Schedule 20 may also be used for 12-in. nominal size with the agreement of the purchaser.

4.2.2 *Finish*—The interior surfaces of all housings shall be clean and free of mold burrs, rust, scale, or other protrusions, that may adversely affect the integrity or performance of the lining.

4.3 *Back-Up Gaskets*:

4.3.1 *General*—Back-up gaskets shall be used to cover the pipe and gasket face of threaded or slip-on flanges unless a full radius is provided at the end of the pipe and flange. Gaskets may also be required on fittings to provide accommodation, or elimination, or both, of sharp corners that could damage the lining.

4.3.2 *Material*—Plain gaskets meeting the temperature requirements, or perforated metallic gaskets, may be used.

5. Requirements

5.1 *Dimensions*:

5.1.1 *Housings*—Housing installation dimensions are as required in the applicable material specification listed in 1.3.

5.1.2 *Wall Thickness*—Fitting linings shall have a minimum wall thickness of 3⁄32 in. (2.38 mm), and shall have a uniform face thickness of not less than 3⁄32 in. (2.38 mm). Pipe linings shall have a minimum wall thickness of 0.050 in. (1.27 mm), and the flared radius and gasket faces shall have a uniform thickness not less than 80 % of the wall thickness.

5.1.3 *PFA Face Diameter*—The outside diameter of the PFA covering the gasket face of the flange or the full face of the lap-joint stub end shall not be less than the diameter specified in Table 1 and they shall be concentric within 1⁄16 in. (1.6 mm).

5.1.4 *Tolerances*—Tolerances for pipe, flanges, and fittings shall be as specified in Table 2. Bolt holes in both flanges on a fixed-flange spool shall straddle the same center line to facilitate alignment. Finished lined (plastic face to plastic face) fabricated fittings shall conform to the nominal face-to-face, etc. as specified in ANSI B 16.5 with the applicable tolerances.

5.2 *Flange Construction*:

5.2.1 Screw-type flanges shall be secured in position to prevent inadvertent turning of the flange.

5.2.2 Socket-type flanges shall be fully back-welded to the pipe housing and the inside surfaces of the socket flanges shall be welded and ground smooth.

5.2.3 Slip-on flanges shall be fully backwelded.

NOTE 4—No welding shall be done on lined components.

5.2.4 Lap-joint (or Van Stone) flanged ends may be manufactured by standard forming techniques or by using fully welded stub ends or collars. Lap-joints shall not contain any cracks or buckles.

NOTE 5—The use of lap-joint flanges in a piping system may simplify alignment.

5.3 *Venting*—Each pipe and fittings shall be provided with a venting system that will release any gases between the linear and the housing (this system will also indiate any leakage through the liner). Two systems that provide adequate venting are a series of 1⁄16 to 5⁄32-in. (1.6 to 4-mm) diameter holes in the housings or a helical groove system inside the housing that connects flange vents.

NOTE 6—Vent holes should not be plugged with paint, cement, etc., since this negates the intended purpose listed in 5.3.

5.4 *Workmanship*:

5.4.1 Pipe and fitting linings shall show no evidence of pinholes, porosity, or cracks when inspected in accordance with 5.5.2. The linings shall fit snugly inside the pipe and fitting housings. Any bulges or other obvious indication of poor contact with the housing shall be cause for rejection.

TABLE 1 Face Diameter

Nominal Pipe Size, in.	Minimum PFA Face Diameter, in. (mm)
1	1 7⁄8 (48)
1.5	2 11⁄16(68)
2	3 7⁄16 (87)
3	4 5⁄8 (117)
4	5 15⁄16 (151)
6	8 (203)
8	10 1⁄16(256)
10	12 1⁄4(311)
12	14 3⁄8(365)

[8] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 2 Tolerances for Pipe, Flanges, and Fittings

Pipe	Tolerance, in. (mm)
Length	± 1/8(±3.2)
Fixed flange bolt hole alignment	± 1/16 (±1.6)
Flange perpendicularity (with pipe centerline)	3/32in./ft. of diameter (7.8 mm/m of diameter
Flanges and Fittings	
All dimensions	per ANSI B 16.5

5.4.2 The gasket face of the PFA-linings shall be free of surface defects that could impair sealing effectiveness. Scratches, dents, nicks, or tool marks on the gasket surface shall not be deeper than 10 % of the wall thickness.

5.5 *Performance*:

5.5.1 *Qualification*—PFA-lined pipe and fittings must be capable of meeting the requirements specified in Section 6.

5.5.2 *Inspection*:

5.5.2.1 Each lined pipe and fitting, prior to shipment, shall be subjected to a hydrostatic test or an electrostatic test, or both, as specified in 8.1 or 8.2. The test or tests to be used shall be at the option of the manufacturer, unless otherwise specified by the purchaser.

5.5.2.2 Each lined pipe and fitting shall subsequently be visually inspected prior to shipment to verify conformance to the design and dimensional requirements of 5.4.

5.5.2.3 Each lined pipe and fitting shall bear an inspection verification impression stamp on the housing to indicate compliance with the requirements of this specification.

6. Qualification Tests

6.1 *Temperature Tests*:

6.1.1 Cycle representative production samples of PFA-lined pipe and fittings in an oven from room temperature to 500 ± 5°F (260 ± 3°C) to determine the ability of the lined components to withstand heat aging and temperature cycling. Test a minimum of two pipe spools, tees, and 90° elbows in each size.

6.1.2 Install companion flanges at the manufacturer's recommended torque value, and affix a thermocouple to the ferrous housing to measure the temperature. Pipe spools shall be at least 3 ft (0.9 m) long. After 3 h in an oven at 500°F (265°C) as indicated by the thermocouple, air-cool the lined components to 122°F (50°C) maximum. Repeat this test for a total of three cycles.

6.1.3 Inspect PFA-lined pipe and fittings after each cycle for distortion or cracks in the PFA lining. At the completion of the third cycle, subject-specimens to either the hydrostatic or electrostatic test described in 8.1 or 8.2.

6.2 *Steam-Cold Water Cycling Test*:

6.2.1 Subject representative production samples of PFA-lined pipe and fittings to steam-cold water cycling to determine the ability of the lined components to withstand rapid temperature changes. Test a minimum of two pipe spools, tees, and 90° elbows in each size.

6.2.2 Assemble PFA-lined pipe and fittings with suitable blind flanges having provision for the introduction of steam, air, or cold water and for drainage. Install the flanges using the manufacturer's recommended torque value. Pipe spool length shall be 10 ft (3.05 m) minimum. Mount the test specimens in such a manner as to permit complete drainage and then subject them to 100 steam-cold water cycles, each of which shall consist of the following in the sequence given:

6.2.2.1 Circulate saturated steam at a gage pressure of 125 ± 5 psi (862 ± 35 kPa) through the specimens until the ferrous housing skin temperature adjacent to the flange at the outlet end of the test specimen has been maintained at the maximum stabilized temperature for 30 min.

6.2.2.2 Close off steam. Vent and introduce air to purge the specimens for a minimum of 1 min.

6.2.2.3 Circulate water at a maximum temperature of 77°F (25°C) until the ferrous housing skin temperature adjacent to the flange at the outlet end of the test specimen measures 122°F (50°C) maximum.

6.2.2.4 Drain, then introduce air to purge the specimens for a minimum of 1 min, making certain that specimens are completely drained.

6.2.3 There shall be no evidence of leakage from the venting system or the flanges during the 100 cycles. At the completion of the test, the linear shall show no evidence of buckling, cracking, or crazing. Formation of water blisters shall not be cause for rejection.

NOTE 7—These surface blisters extend only partially into the wall thickness and are formed due to absorption of steam by the PFA liner and subsequent condensation in the liner. The blisters do not adversely affect PFA liner performance.

6.2.4 At the conclusion of the testing specified in 6.2.2, subject the PFA-lined pipe or fitting to the hydrostatic test specified in 8.1 or, after drying, to the electrostatic test specified in 6.2.

6.3 *Vacuum Testing*:

6.3.1 Test representative production samples of PFA-lined pipe and fittings to determine the vacuum ratings of the lined components. Test a minimum of two pipe spools, tees, and 90° elbows in each size. Conduct tests at room temperature and at the manufacturer's maximum recommended service temperature, and at one intermediate temperature if a full vacuum rating cannot be achieved at the maximum recommended service temperature. Full vacuum is defined as 29.6 in. Hg (100 kPa) corrected.

NOTE 8—Vacuum-temperature ratings are published in the manufacturer's literature.

6.3.2 For pipe spools, specimen length shall be at least ten pipe diameters. Install a flange incorporating a sight glass at one end and a blind flange suitable for drawing a vacuum at the other end. Provide for measuring the ferrous housing temperature.

6.3.3 Heat the specimens uniformly and externally with the sight glass end visible, and after the desired ferrous housing temperature is reached, begin the test. Hold a selected initial vacuum level for 24 h and if no failure occurs, increase the vacuum by 2 in. Hg (6.8 kPa). Repeat this every 4–6 h until failure or full vacuum is reached. Failure is defined as any buckling or collapse of the liner.

6.3.4 If failure occurs at the initial vacuum level selected, test a new test specimen at a lower vacuum level to determine the failure threshold. The vacuum failure threshold is defined as 1 in. Hg (3.4 kPa) below that at which failure occurs.

NOTE 9—The external pressure method to simulate higher than full vacuum can be used to establish the failure threshold when full vacuum is achievable. With the use of pressure taps, an external pressure is applied between the liner outside and the pipe inside diameter.

6.3.5 The vacuum rating shall be 80 % of the failure threshold value.

6.3.6 At the test completion and after the vacuum rating is established, heat a duplicate specimen to the test temperature. Apply the rated vacuum to the specimen after the desired skin temperature has been reached. Achieve the rated vacuum within 2 min and apply continuously for 48 h. If no liner buckling or collapse occurs, the vacuum rating shall be considered acceptable.

6.4 *Retest*—When a test specimen fails to meet the requirements of 6.1, 6.2, or 6.3, the cause of failure shall be sought and corrected. Then repeat the temperature test specified in 6.1 and the steam-cold water cycling test specified in 6.2 and vacuum test specified in 6.3, using double the number of test specimens.

7. Finish

7.1 The outside surface all lined pipe and fittings, other than stainless steel, shall be coated with a corrosion-resistant primer over a properly prepared surface.

8. Inspection Tests

8.1 *Hydrostatic Pressure Test*—The internal test pressure shall be 425 psi (2.93 MPa) minimum. Conduct the test at ambient temperature. Fill the pipe and fitting completely with clean water and bleed the system free of all air pior to the application of pressure. Reach full test pressure within 1 min and maintain for a further 3 min. Observe the pressure gage and the venting system in the test specimen throughout the test for any evidence of leakage, which shall be cause for rejection.

8.2 *Electrostatic Test*—Conduct the test with a nondestructive high-voltage tester at an output voltage of 10 000 V. A visible or audible spark, or both, that occurs at the probe when electrical contact is made with the housing because of a defect in the liner, shall be cause for rejection.

9. Marking

9.1 The markings shall be applied to the pipe in such a manner that they remain legible (easily read) after installation and inspection.

9.2 Marking on the pipe and fitting shall include the following:

9.2.1 Nominal pipe size,

9.2.2 Liner material identification (PFA),

9.2.3 Manufacturer's name (or trademark),

9.2.4 This designation "ASTM F 781", and

9.2.5 Length (on pipe only).

9.2.6 Other information such, as order numbers, part numbers, item numbers, etc., shall be provided at the purchaser's request.

9.3 Pipe liner indentification shall be provided on a band containing the raised letters "PFA".

10. Packaging

10.1 The gasket face of each lined pipe and each fitting shall be protected by end plates or other suitable protective means, such as, individual boxing.

11. Federal Procurement

11.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

NOTE 10—In Federal contracts, the contractor is responsible for inspection.

11.2 *Packaging and Marking for U.S. Government Procurement*:

11.2.1 *Packaging*—Unless otherwise specified in the contract, the material shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition, and which will be acceptable to the carrier at lowest rates. Containers and packaging shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

11.2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE 11—The inclusion of U.S. Government procurement requirements shall not be construed as an indication that the U.S. Government uses or endorses the products described in this document.

12. Quality Assurance

12.1 When the product is marked with this designation, F 781, 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.

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