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An American National Standard

Standard Specification for Metallic Mechanical Fittings for Use on Outside Diameter Controlled Thermoplastic Gas Distribution Pipe and Tubing[1]

This standard is issued under the fixed designation F 1948; 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.

ϵ^1 NOTE—Section 10 was editorially updated in December 2002.

1. Scope

1.1 This specification covers requirements and test methods for the qualification of metallic mechanical fittings for use with outside diameter controlled thermoplastic gas distribution pipe and tubing as specified in Specification D 2513.

1.2 The test methods described are not intended to be routine quality control tests.

1.3 This specification covers the types of mechanical fittings described in 3.3.

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

1.5 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification. *This standard may involve hazardous material, operations and equipment. 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 text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures), shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 638 Test Method for Tensile Property of Plastics[2]

D 1598 Test Methods for Time-To-Failure of Plastic Pipe Under Constant Internal Pressure[3]

D 1600 Abbreviations of Terms Relating to Plastics[2]

D 2513 Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings[3]

D 2837 Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

F 412 Definitions of Terms Relating to Plastic Piping Systems[3]

F 1588 Test Method for Constant Tensile Load Test[3]

2.2 *ASME Standard:*

ASME B 31.8 Gas Transmission and Distribution Piping Systems[4]

2.3 *Federal Specification:*

OPS Part 192 Title 49, Code of Federal Regulations[5]

2.4 *Other Document:*

PPI TR-4 Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fitting Compounds[6]

3. Terminology

3.1 Definitions are in accordance with Definitions F 412 unless otherwise specified. Abbreviations are in accordance with Abbreviations D 1600 unless otherwise specified.

3.1.1 The gas industry terminology used in this specification is in accordance with ASME/ANSI B31.8 or United States CFR 49 Part 192 unless otherwise indicated.

3.1.2 The term "pipe" used herein refers to both pipe and tubing unless specifically stated otherwise. The term "fitting" refers to a mechanical connecting device as described in 3.2.5 and 3.2.7.

3.2 *Definitions:*

3.2.1 *Category 1 mechanical fitting*, *n*—fitting for assembling pipe, which includes a compression zone(s) to provide for pressure integrity, leak tightness, and resistance to end loads sufficient to cause no less than 25 % elongation of the piping, as described in this standard.

3.2.2 *Category 2 mechanical fitting*, *n*—fitting for assembling pipe, which includes a compression zone(s) to provide for pressure integrity and leak tightness; Category 2 fittings do not provide for resistance to end loads.

[1] This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems, and is the direct responsibility of Subcommittee F17.60 on Gas.

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

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

[4] Available from the American Society of Mechanical Engineers, Three Park Ave., New York, NY, 10016-5990.

[5] Available from the Office of Pipeline Safety, Research and Special Programs Administration, U.S. Department of Transportation, 400 Seventh Street, S.W., Washington, DC, 20006-1301.

[6] Available from the Plastics Pipe Institute, 1801 K Street N.W., Suite 600K, Washington, DC, 20006-1301.

3.2.3 *Category 3 mechanical fitting*, *n*—fitting for assembling pipe, which includes a compression zone(s) for pressure integrity, leak tightness, and resistance to end loads; the nominal size of the fitting shall be 4 and larger in diameter.

3.2.3.1 *Discussion*—Resistance to end loads shall be equal to or greater than the maximum thermal stress that would be produced by a temperature change of 100°F (55°C) (for formula, see Annex A1).

3.2.4 *joint*, *n*—the location at which two or more pieces of pipe, or a pipe and a fitting, are connected (an installed coupling has two joints).

3.2.5 *joint*, *mechanical*, *n*—a connection between piping components employing physical force to develop a seal or produce alignment.

3.2.6 *maximum allowable operating pressure, MAOP*, *n*—of the fuel gas piping system, in psig, as determined in accordance with US DOT CFR, Title 49, Part 192.121, and as represented in the following:

$$MAOP = P = 2 \times S/(R–1)xf \quad (1)$$

where:

- S = the pipe material's HDB as published in PPI TR 4,
- R = the pipe's dimension ratio determined by dividing the pipe's specified nominal outside diameter by the pipe's specified nominal wall thickness, and
- f = design (derating) factor for thermoplastic fuel gas piping as set by the authority having jurisdiction. In the United States, the design factor is cited in CFR, Title 49, Part 192.121.

3.2.7 *mechanical fitting*, *n*—fitting for making a mechanical joint to provide for pressure integrity, leak tightness, and, depending on category, as defined in this standard, resistance to end loads.

3.3 *Types of Mechanical Fittings:*

3.3.1 *clamped insert fitting*, *n*—mechanical fitting used to make a mechanical joint that utilizes external clamps, or other mechanical devices, to form a pressure seal between the reinforcing tubular stiffener and the surface of the pipe.

3.3.2 *compression fitting*, *n*—mechanical fitting used to make a mechanical joint by compressing either externally, internally, or radially to form a pressure seal between the fitting and the surface of the pipe.

3.3.3 *compression gasket fitting*, *n*—mechanical fitting used to make a mechanical joint that utilizes a compression nut, tightening ring, bolts, or any other device to compress gasketing onto the surface of the pipe to form a pressure seal.

3.3.4 *stab-type fitting*, *n*—mechanical fitting used to make a mechanical joint in which a seal is achieved by radial compression of a gasket between the outside diameter (OD) of the pipe and the inside diameter (ID) of the fitting.

4. Material

4.1 The physical properties of each material used to produce the fitting shall be available from the fitting manufacturer upon request.

4.2 Specifications outlining the physical and chemical properties of all fitting materials shall be available from the fitting manufacturer upon request.

NOTE 1—Materials in long-term contact with natural gas of line quality and LP gas vapor should be demonstrated to not adversely effect the performance of the fitting.

NOTE 2—Materials should have a demonstrated resistance to environmental stress cracking when exposed, under stress, to chemical compounds encountered in or external to gas piping systems, and a demonstrated resistance to bacteriological decomposition. Such compounds include, but are not limited to, ice thawing chemicals, fertilizers, insecticides, herbicides, leak detection fluids, acids, bases and antifreeze solutions used to thaw frozen lines.

5. Dimensions

5.1 The dimensions and tolerances shall be determined by the manufacturer.

6. Qualification Requirements

6.1 *General*—Unless otherwise specified, each nominal size of fitting shall be tested. Testing the fitting with the thickest wall pipe for which the fitting is designed qualifies that type of fitting for use with pipe of lesser wall thickness.

6.1.1 Mechanical joint qualification shall be performed on assembled joints using the fitting manufacturer's joining procedure. All mechanical fittings offered by the manufacturer shall be capable of meeting the requirements of this standard when connecting thermoplastic piping materials complying with Specification D 2513. It is not the intent of this standard to require the testing of all fitting configurations (that is, tee, ells, etc.) but each joint design in each size.

6.1.2 All mechanical fittings described in 3.3 shall have an internal pipe reinforcing tubular stiffener that extends at least under the seal and gripping device (where used).

6.2 *Performance Requirements*:

6.2.1 *Tensile Strength*—The pipe joint shall accommodate the tensile loads, when tested in accordance with 7.2.

6.2.1.1 *Category 1*—The joint shall provide resistance to a force on the pipe joint equal to or greater than that which will cause no less than 25 % elongation of the pipe, or which causes the pipe to fail outside the joint area when tested in accordance with 7.2.

6.2.1.2 *Category 2*—Joint design that only provides a seal. A mechanical joint designed for this category excludes any provisions in the design of the joint to resist axial pullout forces; therefore, tensile tests are not required.

6.2.1.3 *Category 3*—Joint of nominal pipe size 4 and larger in diameter shall provide resistance to a force on the pipe joint equal to or greater than the maximum thermal stress that would be produced by a temperature change of 100°F (55°C) (for formula, see Annex A1).

NOTE 3—Category 3 has a manufacturer's rated pipe end restraint less than the value required to yield the pipe as outlined in 6.2.1.1 (Category 1).

6.2.1.4 Joint restraint capabilities less than as defined in 6.2.2.1 and 6.2.2.3 shall constitute failure of the test.

6.2.2 *Temperature Cycling Test*—The mechanical joint shall provide a pressure seal after 10 cycles of the temperature cycling test when tested in accordance with 7.3.

6.2.3 *Constant Tensile Load Test*—The joint shall not fail by leakage or pullout when loaded to an axial tensile stress of 1320 psi (9101 kPa) and tested in accordance with 7.4.

6.3 *Elevated Temperature Sustained Pressure*—The fitting, joint or pipe in the area affected by the fitting shall not fail as defined in Test Method D 1598, when tested in accordance with 7.5. The fitting or joint meets this requirement when tested in accordance with any one of the three conditions (A, B, or C) listed in 7.5.

7. Test Methods

7.1 *General*—The test methods in this specification cover mechanical joint designs. Test methods that are applicable from other specifications are referenced in the paragraph pertaining to that particular test.

7.1.1 *Conditioning*—Unless otherwise specified, condition the specimens (pipe and fittings) prior to joining at 73.4 ± 3.6°F (23 ± 2°C) for not less than 16 h.

7.1.2 *Test Conditions*—Conduct the testing at the standard laboratory temperature of 73.4 ± 3.6°F (23 ± 2°C) unless otherwise specified.

7.1.3 *Test Specimens*—Test joints shall be prepared with the appropriate size thermoplastic pipe, complying with the dimensional requirements of Specification D 2513, in accordance with the manufacturer's joining procedures.

7.1.4 *Precautions and Safety Considerations*—It is strongly recommended that liquid be used as the pressurizing fluid when testing systems that may fail in a brittle manner (specifically PVC systems). If that is not possible, the test specimens must be placed in a strong chamber at all times when pressurized. Also, fittings as specified in 6.2.1.2 should be restrained to prevent pull-out during testing.

7.2 *Tensile Strength Test*:

7.2.1 The test pipes, for sizes below NPS 4, shall be prepared so that the minimum length of unreinforced pipe from a joint being tested is equal to five times the nominal outside diameter of the pipe being tested. The test pipes, for sizes NPS 4 and above, shall be prepared so that the minimum length of unreinforced pipe from a joint being tested is equal to three times the nominal outside diameter of the pipe being tested, but in no case less than 12 in. (304 mm). It is permissible to test multiple joints together, provided that the minimum length of unreinforced pipe (as stated above) exists on at least one joint.

7.2.2 The apparatus and report shall be as specified in Test Method D 638. Test six joints.

7.2.3 The test shall be conducted at 73.4°F ± 3.6°F (23°C ± 2°C).

7.2.4 The speed of the testing shall be 0.2 in. (5 mm)/min.± 25 %.

7.2.5 Failure of any two of the six specimens tested shall constitute failure of the test. Failure of one of the six specimens tested is cause for re-test of six additional specimens. Failure of one of the six specimens in re-test shall constitute failure of the test.

7.3 *Temperature Cycling Test*:

7.3.1 The test shall be conducted on six of the smallest and six of the largest nominal pipe sizes of each mechanical joint design and assembled as outlined in 6.1.1.

7.3.2 Leak test specimens at ambient temperature at 7± 3 psig (48.3 ± 20.7 kPa) and a minimum of 1.5 X MAOP.

7.3.3 Cool specimens to a temperature of –20°F± 3.6°F (–29°C ± 2°C) and maintain for a minimum of 2.5 h.

7.3.4 Condition specimens to a temperature of 140°F± 3.6°F (60°C ± 2°C) and maintain for a minimum of 2.5 h.

7.3.5 Repeat 7.3.3 and 7.3.4 for a total of 10 cycles.

7.3.6 Pressurize 50 % of the specimens of each size at 7 ± 3 psig (48.3 ± 20.7 kPa) and the remaining 50 % of each size at 1.5 × MAOP of the piping material and SDR for which the fittings are designed to be used. Leak test first at 140 ± 3.6°F (60 ± 2°C) and then at –20 ± 3.6°F (–29± 2°C).

NOTE 4—If immersion is used for leak testing, and the design of the joint is such that air can be trapped within the joint assembly, allow adequate time for all air trapped within the joint to escape prior to observing for leaks.

7.4 *Constant Tensile Load Joint Test*:

7.4.1 One specimen of each nominal pipe size shall be tested in accordance with Test Method F 1588 for a minimum of 1000 h at an internal pressure between 4 psig (27.6 kPa) and the pipe MAOP.

7.4.2 Failure of the specimen shall constitute failure of the test.

7.5 *Elevated Temperature Sustained Pressure Test*:

7.5.1 The test shall be conducted on six of the smallest and six of the largest nominal pipe sizes of each mechanical joint design and assembled as outlined in 6.1.1.

7.5.2 The apparatus and report shall be as specified in Test Method D 1598.

7.5.3 The assembled joints shall be tested in accordance with Test Method D 1598 with the exception that it is not required that 12 in. or five times the nominal outside diameter of the pipe used in conducting the test be placed on each side of the fitting tested. The test shall be conducted at one of the time/temperature/hoop stress combinations shown in Table 1 with the test pressure calculated using the following equation:

$$P = \frac{2S}{DR - 1} \quad (2)$$

where:
P = test pressure, psig,
S = hoop stress, and
DR = dimension ratio (OD/wall).

If ductile failure occurs in the pipe at 176°F (80°C)/670 psi (4620 kPa) hoop stress, retest at 176°F (80°C)/580 psi (3999 kPa) hoop stress.

7.5.4 Failure of any two of the six specimens tested shall constitute failure of the test. Failure of one of the six specimens tested is cause for re-test of six additional specimens. Failure of one of the six specimens in re-test shall constitute failure of the test. Evidence of failure of the pipe shall be defined in Test Method D 1598.

TABLE 1 Elevated Temperature Sustained Pressure Test Conditions

Condition	Minimum Time	Temperature, °F (°C)	Pipe Hoop Stress, S, psi (kPa)
A	3000 h	140 ± 3.6 (60 ± 2)	1000 (6895)
B	1000 h	176 ± 3.6 (80 ± 2)	580 (3999)
C	170 h	176 ± 3.6 (80± 2)	670 (4620)

8. Product Instructions

8.1 Qualified installation instructions shall be available from the manufacturer and supplied with the fitting.

9. Product Marking

9.1 Fittings shall be marked with the following:

9.1.1 ASTM designation F 1948,

9.1.2 Date or lot code identification,

9.1.3 Manufacturer's name or trademark,

9.1.4 Size, followed by "IPS" or "CTS" designation, SDR or wall thickness range,

9.1.5 The word "gas" or, if space does not permit, the letter "G", and

9.1.6 "Category 1," Category 2," or" Category 3"; abbreviation is permitted as CAT1, CAT2 or CAT3.

9.2 All required markings shall be legible and so applied as to remain legible under normal handling and installation practices. If indentation is used, it shall be demonstrated that these marks have no affect on the long term strength of the fitting.

10. Quality Assurance

10.1 When the product is marked with this designation, F1948, the manufacturer affirms that the product was manufactured, inspected, sampled ad tested in accordance with this specification and has been found to meet the requirements of this specification.

11. Keywords

11.1 gas; manufacturer's joining procedure; metallic mechanical fittings; reinforcing tubular stiffener; temperature cycling test

ANNEX

(Mandatory Information)

A1. THERMAL STRESS

A1.1 Calculate the longitudinal stress (theoretical) induced in a pipe member between fixed points as follows:

$$S = E \times C \times \Delta t \quad \text{(A1.1)}$$

where:
- S = stress, psi (MPa),
- E = modulus of elasticity, psi (MPa), instantaneous, at 73°F (23°C),
- C = coefficient of expansion, in./in./°F (mm/mm/°C), and
- Δt = maximum temperature minus minimum temperature, °F (°C).

A1.1.1 The measured stress has been determined to be less than that calculated. This difference is caused by the stress relaxation in viscoelastic materials.

A1.2 Calculate the theoretical force sustained at the fixed points (typically joints) in a pipe member as follows:

$$F = S \times A \quad \text{(A1.2)}$$

where
- F = force, lbf (N),
- S = stress, psi (MPa), and
- A = cross-section pipe wall area, in.^{2} (mm^2).

A1.3 Calculate pipe contraction in unrestrained pipe caused by a reduction in temperature as follows:

$$\Delta L = k \times L \times C \times \Delta t \quad \text{(A1.3)}$$

where:
- ΔL = change in length,
- k = 1000 for ΔL (mm), L (m), C (°C^{-1}), Δt (°C), or 12 for ΔL (in.), L (ft.), C (°F^{-1}), Δt (°F),
- L = coefficient of linear expansion, and
- Δt = temperature change.

APPENDIXES

(Nonmandatory Information)

X1. CORROSION

X1.1 In considering metallic mechanical fittings in designed joints on thermoplastic piping systems, the corrosion aspect of the fitting material must be addressed. Care should be taken to adequately protect the fitting from the effects of galvanic corrosion in a buried application. These concerns may be alleviated by cathodic protection as specified in Code of Federal Regulations Title 49 Part 192, Paragraph 192.455.

X2. TRANSITION

X2.1 *Material Transition*—In specifying a mechanical fitting for transition use in a plastic piping system, care should be taken to insure that the joint is stronger than the weakest piping material. For example, in the case of a steel pipe to polyethylene transition, the polyethylene should fail before the fitting pulls off of the steel pipe side. In the case of a PVC to polyethylene transition, the joint should be designed to the weakest piping material (that is, the polyethylene).

X2.2 *Pipe Size and Strength Transition*—A fitting designed to joint piping of different size and strengths (for example, reducing fitting or different SDR) is qualified by testing to the properties of the piping with the lesser strength (the weakest link in the piping system). For example, a fitting designed to join 1 IPS, SDR 11, PE to ½IPS, SDR 11, PE piping is qualified by using the ½ IPS, PE as the testing criteria. In this example, the sample is tensile pulled to the yield of the ½IPS, PE piping to be a Category 1 fitting. As another example, a 1 IPS mechanical fitting joining 1 IPS, SDR 11, PE to 1 IPS, SDR 13.5, PE is qualified for both SDRs by testing the SDR 11 end.