

Approval Standard for Polyethylene (PE) Pipe and Fittings for Underground Fire Protection

Class Number 1613

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Foreword

Approvals are intended to verify that the products and services described will meet 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 Approval shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing and/or applications shall ensure a consistently uniform and reliable product or service. Approval Standards strive to be performance-oriented and 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 Master Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility or service/application.

FM Approvals LLC reserves the right in its sole judgement 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 FM Approvals criteria for Polyethylene (PE) pipe and fittings for underground fire service water mains.
- 1.1.2 FM Approvals criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

1.2 Scope

- 1.2.1 This standard encompasses the design and performance requirements for 4 in. through 36 in. nominal size PE pipe and fittings for use in underground fire service mains, other sizes may be evaluated on a case-by-case basis. In cases where metric sized PE pipe and fittings are to be examined for Approval, test criteria comparable to the United States equivalent size shall be used.
- 1.2.2 Approval Standards are intended to verify that the product described will meet stated conditions of performance, safety and quality useful to the ends of property conservation.
- 1.2.3 FM Approvals will consider PE 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 American Water Works Association (AWWA) C-906, *Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 63 in., for Water Distribution*, or other nationally or internationally recognized standards will Approval testing commence. All Approval testing is to be conducted on production samples.

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 PE pipe and fittings for the purpose of obtaining Approval. PE pipe and fittings having characteristics not anticipated by this standard may be FM Approved if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, PE 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 facilities and procedures 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, Facility and Procedures Audit.).

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 Facilities and Procedures Audits (F&PAs) conducted as part of FM Approvals' Product Follow-up 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 **January 31, 2007** 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 American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-97, "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 A21.10 - 1967, *American National Standard for Thickness Design of Cast Iron Pipe*
ANSI/American Water Works Association, (AWWA) C901 - 2002, *Polyethylene (PE) Pressure Pipe and Tubing, 1/2 in (13 mm) through 3 in (76 mm), for Water Service*

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- ANSI/AWWA C906 - 1999, *Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 63 in., for Water Distribution*
- ANSI/IEEE/ASTM SI 10, 2002, *Standard for Use of the International System of Units (SI): The Modern Metric System*
- ASTM D618 - 2000, *Standard Practice for Conditioning Plastics for Testing*
- ASTM D638 - 2003, *Standard Test Method for Tensile Properties of Plastics*
- ASTM D883 - 2000, *Standard Terminology Relating to Plastics*
- ASTM D1238 - 2004c, *Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer*
- ASTM D1505 - 2003, *Standard Test Method for Density of Plastics by the Density-Gradient Technique*
- ASTM D1598 - 2002, *Standard Test Method for Time-to-Failure of Plastic Pipe under Constant Internal Pressure*
- ASTM D1599 - 1999(2005), *Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing and Fittings*
- ASTM D1600 - 1999, *Standard Terminology for Abbreviated Terms Relating to Plastics*
- ASTM D1603 - 2001, *Standard Test Method for Carbon Black in Olefin Plastics*
- ASTM D2122 - 2004, *Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings*
- ASTM D2290 - 2004, *Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method*
- ASTM D2412 - 2002, *Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading*
- ASTM D2444 - 1999 (2005), *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*
- ASTM D2447 - 2003, *Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter*
- ASTM D2487 - 2000, *Standard Classification of Soils for Engineering Purposes, (Unified Soil Classification System)*
- ASTM D2657 - 2003, *Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings*
- ASTM D2683 - 2004, *Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing*
- ASTM D2774 - 2004, *Standard Practice for Underground Installation of Thermoplastic Pressure Piping*
- ASTM D2837 - 2004, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*
- ASTM D2839 - 2002, *Standard Practice for Use of a Melt Index Strand for Determining Density of Polyethylene*
- ASTM D3035 - 2003a, *Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter*
- ASTM D3261 - 2003, *Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing*
- ASTM D3350 - 2004, *Standard Specification for Polyethylene Plastic Pipe and Fittings Materials*
- ASTM D4218 - 1996 (2001), *Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique*
- ASTM 4976 - 2004a, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials*
- ASTM F412 - 2001ae1, *Standard Terminology Relating to Plastic Piping Systems*
- ASTM F714 - 2005, *Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter*
- ASTM F905 - 2004, *Standard Practice for Qualification of Polyethylene Saddle Fusion Joints*
- ASTM F1055 - 1998e1, *Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing*
- ASTM F1290 - 1998a (2004), *Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings*
- American Water Works Association (AWWA) M55 - 2005, *PE Pipe - Design and Installation*
- 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 61-2003e: *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*
 ISO 17025 – 1999, *General Requirements For The Competence of Testing and Calibration Laboratories*

1.9 Definitions

Generally, terminology relating to PE pipe and fittings shall be in accordance with ANSI/ASTM D883, *Standard Definitions of Terms Relating to Plastics* and ASTM F412, *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 PE 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. 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. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

Approval Mark

The Approval Mark is detailed in Appendix B. Its use is mandatory on all units of FM Approved pipe and fittings. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

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).

Electrofusion Joints

A joint where the mating surfaces, typically a pipe outside diameter and the inside diameter of a coupler, are first mated and then brought to the material melt temperature by means of heating elements embedded in the socket. Once cooled, the result is an electrofused joint.

Factor of Safety (F)

A number, typically greater than or equal to 2.0, by which the Hydrostatic Design Basis (*HDB*) is divided to obtain the Hydrostatic Design Stress (*HDS*). This F 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 Approved

This term refers to products FM Approved by FM Approvals. Such products are listed in the Approval Guide, a publication of FM Approvals, issued annually, or its supplements. All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. These forms obligate the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approval’s discretion. 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.

Hydrostatic Design Basis (HDB)

One of a series of established stress values specified in ASTM Test Method D2837 for a plastic compound obtained by categorizing the Long Term Hydrostatic Strength of the material as described in ASTM D2837, *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.

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

For Polyethylene Pressure Pipe for water distribution and transmission the factor of safety is typically 2.

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, *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.

Polyethylene (PE)

A polymer prepared by the polymerization of no less than 85 percent ethylene and no less than 95 percent of total olefins by weight, plus compounding ingredients.

Pressure Class

The pressure class is the design capacity to resist working pressure up to 80°F (27°C) maximum service temperature with specified maximum allowances for recurring positive pressure surges above the working pressure. Pressure Class is defined as:

$$PC = \frac{2}{DR - 1} \times HDB \times DF$$

Where:

- PC - Pressure Class, in pounds per square inch gauge (kPa gauge)
- DR - Dimension Ratio = D_o/t
- HDB - Hydrostatic Design Basis for water, in pounds per square inch, psi, (kPa) as determined in AWWA C906.
- DF - 0.5; Typical Design Factor; Includes Consideration of Degree of Safety and all the variables, including limited surge pressure effects, in the end application
- t - Minimum Pipe Wall Thickness, inches
- D_o - Average Outside Diameter for IPS and DI sizes; minimum outside diameter for ISO sizes, inches

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. Water distribution and transmission pipe pressure classes are typically based on a factor of safety of 2.

Production Run

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

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 PE 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 and 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 constant internal pressure that can be exerted continuously with a high degree of certainty that failure of the pipe will not occur, at a given temperature, exclusive of pressure surges.

Working Pressure Rating (WPR)

The working pressure rating is the design capacity to resist working pressure at the anticipated operating temperature with sufficient capacity against the actual anticipated positive pressure surges above the working pressure. A pipe's *WPR* may be equal to, or less than, its nominal *PC* depending on the positive transient pressure characteristics of the system and pipe operating temperature if above 80°F (27°C). *WPR* should be determined in accordance with AWWA C906, *Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 63 in., for Water Distribution*.