



Member of the FM Global Group

Approval Standard for Polyvinyl Chloride (PVC) Pipe and Fittings for Underground Fire Protection Service

Class Number 1612

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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.

Table of Contents

1. INTRODUCTION	1
1.1 Purpose.....	1
1.2 Scope.....	1
1.3 Basis for Requirements.....	1
1.4 Basis for Approval.....	1
1.5 Basis for Continued Approval.....	2
1.6 Effective Date.....	2
1.7 System of Units	2
1.8 Applicable Documents	2
1.9 Definitions	3
2. GENERAL INFORMATION.....	6
2.1 Product Information	6
2.2 Approval Application Requirements.....	6
2.3 Requirements for Samples for Examination.....	6
3. GENERAL REQUIREMENTS.....	7
3.1 Review of Documentation.....	7
3.2 Physical or Structural Features	7
3.3 Materials	9
3.4 Markings	9
3.5 Manufacturer's Installation and Operation Instructions	10
3.6 Calibration	10
4. PERFORMANCE REQUIREMENTS.....	11
4.1 Examination.....	11
4.2 Quick Burst Strength (Pipe Only)	11
4.3 Hydrostatic Strength (Pipe and Fittings)	12
4.4 Stiffness Factor (Pipe Only)	13
4.5 Abuse Test (Pipe and Fittings).....	13
4.6 Vacuum Test.....	14
4.7 One-Hour Pressure Test	14
4.8 Additional Tests.....	15
5. OPERATIONS REQUIREMENTS.....	16
5.1 Demonstrated Quality Control Program	16
5.2 Surveillance Audit Program.....	17
5.3 Installation Inspections.....	18
5.4 Manufacturer's Responsibilities	18
5.5 Manufacturing and Production Tests.....	18
5.5.1 Test Requirement No. 1 - Dimension and Tolerances (Pipe and Fittings)	18
5.5.2 Test Requirement No. 2 - Heat Reversion Test (Molded Fittings Only)	18
5.5.3 Test Requirement No. 3 - Accelerated Regression Test (Molded Fittings Only)	18
5.5.4 Test Requirement No. 4 - Hydrostatic Proof Test (Pipe Only).....	19
5.5.5 Test Requirement No. 5 - Flattening Test (Pipe Only)	19
5.5.6 Test Requirement No. 6 - Extrusion Quality (Pipe Only).....	19
5.5.7 Test Requirement No. 7 - Quick Burst (Distribution Pipe Only)	19
5.5.8 Test Requirement No. 8 - Sustained Pressure Test (Distribution Pipe Test Only)	19
APPENDIX A: UNITS OF MEASUREMENT	20
APPENDIX B: TOLERANCES	21
APPENDIX C: SAMPLE CALCULATION.....	22
APPENDIX D: SAMPLE LISTING	24

1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states Approval criteria for Polyvinyl Chloride (PVC) 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 in. through 36 in. PVC pipe and fittings for use in underground fire service mains. Other sizes may be considered for Approval on case by case basis.
- 1.2.2 In cases where metric sized PVC pipe and fittings are to be examined for Approval, test criteria comparable to the United States equivalent size shall be used.
- 1.2.4 FM Approvals will consider PVC pipe and fittings which are designed in accordance to national or international standards. Only after verification is made that the products to be reviewed are in conformance to ANSI/AWWA C900, ANSI/AWWA C907, ANSI/AWWA C909 or other nationally or internationally recognized standards will Approval testing commence. All Approval testing is to be conducted on production samples.
- 1.2.5 This standard is intended to verify that the product described will meet stated conditions of performance, safety and quality useful to the ends of property conservation.

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 PVC pipe and fittings for the purpose of obtaining FM Approval. PVC pipe and fittings having characteristics not anticipated by this standard may be Approved if performance is equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, PVC 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:
 - Suitability of the product;
 - Performance of the product as specified by the manufacturer and required by FM Approvals; and, as far as practical,
 - 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 Surveillance Audit 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;
- 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 authorization by FM Approvals. (Refer to Section 5.1.3 for further details regarding changes.)

1.6 Effective Date

The effective date of an FM Approval standard mandates that all products tested for FM Approval after that 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 FM Approval.

The effective date of this standard is **September 1, 2017** 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 the Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing and Materials (ASTM) SI 10-2010, *American National Standard for Metric Practice*. One unit of measurement (liter), outside of, but recognized by SI, is commonly used in international fire protection and is used in this standard.

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*

ASTM D883-12, *Standard Terminology Relating to Plastics*

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 D1784-11, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds*

ASTM D2122-15, *Standard Test Method of Determining Dimensions of Thermoplastic Pipe and Fittings*
ASTM D2152-13, *Standard Test Method for Adequacy of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion*
ASTM D2241-15, *Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)*
ASTM D2412-11, *Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading*
ASTM D2444-99, *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*
ASTM D2487-11, *Standard Practice for Classification of Soils for Engineering Purposes, (Unified Soil Classification System)*
ASTM D2774-12, *Standard Practice for Underground Installation of Thermoplastic Pressure Piping*
ASTM D2837-13, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Bases for Thermoplastic Pipe Products*
ASTM D3139-98(2011), *Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals*
ASTM F412-15, *Standard Terminology Relating to Plastic Piping Systems*
ASTM F477-14, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe*
ASTM F610-610M, *Standard Practice for Evaluating the Quality of Molded Poly(Vinyl Chloride) (PCV) Plastic Pipe Fittings by the Heat Reversion Technique*
ASTM F1483-15, *Standard Specification for Oriented Poly (Vinyl Chloride) (PVCO) Pressure Pipe*
ANSI/AWWA C-900-16, *"Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 60 in. (100 mm Through 1500 mm)*
ANSI/AWWA C-907-12, *Injection Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 in. Through 12 in. (100 mm Through 300 mm) for Water, Wastewater, and Reclaimed Water Service*
ANSI/AWWA C-909-09, *Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 in. through 24 in. (100 mm Through 600 mm) For Water, Wastewater, and Reclaimed Water Service*
AWWA Manual M23, *PVC Pipe - Design and Installation, Second Edition*
FM Global Property Loss Prevention Data Sheets
Plastic Pipe Institute, (PPI) TR-3 - 2004, *Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe*
NSF/ANSI 61-2013: *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 PVC pipe and fittings shall be in accordance with ASTM D883-12, *Standard Terminology 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 PVC 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 Factor of Safety.

Dimension Ratio (DR)

The ratio of the average outside diameter of outside diameter-controlled plastic pipe to the minimum specified wall thickness of the pipe, rounded to the nearest tenth (eg. DR 13.5).

Factor of Safety (SF)

A number, typically greater than 2.0, 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.

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 specified in ASTM Test Method D2837-13 for a plastic compound obtained by categorizing the Long Term Hydrostatic Strength of the material as described in ASTM D2837-13, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*.

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 factor of safety.

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

For water distribution and transmission pipe, nominal sizes 4 in. through 60 in., the minimum factor of safety is 2.0 as described in AWWA C900-16 and AWWA C909-09.

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 proportional to those 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 constants.

This stress, *S*, is the hoop stress in the material due to internal pressure at a constant temperature. ASTM D2837-13, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe*

Materials or Pressure Design Basis for Thermoplastic Pipe Products, 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. For purposes of Approval of PVC Pipe, $T=50$ years shall be used to determine the LTHS.

Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe

PVCO pressure pipe is made through a manufacturing process which reorients the molecular structure of polyvinyl chloride (PVC) in the circumferential or hoop direction. The process starts by extruding a smaller outside diameter, heavier wall stock pipe. The stock pipe is reheated and then expanded with internal pressure to its final dimensions. The expansion causes the polymer molecules to orient in the hoop direction. The orientation is “locked in” by cooling the pipe. The result is PVCO pressure pipe characterized by its strong mechanical properties (HDB) and light weight for water pressure applications.

Polyvinyl Chloride (PVC)

A polymer prepared by the polymerization of vinyl chloride as the sole monomer.

Pressure Class

The pressure class is the design capacity to resist working pressure up to 73.4°F (23°C) maximum service temperature. Pressure Class is defined as:

$$PC = \left[\frac{2}{DR - 1} \right] \left[\frac{HDB}{SF} \right]$$

Where:

- PC - Pressure Class
- DR - Dimension Ratio = D_o/t
- D_o - Average outside diameter
- t - Minimum pipe wall thickness
- HDB - Hydrostatic Design Basis, as determined in AWWA C-900-16 / C909-09.
- SF - 2.0; Safety factor; provides for degree of safety and accounts for installation and operation variables, including limited surge effects.

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, transmission pipe is limited to nominal sizes 14 inches through 36 inches; other sizes will be evaluated on a case-by-case basis. Water distribution and transmission pipe pressure classes are typically based on a factor of safety of 2.

Surge Allowance (P_s)

Surge pressure allowance, in pounds per square inch, based on an instantaneous velocity change of 2 ft/s (0.61 m/s).

Tup B

A cylindrical weight with a 2 in. (55 mm) radius nose, as defined in ASTM D2444-99.

Working Pressure (WP)

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

2. GENERAL INFORMATION

2.1 Product Information

- 2.1.1 PVC pipe and fittings encompassed by this standard are used in underground fire protection systems. Within this Standard a distinction is made between pipe designed as water distribution pipe and that designed as water transmission pipe. For the purposes of this Standard, distribution pipe is limited to nominal sizes 4 in. through 12 in., while transmission pipe is limited to nominal sizes 14 in. through 36 in. Other sizes shall be evaluated on a case-by-case basis.
- 2.1.2 PVC pipe and fittings are manufactured from materials with specific properties. They are thermoplastic compounds prepared by combining PVC resin with modifiers to attain desirable properties, and with stabilizers, lubricants, and pigments for processing, property control, and coloring.
- 2.1.3 PVC compound is usually either extruded (pipes) or injection molded (fittings) of specific thermoplastic formulations, in conformance to nationally or internationally recognized standards.
- 2.1.4 In order to meet the intent of this standard, PVC pipe and fittings components must be examined on a model-by model, type-by-type, manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical designs, fabricated using identical materials by different manufacturers, or even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample PVC pipe and fittings, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

- 2.2.1 To apply for an Approval examination, the manufacturer, or its authorized representative, shall submit a request to information@fmapprovals.com.
- 2.2.2 The manufacturer shall provide the following preliminary information with any request for Approval consideration:
- A complete list of all models, types, sizes, end connections, and options for the products being submitted for Approval consideration,
 - General assembly drawings, one complete set of manufacturing drawings, hydrostatic design basis (HDB) calculations, anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, and
 - Number and location(s) of manufacturing facilities making the products submitted for Approval.
- 2.2.3 All of the above referenced documents shall be controlled by the manufacturer's Quality Assurance procedures, and shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All foreign language documents shall be provided with English translation at the time of submittal.

2.3 Requirements for Samples for Examination

- 2.3.1 Sample requirements are to be determined by FM Approvals following review of the preliminary information used in the preparation of the examination proposal. Sample requirements may vary depending on size range of product under consideration, design features, or results of prior testing. Following the authorization of the examination proposal, the manufacturer shall submit samples for