Origin and Development of NFPA 24

In 1903, the NFPA Committee on Hose and Hydrants first presented Specifications for Mill Yard Hose Houses, taken substantially from a standard published by the Eastern Factory Insurance Association. This text was revised and adopted in 1904. The NFPA Committee on Field Practice amended the Specifications in 1926, published as NFPA 25.

In 1925, the Committee on Field Practice prepared a Standard on Outside Protection, Private Underground Piping Systems Supplying Water for Fire Extinguishment, which was adopted by NFPA. It was largely taken from the 1920 edition of the NFPA Automatic Sprinkler Standard, Section M on Underground Pipes and Fittings. In September 1931, a revision was made, with the resulting standard designated as NFPA 24. In the 1981 edition the title was changed from Standard for Outside Protection to Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

The 1992 edition included amendments to further delineate the point at which the water supply stops and the fixed fire protection system begins. Minor changes were made concerning special topics such as thrust restraint and equipment provisions in valve pits.

The 1995 edition clarified requirements for aboveground and buried piping. Revisions were made to provide additional information regarding listing requirements, signage, valves, valve supervision, hydrant outlets, system attachments, piping materials, and thrust blocks. User friendliness of the document was also addressed.

The 2002 edition represented a complete revision of NFPA 24. Changes included reorganization and editorial modifications to comply with the Manual of Style for NFPA Technical Committee Documents. Additionally, all of the underground piping requirements were relocated into a new Chapter 10.

The 2007 edition has been revised in five major areas: Chapter 10 has been editorially updated and contains minor technical changes. Additionally, Chapter 10 now contains newly established leakage test criteria, as well as updated requirements for thrust blocks and restrained joints. Two annexes are new to this edition: Annex C, Recommended Practice for Fire Flow Testing, and Annex D, Recommended Practice for Marking of Hydrants. These two annexes were developed based on the current edition of NFPA 291.

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(Member Emeritus)

Christian Dubay, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have overall responsibility for documents that pertain to the criteria for the design and installation of automatic, open and foam-water sprinkler systems including the character and adequacy of water supplies, and the selection of sprinklers, piping, valves, and all materials and accessories. This Committee does not cover the installation of tanks and towers, nor the installation, maintenance, and use of central station, proprietary, auxiliary, and local signaling systems for watchmen, fire alarm, supervisory service, nor the design of fire department hose connections.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on private piping systems supplying water for fire protection and for hydrants, hose houses, and valves. The Committee is also responsible for documents on fire flow testing and marking of hydrants.

NFPA 24
Standard for the
Installation of Private Fire Service Mains and Their Appurtenances
2007 Edition

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1.1 Scope.

1.1.1 This standard shall cover the minimum requirements for the installation of private fire service mains and their appurtenances supplying the following:

(1) Automatic sprinkler systems
(2) Open sprinkler systems
(3) Water spray fixed systems
(4) Foam systems
(5) Private hydrants
(6) Monitor nozzles or standpipe systems with reference to water supplies
•
(7) Hose houses

1.1.2 This standard shall apply to combined service mains used to carry water for fire service and other uses.

1.2 Purpose.

The purpose of this standard shall be to provide a reasonable degree of protection for life and property from fire through installation requirements for private fire service main systems based on sound engineering principles, test data, and field experience.
1.3 Retroactivity.

The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.3.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.3.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.3.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction and only where it is clearly evident that a reasonable degree of safety is provided.

1.4 Equivalency.

Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.5 Units.

1.5.1 Metric units of measurement in this standard shall be in accordance with the modernized metric system known as the International System of Units (SI). Liter and bar units are not part of, but are recognized by, SI and are commonly used in international fire protection. These units are shown in Table 1.5.1 with conversion factors.

<table>
<thead>
<tr>
<th>Name of Unit</th>
<th>Unit Symbol</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liter</td>
<td>L</td>
<td>1 gal = 3.785 L</td>
</tr>
<tr>
<td>Liter per minute per square meter</td>
<td>(L/min)/m²</td>
<td>1 gpm/ft² = (40.746 L/min)/m²</td>
</tr>
<tr>
<td>Cubic decimeter</td>
<td>dm³</td>
<td>1 gal = 3.785 dm³</td>
</tr>
<tr>
<td>Pascal</td>
<td>Pa</td>
<td>1 psi = 6894.757 Pa</td>
</tr>
<tr>
<td>Bar</td>
<td>bar</td>
<td>1 psi = 0.0689 bar</td>
</tr>
<tr>
<td>Bar</td>
<td>bar</td>
<td>1 bar = 10⁵ Pa</td>
</tr>
</tbody>
</table>

Note: For additional conversions and information, see IEEE/ASTM-SI-10.

1.5.2 If a value for measurement as given in this standard is followed by an equivalent value...
in other units, the first stated is to be regarded as the requirement. A given equivalent value might be approximate.

1.5.3 SI units have been converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

Chapter 2 Referenced Publications

2.1 General.
The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications.
National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

2.3 Other Publications.

2.3.1 ASME Publications.
American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.
ASME B1.20.1, Pipe Threads, General Purpose (Inch), 1983.
ASME B16.11, Forged Steel Fittings, Socket Welded and Threaded, 1996.
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### 2.3.2 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.


### 2.3.3 AWWA Publications.

American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.


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AWWA C300, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*, 1989.

AWWA C301, *Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*, 1992.

AWWA C302, *Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids*, 1987.

AWWA C303, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids*, 1987.


AWWA C906, *Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 63 in. (1575 mm) for Water Distribution and Transport*, 1999.


### 2.3.4 Other Publications.


### 2.4 References for Extracts in Mandatory Sections.


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## Chapter 3 Definitions

### 3.1 General.

The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using

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their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster’s Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Appurtenance. An accessory or attachment that enables the private fire service main to perform its intended function.

3.3.2 Corrosion Resistant Piping. Piping that has the property of being able to withstand deterioration of its surface or its properties when exposed to its environment.

3.3.3 Corrosion Retardant Material. A lining or coating material that when applied to piping or appurtenances has the property of reducing or slowing the deterioration of the object's surface or properties when exposed to its environment.

3.3.4 Fire Department Connection. A connection through which the fire department can pump supplemental water into the sprinkler system, standpipe, or other system, furnishing water for fire extinguishment to supplement existing water supplies.

3.3.5 Fire Pump. A pump supplying water at the flow and pressure required by water-based...
fire protection systems.

3.3.6 **Hose House.** An enclosure located over or adjacent to a hydrant or other water supply designed to contain the necessary hose nozzles, hose wrenches, gaskets, and spanners to be used in fire fighting in conjunction with and to provide aid to the local fire department.

3.3.7 **Hydrant Butt.** The hose connection outlet of a hydrant.

3.3.8 **Hydraulically Calculated Water Demand Flow Rate.** The water flow rate for a system or hose stream that has been calculated using accepted engineering practices.

3.3.9 **Pressure.**

3.3.9.1 **Residual Pressure.** The pressure that exists in the distribution system, measured at the residual hydrant at the time the flow readings are taken at the flow hydrants.

3.3.9.2 **Static Pressure.** The pressure that exists at a given point under normal distribution system conditions measured at the residual hydrant with no hydrants flowing.

3.3.10 **Pressure Regulating Device.** A device designed for the purpose of reducing, regulating, controlling, or restricting water pressure. Examples include pressure-reducing valves, pressure-control valves, and pressure-restricting devices.

3.3.11* **Private Fire Service Main.** Private fire service main, as used in this standard, is that pipe and its appurtenances on private property (1) between a source of water and the base of the system riser for water-based fire protection systems, (2) between a source of water and inlets to foam-making systems, (3) between a source of water and the base elbow of private hydrants or monitor nozzles, and (4) used as fire pump suction and discharge piping, (5) beginning at the inlet side of the check valve on a gravity or pressure tank. [13:3.8.1]

3.3.12 **Pumper Outlet.** The hydrant outlet intended for use by fire departments for taking supply from the hydrant for pumpers.

3.3.13 **Rated Capacity.** The flow available from a hydrant at the designated residual pressure (rated pressure) either measured or calculated.

3.3.14 **Test.**

3.3.14.1 **Flow Test.** A test performed by the flow and measurement of water from one hydrant and the static and residual pressures from an adjacent hydrant for the purpose of determining the available water supply at that location.

3.3.14.2 **Flushing Test.** A test of a piping system using high velocity flows to remove debris from the piping system prior to it being placed in service.

3.3.14.3 **Hydrostatic Test.** A test of a closed piping system and its attached appurtenances consisting of subjecting the piping to an increased internal pressure for a specified period of duration to verify system integrity and leak rates.

3.3.15 **Valve.**

3.3.15.1 **Check Valve.** A valve that allows flow in one direction only.

3.3.15.2 **Indicating Valve.** A valve that has components that show if the valve is open or

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3.4 Hydrant Definitions.

3.4.1 Hydrant. An exterior valved connection to a water supply system that provides hose connections.

3.4.1.1 Dry Barrel Hydrant. This is the most common type of hydrant; it has a control valve below the frost line between the footpiece and the barrel. A drain is located at the bottom of the barrel above the control valve seat for proper drainage after operation.

3.4.1.2 Flow Hydrant. The hydrant that is used for the flow and flow measurement of water during a flow test.

3.4.1.3 Private Fire Hydrant. A valved connection on a water supply system having one or more outlets and that is used to supply hose and fire department pumpers with water on private property. Where connected to a public water system, the private hydrants are supplied by a private service main that begins at the point of service designated by the AHJ, usually at a manually operated valve near the property line.

3.4.1.4 Public Hydrant. A valved connection on a water supply system having one or more outlets and that is used to supply hose and fire department pumpers with water.

3.4.1.5 Residual Hydrant. The hydrant that is used for measuring static and residual pressures during a flow test.

3.4.1.6 Wet Barrel Hydrant. A type of hydrant that sometimes is used where there is no danger of freezing weather. Each outlet on a wet barrel hydrant is provided with a valved outlet threaded for fire hose.

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Chapter 4 General Requirements

4.1* Plans.

4.1.1 Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled.

4.1.2 Deviation from approved plans shall require permission of the authority having jurisdiction.

4.1.3 Working plans shall be drawn to an indicated scale on sheets of uniform size, with a plan of each floor as applicable, and shall include the following items that pertain to the design of the system:

(1) Name of owner
(2) Location, including street address
(3) Point of compass
4.1.4 The working plan submittal shall include the manufacturer's installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any devices, piping, or fittings.

4.2 Installation Work.

4.2.1 Installation work shall be performed by fully experienced and responsible persons.

4.2.2 The authority having jurisdiction shall always be consulted before the installation or remodeling of private fire service mains.
5.1* Connection to Waterworks Systems.

5.1.1 A connection to a reliable waterworks system shall be an acceptable water supply source.

5.1.2 The volume and pressure of a public water supply shall be determined from waterflow test data.

5.1.3 An adjustment to the waterflow test data to account for the following shall be made, as appropriate:

(1) Daily and seasonal fluctuations
(2) Possible interruption by flood or ice conditions
(3) Large simultaneous industrial use
(4) Future demand on the water supply system
(5) Other conditions that could affect the water supply

5.2 Size of Fire Mains.

5.2.1 Private Fire Service Mains. Pipe smaller than 6 in. (152.4 mm) in diameter shall not be installed as a private service main supplying hydrants.

5.2.2 Mains Not Supplying Hydrants. For mains that do not supply hydrants, sizes smaller than 6 in. (152.4 mm) shall be permitted to be used subject to the following restrictions:

(1) The main shall supply only the following types of systems:
   (a) Automatic sprinkler systems
   (b) Open sprinkler systems
   (c) Water spray fixed systems
   (d) Foam systems
   (e) Class II standpipe systems
(2) Hydraulic calculations shall show that the main is able to supply the total demand at the appropriate pressure.
(3) Systems that are not hydraulically calculated shall have a main at least as large as the riser.

5.3 Pressure-Regulating Devices and Meters.

5.3.1 No pressure-regulating valve shall be used in the water supply, except by special permission of the authority having jurisdiction.

5.3.2 Where meters are required by other authorities, they shall be listed.

5.4* Connection from Waterworks Systems.
5.4.1 The requirements of the public health authority having jurisdiction shall be determined and followed.

5.4.2 Where equipment is installed to guard against possible contamination of the public water system, such equipment and devices shall be listed for fire protection service.

5.5 Connections to Public Water Systems.
Connections to public water systems shall be controlled by post indicator valves of an approved type and installed in accordance with the requirements of Section 6.3.

5.6* Pumps.
A single, automatically controlled fire pump installed in accordance with NFPA 20, shall be an acceptable water supply source.

5.7 Tanks.
Tanks shall be installed in accordance with NFPA 22.

5.8 Penstocks, Flumes, Rivers, Lakes, or Reservoirs.
Water supply connections from penstocks, flumes, rivers, lakes, or reservoirs shall be arranged to avoid mud and sediment and shall be provided with approved, double, removable screens or approved strainers installed in an approved manner.

5.9* Fire Department Connections.

5.9.1 General. A fire department connection shall be provided as described in Section 5.9.

5.9.1.1 Fire department connections shall not be required where approved by the authority having jurisdiction.

5.9.1.2 Fire department connections shall be properly supported.

5.9.1.3 Fire department connections shall be of an approved type.

5.9.1.4 Fire department connections shall be equipped with listed plugs or caps that are secured and arranged for easy removal by fire departments.

5.9.2 Couplings.

5.9.2.1 The fire department connection(s) shall use an NH internal threaded swivel fitting(s) with an NH standard thread(s).

5.9.2.2 At least one of the connections shall be the 2.5-7.5 NH standard thread specified in NFPA 1963.

5.9.2.3 Where local fire department connections do not conform to NFPA 1963, the authority having jurisdiction shall designate the connection to be used.

5.9.2.4 The use of threadless couplings shall be permitted where required by the authority having jurisdiction and where listed for such use.
5.9.3 Valves.

5.9.3.1 A listed check valve shall be installed in each fire department connection.

5.9.3.2 No shutoff valve shall be permitted in the fire department connection piping.

5.9.4 Drainage.

5.9.4.1 The pipe between the check valve and the outside hose coupling shall be equipped with an approved automatic drip.

5.9.4.2 An automatic drip shall not be required in areas not subject to freezing.

5.9.5 Location and Signage.

5.9.5.1 Fire department connections shall be located on the street side of buildings.

5.9.5.2 Fire department connections shall be located and arranged so that hose lines can be readily and conveniently attached to the inlets without interference from any nearby objects, including buildings, fences, posts, or other fire department connections.

5.9.5.3 Each fire department connection to sprinkler systems shall be designated by a sign as follows:

(1) The sign shall have raised or engraved letters at least 1 in. (25.4 mm) in height on a plate or fitting.

(2) The sign shall indicate the service for which the connection is intended and shall read, for example, as follows:

AUTOSPKR
OPEN SPKR
AND STANDPIPE

5.9.5.4 Where the system demand pressure exceeds 150 psi (10.3 bar), the sign required by 5.9.5.3 shall indicate the required design pressure.

5.9.5.5 Where a fire department connection only supplies a portion(s) of the building, a sign shall be attached to indicate the portion(s) of the building supplied.

Chapter 6 Valves

6.1 Types of Valves.

6.1.1 All valves controlling connections to water supplies and to supply pipes to sprinklers shall be listed indicating valves.

6.1.2 Indicating valves shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position.

6.1.3 A listed underground gate valve equipped with a listed indicator post shall be
permitted.

6.1.4 A listed water control valve assembly with a reliable position indication connected to a remote supervisory station shall be permitted.

6.1.5 A nonindicating valve, such as an underground gate valve with approved roadway box, complete with T-wrench, and accepted by the authority having jurisdiction, shall be permitted.

6.2 Valves Controlling Water Supplies.

6.2.1 At least one listed indicating valve shall be installed in each source of water supply.

6.2.2 No shutoff valve shall be permitted in the fire department connection.

6.2.3 Where more than one source of water supply exists, a check valve shall be installed in each connection.

6.2.4 Where cushion tanks are used with automatic fire pumps, a check valve shall not be required in the cushion tank connection.

6.2.5* In a connection serving as one source of supply, listed indicating valves or post indicator valves shall be installed on both sides of all check valves required in 6.2.3.

6.2.6 In the discharge pipe from a pressure tank or a gravity tank of less than 15,000 gal (56.78 m³) capacity, a control valve shall not be required to be installed on the tank side of the check valve.

6.2.7* The following requirements shall apply where a gravity tank is located on a tower in the yard:

(1) The control valve on the tank side of the check valve shall be an outside screw and yoke or a listed indicating valve.

(2) The other control valve shall be either an outside screw and yoke, a listed indicating valve, or a listed valve having a post-type indicator.

6.2.8* The following requirements shall apply where a gravity tank is located on a building:

(1) Both control valves shall be outside screw and yoke or listed indicating valves.

(2) All fittings inside the building, except the drain tee and heater connections, shall be under the control of a listed valve.

6.2.9 One of the following requirements shall be met where a pump is located in a combustible pump house or exposed to danger from fire or falling walls, or where a tank discharges into a private fire service main fed by another supply:

(1)* The check valve in the connection shall be located in a pit.

(2) The control valve shall be of the post indicator type and located a safe distance outside buildings.

6.2.10* All control valves shall be located where readily accessible and free of obstructions.

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6.3 Post Indicator Valves.

6.3.1* General. Unless the requirements of 6.3.2 are met, every connection from the private fire service main to a building shall be provided with a listed post indicator valve located to control all sources of water supply.

6.3.2 Alternate Provision for Post Indicator Valves. The authority having jurisdiction shall be permitted to waive the requirement for the post indicator valves required in 6.3.1 where the provisions of Sections 6.1 and 6.4 are met.

6.3.3 Location.

6.3.3.1 Post indicator valves shall be located not less than 40 ft (12.2 m) from buildings.

6.3.3.2* Where post indicator valves cannot be located in accordance with 6.3.3.1, they shall be permitted to be located closer where approved by the authority having jurisdiction, or wall post indicator valves shall be used, provided they are set in locations near blank walls where the possibility of injury by falling walls is unlikely and from which people are not likely to be driven by smoke or heat.

6.3.4 Arrangement.

6.3.4.1 Post indicator valves shall be set so that the top of the post is 36 in. (0.9 m) above the final grade.

6.3.4.2 Post indicator valves shall be protected against mechanical damage where needed.

6.4 Valves in Pits.

6.4.1 Where it is impractical to provide a post indicator valve, valves shall be permitted to be placed in pits and shall be approved by the authority having jurisdiction.

6.4.2 Valve pits located at or near the base of the riser of an elevated tank shall be designed in accordance with Chapter 9 of NFPA 22.

6.4.3* Where used, valve pits shall be of adequate size and readily accessible for inspection, operation, testing, maintenance, and removal of equipment contained therein.

6.4.4 Valve pits shall be constructed and arranged to properly protect the installed equipment from movement of earth, freezing, and accumulation of water.

6.4.4.1 Depending on soil conditions and the size of the pit, valve pits shall be permitted to be constructed of any of the following materials:

(1) Poured-in-place or precast concrete, with or without reinforcement

(2) Brick

(3) Other approved materials

6.4.4.2 Where the water table is low and the soil is porous, crushed stone or gravel shall be permitted to be used for the floor of the pit.

6.4.5 The location of the valve shall be marked, and the cover of the pit shall be kept free of...
obstructions.

6.5 Sectional Valves.

6.5.1 Large, private, fire service main systems shall have sectional controlling valves at appropriate points to permit sectionalizing the system in the event of a break or to make repairs or extensions.

6.5.2 A sectional valve shall be provided at the following locations:

(1) On each bank where a main crosses water

(2) Outside the building foundation(s) where a main or a section of a main runs under a building

6.6 Identifying and Securing Valves.

6.6.1 Identification signs shall be provided at each valve to indicate its function and what it controls.

6.6.2* Valves on connections to water supplies, sectional control and isolation valves, and other valves in supply pipes to sprinklers and other fixed water-based fire suppression systems shall be supervised by one of the following methods:

(1) Central station, proprietary, or remote station signaling service

(2) Local signaling service that causes the sounding of an audible signal at a constantly attended location

(3) An approved procedure to ensure that valves are locked in the correct position

(4) An approved procedure to ensure that valves are located within fenced enclosures under the control of the owner, sealed in the open position, and inspected weekly

6.6.3 Supervision of underground gate valves with roadway boxes shall not be required.

6.7 Check Valves.

Check valves shall be installed in a vertical or horizontal position in accordance with their listing.

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Chapter 7 Hydrants

7.1 General.

7.1.1 Hydrants shall be of approved type and have not less than a 6 in. (152 mm) diameter connection with the mains.

7.1.1.1 A valve shall be installed in the hydrant connection.

7.1.1.2 The number, size, and arrangement of outlets; the size of the main valve opening; and the size of the barrel shall be suitable for the protection to be provided and shall be
approved by the authority having jurisdiction.

7.1.1.3 Independent gate valves on 2½ in. (64 mm) outlets shall be permitted.

7.1.2* Hydrant outlet threads shall have NHS external threads for the size outlet(s) supplied as specified in NFPA 1963.

7.1.3 Where local fire department connections do not conform to NFPA 1963, the authority having jurisdiction shall designate the connection to be used.

7.1.4* Hydrants on private service mains shall not be equipped with pumper outlets unless the calculated demand for large hose [3½ in. (88.9 mm) and larger] is added to the attack hose and sprinkler system demands when determining the total demand on the fire protection water supply.

7.2 Number and Location.

7.2.1* Hydrants shall be provided and spaced in accordance with the requirements of the authority having jurisdiction.

7.2.2 Public hydrants shall be permitted to be recognized as meeting all or part of the requirements of Section 7.2.

7.2.3* Hydrants shall be located not less than 40 ft (12.2 m) from the buildings to be protected.

7.2.4 Where hydrants cannot be located in accordance with 7.2.3, locations closer than 40 ft (12.2 m) from the building or wall hydrants shall be permitted to be used where approved by the authority having jurisdiction.

7.2.5 Hydrants shall not be installed at less than the equivalent depth of burial from retaining walls where there is danger of frost through the walls.

7.3 Installation.

7.3.1* Hydrants shall be set on flat stones or concrete slabs and shall be provided with small stones (or the equivalent) placed about the drain to ensure drainage.

7.3.2 Where soil is of such a nature that the hydrants will not drain properly with the arrangement specified in 7.3.1, or where groundwater stands at levels above that of the drain, the hydrant drain shall be plugged at the time of installation.

7.3.2.1 If the drain is plugged, hydrants in service in cold climates shall be pumped out after usage.

7.3.2.2 Such hydrants shall be marked to indicate the need for pumping out after usage.

7.3.3* The center of a hose outlet shall be not less than 18 in. (457 mm) above final grade or, where located in a hose house, 12 in. (305 mm) above the floor.

7.3.4 Hydrants shall be fastened to piping and anchored in accordance with the requirements of NFPA 13.
7.3.5 Hydrants shall be protected if subject to mechanical damage.

7.3.6 The means of hydrant protection shall be arranged in a manner that does not interfere with the connection to, or operation of, hydrants.

7.3.7 The following shall not be installed in the service stub between a fire hydrant and private water supply piping:

1. Check valves
2. Detector check valves
3. Backflow prevention valves
4. Other similar appurtenances

**Chapter 8 Hose Houses and Equipment**

8.1 General.

8.1.1* A supply of hose and equipment shall be provided where hydrants are intended for use by plant personnel or a fire brigade.

8.1.1.1 The quantity and type of hose and equipment shall depend on the following:

1. Number and location of hydrants relative to the protected property
2. Extent of the hazard
3. Fire-fighting capabilities of potential users

8.1.2 The authority having jurisdiction shall be consulted regarding quantity and type of hose.

8.1.3* Hose shall conform to NFPA 1961.

8.1.4 Hose Connections.

8.1.4.1 Hose connections shall have external national hose standard (NHS) threads, for the valve size specified, in accordance with NFPA 1963.

8.1.4.2 Hose connections shall be equipped with caps to protect the hose threads.

8.1.4.3 Where local fire department hose threads do not conform to NFPA 1963, the authority having jurisdiction shall designate the hose threads to be used.

8.2 Location.

8.2.1 Where hose houses are utilized, they shall be located over, or immediately adjacent to, the hydrant.

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8.2.2 Hydrants within hose houses shall be as close to the front of the house as possible and still allow sufficient room in back of the doors for the hose gates and the attached hose.

8.2.3 Where hose reels or hose carriers are utilized, they shall be located so that the hose can be brought into use at a hydrant.

8.3 Construction.

8.3.1 Hose houses shall be of substantial construction on foundations.

8.3.2 The construction shall protect the hose from weather and vermin and shall be designed so that hose lines can be brought into use.

8.3.3 Clearance shall be provided for operation of the hydrant wrench.

8.3.4 Ventilation shall be provided.

8.3.5 The exterior shall be painted or otherwise protected against deterioration.

8.4* Size and Arrangement.

Hose houses shall be of a size and arrangement that provide shelves or racks for the hose and equipment.

8.5 Marking.

Hose houses shall be plainly identified.

8.6 General Equipment.

8.6.1* Where hose houses are used in addition to the hose, each shall be equipped with the following:

1. Two approved adjustable spray–solid stream nozzles equipped with shutoffs for each size of hose provided
2. One hydrant wrench (in addition to wrench on hydrant)
3. Four coupling spanners for each size hose provided
4. Two hose coupling gaskets for each size hose

8.6.2 Where two sizes of hose and nozzles are provided, reducers or gated wyes shall be included in the hose house equipment.

8.7 Domestic Service Use Prohibited.

The use of hydrants and hose for purposes other than fire-related services shall be prohibited.

Chapter 9 Master Streams

9.1* Master Streams.

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Master streams shall be delivered by monitor nozzles, hydrant-mounted monitor nozzles, and similar master stream equipment capable of delivering more than 250 gpm (946 L/min).

### 9.2 Application and Special Considerations.

Master streams shall be provided as protection for the following:

1. Large amounts of combustible materials located in yards
2. Average amounts of combustible materials in inaccessible locations
3. Occupancies presenting special hazards as required by the authority having jurisdiction

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### Chapter 10 Underground Piping

#### 10.1* Piping Materials.

**10.1.1* Listing.** Piping shall be listed for fire protection service and shall comply with the standards in Table 10.1.1.

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<th>Table 10.1.1 Manufacturing Standards for Underground Pipe</th>
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<tbody>
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<td>Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water</td>
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<td>Polyethylene Encasement for Ductile Iron Pipe Systems</td>
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<td>Ductile Iron and Gray Iron Fittings, 3-in. Through 48-in., for Water and Other Liquids</td>
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<td>Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings</td>
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<td>Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges</td>
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<td>Thickness Design of Ductile Iron Pipe</td>
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<td>Ductile Iron Pipe, Centrifugally Cast for Water</td>
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<td>Ductile-Iron Compact Fittings for Water Service</td>
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<tr>
<td>Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances</td>
</tr>
</tbody>
</table>

Steel

| **Steel Water Pipe 6 in. and Larger** | AWWA C200 |
| Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape — Hot Applied | AWWA C203 |
| Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 in. and Larger — Shop Applied | AWWA C205 |
| Field Welding of Steel Water Pipe | AWWA C206 |
| Steel Pipe Flanges for Waterworks Service — Sizes 4 in. Through 144 in. | AWWA C207 |
| Dimensions for Fabricated Steel Water Pipe Fittings | AWWA C208 |
| A Guide for Steel Pipe Design and Installation | AWWA M11 |

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Table 10.1.1 Manufacturing Standards for Underground Pipe

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<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
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<td>Concrete</td>
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<tr>
<td>Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids</td>
<td>AWWA C300</td>
</tr>
<tr>
<td>Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids</td>
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</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids</td>
<td>AWWA C302</td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids</td>
<td>AWWA C303</td>
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<tr>
<td>Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water and Other Liquids</td>
<td>AWWA C400</td>
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<tr>
<td>Standard Practice for the Selection of Asbestos-Cement Water Pipe</td>
<td>AWWA C401</td>
</tr>
<tr>
<td>Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place</td>
<td>AWWA C602</td>
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<tr>
<td>Standard for the Installation of Asbestos-Cement Water Pipe</td>
<td>AWWA C603</td>
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<tr>
<td>Plastic</td>
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<tr>
<td>Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water and Other Liquids</td>
<td>AWWA C900</td>
</tr>
<tr>
<td>Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 63 in. (1575 mm) for Water Distribution and Transport</td>
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<td>Copper</td>
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<td>Specification for Seamless Copper Tube</td>
<td>ASTM B 75</td>
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<td>Specification for Seamless Copper Water Tube</td>
<td>ASTM B 88</td>
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<tr>
<td>Requirements for Wrought Seamless Copper and Copper-Alloy Tube</td>
<td>ASTM B 251</td>
</tr>
</tbody>
</table>

10.1.2 Steel Pipe. Steel piping shall not be used for general underground service unless specifically listed for such service.

10.1.3 Steel Pipe Used with Fire Department Connections. Where externally coated and wrapped and internally galvanized, steel pipe shall be permitted to be used between the check valve and the outside hose coupling for the fire department connection.

10.1.4* Pipe Type and Class. The type and class of pipe for a particular underground installation shall be determined through consideration of the following factors:

(1) Fire resistance of the pipe
(2) Maximum system working pressure
(3) Depth at which the pipe is to be installed
(4) Soil conditions
(5) Corrosion

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(6) Susceptibility of pipe to other external loads, including earth loads, installation beneath buildings, and traffic or vehicle loads

10.1.5 **Working Pressure.** Pipe shall be designed to withstand a system working pressure of not less than 150 psi (10.3 bar).

10.1.6* **Lining of Buried Pipe.**

10.1.6.1 Unless the requirements of 10.1.6.2 are met, all ferrous metal pipe shall be lined in accordance with the applicable standards in Table 10.1.1.

10.1.6.2 Steel pipe utilized in fire department connections and protected in accordance with the requirements of 10.1.3 shall not be additionally required to be lined.

10.2 **Fittings.**

10.2.1 **Standard Fittings.** Fittings shall meet the standards in Table 10.2.1(a) or shall be in accordance with 10.2.2. In addition to the standards in Table 10.2.1(b), CPVC fittings shall also be in accordance with 10.2.2 and with the portions of the ASTM standards specified in Table 10.2.1(b) that apply to fire protection service.

### Table 10.2.1(a) Fittings Materials and Dimensions

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
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<td><strong>Cast Iron</strong></td>
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<tr>
<td>Cast Iron Threaded Fittings, Class 125 and 250</td>
<td>ASME B16.4</td>
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<td>Cast Iron Pipe Flanges and Flanged Fittings</td>
<td>ASME B16.1</td>
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<tr>
<td><strong>Malleable Iron</strong></td>
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<tr>
<td>Malleable Iron Threaded Fittings, Class 150 and 300</td>
<td>ASME B16.3</td>
</tr>
<tr>
<td><strong>Steel</strong></td>
<td></td>
</tr>
<tr>
<td>Factory-Made Wrought Steel Butt welded Fittings</td>
<td>ASME B16.9</td>
</tr>
<tr>
<td>Butt welding Ends for Pipe, Valves, Flanges, and Fittings</td>
<td>ASME B16.25</td>
</tr>
<tr>
<td>Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures</td>
<td>ASTM A 234</td>
</tr>
<tr>
<td>Steel Pipe Flanges and Flanged Fittings</td>
<td>ASME B16.5</td>
</tr>
<tr>
<td>Forged Steel Fittings, Socket Welded and Threaded</td>
<td>ASME B16.11</td>
</tr>
<tr>
<td><strong>Copper</strong></td>
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<tr>
<td>Wrought Copper and Bronze Solder Joint Pressure Fittings</td>
<td>ASME B16.22</td>
</tr>
<tr>
<td>Cast Bronze Solder Joint Pressure Fittings</td>
<td>ASME B16.18</td>
</tr>
</tbody>
</table>

### Table 10.2.1(b) Specially Listed Fittings Materials and Dimensions

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
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<tr>
<td>Chlorinated Polyvinyl Chloride (CPVC) Specification for Schedule 80 CPVC Threaded Fittings</td>
<td>ASTM F 437</td>
</tr>
</tbody>
</table>

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Table 10.2.1(b) Specially Listed Fittings Materials and Dimensions

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
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<tbody>
<tr>
<td>Specification for Schedule 40 CPVC Socket-Type Fittings</td>
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<tr>
<td>Specification for Schedule 80 CPVC Socket-Type Fittings</td>
<td>ASTM F 439</td>
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</tbody>
</table>

10.2.2 Special Listed Fittings. Other types of fittings investigated for suitability in automatic sprinkler installations and listed for this service, including, but not limited to, polybutylene, CPVC, and steel differing from that provided in Table 10.2.1(a), shall be permitted when installed in accordance with their listing limitations, including installation instructions.

10.2.3 Pressure Limits. Listed fittings shall be permitted for the system pressures as specified in their listings, but not less than 150 psi (10 bar).

10.2.4* Buried Joints. Joints shall be approved.

10.2.5* Buried Fittings. Fittings shall be of an approved type with joints and pressure class ratings compatible with the pipe used.

10.3 Joining of Pipe and Fittings.

10.3.1 Threaded Pipe and Fittings. All threaded steel pipe and fittings shall have threads cut in accordance with ASME B1.20.1.

10.3.2 Groove Joining Methods. Pipes joined with grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves.

10.3.3 Brazed and Pressure Fitting Methods. Joints for the connection of copper tube shall be brazed or joined using pressure fittings as specified in Table 10.2.1(a).

10.3.4 Other Joining Methods. Other joining methods listed for this service shall be permitted where installed in accordance with their listing limitations.

10.3.5 Pipe Joint Assembly.

10.3.5.1 Joints shall be assembled by persons familiar with the particular materials being used and in accordance with the manufacturer's instructions and specifications.

10.3.5.2 All bolted joint accessories shall be cleaned and thoroughly coated with asphalt or other corrosion-retarding material after installation.

10.4 Depth of Cover.

10.4.1* The depth of cover over water pipes shall be determined by the maximum depth of frost penetration in the locality where the pipe is laid.

10.4.2 The top of the pipe shall be buried not less than 1 ft (0.3 m) below the frost line for the locality.

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10.4.3 In those locations where frost is not a factor, the depth of cover shall be not less than 2½ ft (0.8 m) to prevent mechanical damage.

10.4.4 Pipe under driveways shall be buried at a minimum depth of 3 ft (0.9 m).

10.4.5 Pipe under railroad tracks shall be buried at a minimum depth of 4 ft (1.2 m).

10.4.6 The depth of cover shall be measured from the top of the pipe to finished grade, and due consideration shall always be given to future or final grade and nature of soil.

10.5 Protection Against Freezing.

10.5.1* Where it is impracticable to bury pipe, pipe shall be permitted to be laid aboveground, provided that the pipe is protected against freezing and mechanical damage.

10.5.2 Pipe shall be buried below the frost line where entering streams and other bodies of water.

10.5.3 Where pipe is laid in water raceways or shallow streams, care shall be taken that there will be sufficient depth of running water between the pipe and the frost line during all seasons of frost; a safer method is to bury the pipe 1 ft (0.3048 m) or more under the bed of the waterway.

10.5.4 Pipe shall be located at a distance from stream banks and embankment walls that prevents danger of freezing through the side of the bank.

10.6 Protection Against Damage.

10.6.1 Pipe shall not be run under buildings.

10.6.2 Where pipe must be run under buildings, special precautions shall be taken, including the following:

(1) Arching the foundation walls over the pipe
(2) Running pipe in covered trenches
(3) Providing valves to isolate sections of pipe under buildings

10.6.3 Fire service mains shall be permitted to enter the building adjacent to the foundation.

10.6.4 Where adjacent structures or physical conditions make it impractical to locate risers immediately inside an exterior wall, such risers shall be permitted to be located as close as practical to exterior walls to minimize underground piping under the building.

10.6.5 Where a riser is located close to building foundations, underground fittings of proper design and type shall be used to avoid locating pipe joints in or under the foundations.

10.6.6 Mains shall be subjected to an evaluation of the following specific loading conditions and protected, if necessary:

(1) Mains running under railroads carrying heavy cargo
(2) Mains running under large piles of heavy commodities

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Mains located in areas that subject the main to heavy shock and vibrations

10.6.7* Where it is necessary to join metal pipe with pipe of dissimilar metal, the joint shall be insulated against the passage of an electric current using an approved method.

10.6.8* In no case shall the underground piping be used as a grounding electrode for electrical systems. This does not preclude the bonding of the underground piping to the lightning protection grounding system as required by NFPA 780 in those cases where lightning protection is provided for the structure.

10.7 Requirement for Laying Pipe.

10.7.1 Pipes, valves, hydrants, gaskets, and fittings shall be inspected for damage when received and shall be inspected prior to installation. *(See Figure 10.10.1.)*

10.7.2 The torquing of bolted joints shall be checked.

10.7.3 Pipe, valves, hydrants, and fittings shall be clean inside.

10.7.4 When work is stopped, the open ends of pipe, valves, hydrants, and fittings shall be plugged to prevent stones and foreign materials from entering.

10.7.5 All pipe, fittings, valves, and hydrants shall be carefully lowered into the trench using appropriate equipment and carefully examined for cracks or other defects while suspended above the trench.

10.7.6 Plain ends shall be inspected for signs of damage prior to installation.

10.7.7 Under no circumstances shall water main materials be dropped or dumped.

10.7.8 Pipe shall not be rolled or skidded against other pipe materials.

10.7.9 Pipes shall bear throughout their full length and shall not be supported by the bell ends only or by blocks.

10.7.10 If the ground is soft or of a quicksand nature, special provisions shall be made for supporting pipe.

10.7.11 Valves and fittings used with nonmetallic pipe shall be supported and restrained in accordance with the manufacturer's specifications.

10.8 Joint Restraint.

10.8.1 General.

10.8.1.1* All tees, plugs, caps, bends, reducers, valves, and hydrant branches shall be restrained against movement by using thrust blocks in accordance with 10.8.2 or restrained joint systems in accordance with 10.8.3.

10.8.1.2 Piping with fused, threaded, grooved, or welded joints shall not require additional restraining, provided that such joints can pass the hydrostatic test of 10.10.2.2 without shifting of piping or leakage in excess of permitted amounts.

10.8.1.3 Steep Grades. On steep grades, mains shall be additionally restrained to prevent
slipping.

10.8.1.3.1 Pipe shall be restrained at the bottom of a hill and at any turns (lateral or vertical).

10.8.1.3.2 The restraint specified in 10.8.1.3.1 shall be to natural rock or to suitable piers built on the downhill side of the bell.

10.8.1.3.3 Bell ends shall be installed facing uphill.

10.8.1.3.4 Straight runs on hills shall be restrained as determined by the design engineer.

10.8.2* Thrust Blocks.

10.8.2.1 Thrust blocks shall be considered satisfactory where soil is suitable for their use.

10.8.2.2 Thrust blocks shall be of a concrete mix not leaner than one part cement, two and one-half parts sand, and five parts stone.

10.8.2.3 Thrust blocks shall be placed between undisturbed earth and the fitting to be restrained and shall be capable of such bearing to ensure adequate resistance to the thrust to be encountered.

10.8.2.4 Wherever possible, thrust blocks shall be placed so that the joints are accessible for repair.

10.8.3* Restrained Joint Systems. Fire mains utilizing restrained joint systems shall include one or more of the following:

(1) Locking mechanical or push-on joints
(2) Mechanical joints utilizing setscrew retainer glands
(3) Bolted flange joints
(4) Heat-fused or welded joints
(5) Pipe clamps and tie rods
(6) Other approved methods or devices

10.8.3.1 Sizing Clamps, Rods, Bolts, and Washers.

10.8.3.1.1 Clamps.

(1) ½ in. × 2 in. (12.7 mm × 50.8 mm) for pipe 4 in. to 6 in.
(2) ¾ in. × 2½ in. (15.9 mm × 63.5 mm) for pipe 8 in. to 10 in.
(3) ¾ in. × 3 in. (15.9 mm × 76.2 mm) for 12 in. pipe

10.8.3.1.2 The diameter of a bolt hole shall be ⅞ in. (1.6 mm) larger than that of the corresponding bolt.

10.8.3.1.2 Rods.

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10.8.3.1.2.1 Rods shall be not less than \( \frac{5}{8} \) in. (15.9 mm) in diameter.

10.8.3.1.2.2 Table 10.8.3.1.2.2 provides the numbers of various diameter rods that shall be used for a given pipe size.

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>( \frac{5}{8} ) in. (15.9 mm)</th>
<th>( \frac{3}{4} ) in. (19.1 mm)</th>
<th>( \frac{7}{8} ) in. (22.2 mm)</th>
<th>1 in. (25.4 mm)</th>
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<td>7</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: This table has been derived using pressure of 225 psi (15.5 bar) and design stress of 25,000 psi (172.4 MPa).

10.8.3.1.2.3 Where using bolting rods, the diameter of mechanical joint bolts shall limit the diameter of rods to \( \frac{3}{4} \) in. (19.1 mm).

10.8.3.1.2.4 Threaded sections of rods shall not be formed or bent.

10.8.3.1.2.5 Where using clamps, rods shall be used in pairs for each clamp.

10.8.3.1.2.6 Assemblies in which a restraint is made by means of two clamps canted on the barrel of the pipe shall be permitted to use one rod per clamp if approved for the specific installation by the authority having jurisdiction.

10.8.3.1.2.7 Where using combinations of rods, the rods shall be symmetrically spaced.

10.8.3.1.3 Clamp Bolts. Clamp bolts shall have the following diameters:

(1) \( \frac{5}{8} \) in. (15.9 mm) for pipe 4 in., 6 in., and 8 in.
(2) \( \frac{3}{4} \) in. (19.1 mm) for pipe 10 in.
(3) \( \frac{7}{8} \) in. (22.2 mm) for 12 in. pipe

10.8.3.1.4 Washers.

10.8.3.1.4.1 Washers shall be permitted to be cast iron or steel and round or square.

10.8.3.1.4.2 Cast-iron washers shall have the following dimensions:

(1) \( \frac{5}{8} \) in. \( \times \) 3 in. (15.9 mm \( \times \) 76.2 mm) for 4 in., 6 in., 8 in., and 10 in. pipe
(2) \( \frac{3}{4} \) in. \( \times \) 3\( \frac{1}{2} \) in. (19.1 mm \( \times \) 88.9 mm) for 12 in. pipe

10.8.3.1.4.3 Steel washers shall have the following dimensions:

(1) \( \frac{1}{2} \) in. \( \times \) 3 in. (12.7 mm \( \times \) 76.2 mm) for 4 in., 6 in., 8 in., and 10 in. pipe

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10.8.3.1.4.4 The diameter of holes shall be $\frac{1}{8}$ in. (3.2 mm) larger than that of rods.

### 10.8.3.2 Sizes of Restraint Straps for Tees.

10.8.3.2.1 Restraint straps for tees shall have the following dimensions:

1. $\frac{7}{8}$ in. (15.9 mm) thick and 2½ in. (63.5 mm) wide for 4 in., 6 in., 8 in., and 10 in. pipe
2. $\frac{5}{8}$ in. (15.9 mm) thick and 3 in. (76.2 mm) wide for 12 in. pipe

10.8.3.2.2 The diameter of rod holes shall be $\frac{1}{16}$ in. (1.6 mm) larger than that of rods.

10.8.3.2.3 Figure 10.8.3.2.3 and Table 10.8.3.2.3 shall be used in sizing the restraint straps for both mechanical and push-on joint tee fittings.

![Figure 10.8.3.2.3 Restraint Straps for Tees.](image)

### Table 10.8.3.2.3 Restraint Straps for Tees

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>12½</td>
<td>10½</td>
<td>2½</td>
</tr>
<tr>
<td>6</td>
<td>14½</td>
<td>12½</td>
<td>3½</td>
</tr>
<tr>
<td>8</td>
<td>16½</td>
<td>14½</td>
<td>4½</td>
</tr>
<tr>
<td>10</td>
<td>19½</td>
<td>16½</td>
<td>5½</td>
</tr>
<tr>
<td>12</td>
<td>22½</td>
<td>19½</td>
<td>6½</td>
</tr>
</tbody>
</table>

10.8.3.3 Sizes of Plug Strap for Bell End of Pipe.

10.8.3.3.1 The strap shall be $\frac{3}{4}$ in. (19.1 mm) thick and 2½ in. (63.5 mm) wide.

10.8.3.3.2 The strap length shall be the same as dimension A for tee straps as shown in Figure 10.8.3.2.3.

10.8.3.3.3 The distance between the centers of rod holes shall be the same as dimension B for tee straps as shown in Figure 10.8.3.2.3.

10.8.3.4 Material. Clamps, rods, rod couplings or turnbuckles, bolts, washers, restraint

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straps, and plug straps shall be of a material that has physical and chemical characteristics that indicate its deterioration under stress can be predicted with reliability.

10.8.3.5* Corrosion Resistance. After installation, rods, nuts, bolts, washers, clamps, and other restraining devices shall be cleaned and thoroughly coated with a bituminous or other acceptable corrosion-retarding material.

10.9 Backfilling.

10.9.1 Backfill shall be tamped in layers or puddled under and around pipes to prevent settlement or lateral movement and shall contain no ashes, cinders, refuse, organic matter, or other corrosive materials.

10.9.2 Rocks shall not be placed in trenches.

10.9.3 Frozen earth shall not be used for backfilling.

10.9.4 In trenches cut through rock, tamped backfill shall be used for at least 6 in. (150 mm) under and around the pipe and for at least 2 ft (0.6 m) above the pipe.

10.10 Testing and Acceptance.

10.10.1 Approval of Underground Piping. The installing contractor shall be responsible for the following:

1. Notifying the authority having jurisdiction and the owner's representative of the time and date testing is to be performed

2. Performing all required acceptance tests

3. Completing and signing the contractor's material and test certificate(s) shown in Figure 10.10.1.
# Contractor's Material and Test Certificate for Underground Piping

## Procedure

Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractors. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.

<table>
<thead>
<tr>
<th>Property name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Plans

Accepted by approving authorities (names)

<table>
<thead>
<tr>
<th>Address</th>
<th>Installation conforms to accepted plans</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment used is approved</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>If no, state deviations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Instructions

Has person in charge of the equipment been instructed as to location of control valves and care and maintenance of this new equipment? If no, explain.

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

Have copies of appropriate instructions and care and maintenance charts been left on premises? If no, explain.

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

## Location

Supplies buildings

## Underground pipes and joints

<table>
<thead>
<tr>
<th>Pipe conforming to standard</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fittings conform to standard</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Joints needing anchorage clamped, strapped, or blocked in accordance with standard instructions.

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

## Test description

**Flushing:** Flow the required rate until water is clear as indicated by no collection of foreign material in burr bags at cutouts such as hydrants and blow-offs. Flush at flow not less than 590 gpm (1476 L/min) for 4 in. pipe, 880 gpm (2331 L/min) for 6 in. pipe, 1560 gpm (3392 L/min) for 8 in. pipe, 2440 gpm (6952 L/min) for 10 in. pipe, and 3820 gpm (10328 L/min) for 12 in. pipe. When supply cannot produce stipulated flow rates, obtain maximum available.

**Hydrostatic:** All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bar) or 50 psi (3.4 bar) in excess of the system working pressure, whichever is greater, and shall maintain that pressure ± 5 psi for 2 hours.

**Hydrostatic Testing Allowance:** Where additional water is added to the system to maintain the test pressures required by 10.10.2.2.1, the amount of water shall be measured and shall not exceed the limits of the following equation (For metric system, see 10.10.2.2.4):

\[
L = \frac{SD}{D} - P
\]

where:
- \( L \) = testing allowance (makeup water), in gallons per hour
- \( S \) = length of pipe tested, in feet
- \( D \) = nominal diameter of the pipe, in inches
- \( P \) = average test pressure during the hydrostatic test, in pounds per square inch (gauge)

**New underground piping flushed according to standard by (company):**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

If no, explain

**How flushing flow was obtained**

- Public water
- Tank or reservoir
- Fire pump
- Hydrant butt
- Open pipe

**Lead-ins flushed according to standard by (company):**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

If no, explain

**How flushing flow was obtained**

- Public water
- Tank or reservoir
- Fire pump
- Y connection to flange
- Open pipe

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FIGURE 10.10.1 Sample of Contractor's Material and Test Certificate for Underground Piping.
<table>
<thead>
<tr>
<th><strong>Hydrostatic test</strong></th>
<th>All new underground piping hydrostatically tested at</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>______________________ ps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Leakage test</strong></th>
<th>Total amount of leakage measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>______________________ gallons</td>
</tr>
</tbody>
</table>

| Allowable leakage | ______________________ gallons | ____________________ hours |

<table>
<thead>
<tr>
<th><strong>Hydrants</strong></th>
<th>Number installed</th>
<th>Type and make</th>
<th>All operate satisfactorily</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>□ Yes □ No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Control valves</strong></th>
<th>Water control valves left nice open</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If no, state reason</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Hose threads of fire department connections and hydrants interchangeable with those of fire department answering alarm |
|                                                                                                          |

<table>
<thead>
<tr>
<th><strong>Remarks</strong></th>
<th>Date left in service</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Signatures</strong></th>
<th>Name of installing contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tests witnessed by</td>
</tr>
<tr>
<td></td>
<td>For property owner (signed)</td>
</tr>
<tr>
<td></td>
<td>For installing contractor (signed)</td>
</tr>
</tbody>
</table>

| **Additional explanation and notes** | |

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10.10.2 Acceptance Requirements.

10.10.2.1* Flushing of Piping.

10.10.2.1.1 Underground piping, from the water supply to the system riser, and lead-in connections to the system riser shall be completely flushed before the connection is made to downstream fire protection system piping.

10.10.2.1.2 The flushing operation shall be continued for a sufficient time to ensure thorough cleaning.

10.10.2.1.3 The minimum rate of flow shall be not less than one of the following:

(1) Hydraulically calculated water demand flow rate of the system, including any hose requirements

(2) Flow necessary to provide a velocity of 10 ft/sec (3.1 m/sec) in accordance with Table 10.10.2.1.3

(3) Maximum flow rate available to the system under fire conditions

Table 10.10.2.1.3 Flow Required to Produce a Velocity of 10 ft/sec (3 m/sec) in Pipes

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>in. mm</td>
<td>gpm L/min</td>
</tr>
<tr>
<td>4 102</td>
<td>390 1,476</td>
</tr>
<tr>
<td>6 152</td>
<td>880 3,331</td>
</tr>
<tr>
<td>8 203</td>
<td>1,560 5,905</td>
</tr>
<tr>
<td>10 254</td>
<td>2,440 9,235</td>
</tr>
<tr>
<td>12 305</td>
<td>3,520 13,323</td>
</tr>
</tbody>
</table>

10.10.2.2 Hydrostatic Test.

10.10.2.2.1* All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bar) or 50 psi (3.5 bar) in excess of the system working pressure, whichever is greater, and shall maintain that pressure at ±5 psi (0.35 bar) for 2 hours.

10.10.2.2.2 Pressure loss shall be determined by a drop in gauge pressure or visual leakage.

10.10.2.2.3 The test pressure shall be read from one of the following, located at the lowest elevation of the system or the portion of the system being tested:

(1) A gauge located at one of the hydrant outlets

(2) A gauge located at the lowest point where no hydrants are provided

10.10.2.2.4* Hydrostatic Testing Allowance. Where additional water is added to the system to maintain the test pressures required by 10.10.2.2.1, the amount of water shall be
measured and shall not exceed the limits of Table 10.10.2.2.4 which is based upon the following equation:

U.S. Customary Units:

\[
L = \frac{SD\sqrt{P}}{148,000} \quad [10.10.2.2.4(a)]
\]

where:

\(L\) = testing allowance (makeup water), in gallons per hour

\(S\) = length of pipe tested, feet

\(D\) = nominal diameter of the pipe, in inches

\(P\) = average test pressure during the hydrostatic test, in pounds per square inch (gauge)

Metric Units:

\[
L = \frac{SD\sqrt{P}}{794,797} \quad [10.10.2.2.4(b)]
\]

where:

\(L\) = testing allowance (makeup water), in liters per hour

\(S\) = length of pipe tested, meters

\(D\) = nominal diameter of the pipe, in millimeters

\(P\) = average test pressure during the hydrostatic test, in kPa

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Testing Allowance in Gallons per Hour (gph) per 100 Feet of Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.019</td>
</tr>
<tr>
<td>4</td>
<td>0.038</td>
</tr>
<tr>
<td>6</td>
<td>0.057</td>
</tr>
<tr>
<td>8</td>
<td>0.076</td>
</tr>
<tr>
<td>10</td>
<td>0.096</td>
</tr>
<tr>
<td>12</td>
<td>0.115</td>
</tr>
<tr>
<td>14</td>
<td>0.134</td>
</tr>
<tr>
<td>16</td>
<td>0.153</td>
</tr>
<tr>
<td>18</td>
<td>0.172</td>
</tr>
<tr>
<td>20</td>
<td>0.191</td>
</tr>
<tr>
<td>24</td>
<td>0.229</td>
</tr>
</tbody>
</table>

Table 10.10.2.2.4 Hydrostatic Testing Allowance at 200 psi per 100 Feet of Pipe

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Table 10.10.2.2.4  Hydrostatic Testing Allowance at 200 psi per 100 Feet of Pipe

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Testing Allowance in Gallons per Hour (gph) per 100 Feet of Pipe</th>
</tr>
</thead>
</table>

Notes:
(1) For other length, diameters, and pressures, utilize Equation 10.10.2.2.4(a) or (b) to determine the appropriate testing allowance.
(2) For test sections that contain various sizes and sections of pipe the testing allowance is the sum of the testing allowances for each size and section.

10.10.2.3 Other Means of Hydrostatic Tests. Where required by the authority having jurisdiction, hydrostatic tests shall be permitted to be completed in accordance with the requirements of AWWA C600, AWWA C602, AWWA C603, and AWWA C900.

10.10.2.4 Operating Test.
10.10.2.4.1 Each hydrant shall be fully opened and closed under system water pressure.
10.10.2.4.2 Dry barrel hydrants shall be checked for proper drainage.
10.10.2.4.3 All control valves shall be fully closed and opened under system water pressure to ensure proper operation.
10.10.2.4.4 Where fire pumps are available, the operating tests required by 10.10.2.4 shall be completed with the pumps running.

10.10.2.5 Backflow Prevention Assemblies.
10.10.2.5.1 The backflow prevention assembly shall be forward flow tested to ensure proper operation.
10.10.2.5.2 The minimum flow rate required by 10.10.2.5.1 shall be the system demand, including hose stream demand where applicable.
10.10.2.6* The trench shall be backfilled between joints before testing to prevent movement of pipe.
10.10.2.7 Where required for safety measures presented by the hazards of open trenches, the pipe and joints shall be permitted to be backfilled, provided the installing contractor takes the responsibility for locating and correcting leakage.
10.10.2.8 Provision shall be made for the proper disposal of water used for flushing or testing.

Chapter 11 Hydraulic Calculations

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11.1 Calculations in English Units.

Pipe friction losses shall be determined based on the Hazen–Williams formula, as follows:

\[ p = \frac{4.52 Q^{1.85}}{C^{1.85} d^{4.87}} \]

where:

- \( p \) = frictional resistance (psi/ft of pipe)
- \( Q \) = flow (gpm)
- \( C \) = friction loss coefficient
- \( d \) = actual internal diameter of pipe (in.)

11.2 Calculations in SI Units.

Pipe friction losses shall be determined based on the Hazen–Williams formula in SI units, as follows:

\[ p_m = 6.05 \left( \frac{Q_m^{1.85}}{C^{1.85} d_m^{4.87}} \right) 10^3 \]

where:

- \( p_m \) = frictional resistance (bar/m of pipe)
- \( Q_m \) = flow (L/min)
- \( C \) = friction loss coefficient
- \( d_m \) = actual internal diameter of pipe (mm)

---

Chapter 12 Aboveground Pipe and Fittings

12.1 General.

Aboveground pipe and fittings shall comply with the applicable sections of Chapters 6 and 8 of NFPA 13 that address pipe, fittings, joining methods, hangers, and installation.

12.2 Protection of Piping.

12.2.1 Aboveground piping for private fire service mains shall not pass through hazardous areas and shall be located so that it is protected from mechanical and fire damage.

12.2.2 Aboveground piping shall be permitted to be located in hazardous areas protected by an automatic sprinkler system.

12.2.3 Where aboveground water-filled supply pipes, risers, system risers, or feed mains pass through open areas, cold rooms, passageways, or other areas exposed to freezing temperatures, the pipe shall be protected against freezing by the following:

1. Insulating coverings

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(2) Frostproof casings
(3) Other reliable means capable of maintaining a minimum temperature between 40°F and 120°F (4°C and 48.9°C)

12.2.4 Where corrosive conditions exist or piping is exposed to the weather, corrosion-resistant types of pipe, fittings, and hangers or protective corrosion-resistant coatings shall be used.

12.2.5 To minimize or prevent pipe breakage where subject to earthquakes, aboveground pipe shall be protected in accordance with the seismic requirements of NFPA 13.

12.2.6 Mains that pass through walls, floors, and ceilings shall be provided with clearances in accordance with NFPA 13.

---

Chapter 13 Sizes of Aboveground and Buried Pipe

13.1 Private Service Mains.
Pipe smaller than 6 in. (152 mm) in diameter shall not be installed as a private service main supplying hydrants.

13.2 Mains Not Supplying Hydrants.
For mains that do not supply hydrants, sizes smaller than 6 in. (152 mm) shall be permitted to be used, subject to the following restrictions:

(1) The main shall supply only the following types of systems:
   (a) Automatic sprinkler systems
   (b) Open sprinkler systems
   (c) Water spray fixed systems
   (d) Foam systems
   (e) Class II standpipe systems

(2) Hydraulic calculations shall show that the main is able to supply the total demand at the appropriate pressure.

(3) Systems that are not hydraulically calculated shall have a main at least as large as the riser.

13.3 Mains Supplying Fire Protection Systems.
The size of private fire service mains supplying fire protection systems shall be approved by the authority having jurisdiction, and the following factors shall be considered:

(1) Construction and occupancy of the plant
(2) Fire flow and pressure of the water required

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Chapter 14 System Inspection, Testing, and Maintenance

14.1 General.

A private fire service main and its appurtenances installed in accordance with this standard shall be properly inspected, tested, and maintained in accordance with NFPA 25 to provide at least the same level of performance and protection as designed.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.11 Private Fire Service Main. See Figure A.3.3.11.
A.4.1 Underground mains should be designed so that the system can be extended with a minimum of expense. Possible future plant expansion should also be considered and the piping designed so that it is not covered by buildings.

A.5.1 If possible, dead-end mains should be avoided by arranging for mains to be supplied from both directions. Where private fire service mains are connected to dead-end public mains, each situation should be examined to determine if it is practical to request the water.

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utility to loop the mains to obtain a more reliable supply.

A.5.4 Where connections are made from public waterworks systems, such systems should be guarded against possible contamination as follows (see AWWA M14):

(1) For private fire service mains with direct connections from public waterworks mains only or with booster pumps installed in the connections from the street mains, no tanks or reservoirs, no physical connection from other water supplies, no antifreeze or other additives of any kind, and with all drains discharging to atmosphere, dry well, or other safe outlets, no backflow protection is recommended at the service connection.

(2) For private fire service mains with direct connection from the public water supply main plus one or more elevated storage tanks or fire pumps taking suction from aboveground covered reservoirs or tanks (all storage facilities are filled or connected to public water only, and the water in the tanks is to be maintained in a potable condition), an approved double check valve assembly is recommended.

(3) For private fire service mains directly supplied from public mains with an auxiliary water supply, such as a pond or river on or available to the premises and dedicated to fire department use; or for systems supplied from public mains and interconnected with auxiliary supplies, such as pumps taking suction from reservoirs exposed to contamination or rivers and ponds; driven wells, mills, or other industrial water systems; or for systems or portions of systems where antifreeze or other solutions are used, an approved reduced pressure zone-type backflow preventer is recommended.

A.5.6 A fire pump installation consisting of pump, driver, and suction supply, when of adequate capacity and reliability and properly located, makes a good supply. An automatically controlled fire pump taking water from a water main of adequate capacity, or taking draft under a head from a reliable storage of adequate capacity, shall be permitted to be, under certain conditions, accepted by the authority having jurisdiction as a single supply.

A.5.9 The fire department connection should be located not less than 18 in. (457 mm) and not more than 4 ft (1.2 m) above the level of the adjacent grade or access level. Typical fire department connections are shown in Figure A.5.9(a) and Figure A.5.9(b). Fire department connections should be located and arranged so that hose lines can be readily and conveniently attached without interference from nearby objects including buildings, fences, posts, or other fire department connections. Where a hydrant is not available, other water supply sources such as a natural body of water, a tank, or reservoir should be utilized. The water authority should be consulted when a nonpotable water supply is proposed as a suction source for the fire department.
FIGURE A.5.9(a) Typical Fire Department Connection.
Notes:
1. Various backflow prevention regulations accept different devices at the connection between public water mains and private fire service mains.
2. The device shown in the pit could be any or a combination of the following:
   (a) Gravity check valve
   (b) Detector check valve
   (c) Reduced pressure zone (RPZ) device
   (d) Vacuum breaker
   (e) Double check valve assembly
3. Some backflow prevention regulations prohibit these devices from being installed in a pit.
4. In all cases, the device(s) in the pit should be approved or listed as necessary. The requirements of the local or municipal water department should be reviewed prior to design or installation of the connection.
5. Pressure drop should be considered prior to the installation of any backflow prevention device.
A.6.2.5 See Figure A.6.2.5. For additional information on controlling valves, see NFPA 22.

A.6.2.7 For additional information on controlling valves, see NFPA 22.

A.6.2.8 For additional information on controlling valves, see NFPA 22.

A.6.2.9(1) Where located underground, check valves on tank or pump connections can be placed inside of buildings and at a safe distance from the tank riser or pump, except in cases where the building is entirely of one fire area. Where the building is one fire area, it is ordinarily considered satisfactory to locate the check valve overhead in the lowest level.

A.6.2.10 It might be necessary to provide valves located in pits with an indicator post extending above grade or other means so that the valve can be operated without entering the pit.

A.6.3.1 Outside control valves are recommended in the following order of preference:

(1) Listed indicating valves at each connection into the building at least 40 ft (12.2 m) from buildings if space allows

(2) Control valves installed in a cut-off stair tower or valve room accessible from outside

(3) Valves located in risers with indicating posts arranged for outside operation

(4) Key-operated valves in each connection into the building

A.6.3.2 Usually, in crowded plant yards, indicator valves can be placed beside low buildings, near brick stair towers, or at angles formed by substantial brick walls that are not likely to fall.

A.6.4.3 A valve wrench with a long handle should be provided at a convenient location on the premises.

A.6.6.2 See Annex B.

A.7.1.2 All barrels should be white except in cases where another color has already been adopted. The tops and nozzle caps should be painted with the following capacity-indicating color scheme to provide simplicity and consistency with colors used in signal work for safety, danger, and intermediate condition:

Copyright NFPA
(1) Class AA — light blue
(2) Class A — green
(3) Class B — yellow
(4) Class C — red

For rapid identification at night, it is recommended that the capacity colors be of a reflectivetype paint.

Hydrants rated at less than 20 psi (1.4 bar) should have the rated pressure stenciled in black on the hydrant top.

In addition to the painted top and nozzle caps, it can be advantageous to stencil the rated capacity of high-volume hydrants on the top.

The classification and marking of hydrants provided for in Chapter 5 anticipate determination based on an individual flow test. Where a group of hydrants can be used during a fire, some special marking designating group-flow capacity can be desirable.

A.7.1.4 Location markers for flush hydrants should carry the same color background as specified in A.7.1.2 for class indication, with other such data stenciled thereon as deemed necessary.

Marking on private hydrants within private enclosures is to be done at the owner's discretion.

When private hydrants are located on public streets, they should be painted red, or another color, to distinguish them from public hydrants.

A.7.2.1 Fire department pumpers will normally be required to augment the pressure available from public hydrants.

A.7.2.3 Where wall hydrants are used, the authority having jurisdiction should be consulted regarding the necessary water supply and arrangement of control valves at the point of supply in each individual case. (See Figure A.7.2.3.)
A.7.2.3 See Figure A.7.2.3(a) and Figure A.7.2.3(b).

A.7.3.1 See Figure A.7.3.1(a) and Figure A.7.3.1(b).

Copyright NFPA
Requirement.

A.7.3.3 When setting hydrants, due regard should be given to the final grade line.

A.8.1.1 All hose should not be removed from a hose house for testing at the same time, since the time taken to return the hose in case of fire could allow a fire to spread beyond control. (See NFPA 1962.)

A.8.1.3 Where hose will be subjected to acids, acid fumes, or other corrosive materials, as in chemical plants, the purchase of approved rubber-covered, rubber-lined hose is advised. For hose used in plant yards containing rough surfaces that cause heavy wear or used where working pressures are above 150 psi (10.3 bar), double-jacketed hose should be considered.

A.8.4 Typical hose houses are shown in Figure A.8.4(a) through Figure A.8.4(c).

FIGURE A.8.4(a) House of Five-Sided Design for Installation over a Private Hydrant.
FIGURE A.8.4(b) Closed Steel House of Compact Dimensions for Installation over a Private Hydrant, in Which Top Lifts Up and Doors on Front Side Open for Complete Accessibility.

FIGURE A.8.4(c) Hose House That Can Be Installed on Legs, as Shown, or Installed on a Wall near, But Not Directly over, a Private Hydrant.

A.8.6.1 All hose should not be removed from a hose house for testing at the same time, since the time taken to return the hose in case of fire could allow a fire to spread beyond control. (See NFPA 1962.)

A.9.1 For typical master stream devices, see Figure A.9.1(a) and Figure A.9.1(b). Gear control nozzles are acceptable for use as monitor nozzles.

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A.10.1 The term *underground* is intended to mean direct buried piping. For example, piping installed in trenches and tunnels but exposed should be treated as aboveground piping. Loop systems for yard piping are recommended for increased reliability and improved hydraulics. Loop systems should be sectionalized by placing valves at branches and at strategic locations to minimize the extent of impairments.

A.10.1.1 Copper tubing (Type K) with brazed joints conforming to Table 10.1.1 and Table 10.2.1(a) is acceptable for underground service. Listing and labeling information, along with applicable publications for reference, is as follows:

1. **Listing and Labeling.** Testing laboratories list or label the following:
   
   (a) Cast-iron and ductile iron pipe (cement-lined and unlined, coated and uncoated)
   
   (b) Asbestos-cement pipe and couplings
   
   (c) Steel pipe

Copyright NFPA
Pipe Standards. The various types of pipe are usually manufactured to one of the following standards:

(a) ASTM C296, Standard Specification for Asbestos-Cement Pressure Pipe
(b) AWWA C151, Ductile Iron Pipe, Centrifugally Cast for Water
(c) AWWA C300, Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
(d) AWWA C301, Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
(e) AWWA C302, Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids
(f) AWWA C303, Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids
(g) AWWA C400, Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water and Other Liquids
(h) AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water and Other Liquids

A.10.1.4 The following pipe design manuals can be used as guides:

(1) AWWA C150, Thickness Design of Ductile Iron Pipe
(2) AWWA C401, Standard Practice for the Selection of Asbestos-Cement Water Pipe
(3) AWWA M41, Ductile Iron Pipe and Fittings
(4) Concrete Pipe Handbook, American Concrete Pipe Association

A.10.1.6 The following standards apply to the application of coating and linings:

(1) AWWA C104, Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water
(2) AWWA C105, Polyethylene Encasement for Ductile Iron Pipe Systems
(3) AWWA C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape — Hot Applied
(4) AWWA C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 in. and Larger — Shop Applied
(5) AWWA C602, *Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place*


For internal diameters of cement-lined ductile iron pipe, see Table A.10.1.6.

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<td>0.38</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table A.10.1.6 ID for Cement-Lined Ductile Iron Pipe

<table>
<thead>
<tr>
<th>Pipe Size (in.)</th>
<th>OD (in.)</th>
<th>Pressure Class</th>
<th>Thickness Class</th>
<th>Wall Thickness</th>
<th>Minimum Lining Thickness*</th>
<th>wi</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>21.60</td>
<td>50</td>
<td>0.36</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>21.60</td>
<td>51</td>
<td>0.39</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>21.60</td>
<td>52</td>
<td>0.42</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
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<td>53</td>
<td>0.45</td>
<td>3/32</td>
<td></td>
<td></td>
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<td>20</td>
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<td>0.48</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>21.60</td>
<td>55</td>
<td>0.51</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>21.60</td>
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<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
<td>200</td>
<td>0.33</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
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<td>3/32</td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td></td>
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<tr>
<td>24</td>
<td>25.80</td>
<td>350</td>
<td>0.43</td>
<td>3/32</td>
<td></td>
<td></td>
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<tr>
<td>24</td>
<td>25.80</td>
<td>50</td>
<td>0.38</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
<td>51</td>
<td>0.41</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
<td>52</td>
<td>0.44</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>25.80</td>
<td>53</td>
<td>0.47</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
<td>54</td>
<td>0.50</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
<td>55</td>
<td>0.53</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>25.80</td>
<td>56</td>
<td>0.56</td>
<td>3/32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: This table is appropriate for single lining thickness only. The actual lining thickness should be obtained from the manufacturer.

A.10.2.4 The following standards apply to joints used with the various types of pipe:

1. ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings*
2. AWWA C111, *Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings*
3. AWWA C115, *Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges*
4. AWWA C206, *Field Welding of Steel Water Pipe*
5. AWWA C606, *Grooved and Shouldered Joints*

A.10.2.5 Fittings generally used are cast iron with joints made to the specifications of the manufacturer of the particular type of pipe (*see the standards listed in A.10.2.4*). Steel fittings also have some applications. The following standards apply to fittings:

1. ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings*
2. AWWA C110, *Ductile Iron and Gray Iron Fittings, 3-in. Through 48-in., for Water and Other Liquids*
3. AWWA C153, *Ductile Iron Compact Fittings, 3 in. through 24 in. and 54 in. through 64 in. for Water Service*

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The following documents apply to the installation of pipe and fittings:

1. AWWA C603, Standard for the Installation of Asbestos-Cement Water Pipe
2. AWWA C600, Standard for the Installation of Ductile-Iron Water Mains and Their Appurtenances
3. AWWA M11, A Guide for Steel Pipe Design and Installation
4. AWWA M41, Ductile Iron Pipe and Fittings
5. Concrete Pipe Handbook, American Concrete Pipe Association
6. Handbook of PVC Pipe, Uni-Bell PVC Pipe Association

As there is normally no circulation of water in private fire mains, they require greater depth of covering than do public mains. Greater depth is required in a loose gravelly soil (or in rock) than in compact soil containing large quantities of clay. The recommended depth of cover above the top of underground yard mains is shown in Figure A.10.4.1.
A.10.5.1 In determining the need to protect aboveground piping from freezing, the lowest mean temperature should be considered, as shown in Figure A.10.5.1.
FIGURE A.10.5.1 Isothermal Lines — Lowest One-Day Mean Temperature (°F).

A.10.6.7 Gray cast iron is not considered galvanically dissimilar to ductile iron. Rubber gasket joints (unrestrained push-on or mechanical joints) are not considered connected electrically. Metal thickness should not be considered a protection against corrosive environments. In the case of cast-iron or ductile iron pipe for soil evaluation and external protection systems, see Appendix A of AWWA C105.

A.10.6.8 Where lightning protection is provided for a structure, NFPA 780, 4.14 requires that all grounding media including underground metallic piping systems be interconnected to provide a common ground potential. These underground piping systems are not permitted to be substituted for grounding electrodes but must be bonded to the lightning protection grounding system. Where galvanic corrosion is of concern, this bond may be made via a spark gap or gas discharge tube.
A.10.8.1.1 It is a fundamental design principle of fluid mechanics that dynamic and static pressures, acting at changes in size or direction of a pipe, produce unbalanced thrust forces at locations such as bends, tees, wyes, dead ends, and reducer offsets. This design principle includes consideration of lateral soil pressure and pipe/soil friction, variables that can be reliably determined using current soil engineering knowledge. Refer to A.10.8.3 for a list of references for use in calculating and determining joint restraint systems.

Except for the case of welded joints and approved special restrained joints, such as is provided by approved mechanical joint retainer glands or locked mechanical and push-on joints, the usual joints for underground pipe are expected to be held in place by the soil in which the pipe is buried. Gasketed push-on and mechanical joints without special locking devices have limited ability to resist separation due to movement of the pipe.

A.10.8.2 Thrust Blocks. Concrete thrust blocks are one of the methods of restraint now in use, provided that stable soil conditions prevail and space requirements permit placement. Successful blocking is dependent upon factors such as location, availability and placement of concrete, and possibility of disturbance by future excavations.

Resistance is provided by transferring the thrust force to the soil through the larger bearing area of the block such that the resultant pressure against the soil does not exceed the horizontal bearing strength of the soil. The design of thrust blocks consists of determining the appropriate bearing area of the block for a particular set of conditions. The parameters involved in the design include pipe size, design pressure, angle of the bend (or configuration of the fitting involved), and the horizontal bearing strength of the soil.

Table A.10.8.2(a) gives the nominal thrust at fittings for various sizes of ductile iron and PVC piping. Figure A.10.8.2(a) shows an example of how thrust forces act on a piping bend.

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Total Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dead End</td>
</tr>
<tr>
<td>4</td>
<td>1,810</td>
</tr>
<tr>
<td>6</td>
<td>3,739</td>
</tr>
<tr>
<td>8</td>
<td>6,433</td>
</tr>
<tr>
<td>10</td>
<td>9,677</td>
</tr>
<tr>
<td>12</td>
<td>13,685</td>
</tr>
<tr>
<td>14</td>
<td>18,385</td>
</tr>
<tr>
<td>16</td>
<td>23,779</td>
</tr>
<tr>
<td>18</td>
<td>29,865</td>
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<tr>
<td>20</td>
<td>36,644</td>
</tr>
<tr>
<td>24</td>
<td>52,279</td>
</tr>
<tr>
<td>30</td>
<td>80,425</td>
</tr>
<tr>
<td>36</td>
<td>115,209</td>
</tr>
<tr>
<td>42</td>
<td>155,528</td>
</tr>
<tr>
<td>48</td>
<td>202,683</td>
</tr>
</tbody>
</table>

Table A.10.8.2(a) Thrust at Fittings at 100 psi (6.9 bar) Water Pressure for Ductile Iron and PVC Pipe
Table A.10.8.2(a)  Thrust at Fittings at 100 psi (6.9 bar) Water Pressure for Ductile Iron and PVC Pipe

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Total Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dead End</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Notes:</td>
<td></td>
</tr>
<tr>
<td>(1) For SI units, 1 lb = 0.454 kg.</td>
<td></td>
</tr>
<tr>
<td>(2) To determine thrust at pressure other than 100 psi (6.9 bar), multiply the thrust obtained in the table by the ratio of the pressure to 100 psi (6.9 bar). For example, the thrust on a 12 in., 90 degree bend at 125 psi (8.6 bar) is 19,353 × 125/100 = 24,191 lb.</td>
<td></td>
</tr>
</tbody>
</table>

Table A.10.8.2(b)  Horizontal Bearing Strengths

<table>
<thead>
<tr>
<th>Soil</th>
<th>Bearing Strength ($S_b$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/ft²</td>
</tr>
<tr>
<td>Muck</td>
<td>0</td>
</tr>
<tr>
<td>Soft clay</td>
<td>1000</td>
</tr>
<tr>
<td>Silt</td>
<td>1500</td>
</tr>
<tr>
<td>Sandy silt</td>
<td>3000</td>
</tr>
<tr>
<td>Sand</td>
<td>4000</td>
</tr>
<tr>
<td>Sand clay</td>
<td>6000</td>
</tr>
<tr>
<td>Hard clay</td>
<td>9000</td>
</tr>
</tbody>
</table>

Note: Although the bearing strength values in this table have been used successfully in the design of thrust blocks and are considered to be conservative, their accuracy is totally dependent on accurate soil identification and evaluation. The ultimate responsibility for selecting the proper bearing strength of a particular soil type must rest with the design engineer.
FIGURE A.10.8.2(a) Thrust Forces Acting on a Bend.

\[ T_x = PA (1 - \cos \theta) \]

\[ T_y = PA \sin \theta \]

\[ T = 2PA \sin \frac{\theta}{2} \]

\[ \Delta = \left( 90 - \theta \right) \]

\[ A = 36\pi(D')^2 \]

\[ D' = \text{Outside diameter of pipe (ft)} \]

\[ P = \text{Water pressure (psi)} \]

\[ A = \text{Cross-sectional area of the pipe based on outside diameter (in.}^2) \]

\[ V = \text{Velocity in direction of flow} \]
Thrust blocks are generally categorized into two groups — bearing and gravity blocks. Figure A.10.8.2(b) depicts a typical bearing thrust block on a horizontal bend.

The following are general criteria for bearing block design:

\[ T = \text{thrust force resulting from the change in direction of flow} \]
\[ S_b = \text{horizontal bearing strength of the soil} \]
\[ h = \text{block height} \]
\[ H_t = \text{total depth to bottom of block} \]
The bearing surface should, where possible, be placed against undisturbed soil.

Where it is not possible to place the bearing surface against undisturbed soil, the fill between the bearing surface and undisturbed soil must be compacted to at least 90 percent Standard Proctor density.

Block height \((h)\) should be equal to or less than one-half the total depth to the bottom of the block \((H_t)\) but not less than the pipe diameter \((D)\).

Block height \((h)\) should be chosen such that the calculated block width \((b)\) varies between one and two times the height.

Gravity thrust blocks can be used to resist thrust at vertical down bends. In a gravity thrust block, the weight of the block is the force providing equilibrium with the thrust force. The design problem is then to calculate the required volume of the thrust block of a known density. The vertical component of the thrust force in Figure A.10.8.2(c) is balanced by the weight of the block. For required horizontal bearing block areas, see Table A.10.8.2(c).

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Bearing Block Area (ft²)</th>
<th>Nominal Pipe Diameter (in.)</th>
<th>Bearing Block Area (ft²)</th>
<th>Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.6</td>
<td>12</td>
<td>29.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.8</td>
<td>14</td>
<td>39.0</td>
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<td>6</td>
<td>7.9</td>
<td>16</td>
<td>50.4</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>13.6</td>
<td>18</td>
<td>63.3</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>20.5</td>
<td>20</td>
<td>77.7</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
(1) Although the bearing strength values in this table have been used successfully in the design of thrust block: conservative, their accuracy is totally dependent on accurate soil identification and evaluation. The ultimate re bearing strength of a particular soil type must rest with the design engineer.
(2) Values listed are based on a 90 degree horizontal bend, an internal pressure of 100 psi, a soil horizontal bearing strength of 1,000 lb/ft², and ductile-iron pipe outside diameters.
(a) For other horizontal bends, multiply by the following coefficients: 45 degree: 0.414; 22½ degree: 0.199; 11 degree: 0.098.
(b) For other internal pressures, multiply by ratio to 100 psi.
(c) For other soil horizontal bearing strengths, divide by ratio to 1,000 lb/ft².
(d) For other safety factors, multiply by ratio to 1.5.

Example: Using Table A.10.8.2(c), find the horizontal bearing block area for a 6 in. diameter, 45 degree bend with an internal pressure of 150 psi.
The soil bearing strength is 3,000 lb/ft², and the safety factor is 1.5.
From Table A.10.8.2(c), the required bearing block area for a 6 in. diameter, 90 degree bend with an internal horizontal bearing strength of 1,000 psi is 7.9 ft².
For our problem:

\[
\text{Area} = \frac{7.9\text{ ft}^2 \left(0.414\right) \frac{150}{100}}{\frac{3,000}{1,000}} = 1.64\text{ ft}^2
\]
The required block area \( (A_b) \) is as follows:

\[
A_b = (h)(b) = \frac{T(S_f)}{S_b}
\]

where:

\( A_b \) = required block area (ft\(^2\))
\( h \) = block height (ft)
\( b \) = calculated block width (ft)
\( T \) = thrust force (lbf)
\( S_f \) = safety factor (usually 1.5)
\( S_b \) = bearing strength (lb/ft\(^2\))

Then, for a horizontal bend, the following formula is used:

\[
b = \frac{2(S_f)(P)(A)\sin \left(\frac{\theta}{2}\right)}{(h)(S_b)}
\]

where:

\( b \) = calculated block width (ft)
\( S_f \) = safety factor (usually 1.5 for thrust block design)
\( P \) = water pressure (lb/in.\(^2\))
\( A \) = cross-sectional area of the pipe based on outside diameter
\( h \) = block height (ft)
\( S_h \) = horizontal bearing strength of the soil (lb/ft\(^2\)(in.\(^2\))

A similar approach can be used to design bearing blocks to resist the thrust forces at locations such as tees and dead ends. Typical values for conservative horizontal bearing strengths of various soil types are listed in Table A.10.8.2(b).

In lieu of the values for soil bearing strength shown in Table A.10.8.2(b), a designer might choose to use calculated Rankine passive pressure \( (P_p) \) or other determination of soil bearing strength based on actual soil properties.

It can be easily shown that \( T_y = PA \sin \theta \). The required volume of the block is as follows:

\[
V_b = \frac{S_f PA \sin \theta}{W_m}
\]

where:

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\[ V_g = \text{block volume (ft}^3) \]
\[ S_f = \text{safety factor} \]
\[ P = \text{water pressure (psi)} \]
\[ A = \text{cross-sectional area of the pipe interior} \]
\[ W_m = \text{density of the block material (lb/ft}^3) \]

In a case such as the one shown, the horizontal component of thrust force is calculated as follows:

\[ T_x = PA (1 - \cos \theta) \]

where:
\[ T_x = \text{horizontal component of the thrust force} \]
\[ P = \text{water pressure (psi)} \]
\[ A = \text{cross-sectional area of the pipe interior} \]

The horizontal component of thrust force must be resisted by the bearing of the right side of the block against the soil. Analysis of this aspect follows the same principles as the previous section on bearing blocks.

A.10.8.3 Restrained Joint Systems. A method for providing thrust restraint is the use of restrained joints. A restrained joint is a special type of joint that is designed to provide longitudinal restraint. Restrained joint systems function in a manner similar to that of thrust blocks, insofar as the reaction of the entire restrained unit of piping with the soil balances the thrust forces.

The objective in designing a restrained joint thrust restraint system is to determine the length of pipe that must be restrained on each side of the focus of the thrust force. This will be a function of the pipe size, the internal pressure, the depth of cover, and the characteristics of the solid surrounding the pipe.

The following documents apply to the design, calculation, and determination of restrained joint systems:

(2) AWWA M41, *Ductile Iron Pipe and Fittings*
(3) AWWA M9, *Concrete Pressure Pipe*
(4) AWWA M11, *Steel Pipe — A Guide for Design and Installation*

Figure A.10.8.3 shows an example of a typical connection to a fire protection system riser utilizing restrained joint pipe.
A.10.8.3.5 Examples of materials and the standards covering these materials are as follows:

1. Clamps, steel (see discussion on steel in the following paragraph)
2. Rods, steel (see discussion on steel in the following paragraph)
3. Bolts, steel (ASTM A 307)
4. Washers, steel (see discussion on steel in the following paragraph); cast iron (Class A cast iron as defined by ASTM A 126)
5. Anchor straps and plug straps, steel (see discussion on steel in the following paragraph)
6. Rod couplings or turnbuckles, malleable iron (ASTM A 197)

Steel of modified range merchant quality as defined in U.S. Federal Standard No. 66C, April 18, 1967, change notice No. 2, April 16, 1970, as promulgated by the U.S. Federal Government General Services Administration.

The materials specified in A.10.8.3.5(1) through (6) do not preclude the use of other materials that also satisfy the requirements of this section.

A.10.10.2.1 Underground mains and lead-in connections to system risers should be flushed through hydrants at dead ends of the system or through accessible aboveground flushing outlets allowing the water to run until clear. Figure A.10.10.2.1 shows acceptable examples of flushing the system. If water is supplied from more than one source or from a looped system, divisional valves should be closed to produce a high-velocity flow through each single line. The flows specified in Table 10.10.2.1.3 will produce a velocity of at least 10 ft/sec (3 m/sec), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.
A.10.10.2.2.1 A sprinkler system has for its water supply a connection to a public water service main. A 100 psi (6.9 bar) rated pump is installed in the connection. With a maximum normal public water supply of 70 psi (4.8 bar) at the low elevation point of the individual system or portion of the system being tested and a 120 psi (8.3 bar) pump (churn) pressure, the hydrostatic test pressure is 70 psi + 120 psi + 50 psi or 240 psi (16.5 bar).

To reduce the possibility of serious water damage in case of a break, pressure can be maintained by a small pump, the main controlling gate meanwhile being kept shut during the test.

Polybutylene pipe will undergo expansion during initial pressurization. In this case, a reduction in gauge pressure might not necessarily indicate a leak. The pressure reduction should not exceed the manufacturer's specifications and listing criteria.

When systems having rigid thermoplastic piping such as CPVC are pressure tested, the sprinkler system should be filled with water. The air should be bled from the highest and
farthest sprinklers. Compressed air or compressed gas should never be used to test systems with rigid thermoplastic pipe.

A recommended test procedure is as follows: The water pressure is to be increased in 50 psi (3.4 bar) increments until the test pressure described in 10.10.2.2.1 is attained. After each increase in pressure, observations are to be made of the stability of the joints. These observations are to include such items as protrusion or extrusion of the gasket, leakage, or other factors likely to affect the continued use of a pipe in service. During the test, the pressure is not to be increased by the next increment until the joint has become stable. This applies particularly to movement of the gasket. After the pressure has been increased to the required maximum value and held for 1 hour, the pressure is to be decreased to 0 psi while observations are made for leakage. The pressure is again to be slowly increased to the value specified in 10.10.2.2.1 and held for 1 more hour while observations are made for leakage and the leakage measurement is made.

A.10.10.2.2.4 One acceptable means of completing this test is to utilize a pressure pump that draws its water supply from a full container. At the completion of the 2 hour test, the amount of water to refill the container can be measured to determine the amount of makeup water. In order to minimize pressure loss, the piping should be flushed to remove any trapped air. Additionally, the piping should be pressurized for 1 day prior to the hydrostatic test to account for expansion, absorption, entrapped air, and so on.

The use of a blind flange or skillet is preferred for use when hydrostatically testing segments of new work. Metal-seated valves are susceptible to developing slight imperfections during transport, installation, and operation and thus can be likely to leak more than 1 fl oz (30 ml) per inch of valve diameter per hour. For this reason, the blind flange should be used when hydrostatically testing.

A.10.10.2.6 Hydrostatic tests should be made before the joints are covered so that any leaks can be readily detected. Thrust blocks should be sufficiently hardened before hydrostatic testing is begun. If the joints are covered with backfill prior to testing, the contractor remains responsible for locating and correcting any leakage in excess of that permitted.

A.11.1 When calculating the actual inside diameter of cement-mortar lined pipe, twice the thickness of the pipe wall and twice the thickness of the lining needs to be subtracted from the outside diameter of the pipe. The actual lining thickness should be obtained from the manufacturer.

Table A.11.1(a) and Table A.11.1(b) indicate the minimum lining thickness.

<table>
<thead>
<tr>
<th>Pipe and Fitting Size</th>
<th>Thickness of Lining</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>3–12</td>
<td>76–305</td>
</tr>
<tr>
<td>14–24</td>
<td>356–610</td>
</tr>
</tbody>
</table>

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### Table A.11.1(a) Table for Minimum Thickness of Lining for Ductile-Iron Pipe and Fittings

<table>
<thead>
<tr>
<th>Pipe and Fitting Size</th>
<th>Thickness of Lining</th>
</tr>
</thead>
<tbody>
<tr>
<td>in. mm</td>
<td>in. mm</td>
</tr>
<tr>
<td>30–64 762–1600</td>
<td>$\frac{1}{8}$ 3.2</td>
</tr>
</tbody>
</table>

*Source: AWWA C104.*

### Table A.11.1(b) Table for Minimum Thickness of Lining for Steel Pipe

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Thickness of Lining</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>in. mm</td>
<td>in. mm</td>
<td>in. mm</td>
</tr>
<tr>
<td>4–10 100–250</td>
<td>$\frac{1}{4}$ 6</td>
<td>$-\frac{3}{16}, +\frac{1}{8}$ -1.6, +3.2</td>
</tr>
<tr>
<td>11–23 280–580</td>
<td>$\frac{3}{8}$ 8</td>
<td>$-\frac{3}{16}, +\frac{1}{8}$ -1.6, +3.2</td>
</tr>
<tr>
<td>24–36 600–900</td>
<td>$\frac{3}{4}$ 10</td>
<td>$-\frac{3}{16}, +\frac{3}{16}$ -1.6, +4.8</td>
</tr>
<tr>
<td>&gt;36 &gt;900</td>
<td>$\frac{1}{2}$ 13</td>
<td>$-\frac{3}{16}, +\frac{3}{16}$ -1.6, +4.8</td>
</tr>
</tbody>
</table>

*Source: AWWA C205.*

---

**Annex B Valve Supervision Issues**

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

#### B.1 Responsibility.

The management is responsible for the supervision of valves controlling the water supply for fire protection and should exert every effort to see that the valves are maintained in the normally open position. This effort includes special precautions to ensure that protection is promptly restored by completely opening valves that are necessarily closed during repairs or alterations. The precautions apply equally to the following:

1. Valves controlling sprinklers and other fixed water-based fire suppression systems
2. Hydrants
3. Tanks
4. Standpipes
5. Pumps
6. Street connections
7. Sectional valves

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Central station supervisory service systems or proprietary supervisory service systems, or a combination of these methods of valve supervision, as described in the following paragraphs, are considered essential to ensure that the valves controlling fire protection systems are in the normally open position. The methods described are intended as an aid to the person responsible for developing a systematic method of determining that the valves controlling sprinkler systems and other fire protection devices are open.

Continual vigilance is necessary if valves are to be kept in the open position. Responsible day and night employees should be familiar with the location of all valves and their proper use.

The authority having jurisdiction should be consulted as to the type of valve supervision required. Contracts for equipment should specify that all details are to be subject to the approval of the authority having jurisdiction.

**B.2 Central Station Supervisory Service Systems.**

Central station supervisory service systems involve complete, constant, and automatic supervision of valves by electrically operated devices and circuits. The devices and circuits are continually under test and operate through an approved outside central station in compliance with NFPA 72. It is understood that only the portions of NFPA 72 that relate to valve supervision should apply.

**B.3 Proprietary Supervisory Service Systems.**

Proprietary supervisory service systems include systems in which the operation of a valve produces some form of signal and record at a common point by electrically operated devices and circuits. The device and circuits are continually under test and operate through a central supervising station at the protected property in compliance with the standards for the installation, maintenance, and use of local protective, auxiliary protective, remote-station protective, and proprietary signaling systems. It is understood that only the portions of the standards that relate to valve supervision should apply.

**B.4 Locking and Sealing.**

The standard method of locking, sealing, and tagging valves to prevent, as far as possible, their unnecessary closing, to obtain notification of such closing, and to aid in restoring the valve to normal condition is a satisfactory alternative to valve supervision. The authority having jurisdiction should be consulted for details for specific cases.

Where electrical supervision is not provided, locks or seals should be provided on all valves and should be of a type acceptable to the authority having jurisdiction.

Seals can be marked to indicate the organization under whose jurisdiction the sealing is conducted. All seals should be attached to the valve in such a manner that the valves cannot be operated without breaking the seals. Seals should be of a character that prevents injury in handling and that prevents reassembly when broken. Where seals are used, valves should be inspected weekly. The authority having jurisdiction can require a valve tag to be used in conjunction with the sealing.

A padlock, with a chain where necessary, is especially desirable to prevent unauthorized access.
closing of valves in areas where valves are subject to tampering. Where such locks are employed, valves should be inspected monthly.

If valves are locked, any distribution of keys should be restricted to only those directly responsible for the fire protection system. Multiple valves should not be locked together; they should be individually locked.

The individual performing inspections should determine that each valve is in the normal position and properly locked or sealed, and so noted on an appropriate record form while still at the valve. The authority having jurisdiction should be consulted for assistance in preparing a suitable report form for this activity.

Identification signs should be provided at each valve to indicate its function and what it controls.

The position of the spindle of OS&Y valves or the target on the indicator valves cannot be accepted as conclusive proof that the valve is fully open. The opening of the valve should be followed by a test to determine that the operating parts have functioned properly.

The test consists of opening the main drain valve and allowing a free flow of water until the gauge reading becomes stationary. If the pressure drop is excessive for the water supply involved, the cause should be determined immediately and the proper remedies taken. Where sectional valves or other special conditions are encountered, other methods of testing should be used.

If it becomes necessary to break a seal for emergency reasons, the valve, following the emergency, should be opened by the individual responsible for the fire protection of the plant or his or her designated representative. The responsible individual should apply a seal at the time of the valve opening. The seal should be maintained in place until such time as the authority having jurisdiction can replace it with a seal of its own.

Seals or locks should not be applied to valves that have been reopened after closure until such time as the inspection procedure is carried out.

Where water is shut off to the sprinkler or other fixed water-based fire suppression systems, a guard or other qualified person should be placed on duty and required to continuously patrol the affected sections of the premises until such time as protection is restored.

During specific critical situations, a responsible individual should be stationed at the valve so that the valve can be reopened promptly if necessary. It is the intent of this recommendation that the individual remain within sight of the valve and have no additional duties. This recommendation is considered imperative when fire protection is shut off immediately following a fire.

An inspection of all other fire protection equipment should be made prior to shutting off water in order to ensure that it is in operative condition.

Where changes to fire protection equipment are to be made, as much work as possible should be done in advance of shutting off the water, so that final connections can be made quickly and protection restored promptly. With careful planning, open outlets often can be plugged and protection can be restored on a portion of the equipment while the alterations
Where changes are to be made in underground piping, as much piping as possible should be laid before shutting off the water for final connections. Where possible, temporary feed lines, such as temporary piping for reconnection of risers by hose lines, should be used to afford maximum protection. The plant, public fire department, and other authorities having jurisdiction should be notified of all impairments to fire protection equipment.

### Annex C Recommended Practice for Fire Flow Testing

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

#### C.1

Annex C was developed based upon the procedures contained in NFPA 291. For additional information on fire flow testing, see NFPA 291, Chapter 4, Flow Testing.

#### C.1.1 Scope

The scope of this annex is to provide guidance on fire flow testing of hydrants.

#### C.1.2 Purpose

Fire flow tests are conducted on water distribution systems to determine the rate of flow available at various locations for fire-fighting purposes.

#### C.1.3 Application

C.1.3.1 A certain residual pressure in the mains is specified at which the rate of flow should be available.

C.1.3.2 Additional benefit is derived from fire flow tests by the indication of possible deficiencies, such as tuberculation of piping or closed valves or both, which could be corrected to ensure adequate fire flows as needed.

#### C.1.4 Units

Metric units of measurement in this recommended practice are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table C.1.4 with conversion factors.

<table>
<thead>
<tr>
<th>Table C.1.4</th>
<th>SI Units and Conversion Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Name</td>
<td>Unit Symbol</td>
</tr>
<tr>
<td>Liter</td>
<td>L</td>
</tr>
<tr>
<td>Liter per minute per square meter</td>
<td>(L/min)/m²</td>
</tr>
<tr>
<td>Cubic decimeter</td>
<td>dm³</td>
</tr>
<tr>
<td>Pascal</td>
<td>Pa</td>
</tr>
<tr>
<td>Bar</td>
<td>bar</td>
</tr>
<tr>
<td>Bar</td>
<td>bar</td>
</tr>
</tbody>
</table>

Note: For additional conversions and information, see IEEE/ASTM-SI-10.
C.1.4.1 If a value for measurement as given in this recommended practice is followed by an equivalent value in other units, the first value stated is to be regarded as the recommendation. A given equivalent value might be approximate.

C.2 Referenced Publications.

C.2.1 The documents or portions thereof listed in this chapter are referenced within this annex and should be considered part of the recommendations of this document.

C.2.2 NFPA Publications. (Reserved)

C.2.3 Other Publications.

C.2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.


C.3 Definitions.

C.3.1 The definitions contained in this annex apply to the terms used in this annex practice. Where terms are not included, common usage of the terms applies.

C.3.2 NFPA Official Definitions.

C.3.2.1 Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. (See A.3.2.2.)

C.3.2.2 Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose. (See A.3.2.4.)

C.3.2.3 Should. Indicates a recommendation or that which is advised but not required.

C.3.3 General Definitions.

C.3.3.1 Rated Capacity. The flow available from a hydrant at the designated residual pressure (rated pressure) either measured or calculated.

C.3.3.2 Residual Pressure. The pressure that exists in the distribution system, measured at the residual hydrant at the time the flow readings are taken at the flow hydrants.

C.3.3.3 Static Pressure. The pressure that exists at a given point under normal distribution system conditions measured at the residual hydrant with no hydrants flowing.

C.4 Flow Testing.

C.4.1 Rating Pressure.

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C.4.1.1 For the purpose of uniform marking of fire hydrants, the ratings should be based on a residual pressure of 20 psi (1.4 bar) for all hydrants having a static pressure in excess of 40 psi (2.8 bar).

C.4.1.2 Hydrants having a static pressure of less than 40 psi (2.8 bar) should be rated at one-half of the static pressure.

C.4.1.3 It is generally recommended that a minimum residual pressure of 20 psi (1.4 bar) should be maintained at hydrants when delivering the fire flow. Fire department pumpers can be operated where hydrant pressures are less, but with difficulty.

C.4.1.4 Where hydrants are well distributed and of the proper size and type (so that friction losses in the hydrant and suction line are not excessive), it might be possible to set a lesser pressure as the minimum pressure.

C.4.1.5 A primary concern should be the ability to maintain sufficient residual pressure to prevent developing a negative pressure at any point in the street mains, which could result in the collapse of the mains or other water system components or back-siphonage of polluted water from some other interconnected source.

C.4.1.6 It should be noted that the use of residual pressures of less than 20 psi (1.4 bar) is not permitted by many state health departments.

C.4.2 Test Procedure.

C.4.2.1 Tests should be made during a period of ordinary demand.

C.4.2.2 The procedure consists of discharging water at a measured rate of flow from the system at a given location and observing the corresponding pressure drop in the mains.

C.4.3 Test Layout.

C.4.3.1 After the location where the test is to be run has been determined, a group of test hydrants in the vicinity is selected.

C.4.3.2 Once selected, due consideration should be given to potential interference with traffic flow patterns, damage to surroundings (e.g., roadways, sidewalks, landscapes, vehicles, and pedestrians), and potential flooding problems both local and remote from the test site.

C.4.3.3 One hydrant, designated the residual hydrant, is chosen to be the hydrant where the normal static pressure will be observed with the other hydrants in the group closed, and where the residual pressure will be observed with the other hydrants flowing.

C.4.3.4 This hydrant is chosen so it will be located between the hydrant to be flowed and the large mains that constitute the immediate sources of water supply in the area. In Figure C.4.3.4, test layouts are indicated showing the residual hydrant designated with the letter R and hydrants to be flowed with the letter F.
C.4.3.5 The number of hydrants to be used in any test depends upon the strength of the distribution system in the vicinity of the test location.

C.4.3.6 To obtain satisfactory test results of theoretical calculation of expected flows or rated capacities, sufficient discharge should be achieved to cause a drop in pressure at the residual hydrant of at least 25 percent, or to flow the total demand necessary for fire-fighting purposes.

C.4.3.7 If the mains are small and the system weak, only one or two hydrants need to be flowed.

C.4.3.8 If, on the other hand, the mains are large and the system strong, it may be necessary to flow as many as seven or eight hydrants.

C.4.4 Equipment.

C.4.4.1 The equipment necessary for field work consists of the following:

1. A single 200 psi (14 bar) bourdon pressure gauge with 1 psi (0.0689 bar) graduations
2. A number of pitot tubes
3. Hydrant wrenches
4. 50 or 60 psi (3.5 or 4.0 bar) bourdon pressure gauges with 1 psi (0.0689 bar) graduations, and scales with $\frac{1}{16}$ in. (1.6 mm) graduations [One pitot tube, a 50 or 60 psi (3.5 or 4.0 bar) gauge, a hydrant wrench, a scale for each hydrant to be flowed]
5. A special hydrant cap tapped with a hole into which a short length of $\frac{1}{4}$ in. (6.35 mm) brass pipe is fitted; this pipe is provided with a T connection for the 200 psi (14 bar) gauge and a cock at the end for relieving air pressure.

C.4.4.2 All pressure gauges should be calibrated at least every 12 months, or more
frequently depending on use.

C.4.4.3 When more than one hydrant is flowed, it is desirable and could be necessary to use portable radios to facilitate communication between team members.

C.4.4.4 It is preferred to use stream straightener with a known coefficient of discharge when testing hydrants due to a more streamlined flow and more accurate pitot reading.

C.4.5 Test Procedure.

C.4.5.1 In a typical test, the 200 psi (14 bar) gauge is attached to one of the 2½ in. (64 mm) outlets of the residual hydrant using the special cap.

C.4.5.2 The cock on the gauge piping is opened, and the hydrant valve is opened full.

C.4.5.3 As soon as the air is exhausted from the barrel, the cock is closed.

C.4.5.4 A reading (static pressure) is taken when the needle comes to rest.

C.4.5.5 At a given signal, each of the other hydrants is opened in succession, with discharge taking place directly from the open hydrant butts.

C.4.5.6 Hydrants should be opened one at a time.

C.4.5.7 With all hydrants flowing, water should be allowed to flow for a sufficient time to clear all debris and foreign substances from the stream(s).

C.4.5.8 At that time, a signal is given to the people at the hydrants to read the pitot pressure of the streams simultaneously while the residual pressure is being read.

C.4.5.9 The final magnitude of the pressure drop can be controlled by the number of hydrants used and the number of outlets opened on each.

C.4.5.10 After the readings have been taken, hydrants should be shut down slowly, one at a time, to prevent undue surges in the system.

C.4.6 Pitot Readings.

C.4.6.1 When measuring discharge from open hydrant butts, it is always preferable from the standpoint of accuracy to use 2½ in. (64 mm) outlets rather than pumper outlets.

C.4.6.2 In practically all cases, the 2½ in. (64 mm) outlets are filled across the entire cross section during flow, while in the case of the larger outlets there is very frequently a void near the bottom.

C.4.6.3 When measuring the pitot pressure of a stream of practically uniform velocity, the orifice in the pitot tube is held downstream approximately one-half the diameter of the hydrant outlet or nozzle opening, and in the center of the stream.

C.4.6.4 The center line of the orifice should be at right angles to the plane of the face of the hydrant outlet.

C.4.6.5 The air chamber on the pitot tube should be kept elevated.

C.4.6.6 Pitot readings of less than 10 psi (0.7 bar) and more than 30 psi (2.0 bar) should be
avoided, if possible.

**C.4.6.7** Opening additional hydrant outlets will aid in controlling the pitot reading.

**C.4.6.8** With dry barrel hydrants, the hydrant valve should be wide open to minimize problems with underground drain valves.

**C.4.6.9** With wet barrel hydrants, the valve for the flowing outlet should be wide open to give a more streamlined flow and a more accurate pitot reading. (See Figure C.4.6.9.)

![FIGURE C.4.6.9 Pitot Tube Position.](image)

**C.4.7 Determination of Discharge.**

**C.4.7.1** At the hydrants used for flow during the test, the discharges from the open butts are determined from measurements of the diameter of the outlets flowed, the pitot pressure (velocity head) of the streams as indicated by the pitot gauge readings, and the coefficient of the outlet being flowed as determined from Figure C.4.7.1.

![FIGURE C.4.7.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge.](image)

**C.4.7.2** If flow tubes (stream straighteners) are being utilized, a coefficient of 0.95 is suggested unless the coefficient of the tube is known.

**C.4.7.3** The formula used to compute the discharge, $Q$, in gpm from these measurements is as follows:

\[ Q = cd^2 \sqrt{p} \]

where:

$c = \text{coefficient of discharge (see Figure C.4.7.1)}$

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\[d = \text{diameter of the outlet in inches}\]

\[p = \text{pitot pressure (velocity head) in psi}\]

### C.4.8 Use of Pumper Outlets.

#### C.4.8.1
If it is necessary to use a pumper outlet, and flow tubes (stream straighteners) are not available, the best results are obtained with the pitot pressure (velocity head) maintained between 5 psi and 10 psi (0.3 bar and 0.7 bar).

#### C.4.8.2
For pumper outlets, the approximate discharge can be computed from Equation C.4.7.3 using the pitot pressure (velocity head) at the center of the stream and multiplying the result by one of the coefficients in Table C.4.8.2, depending upon the pitot pressure (velocity head).

<table>
<thead>
<tr>
<th>Velocity Head</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>psi</td>
<td>bar</td>
</tr>
<tr>
<td>2</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>0.21</td>
</tr>
<tr>
<td>4</td>
<td>0.28</td>
</tr>
<tr>
<td>5</td>
<td>0.35</td>
</tr>
<tr>
<td>6</td>
<td>0.41</td>
</tr>
<tr>
<td>7 and over</td>
<td>0.48 and over</td>
</tr>
</tbody>
</table>

#### C.4.8.3
These coefficients are applied in addition to the coefficient in Equation C.4.7.3 and are for average-type hydrants.

### C.4.9 Determination of Discharge Without a Pitot.

#### C.4.9.1
If a pitot tube is not available for use to measure the hydrant discharge, a 50 or 60 psi (3.5 or 4.0 bar) gauge tapped into a hydrant cap can be used.

#### C.4.9.2
The hydrant cap with gauge attached is placed on one outlet, and the flow is allowed to take place through the other outlet at the same elevation.

#### C.4.9.3
The readings obtained from a gauge so located, and the readings obtained from a gauge on a pitot tube held in the stream, are approximately the same.

### C.4.10 Calculation Results.

#### C.4.10.1
The discharge in L/min (gpm) for each outlet flowed is obtained from Table C.4.10.1(a) and Table C.4.10.1(b) or by the use of Equation C.4.7.3.

<table>
<thead>
<tr>
<th>Pitot Pressure(^a) (psi)</th>
<th>Feet(^b)</th>
<th>Velocity Discharge (ft/sec)</th>
<th>2</th>
<th>2.25</th>
<th>2.375</th>
<th>2.5</th>
<th>2.625</th>
<th>2.75</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.31</td>
<td>12.2</td>
<td>119</td>
<td>151</td>
<td>168</td>
<td>187</td>
<td>206</td>
<td>226</td>
<td>269</td>
</tr>
</tbody>
</table>

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Table C.4.10.1(a) Theoretical Discharge Through Circular Orifices (U.S. Gals/min)

<table>
<thead>
<tr>
<th>Pressurea (psi)</th>
<th>Velocityb (ft/sec)</th>
<th>2</th>
<th>2.25</th>
<th>2.375</th>
<th>2.5</th>
<th>2.625</th>
<th>2.75</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4.61</td>
<td>17.25</td>
<td>169</td>
<td>214</td>
<td>238</td>
<td>264</td>
<td>291</td>
<td>319</td>
</tr>
<tr>
<td>3</td>
<td>6.92</td>
<td>21.13</td>
<td>207</td>
<td>262</td>
<td>292</td>
<td>323</td>
<td>356</td>
<td>391</td>
</tr>
<tr>
<td>4</td>
<td>9.23</td>
<td>24.39</td>
<td>239</td>
<td>302</td>
<td>337</td>
<td>373</td>
<td>411</td>
<td>451</td>
</tr>
<tr>
<td>5</td>
<td>11.54</td>
<td>27.26</td>
<td>267</td>
<td>338</td>
<td>376</td>
<td>417</td>
<td>460</td>
<td>505</td>
</tr>
<tr>
<td>6</td>
<td>13.84</td>
<td>29.87</td>
<td>292</td>
<td>370</td>
<td>412</td>
<td>457</td>
<td>504</td>
<td>553</td>
</tr>
<tr>
<td>7</td>
<td>16.15</td>
<td>32.26</td>
<td>316</td>
<td>400</td>
<td>445</td>
<td>493</td>
<td>544</td>
<td>597</td>
</tr>
<tr>
<td>8</td>
<td>18.46</td>
<td>34.49</td>
<td>338</td>
<td>427</td>
<td>476</td>
<td>528</td>
<td>582</td>
<td>638</td>
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<td>9</td>
<td>20.76</td>
<td>36.58</td>
<td>358</td>
<td>453</td>
<td>505</td>
<td>560</td>
<td>617</td>
<td>677</td>
</tr>
<tr>
<td>10</td>
<td>23.07</td>
<td>38.56</td>
<td>377</td>
<td>478</td>
<td>532</td>
<td>590</td>
<td>650</td>
<td>714</td>
</tr>
<tr>
<td>11</td>
<td>25.38</td>
<td>40.45</td>
<td>396</td>
<td>501</td>
<td>558</td>
<td>619</td>
<td>682</td>
<td>748</td>
</tr>
<tr>
<td>12</td>
<td>27.68</td>
<td>42.24</td>
<td>413</td>
<td>523</td>
<td>583</td>
<td>646</td>
<td>712</td>
<td>782</td>
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<td>13</td>
<td>29.99</td>
<td>43.97</td>
<td>430</td>
<td>545</td>
<td>607</td>
<td>672</td>
<td>741</td>
<td>814</td>
</tr>
<tr>
<td>14</td>
<td>32.3</td>
<td>45.63</td>
<td>447</td>
<td>565</td>
<td>630</td>
<td>698</td>
<td>769</td>
<td>844</td>
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<td>15</td>
<td>34.61</td>
<td>47.22</td>
<td>462</td>
<td>585</td>
<td>652</td>
<td>722</td>
<td>796</td>
<td>874</td>
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<tr>
<td>16</td>
<td>36.91</td>
<td>48.78</td>
<td>477</td>
<td>604</td>
<td>673</td>
<td>746</td>
<td>822</td>
<td>903</td>
</tr>
<tr>
<td>17</td>
<td>39.22</td>
<td>50.28</td>
<td>492</td>
<td>623</td>
<td>694</td>
<td>769</td>
<td>848</td>
<td>930</td>
</tr>
<tr>
<td>18</td>
<td>41.53</td>
<td>51.73</td>
<td>506</td>
<td>641</td>
<td>714</td>
<td>791</td>
<td>872</td>
<td>957</td>
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<td>19</td>
<td>43.83</td>
<td>53.15</td>
<td>520</td>
<td>658</td>
<td>734</td>
<td>813</td>
<td>896</td>
<td>984</td>
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<td>20</td>
<td>46.14</td>
<td>54.54</td>
<td>534</td>
<td>676</td>
<td>753</td>
<td>834</td>
<td>920</td>
<td>1009</td>
</tr>
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<td>22</td>
<td>50.75</td>
<td>57.19</td>
<td>560</td>
<td>709</td>
<td>789</td>
<td>875</td>
<td>964</td>
<td>1058</td>
</tr>
<tr>
<td>24</td>
<td>55.37</td>
<td>59.74</td>
<td>585</td>
<td>740</td>
<td>825</td>
<td>914</td>
<td>1007</td>
<td>1106</td>
</tr>
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<td>26</td>
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Table C.4.10.1(a) Theoretical Discharge Through Circular Orifices (U.S. gal/min)

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Notes:
1. This table is computed from the formula \( Q = 29.84cD^2 \sqrt{\rho} \) with \( c = 1.00 \). The theoretical discharge of seawater, as from fireboat nozzles, can be found by subtracting 1 percent from the figures in Table C.4.10.2, or from the formula \( Q = 29.84cD^2 \sqrt{\rho} \).
2. Appropriate coefficient should be applied where it is read from hydrant outlet. Where more accurate results are required, a coefficient appropriate on the particular nozzle must be selected and applied to the figures of the table. The discharge from circular openings of sizes other than those in the table can readily be computed by applying the principle that quantity discharged under a given head varies as the square of the diameter of the opening.

*This pressure corresponds to velocity head.
†1 psi—2.307 ft of water. For pressure in bars, multiply by 0.01.

Table C.4.10.1(b) Theoretical Discharge Through Circular Orifices (L/min)

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### Table C.4.10.1(b) Theoretical Discharge Through Circular Orifices (L)

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Notes:

1. This table is computed from the formula \( Q_s = 0.0666 \times \frac{d}{\sqrt{h}} \) with \( c = 1.00 \). The theoretical discharge of seawater, as from fireboat nozzles, can be found by subtracting 1 percent from the figures in Table 4.10.2, or from the formula \( Q_s = 0.0666 \times \frac{d}{\sqrt{h}} \).

2. Appropriate coefficient should be applied where it is read from hydrant outlet. Where more accurate results are required for a particular nozzle, the nozzle must be selected and applied to the figures of the table. The discharge from circular openings of sizes other than those in the table can readily be computed by applying the principle that quantity discharged under a given head varies as the square of the diameter.

*This pressure corresponds to velocity head.

†1 kPa—0.102 m of water. For pressure in bars, multiply by 0.01.

---

**C.4.10.1.1** If more than one outlet is used, the discharges from all are added to obtain the total discharge.

**C.4.10.1.2** The formula that is generally used to compute the discharge at the specified residual pressure or for any desired pressure drop is Equation C.4.10.1.2:

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\( Q_R = Q_F \times \frac{h_{r0.54}}{h_{f0.54}} \)

where:

- \( Q_R \) = flow predicted at desired residual pressure
- \( Q_F \) = total flow measured during test
- \( h_r \) = pressure drop to desired residual pressure
- \( h_f \) = pressure drop measured during test

**C.4.10.1.3** In this equation, any units of discharge or pressure drop may be used as long as the same units are used for each value of the same variable.

**C.4.10.1.4** In other words, if \( Q_R \) is expressed in gpm, \( Q_F \) must be in gpm, and if \( h_r \) is expressed in psi, \( h_f \) must be expressed in psi.

**C.4.10.1.5** These are the units that are normally used in applying Equation C.4.10.1.2 to fire flow test computations.

**C.4.10.2** Discharge Calculations from Table.

### Table C.4.10.2 Values of \( h \) to the 0.54 Power

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C.4.10.2.1 One means of solving this equation without the use of logarithms is by using Table C.4.10.2, which gives the values of the 0.54 power of the numbers from 1 to 175.

C.4.10.2.2 Knowing the values of $h_f$, $h_r$, and $Q_F$, the values of $h_f^{0.54}$ and $h_r^{0.54}$ can be read from the table and Equation C.4.10.1.2 solved for $Q_R$.

C.4.10.2.3 Results are usually carried to the nearest 100 gpm (380 L/min) for discharges of 1000 gpm (3800 L/min) or more, and to the nearest 50 gpm (190 L/min) for smaller discharges, which is as close as can be justified by the degree of accuracy of the field observations.

C.4.10.2.4 Insert in Equation C.4.10.1.2 the values of $h_f^{0.54}$ and $h_r^{0.54}$ determined from the table and the value of $Q_F$, and solve the equation for $Q_R$.

C.4.11 Data Sheet.

C.4.11.1 The data secured during the testing of hydrants for uniform marking can be valuable for other purposes.

C.4.11.2 With this in mind, it is suggested that the form shown in Figure C.4.11.2 be used to record information that is taken.

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FIGURE C.4.11.2 Sample Report of a Hydrant Flow Test.

C.4.11.3 The back of the form should include a location sketch.

C.4.11.4 Results of the flow test should be indicated on a hydraulic graph, such as the one shown in Figure C.4.11.4.
C.4.11.4 When the tests are complete, the forms should be filed for future reference by interested parties.

C.4.12 System Corrections.

C.4.12.1 It must be remembered that flow test results show the strength of the distribution system and do not necessarily indicate the degree of adequacy of the entire waterworks system.

C.4.12.2 Consider a system supplied by pumps at one location and having no elevated storage.

C.4.12.3 If the pressure at the pump station drops during the test, it is an indication that the distribution system is capable of delivering more than the pumps can deliver at their normal operating pressure.

C.4.12.4 It is necessary to use a value for the drop in pressure for the test that is equal to the actual drop obtained in the field during the test, minus the drop in discharge pressure at the pumping station.

C.4.12.5 If sufficient pumping capacity is available at the station and the discharge pressure could be maintained by operating additional pumps, the water system as a whole could deliver the computed quantity.
C.4.12.6 If, however, additional pumping units are not available, the distribution system would be capable of delivering the computed quantity, but the water system as a whole would be limited by the pumping capacity.

C.4.12.7 The portion of the pressure drop for which a correction can be made for tests on systems with storage is generally estimated upon the basis of a study of all the tests made and the pressure drops observed on the recording gauge at the station for each.

C.4.12.8 The corrections may vary from very substantial portions of the observed pressure drops for tests near the pumping station, to zero for tests remote from the station.

**Annex D Recommended Practice for Marking of Hydrants**

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

D.1

Annex D was developed based upon the procedures contained in NFPA 291. For additional information on marking of hydrants, see NFPA 291, Chapter 5, Marking of Hydrants.

D.1.1 Scope. The scope of this annex is to provide guidance on marking of hydrants.

D.1.2 Purpose. Fire flow tests are conducted on water distribution systems to determine the rate of flow available at various locations for fire-fighting purposes.

D.1.3 Application.

D.1.3.1 A certain residual pressure in the mains is specified at which the rate of flow should be available.

D.1.3.2 Additional benefit is derived from fire flow tests by the indication of possible deficiencies, such as tuberculation of piping or closed valves or both, which could be corrected to ensure adequate fire flows as needed.

D.1.4 Units. Metric units of measurement in this recommended practice are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table D.1.4 with conversion factors.

<table>
<thead>
<tr>
<th>Unit Name</th>
<th>Unit Symbol</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liter</td>
<td>L</td>
<td>1 gal = 3.785 L</td>
</tr>
<tr>
<td>Liter per minute per square meter</td>
<td>(L/min)/m²</td>
<td>1 gpm ft² = (40.746 L/min)/m²</td>
</tr>
<tr>
<td>Cubic decimeter</td>
<td>dm³</td>
<td>1 gal = 3.785 dm³</td>
</tr>
<tr>
<td>Pascal</td>
<td>Pa</td>
<td>1 psi = 6894.757 Pa</td>
</tr>
<tr>
<td>Bar</td>
<td>bar</td>
<td>1 psi = 0.0689 bar</td>
</tr>
<tr>
<td>Bar</td>
<td>bar</td>
<td>1 bar = 10² Pa</td>
</tr>
</tbody>
</table>

Note: For additional conversions and information, see IEEE/ASTM-SI-10.
D.1.4.1 If a value for measurement as given in this recommended practice is followed by an equivalent value in other units, the first value stated is to be regarded as the recommendation. A given equivalent value might be approximate.

D.2 Referenced Publications.

D.2.1 General. The documents or portions thereof listed in this section are referenced within this annex and should be considered part of the recommendations of this document.

D.2.2 NFPA Publications. (Reserved)

D.2.3 Other Publications.

D.2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.


D.3 Definitions.

D.3.1 General. The definitions contained in this annex apply to the terms used in this annex practice. Where terms are not included, common usage of the terms applies.

D.3.2 NFPA Official Definitions.

D.3.2.1 Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. (See A.3.2.2.)

D.3.2.2 Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose. (See A.3.2.4.)

D.3.2.3 Should. Indicates a recommendation or that which is advised but not required.

D.3 General Definitions.

D.3.3.1 Rated Capacity. The flow available from a hydrant at the designated residual pressure (rated pressure), either measured or calculated.

D.4 Classification of Hydrants.

Hydrants should be classified in accordance with their rated capacities [at 20 psi (1.4 bar) residual pressure or other designated value] as follows:

(1) Class AA — Rated capacity of 1500 gpm (5680 L/min) or greater

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Class A — Rated capacity of 1000 to 1499 gpm (3785 to 5675 L/min)

Class B — Rated capacity of 500 to 999 gpm (1900 to 3780 L/min)

Class C — Rated capacity of less than 500 gpm (1900 L/min)

D.5 Marking of Hydrants.

D.5.1 Recommended Hydrant Color Schemes.

D.5.1.1 All barrels are to be chrome yellow except in cases where another color has already been adopted.

D.5.1.2 The tops and nozzle caps should be painted with the following capacity-indicating color scheme to provide simplicity and consistency with colors used in signal work for safety, danger, and intermediate condition:

1. Class AA — light blue
2. Class A — green
3. Class B — orange
4. Class C — red

D.5.1.3 For rapid identification at night, it is recommended that the capacity colors be of a reflective-type paint.

D.5.1.4 Hydrants rated at less than 20 psi (1.4 bar) should have the rated pressure stenciled in black on the hydrant top.

D.5.1.5 In addition to the painted top and nozzle caps, it can be advantageous to stencil the rated capacity of high-volume hydrants on the top.

D.5.1.6 The classification and marking of hydrants provided for in this chapter anticipate determination based on individual flow test.

D.5.1.7 Where a group of hydrants can be used at the time of a fire, some special marking designating group-flow capacity may be desirable.

D.5.2 Permanently Inoperative Hydrants. Fire hydrants that are permanently inoperative or unusable should be removed.

D.5.3 Temporarily Inoperative Hydrants. Fire hydrants that are temporarily inoperative or unusable should be wrapped or otherwise provided with temporary indication of their condition.

D.5.4 Flush Hydrants. Location markers for flush hydrants should carry the same background color as stated above for class indication, with such other data stenciled thereon as deemed necessary.

D.5.5 Marking of Hydrants Within Private Enclosures.

D.5.5.1 When private hydrants are located on public streets, they should be marked in accordance with the requirements of the authority having jurisdiction.

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Annex E Informational References

E.1 Referenced Publications.
The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

E.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

E.1.2 Other Publications.
E.1.2.1 ACPA Publication. American Concrete Pipe Association, 675 Grigsby Way, Cedar Hill, TX 75104-2537.
Concrete Pipe Handbook.

E.1.2.2 ASME Publication. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

E.1.2.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

E.1.2.4 AWWA Publications. American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

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AWWA C153, *Ductile Iron Compact Fittings, 3 in. through 24 in. and 54 in. through 64 in. for Water Service*, 2000.


AWWA C300, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*, 1989.

AWWA C301, *Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*, 1984.

AWWA C302, *Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids*, 1987.

AWWA C303, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids*, 1987.


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AWWA M9, *Concrete Pressure Pipe*, 1995.


AWWA M41, *Ductile Iron Pipe and Fittings*.

**E.1.2.5 DIPRA Publications.** Ductile Iron Pipe Research Association, 245 Riverchase Parkway East, Suite O, Birmingham, AL 35244.


*Thrust Restraint Design for Ductile Iron Pipe.*

**E.1.2.6 EBAA Iron Publications.** EBAA Iron, Inc., P.O. Box 857, Eastland, TX 76448.


**E.1.2.7 UBPPA Publications.** Uni-Bell PVC Pipe Association, 2655 Villa Creek Drive, Dallas, TX 75234.

*Handbook of PVC Pipe.*


**E.2 Informational References. (Reserved)**

**E.3 References for Extracts in Informational Sections. (Reserved)**

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**Formal Interpretation**

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Formal Interpretation

NFPA 24

Standard for the Installation of Private Fire Service Mains and Their Appurtenances

2007 Edition

Reference: 10.1.1
F.I. No.: 24-07-01

Question No. 1: Is it acceptable to use underground pipe that is not referenced in Table 10.1.1, but is specifically listed for Fire protection Service and complies with the applicable AWWA standards for the pipe?

Answer: Yes

Reference: 10.1.1
Issue Date: 01/25/2007
Effective Date: 2/14/2007