



Member of the FM Global Group

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

Class Number 1610

October 2022

Foreword

This standard is 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 this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states testing and certification requirements 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 Testing and certification criteria may include performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2 Scope

- 1.2.1 This standard encompasses the design and performance requirements for:
 - Ductile iron water pipe, from NPS (Nominal Pipe Size) 3 through 36 inch (80 to 915 mm) for underground use;
 - Rigid and flexible fittings or couplings, from NPS 3 through 12 inch (80 to 300 mm) for underground or aboveground use; and
 - Rigid and flexible fittings or couplings, from NPS 14 through 36 inch (350 to 900 mm) for underground use. Other sizes may be considered for certification on case by case basis.

Additional Notes:

- Ductile iron pipe is not permitted aboveground in fire protection systems;
 - Aboveground use is limited to fitting and coupling products up to NPS 12 in. maximum. It may be acceptable to use ductile iron fittings or couplings larger than NPS 12 inch in limited aboveground applications when transitioning from the underground to the aboveground fire protection system. Examples of such use include bridge and river crossings and tunnel applications. In these situations, special consideration must be given to the support system, accommodation for thermal expansion, and anchorage of components subject to hydraulic thrust. This will be reviewed on a case by case basis.
- 1.2.2 In cases where metric sized ductile iron pipe and fittings are to be examined for certification, 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 ANSI/AWWA C150/A21.50, *Thickness Design of Ductile-Iron Pipe*, or ANSI/AWWA C151/A21.51, *Ductile-Iron Pipe, Centrifugally Cast*. Other international standards will be considered on a case by case basis.
 - 1.2.4 The certification agency 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 certification testing commence. All certification 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 certification. Ductile iron pipe, fittings and couplings having characteristics not anticipated by this standard may be certified if performance is equal, or superior, to that required by this standard is demonstrated.

1.4 Basis for Certification

Certification 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 for certification;
 - the durability and reliability of the product.
- 1.4.2 An examination of the manufacturing facilities and audit of quality control procedures may be conducted to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5 Basis for Continued Certification

The basis for continual certification may include the following based upon the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- satisfactory field experience;
- compliance with the terms stipulated by the certification
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agencies product surveillance program.

1.6 Effective Date

The effective date of this examination standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is eighteen (18) months after the publication date of the standard 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. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection and are used in this standard.

1.8 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the cited edition applies:

ANSI/AWWA C110/A21.10, *Ductile-Iron and Gray-Iron Fittings*
ANSI/AWWA C111/A21.11, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*
ANSI/AWWA C150/A21.50, *Thickness Design of Ductile-Iron Pipe*
ANSI/AWWA C151/A21.51, *Ductile-Iron Pipe, Centrifugally Cast*
ANSI/AWWA C153/A21.53, *Ductile-Iron Compact Fittings*
ANSI/AWWA C606, *Grooved and Shouldered Joints*
ANSI/IEEE/ASTM SI 10, *American National Standard for Metric Practice*
ASTM A126, *Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings*
ASTM A536, *Standard Specification for Ductile Iron Castings*

1.9 Terms and 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 (Authority Having Jurisdiction). Acceptance is based upon an overall evaluation of the installation. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere.

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 jute and lead. These joints are no longer permitted by most regulatory and public authorities as of this writing.

Coupling

A coupling is a fitting that is used to join two or more components together.

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.

Ductile Iron Pipe

Ductile iron pipe is a pipe made of ductile cast iron commonly used for potable water transmission and distribution. The pipe may be lined with cement and be provided with push on type unrestrained joints or joints that provide restraint through a number of techniques.

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*, 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.

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 *Grooved and Shouldered Joints*.

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, *Grooved and Shouldered Joints*.

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 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 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 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 pipe, coupling and fitting components, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Certification Application Requirements

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

- a complete list of all models, types, sizes, end connections, and options for the products being submitted for certification consideration;
- general assembly drawings, one complete set of manufacturing drawings, materials list(s) and material specifications (such as ASTM A536, Gr. 65-45-12), anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, and
- the number and location(s) of manufacturing facilities.

All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

- 2.3.1 Following authorization of a certification examination, the manufacturer shall submit samples for examination and testing based on the following:
- Sample requirements to be determined by the certification agency
- 2.3.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.
- 2.3.3 The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of the certification agency
- 2.3.4 It is the manufacturer's responsibility to provide any special test fixtures which may be required to evaluate the ductile iron pipe and fittings, flexible fittings and couplings.
- 2.3.5 If there are failures encountered during the examination testing, the certification agency will provide the manufacturer with information regarding what testing will need to be repeated and any additional sample requirements.

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 certification examination results may further define the limits of the final certification.
- 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.

3.2 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*, 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*, 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, *Grooved and Shouldered Joints*, specifications, or equal. Other grooved profiles can be examined on a case-by-case basis.
- 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 ensure that the factory recommended installation torque has been applied to each connection.

3.3 Materials

All materials used in the fabrication of the ductile iron pipe, couplings and fittings discussed in this examination standard shall be suitable for the intended application. Raw materials shall be evaluated in accordance with the appropriate sections of the manufacturer's Quality Assurance Manual plus any applicable national and/or international standards.

3.4 Markings

3.3.1 Pipe shall be clearly marked with the following information:

- Manufacturer's name or trademark;
- Nominal pipe size;
- Manufacturing source code where necessary;
- Year of Manufacture;
- The letters "DI" or "Ductile"
- Pressure class or pressure rating; and,
- Certification agency's mark of conformity.

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

- Manufacturer's name or trademark;
- Nominal fitting size;
- Recognized standard to which the item is manufactured;
- Manufacturing source code where necessary;
- Material designation;
- Pressure class or pressure rating; and,
- Certification agency's mark of conformity.

3.3.3 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency's mark of conformity.

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 certification agency's mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.

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.

3.5 Manufacturer's Installation and Operation Instructions

3.5.1 The installation instructions, including any special dimension requirements shall be furnished by the manufacturer. Instructions shall be provided in each shipping container.

3.5.2 The installation instructions identified in Section 3.5.1 shall be made available in multiple languages in support of the regions where the product is intended to be sold.

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

- Indicate that the ductile iron pipe and fittings qualified under this standard and certified by the certification agency 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.

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

3.6 Calibration

3.6.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.6.2 When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of this equipment.

3.7 Tolerances

Tolerances on units of measure shall be as described in Appendix A, unless otherwise specified in this standard.

4. PERFORMANCE REQUIREMENTS

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 certification requirements.

4.1.2 Test/Verification

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

4.2 Joint Leakage

4.2.1 Requirement

Joints made between pipe sections, fittings, or couplings shall not leak when subjected to a hydrostatic pressure equal to twice the rated working pressure of the pipe, fitting, or coupling.

4.2.2 Tests/Verification

4.2.2.1 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.

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.

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

4.2.2.2 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.

4.3 Hydrostatic Strength

4.3.1 Requirement

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

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

4.3.2 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.

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.

4.4 Cycling Pressure Resistance (Flexible Fittings)

4.4.1 Requirement

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

4.4.2 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 certification is larger than NPS 6 in., special test arrangements will be defined by the certification agency.

4.5 Gaskets (Underground Only)

4.5.1 Requirement

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

4.5.2 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 certification is larger than NPS 6 inch, special test arrangements will be defined by the certification agency as necessary.

4.6 Gaskets (Aboveground Only)

4.6.1 Requirement

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

4.6.2 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) and submerged in antifreeze if possible. 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 certification is larger than NPS 6 inch size, special test arrangements will be defined by the certification agency as necessary.

4.7 Positive Torque Indication Test

4.7.1 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.

4.7.2 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.

4.8 Mechanical Flexure

4.8.1 Requirement

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 a rate not exceeding one cycle per minute over the allowable range of motion of the product as specified by the manufacturer.

4.8.2 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 4.3 (Hydrostatic Strength).

5. OPERATIONS REQUIREMENTS

5.1 Demonstrated Quality Control Program

5.1.1 A quality assurance 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 examination and tests and may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performances and by periodic re-examination and testing.

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

- 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;
- Handling and disposition of non-conforming materials.

5.1.3 Documentation/Manual

There should be an authoritative collection of procedures/policies. It should 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.

5.1.4 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 certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.

Records of all revisions to all certified products shall be maintained.

5.2 Surveillance Audit Program

5.2.1 An audit of the manufacturing facility may be part of the certification agency's surveillance requirements 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 ensure a uniform product consistent with that which was tested and certified.

5.2.2 Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

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 the certification agency.

5.4 Manufacturer's Responsibilities

The manufacturer shall notify the certification agency of proposed changes in product construction, design, component, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation of such changes.

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 through the manufacturer's own quality control system. 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.

5.5.2 Test Requirement No. 2 - *Dimensional Checks*

The manufacturer shall measure and record critical component dimensions, material thickness, markings, and end 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 examination 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.

6. BIBLIOGRAPHY

ANSI/AWWA C104/A21.4, *Cement-Mortar Lining for Ductile-Iron Pipe and Fittings*
ANSI/AWWA C105/A21.5, *Polyethylene Encasement for Ductile-Iron Pipe Systems*
ANSI/AWWA C115/A21.15, *Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges*
ANSI/AWWA C600, *Installation of Ductile-Iron Water Mains and Their Appurtenances*
AWWA M41, *Ductile-Iron Pipe and Fittings*
ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*
NFPA 13, *Standard for the Installation of Sprinkler Systems*

APPENDIX A: Tolerances

Unless otherwise stated, the following tolerances shall apply:

Angle	$\pm 2^\circ$
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 $68.9^\circ\text{F} \pm 9^\circ\text{F}$ ($20.5^\circ\text{C} \pm 5^\circ\text{C}$).

APPENDIX B: Sample Listing

<i>Model Designation</i>	<i>Product Description</i>	<i>Nominal Pipe Size, in.</i>	<i>Rated Working Pressure, psi (kPa)</i>	<i>Notes</i>
A	Pipe (unrestrained – push on)	4, 5, 6, 8	360 (2485)	
A		10, 12	300 (2070)	
A	Pipe (self restrained – mechanical joint)	4, 5, 6, 8	360 (2485)	
A		10, 12	300 (2070)	
C	Flanged 90° Duckfoot Elbow	4, 5, 6, 8, 10, 12	360 (2485)	
D	Flanged Tees	12x12x12	360 (2485)	
D		12x12x10	360 (2485)	
D		10x10x10	360 (2485)	
D		8x8x8	360 (2485)	
D		8x8x6	360 (2485)	
E	Flanged Reducer	12x10	360 (2485)	
E		10x8	360 (2485)	
E		8x6	360 (2485)	
E		6x4	360 (2485)	
F	Flanged x Spigot Fitting	4, 6, 8, 10, 12	360 (2485)	
G	Blind Flange	4, 5, 6, 8, 10, 12	360 (2485)	
H	Grooved Coupling	4, 5, 6, 8, 10, 12	235 (1620)	
I	Equal Tee	4, 6, 8, 10, 12	360 (2485)	a

Notes:

- a. Flanged or mechanical joint end connections.