3.8.1.3 Corrosion-Retardant 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. [24, 2013-2016]

Submitter Information Verification

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Submittal Date: Tue Sep 30 21:48:47 EDT 2014

Committee Statement

Committee Statement: This definition was revised to match the language in the document it is extracted from.
Response Message:
3.8.1.4 Fire Department Connection.
A connection through which the fire department can pump supplemental water into the sprinkler system, standpipe, or other system water-based fire protection systems, furnishing water for fire extinguishment to supplement existing water supplies.

Submitter Information Verification

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Submit Date: Tue Sep 30 21:39:26 EDT 2014

Committee Statement

Committee Statement: This definition was revised to match the language in the document it is extracted from.
Response Message:
3.8.1.12 Pumper Outlet.
The hydrant outlet intended for use by fire departments for pump to be connected to a fire department pumper for use in taking supply from the hydrant for pumpers. [24,2013 2016 ]

Submitter Information Verification

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Submittal Date: Tue Sep 30 22:03:26 EDT 2014

Committee Statement

Committee Statement: This definition was revised to match the language in the document it is extracted from.
Response Message:
A test of a piping system using high velocity flows flowrates intended to remove debris from the piping system prior to it being placed in service. [24, 2013 – 2016]

Submitter Information Verification
Submitter Full Name: Matthew Klaus
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 30 21:56:36 EDT 2014

Committee Statement
Committee Statement: This definition was revised to match the language in the document it is extracted from.
Response Message:
3.8.1.15.2* Indicating Valve.
A valve that has components that show if the valve is operating position, open or closed. Examples are outside screw and yoke (OS&Y) gate valves and underground gate valves with indicator posts. [24,2013 2016]
A.3.8.1.15.2 Examples are outside screw and yoke (OS&Y) gate valves, butterfly valves, and underground gate valves with indicator posts.
3.8.2.1.1 Dry Barrel Hydrant (Frostproof Hydrant)

This is the most common type of hydrant with the main control valve below the frost line between the footpiece and the barrel. [24,2013 2016]

Submitter Information Verification

Submitter Full Name: Matthew Klaus
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 30 22:11:23 EDT 2014

Committee Statement

Committee Statement: This definition was revised to match the language in the document it is extracted from.
Response Message:
3.8.2.1.6 Wet Barrel Hydrant.

A type of hydrant that sometimes is used is intended for use where there is no danger of freezing weather. Each outlet on a wet barrel hydrant, where each outlet is provided with a valved outlet threaded for fire hose valve and an outlet.

[24, 2013-2016]
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 Listing.
Piping manufactured in accordance with Table 10.1.1.1 shall be permitted to be used.

Table 10.1.1.1 Manufacturing Standards for Underground Pipe

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile Iron</td>
<td></td>
</tr>
<tr>
<td>Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water</td>
<td>AWWA C104</td>
</tr>
<tr>
<td>Polyethylene Encasement for Ductile Iron Pipe Systems</td>
<td>AWWA C105</td>
</tr>
<tr>
<td>Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings</td>
<td>AWWA C111</td>
</tr>
<tr>
<td>Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges</td>
<td>AWWA C115</td>
</tr>
<tr>
<td>Thickness Design of Ductile Iron Pipe</td>
<td>AWWA C150</td>
</tr>
<tr>
<td>Ductile Iron Pipe, Centrifugally Cast for Water</td>
<td>AWWA C151</td>
</tr>
<tr>
<td>Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances</td>
<td>AWWA C600</td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Steel-Cylinder Type</td>
<td>AWWA C300</td>
</tr>
<tr>
<td>Prestressed Concrete Pressure Pipe, Steel-Cylinder Type</td>
<td>AWWA C301</td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Non-Cylinder Type</td>
<td>AWWA C302</td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned</td>
<td>AWWA C303</td>
</tr>
<tr>
<td>Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water Distribution Systems</td>
<td>AWWA C400</td>
</tr>
<tr>
<td>Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place</td>
<td>AWWA C602</td>
</tr>
<tr>
<td>Plastic</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water Distribution</td>
<td>AWWA C900</td>
</tr>
<tr>
<td>Polyvinyl Chloride (PVC) Pressure Pipe, 14 in. Through 48 in., for Water Distribution</td>
<td>AWWA C905</td>
</tr>
<tr>
<td>Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 63 in. (1575 mm) for Water Distribution</td>
<td>AWWA C906</td>
</tr>
<tr>
<td>Molecularly Oriented Polyvinyl Chloride (PVCO) 4-24 in.</td>
<td>AWWA C909</td>
</tr>
<tr>
<td>Brass</td>
<td></td>
</tr>
<tr>
<td>Specification for Seamless Red Brass Pipe</td>
<td>ASTM B43</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
</tr>
<tr>
<td>Specification for Seamless Copper Tube</td>
<td>ASTM B75</td>
</tr>
<tr>
<td>Specification for Seamless Copper Water Tube</td>
<td>ASTM B88</td>
</tr>
<tr>
<td>Requirements for Wrought Seamless Copper and Copper-Alloy Tube</td>
<td>ASTM B251</td>
</tr>
</tbody>
</table>

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

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

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

10.1.3
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. [24:10.1.1.3]

Table 10.1.1.3 Steel Piping for Fire Department Connections

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use</td>
<td>ASTM A795</td>
</tr>
<tr>
<td>Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless</td>
<td>ASTM A53</td>
</tr>
</tbody>
</table>

[24:Table 10.1.1.3]

10.1.1.3.1 External coating and wrapping as required by 10.1.1.3 shall be approved. [24:10.1.1.3.1]

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 bar). [24:10.1.2]

10.1.3* When lined piping is used, the manufacturer’s literature for internal diameter shall be used for all hydraulic calculations. [24:10.1.3]

10.1.4 Where piping installed in a private fire service main must be installed above grade, the piping materials shall conform to NFPA 13. [24:10.1.4]

10.1.4.1* Underground piping shall be permitted to extend into the building through the slab or wall not more than 24 in. (0.6 m). [24:10.1.4.1]

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, or 10.2.1.3. [24:10.2.1]
Fittings manufactured in accordance with Table 10.2.1.1 shall be permitted to be used. [24:Table 10.2.1.1]

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cast Iron</strong></td>
<td></td>
</tr>
<tr>
<td>Gray Iron Threaded Fittings, Classes 125 and 250</td>
<td>ASME B16.4</td>
</tr>
<tr>
<td>Gray Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250</td>
<td>ASME B16.1</td>
</tr>
<tr>
<td><strong>Ductile Iron</strong></td>
<td></td>
</tr>
<tr>
<td>Ductile Iron and Gray Iron Fittings, 3 in. Through 48 in., for Water and other Liquids</td>
<td>AWWA C110</td>
</tr>
<tr>
<td>Ductile Iron Compact Fittings, 3 in. Through 24 in. and 54 in. through 64 in. for Water Service</td>
<td>AWWA C153</td>
</tr>
<tr>
<td><strong>Malleable Iron</strong></td>
<td></td>
</tr>
<tr>
<td>Malleable Iron Threaded Fittings, Class 150 and 300</td>
<td>ASME B16.3</td>
</tr>
<tr>
<td><strong>Steel</strong></td>
<td></td>
</tr>
<tr>
<td>Factory-Made Wrought Steel Buttweld Fittings</td>
<td>ASME B16.9</td>
</tr>
<tr>
<td>Buttwelding Ends</td>
<td>ASME B16.25</td>
</tr>
<tr>
<td>Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures</td>
<td>ASTM A234</td>
</tr>
<tr>
<td>Pipe Flanges and Flanged Fittings, NPS ¼ Through 24</td>
<td>ASME B16.5</td>
</tr>
<tr>
<td>Forged Steel Fittings, Socket Welded and Threaded</td>
<td>ASME B16.11</td>
</tr>
<tr>
<td>Steel Pipe Flanges for Waterworks Service — Sizes 4 in. Through 144 in.</td>
<td>AWWA C207</td>
</tr>
<tr>
<td>Dimensions for Fabricated Steel Water Pipe Fittings</td>
<td>AWWA C208</td>
</tr>
<tr>
<td><strong>Copper</strong></td>
<td></td>
</tr>
<tr>
<td>Wrought Copper and Bronze Solder Joint Pressure Fittings</td>
<td>ASME B16.22</td>
</tr>
<tr>
<td><strong>Bronze Fittings</strong></td>
<td></td>
</tr>
<tr>
<td>Cast Bronze Solder Joint Pressure Fittings</td>
<td>ASME B16.18</td>
</tr>
<tr>
<td><strong>Cast Bronze Threaded Fittings</strong></td>
<td>ASTM B16.15</td>
</tr>
</tbody>
</table>

Fittings specifically listed for use in private fire service mains shall be permitted to be used. [24:10.2.1.2]

Where listed fittings are used, they shall be installed in accordance with their listing limitations including installation instructions. [24:10.2.1.2.1]

Where listing limitations or installation instructions differ from the requirements of this standard, the listing limitations and installation instructions shall apply. [24:10.2.1.2.2]

Approved fittings shall be permitted to be used. [24: 10.2.1.3]

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 bar). [24:10.2.2]

Where fittings installed in a private fire service main must be installed above grade, the fittings shall conform to NFPA 13. [24:10.2.3]

Fittings in accordance with 10.2.1 shall be permitted for the transition to the above ground piping or fittings. [24:10.2.3.1]

Connection of Pipe Fittings and Appurtenances. [24:10.3]

Connection of all fittings and appurtenances to piping shall be in accordance with Section 10.3. [24:10.3.1]

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. [24:10.3.2]

Listed Connections. [24:10.3.3]

Connections utilizing listed products shall be in accordance with the listing limitations and the manufacturer’s installation instructions. [24:10.3.3]
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. [24:10.3.3.1]

10.3.4
Where pipe, fittings or appurtenances are connected using threads, all threads shall be in accordance with ANSI/ASME B1.20.1. [24:10.3.4]

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. [24:10.3.5]

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. [24:10.3.5.1]

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. [24:10.3.5.2]

10.3.5.3*
Pipe joined with grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves. [24:10.3.5.3]

10.3.6
All joints for the connection of copper tube shall be brazed or joined using pressure fittings as specified in Table 10.2.1.1. [24:10.3.6]

10.4 Protection of Private Fire Service Mains. [24:10.4]

10.4.1 Protection from Corrosion.

10.4.1.1 Coatings.
All bolted joint accessories shall be cleaned and thoroughly coated with asphalt or other corrosion-retarding material after installation. [24:10.4.1.1]

10.4.1.2 The requirements of 10.4.1.1 shall not apply to epoxy coated fittings, valves, glands or other accessories. [24:10.4.1.2]

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. [24:10.4.1.3]

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. [24:10.4.2.1]

10.4.2.1.1 The top of the pipe shall be buried not less than 1 ft (0.3 m) below the frost line for the locality. [24:10.4.2.1.1]

10.4.2.1.2 The depth of piping shall be measured from the top of the piping to the final grade. [24:10.4.2.1.2]

10.4.2.1.3 Where listed piping is used and the bury depth differs from this standard, the listing limitations shall apply. [24:10.4.2.1.3]

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. [24:10.4.2.1.4]

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. [24:10.4.2.1.5]

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. [24:10.4.2.1.6]

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. [24:10.4.2.1.7]

10.4.2.1.7.1 Heat tracing not listed for underground use shall be permitted when piping is installed in accordance with 10.4.2.1.7.1. [24:10.4.2.1.7.1]

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 10.4.2.2.3. [24:10.4.2.2]

10.4.2.2.1 The depth of piping shall be measured from the top of the piping to the final grade. [24:10.4.2.2.1]

10.4.2.2.2 In locations where freezing is not a factor, the depth of cover shall not be less than 30 in. (0.8 m) below grade to prevent mechanical damage. [24:10.4.2.2.2]
10.4.2.2.1
Where listed piping is used and the bury depth differs from this standard, the listing limitations shall apply. [24:10.4.2.2.1]

10.4.2.2.3
Private fire service mains installed under driveways or roadways shall be buried at a minimum depth of 3 ft (0.9 m). [24:10.4.2.2.3]

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. [24:10.4.2.2.3.1]

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). [24:10.4.2.2.4]

10.4.2.2.4.1
Where railroad operators require a greater depth of bury, the greater depth shall apply. [24:10.4.2.2.4.1]

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). [24:10.4.2.2.5]

10.4.2.2.6
Where private fire service mains are installed above ground, they shall be protected with bollards or other means as approved by the AHJ when subject to mechanical damage. [24:10.4.2.2.6]

10.4.3
Except as allowed by 10.4.3, private fire service mains shall not be allowed to run under buildings. [24:10.4.3]

10.4.3.1*
Private fire service mains supplying fire protection systems within the building shall be permitted to extend no more than 10 ft (3 m), as measured from the outside of the building, under the building to the riser location. [24:10.4.3.1]

10.4.3.1.1*
Pipe joints shall not be located directly under foundation fittings. [24:10.4.3.1.1]

10.4.3.1.2*
Piping shall be installed a minimum of 12 in. (305 mm) below the bottom of building foundations or footers. [24:10.4.3.1.2]

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. [24:10.4.3.1.2.1]

10.4.3.2*
Where approved, private fire service mains supplying systems within the building shall be permitted to extend more than 10 ft (3 m) under the building when all the requirements of 10.4.3.2.1, through 10.4.3.2.4 are met. [24:10.4.3.2]

10.4.3.2.1
Where the piping is installed under the building, all foundations or footers over the private fire service main shall be arched to create a minimum of 24 in (610 mm) clearance. [24:10.4.3.2.1]

10.4.3.2.2
It shall be acceptable to install the piping in covered trenches where the trenches are accessible from within the building. [24:10.4.3.2.2]

10.4.3.2.3
All joints shall be mechanically restrained. [24:10.4.3.2.3]

10.4.3.2.4
A valve shall be installed before the piping enters under the building and within 24 in. (610 mm) of where the piping enters the building. [24:10.4.3.2.4]

10.5
Grounding and Bonding.

10.5.1*
In no case shall the underground piping be used as a grounding electrode for electrical systems. [24:10.5.1]

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. [24:10.5.1.1]

10.6
Restraint.

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. [24:10.6.1.1]

10.6.1.2
Thrust blocks shall be of concrete, of a mix not leaner than one part cement, two and one-half parts sand, and five parts stone. [24:10.6.1.2]

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. [24:10.6.1.3]

10.6.1.4
Wherever possible, thrust blocks shall be located so that the joints are accessible for repair. [24:10.6.1.4]
Restrained Joint Systems.
Private fire service mains using restrained joint systems shall include one or more of the following:

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

Sizing Clamps, Rods, Bolts, and Washers.

Clamps shall have the following dimensions:

1. \( \frac{1}{2} \text{ in.} \times 2 \text{ in.} \) (12.7 mm \( \times \) 50.8 mm) for 4 in. (102 mm) to 6 in. (152 mm) pipe
2. \( \frac{5}{8} \text{ in.} \times 2\frac{1}{2} \text{ in.} \) (15.9 mm \( \times \) 63.5 mm) for 8 in. (204 mm) to 10 in. (254 mm) pipe
3. \( \frac{5}{8} \text{ in.} \times 3 \text{ in.} \) (15.9 mm \( \times \) 76.2 mm) for 12 in. (305 mm) pipe

The diameter of a bolt hole shall be \( \frac{1}{8} \text{ in.} \) (3.2 mm) larger than that of the corresponding bolts.

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

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

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>( \frac{5}{8} \text{ in.} (15.9 \text{ mm}) )</th>
<th>( \frac{3}{4} \text{ in.} (19.1 \text{ mm}) )</th>
<th>( \frac{7}{8} \text{ in.} (22.2 \text{ mm}) )</th>
<th>( 1 \text{ in.} (25.4 \text{ mm}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>8</td>
<td>3</td>
<td>2</td>
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<td>4</td>
<td>3</td>
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<td>2</td>
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<td>8</td>
<td>5</td>
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<td>3</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

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

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

Threaded sections of rods shall not be formed or bent.

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

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.

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) 5⁄8 in. (15.9 mm) for pipe 4 in. (102 mm), 6 in. (152 mm), and 8 in. (204 mm)
2) 3⁄4 in. (19.1 mm) for 10 in. (254 mm) pipe
3) 7⁄8 in. (22.2 mm) for 12 in. (305 mm) pipe

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

10.6.2.1.4.1 Washers shall have the following dimensions:
1) 5⁄8 in. × 3 in. (15.9 mm × 76.2 mm) for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe
2) 3⁄4 in. × 39⁄16 in. (19.1 mm × 88.9 mm) for 12 in. (305 mm) pipe

10.6.2.1.4.2 Cast-iron washers shall have the following dimensions:
1) 1⁄2 in. × 3 in. (12.7 mm × 76.2 mm) for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe
2) 1⁄2 in. × 39⁄16 in. (12.7 mm × 88.9 mm) for 12 in. (305 mm) pipe

10.6.2.1.4.3 Steel washers shall have the following dimensions:
1) 15⁄16 in. × 3 in. (24.2 mm × 76.2 mm) for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe
2) 15⁄16 in. × 39⁄16 in. (24.2 mm × 88.9 mm) for 12 in. (305 mm) pipe

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) 5⁄8 in. (15.9 mm) thick and 29⁄16 in. (63.5 mm) wide for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe
2) 5⁄8 in. (15.9 mm) thick and 3 in. (76.2 mm) wide for 12 in. (305 mm) pipe

10.6.2.2.2 The diameter of rod holes shall be 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.

Table 10.6.2.2.3 Restraint Straps for Tees

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>mm</td>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>4</td>
<td>12¹⁄₂</td>
<td>318</td>
<td>10¹⁄₂</td>
<td>257</td>
</tr>
<tr>
<td>6</td>
<td>14¹⁄₂</td>
<td>368</td>
<td>12¹⁄₂</td>
<td>308</td>
</tr>
<tr>
<td>8</td>
<td>16⁷⁄₈</td>
<td>425</td>
<td>14⁷⁄₈</td>
<td>365</td>
</tr>
<tr>
<td>10</td>
<td>19¹⁄₄</td>
<td>484</td>
<td>16⁷⁄₈</td>
<td>424</td>
</tr>
<tr>
<td>12</td>
<td>22³¹⁄₈</td>
<td>567</td>
<td>19¹⁄₄</td>
<td>487</td>
</tr>
</tbody>
</table>

10.6.2.3 Sizes of Plug Strap for Bell End of Pipe.

10.6.2.3.1 The strap shall be ¾ in. (19.1 mm) thick and 2¹⁄₂ in. (63.5 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. [24:10.6.2.3.2]

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. [24:10.6.2.3.3]

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. [24:10.6.2.4]

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 bituminous or other acceptable corrosion-retarding material. [24:10.6.2.5]

10.6.2.5.1
The requirements of 10.6.2.5 shall not apply to epoxy coated fittings, valves, glands or other accessories. [24:10.6.2.5.1]

10.6.* 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

[24:10.6.3]

10.7 Steep Grades.

10.7.1
On steep grades, mains shall be additionally restrained to prevent slipping. [24:10.7.1]

10.7.1.1
Pipe shall be restrained at the bottom of a hill and at any turns (lateral or vertical). [24:10.7.1.1]

10.7.1.1.1
The restraint specified in 10.7.1.1 shall be to natural rock or to suitable piers built on the downhill side of the bell. [24:10.7.1.1.1]

10.7.1.2
Bell ends shall be installed facing uphill. [24:10.7.1.2]

10.7.1.3
Straight runs on hills shall be restrained as determined by a design professional. [24:10.7.1.3]

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. [24:10.8.1]

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. [24:10.8.2]

10.8.3
Pipe, valves, hydrants, and fittings shall be clean and free from internal debris. [24:10.8.3]

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. [24:10.8.4]

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 appropriate equipment. [24:10.8.5]

10.8.6
Plain ends shall be inspected for signs of damage prior to installation. [24:10.8.6]

10.8.7
Piping, fittings, valves, hydrants and appurtenances shall not be dropped, dumped or rolled or skidded against other materials. [24:10.8.7]

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. [24:10.8.8]

10.8.9
If the ground is soft, other means shall be provided to support the pipe. [24:10.8.9]
10.8.10 Valves and fittings used with nonmetallic pipe shall be supported and restrained in accordance with the manufacturer's installation instructions. [24:10.8.10]

10.9 Backfilling.
[24:10.9]

10.9.1 Backfill material shall be tamped in layers or puddled under and around pipes to prevent settlement or lateral movement. [24:10.9.1]

10.9.2 Backfill material shall not contain ash, cinders, refuse, organic matter or other corrosive materials. [24:10.9.2]

10.9.3 Rocks shall not be used for backfill. [24:10.9.3]

10.9.4 Frozen earth shall not be used as backfill material. [24:10.9.4]

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 (0.6 m) above the pipe. [24:10.9.5]

10.9.6 Where using piping listed for private fire service mains, the manufacturer's installation instructions for backfill shall be followed. [24:10.9.6]

10.10 Testing and Acceptance.
[24:10.10]
10.10.1 Approval of Underground Piping.
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 the contractor's material and test certificate(s) shown in Figure 10.10.1.

[24:10.10.1]
Figure 10.10.1 Sample of Contractor's Material and Test Certificate for Underground Piping. [24: Figure 10.10.1]

10.10.2 Acceptance Requirements.
[24:10.10.2]
10.10.2.1* Flushing of Piping.
[24:10.10.2.1]
10.10.2.1
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 connection is made to downstream fire protection system piping. [24:10.10.2.1.1]

10.10.2.1.2
The flushing operation shall continue until water flow is verified to be clear of debris. [24:10.10.2.1.2]

10.10.2.1.3
The minimum rate of flow shall be in accordance with Table 10.10.2.1.3. [24: 10.10.2.1.3]

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

- Hydraulically calculated water demand rate of the system, including any hose requirements
- Flow in accordance with Table 10.10.2.1.3
- Maximum flow rate available to the system under fire conditions

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

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Flow Rate</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>2½</td>
<td>63</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
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<tr>
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<td>152</td>
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<tr>
<td>8</td>
<td>203</td>
</tr>
<tr>
<td>10</td>
<td>254</td>
</tr>
<tr>
<td>12</td>
<td>305</td>
</tr>
</tbody>
</table>

Where the flow rates established in Table 10.10.2.1.3 are not attainable, the maximum flow rate available to the system shall be acceptable. [24: 10.10.2.1.3.1]

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 (13.8 bar) or 50 psi (3.5 bar) in excess of the system working pressure, whichever is greater, and shall maintain that pressure at gauge pressure of ±5 psi (0.35 bar) for 2 hours. [24:10.10.2.2.1]

10.10.2.2.2
Acceptable test results shall be determined by indication of either a pressure loss less than gauge pressure of 5 psi or by no visual leakage. [24:10.10.2.2.2]

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. [24:10.10.2.2.4]

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. [24:10.10.2.2.5]
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 equation:

**U.S. Customary Units:**

$$L = \frac{SD\sqrt{P}}{148,000} \quad \text{[10.10.2.2.6(a) a]}$$

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

**Metric Units:**

$$L = \frac{SD\sqrt{P}}{794,797} \quad \text{[10.10.2.2.6(b) b]}$$

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 the hydrostatic test (kPa) [24:10.10.2.2.6]

Table 10.10.2.2.6 Hydrostatic Testing Allowance at 200 psi (gph/100 ft of Pipe)

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Testing Allowance</th>
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</thead>
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<tr>
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<td>0.096</td>
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<td>12</td>
<td>0.115</td>
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<tr>
<td>14</td>
<td>0.134</td>
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<tr>
<td>16</td>
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<td>0.191</td>
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<tr>
<td>24</td>
<td>0.229</td>
</tr>
</tbody>
</table>

Notes:

(1) For other length, diameters, and pressures, utilize Equation 10.10.2.2.6(a) a or 10.10.2.2.6(b) b to determine the appropriate testing allowance.

(2) For test sections that contain various sizes and sections of pipe, the testing allowance is the sum of the testing allowances for each size and section.

[24: Table 10.10.2.2.6]

Other Means of Hydrostatic Tests.

Where required by the AHJ, hydrostatic tests shall be permitted to be completed in accordance with the requirements of AWWA C600, AWWA C602, AWWA C603, and AWWA C900. [24:10.10.2.3]

Operating Test.

[24:10.10.2.4]

Each hydrant shall be fully opened and closed under system water pressure. [24:10.10.2.4.1]

Dry barrel hydrants shall be checked for proper drainage. [24:10.10.2.4.2]

All control valves shall be fully closed and opened under system water pressure to ensure proper operation. [24:10.10.2.4.3]

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. [24:10.10.2.4.4]

Backflow Prevention Assemblies.

[24:10.10.2.5]

The backflow prevention assembly shall be forward flow tested to ensure proper operation. [24:10.10.2.5.1]
10.10.2.5.2
The minimum flow rate required by 10.10.2.5.1 shall be the system demand, including hose stream demand where applicable.

Supplemental Information

<table>
<thead>
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<th>File Name</th>
<th>Description</th>
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<tr>
<td>13_Chapter_10_from_24.docx</td>
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</tr>
</tbody>
</table>

Submitter Information Verification

Submitter Full Name: Matthew Klaus
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City: 
State: 
Zip: 
Submittal Date: Wed Sep 24 10:14:34 EDT 2014

Committee Statement

Committee Statement: Chapter 10 from NFPA 24 has historically been extracted into Chapter 10 of NFPA 13. This revision will bring all of the second revisions to chapter 10 of NFPA 24 2016 edition into NFPA 13.
Response Message:
A.10.1
Copper tubing (Type K) with brazed joints conforming to Table 10.1.1 and Table 10.2.1.1 is acceptable for underground service.

(1) Listing and labeling. Certification organizations list or label the following:
   (a) Cast iron and ductile iron pipe (cement-lined and unlined, coated and uncoated)
   (b) Steel pipe
   (c) Copper pipe
   (d) Fiberglass filament-wound epoxy pipe and couplings
   (e) Polyethylene pipe
   (f) Polyvinyl chloride (PVC) pipe and couplings
   (g) 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, Thickness Design of Ductile Iron Pipe
(2) AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in. for Water Distribution
(3) AWWA C905, AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 in. through 48 in. (350 mm through 1,200 mm)
(4) AWWA C906, Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) through 68 in. (1,600 mm), for Water Distribution and Transmission
(5) AWWA M41, Ductile Iron Pipe and Fittings
(6) 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 10.1.5, 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.

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

<table>
<thead>
<tr>
<th>Pipe Size (in.)</th>
<th>OD (in.)</th>
<th>Pressure Class</th>
<th>Thickness Class</th>
<th>Wall Thickness</th>
<th>Minimum Lining Thickness*</th>
<th>ID (in.) with Lining</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3.96</td>
<td>350</td>
<td>50</td>
<td>0.25</td>
<td>1/16</td>
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</tr>
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<td>1/16</td>
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</tr>
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<td>3.96</td>
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<td>52</td>
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<td>1/16</td>
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</tr>
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<td>3.96</td>
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<td>53</td>
<td>0.31</td>
<td>1/16</td>
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<tr>
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<td>3.96</td>
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<td>54</td>
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<td>1/16</td>
<td>3.16</td>
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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.

A.10.1.4.1

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

1. Exposure from direct rays of sunlight
Compatibility with chemicals such as floor coatings and termiticides/insecticides

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

A.10.3.5.3
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.

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(a).

Figure A.10.4.2(a) Recommended Depth of Cover (in feet) Above Top of Underground Yard Mains.
In determining the need to protect aboveground piping from freezing, the lowest mean temperature should be considered as shown in Figure A.10.4.2(b).

Figure A.10.4.2(b) Isothermal Lines — Lowest One-Day Mean Temperature (°F).
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
Items such as sidewalks or patios should not be included as they are no different from roadways. See Figure A.10.4.3.1.

Figure A.10.4.3.1 Riser Entrance Location.

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.

Figure A.10.4.3.1.1 shows location where pipe joints would be prohibited.

Figure A.10.4.3.1.1 Pipe Joint Location in Relation to Foundation Footings.
A.10.4.3.1.2
Sufficient clearance should be provided when piping passes beneath foundations or footers. See Figure A.10.4.3.1.2.

Figure A.10.4.3.1.2 Piping Clearance from Foundation.
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.10.5.1

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.

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.

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

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Notes:
(1) For SI units, 1 lb = 0.454 kg; 1 in. = 25.4 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 $19,353 \times \frac{125}{100} = 24,191$ lb (10,973 kg).

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

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<th>Nominal Pipe Diameter (in.)</th>
<th>Bearing Block Area (ft²)</th>
<th>Nominal Pipe Diameter (in.)</th>
<th>Bearing Block Area (ft²)</th>
<th>Nominal Pipe Diameter (in.)</th>
<th>Bearing Block Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.6</td>
<td>12</td>
<td>29.0</td>
<td>24</td>
<td>110.9</td>
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<td>30</td>
<td>170.6</td>
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<tr>
<td>6</td>
<td>7.9</td>
<td>16</td>
<td>50.4</td>
<td>36</td>
<td>244.4</td>
</tr>
<tr>
<td>8</td>
<td>13.6</td>
<td>18</td>
<td>63.3</td>
<td>42</td>
<td>329.9</td>
</tr>
<tr>
<td>10</td>
<td>20.5</td>
<td>20</td>
<td>77.7</td>
<td>48</td>
<td>430.0</td>
</tr>
</tbody>
</table>

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, a soil horizontal bearing strength of 1000 lb/ft², 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 22\(\frac{1}{2}\) degrees, 0.276; for 11\(\frac{1}{4}\) degrees, 0.139.

(b) For other internal pressures, multiply by ratio to 100 psi

(c) For other soil horizontal bearing strengths, divide by ratio to 1000 lb/ft²

(d) For other safety factors, multiply by ratio to 1.5

*Example:* Using Table A.10.8.2(b), find the horizontal bearing block area for a 6 in. diameter, 45-degree bend with an internal pressure of 150 psi. The soil bearing strength is 3000 lb/ft², and the safety factor is 1.5.

From Table A.10.8.2(b), the required bearing block area for a 6 in. diameter, 90-degree bend with an internal pressure of 100 psi and a soil horizontal bearing strength of 1000 psi is 7.9 ft².

For example: \[\text{Area} = 7.9 \text{ ft}^2 \times 0.541 \times \frac{150}{100} = 2.1 \text{ ft}^2\]

Table A.10.6.1(c) Horizontal Bearing Strengths

<table>
<thead>
<tr>
<th>Soil</th>
<th>Bearing Strength ((S_b))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/ft²</td>
</tr>
<tr>
<td>Muck</td>
<td>0</td>
</tr>
<tr>
<td>Soil</td>
<td>Bearing Strength ($S_b$)</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Soft clay</td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td></td>
</tr>
<tr>
<td>Sandy silt</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>Sand clay</td>
<td></td>
</tr>
<tr>
<td>Hard clay</td>
<td></td>
</tr>
</tbody>
</table>

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

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

$$T_x = PA (1 - \cos \theta)$$
$$T_y = PA \sin \theta$$
$$T = 2PA \sin \frac{\theta}{2}$$

$$\Delta = \left(90 - \frac{\theta}{2}\right)$$

$T = \text{thrust force resulting from change in direction of flow (lbf)}$

$T_x = \text{component of thrust force acting parallel to original direction of flow (lbf)}$

$T_y = \text{component of thrust force acting perpendicular to original direction of flow (lbf)}$

$P = \text{water pressure (psi)}$

$A = \text{cross-sectional area of pipe based on outside diameter (in.}^2\text{)}$

$V = \text{velocity in direction of flow}$

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.

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

Figure A.10.6.1(b) Bearing Thrust Block.
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:

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

where:

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

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

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

where:

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

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).

**Figure A.10.6.1(c)** Gravity Thrust Block.
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:

\[
V_g = \frac{S_f PA \sin \theta}{W_m} \tag{A.10.6.1(d)\ref{A.10.6.1(d)}}
\]

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:

\[
T_x = PA(1 - \cos \theta) \tag{A.10.6.1(e)\ref{A.10.6.1(e)}}
\]

where:

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

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:

2. AWWA M41, *Ductile Iron Pipe and Fittings*
3. AWWA M9, *Concrete Pressure Pipe*

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

*Figure A.10.6.2 Typical Connection to Fire Protection System Riser Illustrating Restrained Joints.*
A.10.6.2.5

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

1. Clamps, steel
2. Rods, steel
4. Washers, steel, cast iron (Class A cast iron as defined by ASTM A-126A126)
5. Anchor straps, plug straps, steel
6. Rod couplings, turnbuckles, malleable iron (ASTM A-197A197)

The materials specified in A.10.6.2.5(1) through (6) do not preclude the use of other materials that also satisfy the requirements of this section.

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.

A.10.10.2.1

Underground mains and lead-in connections to system risers should be flushed through hydrants at dead ends of the system or through accessible aboveground flushing outlets allowing the water to run until clear. Figure A.10.10.2.1 shows acceptable examples of flushing the system. If water is supplied from more than one source or from a looped system, divisional valves should be closed to produce a high-velocity flow through each single line. The flows specified in Table 10.10.2.1.3 will produce a velocity of at least 10 ft/sec (3 m/sec), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.

Figure A.10.10.2.1 Methods of Flushing Water Supply Connections.

A.10.10.2.1.3(2)
The velocity of approximately 10 ft/sec (3.1 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 (3.1 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.10.10.2.2.1

A sprinkler system has for its water supply a connection to a public water service main. A 100 psi (6.9 bar) rated pump is installed in the connection. With a maximum normal public water supply of 70 psi (4.8 bar), at the low elevation point of the individual system or portion of the system being tested and a 120 psi (8.3 bar) pump (churn) pressure, the hydrostatic test pressure is 70 psi (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 maintained by a small pump, the main controlling gate meanwhile being kept shut during the test. Polybutylene pipe will undergo expansion during initial pressurization. In this case, a reduction in gauge pressure might not necessarily indicate a leak. The pressure reduction should not exceed the manufacturer's specifications and listing criteria.

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

A recommended test procedure is as follows: The water pressure is to be increased in 50 psi (3.5 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 and held for 1 hour, the pressure is to be decreased to 0 psi while observations are made for leakage. The pressure is again to be slowly increased to the value specified in 10.10.2.2.1 and held for 1 more hour while observations are made for leakage and the leakage measurement is made.

A.10.10.2.2.4

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 should be pressurized for 1 day prior to the hydrostatic test to account for expansion, absorption, entrapped air, and so on.

The use of a blind flange or skillet is preferred for 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.
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 Listing.

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

Table 10.1.1.1 Manufacturing Standards for Underground Pipe

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ductile Iron</strong></td>
<td></td>
</tr>
<tr>
<td>Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water</td>
<td>AWWA C104</td>
</tr>
<tr>
<td>Polyethylene Encasement for Ductile Iron Pipe Systems</td>
<td>AWWA C105</td>
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<tr>
<td>Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings</td>
<td>AWWA C111</td>
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<tr>
<td>Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges</td>
<td>AWWA C115</td>
</tr>
<tr>
<td><strong>Thickness Design of Ductile Iron Pipe</strong></td>
<td>AWWA C150</td>
</tr>
<tr>
<td><strong>Ductile Iron Pipe, Centrifugally Cast for Water</strong></td>
<td>AWWA C151</td>
</tr>
<tr>
<td><strong>Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances</strong></td>
<td>AWWA C600</td>
</tr>
<tr>
<td><strong>Concrete</strong></td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Steel-Cylinder Type</td>
<td>AWWA C300</td>
</tr>
<tr>
<td>Prestressed Concrete Pressure Pipe, Steel-Cylinder Type</td>
<td>AWWA C301</td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Non-Cylinder Type</td>
<td>AWWA C302</td>
</tr>
<tr>
<td>Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned</td>
<td>AWWA C303</td>
</tr>
</tbody>
</table>
### Materials and Dimensions

<table>
<thead>
<tr>
<th>Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water Distribution Systems</th>
<th>AWWA C400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place</td>
<td>AWWA C602</td>
</tr>
</tbody>
</table>

**Plastic**

- Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water Distribution — AWWA C900
- Polyvinyl Chloride (PVC) Pressure Pipe, 14 in. Through 48 in., for Water Distribution — AWWA C905
- Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 63 in. (1575 mm) for Water Distribution — AWWA C906
- Molecularly Oriented Polyvinyl Chloride (PVCO) 4 in. Through 12 in. (100 mm Through 600 mm) for Water Distribution — AWWA C909

**Brass**

- Specification for Seamless Red Brass Pipe — ASTM B 43

**Copper**

- Specification for Seamless Copper Tube — ASTM B 75
- Specification for Seamless Copper Water Tube — ASTM B 88
- Requirements for Wrought Seamless Copper and Copper-Alloy Tube — ASTM B 251

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.

**Table 10.1.1.3 Steel Piping for Fire Department Connections**
Materials and Dimensions | Standard
--- | ---
Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use | ASTM A 795
Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless | ASTM A 53

10.1.1.3.1

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

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 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

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

10.1.4.1*

Underground piping shall be permitted to extend into the building through the slab or wall not more than 24 in. (0.6 m).

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, or 10.2.1.3.

10.2.1.1

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

Table 10.2.1.1 Fittings Materials and Dimensions

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Iron</td>
<td></td>
</tr>
<tr>
<td>Gray Iron Threaded Fittings, Classes 125 and 250</td>
<td>ASME B16.4</td>
</tr>
<tr>
<td>Gray Iron Pipe Flanges and Flanged Fittings, Classes 12, 125, and 250</td>
<td>ASME B16.1</td>
</tr>
</tbody>
</table>

Ductile Iron

<table>
<thead>
<tr>
<th>Materials and Dimensions</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile Iron and Gray Iron Fittings, 3 in. Through 48 in., for Water and other Liquids</td>
<td>AWWA C110</td>
</tr>
<tr>
<td>Ductile Iron Compact Fittings, 3 in. Through 24 in. and 54 in. through 64 in. for Water Service</td>
<td>AWWA C153</td>
</tr>
</tbody>
</table>
### Materials and Dimensions

<table>
<thead>
<tr>
<th>Malleable Iron</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malleable Iron Threaded Fittings, Class 150 and 300</td>
<td>ASME B16.3</td>
</tr>
</tbody>
</table>

**Steel**

<table>
<thead>
<tr>
<th>Factory-Made Wrought Steel Buttweld Fittings</th>
<th>ASME B16.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buttwelding Ends</td>
<td>ASME B16.25</td>
</tr>
<tr>
<td>Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures</td>
<td>ASTM A234</td>
</tr>
<tr>
<td>Pipe Flanges and Flanged Fittings, NPS 1/2 Through 24</td>
<td>ASME B16.5</td>
</tr>
<tr>
<td>Forged Steel Fittings, Socket Welded and Threaded</td>
<td>ASME B16.11</td>
</tr>
<tr>
<td>Steel Pipe Flanges for Waterworks Service — Sizes 4 in. Through 144 in.</td>
<td>AWWA C207</td>
</tr>
<tr>
<td>Dimensions for Fabricated Steel Water Pipe Fittings</td>
<td>AWWA C208</td>
</tr>
</tbody>
</table>

**Copper**

<table>
<thead>
<tr>
<th>Wrought Copper and Bronze Solder Joint Pressure Fittings</th>
<th>ASME B16.22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Bronze Solder Joint Pressure Fittings</td>
<td>ASME B16.18</td>
</tr>
</tbody>
</table>

**Bronze Fittings**

| Cast Bronze Threaded Fittings                                               | ASTM B16.15  |

### 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.

**10.2.1.3**

Approved fittings shall be permitted to be used.

**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 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 Threaded Pipe and Fittings.
Connections of pipe and fittings indicated in Table 10.1.1 and Table 10.2.1 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 Where pipe, fittings or appurtenances are connected using threads, all threads shall be in accordance with ANSI/ASME B1.20.1.

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.

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.

10.3.6 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 or other corrosion-retarding material after installation.

10.4.1.2 The requirements of 10.3.5.3 shall not apply to 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 1 ft (0.3 m) 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 10.4.2.5.10.1.4.

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 10.4.2.3.

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. (0.8 m) 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 3 ft (0.9 m).

10.4.2.2.3.1
Sidewalks, walkways and other paved or concrete pedestrian passageways shall not be required to comply with 10.4.2.3.

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).

10.4.2.2.6
Where private fire service mains are installed above ground, they shall be protected with bollards or other means as approved by the AHJ when subject to mechanical damage.

10.4.3 Private Fire Service Mains Under Buildings.
Except as allowed by 10.4.3, private fire service mains shall not be allowed to run under buildings.

10.4.3.1*
Private fire service mains supplying fire protection systems within the building shall be permitted to extend no more than 10 ft (3 m), 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 fittings.

10.4.3.1.2*
Piping shall be installed a minimum of 12 in. (305 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*
Where approved, private fire service mains supplying systems within the building shall be permitted to extend more than 10 ft (3 m) under the building when all the requirements of 10.4.3.2.1, through 10.4.3.2.4 are met.

10.4.3.2.1
Where the piping is installed under the building, all foundations or footers over the private fire service main shall be arched to create a minimum of 24 in (610 mm) clearance.

10.4.3.2.2
It shall be acceptable to install the piping in covered trenches where the trenches are accessible from within the building.

10.4.3.2.3
All joints shall be mechanically restrained.

10.4.3.2.4
A valve shall be installed before the piping enters under the building and within 24 in. (610 mm) of where the piping enters the building.

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 10.6.810.5.1 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.

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.

Private fire service mains using restrained joint systems shall include one or more of the following:

(1)锁紧机械或推入式接头
(2)机械接头利用带锁紧螺帽的接头
(3)螺栓法兰接头
(4)管道夹箍和拉杆
(5)其他批准的方法或设备

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) $\frac{1}{2}$ in. × 2 in. (12.7 mm × 50.8 mm) for 4 in. (102 mm) to 6 in. (152 mm) pipe
(2) \( \frac{5}{8} \text{ in.} \times 2\frac{1}{2} \text{ in.} \) (15.9 mm × 63.5 mm) for 8 in. (204 mm) to 10 in. (254 mm) pipe

(3) \( \frac{5}{8} \text{ in.} \times 3 \text{ in.} \) (15.9 mm × 76.2 mm) for 12 in. (305 mm) pipe

10.6.2.1.1.2
The diameter of a bolt hole shall be \( \frac{1}{8} \) in. (3.2 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 \( \frac{5}{8} \) in. (15.9 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.

**Table 10.6.2.1.2.2 Rod Number — Diameter Combinations**

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>( \frac{5}{8} ) in. (15.9 mm)</th>
<th>( \frac{3}{4} ) in. (19.1 mm)</th>
<th>( \frac{7}{8} ) in. (22.2 mm)</th>
<th>1 in. (25.4 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

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

10.6.2.1.2.3
Where using bolting rods, the diameter of mechanical joint bolts shall limit the diameter of rods to \( \frac{3}{4} \) in. (19.1 mm).

10.6.2.1.2.4
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) \( \frac{5}{8} \) in. (15.9 mm) for pipe 4 in. (102 mm), 6 in. (152 mm), and 8 in. (204 mm)
(2) \(\frac{5}{4}\) in. (19.1 mm) for 10 in. (254 mm) pipe

(3) \(\frac{3}{8}\) in. (22.2 mm) for 12 in. (305 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. \(\frac{5}{8}\) in. \(\times\) 3 in. (15.9 mm \(\times\) 76.2 mm) for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe

2. \(\frac{3}{4}\) in. \(\times\) 3\(\frac{1}{2}\) in. (19.1 mm \(\times\) 88.9 mm) for 12 in. (305 mm) pipe

10.6.2.1.4.3

Steel washers shall have the following dimensions:

1. \(\frac{1}{2}\) in. \(\times\) 3 in. (12.7 mm \(\times\) 76.2 mm) for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe

2. \(\frac{1}{2}\) in. \(\times\) 3\(\frac{1}{2}\) in. (12.7 mm \(\times\) 88.9 mm) for 12 in. (305 mm) pipe

10.6.2.1.4.4

The diameter of holes shall be \(\frac{1}{8}\) in. (3.2 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. thick and 2\(\frac{1}{2}\) in. (63.5 mm) wide for 4 in. (102 mm), 6 in. (152 mm), 8 in. (204 mm), and 10 in. (254 mm) pipe

2. \(\frac{5}{8}\) in. thick and 3 in. (76.2 mm) wide for 12 in. (305 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.

Figure 10.6.2.2.3 Restraint Straps for Tees.

Table 10.6.2.2.3 Restraint Straps for Tees
<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>mm</td>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>4</td>
<td>12½</td>
<td>318</td>
<td>10½</td>
<td>257</td>
</tr>
<tr>
<td>6</td>
<td>14½</td>
<td>368</td>
<td>12½</td>
<td>308</td>
</tr>
<tr>
<td>8</td>
<td>16½</td>
<td>425</td>
<td>14½</td>
<td>365</td>
</tr>
<tr>
<td>10</td>
<td>19½</td>
<td>484</td>
<td>16½</td>
<td>424</td>
</tr>
<tr>
<td>12</td>
<td>22½</td>
<td>567</td>
<td>19½</td>
<td>487</td>
</tr>
</tbody>
</table>

10.6.2.3 Sizes of Plug Strap for Bell End of Pipe.

10.6.2.3.1 The strap shall be ¾ in. (19.1 mm) thick and 2¾ in. (63.5 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 bituminous or other acceptable corrosion-retarding material.

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

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 suitable 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 appropriate equipment.

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.

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
Rocks shall not be used for backfill.

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 (0.6 m) 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.
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 the contractor’s material and test certificate(s) shown in Figure 10.10.1

Figure 10.10.1 Sample of Contractor’s Material and Test Certificate for Underground Piping.
Contractor’s Material and Test Certificate for Underground

**PROCEDURE**
Upon completion of work, inspection and tests shall be made by the contractor’s representative and witness. All defects shall be corrected and system left in service before contractor’s personnel finalize.

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

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

<table>
<thead>
<tr>
<th>Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted by approving authorities (names)</td>
</tr>
<tr>
<td>Address</td>
</tr>
<tr>
<td>Installation conforms to accepted plans</td>
</tr>
<tr>
<td>Equipment used is approved</td>
</tr>
<tr>
<td>If no, state deviations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has person in charge of fire equipment been instructed as to location of control valves and care and maintenance of this new equipment?</td>
</tr>
<tr>
<td>If no, explain</td>
</tr>
<tr>
<td>Have copies of appropriate instructions and care and maintenance charts been left on premises?</td>
</tr>
<tr>
<td>If no, explain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplies buildings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Underground pipes and joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe types and class</td>
</tr>
<tr>
<td>Pipe conforms to standard</td>
</tr>
<tr>
<td>Fittings conform to standard</td>
</tr>
<tr>
<td>If no, explain</td>
</tr>
<tr>
<td>Joints needing anchorage clamped, strapped, or blocked in accordance with standard</td>
</tr>
<tr>
<td>If no, explain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flushing: Flow the required rate until water is clear as indicated by no collection of foreign matter at hydrants and blow-offs. Flush at one of the flow rates as specified in 10.10.2.1.3.</td>
</tr>
<tr>
<td>Hydrostatic: All piping and attached appurtenances subjected to system working pressure plus 25% (13.8 bar) or 50 psi (3.5 bar) in excess of the system working pressure, whichever is greater, (0.35 bar) for 2 hours.</td>
</tr>
<tr>
<td>Hydrostatic Testing Allowance: Where additional water is added to the system to maintain the amount of water shall be measured and shall not exceed the limits of the following:</td>
</tr>
</tbody>
</table>

\[
L = \frac{SD^2}{148,000}
\]

\(L = \text{testing allowance (makeup water), in gallons}
\(S = \text{length of pipe tested, in feet}
\(D = \text{nominal diameter of the pipe, in inches}
\(P = \text{surge test pressure during the hydrostatic test, in pounds per square inch (psi)}

- **Note:** The above formula is for determining the testing allowance for hydrostatic testing. It is used to calculate the amount of makeup water needed to maintain the water level during the test.
## Contractor’s Material and Test Certificate for Underground System

### PROCEDURE
Upon completion of work, inspection and tests shall be made by the contractor’s representative and witness representative. All defects shall be corrected and system left in service before contractor’s personnel finalize acceptance.

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

### Property Information
- **Property Name:***
- **Property Address:***

### Plans
- Accepted by approving authorities (names)
- Address
- Installation conforms to accepted plans
- Equipment used is approved
- If no, state deviations

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

### Location
- Supplies buildings

### Underground Pipes and Joints
- Pipe types and class
- Type joint
- Pipe conforms to standard
- Fittings conform to standard
- If no, explain
- Joints needing anchorage clamped, strapped, or blocked in accordance with standard
- If no, explain

### Test Description
- **Flushing:** Flow the required rate until water is clear as indicated by no collection of foreign objects from hydrants and blow-offs. Flush in accordance with the requirements of 10.10.2.1.3.
- **Hydrostatic:** All piping and attached appurtenances subjected to system working pressure (13.8 bar) or 50 psi (3.5 bar) in excess of the system working pressure, whichever is greater, (0.35 bar) for 2 hours.
- **Hydrostatic Testing Allowance:** Where additional water is added to the system to maintain the amount of water shall be measured and shall not exceed the limits of the following:

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

- \(L\) = testing allowance (makeup water), in gallons
- \(S\) = length of pipe tested, in feet
- \(D\) = nominal diameter of the pipe, in inches
- \(P\) = average test pressure during the hydrostatic test, in pounds per square inch (psi)
| **Hydrostatic test** | All new underground piping hydrostatically tested at
| | __________ psi for __________ hours |
| **Leakage test** | Total amount of leakage measured
| | __________ gallons __________ hours |
| Allowable leakage
| | __________ gallons __________ hours |
| **Forward flow test of backflow preventer** | Forward flow test performed in accordance with 10.10.2.5.2: |
| **Hydrants** | Number installed | Type and make |
| **Control valves** | Water control valves left wide open
| | If no, state reason |
| Hose threads of fire department connections and hydrants interchangeable with those of fire department answering alarm |
| **Remarks** | Date left in service |
| **Signatures** | Name of installing contractor
| | Tests witnessed by
| | For property owner (signed) | Title |
| | For installing contractor (signed) | Title |
| **Additional explanation and notes** | |
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 not less than one of the following:in accordance with Table 10.10.2.1.3.

1. Hydraulically calculated water demand flow rate of the system, including any hose requirements
2. Flow in accordance with Table 10.10.2.1.3
3. Maximum flow rate available to the system under fire conditions

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

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>gpm</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>2½</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>220</td>
</tr>
<tr>
<td>4</td>
<td>390</td>
</tr>
<tr>
<td>5</td>
<td>610</td>
</tr>
<tr>
<td>6</td>
<td>880</td>
</tr>
<tr>
<td>8</td>
<td>1,560,1560</td>
</tr>
<tr>
<td>10</td>
<td>2,440,2440</td>
</tr>
<tr>
<td>12</td>
<td>3,520,3520</td>
</tr>
</tbody>
</table>

10.10.2.1.3.1 Where the flow rates established in Table 10.10.2.1.3 are not attainable, the maximum flow rate available to the system shall be acceptable.

10.10.2.1.4 Provision shall be made for the proper disposal of water used for flushing or testing.

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 (13.8 bar) or 50 psi (3.5 bar) in excess of the system working pressure, whichever is greater, and shall maintain that pressure at gauge pressure of ±5 psi (0.35 bar) for 2 hours.
10.10.2.2
Acceptable test results shall be determined by indication of either a pressure loss less than
gauge pressure of 5 psi or by no visual leakage.

10.10.2.3
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

10.10.2.4
The trench shall be backfilled between joints before testing to prevent movement of pipe.

10.10.2.5
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.

10.10.2.6* 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:

U.S. Customary Units:
\[ L = \frac{SD\sqrt{P}}{148,000} \]  \[ 10.10.2.2.6(a) \]
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:
\[ L = \frac{SD\sqrt{P}}{794,797} \]  \[ 10.10.2.2.6(b) \]
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)

Table 10.10.2.2.6 Hydrostatic Testing Allowance at 200 psi (gph/100 ft of Pipe)
<table>
<thead>
<tr>
<th>Nominal Pipe Diameter (in.)</th>
<th>Testing Allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.019</td>
</tr>
<tr>
<td>4</td>
<td>0.038</td>
</tr>
<tr>
<td>6</td>
<td>0.057</td>
</tr>
<tr>
<td>8</td>
<td>0.076</td>
</tr>
<tr>
<td>10</td>
<td>0.096</td>
</tr>
<tr>
<td>12</td>
<td>0.115</td>
</tr>
<tr>
<td>14</td>
<td>0.134</td>
</tr>
<tr>
<td>16</td>
<td>0.153</td>
</tr>
<tr>
<td>18</td>
<td>0.172</td>
</tr>
<tr>
<td>20</td>
<td>0.191</td>
</tr>
<tr>
<td>24</td>
<td>0.229</td>
</tr>
</tbody>
</table>

Notes:

(1) For other length, diameters, and pressures, utilize Equation 10.10.2.6(a) or 10.10.2.6(b) to determine the appropriate testing allowance.

(2) For test sections that contain various sizes and sections of pipe, the testing allowance is the sum of the testing allowances for each size and section.

10.10.2.3 Other Means of Hydrostatic Tests.

Where required by the AHJ, hydrostatic tests shall be permitted to be completed in accordance with the requirements of AWWA C600, AWWA C602, AWWA C603, and AWWA C900.

10.10.2.4 Operating Test.

10.10.2.4.1 Each hydrant shall be fully opened and closed under system water pressure.

10.10.2.4.2 Dry barrel hydrants shall be checked for proper drainage.

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

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

10.10.2.5 Backflow Prevention Assemblies.

10.10.2.5.1 The backflow prevention assembly shall be forward flow tested to ensure proper operation.

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