



Approval Standard for Fiber Reinforced Composite (FRC) Pipe and Fittings for Underground Fire Protection Service

Class Number 1614

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Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) Must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) Must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, successful re-examinations of equipment, materials, and services as appropriate, and surveillance audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states Approval criteria for Fiber Reinforced Composite (FRC) pipe and fittings for underground fire service water mains.
- 1.1.2 Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance audit program.

1.2 Scope

- 1.2.1 This standard encompasses the design and performance requirements for NPS (Nominal Pipe Size) 4 inch through 36 inch nominal size FRC pipe and fittings for use in underground fire service mains, other sizes may be evaluated on a case-by-case basis.
- 1.2.2 In cases where metric sized FRC pipe and fittings are to be examined for Approval, test criteria comparable to the United States equivalent size shall be used.
- 1.2.3 FM Approvals will consider FRC pipe and fittings which are designed in accordance to national or international standards, such as the American Water Works Association (AWWA) C-950-13 for *Fiberglass Pressure Pipe*. Pipe manufactured in accordance with other nationally or internationally recognized standards will be considered on a case-by-case basis. All Approval testing is to be conducted on production samples.
- 1.2.4 Approval Standards are intended to verify that the product described will meet the stated conditions of performance, safety and quality useful to the ends of property conservation.
- 1.2.5 This standard is primarily intended for use in Approving fiberglass pipe and fittings. Other Fiber Reinforced Composite materials can be FM Approved under this standard and will be evaluated on a case-by-case basis.

1.3 Basis for Requirements

- 1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.
- 1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of FRC pipe and fittings for the purpose of obtaining Approval. FRC pipe and fittings having characteristics not anticipated by this standard may be FM Approved if performance equal to, or superior to, that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, FRC pipe and fittings which meet all of the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for Approval

Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate:

- The suitability of the product
- The performance of the product as specified by the manufacturer and required by FM Approvals; and as far as practical,
- The durability and reliability of the product.

1.4.2 An initial audit shall be conducted to evaluate the manufacturer's ability to consistently produce the product that was examined and tested as part of the Approval project. The audit shall review the facility and in-place quality control procedures used in the manufacturing of the product. Typically, areas of review are incoming inspection, work in progress, production testing, final quality control, marking, calibration of equipment, shipping procedures, and document and drawing control. These examinations are repeated periodically as part of the FM Approvals product follow-up program. (Refer to Section 5.2, Surveillance Audit Program).

1.5 Basis for Continued Approval

1.5.1 Continued Approval is based upon:

- Production or availability of the product as currently FM Approved;
- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Master Agreement;
- Satisfactory re-examination of production samples for continued conformity to requirements; and
- Satisfactory Surveillance Audits conducted as part of FM Approvals' Surveillance Audit Program.

1.5.2 Also, as a condition of retaining Approval, manufacturers may not change an FM Approved product or service without prior written authorization by FM Approvals. (Refer to Section 5.1.3 for further details regarding changes.)

1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or forfeit Approval.

The effective date of this standard is **May 1, 2018** for compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with SI 10-02 Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) *"Standard for Use of the International System of Units (SI): The Modern Metric System."*

1.8 Applicable Documents

The following standards, test methods, and practices are referenced in this standard:

ANSI A21.1-1967, *American National Standard for Thickness Design of Cast Iron Pipe*
ANSI/American Water Works Association, (AWWA) C950-2013, *Fiberglass Pressure Pipe*
ASTM D618-13, *Standard Practice for Conditioning Plastics for Testing*
ASTM D638-14, *Standard Test Method for Tensile Properties of Plastics*
ASTM D695-15, *Test Method for Compressive Properties of Rigid Plastics*
ASTM D883-12, *Standard Terminology Relating to Plastics*
ASTM D1238-13, *Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer*
ASTM D1505-10, *Standard Test Method for Density of Plastics by the Density-Gradient Technique*
ASTM D1598-15a, *Standard Test Method for Time-to-Failure of Plastic Pipe under Constant Internal Pressure*
ASTM D1599-14, *Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing and Fittings*
ASTM D1600-14, *Standard Terminology for Abbreviated Terms Relating to Plastics*
ASTM D2290-12, *Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method*
ASTM D2412-11, *Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading*
ASTM D2444-99(2010), *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*
ASTM D2837-13e1, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*
ASTM D2992-12, *Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings*
ASTM D2996-15, *Specification for Filament-Wound 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe*
ASTM D2997-15, *Specification for Centrifugally Cast 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe*
ASTM D3517-14, *Standard Specification for 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe*
ASTM D3567-97(2011), *Standard Practice for Determining Dimensions of 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings*
ASTM D3681-12e1, *Standard Test Method for Chemical Resistance of 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition*
ASTM D4161-14, *Standard Specification for 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals*
ASTM D5365-12, *Standard Test Method for Long-Term Ring-Bending Stain of 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe*
ASTM F412-15, *Standard Terminology Relating to Plastic Piping Systems*
ASTM F477-14, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe*
American Water Works Association (AWWA) *Fiberglass Pipe Design (M45)*, Third Edition
FM Global *Property Loss Prevention Data Sheets*
NSF/ANSI 61-2013: *Standard for Drinking Water Systems Components - Health Effects*
International Standards Organization (ISO) 161-1-1996, *Thermoplastic Pipe for the Conveyance of Fluids, Nominal Outside Diameters and Nominal Pressures, Part 1 Metric Series*
IEEE/ASTM SI 10-2010, *American National Standard for Metric Practice*
ISO 17025-2005, *General Requirements for the Competence of Testing and Calibration Laboratories*

1.9 Definitions

Generally, terminology relating to FRC pipe and fittings shall be in accordance with ANSI/ASTM D883-12, *Standard Definitions of Terms Relating to Plastics* and ASTM F412-15, *Standard Terminology Relating to Plastic Piping Systems*, respectively. Any terminology not included within, or in contradiction to, those documents will be separately defined where used in the Approval examination of FRC pipe and fittings. For purposes of this standard, the following terms apply:

Accepted

This term refers to installations acceptable to the authority enforcing the applicable installation rules (Authority Having Jurisdiction). When the authority is FM Global, such locations are termed “FM Global Accepted.” Acceptance is based upon an overall evaluation of the installation. Factors other than the use of FM Approved equipment impact upon the decision to accept, or not to accept. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

Design Factor (DF)

The factor that is used to reduce the Hydrostatic Design Basis (HDB) to arrive at the Hydrostatic Design Stress (HDS). The Design Factor is the inverse of the Safety Factor.

FM Approvals Certification Marks

Its use is mandatory on all FM Approved products. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

FM Approved

This term refers to products FM Approved by FM Approvals. Such products are listed in the Approval Guide, an online resource of FM Approvals. All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. This form obligates the manufacturer to allow re-examination of the product and surveillance audits at the discretion of FM Approvals. It further requires the manufacturer not to deviate from the as - FM Approved configuration of the product without review by and agreement of FM Approvals. Approval is product and site specific.

Hydrostatic Design Basis (HDB)

One of a series of established stress values obtained by categorizing the Long Term Hydrostatic Strength of the material as described in ASTM D2992-12, *Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for ‘Fiberglass’ (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe*.

Hydrostatic Design Stress (HDS)

The recommended maximum allowable hoop stress used in the design of plastic pipe of a given material. It is obtained by dividing the Hydrostatic Design Basis (HDB) by a safety factor.

$$HDS = \frac{HDB}{SF}$$

Long Term Hydrostatic Strength (LTHS)

Plastic materials exhibit a time-dependent response to stress. This occurs in a predictable fashion. If samples of plastic pipe are pressurized to various levels, they will fail after periods of time that depends on these pressures. The specific relationship is that the logarithm of the time to failure is negatively proportional to the logarithm of the stress.

$$\log T = a - b \log S$$

Where a and b are material constants.

This stress, S , is the hoop stress in the material due to internal pressure at a constant temperature. ASTM D2992-12, *Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe*, details test procedures for obtaining this relationship. The relationship is then used to determine a particular maximum S that should not cause failure until at least after a minimum desired life. That S is termed the Long Term Hydrostatic Stress (LTHS) for the material in question.

Pressure Class

The pressure class is the design capacity to resist working pressure at 73.4°F (23°C) with specified maximum allowances for recurring positive pressure surges above the working pressure. Pressure Class is defined in AWWA *Fiberglass Pipe Design (M45)*, Third Edition as:

For stress basis HDB:

$$P_c < \left(\frac{HDB}{FS} \right) \left(\frac{2t}{D} \right)$$

For strain basis HDB:

$$P_c < \left(\frac{HDB}{FS} \right) \left(\frac{2tE_H}{D} \right)$$

Where:

- P_c - Pressure Class, in psi (kPa)
- HDB - Hydrostatic Design Basis for water, in psi, (kPa) as determined in ASTM D2992-12.
- FS - Typical Design Factor; Includes Consideration of Degree of Safety and all the variables, including limited surge pressure effects, in the end application
- t - Thickness of the pipe wall, in. (mm) as defined in ASTM D3567
- D - Mean Pipe Diameter, in. (mm)
- E_H - hoop tensile modulus of elasticity, lb/in² (kPa)

Pressure Pipe for Water Distribution and Transmission

Underground pipe used to carry water from a source of supply and distribute it throughout a distribution system or a service area. For the purposes of this standard, distribution and transmission pipe is limited to nominal sizes 4 inches through 36 inches; other sizes will be evaluated on a case-by-case basis.

Production Run

The length of time a particular piece of extrusion equipment is set up to produce a certain size and class of pipe.

Safety Factor (SF)

A number, typically greater than or equal to 1.8, by which the Hydrostatic Design Basis (HDB) is divided to obtain the Hydrostatic Design Stress (HDS). This SF is used to account for variations in conditions from those contemplated in the design of an installation, rough handling of piping, and manufacturing variations.

Surge Pressure (P_s)

The maximum transient pressure increase in excess of the operating pressure that is anticipated in the system as a result of changes in velocity. For the purposes of FRC piping product selection and system design two types of surge are considered:

Occasional Surge Pressure (P_{os})

Occasional surge pressure is the result of an infrequent event and is usually the result of a malfunction, such as a power failure or system component failure (such as pump seize-up, valve-stem failure or pressure relief valve failure).

Recurring Surge Pressure (P_{rs})

Recurring surge pressures occur frequently and are inherent in the design and operation of the piping system (such as normal pump startup or shutdown and normal valve opening and closing).

Working Pressure (WP)

The maximum anticipated, sustained operating pressure applied to the pipe exclusive of hydraulic transient pressures.