



Member of the FM Global Group

Approval Standard for Ductile Iron Pipe and Fittings, Flexible Fittings and Couplings

Class Number 1610

September 2006

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 FM 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, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up 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 FM Approvals criteria for ductile iron pipe for use in underground fire protection mains. This standard also addresses rigid (elbows, tees, etc.) and flexible (swivel, etc.) fittings and couplings for joining pipe and fittings. The fittings and couplings may be rated for use below and above ground.
- 1.1.2 Displacements due to seismic events (earthquake) are beyond the scope of this standard.
- 1.1.3 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 audit program.

1.2 Scope

- 1.2.1 This standard encompasses the design and performance requirements for:
- Ductile iron water pipe, from 3 through 36 inch (80 to 915 mm) nominal sizes for underground use;
 - Rigid and flexible fittings for underground or aboveground use; and,
 - Rigid and flexible couplings for underground or aboveground use
- Note: Aboveground use is limited to fitting products up to 12 in. NPS maximum. Ductile iron pipe is not permitted aboveground in fire protection systems.
- 1.2.2 In cases where metric sized ductile iron pipe and fittings are to be examined for Approval, test criteria comparable to the United States equivalent size shall be used.
- 1.2.3 Recognized pipe wall thickness classes or pressure classes are as defined in Standards American National Standards Institute (ANSI)/American Water Works Association (AWWA) C150/A21.50, *Thickness Design of Ductile-Iron Pipe*, or Standard ANSI/AWWA C151/A21.51, *Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids*. Other International Standards will be considered on a case by case basis.
- 1.2.4 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.
- 1.2.5 FM Approvals will consider ductile iron 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 C150/A21.50, or Standard ANSI/AWWA C151/A21.51, 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 ductile iron pipe, fittings and couplings for the purpose of obtaining FM Approval. These requirements are intended primarily as guides, and strict conformity is not always mandatory. Pipe, fittings and couplings 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, pipe,

fittings and couplings 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 examination. The audit shall review the facility and in-place quality control procedures used in the manufacture 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 as part of 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 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 September 28, 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

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accordance with the Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing and Materials (ASTM) SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*. One unit of measurement (bar), 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/AWWA C104/A21.4-2003, *Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water*
ANSI/AWWA C105/A21.5-2005, *Polyethylene Encasement for Ductile-Iron Pipe Systems*
ANSI/AWWA C110/A21.10-2003, *Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in (75 mm through 1200 mm), for Water and Other Liquids*
ANSI/AWWA C111/A21.11-2000, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*
ANSI/AWWA C115/A21.15-2005, *Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges*
ANSI/AWWA C150/A21.50-2002, *Thickness Design of Ductile-Iron Pipe*
ANSI/AWWA C151/A21.51-2002, *Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids*
ANSI/AWWA C153/A21.53-2000, *Ductile-Iron Compact Fittings, 3 in. through 24 in. (76 mm Through 610 mm) and 54 in. through 64 in. (1,400 mm Through 1,600 mm), for Water Service*
ANSI/AWWA C600-2005, *Installation of Ductile-Iron Water Mains and Their Appurtenances*
ANSI/AWWA C606-2004, *Joints, Grooved and Shouldered Type*
ASTM A126-04, *Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings*
ASTM A536 -84(2004), *Standard Specification for Ductile Iron Castings*
AWWA M41-2003, Second Edition, *Ductile-Iron Pipe and Fittings*
FM Global Property Loss Prevention Data Sheets
IEEE/ASTM SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*
ISO 17025-1999, *General Requirements for the Competence of Testing and Calibration Laboratories*
National Fire Protection Association (NFPA) 13-2002, *Standard for the Installation of Sprinkler Systems*

1.9 Definitions

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. It is installation specific. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

Bell and Spigot Pipe

A general pipe design where one end of a length of pipe is straight (spigot) and the other larger end is bell shaped and contains a gasket seal. The spigot end of one pipe is designed to fit into the bell end of another pipe and to fit under the gasket seal. Generally, this joint uses an elastomeric gasket to obtain a seal. Older version of bell and spigot pipe used a poured seal made up of juke and lead. These joints are rarely used as of this writing.

Ductile Iron Fittings

A device, such as a tee or elbow, which is cast from ductile iron, in accordance with the material requirements of ASTM A536, *Standard Specification for Ductile Iron Castings*, Grade 65-45-12 or equivalent.

Flanged End Fitting

A device, such as a tee or elbow, which has an integral rim on each end that is drilled in a symmetric hole pattern and which is connected to a mating device by means of a gasket, bolts and hex nuts. Critical flange dimensions are as tabulated in AWWA C110, *Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in (75 mm through 1200 mm), for Water and Other Liquids*, or other nationally or internationally recognized standard.

Flexible Fitting

A fitting which is rigid at the joint, but will tolerate misalignments in one or more sections.

Flexible Joint

A connection between two pipe sections, or a pipe section and a fitting, where misalignments may be tolerated when un-pressurized.

FM Approvals Certification Marks

The FM Approvals Certification Marks are detailed in Appendix B. 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, a publication of FM Approvals, issued annually, or one of 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. This form obligates the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approvals' discretion. It further requires the manufacturer not to deviate from the FM Approved configuration of the product without review by and agreement of FM Approvals. Approval is product and site specific.

Grey Iron Fittings

A device, such as a tee or elbow, which is cast from grey iron, in accordance with the material requirements of ASTM A126, *Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings*, Class A or equivalent.

Grooved Coupling, Flexible

A grooved coupling is an assembly that is used to join two similar sized grooved ends together. The flexible grooved coupling is characterized by its ability to allow for angular, or rotational differences between the components being joined after assembly. These products may provide greater system reliability in situations involving excessive vibration, difficult alignment, or seismic activity. They may also provide greater system flexibility than historic use of rigid systems of flanged pipe and fittings.

Grooved Coupling, Rigid

A rigid grooved coupling is an assembly that is used to join two similar sized grooved ends together. The rigid grooved coupling is characterized by its prevention of rotation of the joined ends, and reduced tolerance for angular variations after assembly.

Grooved End Pipe

Ductile iron pipe which contains cut grooves at the ends, to be joined by grooved couplings. Groove dimensions are per ANSI/AWWA C606 *Joints, Grooved and Shouldered Type*.

Push-On Joint

A joint which results from the method of joining pipe by forcing the spigot end of a pipe into the bell of another pipe suitably equipped with a "push-on" elastomeric gasket. The spigot end of one length of pipe passes into the bell end of the receiving pipe, which contains the gasket seal. When the spigot end is pushed to the bottom of the socket a seal is obtained. This joint is considered a non-restrained joint.

Rigid Fitting

A fitting which permits no flexibility at any joint or any segment when installed. An example would be flanged tees or elbows.

Rigid Joint

A connection between two pipe sections, or a pipe section and a fitting, where no flexibility is allowed when un-pressurized. An example would be a flanged end pipe connected to a flanged gate valve.

Restrained Joint

A joint design used to counteract unbalanced forces in a piping system which includes the joint gasket. In some designs, the rubber gasket contains toothed metal strips, in a cam shape, inserted along the perimeter of the gasket. The gasket is initially inserted into the bell end of the joint. The spigot end of the pipe is inserted into the bell and through the gasket to the bottom of the socket. The cam rotates and the metal teeth engage the grooved section of the spigot so that the joint is adequately secured as the pipe is pressurized. Other designs which incorporate other methods of restraint and sealing are also acceptable. This joint is considered a self-restrained joint.

Shoulder End Pipe

Pipe which ends in a raised shoulder, to be joined by specialized grooved couplings. Shoulder dimensions are per ANSI/AWWA C606, *Joints, Grooved and Shouldered Type*.

Standardized Mechanical Joint (SMJ)

A bolted joint of the stuffing box type, which when assembled, forces an elastomeric gasket into the joint, as detailed in ANSI/AWWA C111, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*.

Standardized Mechanical Joint Retaining Gland

An additional ring fitting which is added to a bolted joint of the stuffing box type. The gland is secured to the spigot by tightening its setscrews against the pipe wall providing positive restraint. Bolt holes along the flanged section of the gland provide the means by which it is secured to the flanged bell of standardized mechanical joint pipe or fitting.

Thrust Block

A large block of concrete used to transfer reaction forces from water flow in piping systems to adjacent soil which would cause an unrestrained joint to open and leak. Thrust blocks are especially useful at changes of direction in buried piping systems. Thrust blocks should not prohibit access to the pipe joints.

2. GENERAL INFORMATION

2.1 Product Information

- 2.1.1 Ductile iron pipe and fittings encompassed by this standard are used in underground fire protection systems. This standard addresses rigid and flexible fittings and couplings for joining pipe and fittings. The fittings and couplings may be rated for use below and above ground. Installation shall be in accordance with FM Global Property Loss Prevention Data Sheets and the manufacturer's installation instructions.
- 2.1.2 In order to meet the intent of this standard, pipe, coupling and fittings components must be examined on a type-by-type, manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical products, produced with identical materials by different manufacturers, or even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample pipe, coupling and fitting components, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

To apply for an Approval examination the manufacturer, or its authorized representative, should submit a written request to:

Hydraulics Group Manager
FM Approvals Hydraulics Laboratory
743A Reynolds Road
West Glocester, RI 02814 U.S.A.

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration,
- General assembly drawings, a complete set of manufacturing drawings, materials list(s) and material specifications (such as ANSI/AWWA C151/A21.51 - Ductile Iron), anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, etc; and,
- The number and location of manufacturing facilities producing the products submitted for Approval.

All documents 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.

2.3 Requirements for Samples for Examination

Following set-up and authorization of an Approval examination, the manufacturer shall submit samples for examination and testing. Sample requirements are to be determined by FM Approvals following review of the preliminary information. Sample requirements may vary depending on formulation features, results of prior testing, and results of the foregoing tests. It is the manufacturer's responsibility to submit samples representative of production. Any decision to use data generated utilizing prototypes is at the discretion of FM Approvals. It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate the Ductile Iron Pipe and Fittings, Flexible Fittings and Couplings. Testing may be performed at FM Approvals, at the manufacturer's test facility, or at a third-party location, as mutually agreed.

3. GENERAL REQUIREMENTS

3.1 Review of Documentation

- 3.1.1 During the initial investigation and prior to physical testing, the manufacturer's specifications, technical data sheets, and design details shall be reviewed to assess the ease and practicality of installation and use. The product shall be capable of being used within the limits of the Approval investigation.
- 3.1.2 The manufacturer's dimensional specifications and / or design drawings shall fully describe the product. All critical dimensions shall be indicated with allowed upper and lower tolerance limits clearly shown.
- 3.1.3 All documents pertaining to the product materials, dimensions, processing, and marking 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 drawings shall be provided with an English translation.

3.2 Physical or Structural Features

- 3.2.1 Pipe shall be cast from ductile iron, and shall be in accordance with ANSI/AWWA C150/A21.50, *Thickness Design of Ductile-Iron Pipe*, or ANSI/AWWA C151/A21.51, *Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids*, specifications, or equivalent national or international standard.
- 3.2.2 Fitting components may be cast from ductile iron, and shall be in accordance with ANSI/AWWA C153/A21.53, *Ductile-Iron Compact Fittings, 3 in. through 24 in. (76 mm Through 610 mm) and 54 in. through 64 in. (1,400 mm Through 1,600 mm), for Water Service*, specifications, or equal. They may also be cast from cast gray iron, and shall be in accordance with ANSI/AWWA C110/A21.10, *Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in (75 mm through 1200 mm), for Water and Other Liquids*, specifications, or equivalent national or international standard.
- 3.2.3 Coupling components will be cast from ductile iron. Grooved couplings shall be designed for use with cut grooved ductile iron pipe, with grooves in accordance with ANSI /AWWA C606, *Joints, Grooved and Shouldered Type*, specifications, or equal.
- 3.2.4 Elastomeric gaskets shall be made in accordance with ANSI/AWWA C111/A21.11, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*, specifications, or equal, for underground service. For aboveground use an Ethylene Propylene Diene Monomer (EPDM) compound or other suitable compound may need to be substituted for the typical Styrene-Butadiene Rubber (SBR) compound used in underground service, due to higher temperature requirements for above ground components.
- 3.2.5 The minimum rated working pressure of all items covered by this standard shall be 175 psi (1205 kPa).
- 3.2.6 Retainer joints, where applicable, shall have bolts or nuts with a breakaway feature or other method of positive indication to insure that the factory recommended installation torque has been applied to each connection.

3.3 Markings

- 3.3.1 Pipe shall be clearly marked with the following information:
- Manufacturer's name, code, or trademark traceable to the manufacturer;
 - Pipe size;
 - Casting date and source code, where applicable;

- Year of Manufacture;
- The letters “DI” or “Ductile”
- Pressure class or pressure rating; and,
- FM Approvals Certification Mark (see Appendix B).

3.3.2 Fittings or couplings shall be clearly marked with the following information:

- Manufacturer’s name, code, or trademark traceable to the manufacturer;
- Nominal pipe size or outside diameter;
- Recognized standard to which the item is manufactured;
- Casting date and source code; where applicable,
- Material designation;
- Pressure class or pressure rating; and,
- FM Approvals Certification Mark (see Appendix B).

3.3.3 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product as FM Approved. The manufacturer shall not place this model or type identification on any other product unless covered by a separate agreement with FM Approvals.

3.3.4 The order of these markings is optional, as long as all are present.

3.3.5 Additional markings are allowed if arranged in such a way as not to interfere with the legibility of the required markings.

3.3.6 The FM Approvals Certification Mark (see Appendix B) shall be displayed visibly and permanently on the product and/or packaging as appropriate. The manufacturer shall not use this mark on any other product unless such product is covered by separate agreement with FM Approvals.

3.3.7 Pipe, fittings and/or couplings that are produced at more than one location shall be identified as the product of a particular location.

3.3.8 All markings shall be legible and durable.

3.4 Manufacturer's Installation and Operation Instructions

The manufacturer shall provide installation instructions which clearly address the following:

- Indicate that the ductile iron pipe and fittings qualified under this standard and FM Approved by FM Approvals are restricted to underground service;
- Define requirements of installation including assembly of pipe sections, couplings, and other components;
- Define laying and back filling procedures. Adequate compaction of soil is of particular importance;
- Define thrust blocking and other restraint requirements;
- Define suitable methods for transition connections to other materials.

FM Approvals shall determine the minimum acceptable extent of these instructions based upon the specific nature of the pipe and fittings submitted for Approval. Any instructions specific to Approval constraints shall be labeled as such. FM Approvals required instructions may be included in a more general instruction publication, provided that it is clearly stated that Approval of these products is contingent upon observance of the Approval constraints. Instructions shall be furnished by the manufacturer.

3.5 Calibration

All equipment used to verify the test parameters discussed in this standard shall be calibrated within an interval determined on the basis of stability, purpose, and usage of the equipment. A copy of the calibration certificate for each piece of test equipment is required for FM Approvals records, indicating that the calibration was performed against working standards whose calibration is certified as traceable to the National Institute of Standards and Technology (NIST) or to other acceptable reference standards and certified by a ISO 17025 calibration laboratory. The test equipment must be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service accreditation certificate as an ISO 17025, "General Requirements for the Competence of Testing and Calibration Laboratories", calibration laboratory is required for FM Approvals records.

The calibration of recently purchased new equipment is also required. Documentation indicating either the date of purchase or date of shipment, equipment description, model and serial number is required for identification. The period from the time the equipment was put into service to the date of testing must be within an interval that does not require the equipment to be calibrated as determined on the basis of the parameters mentioned above.

4. PERFORMANCE REQUIREMENTS

For all new Approval examinations, each type of joint and size shall be tested for each pressure class. Pipe lengths shall be at least seven diameters long, through 8 inch nominal size. For larger diameter pipes where handling may be problematic, shorter lengths may be used. For flexible fittings being tested for above ground use tests are to be run with minimum thickness sprinkler pipe. Subsequent Approval projects may be conducted using sampling techniques, based on original test data and satisfactory audit history.

Table of Approval Tests Required

<i>Section</i>	<i>4-36 in. Pipe- Underground</i>	<i>Rigid Fittings</i>	<i>Flexible Fittings - Aboveground and Underground</i>	<i>Grooved Couplings - Underground</i>
4.1 Examination	X	X	X	X
4.2 Standards Review	X	X	X	X
4.3 Joint Leakage	X	X	X	X
4.4 Hydrostatic Strength	X	X	X	X
4.5 Cycling Pressure Resistance	-	-	X	-
4.6 Gaskets (Underground)	X	-	X	X
4.7 Gaskets (Aboveground)	-	-	X	-
4.8 Positive Torque Indication	-	-	X	X
4.9 Mechanical Flexure	-	-	X	X
4.10 Other	X	X	X	X

4.1 Examination

4.1.1 Requirement

All ductile iron pipe, rigid and flexible fittings, and couplings shall conform to the manufacturer's drawings and specifications and to FM Approvals requirements.

4.1.2 Test/Verification

The samples shall be examined and compared to drawings and specifications. It shall be verified that the sample conforms to the physical and structural requirements described in Section 3, General Requirements.

4.2 Standards Review

4.2.1 Requirements

If the manufacturer's literature or product markings reference any recognized standard specifying design, manufacture, or performance, FM Approvals shall verify, as a part of its examination, that all criteria of such a referenced standard are met. The intent of the requirement is that the pipe or fittings conform to any recognized standard to which they are claimed to be manufactured.

4.2.2 Tests/verification

The manufacturer shall submit to FM Approvals a copy of the relevant standard(s), along with drawings, specifications, and other documents necessary to confirm compliance. FM Approvals shall verify by desk review, test, or field inspection that all requirements of that standard are met.

4.3 Joint Leakage

4.3.1 Requirements

Joints shall not leak when subjected to hydrostatic pressure testing.

4.3.2 Tests/Verification

4.3.2.1 Pipe

Each style of pipe shall be tested at the maximum deflected angle as recommended by the manufacturer. Pipe samples shall have maximum clearances between bell and spigot as allowed by the design tolerances. Pipe assemblies consisting of two pipe sections with a joint in the middle, shall not leak when hydrostatically pressurized to two times the rated working pressure for a period of 5 minutes.

The manufacturer shall provide means of maintaining each size test assembly at the maximum deflected angle for this test.

4.3.2.2 Fittings

Each style of rigid or flexible fitting, or coupling shall be hydrostatically tested at the maximum deflected angle as recommended by the manufacturer for 5 minutes at two times the rated working pressure. There shall be no joint leakage as a result of this test. The manufacturer shall supply any necessary restraints to accomplish this test.

4.4 Hydrostatic Strength

4.4.1 Requirement

4.4.1.1 Pipe assemblies consisting of two pipe lengths with a joint in the middle shall not rupture or crack when subjected to hydrostatic pressure testing.

4.4.1.2 Rigid and flexible fittings and couplings shall not rupture, or crack when subjected to hydrostatic pressure testing.

4.4.2 Test/Verification

Pipe and fitting assemblies are to be deflected to the manufacturer's maximum allowed installation angle. The manufacturer shall provide means of maintaining each size test assembly at the maximum deflected angle for this test. All joint assemblies shall be hydrostatically tested for 5 minutes at four times the rated working pressure. There shall be no rupture or cracking of the pipe or fitting as a result of this test. Joint gaskets may be reinforced, if necessary, to withstand the pressure.

4.5 Cycling Pressure Resistance (Flexible Fittings)

4.5.1 Requirement

A flexible fitting shall withstand 20,000 pressure surges without leakage.

4.5.2 Test/Verification

A representative sample assembly shall be subjected to 20,000 cycles of hydrostatic pressure from 0 to rated working pressure, with 175 psi (1205 kPa) as a minimum. The rate of application will be 8 cycles per minute or less. Subsequently, the assembly shall be tested for hydrostatic integrity per Section 4.3 (Hydrostatic Strength). No rupture or other failure shall be observed at four times the rated working pressure for a period of five minutes. If the smallest size coupling or fitting for Approval is larger than 6 in. NPS, special test arrangements will be defined by FM Approvals.

4.6 Gaskets (Underground Only)

4.6.1 Requirements

Gaskets shall resist leakage, hardening and cracking when subjected to high and low temperatures.

4.6.2 Tests/Verification

The manufacturer shall provide certification that the elastomer for below ground service meets the requirements of AWWA C111/A21.11, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*. Performance tests shall be performed at 0°F (-18°C) and 160°F (71°C) as described below. Separate samples are allowed for the two tests.

- a. One representative sample gasket of each material under examination shall be subjected to high temperature exposure and one to low temperature exposure. Samples subjected to the temperature exposure tests shall be installed in their normal assemblies during exposure.
- b. The high temperature exposure shall consist of a 160°F (71°C) air exposure for 45 days. After exposure, the assembly shall be allowed to cool to ambient temperature. It shall then be pneumatically pressurized to 50 psi (345 kPa) and submerged in water. No leakage shall occur. The gasket, after removal from the assembly, shall not crack when squeezed together from any two diametrically opposite points.

- c. The low temperature exposure shall consist of a 0°F (-18°C) air exposure for four days. After exposure, immediately after removal from the test chamber, the assembly shall be pneumatically pressurized to 50 psi (345 kPa). No leakage shall occur. The assembly shall then be allowed to warm to ambient temperature and be disassembled. The gasket shall not crack when squeezed together from two diametrically opposite points.
- d. If the smallest size coupling or fitting for Approval is larger than six inch nominal size, special test arrangements will be defined by FM Approvals as necessary.

4.7 Gaskets (Aboveground Only)

4.7.1 Requirements

Gaskets shall resist leakage, hardening and cracking when subjected to high and low temperatures.

4.7.2 Tests/Verification

- a. One representative sample gasket of each material under examination shall be subjected to high temperature exposure and one to low temperature exposure. Samples subjected to the temperature exposure tests shall be installed in their normal assemblies during exposure.
- b. The high temperature exposure shall consist of 275°F (135°C) air exposure for 45 days. After exposure, the assembly shall be allowed to cool to ambient temperature. It shall then be pneumatically pressurized to 50 psi (345 kPa) and submerged in water if possible. No leakage shall occur. The gasket, after removal from the assembly, shall not crack when squeezed together from any two diametrically opposite points.
- c. The low temperature exposure shall consist of -40°F (-40°C) air exposure for four days. After exposure, immediately after removal from the test chamber, the assembly shall be pneumatically pressurized to 50 psi (345 kPa). No leakage shall occur. The assembly shall then be allowed to warm to ambient temperature and be disassembled. The gasket shall not crack when squeezed together from two diametrically opposite points.
- d. If the smallest size coupling or fitting for Approval is larger than six inch nominal size, special test arrangements will be defined by FM Approvals as necessary.

4.8 Positive Torque Indication Test

4.8.1 Requirement

Bolts or nuts having a breakaway feature to indicate proper application of installation assembly torque shall be tested to verify that the shearing action is consistent. Other means of positive indication shall be reviewed and examined on a case-by-case basis.

4.8.2 Test/Verification

A minimum of six of each nominal size of breakaway bolt or nut shall be clamped and torqued with a calibrated torque wrench to obtain the value at breakaway. The average of all tests shall be consistent with the manufacturer's installation instructions. Other means of positive indication shall be evaluated and recorded as appropriate.

4.9 Mechanical Flexure

4.9.1 Requirements

One of each type of flexible fitting shall be subjected to a mechanical flexure test of 5000 cycles while internally hydrostatically pressurized to 50 psi (345 kPa). The flexure shall be applied to the fitting by a mechanical linkage at the rate not exceeding one cycle per minute over the allowable range of motion of the product as specified by the manufacturer.

4.9.2 Tests/Verification

The manufacturer shall supply a test fixture to support the test sample and provide the means to apply the cycling motion to each test assembly. The sample shall not leak during or at the conclusion of this test. At the completion of the cycling test, the assembly shall be subjected to the test outlined in Section 4.4 (Hydrostatic Strength).

4.10 Additional Tests

Additional tests may be required, depending on design features, results of any of the above tests, material application, or to verify the integrity and reliability of the ductile iron pipe and fittings, flexible fittings and couplings, at the discretion of FM Approvals.

Unexplainable failures shall not be permitted. A re-test shall only be acceptable at the discretion of FM Approvals and with adequate technical justification of the conditions and reasons for failure.

5. OPERATIONS REQUIREMENTS

A quality control program is required to assure that subsequent ductile iron pipe, fittings and/or couplings produced by the manufacturer at an authorized location shall present the same quality and reliability as the specific pipe, fittings and/or couplings examined. Design quality, conformance to design, and performance are the areas of primary concern. Design quality is determined during the Approval examination and tests, and is covered in the Approval Report. Conformance to design is verified by control of quality and is covered in the Facilities and Procedures Audit (F&PA). Quality of performance is determined by field performances and by periodic re-examination and testing.

5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- Existence of corporate quality assurance guidelines;
- Incoming quality assurance, including testing;
- In-process quality assurance, including testing;
- Final inspection and tests;
- Equipment calibration;
- Drawing and change control;
- Packaging and shipping; and,
- Handling and disposition of non-conformance materials.

- In order to assure adequate traceability of materials and products, the manufacturer shall maintain records of all quality control tests performed for a minimum period of two years from the date of manufacture.

5.1.2 Documentation/Manual

There shall be an authoritative collection of procedures and policies. Such documentation shall provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production.
- The manufacturer shall assign an appropriate person or group to be responsible for, and require that, proposed changes to FM Approved or Listed products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals Form 797, FM Approved Product/Specification-Tested Revision Report or Address/Main Contact Change Report.
- Records of all revisions to all FM Approved products shall be maintained.

5.1.3.1 The table below has been included as a guide to manufacturers of what is considered to be a significant change to FM Approvals. To facilitate the Approval of significant changes, modifications that fit this category shall be documented by means of a letter stating the change, and requesting a quotation for an Approval examination.

<i>Modification</i>	<i>Description/ Example</i>
Increase in pressure rating:	<ul style="list-style-type: none"> • The product was originally FM Approved at 175 psi (1205 kPa) and now is to be evaluated at 250 psi (1725 kPa)
Addition of Allowed Sizes:	<ul style="list-style-type: none"> • The product was originally FM Approved in 4 through 12 inch NPS, and now is to be evaluated at 14 and 16 inch NPS
Addition or relocation of the manufacturing location:	<ul style="list-style-type: none"> • The product was originally FM Approved when made in location A, and now it is desired to make the same product in locations A and B, or in Location B only.
Changes to Critical Dimensions:	<ul style="list-style-type: none"> • Modifications that would depart from the national or international standards that are used in the manufacturing of the product as originally FM Approved. • Modifications that would have an effect on the use of the pipe with standardized fittings/couplings. • Modifications that would have an effect on the ability of the product to maintain the same performance as the originally FM Approved product. An example of this would be a significant reduction of pipe wall thickness.

- 5.1.3.2 The table below has been included as a guide to manufacturers of modifications which may be submitted on FM Approvals Form 797.

<i>Modification</i>	<i>Description/Example</i>
Change in Company Contact Information:	• Contact Name, Title, Phone Number, FAX Number, Office Address, Company Name
Updating of Drawings:	• Minor dimensional changes, or note changes, Re-creation of old drawing on CAD
Change in material or marking:	• Where new material is superior, or to show proposed new marking

- 5.1.3.3 For the instances where the modification is difficult to categorize, manufacturers are encouraged to contact FM Approvals and to discuss the nature of the proposed change, and how to send the information to FM Approvals. The examples shown in Sections 5.1.3.1 and 5.1.3.2 are based on common examples of modifications as they relate to the manufacture of ductile iron pipe and fittings, flexible fittings and couplings.

- 5.1.3.4 FM Approvals, at its sole discretion, shall determine when additional testing is necessary to validate proposed changes.

5.2 Facilities and Procedures Audit (F&PA)

- 5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a uniform product consistent with that which was tested and FM Approved.
- 5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives or more frequently dependent on jurisdictional requirements. At issue of this standard the Occupational and Safety Health Administration (OSHA) of the United States Department of Labor requires audits of manufacturing sites producing products for use in hazardous locations during each quarter the product is manufactured.
- 5.2.3 FM Approved products or services shall be produced or provided at or from the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the Approval Mark is not permitted at any other location without prior written authorization by FM Approvals.

5.3 Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

5.4 Manufacturer's Responsibilities

- 5.4.1 The manufacturer shall notify FM Approvals of changes in product construction, design, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation of such changes.

- 5.4.2 Where all or part of the quality control has been subcontracted, the manufacturer shall, at a minimum, conduct sufficient oversight audits to verify the continued application of the required controls.

5.5 Manufacturing and Production Tests

5.5.1 Test Requirement No. 1 - *Material Composition*

Composition of raw materials shall be verified by vendor certifications or the manufacturer's own in process examination. The chemical or physical properties that are critical to the functioning of the item shall be sample tested. Testing shall be performed by the manufacturer or, on their behalf, by an agency independent of the vendor. Testing shall be conducted at regular intervals for each vendor, as specified in the quality assurance manual, but not less than once a year.

5.5.2 Test Requirement No. 2 - *Dimensional Checks*

The manufacturer shall measure and record critical component dimensions, material thickness, markings, and threaded connections (as applicable) at the beginning of each production run. Thereafter, these measurements shall be recorded, at minimum, every 4 hours. The number of samples to be measured shall be based on the manufacturer's Quality Control Manual, but in no case shall be less than five samples. Measurements shall be compared to the latest revision of the component drawings.

5.5.3 Test Requirement No. 3 - *Assembly Tests*

The manufacturer's Quality Assurance program shall itemize the production tests or sample tests for the various products covered by this Approval Standard, including the test pressure, the test time, the frequency of the test, which shall be based on lot size, and the data records that shall be maintained. Instrument calibration records shall be documented.

APPENDIX A: Units Of Measurement

AREA:	in^2 - "square inches"; (mm^2 - "square millimeters") $\text{mm}^2 = \text{in}^2 \times 6.4516 \times 10^2$ ft^2 - "square feet"; (m^2 - "square meters") $\text{m}^2 = \text{ft}^2 \times 0.0929$
FORCE:	lb - "pounds"; (N - "Newtons") $\text{N} = \text{lb} \times 4.4482$
LENGTH:	in. - "inches"; (mm - "millimeters") $\text{mm} = \text{in.} \times 25.4$ ft - "feet"; (m - "meters") $\text{m} = \text{ft} \times 0.3048$
MASS:	lb - "pounds"; (kg - "kilograms") $\text{kg} = \text{lb} \times 0.454$
PRESSURE:	psi - "pounds per square inch"; (kPa - "kilopascals") (mPa - "megapascals") $\text{kPa} = \text{psi} \times 6.895$ $\text{mPa} = \text{psi} \times 0.00689$ $\text{Bar} = \text{psi} \times 0.0689$
TEMPERATURE:	$^{\circ}\text{F}$ - "degrees Fahrenheit"; ($^{\circ}\text{C}$ - "degrees Celsius") $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 0.556$
TORQUE:	$\text{ft}\cdot\text{lb}_f$ - "foot pounds - force", ($\text{N}\cdot\text{m}$ - "Newton-meters") $\text{N}\cdot\text{m} = \text{ft}\cdot\text{lb}_f \times 1.356$

APPENDIX B: FM Approvals Certification Marks

FM Approvals certifications marks are to be used only in conjunction with products or services that have been Approved by FM Approvals and in adherence with usage guidelines.



FM APPROVED mark:

Authorized by FM Approvals as a certification mark for any product that has been FM Approved. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.



Cast-On FM Approvals marks:

Where reproduction of the FM Approved mark described above is impossible because of production restrictions, use these modified versions of the FM Approved mark. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable.



FM APPROVED mark With "C" only:

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.



FM APPROVED mark with "C" and "US":

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with US and Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

USAGE GUIDELINES

All FM Approvals certification marks are the sole property of FM Approvals LLC (“FM Approvals”) and are registered or the subject of applications for registration in the United States and many other countries. They are for use only according to these guidelines.

FM Approvals certification marks may be used only on FM Approved products and related product packaging, in advertising material, catalogs and news releases. Use of FM Approvals certification marks on such material is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging.

No FM Approvals certification mark or aspect thereof may be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. This includes both design aspects (the FM Approvals “diamond,” etc.) and word aspects (“FM,” “Approved,” etc.). The use of any FM Approvals certification mark as a trademark is strictly prohibited.

The Approval Standard number or class number may not be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. For example, a company may not say “ABC Company’s 4100 Fire Door is FM Approved”; the proper terminology is, “ABC Company’s Fire Door is FM Approved per Approval Standard 4100.”

FM Approvals certification marks, except for the FM Approvals Quality System Registration mark, may not be used on business stationery/cards/signage because this could mischaracterize the relationship with FM Approvals. Additionally, these items should not reference any FM Approvals certification mark.

Products or services may not be marketed under any mark or name similar to “FM Global,” “FM Approvals” or any of the FM Approvals certification marks. Further, products or services may not be marketed to imply a relationship beyond the scope of any Approval made by FM Approvals.

When an FM Approvals certification mark is used in advertising material or on product packaging, all material must reflect the specific circumstances under which the product was FM Approved. The material must clearly differentiate between products that are FM Approved and those that are not, and may not, in any way, imply a more substantial relationship with FM Approvals.

A company may not reference the intent to submit a product for Approval or the expectation that a company will have a certain product FM Approved in the future. For example, a company may not state, “Approval by FM Approvals pending” or “Approval by FM Approvals applied for.”

FM Approvals certification marks should not be preceded or followed by a qualifier that indicates a degree of certification or acceptability. For example, “exceeds,” “first” or “only” may not be used to qualify any FM Approvals certification mark.

Only original artwork issued by FM Approvals should be used. The FM Approvals certification marks should not be altered in any way other than to resize the artwork proportionately. Unacceptable uses of the marks include, but are not limited to, adding/deleting wording or artwork, reducing the artwork to an illegible size, animation or distortion.

The text of the FM Approvals certification marks may not be translated into any language other than English.

FM Approvals certification marks must appear in a size and location that is readily identifiable, but less prominent than the name of the owner of the certification or the manufacturer/seller/distributor of the certified products.

APPENDIX C: Tolerances

Unless otherwise stated, the following tolerances shall apply:

Angle	$\pm 2^\circ$
Frequency (Hz)	± 5 percent of value
Length	± 2 percent of value
Volume	± 5 percent of value
Volume Per Unit Area	± 5 percent of value
Pressure	± 5 psi (± 35 kPa)
Temperature	$\pm 4^\circ\text{F}$ ($\pm 2^\circ\text{C}$)
Time	+ 5/-0 seconds +0.1/-0 minutes

Unless stated otherwise, all tests shall be carried out at a room (ambient) temperature of 68.9°F (20.5°C).

APPENDIX D: Sample Listing

Company Name and Address

<i>Description</i>	<i>Nominal Pipe Size, in.</i>	<i>Rated Working Pressure</i>		<i>Notes: (see end of listing)</i>
		<i>psi</i>	<i>(bar)</i>	
Pipe				
Standard Push-On (unrestrained)	4, 5, 6, 8, 10, 12	360	(25)	
Standard self-restrained gasket	4, 5	300	(20)	
	6	235	(16)	
	8, 10, 12	200	(14)	
Standard self-restrained mechanical joint	4, 5, 6	360	(25)	
	8	325	(22)	
	10	300	(20)	
	12	235	(16)	
Fittings				
Flanged 90° Duckfoot Elbow	4, 5, 6, 8, 10, 12	360	(25)	
Flanged Tees	12x12x12	300	(20)	
	12x12x10	300	(20)	
	12x12x8	300	(20)	
	12x12x6	300	(20)	
	10x10x10	300	(20)	
	10x10x8	300	(20)	
	10x10x6	300	(20)	
	8x8x8	360	(25)	
	8x8x6	360	(25)	
	8x8x5	360	(25)	
	6x6x6	360	(25)	
	6x6x5	360	(25)	
	4x4x4	360	(25)	
Flanged Reducer	12x10	360	(25)	
	12x8	360	(25)	
	10x8	360	(25)	
	10x6	360	(25)	
	8x6	360	(25)	
	8x5	360	(25)	
	6x5	360	(25)	
	6x4	360	(25)	
	5x4	360	(25)	
Flanged x Spigot Fitting	4, 6, 8, 10, 12	360	(25)	
Reducing Flange - Type 1	10x4	360	(25)	
	8x5	360	(25)	
	8x4	360	(25)	
	12x8	360	(25)	
Reducing Flange - Type 2	12x6	360	(25)	
	12x4	360	(25)	
Blind Flange	4, 5, 6, 8, 10, 12	360	(25)	
Coupling	4, 5, 6, 8, 10, 12	235	(16)	



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