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An American National Standard

Standard Specification for Thermosetting Resin Fiberglass Pipe Systems to Be Used for Marine Applications[1]

This standard is issued under the fixed designation F1173; 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 reinforced thermosetting resin pipe systems with nominal pipe sizes (NPS) 1 in. through 48 in. (25 mm through 1200 mm) which are to be used for all fluids approved by the authority having jurisdiction in marine piping systems.

1.2 The dimensionless designator NPS has been substituted for traditional terms as "nominal diameter," "size," and "nominal size."

1.3 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.

1.4 The following safety hazards caveat pertains to the test methods which are included in 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.*

1.5 *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:*[2]

D883 Terminology Relating to Plastics

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

D2105 Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube

D2310 Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe (Withdrawn 2017)[3]

D2584 Test Method for Ignition Loss of Cured Reinforced Resins

D2924 Test Method for External Pressure Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

D2992 Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D5028 Test Method for Curing Properties of Pultrusion Resins by Thermal Analysis

D5686 Specification for "Fiberglass"(Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Pipe Fittings, Adhesive Bonded Joint Type Epoxy Resin, for Condensate Return Lines (Withdrawn 2002)[3]

E1529 Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies

F412 Terminology Relating to Plastic Piping Systems

2.2 *Other Documents:*

ANSI B16.1 Cast Iron Pipe Flanges and Flanged Fittings[4]

ANSI B16.5 Pipe Flanges and Flanged Fittings[4]

IMO Resolution A.753(18) Guidelines for the Application of Plastic Pipes on Ships[5]

NSF-61[6]

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.11 on Machinery and Piping Systems.

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

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

[5] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

[6] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48105, http://www.nsf.org.

Code of Federal Regulations 21CFR175.105, 21CFR177.2280, 21CFR177.2410, and 21CFR177.2420[5]
Code of Federal Regulations Title 46, Part 56, for Piping Systems, and Subpart 56.60-25 for Nonmetallic Materials[5]
IMO Resolution A.653(16) Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling, and Deck Finish Materials[5]
IMO Resolution MSC.61(67) International Code for Application of Fire Test Procedures[5]
OTI 95 634 Jet-Fire Resistance Test of Passive Fire Protection Materials[7]

2.3 *ISO Documents:*
ISO 9001 Quality Management Systems—Requirements[4]
ISO 75 Plastics—Determination of Temperature of Deflection Under Load [4]

3. Terminology

3.1 Definitions are in accordance with Terminologies D883 and F412.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *continuously electrically conductive, adv*—pipe and fittings made conductive using discretely conductive materials or layers.

3.2.2 *homogeneously electrically conductive, adv*—pipe and fittings made conductive using a resin additive so that conductivity is maintained between any two points on the pipe or fitting.

3.2.2.1 *Discussion*—For conveying nonconducting fluids (those having conductance less than 1000 pico-Siemens per metre), pipe systems which are continuously or homogeneously conductive or have conductivity from the inside surface to the outside surface are recommended. In accordance with IMO Resolution A.753(18), all pipe located in a hazardous area, regardless of the fluid being conveyed, must be electrically conductive.

3.2.3 *maximum operating pressure, n*—the highest pressure that can exist in a system or subsystem under normal operating conditions.

3.2.4 *representative piping system, n*—a system composed of a single manufacturer's pipes, fittings, joints, and adhesives that would normally be used by a customer or installer.

4. Classification

4.1 *General*—Pipe and fittings are to be classified using the following system which is similar to that of Classification D2310 for pipe.

4.1.1 *Types:*
4.1.1.1 *Type I*—Filament wound.
4.1.1.2 *Type II*—Centrifugally cast.
4.1.1.3 *Type III*—Molded (fittings only).
4.1.2 *Resin:*
4.1.2.1 *Resin 1*—Epoxy resin.
4.1.2.2 *Resin 2*—Vinylester resin.
4.1.2.3 *Resin 3*—Polyester resin.
4.1.2.4 *Resin 4*—Phenolic resin.
4.1.2.5 *Resin 5*—Customer-specified resin.
4.1.3 *Class:*
4.1.3.1 *Class A*—No liner.
4.1.3.2 *Class B*—Reinforced liner.
4.1.3.3 *Class C*—Nonreinforced liner.

4.2 *Pressure Rating*—Pipe and fittings shall be classified as to the method used to obtain their pressure rating (refer to Appendix X1).

4.2.1 *Rating Method 1*—Short-term test.
4.2.2 *Rating Method 2*—Medium-term (1000 h) test.
4.2.3 *Rating Method 3*—Long-term (10 000 h) test.
4.2.4 *Rating Method 4*—Long-term (10 000 h) regression test.

4.3 *Fire Endurance*—Piping systems are to be classified in accordance with the following cells if fire performance is to be specified (refer to Appendix X2).

4.3.1 *Fluid:*
4.3.1.1 *Fluid E*—Empty.
4.3.1.2 *Fluid EF*—Initially empty for 5 min, followed by flowing water. Fluid velocity of 3 ft/s maximum during qualification test.)
4.3.1.3 *Fluid S*—Stagnant water.
4.3.2 *Fire Type:*
4.3.2.1 *Fire Type JF*—Jet fire with heat flux between 95 100 Btu/(h-ft^2) and 126 800 Btu/(h-ft^2) (300 kW/m^2 and 400 kW/m^2).
4.3.2.2 *Fire Type IF*—Impinging flame with heat flux of 36 011 Btu/(h-ft^2) (113.6 kW/m^2).
4.3.2.3 *Fire Type HF*—Hydrocarbon furnace test at 2012 °F (1100 °C).
4.3.3 *Integrity/Duration:*
4.3.3.1 *Integrity A*—No leakage during or after fire test.
4.3.3.2 *Integrity B*—No leakage during fire test, except a slight weeping is acceptable. Capable of maintaining rated pressure for a minimum of 15 min with a leakage rate of 0.05 gal/min (0.2 L/min) after cooling.
4.3.3.3 *Integrity C*—Minimal or no leakage (0.13 gal/min (0.5 L/min)) during fire test. Capable of maintaining rated pressure with a customer-specified leakage rate after cooling.
4.3.3.4 *Duration*—The duration of the test shall be specified in minutes and shall be specified or approved by the authority having jurisdiction.

5. Ordering Information

5.1 When ordering pipe and fittings under this specification, the following should be specified (where applicable):

5.1.1 *Service Conditions:*
5.1.1.1 Fluid being transported.
5.1.1.2 Design temperature (reference 6.6).
5.1.1.3 Internal design pressure.
5.1.1.4 External design pressure.
5.1.2 *General Information:*
5.1.2.1 Type (reference 4.1.1).
5.1.2.2 Resin (reference 4.1.2).
5.1.2.3 Class (reference 4.1.3).
5.1.3 *Pressure Rating Method (Internal Only) (reference 4.2).*

[7] Offshore Technology Information (OTI) Report is available from Health and Safety Executive, HSE Information Centre, Broad Ln., Sheffield, S3 7HQ, U.K.

5.1.4 *Fire Endurance:*
5.1.4.1 Fluid (reference 4.3.1).
5.1.4.2 Fire type (reference 4.3.2).
5.1.4.3 Integrity (reference 4.3.3).
5.1.4.4 Flame spread rating (reference 6.4).
5.1.4.5 Smoke and other toxic products of combustion (reference 6.5).
5.1.5 NPS.
5.1.6 Manufacturer's Identification (part number, product name, and so forth).
5.1.7 Specific job requirements (that is, potable water usage, electrical conductivity).

6. Performance Requirements

6.1 *Internal Pressure*—All components included in the piping system shall have pressure ratings suitable for the intended service. Pressure ratings shall be determined in accordance with Appendix X1 using the method specified by the customer or a longer-term method, if available. If, for example, a Rating Method 2—medium-term test is specified and data for Rating Method 3—long-term test is available, then the long-term test data is acceptable. Note that for some components, particularly specialty fittings, long-term testing is not practical and ratings for these items will typically be determined using Rating Test Method 1.

6.2 *External Pressure*—All pipe included in the piping system shall have external pressure ratings suitable for the intended service. External pressure ratings shall be determined by dividing the results of Test Method D2924 by a minimum safety factor of 3.

6.3 *Fire Endurance*—The piping system shall have the fire endurance required by the authority having jurisdiction based on the intended location and service. Fire endurance shall be determined using the appropriate method in Appendix X2.

6.4 *Flame Spread*—The authority having jurisdiction shall designate any flame spread requirements based on the location of the piping. For ships, mobile offshore drilling units (MODU's), and floating oil production platforms subject to the requirements of SOLAS or Title 46 of the U.S. Code of Federal Regulations, performance shall be determined by test procedures given in IMO Resolution MSC.61(67), Annex 1, Part 5—Test for Surface Flammability, as modified for pipes in Appendix 3 of IMO Resolution A.753(18).

6.5 *Smoke and Other Toxic Products of Combustion*—The authority having jurisdiction shall designate any smoke and toxicity requirements based on the location of the piping. For ships, MODUs, and floating oil production platforms subject to the requirements of SOLAS or Title 46 of the U.S. Code of Federal Regulations, performance shall be determined by test procedures given in IMO Resolution MSC.61(67), Annex 1, Part 2—Smoke and Toxicity Test, as modified in B.9.0 of Appendix B—Fire Performance Tests.

6.6 *Temperature*—The maximum working temperature shall be at least 36 °F (20 °C) less than the minimum glass transition temperature (determined in accordance with Test Method D5028 or equivalent) or heat distortion temperature (determined in accordance with ISO 75 Method A, or equivalent) of the resin or plastic material. The minimum glass transition temperature or heat distortion temperature, whichever is less, shall not be less than 176 °F (80 °C).

NOTE 1—Glass transition temperature shall be used for in-process quality control testing (reference 9.1.4, 9.2.4, and 9.3.3).

6.7 *Material Compatibility*—The piping material shall be chemically compatible with the fluid being carried and any fluid in which it will be immersed.

6.8 *Electrical Resistance*—Conductive piping systems shall have a resistance per unit length not to exceed 3.05×10^4 Ω/ft (1×10^5 Ω/m) when tested in accordance with Appendix X3. Resistance to earth at any location on an installed piping system required to be conductive shall be no greater than 1×10^6 Ω.

6.9 *Static Charge Shielding*—Conductive piping systems shall have a maximum resulting voltage not to exceed 1 % of the supply voltage induced on the exterior surface of the pipe when tested in accordance with Appendix X3.

6.10 *Potable Water Usage*—The material, including pipe, fittings, adhesive, and any elastomeric gaskets required shall have no adverse effect on the health of personnel when used for potable water service. Material shall conform to National Sanitation Standard 61 or meet the requirements of FDA Regulations 21 CFR 175.105 and 21 CFR 177.2280, 21 CFR 177.2410, or 21 CFR177.2420.

7. Other Requirements

7.1 *Flanges*—Standard flanges shall have bolt patterns in accordance with ANSI B16.5 Class 150 for nominal pipe sizes 24 in. and smaller and in accordance with ANSI B16.1 Class 125 for larger flanges. Consult the manufacturer's literature for bolt length, torque specifications, and tightening sequence.

7.2 *Military Usage*—Piping and fittings used in military applications shall comply with the provisions of Appendix D, Supplementary Requirements to Specification F1173 for U.S. Navy use.

8. Workmanship and Appearance

8.1 All pipe, fittings, and spools shall be visually inspected for compliance with the requirements stated in Table 1, and, if appropriate, either repaired or rejected. After all minor repairs, a pressure test in accordance with 9.1.1, 9.2.1, or 9.3.1 shall be performed on the component.

9. Inspection and Sampling

9.1 *Pipe:*
9.1.1 *Pressure Tests*—A minimum of 5 % of pipe joints shall be tested at a pressure of not less than 1.5× the pipe system pressure rating.
9.1.2 *Lot Size*—A lot of pipe shall consist of 150 joints, or fractions thereof, of one size, wall thickness, and grade in continuous production.
9.1.3 *Short-Term Burst Tests*—Short-term hydrostatic burst tests shall be conducted in accordance with Test Method D1599 at a minimum frequency of one test per lot. If the measured value is less than 85 % of the published value, the lot is rejected or subject to retest.

TABLE 1 Visual Acceptance Criteria

Defect Type	Description	Acceptance Criteria	Corrective Action
Burn	thermal decomposition indicated by distortion or discoloration of the laminate surface	none permitted	reject
Chip	small piece broken from edge or surface—if reinforcement fibers are broken, the damage is considered a crack	if there are undamaged fibers exposed over any area; or no fibers are exposed but an area greater than 0.4 in. by 0.4 in. (10 mm by 10 mm) lacks resin	minor repair
		if no fibers are exposed, and the area lacking resin is less than 0.4 in. by 0.4 in. (10 mm by 10 mm)	accept
Crack	actual separation of the laminate which is visible on opposite surfaces and often extends through the wall; reinforcement fibers are often visible/broken	none permitted	reject
Crazing	fine hairline cracks at or under the surface of the laminate; white areas are not visible	crack lengths greater than 1.0 in. (25.4 mm)	minor repair
		crack lengths less than 1.0 in. (25.4 mm)	accept
Dry spot	area of incomplete surface film where the reinforcement has not been wetted by resin	none permitted	reject
Fracture	rupture of the laminate with complete penetration; majority of fibers broken; visible as lighter colored area of interlaminar separation	none permitted	reject
Inclusion	foreign matter wound into the laminate	none permitted in structural wall (treat same as pit if located at the surface)	reject
Pit (pinhole)	small crater in the surface of the laminate; width is on the same order of magnitude as the depth	diameter greater than 0.032 in. (0.8 mm) or depth greater than 10 % of wall thickness, or both	minor repair
		diameter less than 0.032 in. (0.8 mm) and depth less than 10 % of wall thickness	accept
Restriction	excessive resin, adhesive, or foreign matter on the internal wall of pipe/fittings	none permitted	remove by careful grinding
Wear scratch	shallow mark caused by improper handling, storage, or transportation, or combination thereof—if reinforcement fibers are broken, the damage is considered to be a crack	undamaged fibers exposed over any area or no fibers are exposed but an area greater than 0.4 in. by 0.4 in. (10 mm by 10 mm) lacks resin	minor repair
		no fibers exposed and the area lacking resin is less than 0.4 in. by 0.4 in. (10 mm by 10 mm)	accept

9.1.4 *Degree of Cure*—The glass transition temperature (*Tg*) shall be determined at a minimum frequency of one test per production lot. If the measured value is more than 10 °F less than the value in the manufacturer's specification, the lot is rejected or subject to retest.

9.1.5 *Glass Content*—The glass content (mass fraction expressed as percentage) of at least one sample per production lot shall be determined in accordance with Test Method D2584. If the measured glass content is not within 5 % of the value in the manufacturer's specification, the lot is rejected or subject to retest.

9.1.6 *Wall Thickness*—Total wall thickness and reinforced wall thickness shall be determined in accordance with Practice D3567 once per every production lot. Total and reinforced wall thickness shall be as specified in Table 2. Any out of tolerance components shall be rejected and the remainder of the lot be subject to retest.

9.2 *Fittings:*

9.2.1 *Pressure Tests*—A minimum of 5 % of each fitting lot shall be tested at a pressure of not less than 1.5× the pipe system pressure rating. All samples shall hold the test pressure for a minimum of 2 min.

9.2.2 *Lot Size*—A lot shall consist of 50 fittings or one day's production of a specific fitting, whichever is greater. By agreement between the manufacturer, the purchaser, and the authority having jurisdiction, the lot size shall be permitted to be altered.

TABLE 2 Wall Thickness Tolerances

NOTE 1—Where measurement of the reinforced wall thickness would cause destruction or damage to the part, only the total wall thickness measurement need be taken.

Dimension	Tolerance, %
Total wall thickness	+22.5[A] −0
Reinforced wall thickness	+22.5[A] −0

[A] The tolerance on total and reinforced wall thickness for fittings shall refer to the manufacturer's designated location on the body of the fitting.

9.2.3 *Short-Term Burst Tests*—Short-term hydrostatic burst tests shall be conducted in accordance with Test Method D1599 at a minimum frequency of one test per lot. If the measured value is less than 85 % of the published value, the lot is rejected or subject to retest.

9.2.4 *Degree of Cure*—The *Tg* shall be determined at a minimum frequency of one test per production lot. If the measured value is more than 10 °F less than the value in the manufacturer's specification, the lot is rejected or subject to retest.

9.2.5 *Glass Content*—The glass content (mass fraction expressed as percentage) of at least one sample per production lot shall be determined in accordance with Test Method D2584. If the measured glass content is not within 5 % of the value in the manufacturer's specification, the lot is rejected or subject to retest.

9.2.6 *Wall Thickness*—Total wall thickness and reinforced wall thickness shall be determined in accordance with Practice D3567 once per every production lot. Total and reinforced wall thickness shall be as specified in Table 2. Any out of tolerance components shall be rejected.

9.3 *Flanges and Mitered Fittings:*

9.3.1 *Pressure Tests*—One mitered fitting from each lot shall be tested to a pressure equal to or greater than 1.5× the pipe system rating. All samples shall hold the pressure for a minimum of 2 min.

9.3.2 *Lot Size*—A lot shall consist of 20 flanges or 10 mitered fittings of any given configuration.

9.3.3 *Degree of Cure*—The *Tg* shall be determined at a minimum frequency of one test per production lot. If the measured value is more than 10 °F less than the value in the manufacturer's specification, the lot is rejected or subject to retest.

9.3.4 *Glass Content*—The glass content (mass fraction expressed as percentage) of at least one sample per production lot shall be determined in accordance with Test Method D2584. If the measured glass content is not within 5 % of the value in the manufacturer's specification, the lot is rejected or subject to retest.

9.3.5 *Wall Thickness*—Total wall thickness and reinforced wall thickness shall be determined in accordance with Practice D3567 once per every production lot. Total and reinforced wall thickness shall be as specified in Table 2. Any out-of-tolerance components shall be rejected and the remainder of the lot be subject to retest.

9.4 *Retest*—If any test result in 9.1, 9.2, or 9.3, or combination thereof, fails to conform to the specified requirements, the manufacturer shall be permitted to elect to reject the entire lot, or retest two additional samples from the same lot. If both of the retest specimens conform to the requirements, all items in the lot shall be accepted except the sample which initially failed. If one or both of the retest samples fail to conform to the specified requirements, the manufacturer shall reject the entire lot or test individually the remaining samples in the lot in accordance with 9.1.1, 9.2.1, or 9.3.1, as applicable. Note that in the final case, all samples need only be subjected to the tests that the original samples failed.

9.5 *Production Quality Documentation*—The manufacturer shall have manufacturing procedures for each component to be supplied, raw material test certificates for each component to be used in manufacturing, and production quality control reports available for the procurement officer.

10. Certification

10.1 The pipe manufacturer shall be registered by an accredited agency to meet the requirements of ISO 9001. For purposes of this specification, the manufacture shall be considered a "special process" as defined in ISO 9001, Section 4.9.

11. Product Marking

11.1 Pipe and fittings shall be marked with the name, brand, or trademark of the manufacturer; NPS; manufacture date; pressure rating; pressure rating method; and other information upon agreement between the manufacturer and the purchaser.

12. Keywords

12.1 epoxy resin fittings; epoxy resin pipe; marine piping; nominal pipe size; thermoset epoxy resin pipe

APPENDIXES

(Nonmandatory Information)

X1. DETERMINATION OF INTERNAL PRESSURE RATING FOR PIPE, FITTINGS, AND JOINTS

X1.1 Internal pressure rating for a piping system shall be determined using one of four methods. The method used to determine this rating shall be clearly identified by the manufacturer in published literature.

X1.1.1 *Rating Method 1—Short-Term Test Method*—Two samples of each pipe, joint, fitting, or other component shall be tested in accordance with Test Method D1599 at ambient temperature. The maximum rating for mitered (hand lay-up) fittings shall be determined by dividing the lesser result by a safety factor of 5.0. The maximum rating for all other components shall be determined by dividing the lesser result by a safety factor of 4.0.

X1.1.2 *Rating Method 2—Medium-Term (1000 h) Test*—Two samples of each pipe, joint, fitting, or other component are to be tested in accordance with Test Method D1598 for a period of 1000 h at the rated temperature. Both specimens must survive the exposure period without leakage. The maximum rating for mitered (hand lay-up) fittings shall be determined by dividing the test pressure by a safety factor of 2.5. The maximum rating for all other components shall be determined by dividing the test pressure by a safety factor of 2.2.

X1.1.3 *Rating Method 3—Long-Term (10 000 h) Test*—Two samples of each pipe, joint, fitting or other component are to be tested in accordance with Test Method D1598 for a period of

10 000 h at the rated temperature. Both specimens must survive the exposure period without leakage. The maximum rating for mitered (hand lay-up) fittings shall be determined by dividing the test pressure by a safety factor of 2.0. The maximum rating for all other components shall be determined by dividing the test pressure by a safety factor of 1.87.

X1.1.4 *Rating Method 4—Long-Term (10 000 h) Regression Test*—Pipe, fittings, and joints shall be tested in accordance with Practice D2992 Procedure B at the rated temperature. The pressure rating for all components shall be determined in accordance with the hydrostatic design basis (HDB) and lower confidence limit (LCL) as calculated in the test method. Ratings shall be determined by dividing the LCL at 20 years by a factor of 1.5. Scaling of the results is allowed for pipe bodies only in accordance with the ISO equation:

$$S \times SF = P(D - t_r)/2t_r \quad \text{(X1.1)}$$

where:

S = hoop stress, psi (kPa),
SF = service factor,
D = mean reinforced diameter (OD – t) or (ID + t), in. (mm),
P = internal pressure psig (kPa), and
t_r = minimum reinforced wall thickness, in. (mm).

NOTE X1.1—Liner thickness is not to be used in determining inside diameter.

NOTE X1.2—Coating thickness is not to be used in determining outside diameter.

X2. FIRE PERFORMANCE TESTS

X2.1 Fire performance tests shall be performed at an independent third-party laboratory to the satisfaction of the authority having jurisdiction.

X2.2 *Piping Material Systems:*

X2.2.1 All fire endurance, flame spread, and smoke and toxicity testing, where required, shall be conducted on each piping material system.

X2.2.2 Changes in either the type, amount, or architecture, or combination thereof, of either the reinforcement materials, resin matrix, liners, coatings, or manufacturing processes shall require separate testing in accordance with the requirements of this specification.

X2.3 *Fire-Protective Coatings:*

X2.3.1 Where a fire-protective coating is necessary for achieving the fire endurance, flame spread, or smoke and toxicity criteria, the following requirements apply:

X2.3.1.1 Pipes shall be delivered from the manufacturer with the protective coating on. On site application will be limited to what is physically necessary for installation (that is, joints).

X2.3.1.2 The fire-protection properties (that is, fire endurance, flame spread, smoke production, and so forth) of the coating shall not be diminished when exposed to (*1*) salt water, oil, or bilge slops, (*2*) other environmental conditions such as high and low temperatures, high and low humidity, and ultraviolet rays, or (*3*) vibration.

X2.3.1.3 The adhesion qualities of the coating shall be such that the coating does not flake, chip, or powder, when subject to an adhesion test.

X2.3.1.4 The fire-protective coating shall be resistant to impact and abrasion. It shall not be separated from the piping during normal handling.

X2.4 *General Fire Endurance Test Requirements:*

X2.4.1 All typical joints, including but not limited to pipe to pipe, fiberglass flange to fiberglass flange, and fiberglass flange to metallic flange intended to be used shall be tested. Elbows and tees need not be tested provided the same adhesive or method of joining utilized in straight piping tests will be used in the actual application.

X2.4.2 Qualification of piping systems of sizes different than those tested shall be allowed as provided for in Table X2.1. This applies to all pipe, fittings, system joints (including joints between metal and fiberglass pipes and fittings), methods of joining, and any internal or external liners, coverings, and coatings required to comply with the performance criteria.

X2.4.3 No alterations to couplings, fittings, joints, fasteners, insulation, or other components shall be made after the commencement of the fire endurance testing. Flange bolts shall not be retorqued after completion of the fire exposure testing, before hydrostatic testing. Postfire hydrostatic testing shall be conducted without altering the component in any way.

X2.5 *Fire Type JF–Jet Fire*—This test is based upon Health & Safety Executive document OTI 95 634, except that is modified so that actual pipe, joints, and fittings are exposed to the flame.

X2.5.1 *Equipment:*

X2.5.1.1 A propane vaporization and propulsion system capable of delivering 0.66 lb⁄s ± 0.11 lb⁄s (0.3 kg⁄s ± 0.05 kg⁄s) flow under controlled conditions into a backing "box" which has the test specimen mounted at the box's front opening. The nozzle shall be a tapered, converging type, 7.875 in. (200 mm) in length with an inlet diameter of 2.0 in. (52 mm) and an outlet diameter of 0.70 in. (17.8 mm). The nozzle is to be located 3.281 ft (1.0 m) from the front of the

TABLE X2.1 Qualification of Piping Systems of Different Sizes

Size Tested [NPS], in. (mm)	Minimum Size Approved, in. (mm)	Maximum Size Approved, in. (mm)
0 to 1.5 (0 to 40)	size tested	size tested
2 to 4 (50 to 100)	size tested	4 (100)
5 to 10 (125 to 250)	size tested	10 (250)
12 to 22 (300 to 550)	size tested	22 (550)
24 to 34 (600 to 850)	size tested	34 (850)
36 to 48 (900 to 1200)	size tested	48 (1200)

box, centered across the box, and mounted horizontally between 15 in. (375 mm) and 30 in. (750 mm) from the bottom of the box. The flow shall directly impinge on the test specimen.

X2.5.1.2 Water-handling and timing equipment suitable for delivering sufficient quantities of water to produce a fluid velocity of 3 ft/s (0.91 m/s) at the rated pressure of the piping system being tested.

X2.5.1.3 Instrumentation to record fuel flow rate, water flow rate, temperatures in the specimen and in various locations in the backing panel, and water leakage rate from the pipe assembly or individual components.

X2.5.2 *Test Specimen*—The test specimen shall be prepared with the joints, fittings, and fire-protection coverings, if any, intended for use in the proposed application. It is up to the authority having jurisdiction to determine the number and size of test specimens, as well as requirements for the qualification of a range of pipe diameters.

X2.5.3 *Test Conditions:*

X2.5.3.1 If fire-protective coatings or coverings contain or are liable to absorb moisture, the test specimen shall not be tested until the insulation has reached an air-dry condition. This condition is defined as equilibrium with an ambient temperature at 50 % relative humidity of 70 °F ± 10 °F (20 °C ± 5 °C). Where fire-protective coatings or coverings are required to enable a pipe system to pass a fire endurance test, the coatings' or coverings' properties should not degrade over time or due to exposure to the environment as discussed in IMO FTP Code Res A.753(18) Paragraph 2.2.6, or both.

X2.5.3.2 The test specimen shall be planar and shall be mounted flush to the opening of a 5 ft by 5 ft (1.5 m by 1.5 m) open-ended, steel box (closed back panel with a depth of 1.64 ft (0.5 m). Suitable auxiliary equipment shall be attached to the box to ensure the box's structural stability and to prevent any transient ambient conditions from significantly affecting the testing. The purpose of the box is to provide a "backstop" to the flame and cause swirling of the fire to completely engulf the sample.

X2.5.3.3 If required to record temperature conditions during testing, mount thermocouples on the specimen and within the box or its structure.

X2.5.3.4 The test building shall be suitably constructed to ensure there is not a hazardous amount of heat or smoke allowed to accumulate during or after the test.

X2.5.3.5 Before conducting the test, calibration runs of the gas flow controls and water flow system shall be conducted.

X2.5.3.6 Fuel used shall be commercial grade propane delivered to the nozzle as a vapor without a liquid fraction.

X2.5.4 *Test Procedure:*

X2.5.4.1 Pressure test each test specimen to 1.5× its rated pressure prior to mounting in the test rig. No leakage is allowed during this test.

X2.5.4.2 Unless Fluid S is specified, completely drain the specimen of water after the initial test and secure into position. Make all thermocouple and plumbing connections at this time. For Fluid S conditions, secure the specimen into position filled with water.

X2.5.4.3 It is acceptable to start the test using a small "pilot" flame to ensure safe ignition of the fuel before full flow being established.

X2.5.4.4 Increase the flow to the rate as specified in X2.5.1.1. This rate has been shown to produce a heat flux between 95 100 Btu/(h-ft^2) and 126 800 Btu/(h-ft^2) (300 kW/m^2 and 400 kW/m^2). Timing of the test is to begin when the specimen is fully engulfed. Establish fully controlled flow within 30 s of the start of the test.

X2.5.4.5 If Fluid E or S is specified in 4.3.1, then continue the test for a minimum of 20 min under the initial conditions.

X2.5.4.6 If Fluid EF in 4.3.1 is specified, take the following steps:

(1) Continue the test in the dry condition for 5 min.

(2) After the 5 min dry period, introduce water at a flow velocity not to exceed 3.0 ft/s. Pressure in the system is to be maintained at a minimum of 90 % of the rated pressure for the system. These conditions are to be established within 1 min after the flow of water begins.

(3) Continue the test under flowing water conditions for a minimum of 15 min.

X2.5.4.7 Increased exposure times over those previously specified are acceptable upon agreement between the manufacturer and the buyer.

X2.5.4.8 Upon completion of the fire exposure period, discontinue the fuel flow, extinguish the flame, and allow the sample to cool (with flowing water, if desired) to room temperature.

X2.5.4.9 After cooling, pressurize the specimen at it's rated pressure for a minimum of 15 min with stagnant water (make-up water is allowed). Measure overall leakage and leakage of each component and record after this period.

X2.5.5 *Acceptance Criteria*—Piping shall be deemed to have passed the test if the performance meets the criteria set by the authority having jurisdiction regarding integrity and duration in 4.3.3. If no criteria is established, a maximum leakage of 10 % of the rated flow will be used as the default limit.

X2.5.6 *Report*—Report the following information:

X2.5.6.1 Complete identification of the pipe or fitting tested including the manufacturer's name and code.

X2.5.6.2 Description of fire-protective coating, if applicable.

X2.5.6.3 Diameter of pipe, fitting, or joint.

X2.5.6.4 Endurance time.

X2.5.6.5 Appearance of test specimen.

X2.5.6.6 Date of test.

X2.5.6.7 Leakage rate.

X2.6 *Fire Type HF–Hydrocarbon Furnace Test Method*—This test method covers the determination of the fire endurance of thermosetting resin fiberglass pipe, fittings, and joints to be used in marine applications. The procedure in Test Method E1529 with additional steps as outlined shall be followed. This procedure is similar to IMO Assembly Resolution A.753(18), Appendix 1, which is an alternative to this test.

X2.6.1 *Significance*—This test method is intended to provide a basis for evaluating the time period during which fiberglass pipe will continue to perform its intended function