NFPA® 24

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

2025 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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Text revisions are shaded. A Δ before a section number indicates that words within that section were deleted and a Δ to the left of a table or figure number indicates a revision to an existing table or figure. When a chapter was heavily revised, the entire chapter is marked throughout with the Δ symbol. Where one or more sections were deleted, a • is placed between the remaining sections. Chapters, annexes, sections, figures, and tables that are new are indicated with an ***N***.

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NFPA® 24

Standard for the

Installation of Private Fire Service Mains and Their Appurtenances

2025 Edition

This edition of NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, was prepared by the Technical Committee on Private Water Supply Piping Systems and released by the Correlating Committee on Automatic Sprinkler Systems. It was issued by the Standards Council on April 22, 2024, with an effective date of May 12, 2024, and supersedes all previous editions.

This edition of NFPA 24 was approved as an American National Standard on May 12, 2024.

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.*

In 1953, on recommendation of the Committee on Standpipes and Outside Protection, the two standards (NFPA 24 and NFPA 25) were completely revised and adopted as NFPA 24. Amendments were made leading to separate editions in 1955, 1959, 1962, 1963, 1965, 1966, 1968, 1969, 1970, 1973, 1977, 1981, 1983, and 1987.

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 was revised in five major areas: Chapter 10 was updated editorially, and minor technical changes were made. Newly established leakage test criteria, as well as updated requirements for thrust blocks and restrained joints, were added to Chapter 10. Two annexes were 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 2002 edition of NFPA 291.

The 2010 edition was revised in three major areas: the provisions for location and identification of fire department connections, valves controlling water supply, and protection of fire service mains entering the building.

The 2013 edition of NFPA 24 included clarifications on the requirements for running piping under buildings, including annex figures depicting clearances. The Contractors Material and Test

Certificate for Underground Piping (Figure 10.10.1) was modified to include confirmation that the forward flow test of the backflow preventer had been conducted. A provision was also added that required the automatic drip valve to be in an accessible location that permits inspections in accordance with NFPA 25.

NFPA 24 underwent a structural rewrite for the 2016 edition. The hydrant definitions were clarified to describe the type of hydrant in question, as opposed to describing when and where they would be used. The valve arrangement requirements were rewritten for clarity, and annex figures added to provide figures that are consistent with NFPA 13. The title of Chapter 6 was changed from Valves to Water Supply Connections to better describe the material in the chapter. Revisions to Section 6.1 more clearly call out the permitted exceptions to indicating valves and permit nonlisted tapping sleeve and valve assemblies in connections to municipal water supplies. The center of hose outlet measurements was updated to include clear minimum and maximum values for the location of the outlet, along with the appropriate measurement for a hose house installation. The steel underground piping references have been removed from the table in Chapter 10 because steel pipe is required to be listed other than in the FDC line. A statement also was added to allow underground fittings to be used above the ground to transition to aboveground piping.

The 2019 edition included minor changes related to trenching and backfill. Acceptance testing requirements for aboveground piping were included. The standard was also revised to clarify the unacceptable use of steel piping for underground service.

The 2022 edition explained that NFPA 24 does not apply to dry fire hydrants used for drafting. Chapter 5 clarified that a single fire department connection can supply multiple buildings where approved by the AHJ. Alternate distance criteria were added to Chapter 6 for post indicator valves and backflow preventors. A new section was added to Chapter 10 to clarify that the flush rates of NFPA 20 need to be used where a fire pump is connected to the water supply. Also, a new section was added that provides an alternate cleaning procedure in place of traditional flushing. New annex material was added to help determine ice thickness where taking water from a source exposed to freezing conditions.

For the 2025 edition, a revision in Chapter 1 makes it clear that new technologies and alternate methods are permitted if the level of safety prescribed by the standard is not lowered. In Chapter 7, clarification is provided for the orientation of hydrant outlets. Chapter 10 addresses the requirements for the joining of plain end pipe, adds that bituminous coating is an acceptable corrosion retarding material, and clarifies that, since the maximum force that a thrust block will face is from hydrostatic testing, that the requirement of sizing thrust blocks shall be based on test pressure. Chapter 12 provides annex language on what is considered a hazardous area.

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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 the 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.

Contents

NFPA 24

Standard for the

Installation of Private Fire Service Mains and Their Appurtenances

2025 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex E.

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard shall provide the minimum requirements for the installation of private fire service mains and their appurtenances, which include 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 intended to carry water for fire service and other uses.

Δ **1.1.3** This standard shall not apply to the following situations:

(1) Mains under the control of a water utility
(2) Mains providing fire protection and/or domestic water that are privately owned but are operated as a water utility
(3)* Dry fire hydrants utilized for drafting or mains connected to dry hydrants utilized for drafting

1.1.4 This standard shall not apply to underground mains serving sprinkler systems designed and installed in accordance with NFPA 13R that are less than 4 in. (100 mm) in nominal diameter.

1.1.5 This standard shall not apply to underground mains serving sprinkler systems designed and installed in accordance with NFPA 13D.

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.

N **1.2.1** Private fire service mains are specialized fire protection systems and shall require design and installation by knowledgeable and trained personnel.

1.3 Retroactivity. The provisions of this standard reflect a consensus for 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 (AHJ) determines that the existing situation presents an unacceptable degree of risk, the AHJ 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 AHJ and only where it is clearly evident that a reasonable degree of safety is provided.

Δ **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.

N **1.4.1** Technical documentation shall be submitted to the AHJ to demonstrate equivalency.

N **1.4.2** The system, method, or device shall be approved for the intended purpose by the AHJ.

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).

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

1.5.1.2 These units with conversion factors shall be used as listed in Table 1.5.1.2.

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

Δ **Table 1.5.1.2 Conversion Table for SI Units**

Quantity	Name of Unit	Unit Symbol	Conversion Factor
Length	Meter	m	1 ft = 0.3048 m
Area	Square meter	m^2	1 ft^2 = 0.092903 m^2
Volume	Cubic meter	m^3	1 ft^3 = 0.028317 m^3
Fluid capacity	Liter	L	1 gal = 3.785 L
Flow	Liter per minute	L/min	1 gpm = 3.785 L/min
Pressure	Bar Kilopascal Newton per square meter	bar kPa N/m^2	1 psi = 0.0689 bar 1 psi = 6.894757 kPa 1 lbf/ft^2 = 47.8800 N/m^2
Temperature	Degrees Celsius	°C	1°F = $\frac{9}{5}$ × °C + 32
Velocity	Meter per second	m/sec	1 fps = 0.3048 m/sec
Force	Newton	N	1 lbf = 4.448822 N
Stress	Kilonewton per square meter Megapascal	kN/m^2 MPa	1 lbf/ft^2 = 0.047880 kN/m^2 1 $lbf/in.^2$ = 0.006895 MPa

Note: For additional conversions and information, see ASTM SI 10, *IEEE/ASTM SI 10 American National Standard for Metric Practice.*

1.5.3* It shall be acceptable to use the exact conversion or the conversions stated in the standard, even though they might not be exact.

N **1.6 New Technology.**

N **1.6.1** Nothing in this standard shall be intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered.

N **1.6.2** Materials or devices not specifically designated by this standard shall be utilized in complete accord with all conditions, requirements, and limitations of their listings.

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.

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

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2025 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* 2025 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies,* 2025 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2025 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2023 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2023 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 2023 edition.

NFPA 1960, *Standard for Fire Hose Connections, Spray Nozzles, Manufacturer's Design of Fire Department Ground Ladders, Fire Hose, and Powered Rescue Tools,* 2024 edition.

2.3 Other Publications.

2.3.1 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B1.20.1, *Pipe Threads, General Purpose, Inch*, 2013 (R2018).

ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*, 2020.

ASME B16.3, *Malleable Iron Threaded Fittings, Classes 150 and 300*, 2021.

ASME B16.4, *Gray Iron Threaded Fittings, Classes 125 and 250*, 2021.

ASME B16.15, *Cast Copper Alloy Threaded Fittings: Classes 125 and 250*, 2018.

ASME B16.18, *Cast Copper Alloy Solder Joint Pressure Fittings*, 2021.

ASME B16.22, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*, 2021.

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

ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 2022.

ASTM A135/A135M, *Standard Specification for Electric-Resistance-Welded Steel Pipe*, 2021.

ASTM A312/312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*, 2022.

ASTM A403/A403M, *Specification for Wrought Austenitic Stainless Steel Pipe Fittings*, 2022.

ASTM A795/A795M, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*, 2013.

ASTM B43, *Specification for Seamless Red Brass Pipe, Standard Sizes*, 2020.

ASTM B75/B75M, *Specification for Seamless Copper Tube*, 2020.

ASTM B88, *Specification for Seamless Copper Water Tube*, 2020.

ASTM B251/B251M, *Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube*, 2017.

ASTM SI 10, *IEEE/ASTM SI 10 American National Standard for Metric Practice*, 2016.

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

AWWA C104/A21.4, *Cement-Mortar Lining for Ductile-Iron Pipe and Fittings*, 2023.

AWWA C105/A21.5, *Polyethylene Encasement for Ductile-Iron Pipe Systems*, 2018.

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AWWA C600, *Installation of Ductile-Iron Water Mains and Their Appurtenances*, 2017.

AWWA C602, *Cement-Mortar Lining of Water Pipelines Lines in Place, 4 in. (100 mm) and Larger*, 2023.

AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 60 in. (100 mm Through 1,500 mm)*, 2022.

AWWA C906, *Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 65 in. (1650 mm) for Waterworks*, 2021.

AWWA C909, *Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 in. – 24 in. (100 mm – 600 mm) for Water, Wastewater, and Reclaimed Water Service*, 2022.

AWWA M9, *Concrete Pressure Pipe*, 2008, errata 2014.

AWWA M23, *PVC Pipe — Design and Installation*, 2020.

AWWA M55, *PE Pipe — Design and Installation*, 2020.

2.3.4 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2020.

Δ **2.4 References for Extracts in Mandatory Sections.**

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2025 edition.

Chapter 3 Definitions

Δ **3.1 General.**

N **3.1.1** The definitions contained in this chapter shall apply to the terms used in this standard.

N **3.1.2** Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used.

N **3.1.3** *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. An NFPA standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases "standards development process" or "standards development activities," the term "standards" includes all NFPA standards, including codes, standards, recommended practices, and guides.

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 Automatic Drain Valve (Automatic Drip or Ball Drip). A device intended to remove water using gravity from piping or valve cavities, which is required to be empty when the system is not discharging water.

3.3.3* Control Valve (Shutoff Valve). A valve controlling flow to water-based fire protection systems and devices.

3.3.4 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.

3.3.5 Corrosion-Retarding 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.

3.3.6 Fire Department Connection. A connection through which the fire department can pump supplemental water into the sprinkler system, standpipe, or other water-based fire protection systems, thereby supplementing existing water supplies.

3.3.7 Fire Pump. A pump that is a provider of liquid flow and pressure dedicated to fire protection. [**20,** 2025]

3.3.8 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 firefighting in conjunction with and to provide aid to the local fire department.

3.3.9 Hydrant Butt. The hose connection outlet of a hydrant.

3.3.10 Hydraulically Calculated Water Demand Flow Rate. The waterflow rate for a system or hose stream that has been calculated using accepted engineering practices.

3.3.11 Pressure.

3.3.11.1 ***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.

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

3.3.12* Pressure-Regulating Device. A device designed for the purpose of reducing, regulating, controlling, or restricting water pressure.

3.3.13* Private Fire Service Main. A private fire service main, as used in this standard, is that pipe and its appurtenances on private property that is between a source of water and the base of the system riser for water-based fire protection systems; between a source of water and inlets to foam-making systems; between a source of water and the base elbow of private hydrants or monitor nozzles; and used as fire pump suction and discharge piping, beginning at the inlet side of the check valve on a gravity or pressure tank.

3.3.14 Pumper Outlet. The hydrant outlet intended to be connected to a fire department pumper for use in taking supply from the hydrant.

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

3.3.16 System Working Pressure. The maximum anticipated static (nonflowing) or flowing pressure applied to fire protection system components exclusive of surge pressures and exclusive of pressure from the fire department connection.

3.3.17 Test.

3.3.17.1 ***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.

3.3.17.2 ***Flushing Test.*** A test of a piping system using flow rates intended to remove debris from the piping system prior to it being placed in service.

3.3.17.3 ***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 duration to verify system integrity and system leakage rates.

3.3.18 Valve.

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

3.3.18.2* ***Indicating Valve.*** A valve that has components that provide the valve operating condition, open or closed.

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 (Frostproof Hydrant).*** A type of hydrant with the main control valve below the frost line between the footpiece and the barrel.

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 that is used to supply hose and fire department pumpers with water on private property.

3.4.1.4 ***Public Hydrant.*** A valved connection on a water supply system having one or more outlets 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 is intended for use where there is no danger of freezing weather and where each outlet is provided with a valve and an outlet.

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) A graphic representation of the scale used on all plans
(5) Name and address of contractor
(6) Size and location of all water supplies
(7) Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment
(8) The following items that pertain to private fire service mains:
  (a) Size
  (b) Length
  (c) Location
  (d) Weight
  (e) Material
  (f) Point of connection to city main
  (g) Sizes, types, and locations of valves, valve indicators, regulators, meters, and valve pits
  (h) Depth at which the top of the pipe is laid below grade
  (i) Method of restraint
(9) The following items that pertain to hydrants:
  (a) Size and location, including size and number of outlets and whether outlets are to be equipped with independent gate valves
  (b) Thread size and coupling adapter specifications if different from NFPA 1960
  (c) Whether hose houses and equipment are to be provided, and by whom
  (d) Static and residual hydrants used in flow
  (e) Method of restraint
(10) Size, location, and piping arrangement of fire department connections

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.

Chapter 5 Water Supplies

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 flow rate and pressure of a public water supply shall be determined from waterflow test data or other approved method.

5.2 Size of Fire Mains.

5.2.1 Private Fire Service Mains.

5.2.1.1 Hydraulic calculations shall show that the main is able to supply the total flow rate at the required design pressure.

Δ **5.2.1.2** For mains that supply hydrants, pipe size shall not be less than 6 in. (150 mm) nominal size.

5.2.2 Mains Not Supplying Hydrants. For mains that do not supply hydrants, pipe sizes less than 6 in. (150 mm) nominal size 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) Standpipe systems
(2) Hydraulic calculations shall show that the main is able to supply the total flow rate at the required design 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 Pressure-regulating valves shall not be used.

5.3.1.1 Pressure-regulating valves shall be permitted to be used when acceptable to the AHJ.

5.3.2 Where meters are required, they shall be listed for fire protection service.

5.4* Connection from Waterworks Systems.

5.4.1 The requirements of the public health AHJ shall be determined and followed.

5.4.2 Where a backflow prevention device is installed to guard against possible cross-contamination of the public water system, it shall be listed for fire protection service.

5.4.2.1* Where a check valve or alarm check valve is permitted by the AHJ in lieu of a backflow preventer, it shall be listed for fire protection service.

5.5 Connections to Public Water Systems. Connections to public water systems shall be arranged to be isolated by one of the methods permitted in 6.2.9.

5.6* Pumps. Fire pump units installed in accordance with NFPA 20 and connected to a water supply source complying with Sections 5.5, 5.7, or 5.8 shall use an acceptable water supply source.

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

5.8 Penstocks, Rivers, Lakes, or Reservoirs. Water supply connections from penstocks, rivers, lakes, or reservoirs shall be designed to prevent the introduction of mud and sediment and shall be provided with approved, double, removable screens or approved strainers installed in an approved manner.

5.8.1* When water supply connections are from penstocks, rivers, lakes, or reservoirs, measures shall be taken to prevent freezing at the water supply inlet.

5.9* Remote Fire Department Connections.

5.9.1 General. Where the AHJ requires a remote fire department connection for systems requiring one by another standard, a fire department connection shall be provided as described in Section 5.9.

5.9.1.1 Fire department connections shall be permitted to be omitted where approved by the AHJ.

5.9.1.2 A single fire department connection shall be permitted to supply multiple buildings where acceptable to the AHJ.

5.9.1.3 Fire department connections shall be of an approved type.

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

5.9.1.5 Fire department connections shall be protected where subject to mechanical damage.

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), except as permitted by 5.9.2.3 and 5.9.2.4.

5.9.2.2 At least one of the connections shall be the 2.5 to 7.5 NH standard thread specified in NFPA 1960.

5.9.2.3 Where local fire department connections use threads that do not conform to NFPA 1960, the AHJ shall designate the thread to be used.

5.9.2.4 Nonthreaded couplings shall be permitted where required by the AHJ.

5.9.2.4.1 Nonthreaded couplings shall be listed.

5.9.3 Valves.

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

5.9.3.2 Control valves shall not be installed in the piping from the fire department connection to the fire service main.

5.9.3.2.1* Control valves shall be permitted in the system piping downstream of 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 drain valve.

5.9.4.2 The automatic drain valve shall be installed in a location that permits inspection and testing as required by NFPA 25 and reduces the likelihood of freezing.

5.9.4.2.1 The automatic drip shall be permitted to be buried where permitted by the AHJ.

5.9.4.2.2 Where the automatic drip is buried as allowed by 5.9.4.2.1, the outlet shall discharge into a bed of crushed stone or pea gravel.

5.9.4.3 An automatic drain valve is permitted to be omitted from areas where the piping is not subject to freezing.

5.9.5 Location and Signage.

5.9.5.1* Remote fire department connections shall be located adjacent to a street or an access route to permit fire department apparatus accessibility, or at a location approved by the AHJ.

5.9.5.2* Remote fire department connections shall be located and arranged so that hose lines can be attached to the inlets without interference.

5.9.5.3 Each remote fire department connection shall be designated by a sign as follows:

(1) The sign shall have raised or engraved letters at least 1 in. (25 mm) in height on a plate or fitting.
(2)* The sign shall indicate the type of system for which the connection is intended.

5.9.5.4 Where the system demand pressure exceeds 150 psi (10.3 bar), a sign located at the fire department connection shall indicate the required inlet pressure.

5.9.5.5 Where a remote 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.

5.9.5.6 Remote fire department connections shall not be connected on the suction side of fire pumps.

5.9.5.7 Where a remote fire department connection services multiple buildings, structures, or locations, a sign shall be provided indicating the buildings, structures, or locations served.

Chapter 6 Water Supply Connections

6.1 Valves.

6.1.1 All valves controlling connections to water supplies and to supply pipes to water-based fire protection systems shall be listed indicating valves, except as permitted by 6.1.1.3 and 6.1.1.4.

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

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

6.1.1.3* A listed, nonindicating valve, such as an underground gate valve, including a T-wrench, shall be permitted to be installed in a roadway box when acceptable to the AHJ.

6.1.1.3.1 For new installations, where more than one nonindicating underground gate valve is installed in a water system, all underground gate valves shall be of the same opening direction.

6.1.1.4* A new connection to a municipal water supply shall be permitted to utilize a nonlisted, nonindicating valve, including a T-wrench as part of a tapping assembly.

6.1.1.4.1 For new installations, where more than one nonindicating underground gate valve is installed in a water system, all underground gate valves shall be of the same opening direction.

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

6.2 Connections to Water Supplies.

6.2.1 A valve in accordance with Section 6.1 shall be installed in each pipeline from each water supply.

6.2.1.1 Control valves shall not be installed in the piping from the fire department connection to the point it connects to the fire service main.

6.2.1.2 Control valves shall be permitted in the system piping downstream of the fire department connection.

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

6.2.2.1 Except for the check valve installed in the fire department connection piping, all check valves shall have a control valve installed upstream and downstream of the check valve.

6.2.2.2* When water supply connections serve as one source of supply, valves shall be installed in accordance with 6.1.1 on both sides of all check valves required in 6.2.2.

6.2.3 Check valves shall not be required in a break tank where break tanks are used with automatic fire pumps.

6.2.4 In the discharge pipe from a pressure tank or a gravity tank of less than 15,000 gal (57 m^3) capacity, a control valve shall not be required to be installed on the tank side of the check valve.

6.2.5* 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 an outside screw and yoke, a listed indicating valve, or a listed valve having a post-type indicator.

6.2.6* 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.

6.2.7 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, one of the following requirements shall be met:

(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 not less than 40 ft (12 m) from outside buildings.
(3) For buildings less than 40 ft (12 m) in height, a post indicator valve shall be permitted to be installed closer than 40 ft (12 m) but at least as far from the building as the height of the wall facing the post indicator valve.

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

6.2.9 All connections to private fire service mains for fire protection systems shall be arranged in accordance with one of the following so that they can be isolated:

(1)* A post indicator valve installed not less than 40 ft (12 m) from the building
  (a) For buildings less than 40 ft (12 m) in height, a post indicator valve shall be permitted to be installed closer than 40 ft (12 m) but at least as far from the building as the height of the wall facing the post indicator valve.
  (b) Post indicating valves shall be allowed to be closer than 40 ft (12 m) to the building when a property line or other physical barriers make it impossible to have a post indicating valve 40 ft (12 m) away.
  (c) Post indicating valves shall be allowed to be closer than 40 ft (12 m) to the building when building driveway or fire access roadways or other building traffic make it impractical to be 40 ft (12 m).
(2) A wall post indicator valve on risers located within the building, either a nonrising stem gate valve with a wall post indicator or a listed butterfly valve with an indicating handle extending out through the building wall.
(3) An indicating valve in a pit, installed in accordance with Section 6.4
(4)* A backflow preventer with at least one indicating valve not less than 40 ft (12 m) from the building
  (a) For buildings less than 40 ft (12 m) in height, a backflow preventer with at least one indicating valve shall be permitted to be installed closer than 40 ft (12 m) but at least as far from the building as the height of the wall facing the backflow preventer.
  (b) Backflow preventer valves shall be allowed to be closer than 40 ft (12 m) to the building when a property line or other physical barriers make it impossible to have a backflow preventer valve 40 ft (12 m) away.
  (c) Backflow preventer valves shall be allowed to be closer than 40 ft (12 m) to the building when building driveway or fire access roadways or other building traffic make it impractical to be 40 ft (12 m).
(5)* A nonindicating valve, such as an underground nonrising stem gate valve with an approved roadway box, complete with T-wrench, located not less than 40 ft (12 m) from the building
  (a) For buildings less than 40 ft (12 m) in height, a nonindicating valve, such as an underground nonrising stem gate valve with an approved roadway box, complete with T-wrench, shall be permitted to be installed closer than 40 ft (12 m) but at least as far from the building as the height of the wall facing the nonindicating valve.
  (b) A nonindicating valve, such as an underground nonrising stem gate valve with an approved roadway box complete with T-wrench shall be allowed to be closer than 40 ft (12 m) to the building when a

property line or other physical barriers make it impossible to have the valve 40 ft (12 m) away.
(6) Indicating control valves installed in a fire-rated room accessible from the exterior
(7) Indicating control valves in a fire-rated stair enclosure accessible from the exterior as permitted by the AHJ
(8) Any other valve type or location as permitted by the AHJ.

6.3 Post Indicator Valves.

6.3.1 Where post indicator valves are used, they shall be set so that the top of each post is 32 in. to 40 in. (800 mm to 1000 mm) above the final grade.

6.3.2 Where post indicator valves are used, they shall be protected against mechanical damage where needed.

6.4 Valves in Pits.

6.4.1 Valve pits located on the discharge pipe of an elevated tank shall be designed in accordance with NFPA 22.

6.4.2 Where used, valve pits shall be of a size to permit access for inspection, operation, testing, maintenance, and removal of equipment contained therein.

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

6.4.3.1 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

6.4.3.2 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.

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

6.5 Backflow Prevention Assemblies.

6.5.1 Where used in accordance with 6.2.9(4), backflow prevention assemblies shall be installed in accordance with their installation instructions.

6.5.2 Backflow prevention assemblies shall be protected against mechanical damage and freezing where the potential exists.

6.6 Sectional Valves.

6.6.1* Sectional valves shall be provided on looped systems at locations within piping sections such that the number of fire protection connections between sectional valves does not exceed six.

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

(1) On each bank of a river, pond, or lake where a main crosses water
(2) Outside the building foundation(s) where a main or a section of a main is installed under a building

6.7 Identifying and Securing Valves.

6.7.1 Identification signs shall be provided at each valve to indicate the valve's function and the part of the system the valve controls.

6.7.1.1 Identification signs in 6.7.1 shall not be required for underground gate valves with roadway boxes.

6.7.2* Control valves 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 verify that valves are located within fenced enclosures under the control of the owner, sealed in the open position, and inspected weekly

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

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

Chapter 7 Hydrants

7.1* General.

7.1.1 Hydrants shall be listed and approved.

7.1.1.1 The connection from the hydrant to the main shall not be less than 6 in. (150) (nominal).

7.1.1.2 A listed control valve shall be installed in each hydrant connection.

7.1.1.2.1 A valve required by 7.1.1.2 shall be permitted to be a listed, nonindicating valve, such as an underground gate valve in a roadway box.

7.1.1.2.2 Valves required by 7.1.1.2 shall be installed within 20 ft (6.1 m) of the hydrant.

7.1.1.2.2.1 Valves shall be clearly identified and kept free of obstructions.

7.1.1.2.3 Where valves cannot be located in accordance with 7.1.1.2.2, valve locations shall be permitted where approved by the AHJ.

7.1.1.3* The number, size, and arrangement of outlets; the size of the main valve opening; the size of the barrel; and the color of the hydrant shall be determined by the required flow and pressure for the protection to be provided and shall be approved by the AHJ.

7.1.1.4 Independent gate valves on 2½ in. (65 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 1960.

7.1.3 Where local fire department connections do not conform to NFPA 1960, the AHJ shall designate the connection to be used.

7.2 Number and Location.

7.2.1* Hydrants shall be provided and spaced in accordance with the requirements of the AHJ.

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 m) from the buildings or structures to be protected.

7.2.4 Where hydrants cannot be located in accordance with 7.2.3, hydrants located closer than 40 ft (12 m) from the building or wall hydrants shall be permitted to be used where approved by the AHJ.

7.3 Installation.

7.3.1* Hydrants shall be installed on flat stones, concrete slabs, or other approved materials.

7.3.2 Small stones or an approved equivalent shall be provided below and around the drain in an adequate amount to prevent the weep hole from being clogged with native soil, mud, or debris that would prevent adequate drainage for dry barrel hydrants.

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

7.3.2.1.1* Hydrants with drain plugs 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. (450 mm) above final grade.

7.3.3.1 The center of a hose outlet shall not be more than 36 in. (900 mm) above final grade.

7.3.3.2 The center of a hose outlet located in a hose house shall not be less than 12 in. (300 mm) above the floor.

N **7.3.3.3*** Where a 4 in. (100 mm) outlet or larger is provided on a hydrant, this outlet shall be installed facing the access utilized by the responding fire apparatus.

7.3.4 Hydrants shall be restrained in accordance with the requirements of Chapter 10.

7.3.5 Hydrants shall be protected if subject to mechanical damage, in accordance with the requirements of Chapter 10.

7.3.5.1 The means of hydrant protection shall be arranged so that it does not interfere with the connection to, or operation of, hydrants.

7.3.6 The following shall not be installed between a fire hydrant and the control valve for that hydrant:

(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) Firefighting capabilities of potential users

8.1.1.2 The AHJ shall be consulted regarding quantity and type of hose.

8.1.2 Hose shall be stored so it is accessible and is protected from the weather.

8.1.2.1 Hose shall be permitted to be stored in hose houses or by placing hose reels or hose carriers in weather-protected enclosures.

8.1.3* Hose shall conform to NFPA 1960.

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 1960.

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 1960, the AHJ 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.

8.2.2 Hydrants within hose houses shall be located at the front of the house with space behind 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 The construction shall protect the hose from weather and vermin.

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

8.3.3 Ventilation shall be provided.

8.3.4 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 shutoff features 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. Master streams shall be delivered by monitor nozzles, hydrant-mounted monitor nozzles, and other master stream equipment capable of delivering more than 250 gpm (950 L/min).

9.2 Application and Special Situations. Master streams shall be provided as protection for the following:

(1) Large amounts of combustible materials located in yards
(2) Large amounts of combustible materials in inaccessible locations
(3) Occupancies presenting special hazards, as required by the AHJ

Chapter 10 Underground Requirements

10.1* Piping.

10.1.1* All piping used in private fire service mains shall be in accordance with 10.1.1.1, 10.1.1.2, or 10.1.1.3.

10.1.1.1 Use. Piping manufactured in accordance with Table 10.1.1.1 shall be permitted to be used.

10.1.1.2 Piping specifically listed for use in private fire service mains shall be permitted to be used.

10.1.1.2.1 Where listed pipe is used, it shall be installed in accordance with the listing limitations including installation instructions.

10.1.1.2.2 Where listing limitations or installation instructions differ from the requirements of this standard, the listing limitations and installation instructions shall apply.

10.1.1.3 Steel piping manufactured in accordance with Table 10.1.1.3 that is externally coated and wrapped and internally galvanized shall be permitted to be used between the hose coupling(s) on the fire department connection and the check valve installed in the fire department connection piping.

10.1.1.3.1 External coating and wrapping as required by 10.1.1.3 shall be approved.

Δ Table 10.1.1.1 Manufacturing Standards for Underground Pipe

Materials and Dimensions	Standard
Ductile Iron	
Cement-mortar lining for ductile-iron pipe and fittings	AWWA C104/A21.4
Polyethylene encasement for ductile-iron pipe systems	AWWA C105/A21.5
Rubber-gasket joints for ductile-iron pressure pipe and fittings	AWWA C111/A21.11
Flanged ductile-iron pipe with ductile-iron or gray-iron threaded flanges	AWWA C115/A21.15
Thickness design of ductile-iron pipe	AWWA C150/A21.50
Ductile-iron pipe, centrifugally cast	AWWA C151/A21.51
Ductile iron water mains and their appurtenances	AWWA C600
Concrete	
Reinforced concrete pressure pipe, steel-cylinder type	AWWA C300
Prestressed concrete pressure pipe, steel-cylinder type	AWWA C301
Reinforced concrete pressure pipe, non-cylinder type	AWWA C302
Reinforced concrete pressure pipe, steel-cylinder type, pretensioned	AWWA C303
Cement-mortar lining of water pipe lines in place, 4 in. (100 mm) and larger	AWWA C602
Plastic	
Polyvinyl chloride (PVC) pressure pipe and fabricated fittings, 4 in. through 60 in. (100 mm through 1,500 mm)	AWWA C900
Polyethylene (PE) pressure pipe and fittings, 4 in. (100 mm) through 63 in. (1575 mm) for waterworks	AWWA C906
Molecularly oriented polyvinyl chloride (PVCO), 4 in. through 24 in. (100 mm through 600 mm) for water, wastewater, and reclaimed water service	AWWA C909
Brass	
Seamless red brass pipe, standard sizes	ASTM B43
Copper	
Seamless copper tube	ASTM B75/B75M
Seamless copper water tube	ASTM B88
Wrought seamless copper and copper-alloy tube	ASTM B251/B251M
Stainless Steel	
Seamless, welded, and heavily cold worked austenitic stainless steel pipes	ASTM A312/312M

Table 10.1.1.3 Steel Piping for Fire Department Connections

Materials and Dimensions	Standard
Black and hot-dipped zinc-coated (galvanized) welded and seamless steel pipe for fire protection use	ASTM A795/A795M
Pipe, steel, black and hot-dipped, zinc-coated, welded and seamless	ASTM A53/A53M
Electric-resistance-welded steel pipe	ASTM A135/A135M

N **10.1.1.3.2** The requirements of 10.1.1.3 shall not apply to listed stainless steel piping.

10.1.2* All piping used in private fire service mains shall be rated for the maximum system working pressure to which the piping is exposed to but shall not be rated at less than 150 psi (10.3 bar).

10.1.3* When lined piping is used, the manufacturer's literature for internal diameter shall be used for all hydraulic calculations.

10.1.4* Regardless of pipe type, underground piping shall be permitted to extend into the building through the slab or wall not more than 24 in. (600 mm).

10.1.4.1 Underground piping extended vertically into the building through the slab shall be installed plumb.

10.2 Fittings.

10.2.1 All fittings used in private fire service mains shall be in accordance with 10.2.1.1 or 10.2.1.2.

10.2.1.1 Fittings manufactured in accordance with Table 10.2.1.1 shall be permitted to be used.

10.2.1.2 Special Listed Fittings. Fittings specifically listed for use in private fire service mains shall be permitted to be used.

10.2.1.2.1 Where listed fittings are used, they shall be installed in accordance with their listing limitations including installation instructions.

10.2.1.2.2 Where listing limitations or installation instructions differ from the requirements of this standard, the listing limitations and installation instructions shall apply.

10.2.2 All fittings used in private fire service mains shall be rated for the maximum system working pressure to which the fittings are exposed, but shall not be rated at less than 150 psi (10.3 bar).

10.2.3 Where fittings installed in a private fire service main must be installed above grade, the fittings shall conform to NFPA 13.

10.2.3.1 Fittings in accordance with 10.2.1 shall be permitted for the transition to the above ground piping or fittings.

10.3 Connection of Pipe, Fittings, and Appurtenances.

10.3.1* Connection of all fittings and appurtenances to piping shall be in accordance with Section 10.3.

10.3.2 Connections of pipe and fittings indicated in Table 10.1.1.1 and Table 10.2.1.1 shall be in accordance with the referenced standard in the table.

10.3.3 Listed Connections. Connections utilizing listed products shall be in accordance with the listing limitations and the manufacturer's installation instructions.

10.3.3.1 Where listing limitations or installation instructions differ from the requirements of this standard, the listing limitations and installation instructions shall apply.

10.3.4 Threaded Pipe and Fittings. Where pipe, fittings, or appurtenances are connected using threads, all threads shall be in accordance with ASME B1.20.1, *Pipe Threads, General Purpose, Inch*.

10.3.5 Grooved Connections. Where pipe, fittings, or appurtenances are connected using grooves, they shall be connected in accordance with 10.3.5.1 through 10.3.5.3.

10.3.5.1 Pipe, fittings, and appurtenances to be joined with grooved couplings shall contain cut, rolled, or cast grooves that are dimensionally compatible with the couplings.

Δ **Table 10.2.1.1 Fittings Materials and Dimensions**

Materials and Dimensions	Standard
Cast Iron	
Gray iron threaded fittings, classes 125 and 250	ASME B16.4
Gray iron pipe flanges and flanged fittings, classes 25, 125, and 250	ASME B16.1
Ductile Iron	
Ductile-iron and gray-iron fittings	AWWA C110/A21.10
Ductile-iron compact fittings	AWWA C153/A21.53
Malleable Iron	
Malleable iron threaded fittings, classes 150 and 300	ASME B16.3
Copper	
Wrought copper and copper alloy solder joint pressure fittings	ASME B16.22
Cast copper alloy solder joint pressure fitting	ASME B16.18
Bronze Fittings	
Cast copper alloy threaded fittings, classes 125 and 250	ASME B16.15
Stainless Steel	
Wrought austenitic stainless steel pipe fittings	ASTM A403/A403M

10.3.5.2 Pipe, fittings, and appurtenances that are connected with grooved couplings and are part of a listed assembly shall be permitted to be used.

10.3.5.3* Pipe joined with grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves.

N **10.3.6 Connection of Plain End Pipe.** Plain end pipe, fittings, and appurtenances joined with couplings shall be joined by a listed combination of fittings, gaskets, and couplings.

10.3.7 Copper Tube. All joints for the connection of copper tube shall be brazed or joined using pressure fittings as specified in Table 10.2.1.1.

10.4 Protection of Private Fire Service Mains.

10.4.1 Protection from Corrosion.

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

10.4.1.2 The requirements of 10.4.1.1 shall not apply to stainless steel or epoxy-coated fittings, valves, glands, or other accessories.

10.4.1.3* 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.

10.4.2* Protection of Piping.

10.4.2.1 Protection from Freezing. The depth of cover for private fire service mains and their appurtenances to protect against freezing shall be in accordance with 10.4.2.

10.4.2.1.1* The top of the pipe shall be buried not less than 12 in. (300 mm) below the frost line for the locality.

10.4.2.1.2 The depth of piping shall be measured from the top of the piping to the final grade.

10.4.2.1.3 Where listed piping is used and the bury depth differs from this standard, the listing limitations shall apply.

10.4.2.1.4 Where private fire service mains are installed above ground, they shall be protected from freezing in accordance with NFPA 13.

10.4.2.1.5 Private fire service mains installed in water raceways or shallow streams shall be installed so that the piping will remain in the running water throughout the year.

10.4.2.1.6 Where piping is installed adjacent to a vertical face, it shall be installed from the vertical face at the same distance as if the piping were buried.

10.4.2.1.7 Protection of private fire service mains from freezing using heat tracing shall be permitted when the heat tracing is specifically listed for underground use.

10.4.2.1.7.1 Heat tracing not listed for underground use shall be permitted when piping is installed in accordance with 10.1.4.

10.4.2.2 Protection from Mechanical Damage. The depth of cover for private fire service mains and their appurtenances to protect against mechanical damage shall be in accordance with 10.4.2.2.

10.4.2.2.1 The depth of piping shall be measured from the top of the piping to the final grade.

10.4.2.2.2 In locations where freezing is not a factor, the depth of cover shall not be less than 30 in. (750 mm) below grade to prevent mechanical damage.

10.4.2.2.2.1 Where listed piping is used and the bury depth differs from this standard, the listing limitations shall apply.

10.4.2.2.3 Private fire service mains installed under driveways or roadways shall be buried at a minimum depth of 36 in. (900 mm).

10.4.2.2.3.1 Sidewalks, walkways, and other paved or concrete pedestrian passageways shall not be required to comply with 10.4.2.2.3.

10.4.2.2.4 Private fire service mains installed under railroad tracks shall be buried at a minimum depth of 4 ft (1.2 m).

10.4.2.2.4.1 Where railroad operators require a greater depth of bury, the greater depth shall apply.

10.4.2.2.5 Private fire service mains installed under large piles of heavy commodities or subject to heavy shock and vibrations shall be buried at a minimum depth of 4 ft (1.2 m).

10.4.3 Private Fire Service Mains Beneath Buildings. Except as permitted by 10.4.3, private fire service mains shall not be installed beneath buildings.

10.4.3.1* Private fire service mains supplying fire protection systems within the building shall be permitted to extend horizontally no more than 10 ft (3.0 m) cumulatively, as measured from the outside of the building, under the building to the riser location.

10.4.3.1.1* Pipe joints shall not be located directly under foundation footings.

10.4.3.1.2* Piping shall be installed a minimum of 12 in. (300 mm) below the bottom of building foundations or footers.

10.4.3.1.2.1 The requirements of 10.4.3.1.2 shall not apply when the piping is sleeved with an approved material.

10.4.3.2* Private fire service mains shall not be permitted to extend more than 10 ft (3 m) under the building except as allowed in 10.4.3.2.1.

10.4.3.2.1* Where private fire service mains extend more than 10 ft (3 m) into the building, they shall be run in a covered trench.

10.4.3.2.1.1* The trench shall be accessible from within the building.

10.4.3.2.1.2 The trench shall have rigid walls and a base.

10.4.3.2.1.3 The trench shall be constructed of noncombustible materials.

10.4.3.2.1.4* Provisions for draining water shall be provided for the trench.

10.4.3.2.1.5 Where the piping in the trench is installed under foundations or footers, clearance shall be provided in accordance with 10.4.3.1.2 or 10.4.3.1.2.1.

10.4.3.2.2 Piping in the trench shall be permitted to be in accordance with 10.1.1.

10.4.3.2.2.1 Aboveground piping in accordance with NFPA 13 shall be permitted to be used.

10.4.3.2.2.2 Where piping installed in the trench is in accordance with 10.1.1, all joints shall be restrained in accordance with 10.6.2 or 10.6.3.

10.4.3.2.3* Where piping is installed in a trench as permitted by 10.4.3.2.1, a valve shall be provided where the underground piping enters the trench.

10.4.3.2.4 When piping is installed in a trench, bury depths of 10.4.2.2 shall not apply.

10.4.3.2.4.1 Piping in the trench shall be protected from freezing in accordance with 10.4.2.1.4.

10.5 Grounding and Bonding.

10.5.1* In no case shall the underground piping be used as a grounding electrode for electrical systems.

10.5.1.1* The requirement of 10.5.1 shall 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.

10.6* Restraint. Private fire service mains shall be restrained against movement at changes in direction in accordance with 10.6.1, 10.6.2, or 10.6.3.

10.6.1* Thrust Blocks.

10.6.1.1 Thrust blocks shall be permitted where soil is stable and capable of resisting the anticipated thrust forces.

N **10.6.1.1.1** The anticipated thrust forces shall be based on the test pressure.

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

10.6.1.3 Thrust blocks shall be placed between undisturbed earth and the fitting to be restrained and shall be capable of resisting the calculated thrust forces.

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

10.6.2* Restrained Joint Systems. Private fire service mains using restrained joint systems shall include one or more of the following:

(1) Listed locking mechanical or push-on joints
(2) Listed mechanical joints utilizing setscrew retainer glands
(3) Listed bell joint restraints
(4) Bolted flange joints
(5) Pipe clamps and tie rods in accordance with 10.6.2.1
(6) Other approved methods or devices

10.6.2.1* Sizing Clamps, Rods, Bolts, and Washers.

10.6.2.1.1 Clamps.

10.6.2.1.1.1 Clamps shall have the following dimensions:

(1) ½ in. × 2 in. (13 mm × 50 mm) for 4 in. (100 mm) to 6 in. (150 mm) pipe
(2) ⅝ in. × 2½ in. (16 mm × 65 mm) for 8 in. (200 mm) to 10 in. (250 mm) pipe
(3) ⅝ in. × 3 in. (16 mm × 75 mm) for 12 in. (300 mm) pipe

10.6.2.1.1.2 The diameter of a bolt hole shall be ⅛ in. (3 mm) larger than that of the corresponding bolt.

10.6.2.1.2 Rods.

10.6.2.1.2.1 Rods shall be not less than ⅝ in. (16 mm) in diameter.

10.6.2.1.2.2 Table 10.6.2.1.2.2 provides the numbers of various diameter rods that shall be used for a given pipe size.

10.6.2.1.2.3 Where using bolting rods, the diameter of mechanical joint bolts shall limit the diameter of rods to ¾ in. (20 mm).

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

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

10.6.2.1.2.6 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 AHJ.

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

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

(1) ⅝ in. (16 mm) for pipe 4 in. (100 mm), 6 in. (150 mm), and 8 in. (200 mm)
(2) ¾ in. (20 mm) for 10 in. (250 mm) pipe
(3) ⅞ in. (22 mm) for 12 in. (300 mm) pipe

10.6.2.1.4 Washers.

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

10.6.2.1.4.2 Cast iron washers shall have the following dimensions:

(1) ⅝ in. × 3 in. (16 mm × 75 mm) for 4 in. (100 mm), 6 in. (150 mm), 8 in. (200 mm), and 10 in. (250 mm) pipe
(2) ¾ in. × 3½ in. (20 mm × 90 mm) for 12 in. (300 mm) pipe

10.6.2.1.4.3 Steel washers shall have the following dimensions:

(1) ½ in. × 3 in. (13 mm × 75 mm) for 4 in. (100 mm), 6 in. (150 mm), 8 in. (200 mm), and 10 in. (250 mm) pipe
(2) ½ in. × 3.5 in. (13 mm × 90 mm) for 12 in. (300 mm) pipe

Δ **Table 10.6.2.1.2.2 Rod Number — Diameter Combinations**

Nominal Pipe Size		⅝ in.	¾ in.	⅞ in.	1 in.
in.	mm	(16 mm)	(20 mm)	(22 mm)	(25 mm)
4	100	2	—	—	—
6	150	2	—	—	—
8	200	3	2	—	—
10	250	4	3	2	—
12	300	6	4	3	2
14	350	8	5	4	3
16	400	10	7	5	4

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

10.6.2.1.4.4 The diameter of holes shall be $\frac{1}{8}$ in. (3 mm) larger than that of bolts or rods.

10.6.2.2 Sizes of Restraint Straps for Tees.

10.6.2.2.1 Restraint straps for tees shall have the following dimensions:

(1) $\frac{5}{8}$ in. (16 mm) thick and $2\frac{1}{2}$ in. (65 mm) wide for 4 in. (100 mm), 6 in. (150 mm), 8 in. (200 mm), and 10 in. (250 mm) pipe
(2) $\frac{5}{8}$ in. (16 mm) thick and 3 in. (75 mm) wide for 12 in. (300 mm) pipe

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

10.6.2.2.3 Figure 10.6.2.2.3 and Table 10.6.2.2.3 shall be used in sizing the restraint straps for both mechanical and push-on joint tee fittings.

10.6.2.3 Sizes of Plug Strap for Bell End of Pipe.

10.6.2.3.1 The strap shall be $\frac{3}{4}$ in. (20 mm) thick and $2\frac{1}{2}$ in. (65 mm) wide.

10.6.2.3.2 The strap length shall be the same as dimension *A* for tee straps as shown in Figure 10.6.2.2.3.

10.6.2.3.3 The distance between the centers of rod holes shall be the same as dimension *B* for tee straps as shown in Figure 10.6.2.2.3.

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

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

10.6.2.5.1 The requirements of 10.6.2.5 shall not apply to stainless steel or epoxy-coated fittings, valves, glands, or other accessories.

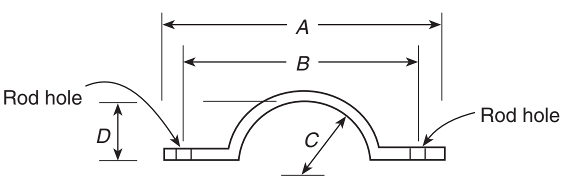

FIGURE 10.6.2.2.3 Restraint Straps for Tees.

10.6.3* Private fire service mains utilizing one or more of the following connection methods shall not require additional restraint, provided that such joints can pass the hydrostatic test of 10.10.2.2 without shifting of piping:

(1) Threaded connections
(2) Grooved connections
(3) Welded connections
(4) Heat-fused connections
(5) Chemical or solvent cemented connections

10.7 Steep Grades.

10.7.1 On steep grades, mains shall be additionally restrained to prevent slipping.

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

10.7.1.1.1 The restraint specified in 10.7.1.1 shall be to natural rock or to piles or piers built on the downhill side of the bell.

10.7.1.2 Bell ends shall be installed facing uphill.

10.7.1.3 Straight runs on hills shall be restrained as determined by a design professional.

10.8 Installation Requirements.

10.8.1 Piping, valves, hydrants, gaskets, and fittings shall be inspected for damage when received and shall be inspected prior to installation.

10.8.2 The tightness of bolted joints shall be verified by the bolt torque or by the method described in the listing information or manufacturer's installation instructions.

10.8.3 Pipe, valves, hydrants, and fittings shall be clean and free from internal debris.

10.8.4 When work is stopped, the open ends of piping, valves, hydrants, and fittings shall be plugged or covered to prevent foreign materials from entering.

10.8.5 All piping, fittings, valves, and hydrants shall be examined for cracks or other defects while suspended above the trench and lowered into the trench using equipment designed for such use.

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

10.8.7 Piping, fittings, valves, hydrants, and appurtenances shall not be dropped, dumped or rolled or skidded against other materials.

Table 10.6.2.2.3 Restraint Straps for Tees

Nominal Pipe Size		A		B		C		D	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
4	100	$12\frac{1}{2}$	315	$10\frac{1}{8}$	255	$2\frac{1}{2}$	65	$1\frac{3}{4}$	45
6	150	$14\frac{1}{2}$	365	$12\frac{1}{8}$	305	$3\frac{9}{16}$	90	$2\frac{13}{16}$	70
8	200	$16\frac{3}{4}$	420	$14\frac{3}{8}$	360	$4\frac{21}{32}$	115	$3\frac{29}{32}$	100
10	250	$19\frac{1}{16}$	475	$16\frac{11}{16}$	415	$5\frac{3}{4}$	145	5	125
12	300	$22\frac{5}{16}$	560	$19\frac{3}{16}$	480	$6\frac{3}{4}$	170	$5\frac{7}{8}$	145

10.8.8 Pipes shall be supported in the trench throughout their full length and shall not be supported by the bell ends only or by blocks.

10.8.9 If the ground is soft, other means shall be provided to support the pipe.

10.8.10 Valves and fittings used with nonmetallic pipe shall be supported and restrained in accordance with the manufacturer's installation instructions.

10.9 Backfilling.

10.9.1 Backfill material shall be tamped in layers or in puddles 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 Backfill material shall not contain ash, cinders, refuse, organic matter or other corrosive materials.

10.9.3* In the absence of specific guidelines or specifications, the maximum allowable particle size for backfill within 1 ft (300 mm) of the pipe shall not be larger than 1½ in. (40 mm).

10.9.3.1 Nominal pipe sizes of 4 in. (100 mm) or smaller shall not exceed ½ in. (13 mm) maximum particle size.

10.9.3.2 Nominal pipe sizes of 6 in. to 12 in. (150 mm to 300 mm) shall not exceed ¾ in. (19 mm) maximum particle size.

10.9.4 Frozen earth shall not be used as backfill material.

10.9.5 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 (600 mm) above the pipe.

10.9.6 Where using piping listed for private fire service mains, the manufacturer's installation instructions for backfill shall be followed.

10.10 Testing and Acceptance.

10.10.1 Approval of Underground Piping.

10.10.1.1 The installing contractor shall be responsible for the following:

(1) Notifying the AHJ 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 a contractor's material and test certificate(s) shown in Figure 10.10.1.1

10.10.1.2 Alternate forms or electronic records providing at minimum the required information found in Figure 10.10.1.1 shall be permitted.

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, including all hydrants, 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 continue until water flow is verified to be clear of debris.

10.10.2.1.3* The minimum rate of flow shall be in accordance with Table 10.10.2.1.3.

10.10.2.1.3.1 Where the flow rates established in Table 10.10.2.1.3 are not attainable, the allowable flow rate at the minimum allowable residual pressure to the system shall be acceptable.

Δ **10.10.2.1.3.2** When connected to a fire pump, piping shall be flushed at a flow rate not less than indicated in Table 10.10.2.1.3.2 or at the hydraulically calculated water demand rate of the system, whichever is greater.

N **(A)** Flushing shall occur prior to hydrostatic test. [**20:**14.1.1.2]

N **(B)** Where the maximum flow available from the water supply cannot provide the flow rate provided in Table 10.10.2.1.3.2, the flushing flow rate shall be equal to or greater than 150 percent of rated flow of the connected fire pump. [**20:**14.1.1.3]

N **(C)** Where the maximum flow available from the water supply cannot provide a flow of 150 percent of the rated flow of the pump, the flushing flow rate shall be the greater of 100 percent of rated flow of the connected fire pump or the maximum flow demand of the fire protection system. [**20:**14.1.1.3.1]

N **(D)** A reduced flushing flow capacity in accordance with Table 10.10.2.1.3.2 shall constitute an acceptable test, provided that the flow rate is as much as can be safely achieved and it exceeds the fire protection system design flow rate. [**20:**14.1.1.3.2]

10.10.2.1.4* In lieu of flushing with the waterflow rates prescribed in 10.10.2.1.3 and 10.10.2.1.3.1, water main cleaning of the piping by the forceful introduction of swabs through the pipe shall be permitted.

10.10.2.1.4.1 Water main swabbing shall be repeated, as necessary, until the last swab that has fully penetrated the pipe is clean and the discharge water is clear.

10.10.2.1.5 Provision shall be made for the disposal of water used for flushing or testing to minimize any water damage caused by the discharge.

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 gauge pressure of 200 psi (14 bar) or 50 psi (3.4 bar) in excess of the system working pressure, whichever is greater, and shall maintain that pressure at gauge pressure of ±5 psi (0.3 bar) for 2 hours.

10.10.2.2.2 Successful test results shall be determined by indication of either a pressure loss less than gauge pressure of 5 psi (0.3 bar) or by no 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* The trench shall be backfilled between joints before testing to prevent movement of pipe.

10.10.2.2.5 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.

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 contractor. 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.

Property name		Date	
Property address			
Plans	Accepted by approving authorities (names)		
	Address		
	Installation conforms to accepted plans	❑ Yes	❑ No
	Equipment used is approved If no, state deviations	❑ Yes	❑ No
Instructions	Has person in charge of fire equipment been instructed as to location of control valves and care and maintenance of this new equipment? If no, explain	❑ Yes	❑ No
	Have copies of appropriate instructions and care and maintenance charts been provided to the owner or owner's representative? If no, explain	❑ Yes	❑ No
Location	Supplies buildings		
Underground pipes and joints	Pipe types and class	Type joint	
	Pipe conforms to ____________ standard	❑ Yes	❑ No
	Fittings conform to ____________ standard If no, explain	❑ Yes	❑ No
	Joints needing anchorage clamped, strapped, or blocked in accordance with ____________ standard If no, explain	❑ Yes	❑ No

Test description

Flushing: Flow the required rate until water is verified to be clear of debris at outlets such as hydrants and blow-offs. Flush at one of the flow rates as specified in 10.10.2.1.3.

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 (0.34 bar) 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 equation, see 10.10.2.2.6):

$$L = \frac{SD\sqrt{P}}{148{,}000}$$

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

Flushing tests

New underground piping flushed according to ____________ standard by (company) If no, explain		❑ Yes	❑ No
How flushing flow was obtained ❑ Public water ❑ Tank or reservoir ❑ Fire pump	Through what type opening ❑ Hydrant butt ❑ Open pipe		
Lead-ins flushed according to ____________ standard by (company) If no, explain		❑ Yes	❑ No
How flushing flow was obtained ❑ Public water ❑ Tank or reservoir ❑ Fire pump	Through what type opening ❑ Y connection to flange and spigot ❑ Open pipe		

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Δ FIGURE 10.10.1.1 Sample of Contractor's Material and Test Certificate for Underground Piping.

<table>
<tr><td rowspan="1">Hydrostatic test</td><td colspan="2">All new underground piping hydrostatically tested at
________ psi (bar) for ________ hours</td><td>Joints covered
❑ Yes ❑ No</td></tr>
<tr><td rowspan="2">Leakage test</td><td colspan="3">Total amount of leakage measured
________ gallons (liters) ________ hours</td></tr>
<tr><td colspan="3">Allowable leakage
________ gallons (liters) ________ hours</td></tr>
<tr><td>Forward flow test of backflow preventer</td><td colspan="3">Forward flow test performed in accordance with 10.10.2.6.2:
❑ Yes ❑ No</td></tr>
<tr><td>Hydrants</td><td>Number installed</td><td>Type and make</td><td>All operate satisfactorily
❑ Yes ❑ No</td></tr>
<tr><td rowspan="2">Control valves</td><td colspan="3">Water control valves left wide open ❑ Yes ❑ No
If no, state reason</td></tr>
<tr><td colspan="3">Hose threads of fire department connections and hydrants interchangeable with those of fire department answering alarm ❑ Yes ❑ No</td></tr>
<tr><td rowspan="3">Remarks</td><td colspan="3">Date left in service</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="4">Signatures</td><td colspan="3">Name of installing contractor</td></tr>
<tr><td colspan="3">Tests witnessed by</td></tr>
<tr><td>For property owner (signed)</td><td>Title</td><td>Date</td></tr>
<tr><td>For installing contractor (signed)</td><td>Title</td><td>Date</td></tr>
<tr><td colspan="4">Additional explanation and notes

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</table>

Δ **FIGURE 10.10.1.1** ***Continued***

Table 10.10.2.1.3 Flow Required to Produce Velocity of 10 ft/sec (3.0 m/sec) in Pipes

Nominal Pipe Size (in.)	Flow Rate (gpm)	Nominal Pipe Size (mm)	Flow Rate (L/min)
2	100	50	380
2½	150	65	570
3	220	75	833
4	390	100	1,500
5	610	125	2,300
6	880	150	3,350
8	1,560	200	5,900
10	2,440	250	9,250
12	3,520	300	13,300

N **Table 10.10.2.1.3.2 Minimum Flow Rates for Flushing Suction Piping**

Nominal Pipe Size (in.)	Flow rate (gpm)	Nominal Pipe Size (mm)	Flow Rate (L/min)
1	37	25	140
1½	85	38	330
2	150	50	570
2½	229	65	870
3	330	75	1,250
3½	450	85	1,710
4	590	100	2,240
5	920	125	3,490
6	1,360	150	5,150
8	2,350	200	8,900
10	3,670	250	13,900
12	5,290	300	20,100
14	7,200	350	27,300
16	9,400	400	35,600

[**20:**Table 14.1.1.1]

Δ **10.10.2.2.6* 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 10.10.2.2.6, which are based upon the following equations:

US Customary Units:

[10.10.2.2.6a]

$$L = \frac{SD\sqrt{P}}{148{,}000}$$

where:
L = testing allowance (makeup water) [gph (gal/hr)]
S = length of pipe tested (ft)
D = nominal diameter of pipe (in.)
P = average test pressure during hydrostatic test (gauge psi)

Metric Units:

[10.10.2.2.6b]

$$L = \frac{SD\sqrt{P}}{794{,}797}$$

where:
L = testing allowance (makeup water) (L/hr)
S = length of pipe tested (m)
D = nominal diameter of pipe (mm)
P = average test pressure during hydrostatic test (kPa)

10.10.2.3* Other Means of Hydrostatic Tests. Where acceptable to the AHJ, hydrostatic tests shall be permitted to be completed in accordance with the guidelines provided in AWWA C600, *Installation of Ductile-Iron Water Mains and Their Appurtenances*; AWWA M9, *Concrete Pressure Pipe*; AWWA M23, *PVC Pipe — Design and Installation*; or AWWA M55, *PE Pipe — Design and Installation*; as long as the test pressure and test duration requirements of 10.10.2.2.1 are still employed.

10.10.2.3.1* For existing system modifications or repairs that cannot be isolated, hydrostatic testing shall be limited to visual evidence of leakage at system working pressure.

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 drainage.

10.10.2.4.3 All control valves shall be fully closed and opened under system water pressure to ensure operation.

10.10.2.4.4 Where fire pumps supply the private fire service main, the operating tests required by 10.10.2.4 shall be completed with the pumps running.

Table 10.10.2.2.6 Hydrostatic Testing Allowance at 200 psi (14 bar)

Nominal Pipe Diameter		Testing Allowance	
in.	mm	gal/hr/100 ft	L/hr/100 m
2	50	0.019	0.236
4	100	0.03	0.472
6	150	0.057	0.708
8	200	0.076	0.944
10	250	0.096	1.19
12	300	0.115	1.43
14	350	0.134	1.66
16	400	0.153	1.90
18	450	0.172	2.14
20	500	0.191	2.37
24	600	0.229	2.84

Notes:
(1) For other length, diameters, and pressures, utilize Equation 10.10.2.2.6a or 10.10.2.2.6b 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.

10.10.2.5 Backflow Prevention Assemblies.

10.10.2.5.1 The backflow prevention assembly shall be forward flow tested.

10.10.2.5.2 The minimum flow rate tested in 10.10.2.5.1 shall be the system demand, including hose stream demand where applicable.

Chapter 11 Hydraulic Calculations

11.1 Hydraulic Calculation Procedures. Hydraulic calculations of system piping where required shall be in accordance with NFPA 13.

11.2 Calculations in US Customary Units. Pipe friction losses shall be determined based on the Hazen–Williams formula, as follows:

[11.2]

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

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

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

[11.3]

$$p_m = 6.05\left(\frac{Q_m^{1.85}}{C^{1.85}d_m^{4.87}}\right)10^5$$

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 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
(2) Frostproof casings
(3) Other reliable means capable of maintaining a minimum temperature between 40°F and 120°F (4°C and 49°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.

12.2.7 Aboveground private fire service mains shall be protected with bollards or other means as approved by the AHJ when subject to mechanical damage.

Chapter 13 Sizes of Aboveground and Buried Pipe

13.1 Private Service Mains. Pipe smaller than 6 in. (150 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. (150 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) 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, based on the following:

(1) Construction and occupancy of the building or structure
(2) Fire flow and pressure of the water required
(3) Adequacy of the water supply

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 inspected, tested, and maintained in accordance with NFPA 25.

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.

Δ **A.1.1.3(3)** The installation of dry hydrants is covered in NFPA 1142.

N **A.1.4** Subsequent editions of NFPA standards are not always adopted as soon as they are published and could lag several code cycles before the new edition is referenced. Where a newer edition of this standard is published, that standard should be permitted to be used in its entirety.

A.1.5.3 Some dimensions used in this standard are exact and some are not. Nominal dimensions are often used, such as the dimensions used for pipe sizes. The metric equivalent shown in this standard might not be an exact conversion to the SI unit, but the nominal metric equivalent is typically used, or a reasonably equivalent value or approximate conversion is used.

Δ **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 or 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 standards in a broad manner because 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.3.3.3 Control Valve (Shutoff Valve). Control valves do not include drain valves, check valves, or relief valves.

A.3.3.12 Pressure-Regulating Device. Examples include pressure-reducing valves, pressure-control valves, and pressure-restricting devices.

A.3.3.13 Private Fire Service Main. See Figure A.3.3.13.

A.3.3.18.2 Indicating Valve. Examples are outside screw and yoke (OS&Y) gate valves, butterfly valves, and underground gate valves with indicator posts.

A.3.4.1.1 Dry Barrel Hydrant (Frostproof Hydrant). A drain is located at the bottom of the barrel above the control valve seat for proper drainage after operation.

A.3.4.1.3 Private Fire Hydrant. Where connected to a public water system, private hydrants are supplied by a private service main that begins at the point designated by the AHJ, usually at a manually operated valve near the property line.

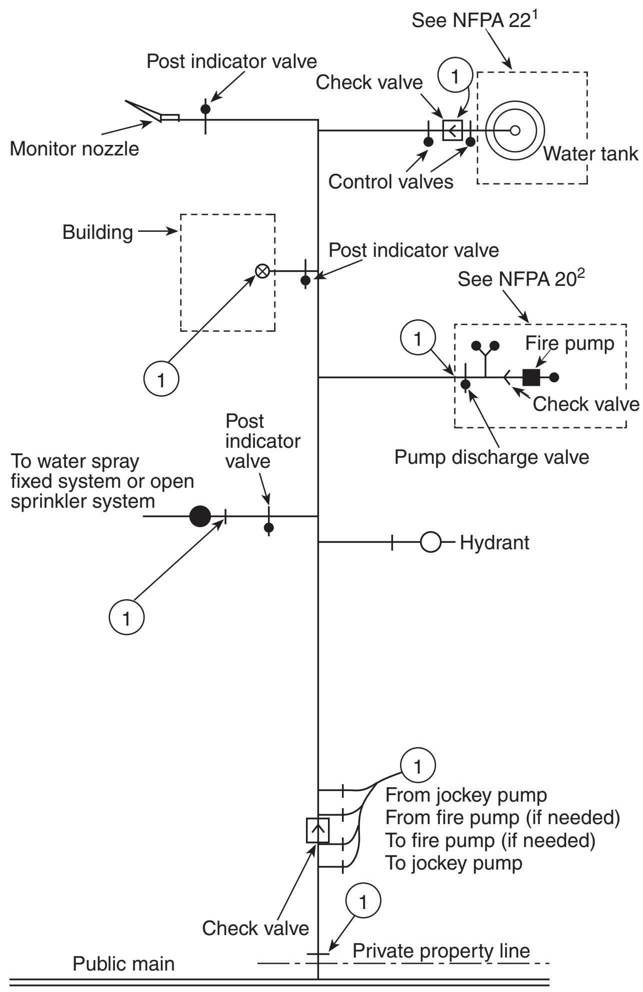


FIGURE A.3.3.13 Typical Private Fire Service Main.

A.4.1 Underground mains should be designed so that the system can be extended with a minimum of expense. Possible future expansion should also be considered and the piping designed so that it is not covered by future 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 utility to loop the mains to obtain a more reliable supply.

A.5.1.2 An adjustment to the waterflow test data to account for the following should 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

A.5.4 Where connections are made from public waterworks systems, such systems should be guarded against possible contamination as follows *(see AWWA M14, Backflow Prevention and Cross-Connection Control Recommended Practices, local plumbing code, or consult the local water purveyor)*:

(1) For private fire service mains with direct connections from public waterworks mains only or with fire 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, an approved double check valve assembly might be required by other codes or standards.
(2) For private fire service mains with direct connections 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 might be required by other codes or standards.
(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 might be required by other codes or standards.
(4) For private fire service mains with fire department connections located near a non-potable water source, an approved reduced-pressure zone-type backflow preventer might be required by other codes or standards.

A.5.4.2.1 In this instance, the AHJ might be the water purveyor, plumbing inspector, or public health official.

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

Δ **A.5.8.1** Intakes installed in surface water such as springs, creeks, lakes, and man-made reservoirs should be designed to protect against ice development. Still water (nonflowing) will freeze at the air/water interface and form sheet ice, reducing the total volume of available water for fire protection needs. Turbulent or flowing water can still have icing issues called frazil ice.

The density of water is at its highest at 39°F (4°C) causing any ice formations to float and not pose any potential danger to intakes below the surface. While ice can be present on the surface, warmer water can settle to the bottom of the reservoir. Circulating this warmer water can be another method of freeze protection. Further, submerged aeration systems whether by solar, wind, or commercial power can create a mixing effect and prevent freezing.

The effects of cold temperatures can be estimated by obtaining the freezing index of the local area. The freezing index can be used to estimate the thickness of ice using the following formula:

[A.5.8.1]

$$\text{Maximum ice thickness (in.)} = 1.42\sqrt{\text{freezing index }(°\text{C})}$$

For example a freezing index of 68 will result in: maximum ice thickness = $1.42\sqrt{68}$ = 11.7 in.

Therefore, an intake drawing water from a pond or lake in this locale should be deeper than 12 in. to remain free of any ice buildup during winter months.

For more information see the fact sheet "Winter Considerations, Ice Formation, Freezing Index, and Frost Penetration," Ministry of Agriculture and Lands, British Columbia.

A.5.9 The fire department connection should be located not less than 18 in. (450 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). Where a hydrant is not available, other water supply sources such as a natural body of water, a tank, or a 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.

A.5.9.3.2.1 Figure A.5.9.3.2.1(a) and Figure A.5.9.3.2.1(b) depict fire department connections to the underground pipe.

A.5.9.5.1 The requirement in 5.9.5.1 applies to fire department connections attached to underground piping. If the fire department connection is attached directly to a system riser, the requirements of the appropriate installation standard apply.

A.5.9.5.2 Obstructions to fire department connections include, but are not limited to, buildings, fences, posts, landscaping, other fire department connections, fire protection equipment, gas meters, and electrical equipment.

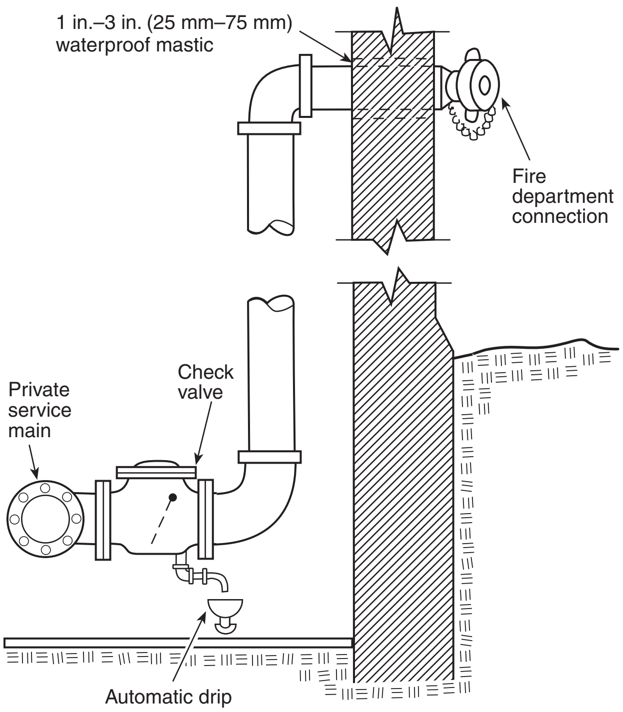


FIGURE A.5.9(a) Typical Fire Department Connection.

A.5.9.5.3(2) Examples for wording of signs are:

AUTOSPKR

OPEN SPKR STANDPIPE

STANDPIPE-SPRINKLER

DRY STANDPIPE

STANDPIPE-AUTO SPKR

A.6.1.1.3 A valve wrench with a long handle should be provided at a convenient location on the premises.

A.6.1.1.4 A connection to a municipal water supply can utilize a tapping sleeve and a nonlisted, nonindicating valve as the valve controlling the water supply.

A.6.2.2.2 See Figure A.6.2.2.2. For additional information on controlling valves, see NFPA 22.

A.6.2.5 For additional information on controlling valves, see NFPA 22.

A.6.2.6 For additional information on controlling valves, see NFPA 22.

A.6.2.7(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.6.2.8 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.6.2.9(1) Distances greater than 40 ft (12 m) are not required but can be permitted regardless of the building height.

A.6.2.9(4) Distances greater than 40 ft (12 m) are not required but can be permitted regardless of the building height.

A.6.2.9(5) Distances greater than 40 ft (12 m) are not required but can be permitted regardless of the building height.

A.6.6.1 Sectional valves are necessary to allow isolation of piping sections to limit the number of fire protection connections impaired in event of a break or to make repairs or extensions to the system. Fire protection connections can consist of sprinkler system lead-ins, hydrants, or other fire protection connections.

A.6.7.2 See Annex B.

A.7.1 For information regarding identification and marking of hydrants, see Annex D.

A.7.1.1.3 The flows required for private fire protection service mains are determined by system installation standards or fire codes. The impact of the number and size of hydrant outlets on the fire protection system demand is not addressed in this standard. The appropriate code or standard should be consulted for the requirements for calculating system demand.

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 AHJ 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.7.3.1 See Figure A.7.3.1.

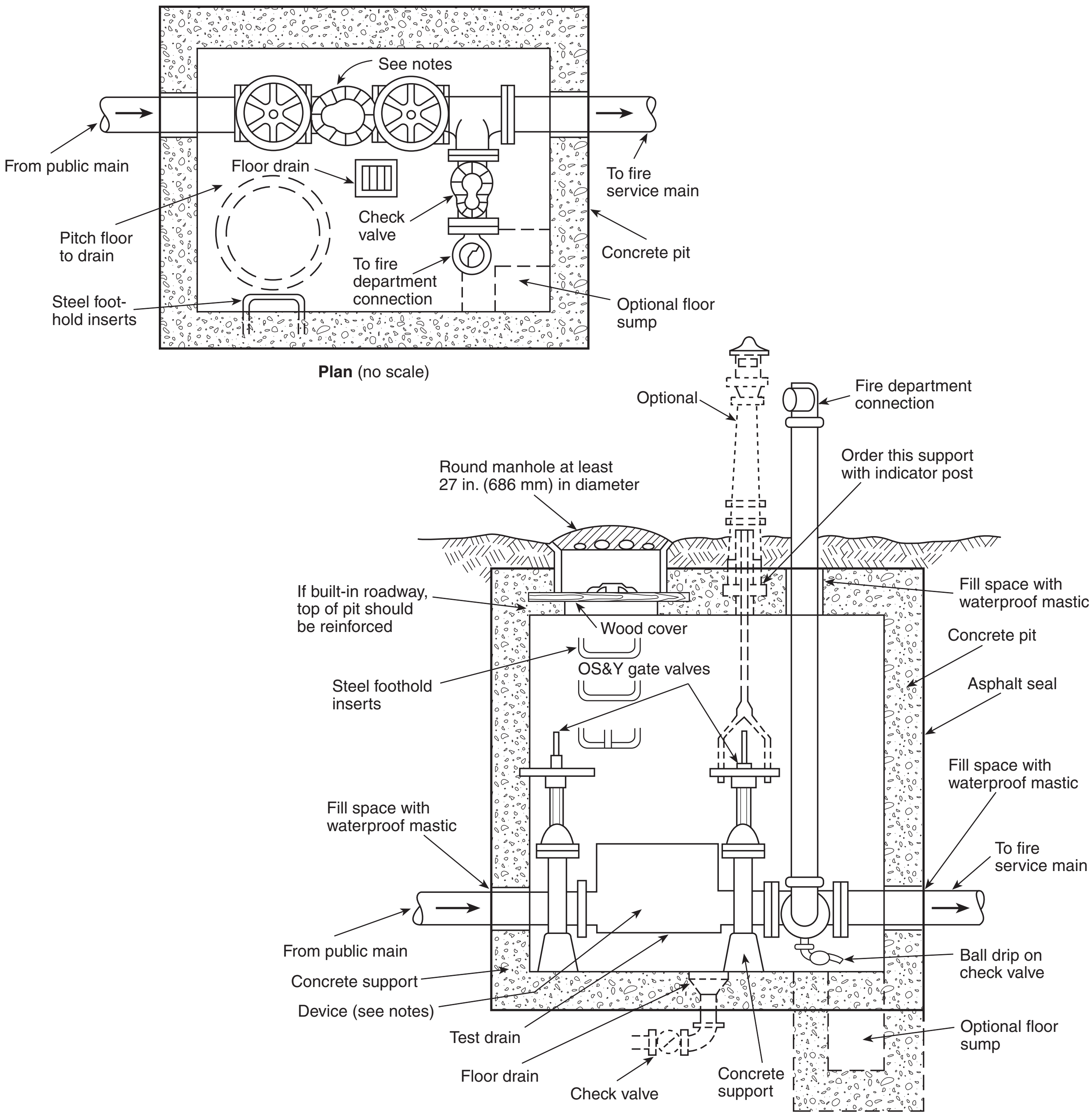
A.7.3.2.1.1 Hydrants with the drain plugged that are subject to freezing should be pumped out after usage to prevent potential damage to and inoperability of the hydrant.

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

N **A.7.3.3.3** The large diameter outlet, traditionally known as a “steamer” or “pumper” connection, should face the approved adjacent roadway, fire lane, fire access, or driveway intended for fire department response. Access to the large diameter outlet is vital to fire department response. Providing easy access allows for more timely fire suppression and extinguishment activities because a large diameter hose is difficult to maneuver and position.

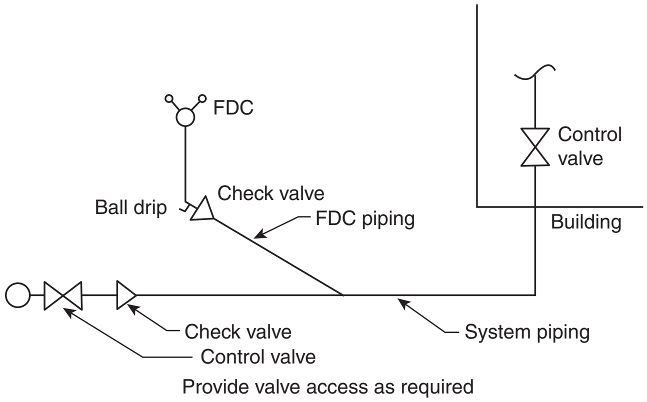
A.8.1.1 All hose should not be removed from a hose house for testing at the same time, since in the event of a fire the time taken to return the hose could allow a fire to spread beyond control. *(See NFPA 1962.)*

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 bar), double-jacketed hose should be considered.

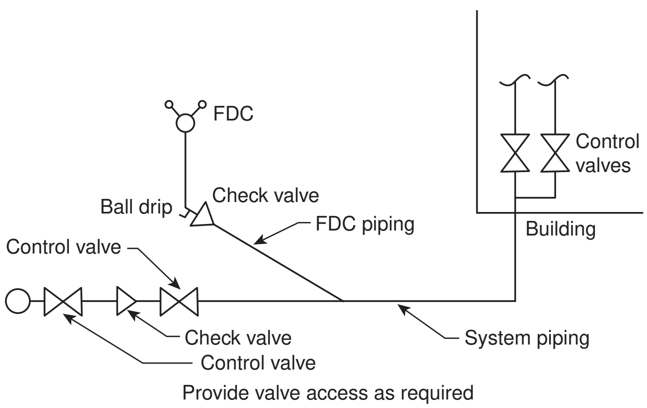


Notes:
1. Various backflow prevention regulations accept different devices at the connection between public water mains and private fire service mains.
2. The device shown in the pit could be any or a combination of the following:
   (a) Gravity check valve
   (b) Detector check valve
   (c) Double check valve assembly
   (d) Reduced-pressure zone (RPZ) device
   (e) Vacuum breaker
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.

FIGURE A.5.9(b) Typical City Water Pit — Valve Arrangement.



Δ FIGURE A.5.9.3.2.1(a) Fire Department Connection Connected to Underground Piping (Sample 1). [13:Figure A.16.12.5.5(a)]



Δ FIGURE A.5.9.3.2.1(b) Fire Department Connection Connected to Underground Piping (Sample 2). [13:Figure A.16.12.5.5(b)]

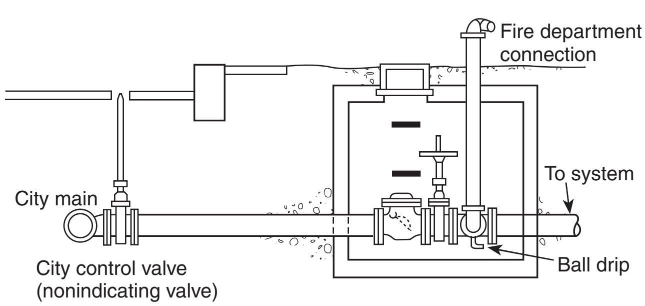


FIGURE A.6.2.2.2 Pit for Gate Valve, Check Valve, and Fire Department Connection.

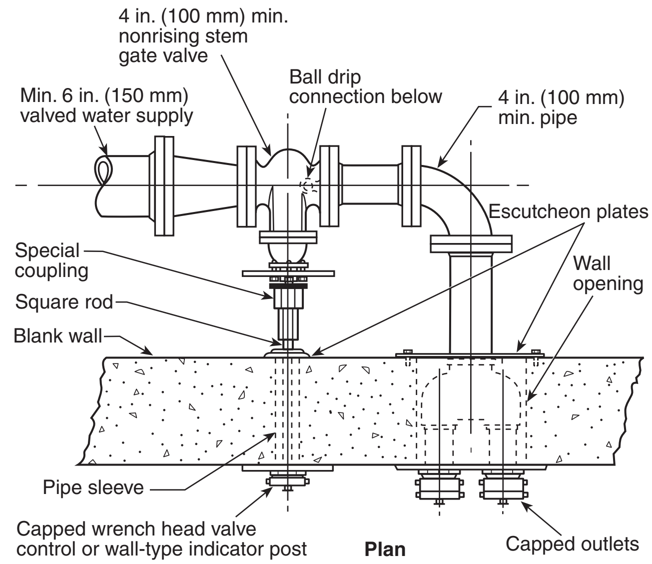
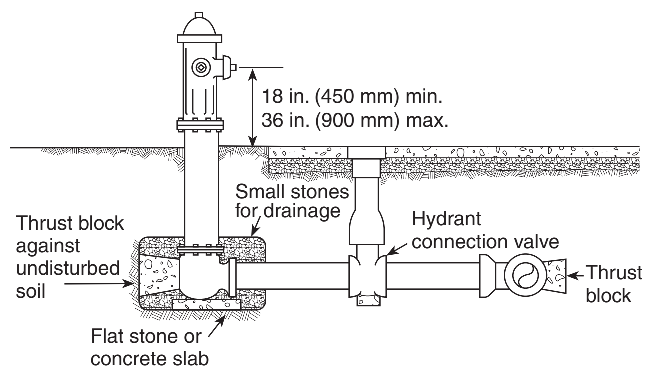


FIGURE A.7.2.3 Typical Wall Fire Hydrant Installation.



Δ FIGURE A.7.3.1 Typical Dry Barrel Hydrant Connection.

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

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.

Δ A.10.1 Copper tubing (Type K) with brazed joints conforming to Table 10.1.1.1 and Table 10.2.1.1 is acceptable for underground service.

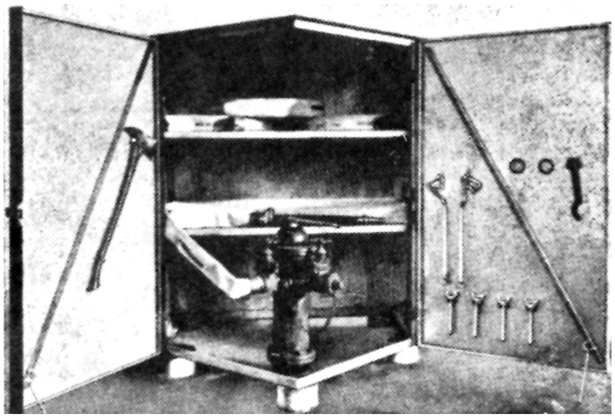


FIGURE A.8.4(a) Hose House of Five-Sided Design for Installation over Private Hydrant.

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

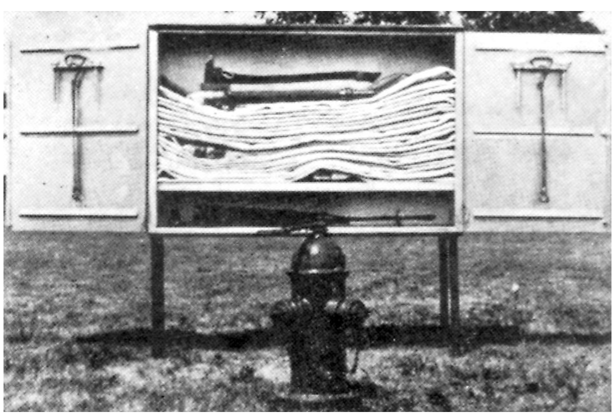


FIGURE A.8.4(c) Hose House That Can Be Installed on Legs, or Installed on Wall Near, but Not Directly Over, Private Hydrant.

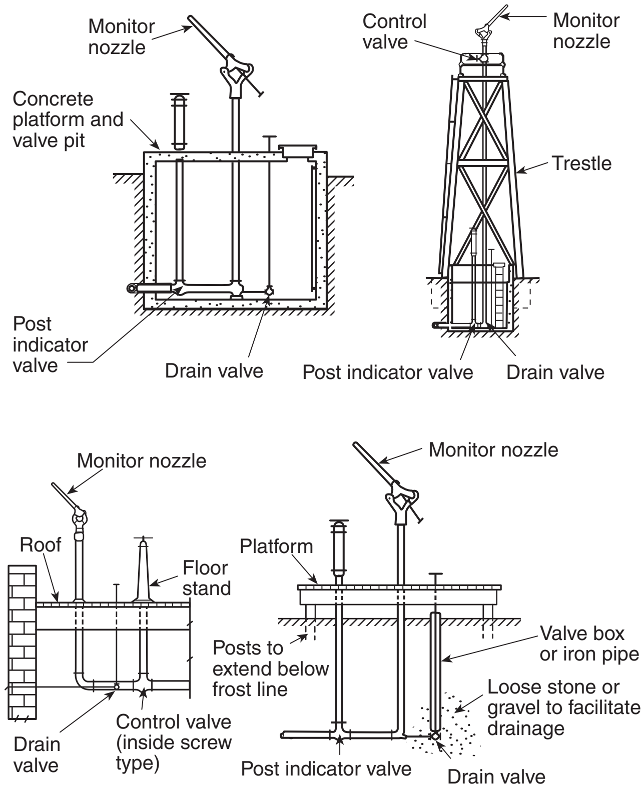


FIGURE A.9.1(a) Standard Monitor Nozzles.

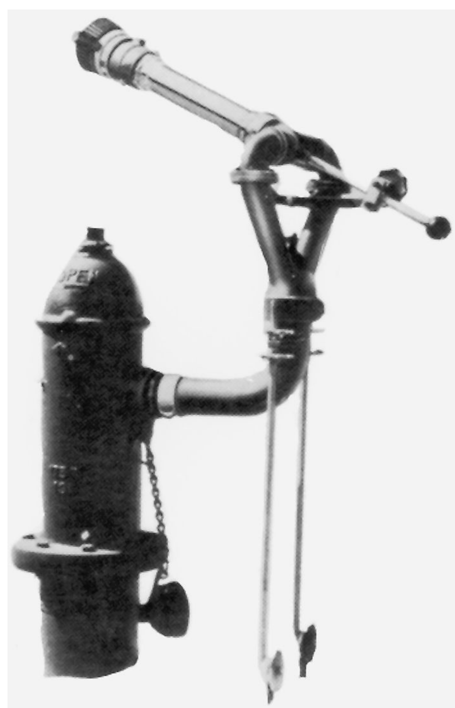


FIGURE A.9.1(b) Typical Hydrant-Mounted Monitor Nozzle.

Listing and *labeling*. Certification organizations list or label the following:

(1) Cast iron and ductile iron pipe (cement-lined and unlined, coated and uncoated)
(2) Steel pipe
(3) Copper pipe
(4) Fiberglass filament-wound epoxy pipe and couplings
(5) Polyethylene pipe
(6) Polyvinyl chloride (PVC) pipe and couplings
(7) Reinforced concrete pipe (cylinder pipe, nonprestressed and prestressed)

A.10.1.1 The type and class of pipe for a particular underground installation should be determined through consideration of the following factors:

(1) Maximum system working pressure
(2) Maximum pressure from pressure surges and anticipated frequency of surges
(3) Depth at which the pipe is to be installed
(4) Soil conditions
(5) Corrosion
(6) Susceptibility of pipe to external loads, including earth loads, installation beneath buildings, and traffic or vehicle loads

The following pipe design manuals and standards can be used as guides:

(1) AWWA C150/A21.50, *Thickness Design of Ductile-Iron Pipe*
(2) AWWA M23, *PVC Pipe — Design and Installation*
(3) AWWA M55, *PE Pipe — Design and Installation*
(4) AWWA M41, *Ductile-Iron Pipe and Fittings*
(5) *Concrete Pipe Handbook*, American Concrete Pipe Association

A.10.1.2 For underground system components, a minimum system pressure rating of 150 psi (10 bar) is specified in 10.1.2, based on satisfactory historical performance. Also, this pressure rating reflects that of the components typically used underground, such as piping, valves, and fittings. Where system pressures are expected to exceed pressures of 150 psi (10.3 bar), system components and materials manufactured and listed for higher pressures should be used. Systems that do not incorporate a fire pump or are not part of a combined standpipe system do not typically experience pressures exceeding 150 psi (10.3 bar) in underground piping. However, each system should be evaluated on an individual basis. It is not the intent of this section to include the pressures generated through fire department connections as part of the maximum working pressure.

A.10.1.3 See Table A.10.1.3.

A.10.1.4 Where nonmetallic underground piping is provided above grade or inside a building, the following should be considered:

(1) Exposure from direct rays of sunlight
(2) Compatibility with chemicals such as floor coatings and termiticides/insecticides
(3) Support of piping and appurtenances attached thereto (e.g., sprinkler risers, backflow preventers)

A.10.3.1 The following standards apply to joints used with the various types of pipe:

(1) ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*
(2) AWWA C111/A21.11, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*
(3) AWWA C115/A21.15, *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.10.3.5.3 Fittings and couplings are listed for specific pipe materials that can be installed underground. Fittings and couplings do not necessarily indicate that they are listed specifically for underground use.

A.10.4.1.3 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/A21.5, *Polyethylene Encasement for Ductile-Iron Pipe Systems*.

A stainless steel in-building riser can connect to dissimilar metallic materials such as ductile iron or black steel. The product performance of many installations has not reported any instances of system failures or corrosion.

A.10.4.2 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.10.4.2.

In determining the need to protect aboveground piping from freezing, the lowest mean temperature should be considered.

A.10.4.2.1.1 Consideration should be given to the type of soil and the possibility of settling. Also, many times the inspection of the piping might occur before final grading and fill of the installation is complete. The final grade should be verified.

A.10.4.3.1 The intent of this section is to limit the total length of horizontal pipe beneath the building to not more than 10 ft (3 m). See Figure A.10.4.3.1.

A.10.4.3.1.1 The individual piping standards should be followed for load and bury depth, accounting for the load and stresses imposed by the building foundation.

A.10.4.3.1.2 Sufficient clearance should be provided when piping passes beneath foundations or footers.

A.10.4.3.2 The design concepts in 10.4.3.2.1 through 10.4.3.2.4 should apply to both new installations and existing private fire service mains approved to remain under new buildings.

A.10.4.3.2.1 See Figure A.10.4.3.2.1.

A.10.4.3.2.1.1 A grate or steel plate are common methods of accessing the trench.

A.10.4.3.2.1.4 The intent of this requirement is to prevent the piping from being exposed to standing water. Draining can be accomplished by providing a floor drain, sloping of the trench, or other approved method.

Δ Table A.10.1.3 Internal Diameters (IDs) for Cement-Lined Ductile Iron Pipe

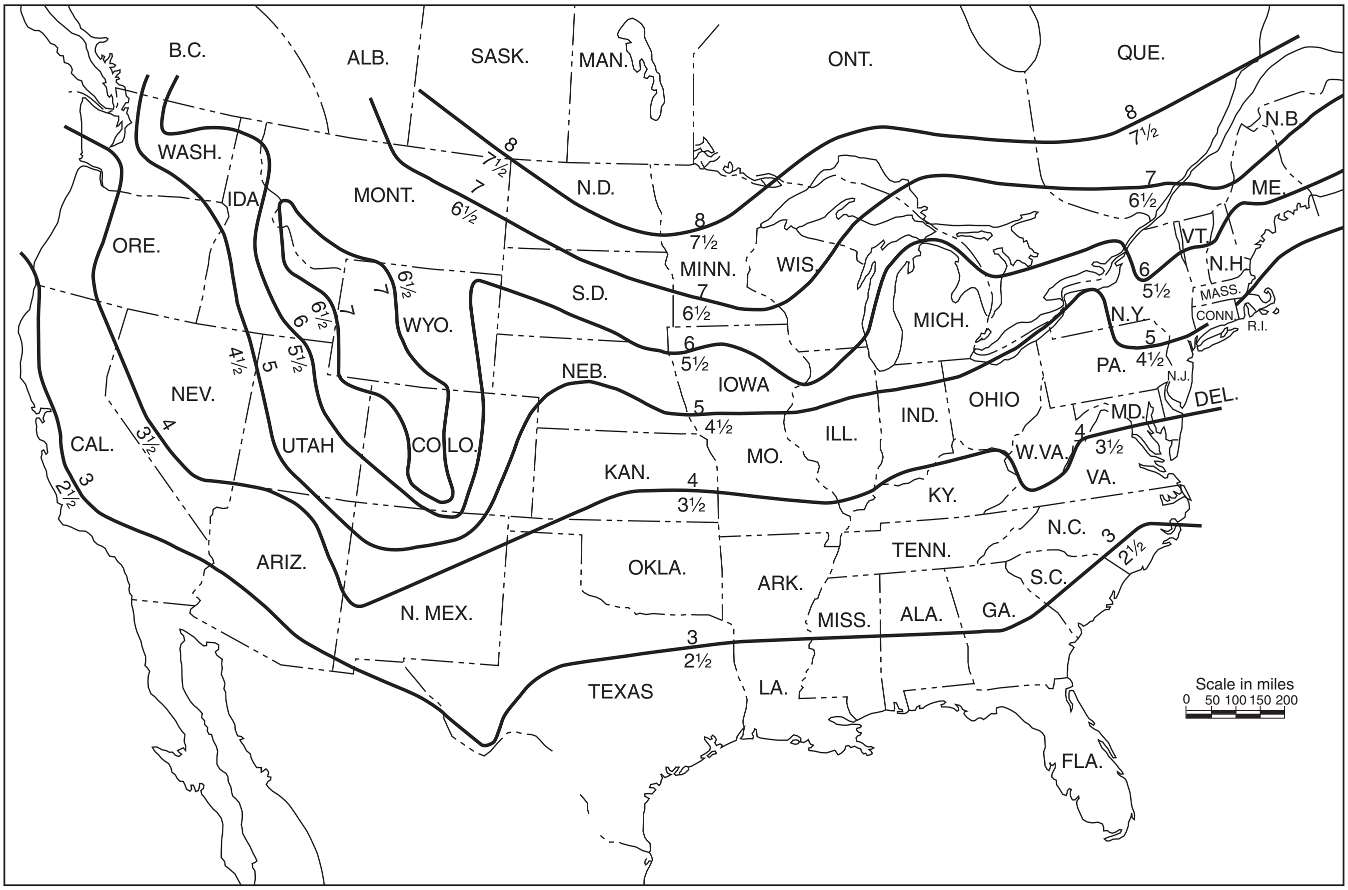
Pipe Size		OD		Pressure Class	Thickness Class	Wall Thickness		Minimum Lining Thickness*		ID with Lining	
in.	mm	in.	mm			in.	mm	in.	mm	in.	mm
3	80	3.96	100	350	51	0.25	6	1/16	1.6	3.34	84
3	80	3.96	100	350	52	0.28	7	1/16	1.6	3.28	82
3	80	3.96	100	350	53	0.31	8	1/16	1.6	3.22	81
3	80	3.96	100	350	54	0.34	9	1/16	1.6	3.16	79
3	80	3.96	100	350	55	0.37	9	1/16	1.6	3.1	78
3	80	3.96	100	350	56	0.4	10	1/16	1.6	3.04	76
4	100	4.8	120	350		0.25	6	1/16	1.6	4.18	105
4	100	4.8	120	350	51	0.26	7	1/16	1.6	4.16	104
4	100	4.8	120	350	52	0.29	7	1/16	1.6	4.1	103
4	100	4.8	120	350	53	0.32	8	1/16	1.6	4.04	101
4	100	4.8	120	350	54	0.35	9	1/16	1.6	3.98	100
4	100	4.8	120	350	55	0.38	10	1/16	1.6	3.92	98
4	100	4.8	120	350	56	0.41	10	1/16	1.6	3.86	97
6	150	6.90	175	350		0.25	6	1/16	1.6	6.28	157
6	150	6.90	175	350	50	0.25	6	1/16	1.6	6.28	157
6	150	6.90	175	350	51	0.28	7	1/16	1.6	6.22	156
6	150	6.90	175	350	52	0.31	8	1/16	1.6	6.16	154
6	150	6.90	175	350	53	0.34	9	1/16	1.6	6.1	153
6	150	6.90	175	350	54	0.37	9	1/16	1.6	6.04	151
6	150	6.90	175	350	55	0.4	10	1/16	1.6	5.98	150
6	150	6.90	175	350	56	0.43	11	1/16	1.6	5.92	148
8	200	9.05	225	350		0.25	6	1/16	1.6	8.43	211
8	200	9.05	225	350	50	0.27	7	1/16	1.6	8.39	210
8	200	9.05	225	350	51	0.3	8	1/16	1.6	8.33	208
8	200	9.05	225	350	52	0.33	8	1/16	1.6	8.27	207
8	200	9.05	225	350	53	0.36	9	1/16	1.6	8.21	205
8	200	9.05	225	350	54	0.39	10	1/16	1.6	8.15	204
8	200	9.05	225	350	55	0.42	11	1/16	1.6	8.09	202
8	200	9.05	225	350	56	0.45	11	1/16	1.6	8.03	201
10	250	11.1	280	350		0.26	7	1/16	1.6	10.46	262
10	250	11.1	280	350	50	0.29	7	1/16	1.6	10.4	260
10	250	11.1	280	350	51	0.32	8	1/16	1.6	10.34	259
10	250	11.1	280	350	52	0.35	9	1/16	1.6	10.28	257
10	250	11.1	280	350	53	0.38	10	1/16	1.6	10.22	256
10	250	11.1	280	350	54	0.41	10	1/16	1.6	10.16	254
10	250	11.1	280	350	55	0.44	11	1/16	1.6	10.1	253
10	250	11.1	280	350	56	0.47	12	1/16	1.6	10.04	251
12	300	13.2	330	350		0.28	7	1/16	1.6	12.52	313
12	300	13.2	330	350	50	0.31	8	1/16	1.6	12.46	312
12	300	13.2	330	350	51	0.34	9	1/16	1.6	12.4	310
12	300	13.2	330	350	52	0.37	9	1/16	1.6	12.34	309
12	300	13.2	330	350	53	0.4	10	1/16	1.6	12.28	307
12	300	13.2	330	350	54	0.43	11	1/16	1.6	12.22	306
12	300	13.2	330	350	55	0.46	12	1/16	1.6	12.16	304
12	300	13.2	. 330	350	56	0.49	12	1/16	1.6	12.1	303
14	350	15.3	385	250		0.28	7	3/32	2	14.55	364
14	350	15.3	385	300		0.3	8	3/32	2	14.51	363
14	350	15.3	385	350		0.31	8	3/32	2	14.49	362
14	350	15.	385		50	0.33	8	3/32	2	14.45	361
14	350	15.3	385		51	0.36	9	3/32	2	14.39	360
14	350	15.3	385		52	0.39	10	3/32	2	14.33	358
14	350	15.3	385		53	0.42	11	3/32	2	14.27	357
14	350	15.3	385		54	0.45	11	3/32	2	14.21	355
14	350	15.3	385		55	0.48	12	3/32	2	14.15	354
14	350	15.3	385		56	0.51	13	3/32	2	14.09	352

(continues)

Δ Table A.10.1.3 *Continued*

Pipe Size		OD		Pressure Class	Thickness Class	Wall Thickness		Minimum Lining Thickness*		ID with Lining	
in.	mm	in.	mm			in.	mm	in.	mm	in.	mm
16	400	17.4	435	250		0.3	8	3/32	2	16.61	415
16	400	17.4	435	300		0.32	8	3/32	2	16.57	414
16	400	17.4	435	350		0.34	9	3/32	2	16.53	413
16	400	17.4	435		50	0.34	9	3/32	2	16.53	413
16	400	17.4	435		51	0.37	9	3/32	2	16.47	412
16	400	17.4	435		52	0.4	10	3/32	2	16.41	410
16	400	17.4	435		53	0.43	11	3/32 in.	2	16.35	409
16	400	17.4	435		54	0.46	12	3/32	2	16.29	407
16	400	17.4.	435		55	0.49	12	3/32	2	16.23	406
16	400	17.4	435		56	0.52	13	3/32	2	16.17	404
18	450	19.5	488	250		0.31	8	3/32	2	18.69	467
18	450	19.5	488	300		0.34	9	3/32	2	18.63	466
18	450	19.5	488	350		0.36	9	3/32	2	18.59	465
18	(50	19.5	488		50	0.35	9	3/32	2	18.61	465
18	450	19.5	488		51	0.35	9	3/32	2	18.61	465
18	450	19.5	488		52	0.41	10	3/32	2	18.49	462
18	450	19.5	488		53	0.44	11	3/32	2	18.43	461
18	450	19.5	488		54	0.47	12	3/32	2	18.37	459
18	450	19.5	488		55	0.5	13	3/32	2	18.31	458
18	450	19.5	488		56	0.53	13	3/32	2	18.25	456
20	500	21.6	540	250		0.33	8	3/32	2	20.75	519
20	500	21.6	540	300		0.36	9	3/32	2	20.69	517
20	500	21.6	540	350		0.38	10	3/32	2	20.65	516
20	500	21.6	540		50	0.36	9	3/32	2	20.69	517
20	500	21.6	540		51	0.39	10	3/32	2	20.63	516
20	500	21.6	540		52	0.42	11	3/32	2	20.57	514
20	500	21.6	540		53	0.45	11	3/32	2	20.51	513
20	500	21.6	540		54	0.48	12	3/32	2	20.45	511
20	500	21.6	540		55	0.51	13	3/32	2	20.39	510
20	500	21.6	540		56	0.54	14	3/32	2	20.33	508
24	600	25.8	645	200		0.33	8	3/32	2	24.95	624
24	600	25.8	645	250		0.37	9	3/32	2	24.87	622
24	600	25.8	645	300		0.4	10	3/32	2	24.81	620
24	600	25.8	645	350		0.43	11	3/32	2	24.75	619
24	600	25.8	645		50	0.38	10	3/32	2	24.85	621
24	600	25.8	645		51	0.41	10	3/32	2	24.79	620
24	600	25.8	645		52	0.44	11	3/32	2	24.73	618
24	600	25.8	645		53	0.47	12	3/32	2	24.67	617
24	600	25.8	645		54	0.5	13	3/32	2	24.61	615
24	600	25.8	645		55	0.53	13	3/32	2	24.55	614
24	600	25.8	645		56	0.56	14	3/32	2	24.49	612

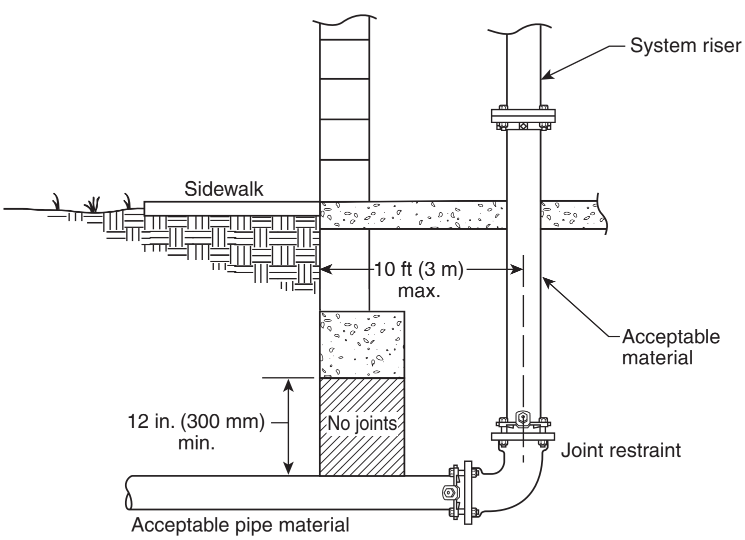
ID: internal diameter; OD: outside diameter.
*Note: This table is appropriate for single lining thickness only. The actual lining thickness should be obtained from the manufacturer.



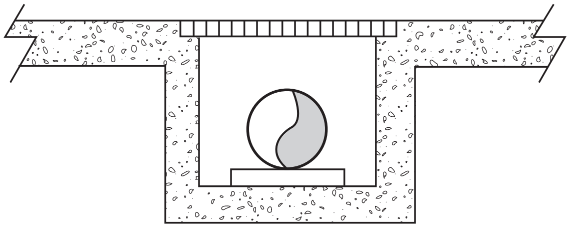
Notes:

1. For SI Units, 1 in. = 25.4 mm; 1 ft = 0.304 m.
2. Where frost penetration is a factor, the depth of cover shown averages 6 in. greater than that usually provided by the municipal waterworks. Greater depth is needed because of the absence of flow in yard mains.

FIGURE A.10.4.2 Recommended Depth of Cover (in feet) Above Top of Underground Yard Mains.



Δ FIGURE A.10.4.3.1 Riser Entrance Location and Clearance.



Δ **FIGURE A.10.4.3.2.1 Private Service Main in a Covered Trench.**

A.10.4.3.2.3 It is the intent of this section to require a valve at each point where the pipe enters the trench when the trench traverses the entire building. Generally if the piping terminates at a point within the building, a valve is usually provided at a riser, allowing isolation of the pipe section in the trench.

A.10.5.1 Where lightning protection is provided for a structure, NFPA 780, Section 4.14, requires that all grounding media, including underground metallic piping systems, be interconnected to provide 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 can be made via a spark gap or gas discharge tube.

A.10.5.1.1 While the use of the underground fire protection piping as the grounding electrode for the building is prohibited, *NFPA 70* requires that all metallic piping systems be bonded and grounded to disperse stray electrical currents. Therefore, the fire protection piping will be bonded to other metallic systems and grounded, but the electrical system will need an additional ground for its operation.

A.10.6 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.10.6.2 for a list of references for use in calculating and determining joint restraint systems.

Section 10.6 does not mandate which method of restraint should be used. This decision is left to the design professional or the owner.

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.

Δ **A.10.6.1** The use of concrete thrust blocks is one method of restraint, provided that stable soil conditions prevail and space requirements permit placement. Successful blocking is dependent on 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 so 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.10.6.1(a) gives the nominal thrust at fittings for various sizes of ductile iron and PVC piping. Figure A.10.6.1(a) shows an example of how thrust forces act on a piping bend.

Thrust blocks are generally categorized into two groups — bearing and gravity blocks. Figure A.10.6.1(b) depicts a typical bearing thrust block on a horizontal bend.

The following are general criteria for bearing block design:

(1) The bearing surface should, where possible, be placed against undisturbed soil.
(2) Where it is not possible to place the bearing surface against undisturbed soil, the fill between the bearing surface and undisturbed soil should be compacted to at least 90 percent Standard Proctor density.
(3) 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).
(4) Block height (h) should be chosen so that the calculated block width (b) varies between one and two times the height.
(5) 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.10.6.1(c) is balanced by the weight of the block. For required horizontal bearing block areas, see Table A.10.6.1(b).

The required block area (A_b) is as follows:

[A.10.6.1a]

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

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:

[A.10.6.1b]

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

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 pipe based on outside diameter
h = block height (ft)
S_b = horizontal bearing strength of 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.10.6.1(c).

In lieu of the values for soil bearing strength shown in Table A.10.6.1(c), 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:

[A.10.6.1d]

$$V_g = \frac{S_f PA \sin \theta}{W_m}$$

where:
V_g = block volume (ft^3)
S_f = safety factor
P = water pressure (psi)
A = cross-sectional area of pipe interior
W_m = density of block material (lb/ft^3)

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

[A.10.6.1e]

$$T_x = PA(1 - \cos \theta)$$

where:
T_x = horizontal component of thrust force
P = water pressure (psi)
A = cross-sectional area of 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.10.6.2 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, which occurs at a change in direction. 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 manufacturer's installation instructions should be referenced to determine the distance from each change in direction that joints should be restrained.

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

(1) *Thrust Restraint Design for Ductile Iron Pipe*, Ductile Iron Pipe Research Association
(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*
(5) *Thrust Restraint Design Equations and Tables for Ductile Iron and PVC Pipe*, EBAA Iron, Inc.

Figure A.10.6.2 shows an example of a typical connection to a fire protection system riser utilizing restrained joint pipe.

Δ Table A.10.6.1(a) Thrust at Fittings at 100 psi (6.9 bar) Water Pressure for Ductile Iron and PVC Pipe

Nominal Pipe Diameter [in. (mm)]	Total Pounds (Newtons)											
	Dead End		90 Degree		45 Degree		22½ Degree		11¼ Degree		5⅛ Degree	
	lbf	N	lbf	N	lbf	N	lbf	N	lbf	N	lbf	N
4 (100)	1,810	8,051	2,559	11,383	1,385	6,161	706	3,140	355	1,579	162	721
6 (150)	3,739	16,632	5,288	23,522	2,862	12,731	1,459	6,490	733	3,261	334	1,486
8 (200)	6,433	28,615	9,097	40,465	4,923	21,899	2,510	11,165	1,261	5,609	575	2,558
10 (250)	9,677	43,045	13,685	60,874	7,406	32,944	3,776	16,796	1,897	8,438	865	3,848
12 (300)	13,685	60,874	19,353	86,086	10,474	46,591	5,340	23,753	2,683	11,935	1,224	5,445
14 (350)	18,385	81,781	26,001	115,658	14,072	62,595	7,174	31,912	3,604	16,031	1,644	7,313
16 (400)	23,779	105,774	33,628	149,585	18,199	80,953	9,278	41,271	4,661	20,733	2,126	9,457
18 (450)	29,865	132,846	42,235	187,871	22,858	101,677	11,653	51,835	5,855	26,044	2,670	11,877
20 (500)	36,644	163,001	51,822	230,516	28,046	124,755	14,298	63,601	7,183	31,952	3,277	14,577
24 (600)	52,279	232,548	73,934	328,875	40,013	177,987	20,398	90,735	10,249	45,590	4,675	20,795
30 (750)	80,425	357,748	113,738	505,932	61,554	273,806	31,380	139,585	15,766	70,131	7,191	31,987
36 (900)	115,209	512,475	162,931	724,753	88,177	392,231	44,952	199,956	22,585	100,463	10,302	45,826
42 (1,050)	155,528	691,823	219,950	978,386	119,036	529,498	60,684	269,936	30,489	135,622	13,907	61,861
48 (1,200)	202,683	901,579	286,637	1,275,024	155,127	690,039	79,083	351,779	39,733	176,741	18,124	80,620

Notes:
(1) For SI units, 1 lb = 0.454 kg; 1 in. = 25 mm.
(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. (305 mm), 90-degree bend at 125 psi (8.6 bar) is 19,353 × 125/100 = 24,191 lb (10,973 kg).

Δ Table A.10.6.1(b) Required Horizontal Bearing Block Area

Nominal Pipe Diameter		Bearing Block Area		Nominal Pipe Diameter		Bearing Block Area		Nominal Pipe Diameter		Bearing Block Area	
in.	mm	ft^2	m^2	in.	mm	ft^2	m^2	in.	mm	ft^2	m^2
3	80	2.6	0.24	12	300	29.0	2.7	24	600	110.9	10.3
4	100	3.8	0.35	14	350	39.0	3.6	30	750	170.6	15.8
6	150	7.9	0.73	16	400	50.4	4.7	36	900	244.4	22.7
8	200	13.6	1.3	18	450	63.3	5.9	42	1050	329.9	30.6
10	250	20.5	2	20	500	77.7	7.2	48	1200	430.0	39.9

Notes:
(1) 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.
(2) Values listed are based on a 90-degree horizontal bend, an internal pressure of 100 psi (6.9 bar), a soil horizontal bearing strength of 1000 lb/ft^2 (4880 kg/m^2), a safety factor of 1.5, and ductile iron pipe outside diameters.
(a) For other horizontal bends, multiply by the following coefficients: for 45 degrees, 0.541; for 22½ degrees, 0.276; for 11¼ degrees, 0.139.
(b) Hydrostatic test pressures should be used when modifying the thrust-force bearing block area by the ratio of the test pressure to 100 psi (6.9 bar).
(c) For other soil horizontal bearing strengths, divide by ratio to 1000 lb/ft^2 (4880 kg/m^2).
(d) For other safety factors, multiply by ratio to 1.5.
Example: Using Table A.10.6.1(b), find the horizontal bearing block area for a 6 in. (150 mm) diameter, 45-degree bend with an internal pressure of 150 psi (10.3 bar). The soil bearing strength is 3000 lb/ft^2 (14850 kg/m^2), and the safety factor is 1.5.
From Table A.10.6.1(b), the required bearing block area for a 6 in. (150 mm) diameter, 90-degree bend with an internal pressure of 100 psi (6.9 bar) and a soil horizontal bearing strength of 1000 psi (70 bar) is 7.9 ft^2 (0.73 m^2).
For example:

N **[A.10.6.1c]**

$$Area = \frac{7.9\ ft^2 (0.541)\left(\frac{150}{100}\right)}{\left(\frac{3000}{1000}\right)} = 2.1\ ft^2$$

Table A.10.6.1(c) Horizontal Bearing Strengths

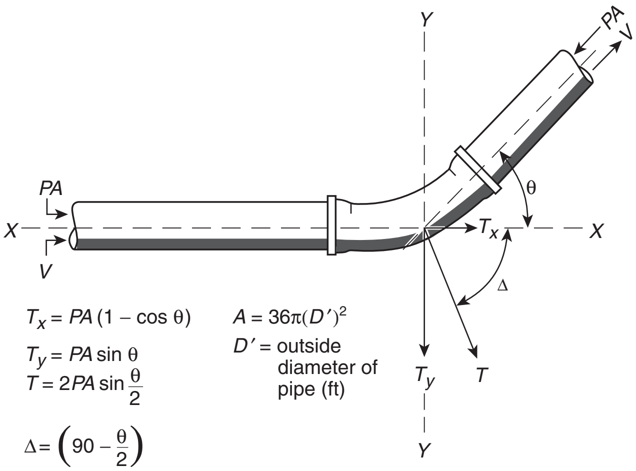
Soil	Bearing Strength (S_b) lb/ft^2	kN/m^2
Muck	0	0
Soft clay	1000	48
Silt	1500	72
Sandy silt	3000	145
Sand	4000	190
Sand clay	6000	285
Hard clay	9000	430

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.

A.10.6.2.1 Examples of materials and the standards covering these materials are as follows:

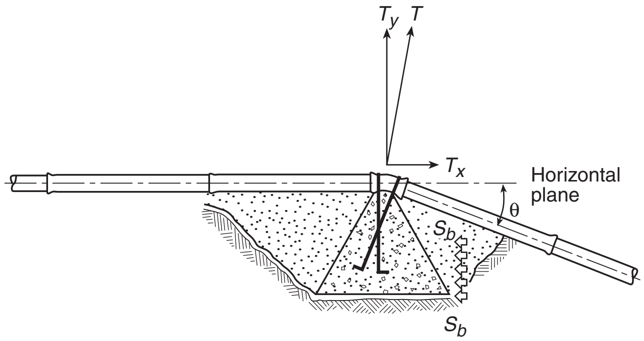
(1) Clamps, steel
(2) Rods, steel
(3) Bolts, steel (ASTM A307, *Standard Specification for Carbon Steel Bolts, Studs, Threaded Rod 60,000 PSI Tensile Strength*)
(4) Washers, steel, cast iron (Class A cast iron as defined by ASTM A126, *Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings*)
(5) Anchor straps, plug straps, steel
(6) Rod couplings, turnbuckles, malleable iron (ASTM A197/A197M, *Standard Specification for Cupola Malleable Iron*)

A.10.6.3 Solvent-cemented and heat-fused joints such as those used with CPVC piping and fittings are considered restrained. They do not require thrust blocks.



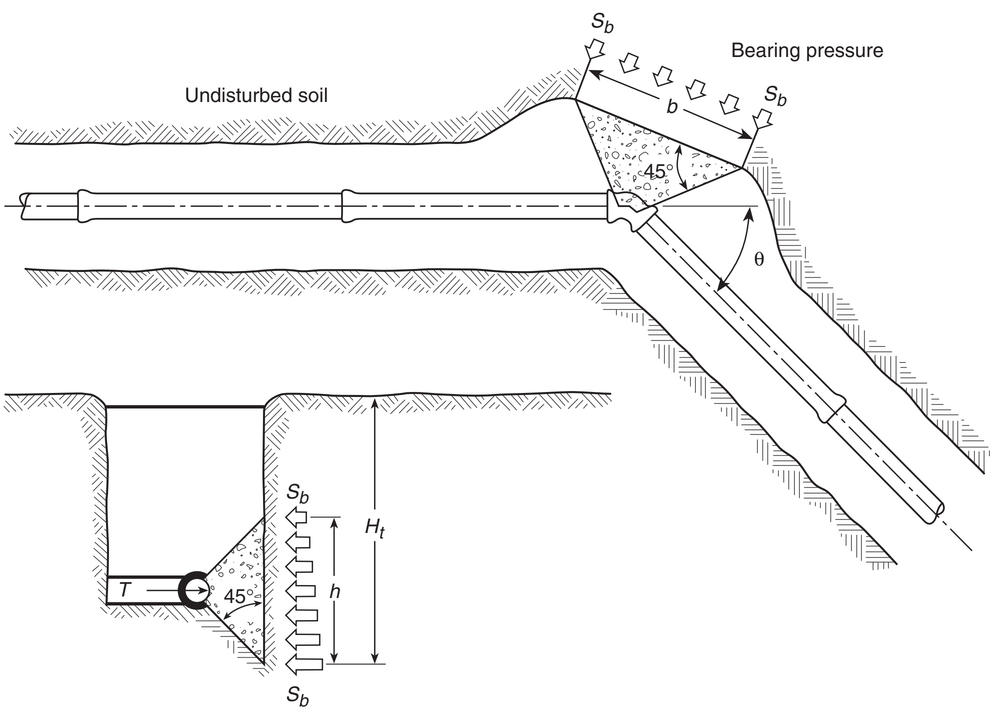
T = thrust force resulting from change in direction of flow (lbf)
T_x = component of thrust force acting parallel to original direction of flow (lbf)
T_y = component of thrust force acting perpendicular to original direction of flow (lbf)
P = water pressure (psi^2)
A = cross-sectional area of pipe based on outside diameter (in.^{2})
V = velocity in direction of flow

FIGURE A.10.6.1(a) Thrust Forces Acting on Bend.



T = thrust force resulting from change of direction of flow
T_x = horizontal component of thrust force
T_y = vertical component of thrust force
S_b = horizontal bearing strength of soil

FIGURE A.10.6.1(c) Gravity Thrust Block.



T = thrust force resulting from change in direction of flow
S_b = horizontal bearing strength of soil
h = block height
H_t = total depth to bottom of block

FIGURE A.10.6.1(b) Bearing Thrust Block.

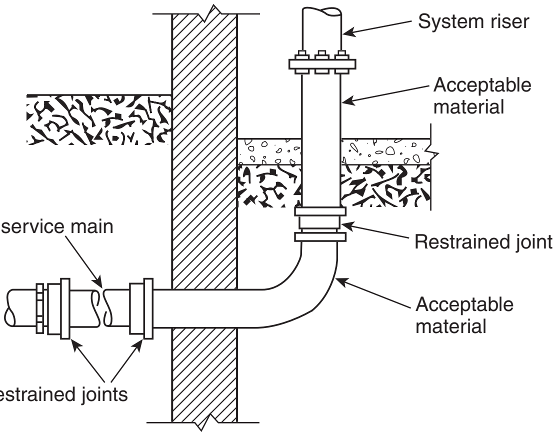


FIGURE A.10.6.2 Typical Connection to Fire Protection System Riser Illustrating Restrained Joints.

A.10.9.3 The maximum particle size allowed next to most types of pipe can be found in ASTM C136/136M, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*, ASTM D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, AWWA M55, *PE Pipe — Design and Installation*, AWWA M23, *PVC Pipe — Design and Installation*, trade association handbooks, or manufacturers' literature. These publications typically recommend one maximum allowable particle size that applies to the bedding, embedment, and backfill, which might be different materials. The maximum particle size might be dependent on the pipe diameter.

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 (3.0 m/sec), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.

A.10.10.2.1.3 The velocity of approximately 10 ft/sec (3.0 m/sec) was used to develop Table 10.10.2.1.3 because this velocity has been shown to be sufficient for moving obstructive material out of the pipes. It is not important that the velocity equal exactly 10 ft/sec (3.0 m/sec), so there is no reason to increase the flow during the test for slightly different internal pipe dimensions. Note that where underground pipe serves as suction pipe for a fire pump, NFPA 20 requires greater flows for flushing the pipe.

A.10.10.2.1.4 An example of a swab would be polyurethane foam. The manufacturer's recommended procedure should be followed when swabbing is used.

A.10.10.2.2.1 For example, consider a sprinkler system with a connection to a public water service main for its water supply. 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

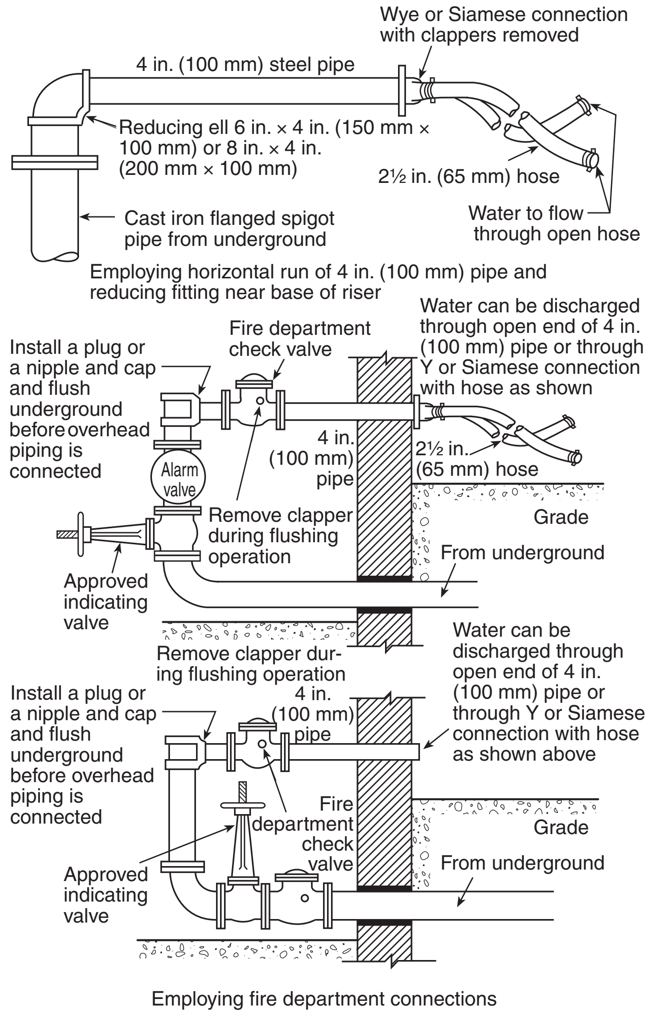


FIGURE A.10.10.2.1 Methods of Flushing Water Supply Connections.

portion of the system being tested and a 120 psi (8.3 bar) pump (churn) pressure, the hydrostatic test pressure is 70 psi (4.8 bar), 120 psi (8.3 bar), 50 psi (3.5 bar), or 240 psi (16.5 bar).

To reduce the possibility of serious water damage in case of a break, pressure can be introduced 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 (3.5 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, it is held for 2 hours while observations are made for leakage and the pressure readings are checked.

A.10.10.2.2.4 Hydrostatic tests should be made before the joints are covered, so that any leaks can be 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.10.10.2.2.6 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 could be pressurized 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 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/in. (1.2 mL/mm) of valve diameter per hour. For this reason, the blind flange should be used when hydrostatically testing.

Δ **A.10.10.2.3** As an example, the following standards contain test requirements: AWWA C600, *Installation of Ductile-Iron Water Mains and Their Appurtenances*, AWWA C602, *Cement-Mortar Lining of Water Pipelines in Place, 4 in. (100 mm) and Larger*, AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 60 in. (100 mm Through 1,500 mm)*, or ASTM F2164, *Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure*.

A.10.10.2.3.1 Examples include cut-in tees, repair sleeves, or hot taps.

N **A.12.2.1** Protection should be provided in any area of a structure or building that poses a degree of hazard greater than that normal to the general occupancy of the building or structure. These areas include areas for the storage or use of combustibles or flammables; toxic, noxious, or corrosive materials; and heat-producing appliances.

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

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 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 are being made.

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 Water Flow Testing

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

Δ **C.1** Annex C was developed based upon the procedures contained in NFPA 291. For additional information on water flow testing, see NFPA 291, 2025 edition, Chapter 4, Flow Testing.

C.1.1 Scope. The scope of this annex is to provide guidance on water flow testing of hydrants.

C.1.2 Purpose. Water flow tests are conducted on water distribution systems to determine the rate of flow available at various locations for firefighting 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 water 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 water 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.

Δ **Table C.1.4 SI Units and Conversion Factors**

Unit Name	Unit Symbol	Conversion Factor
Liter	L	1 gal = 3.785 L
Liter per minute per square meter	$(L/min)/m^2$	1 gpm ft^2 = $(40.746\ L/min)/m^2$
Cubic decimeter	dm^3	1 gal = 3.785 dm^3
Pascal	Pa	1 psi = 6894.757 Pa
Bar	bar	1 psi = 0.0689 bar
Bar	bar	1 bar = 10^5 Pa

Note: For additional conversions and information, see ASTM SI 10, *IEEE/ASTM SI 10 American National Standard for Metric Practice.*

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 annex 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.

ASTM SI 10, *IEEE/ASTM SI 10 American National Standard for Metric Practice*, 2016.

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. [291:4.2]

Δ **C.4.1.1** For the purpose of uniform marking of hydrants, the ratings should be based on a residual pressure of 20 psi (1.4 bar). [**291:**4.2.1]

C.4.1.2 It is generally recommended that a minimum residual pressure of 20 psi (1.4 bar) should be maintained at hydrants when delivering the water flow. Fire department pumpers can be operated where hydrant pressures are less, but with difficulty. [**291:**4.2.2]

Δ **C.4.1.3** A primary concern should be the ability to maintain sufficient residual pressure to prevent back-siphonage of polluted water from some other interconnected source. [**291:**4.2.3]

C.4.1.4 It should be noted that the use of residual pressures of less than 20 psi (1.4 bar) is not permitted by many water authorities and health departments. [**291:**4.2.4]

C.4.2 Procedure. [291:4.3]

C.4.2.1 Tests should be made during periods of peak demand, based on knowledge of the water supply and engineering judgment. [**291:**4.3.1]

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. [**291:**4.3.2]

N **C.4.2.3** The hydrant and the area around the hydrant should be visually inspected for safety concerns prior to conducting the flow test. [**291:**4.3.3]

C.4.3 Layout of Test and Procedure to Determine the Available Water Supply in a Water Main. [291:4.4]

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. [**291:**4.4.1]

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. [**291:**4.4.2]

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. [**291:**4.4.3]

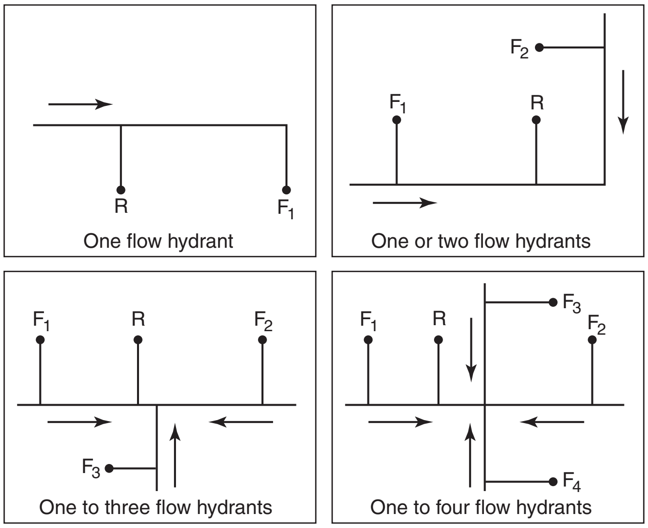
C.4.3.4 This hydrant is chosen so it will be located between the hydrant to be flowed and the large mains that constitute the immediate sources of water supply in the area. In Figure C.4.3.4, test layouts are indicated showing the residual hydrant designated with the letter R and hydrants to be flowed with the letter F. [**291:**4.4.4]

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. [**291:**4.4.5]

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 10 percent. In water supply systems where additional municipal pumps increase the flow and pressure as additional test hydrants are opened, it might be necessary to declare an artificial drop in the static pressure of 10 percent to create a theoretical water supply curve. [**291:**4.4.6]

N **C.4.3.7** When conducting a flow test for the purpose of fire protection system design, the flow and pressure results should be adequate for the total demand of the system. [**291:**4.4.7]

C.4.3.8 If the mains are small and the system weak, only one or two hydrants need to be flowed. [**291:**4.4.8]



Arrows indicate direction of flow: R – residual hydrant; F – flow hydrant

FIGURE C.4.3.4 Suggested Test Layout for Hydrants. [291:Figure 4.4.4]

C.4.3.9 If the mains are large and the system strong, it might be necessary to flow as many as seven or eight hydrants. [**291:**4.4.9]

N **C.4.4 Layout of Test and Procedure to Evaluate the Available Flow Through a Hydrant. [291:4.5]**

N **C.4.4.1** When the purpose of a flow test is to determine the available flow through an individual hydrant only, the static and residual pressures should be taken at a single hydrant. The flow hydrant is also used as the static/residual hydrant. [**291:**4.5.1]

N **C.4.4.1.1** This procedure should be used to evaluate the available water flow at a given hydrant. [**291:**4.5.1.1]

N **C.4.4.1.2** The recommended procedures for determining the available water supply for the design of a water-based protection system should be in accordance with C.4.3. [**291:**4.5.1.2]

N **C.4.4.2** A pressure gauge (or other pressure measuring device) should be located on one of the 2½ in. (65 mm) hydrant outlets *[see C.4.5.1(1)]*. [**291:**4.5.2]

N **C.4.4.3** A closed control valve connected to a discharge nozzle(s) for the purpose of rate of flow measurement should be located on one of the other hydrant outlets. [**291:**4.5.3]

N **C.4.4.4** The test procedures in Section 4.7 of NFPA 291 for venting air and taking static/residual readings and Section 4.8 of NFPA 291 for taking pitot readings should be followed. [**291:**4.5.4]

N **C.4.4.5** The control valve on another hydrant outlet should be opened. When the rate of flow stabilizes, rate of flow and residual pressure measurements are taken and recorded. [**291:**4.5.5]

C.4.5 Equipment. [291:4.6]

Δ **C.4.5.1** The equipment necessary for field work consists of the following:

(1) A special hydrant cap tapped with a hole into which is fitted a short length of ¼ in. (6 mm) nipple provided with a "T" connection for a pressure gauge and a petcock at the end for relieving air pressure
(2) A single 100 psi (6.9 bar) or 200 psi (13.8 bar) bourdon pressure gauge with 1 psi (0.07 bar) graduations fixed onto the hydrant cap [If the static pressure on the system is greater than 100 psi (6.9 bar), the 200 psi (13.8 bar) gauge will be required.]
(3) A pitot tube and a 100 psi (6.9 bar) bourdon pressure gauge with 1 psi (0.07 bar) graduations, for each hydrant to be flowed simultaneously
(4) A sufficient number of hydrant wrenches to operate the hydrants simultaneously
(5) Playpipes, stream straighteners, or other specially designed flow test outlets with known coefficients of discharge

[**291:**4.6.1]

N **C.4.5.2** It is preferred to use playpipes or stream straighteners or other specially designed flow test outlets with known coefficients of discharge when testing hydrants due to more streamlined flows and more accurate pitot readings. [**291:**4.6.2]

C.4.5.3 All pressure gauges should be calibrated at least every 12 months, or more frequently depending on use. [**291:**4.6.3]

C.4.5.4 When more than one hydrant is flowed, it is desirable and could be necessary to use portable radios to facilitate communication between team members. [**291:**4.6.4]

C.4.6 Test Procedure. [291:4.7]

C.4.6.1 In a typical test, the 100 psi (6.9 bar) or 200 psi (13.8 bar) gauge is attached to one of the 2½ in. (65 mm) outlets of the residual hydrant using the special cap. [**291:**4.7.1]

C.4.6.2 The cock on the gauge piping is opened, and the hydrant valve is opened full. [**291:**4.7.2]

C.4.6.3 As soon as the air is exhausted from the barrel, the cock is closed. [**291:**4.7.3]

C.4.6.4 A reading (static pressure) is taken when the needle comes to rest. [**291:**4.7.4]

C.4.6.5 At a given signal, each of the other hydrants is opened in succession, with discharge taking place directly from the open hydrant butts. [**291:**4.7.5]

C.4.6.6 Hydrants should be opened one at a time. [**291:**4.7.6]

C.4.6.7 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). [**291:**4.7.7]

C.4.6.8 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. [**291:**4.7.8]

C.4.6.9 The final magnitude of the pressure drop can be controlled by the number of hydrants used and the number of outlets opened on each. [**291:**4.7.9]

C.4.6.10 After the readings have been taken, hydrants should be shut down slowly, one at a time, to prevent undue surges in the system. [**291:**4.7.10]

Δ **C.4.7 Pitot Readings. [291:4.8]**

C.4.7.1 When measuring discharge from open hydrant butts, it is always preferable from the standpoint of accuracy to use 2½ in. (65 mm) outlets rather than pumper outlets. [**291:**4.8.1]

C.4.7.2 In practically all cases, the 2½ in. (65 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. [**291:**4.8.2]

C.4.7.3 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. *(See Figure C.4.7.3.)* [**291:**4.8.3]

C.4.7.4 The center line of the orifice should be at right angles to the plane of the face of the hydrant outlet. [**291:**4.8.4]

C.4.7.5 The air chamber on the pitot tube should be kept elevated. [**291:**4.8.5]

C.4.7.6 Pitot readings of less than 10 psi (0.7 bar) and more than 30 psi (2.1 bar) should be avoided, if possible. [**291:**4.8.6]

C.4.7.7 Opening additional hydrant outlets will aid in controlling the pitot reading. [**291:**4.8.7]

C.4.7.8 With dry barrel hydrants, the hydrant valve should be wide open to minimize problems with underground drain valves. [**291:**4.8.8]

Δ **C.4.7.9** 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.4.7.3.)* [**291:**4.8.9]

C.4.8 Determination of Discharge. [291:4.9]

C.4.8.1 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.4.8.1. [**291:**4.9.1]

C.4.8.2 If flow tubes (stream straighteners) are being utilized, a coefficient of 0.95 is suggested unless the coefficient of the tube is known. [**291:**4.9.2]

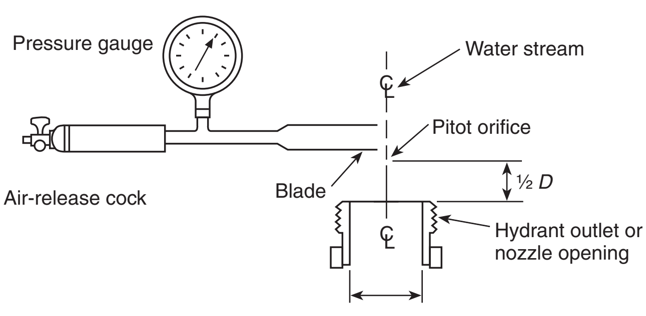


FIGURE C.4.7.3 Pitot Tube Position. [291:Figure 4.8.3]

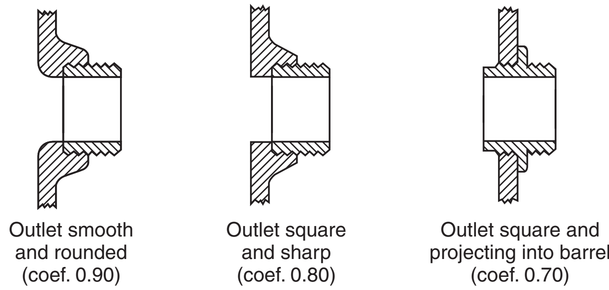


FIGURE C.4.8.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge. [291:Figure 4.9.1]

C.4.8.3 The formula used to compute the discharge, Q, in gpm (L/min) from these measurements is as shown in Equations C.4.8.3a and C.4.8.3b.

[C.4.8.3a]

$$Q = 29.84cd^2\sqrt{p}$$

where:
c = coefficient of discharge *(see Figure C.4.8.1)*
d = diameter of the outlet (in.)
p = pitot pressure (velocity head) (psi)

Δ **[C.4.8.3b]**

$$Q_M = 0.666cd^2\sqrt{p_M}$$

where:
Q_M = flow (L/min)
c = coefficient of discharge *(see Figure C.4.8.1)*
d = diameter of the outlet (mm)
p_M = pitot pressure (velocity head) (bar)

[**291:**4.9.3]

C.4.9 Use of Pumper Outlets. [291:4.10]

C.4.9.1 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 (0.34 bar and 0.7 bar). [**291:**4.10.1]

C.4.9.2 For pumper outlets, the approximate discharge can be computed from Equations C.4.8.3a and C.4.8.3b using the pitot pressure (velocity head) at the center of the stream and multiplying the result by one of the coefficients in Table C.4.9.2, depending upon the pitot pressure (velocity head). [**291:**4.10.2]

C.4.9.3 These coefficients are applied in addition to the coefficient in Equations C.4.8.3a and C.4.8.3b and are for average-type hydrants. [**291:**4.10.3]

C.4.10 Determination of Discharge Without a Pitot. [291:4.11]

C.4.10.1 If a pitot tube is not available for use to measure the hydrant discharge, a gauge of sufficient pressure range, tapped into a hydrant cap can be used when the flow is through a hydrant outlet or a nozzle attached to a hydrant outlet. [**291:**4.11.1]