INSTALLATION AND MAINTENANCE OF PRIVATE FIRE SERVICE MAINS AND THEIR APPURTENANCES

Table of Contents

Page

List of Figures

List of Tables

1.0 SCOPE

This data sheet covers the installation, arrangement, location and preventive and corrective maintenance of private fire service mains and their appurtenances. This equipment includes manually operated valves, hydrants, meters and outside hose equipment including hose houses and cabinets. The hydraulics of underground mains, including hydrant and other orifice discharge coefficients and Hazen-Williams pipe coefficients are covered in Data Sheet 3-0, *Hydraulics of Fire Protection Systems.* Cross connections and the use of backflow preventers are covered in Data Sheet 3-3, *Cross Connections.* Guidelines for the installation, maintenance and testing of pressure reducing valves are covered in Data Sheet 3-11, *Flow and Pressure Regulating Devices for Fire Protection Service* .

For the purpose of this data sheet, a *private fire service main* is that pipe between a source of water and the water supply side of the first above ground connection to a sprinkler or standpipe system. When connected to a public water system, the private fire service main begins at a point designated by the public utility, usually at a manually operated valve near the property line. When connected to a fire pump, the main begins at the system side of the pump discharge water control valve. A main connected to a gravity or pressure tank begins at the system side of the tank's discharge water control valve.

Some mains are used to carry water for both fire service and industrial use. This data sheet also applies to these ‘‘combined service’’ mains.

1.1 Hazards

Underground mains are a critical component of a fire protection system linking the water source and above ground components such as sprinklers, hydrants and hoses. The one purpose of underground mains is to get water to the attached fire protection systems and equipment where it can be used. A lack of water to the fire protections systems can lead to a large and devastating loss. Proper design, installation and maintenance of underground mains reduces the potential of any disruption to this water supply, allowing water to reach sprinklers and other equipment in the areas where it is needed.

1.2 Changes

January 2022. Interim revision. The following significant changes were made:

A. Added Section 2.1 on using FM Approved equipment and services. Removed all subsequent redundant iterations of this language in the document.

B. Added guidance for the new FM Approved pipe rehabilitation system in Section 2.0.

C. Updated explanatory text on pipe rehabilitation systems in Section 3.0 to support the new Section 2.0 guidance on FM Approved pipe rehabilitation systems.

D. Updated guidance on thrust block areas in Table 2.

E. Relocated information on leak detection methods and equipment to Section 3.0. This material contains no recommendations.

F. Replaced unreadable figures in the document.

G. Updated references and terminology to current FM Global and FM Approval brand assurance standards.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Use FM Approved equipment, materials, and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide*, an online resource of FM Approvals.

2.2 Construction and Location

2.2.1 System Components

2.2.1.1 Local governing authorities may require the installation of various system components. If FM Approved components are not available, then components made in accordance with American Water Works Association (AWWA) or to similarly recognized standards are acceptable.

2.2.2 Maintenance of System Components

2.2.2.1 Supervise and maintain system components in accordance with Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance,* and Section 2.3.8, of this data sheet.

2.2.3 Single Check Valves

2.2.3.1 If a single check valve is required to prevent water from the private fire protection main system from being lost through the tanks and pump supply, install the valve at the discharge from fire pumps and at gravity tank and pressure tank connections.

2.2.3.2 When check valves are installed in a vertical pipe, flow must be in the upward direction.

2.2.3.3 Install check valves so that they are accessible and, when located underground, in watertight, frost-proof concrete or masonry pits. Provide clearance around the main where it passes through the wall, and pack the annulus with a sealant.

2.2.3.4 Provide manually operated valves, preferably the indicating type, on both sides of the check valve to allow isolation for maintenance or repair.

2.2.3.5 Frequently there is a curb box valve at the connection to the public main that can serve as the upstream valve. Roadway box valves (curb box installation) use inside screw gate valves.

Provide ample clearance for valves with side mounted covers to permit clapper removal. Wafer check valves have a shorter body length and many do not have covers. Check valves without covers must be removed from the system for clapper replacement or repair.

2.2.4 Anti-Water Hammer Check Valves and Surge Arresters

2.2.4.1 Install check valves at the discharge of the fire pump. Install surge arresters on the system side of the fire pump discharge check valve and as close to the valve as possible.

2.2.4.2 Special anti-water hammer check valves are Approved for use in the discharge of a fire pump, where conditions may cause severe water hammer with the usual single swing type check valve.

Because of the relatively high friction loss through anti-water hammer check valves, consult the friction loss data tabulated in the FM *Approval Guide* and consider the loss when designing the private fire service system. Some Approved anti-water hammer check valves are not suited for direct bolting to the body of butterfly valves because of clearance problems between the butterfly vane and the check valve clapper. Limit the use of anti-water hammer check valves to installations on the discharge side of fire pumps or other water hammer problem areas.

For other situations use Approved single swing check valves.

2.2.4.3 Use a surge arrester or damper if an anti-water hammer check valve alone proves inadequate to control the problem.

2.2.5 Backflow Preventers

2.2.5.1 When backflow prevention is required, refer to Data Sheet 3-3, *Cross Connections,* for cross connection control guidelines.

2.2.6 Fire Department Pumper Connections

2.2.6.1 To prevent loss of system pressure through the pumper connection, install the Approved single check valve at each fire department connection, located as near as practicable to the point where it joins the system.

2.2.6.2 Do not provide a shutoff valve in the piping between the pumper connection and the fire service mains. Provide an Approved automatic drip valve (ball drip) at a low point in the pipe between the check valve and the outside hose coupling of the pumper connection. Arrange the automatic drip system so that it discharges to a proper frost-free location.

2.2.7 Manually Operated Valves

2.2.7.1 In both new fire service main system installations and valve replacement situations, install valves that open in a counterclockwise direction. In existing installations where all valves open clockwise or a mixture of opening directions are present, clearly identify the direction of opening.

2.2.7.2 For underground fire service main use, install either a post indicator valve assembly or a gate valve with an indicator post to readily show the open or closed position of the valve. If a valve must be placed where an indicator post cannot be used, such as in a road, use an indicating valve (such as an indicating butterfly valve or an outside screw and yoke gate valve), installed in a watertight, frost-proof concrete or masonry pit (see Data Sheet 3-2, *Water Tanks for Fire Protection.* The section titled *Valve Enclosures and Frost Protection* describes the Valve Pit Enclosure).

2.2.7.3 Limit the use of non-indicating type underground gate valves on branch mains to hydrants and building lead-ins. Indicating valves are preferred. Such valves are normally nonrising stem type, and require a key wrench for operation. A curb box with cover plate at grade level provides access for the wrench to the valve stem nut.

2.2.8 Hydrants

2.2.8.1 Do not install pumper connections (also known as pumper-suction connections and steamer connections) with hydrants for private fire protection systems. The draft created by the pumpers connected to the pumper connections could deplete the water supply to the automatic sprinkler system.

2.2.8.2 Consult the relevant occupancy data sheets if hose streams from hydrants as supplementary protection are required.

The number of hydrants may be modified according to varying conditions:

1. Hose connections at standpipes may reduce the total number of hydrants required. Include the water demand requirements for hose connections at standpipes when determining the total system water demand.

2. Extra hydrants may be necessary to fight fires in yard storage and exposed buildings.

3. For buildings having long, blank masonry walls with few windows, hydrants are often unnecessary for considerable distances unless required for protection of yard storage or other purposes.

4. Where the roofs of windowless buildings are of combustible construction, provide intermediate hydrants roughly 300 ft (90 m) apart for use in the event of a roof fire.

5. Provide hydrants approximately 300 ft (90 m) apart along walls of buildings with windows for hose stream use on indoor fires.

6. For buildings over 300 ft (90 m) wide, provide hydrants on opposite sides of the building, unless long, blank masonry or metal walls are present (see 3 above).

7. Roof hydrants may be necessary to protect conveyors passing over buildings, for fighting fires in ducts and applying hose streams through roof monitors and skylights.

8. Sometimes a hose header at the pump house may be substituted for a hydrant.

9. A wall hydrant supplied from oversized (4 in. [100 mm] minimum) sprinkler system piping may substitute for a yard hydrant.

2.2.9 Fire Service Mains

2.2.9.1 Acceptance of pipe, joints and fittings that are not Approved is based on satisfactory experience and conformity to specifications of recognized engineering bodies. Cast and ductile iron, steel, and asbestos cement pipe are acceptable on that basis. Plastic and other nonmetallic pipe and fittings are acceptable when they are Approved.

2.2.9.2 Do not use polyvinyl chloride (PVC) pipe in areas subject to potential spillage of aromatic hydrocarbons. Aromatic hydrocarbons such as benzene and toluene will dissolve polyvinyl chloride.

Table 2.2.9.2 summarizes the various types of pipe, joints, anchorage, applicable standards and working pressures.

Table 2.2.9.2. Description of Pipe and Joints

	Material[1]					
	Cast[2] *and Ductile Iron*	*Steel*	*Asbestos Cement*	*Plastic*		
				Polyethylene	*Polyvinyl Chloride (PVC)*	*Fiber-reinforced Composite*
Standard[3] (ANSI/AWWA)	C110/A21.10 C150/A21.50	C200	C400	C901	C900	C950
Working pressure	See FM Approvals *Approval Guide* Reference: C110/A21.10 C150/A21.50	See C200 Also Data Sheet 2-8N, *Installation of Sprinkler Systems (NFPA)*	Class 150 150 psi (1035 kPa, 10.3 bar) Class 200 200 psi (1380 kPa, 13.8 bar)	See FM Approvals *Approval Guide* Reference: AWWA Standard		
Joint type	Approved push-on, standardized mechanical, ball and socket, poured lead bell and spigot	Welded, threaded, Flagged, Approved Grooved couplings	Approved push-on cast iron	Butt fusion or Approved adapters	Push-on, bell and spigot, cast iron or Approved materials	Approved using solvent cement, push-on cast iron
Restraint[4]	Approved, rods and clamps, thrust blocks	Not necessary	Thrust blocks	Thrust blocks		

Note 1. Acceptance of pipe, joints and fittings that are not Approved is based on satisfactory experience and conformity to specifications of recognized engineering bodies. Cast and ductile iron, steel, and asbestos cement pipe are acceptable on that basis.

Note 2. Cast Iron Standards, C106/A21.6 and C108/A21.8 withdrawn in 1982 and 1979 respectively. Ductile iron pipe has replaced cast iron.

Note 3 AWWA: American Water Works Association. ANSI: American National Standards Institute, Inc.

Note 4. Thrust blocks are the preferred method of restraint.

2.2.10 Connections From Water Supplies

2.2.10.1 Size connections from water supplies to restrict velocities to less than 20 ft/sec (6.1 m/sec) and minimize friction loss at anticipated rates of flow. A minimum pipe size of 6 in. (150 mm) is recommended.

2.2.10.2 If the main does not supply hydrants a pipe size of less than 6 in. (150 mm) may be used if:

A. hydraulic calculations have determined that the main will supply the total demand at the appropriate pressure and

B. the main size shall be at least as large as the riser.

Take into consideration future needs and hose stream flows.

2.2.10.3 Provide minimum 6 in. (150 mm nominal) diameter connections between hydrants and mains.

See also Data Sheet 3-3, *Cross Connections,* which details cross-connection control, achieved by backflow prevention devices or by air gap separation.

2.2.11 Arrangement and Location of Fire Service Mains

2.2.11.1 Arrange private fire service mains to minimize, insofar as practical, impairments (loss of protection) in the event the mains or their appurtenances are damaged or in cases of system shutdown for other reasons.

2.2.11.2 Where looped mains are present, provide divisional valves so that sections of the loop may be isolated.

2.2.11.3 Limit the number of risers served by one divisional valve to approximately six (6).

2.2.11.4 Locate underground mains, except lead-ins, to maintain minimum 5 ft (1.5 m) clearance between building foundation footings and near side of trench. Run mains outside buildings.

2.2.11.5 If placement of a fire service main inside a building is unavoidable, place the main in a covered masonry or concrete trench. The trench may be sand-packed with a removable cover, or simply grate-covered.

2.2.11.5.1 Provide clearance around the main where it passes under or through a foundation wall so that building settlement will not damage the main.

2.2.11.5.2 Provide outdoor valves on each side of a building beneath which a main passes so that an indoor break can be isolated.

2.2.11.6 Avoid overhead runs of fire service mains. Overhead mains are subject to mechanical damage.

2.2.11.7 In cold climates, provide sufficient building heat to prevent freezing of the main, or protect the main against freezing.

2.2.12 Pipe Installation: Trenching and Laying

2.2.12.1 Install ductile iron piping in accordance with American Water Works Association (AWWA) C600, asbestos-cement pipe in accordance with AWWA C603 and polyvinyl chloride pipe in accordance with AWWA C900. These AWWA standards were written for water utility piping, but the same principles and procedures apply to fire service mains.

A. Provide bell holes in the trench bottom to allow joint assembly and to ensure that the pipe barrel will lie flat on the trench bottom. For asbestos cement pipe excavate a coupling hole with sufficient length, width and depth to permit assembly, and provide a minimum clearance of 2 in. (51 mm) below the coupling.

B. Except for bell holes and coupling holes, maintain a level trench bottom so that the pipe is supported along its full length.

C. When excavation of rock is encountered, remove all rock necessary to provide a clearance of at least 6 in. (152 mm) below and on each side of all pipe, valves and fittings. When excavation is completed, place a bed of sand, crushed stone or earth that is free of stones or large clods of frozen earth, on the bottom of the trench to a minimum depth of 6 in. (152 mm). Level and tamp the bedding material.

D. When the subgrade is found to be unstable or to include ashes, cinders, refuse, organic material or other unsuitable material, remove such material to a minimum of at least 6 in. (152 mm) below the bottom of the pipe. Replace the material with clean, stable backfill material. When such unsuitable materials are encountered, consider providing polyethylene encasement (see Section 2.1.5.3, *Protection Against External Corrosion).*

E. When the bottom of the trench or the subgrade is found to consist of material that is unstable to such a degree that it cannot be removed, construct a foundation for the pipe and/or appurtenances using piling, timber, concrete or other materials.

F. Lower all pipe, fittings, valves and hydrants into the trench in such a manner as to prevent damage to materials and protective coatings and linings.

G. Complete the specified laying conditions:

1. for ductile iron pipe according to AWWA C150 and as illustrated in Section 3.0, Figure 35

2. for asbestos cement pipe according to AWWA C603 and as illustrated in Section 3.0, Figure 36

3. for polyethylene, PVC, glass fiber-reinforced and other Approved pipe according to the manufacturer's installation instructions

H. Do not allow foreign material and water to enter the pipe during installation. At times when pipe laying is not in progress, close the open ends of pipe by installing a watertight plug or by other means. Prevent pipe flotation, which is possible if the trench fills with water, by backfilling as necessary.

I. Limit maximum deflection at joints to that given in the appropriate standard.

J. Consult the railroad authority for special conditions and procedures that may apply to mains laid below their tracks. Where iron pipe is laid under a single track, install the pipe so that the center point of its full length is positioned midway between the rails. Where ductile-iron pipe is laid under multiple tracks, position the joints midway between the tracks. Asbestos cement and glass fiber-reinforced pipe laid under railroad tracks or highways may need to be enclosed within a larger protective pipe, following the manufacturer's recommendations. See also AWWA C600.

2.2.13 Setting Valves, Fittings, Indicator Posts and Hydrants

2.2.13.1 Join valves and pipe fittings to the pipe in the manner required for the type of pipe being used. Set valves so that the attached indicator posts are vertical, and inspect to ensure that they operate properly.

2.2.13.2 Set hydrants plumb after dirt or other foreign material has been cleaned out. Locate the center line of the butts at least 12 in. (305 mm) above the ground to allow ready access for attaching hoses. Provide valves on pipe that supplies hydrants so that one hydrant can be repaired without impairing the rest of the system. Provide dry-barrel hydrants with drainage. In permeable soil, provide coarse gravel or crushed stone for at least 1 ft (0.3 m) around the base of the hydrant and at least 6 in. (152 mm) above the drain port. In clay or other impervious soil, dig a drainage pit about 2×2×2 ft (0.6×0.6×0.6 m) below the hydrant and fill with compacted, crushed stone and coarse sand around the hydrant elbow and 6 in. (152 mm) above the drain port. Do not connect hydrant drainage systems to sewers. Some local authorities require the dry-barrel hydrant drain ports to be plugged. The hydrant barrels must then be pumped following use in cold weather to avoid freezing.

2.2.13.3 Provide individual support for valves, hydrants, check valves and meters used with plastic pipe. Further details on installation of valves, fittings, and hydrants are given in AWWA C600.

2.2.14 Protection Against External Corrosion

2.2.14.1 Avoid installing iron or steel pipe under coal piles, in cinder fill, or wherever acids, alkalis, pickling liquors, etc., can penetrate the soil.

2.2.14.2 When using polyethylene encasement as a method of protection against external corrosion, apply the following guidelines:

1. Install polyethylene encasement in accordance with ANSI/AWWA C105/A21.5.
2. Use polyethylene film of minimum 0.008 in. (0.20 mm) thickness.
3. Use polyethylene tubes or polyethylene sheets.
4. Install polyethylene encasement to prevent contact between the pipe and the surrounding backfill and bedding material. Complete air tightness and water tightness are not necessary.
5. Encase fittings, valves and other appurtenances to iron fire service mains.
6. Avoid prolonged exposure of the polyethylene film to sunlight. Such exposure will eventually deteriorate the polyethylene film.
7. Use the same backfill material as that specified for pipe without polyethylene wrapping. Use care to prevent damage to the polyethylene wrapping when placing backfill.

2.2.14.3 When stray electric currents are suspected, determine their extent and origin by professional ground surveys. If the stray currents cannot be eliminated or diverted, and the main is not yet seriously corroded, it can be protected by bonding all the joints and providing direct low resistance metallic ground connections. Cathodic protection is sometimes used. This technique imposes direct electric current from a galvanic anode to the buried main. Cathodic protection is also effective against corrosive soils, but is rarely used in fire protection installations due to the costs of installation and maintenance.

2.2.15 Protection Against Freezing

2.2.15.1 Determine the required depth of cover over water mains by considering the maximum depth of frost penetration. Local soil conditions and elevation will affect the depth of frost cover. Consult local officials for recommended frost depth levels. For areas where frost is a factor, bury fire service mains at least 6 in. (152 mm) deeper than municipal water works piping. The additional depth of cover is necessary because of the lack of water circulation in fire service mains.

2.2.15.2 Avoid locations where mains pass over raceways of near embankment walls. Special protection is needed to prevent freezing in these areas. Insulation cannot protect exposed mains from freezing unless heat is added or there is sufficient flow of water to replace the heat loss.

2.2.15.2.1 Wrap, box and heat exposed mains containing static water on bridges.

2.2.16 Restraining

2.2.16.1 Unbalanced thrust forces occur in the water main where the piping stops or changes cross-sectional area or direction. At bends, hydrants, reducers, tees, valves, wyes, dead-ends and offsets on pipe systems, these unbalanced forces must be overcome to prevent the joints from separating.

2.2.16.2 Several methods of restraint are available to keep the piping system intact when subjected to these unbalanced thrust forces. Thrust blocks, tie rods and clamps, and devices specifically Approved to counteract thrust forces without the use of thrust blocks, or a combination of these methods with the friction forces between the pipe and the soil may be used as methods of restraint.

2.2.16.3 Thrust blocks may be used with steel, cast iron, plastic or asbestos cement pipe. Make them of concrete mix not leaner than one part cement, two and one-half parts sand and five parts stone or washed gravel. Cast thrust blocks in place to bear against an area of undisturbed soil in the trench wall. Leave the pipe joint accessible for inspection and repair. Tie rods and clamps may be used with ductile-iron pipe.

2.2.16.4 A thrust block under a hydrant or valve to prevent upward movement requires rods bent over the bells to hold the hydrant or valve to the thrust block. Locate thrust blocks under hydrants so as not to prevent the hydrant from draining properly. Place small stones alongside the thrust block to provide a place where water from the hydrant barrel may drain without washing away bearing surfaces.

2.2.16.5 If thrust blocks are to be used alone, Table 2.2.16.5 shows the required bearing area.

Table 2.2.16.5. Area of Bearing Surface of Concrete Thrust Blocks

Pipe Size in. (mm)	*90° Bend or ¼ Bend ft^2 (m^2)*	*45° Bend or ⅛ bend ft^2 (m^2)*	*Tees, Hydrants, Caps, Plugs ft^2 (m^2)*
4 (100)	*3 (0.3)*	*2 (0.2)*	*3 (0.3)*
6 (150)	6 (0.6)	4 (0.4)	5 (0.5)
8 (200)	11 (1.0)	6 (0.6)	8 (0.7)
10 (250)	16 (1.5)	9 (0.8)	11 (1.0)
12 (300)	22 (2.0)	12 (1.1)	16 (1.5)
14 (350)	30 (2.8)	16 (1.5)	21 (2.0)
16 (400)	38 (3.5)	21 (2.0)	27 (2.5)

Areas in this table were derived using 225 psi (1551 kPa, 15.5 bar) water pressure and 2000 lb/ft^2 (96 kPa, 1 bar) soil resistance. This is typical of sand and gravel with clay. For other soils, multiply the table values by the following factors:
- Soft clay 4
- Sand 2
- Sand and gravel 1.3
- Sand and gravel cemented with clay 0.5
- Shale, hardpan 0.4

Note: Wide variations of bearing load capacity may be encountered within each soil type.

2.2.16.6 Tie rods and clamps may be used with ductile-iron pipe. Table 2.2.16.6 shows, for various pipe sizes, the clamp size, bolt size, washer size (washers may be cast iron or steel, round or square) and the number of rods needed when rod and clamp restraint is used. For pipes over 12 in. (300 mm) in diameter, the use of rods alone is not adequate.

Table 2.2.16.6. Rod and Clamp Anchorage

<table>
<tr><th rowspan="3">Pipe Size in. (mm)</th><th rowspan="3">Clamp Size in. (mm)</th><th rowspan="3">Bolt Size in. (mm)</th><th colspan="2">Washers in. (mm)</th><th colspan="6">Number of Rods and Rod Size (in. [mm]) for Rod and Clamp Anchorage</th></tr>
<tr><th rowspan="2">Cast Iron</th><th rowspan="2">Steel</th><th colspan="3">Mechanical Joint</th><th colspan="3">Push-on Joint</th></tr>
<tr><th>90° ¼ bend</th><th>45° ⅛ bend</th><th>Tee, hydrant cap, plug</th><th>90° ¼ bend</th><th>45° ⅛ bend</th><th>Tee, hydrant cap, plug</th></tr>
<tr><td>4 (100)</td><td rowspan="2">½×2 (13×50)</td><td rowspan="3">⅝ (16)</td><td rowspan="4">⅝×3 (16×80)</td><td rowspan="4">½×3 (13×80)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td></tr>
<tr><td>6 (150)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td><td>2 ¾ (20)</td></tr>
<tr><td>8 (200)</td><td rowspan="2">⅝×2-½ (16×65)</td><td>4 ¾ (20)</td><td>2 ¾ (20)</td><td>4 ¾ (20)</td><td>4 ¾ (20)</td><td>2 ¾ (20)</td><td>4 ¾ (20)</td></tr>
<tr><td>10 (250)</td><td>7/8 (22)</td><td>6 ¾ (20)</td><td>4 ¾ (20)</td><td>4 ¾ (20)</td><td>4 7/8 (22)</td><td>4 7/8 (20)</td><td>4 7/8 (22)</td></tr>
<tr><td>12 (300)</td><td>⅝×3 (16×80)</td><td>1 (25)</td><td>¾×3-½ (18×90)</td><td>½×3-½ (13×90)</td><td>8 ¾ (20)</td><td>6 ¾ (20)</td><td>6 ¾ (20)</td><td>4 1 (25)</td><td>4 1 (25)</td><td>4 1 (25)</td></tr>
</table>

Note 1. After installation, protect tie rods, bolts, nuts, washers and clamps against corrosion with a heavy coat of asphalt material.

Note 2. The length of the rod required will vary with the pipe fitting, and must be determined by field measurement. If the distance between the joints is less than 12 ft (3.7m), extend the anchorage to the second bell.

Note 3. When ordering fittings, specify lugs if tie rods and clamps are to be used.

Note 4. Bolt holes 1/16 in. (1.6 mm) larger than bolts. Rod holes ⅛ in. (3.2 mm) larger than rods.

Note 5. Washers may be round or square.

2.2.16.7 Mechanical joints should not be used unless full consideration of frictional and lateral soil resistance has been engineered into the system design. The resistance to thrust forces is a function of the joint mechanics and also depends on conduit frictional resistance, which is a function of soil properties (i.e., soil pressure, cohesion friction and density) and lateral resistance. (Reference: Carlson, R.J., ''Thrust Restraint for Underground Piping Systems.'' Cast Iron Pipe News, Fall 1975 or ''Thrust Restraint Design for Ductile Iron Pipe,'' Second Edition 1989 Ductile Iron Pipe Research Institute).

2.2.16.8 These references outline the minimum length of pipe to be restrained on either side of the fitting. Care must be taken to ensure that the joints are installed according to the manufacturers' specifications. When mechanical joints are used, conduct a visual verification of proper installation (e.g., for bolt heads that shear and break off when a predetermined torque is achieved).

2.2.16.8.1 Apply protective coatings to exposed nuts, bolts, etc., prior to filling the trench to protect against failure due to corrosion.

2.2.16.9 The determination and selection of the proper methods of restraining underground pipe and its appurtenances requires on-site planning prior to installation. Conduct soil tests to determine the soil properties. The proper selection of the method of restraint depends on the soil characteristics as well as other utilities (gas or electric) and structures (foundations) in the proposed excavation area.

2.2.17 Backfilling

2.2.17.1 Accomplish backfilling according to the specified laying condition. The type and degree of compaction of the backfill determines the type of ''laying condition'' which, in turn, determines in part the wall thickness of pipe to be used. Additional backfilling details are given in AWWA C600 for cast- and ductile-iron pipe and in AWWA C603 for asbestos cement pipe.

2.2.17.2 Use only backfill that is free of cinders, ashes, refuse, vegetable or organic material, boulders, rocks or stones, frozen soil, and other unsuitable material.

2.2.17.3 With plastic pipe it is particularly important that adjacent backfill be clean, well-compacted sand. Special precautions are needed where ambient or ground temperatures before backfilling are considerably higher than normal water temperature, because plastic pipe expands at a rate greater than that of steel. Make provisions for the contraction of plastic pipe that will occur upon filling the system. With polyethylene pipe, such a provision can be made by ''snaking'' the pipe in the trench.

2.2.17.4 As a further precaution, fill the pipes with water prior to backfilling. Ideally, conduct backfilling early in the morning when pipe and soil are nearly at the same temperature. Deposit selected backfill material on both sides of the pipe for the full width of the trench. Tamp the backfill in thin layers not exceeding 3 in. (76 mm) in depth to 12 in. (305 mm) above the top of the pipe. Compact thoroughly to provide solid backing against the external surface of the pipe. For complete backfilling procedures for plastic pipe, follow the manufacturer's instructions.

2.3 Operations and Maintenance

2.3.1 Hydrostatic Leakage Testing

2.3.1.1 Conduct Hydrostatic testing on new mains and mains that have been relined to determine if the joints are tight and to ensure that there are no defective pipes or fittings. Before tests are made, tamp clean backfill to a depth of 1 ft (0.3 m), (2 ft [0.6 m] for 10 in. [254 mm] pipe or larger), over asbestos cement or plastic pipe, or at least to the center line of cast- or ductile-iron pipe. Leave the joints uncovered until the tests have been completed satisfactorily. Large installations may be tested in their entirety, or sections between valves may be tested individually. In some cases, it may be necessary to include older pipe within the test section.

2.3.1.2 Hydrostatically test all new yard piping at not less than 200 psi (1380 kPa, 13.8 bar) pressure for two hours, or at 50 psi (345 kPa, 3.4 bar) over the maximum static pressure when the maximum static pressure is above 150 psi (1034 kPa, 10.3 bar). If a booster pump is present, consider the pump shut-off (churn) pressure in determining the maximum static pressure.

2.3.1.3 Slowly fill with water each section of the main to be tested. Expel all air by opening hydrants at the high points of the system and at both ends, or by bleeding air through the sprinkler drains. Open wide the valve controlling the admission of water before shutting the hydrants or drains. After the system has been filled with water and the entrapped air expelled, close the valve that controls the section being tested and begin applying pressure.

2.3.1.4 Increase the water pressure in 50 psi (345 kPa, 3.5 bar) increments until the specified test pressure is attained. After each increase in pressure, make observations of the stability of the joints. In these observations, 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 increase the pressure to the next increment only after the joint has become stable. This applies particularly to movement of the gasket.

2.3.1.5 After the pressure has been increased to the required maximum value and held for one hour, decrease the pressure to 0 psi (0 kPa, 0 bar) while observing for leakage. Then slowly increase the pressure to the specified maximum and hold the pressure for one more hour while leakage measurements are made. Do not use fire pumps to supply pressure because a pipeline break during testing could result in damage from the large flow of escaping water. Instead, use a small hydrostatic test pump.

2.3.1.6 Measure the amount of leakage at the specified test pressure by pumping from a calibrated container. For new pipe, the amount of leakage at the joints is limited to a maximum of 2 qts/hr (1.9 l/h) per 100 gaskets or joints irrespective of pipe diameter. The amount of allowable leakage may be increased by 1 fluid ounce per inch valve diameter per hour (12 ml/hour for each cm of valve diameter) for each metal seated valve isolating the test section. If dry-barrel hydrants are tested with the main hydrant valve open, so the hydrants are under pressure, an additional 5 oz/min (150 ml/min) leakage is permitted for each hydrant.

2.3.1.7 On completion of all work except backfilling, ensure that representatives of the contractor and management make a joint inspection and witness the hydrostatic tests. The purpose of the inspection is to ensure that there are no defects serious enough to prevent the system from being put into commission immediately. Ensure that a ''Contractor's Material and Test Certificate'' as shown in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers* is signed, in triplicate, by the contractor's and management's representatives. One copy is to be kept by management, one by the contractor and one sent to the FM Global district office serving the area in which the installation is located.

2.3.1.8 After the pressure test, open the control valves wide and then fully open and close every hydrant at the normal operating rate.

2.3.2 Flushing Underground Mains

2.3.2.1 Flush underground mains and lead-in connections to system risers through hydrants at dead ends of the system or through accessible aboveground flushing outlets, allowing the water to run until clear. If water is supplied from more than one source or from a looped system, have divisional valves closed to produce a high velocity flow through each single line. The flows specified in Table 2.3.2.1 will produce a velocity of at least 10 ft/sec (3.0 m/sec), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.

Table 2.3.2.1. Flushing Flows

Pipe Size		*Flow Rate*	
in.	*mm*	*gpm*	*l/min*
4	100	390	1500
6	150	880	3300
8	200	1560	5900
10	250	2440	9200
12	300	3500	13,300

Note: Flow rates based on nominal values of pipe diameters.

2.3.2.2 When the water supply will not produce the stipulated flow rate, connections to a hydraulically-designed system may be flushed at the demand rate of the system, including hose streams if hose or hydrants or both are supplied from that connection. For pipe-schedule systems, when the water supply will not produce the stipulated flow rate, use the maximum flow rate available.

2.3.2.3 Provide for the safe disposal of water issuing from the test outlets to avoid property damage or danger to personnel.

2.3.3 Tapping Machines

2.3.3.1 Make certain that the contractor or local water department has suitable tapping equipment.

2.3.3.2 It is vital that the disk be removed after the cutting operation is complete. In operating a tapping machine, care must be taken not to withdraw the shaft until the cut is completed. Otherwise, the retaining thread may be stripped and the disk not withdrawn with the cutter. If this does occur, a brief shutdown will be necessary, and the disk can readily be recovered by reaching through the open valve.

2.3.4 Fire Hose and Equipment for Private Hydrants

Recommendations in this section apply only to those locations having personnel trained to use the recommended equipment.

2.3.4.1 Provide sufficient underwriter playpipes for 2-½ in. (60 mm) hose to permit adequate flow testing of the fire protection water supplies if meters are not used for flow testing.

2.3.4.2 For plant yards where rough surfaces cause heavy wear, or where working pressures are above 150 psi (1034 kPa, 10.4 bar), use double-jacket lined hose or other Approved hose for use in such areas.

2.3.4.2.1 Use woven-jacket lined hose with a protective cover where the hose is exposed to acids, acidic gases or other corrosive materials.

2.3.5 Size of Hose and Type of Nozzle

2.3.5.1 Provide hose threads for couplings, hydrants and nozzles that conform to those used by the local fire department.

2.3.6 Storing and Transporting Hose

2.3.6.1 At facilities that have no mobile equipment, provide Approved hose houses at most yard hydrants.

2.3.6.2 Construct hose houses to provide good inside air circulation. Provide roofs that are substantial and watertight. Provide screening for protection against vermin

2.3.6.3 Install foundations that are above the yard level to ensure good drainage. Provide at least 6 in. (152 mm) between swinging door bottom and the ground. Arrange doors and shelves to permit easy operation of the hydrant and attachment of the hose.

2.3.6.4 The type and amount of equipment needed for individual hose houses or cabinets depends on the needs of the immediate area and the specific hardware used. Individual requirements may call for all 1-½ in. (40 mm) hose, all 2-½ in. (60 mm) hose, or some of each. Table 2.3.6.4 is to serve as a guide. The amount specified may vary depending on the user and on local occupancy and combustibility conditions.

2.3.6.5 Keep special firefighting equipment as needed at the facility's fire department headquarters, e.g., breathing apparatus, protective clothing, forcible entry tools, power tools, hand lights, etc.

Table 2.3.6.4. Recommended List of Hose House Equipment

Quantity	*Description*
200 ft (61 m)	Approved 2-½ in. (60 mm) lined hose
100 ft (30 m)	Approved 1-½ in. (40 mm) lined hose
Two	Approved combination spray, solid stream, shutoff nozzles for 1-½ in. (40 mm) hose
Two	Approved combination spray, solid stream, shutoff nozzles for 2-½ in. (60 mm) hose
One	Hydrant wrench
Four	Spanners for 1-½ in. (40 mm) hose
Four	Spanners for 2-½ in. (60 mm) hose
Four	Spare hose washers (1-½ in. and 2-½ in. [40 and 60 mm])
One	Gated wye (2-½ by 1-½ in. [60 by 40 mm])
Two	Adapter fittings (2-½ to 1-½ in. [60 to 40 mm])

2.3.7 Cleaning and Lining Fire Service Mains

At the time of publication of this data sheet (January 2022), at least one FM Approved pipe rehabilitation and lining product is available for use in underground mains. Additional details on FM Approved products can be found in the *Approval Guide*.

2.3.7.1 Confirm the scope of work to be conducted as part of any pipe relining/rehabilitation operation before commencing any work. Include, at a minimum, the following:

A. Soil conditions. Polyethylene pipe or pipes externally coated with polyethylene can degrade under certain soil conditions. See additional guidance in Section 2.1.5.3.

B. The suitability of the pipe rehabilitation system for correcting the type and size of the defect in the existing pipe.

C. The suitability of the material used in the pipe rehabilitation for use in the existing pipe.

D. The method of cleaning to be used. Certain cleaning methods can negatively impact existing pipe joins. See Section 3.1.8.2 for further information. Cleaning underground piping is essential before relining.

2.3.7.2 Analyze the impact of changes made as part of pipe relining to ensure the relined pipe is still adequate. This can be done via a flow test. Certain pipe properties (internal diameter, C-factor, etc.) will change during the relining process.

2.3.7.3 Conduct hydrostatic testing on relined mains in accordance with Section 2.3.1.1.

2.3.8 Maintenance of Single Check Valves

2.3.8.1 Single check valves on public water connections to private fire systems need internal inspection and cleaning at least once every five years.

2.3.8.2 If there are several check-valved fire service connections from public mains, overhaul and clean one check valve at a time, leaving the others in service. When there is only one connection, observe the following precautions:

A. If there is a secondary supply from a fire pump or from a tank, ensure that the secondary source will maintain pressure on the sprinklers while the public water connection is shut off.

B. If other supplies cannot be maintained in service or if there is no other supply, overhaul the check valve while the plant is not in operation.

2.3.8.3 Clean rust and tubercles from the inside of the valve body —particularly around the seat ring, between the clapper and its arm, around the hub of the clapper arm and in the space between the bottom of the seat ring and the body. This will probably require removing the clapper. When cleaning around the seat ring, take care the face of the seat ring is not injured. Remove any roughness or corrosion on the clapper face or seat ring that would prevent the clapper from seating tightly, using a piece of fine emery cloth wet with water. Do not use a file or coarse scraper on the clapper face or seat ring. Scrape any incrustation formed by hard water from interior bronze parts.

2.3.8.4 Clean the underside of the cover if necessary.

2.3.8.5 Make sure that the side plugs that hold the hinge pin in place are tightly screwed without binding the clapper arm. Ensure the clapper is free to open wide and seat positively.

2.3.9 Maintenance of Double Check Valves and Reduced-Pressure Backflow Preventers

2.3.9.1 Details of testing and maintenance of double check valves and testing of reduced pressure backflow preventers are given in Data Sheet 3-3, *Cross Connections.* Maintain reduced pressure backflow preventers according to the manufacturer's instructions.

2.3.10 Maintenance of Manually Operated Valves

2.3.10.1 At least once a year, operate all valves to the full travel of their mechanism to make sure they can be operated easily when necessary. Maintain a record of the number of turns required to operate each valve from the fully open to the fully shut position. This record is valuable in determining whether a valve has jammed partially open.

2.3.10.2 Clean and lubricate the stems and threads of outside screw and yoke valves regularly.

2.3.10.3 Lubricate indicator post mechanisms regularly, using the oil hole on the cap.

2.3.10.4 Do not tighten stuffing box glands excessively, as this can score the valve stem and cause hard operation. Repack the valve instead.

2.3.11 Maintenance of Hydrants

2.3.11.1 Introduction

2.3.11.1.1 Ensure that hydrants are accessible at all times.

2.3.11.1.2 Ensure that the hydrant wrench is readily available.

2.3.11.1.3 Examine nozzle and cap threads and gasket.

2.3.11.1.4 Ensure that nozzles are tight; they may need caulking.

2.3.11.1.5 Examine the barrel for cracks.

2.3.11.1.6 Ensure that nozzles are accessible for attaching hose.

2.3.11.1.7 Lubricate threads on nozzles and caps.

2.3.11.2 Dry-Barrel Hydrants

2.3.11.2.1 Remove the cap from one of the discharge outlets and determine, by sounding or by dropping a weight on a string into the barrel, if water or ice is present. If either is found, take the necessary steps to eliminate the cause and drain the hydrant. The trouble may be due to groundwater, a plugged drain, or leakage through the hydrant valve.

2.3.11.2.2 When hydrants do not drain properly, attempt to clear the drain hole by opening the hydrant one or two turns with the hose outlets closed. If this is not successful, most hydrants must be dug up to expose and clear the drain hole with a rod. Other types can be disassembled, and a rod driven through the drain hole.

2.3.11.2.3 At locations where groundwater stands at levels above that of the drain, plug the hydrant at the time of installation. If the drain hole is plugged, hydrants in service in cold climates shall be pumped out after usage. Such hydrants shall be marked to indicate the need for pumping after usage.

2.3.11.2.4 If a hydrant leaks at the valve, the cause may be an obstruction, or a defective valve facing or seat ring. Attempt to remove any obstruction by opening the valve wide and allowing water to flow from the hydrant outlet. If this is not successful, disassemble the hydrant and remove the obstruction. The hydrant must also be disassembled to install a new valve facing or replace a damaged seat ring. The latter sometimes requires that the hydrant be dug up.

2.3.11.2.5 For certain compression type hydrants, use the special socket-key wrench supplied by the manufacturer to remove a retainer ring or the seat ring before the hydrant's valve mechanism can be removed.

2.3.11.2.6 Lubricate the threads of the stem nut through grease fittings, or by removing a bolt in the top of the weather cap or stem nut, and pouring oil in the bolt hole.

When hydrants leak at the packing, replace the packing or tighten the packing gland.

2.3.11.3 Wet-Barrel Hydrants

2.3.11.3.1 If wet-barrel hydrants leak at the valve, the cause may be an obstruction or a defective valve facing. Attempt to remove the obstruction by opening the valve and flowing water from the outlet. If not successful, disassemble the hydrant and remove the obstruction.

2.3.11.4 Maintenance of Fire Hose for Use Outdoors

2.3.11.4.1 Dry hoses with jackets made from a combination of cotton and synthetic yarns.

2.3.11.4.2 Hydrostatically test fire hose for outdoor use at least once a year. Use a hydrostatic pump and test double jacket hose to 250 psi (1723 kPa, 17.3 bar) and single jacket hose to 150 psi (1034 kPa, 10.4 bar) in separate tests.

2.3.11.4.3 Several lengths may be connected and tested together. Lay the hose without kinks or twists on a flat, horizontal surface or on one sloping gently upward from the inlet end. At the outlet end, attach a shutoff nozzle or a threaded cap with a petcock, or small valve, as an air vent. Mark the hose at the couplings to show any movement of the coupling on the hose during the test.

2.3.11.4.4 With the air vent open, gradually fill the hose with water, taking care to replace all air. Close the air vent after the hose has been filled. Move personnel out of range of the whiplash of any hose that may burst during the test. Apply full test pressure for five minutes, then release.

2.3.11.4.5 Take burst or leaking hose out of service. Replace any coupling that has moved on the hose, is found defective or has damaged threads. Replace gaskets that are worn or cracked, or if a coupling leaks after tightening.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General Information

3.1.1 System Components

3.1.1.1 Flow Meters

Some water utilities require the installation of flow meters in connections from public water mains to private fire service systems. Approved meters include both full registration meters and waterflow detector check valves. Each experiences friction loss, which must be accounted for in the design of a private fire service system.

One Approved full registration fire service meter uses a weighted check valve and a compound meter on a main line, combined with a single disk meter on a bypass line for the purpose of measuring small rates of flow. The weighted lever valve diverts small flows through the bypass meter for accurate measurement, and opens automatically to full capacity when there is a large demand for water. A compound type meter is available as an option on the bypass line. With this type, small flows are measured accurately by a disk meter and the larger flows by a torrent (current type) meter (see Figs. 3.1.1.1-1 and 3.1.1.1-2).

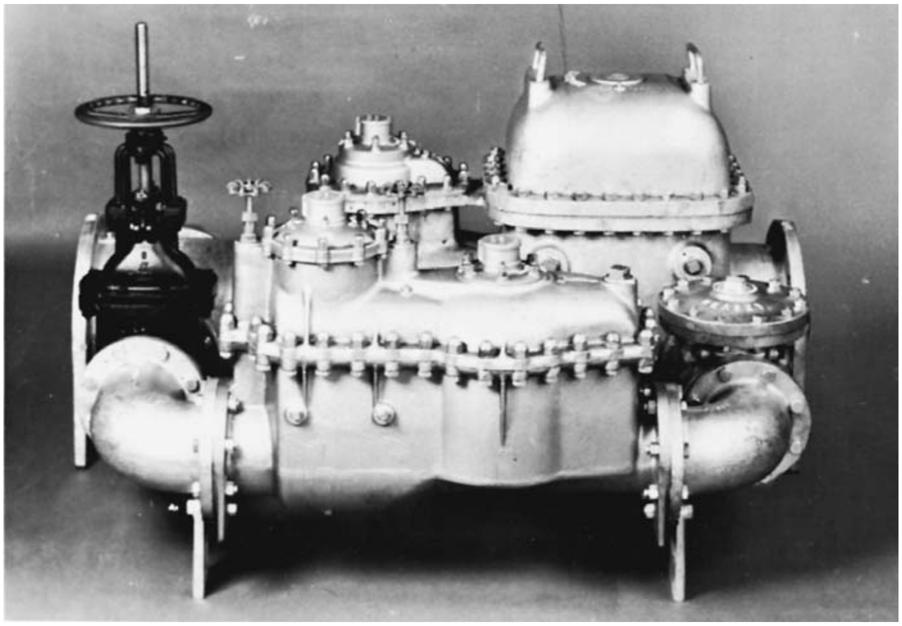


Fig. 3.1.1.1-1. Full registration fire service meter, exterior view showing bypass meter

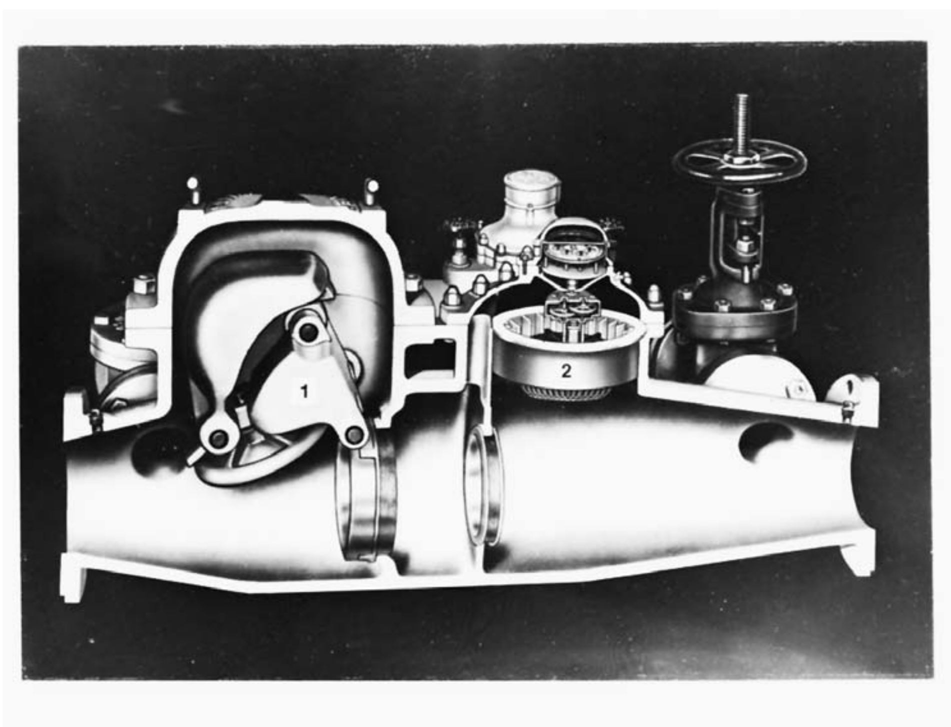


Fig. 3.1.1.1-2. Full registration fire service meter, section view showing weighted lever valve (1) and mainline torrent meter (2)

Waterflow detector check valves are used where the water utility accepts a simple indication of high water flow, rather than a record of the actual amount of water used.

Approved waterflow detector check valves generally operate as follows: the clapper starts to open when the differential pressure across the clapper assembly exceeds the established differential pressure of the check valve.

Small flows that produce a differential pressure less than the established differential pressure do not move the clapper. These are directed through the bypass piping and are metered. Large flows, caused by water demand in the fire protection system, produce a greater differential pressure and move the clapper out of the waterway, allowing the full flow to pass into the system unmetered (see Figs. 3.1.1.1-3 and 3.1.1.1-4).

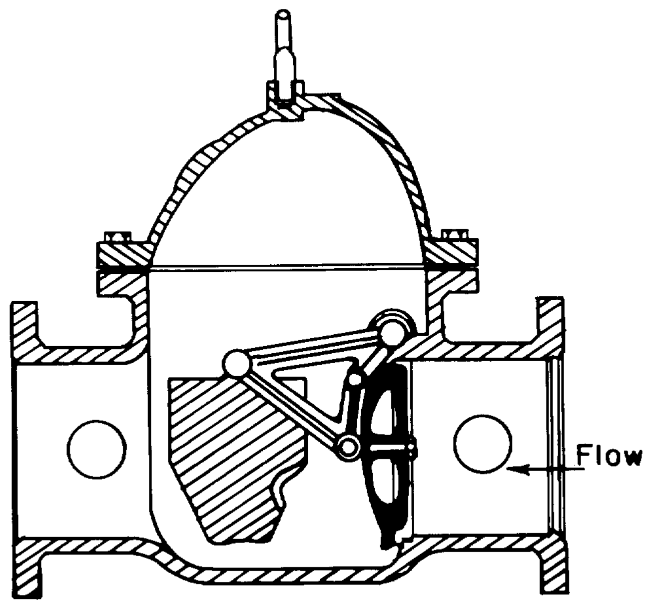


Fig. 3.1.1.1-3. Waterflow detector check valve, section view showing weighted clapper arrangement

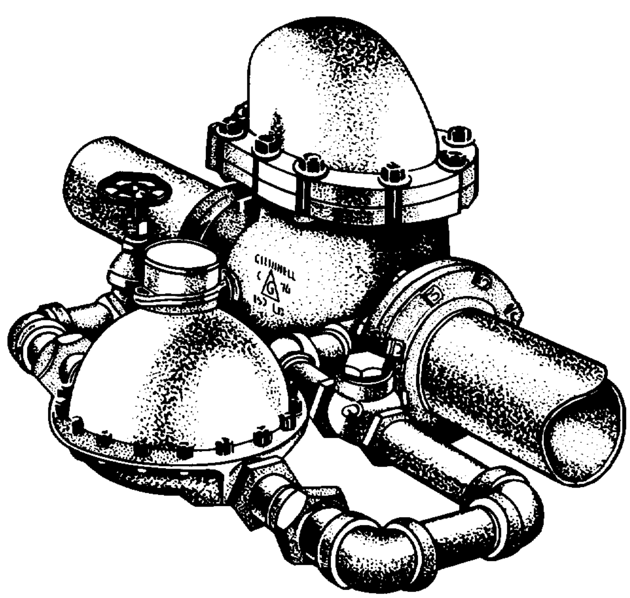


Fig. 3.1.1.1-4. Waterflow detector check valve, exterior view showing bypass meter

Typical meter installations are illustrated in Section 2.2.10, *Connections From Water Supplies.*

3.1.1.2 Single Check Valves

Single check valves are used in fire protection piping systems to allow water to flow in one direction only. Gravity-operated swing check valves (see Fig. 3.1.1.2-1) are kept open by water flow. Closure is effected by back pressure in the line or by the weight of the check mechanism when there is no flow.

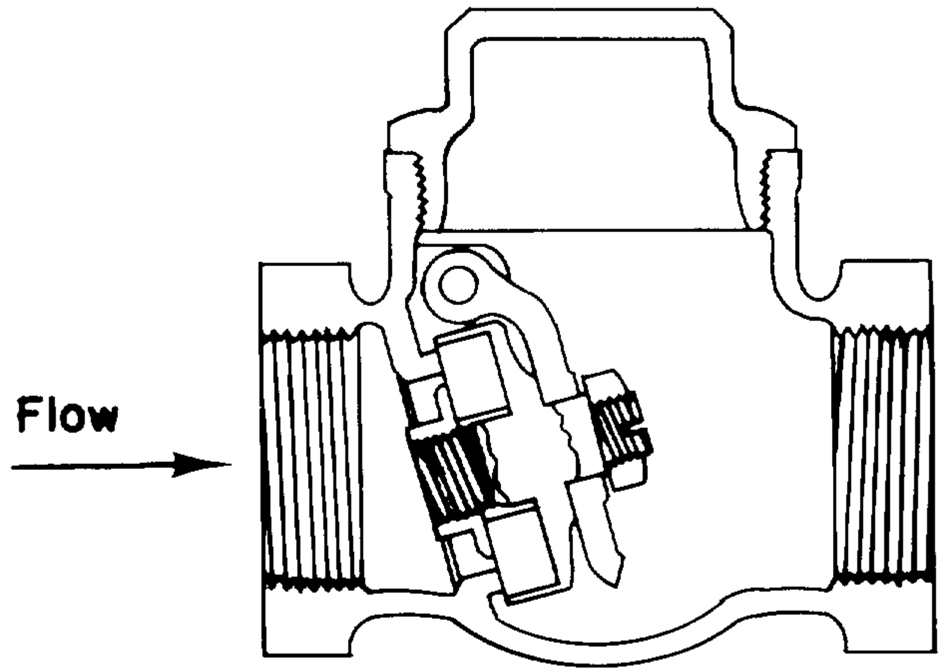


Fig. 3.1.1.2-1. Single check valve

Water authorities often require a single check valve or other backflow preventer at connections to public water sources (see Data Sheet 3-3, *Cross Connections).* This is to prevent the backflow of fire protection system water from mixing with the public water supply, possibly contaminating the public supply.

Providing a single check valve in each connection to a public water source permits the fire pump or fire department pumper to raise the private fire protection system pressure to a higher level than that of the public mains.

Providing a single check valve at the discharge from fire pumps and at gravity tank and pressure tank connections will help to prevent water from the private fire protection main system from being lost through the tanks and pump supply.

Single check valves may be installed in either horizontal or vertical pipe unless restricted to a specific positioning as noted in the *Approval Guide* listing. For installation in vertical pipe the flow must be upward.

Figure 3.1.1.2-2 indicates a location where the check valve is installed in a water-tight, frost-proof concrete or masonry pit.

3.1.1.3 Anti-Water Hammer Check Valves and Surge Arresters

Water hammer is the term associated with the destructive forces, exemplified by pounding noises and vibration, which develop in a piping system where a column of noncompressible liquid flowing through a pipe line at a given pressure and velocity is stopped abruptly. When water hammer occurs, a high intensity

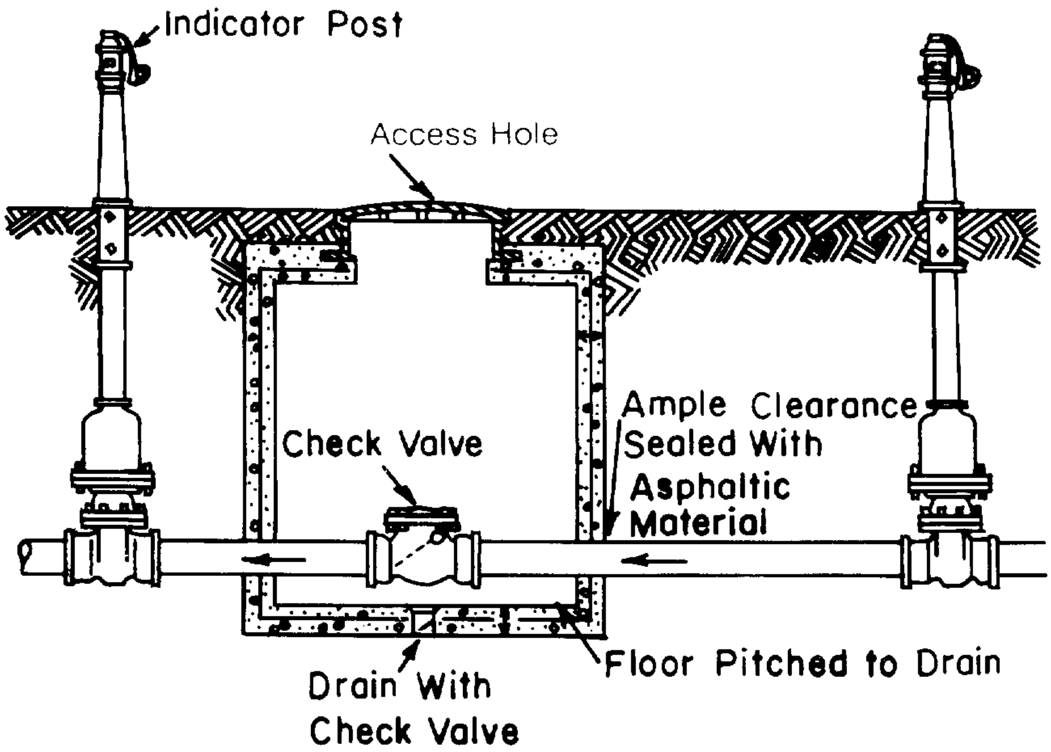


Fig. 3.1.1.2-2. Single check valve in concrete pit

pressure wave travels back through the piping system until it reaches a point of some relief, such as a larger diameter riser or piping main. The shock wave then surges back and forth between the point of relief and the point of impact until the destructive energy is dissipated in the piping system, sometimes in the form of broken piping. This violent action accounts for the piping noise and vibration. Water hammer also can occur without any noticeable sound.

Generally the anti-water hammer check valve (see Fig. 3.1.1.3-1) has a spring mechanism that automatically closes the valve disk at zero flow, before flow reversal occurs, thereby preventing surge and water hammer.

Approved single swing check valves may be utilized in other situations. The swing check valves have a lower friction loss, greater clearance between parts, and lower susceptibility to being obstructed.

Surge arresters or dampers are used to moderate the potentially destructive effects of pressure surges, or water hammer, due to a pump starting and stopping and a valve opening and closing. They are employed and used when an anti-water hammer check valve alone proves inadequate to control the problem.

These hydropneumatic devices absorb pressure surges into a precalculated volume of captive gas and return the absorbed water volume to the system in a controlled fashion. Surge arresters are installed on the system side of the fire pump discharge check valve, and as close to the check valve as possible. Water hammer arresters are covered in ANSI/ASME Standard, *Water Hammer Arresters,* ANSI/ASME A112.26.1.

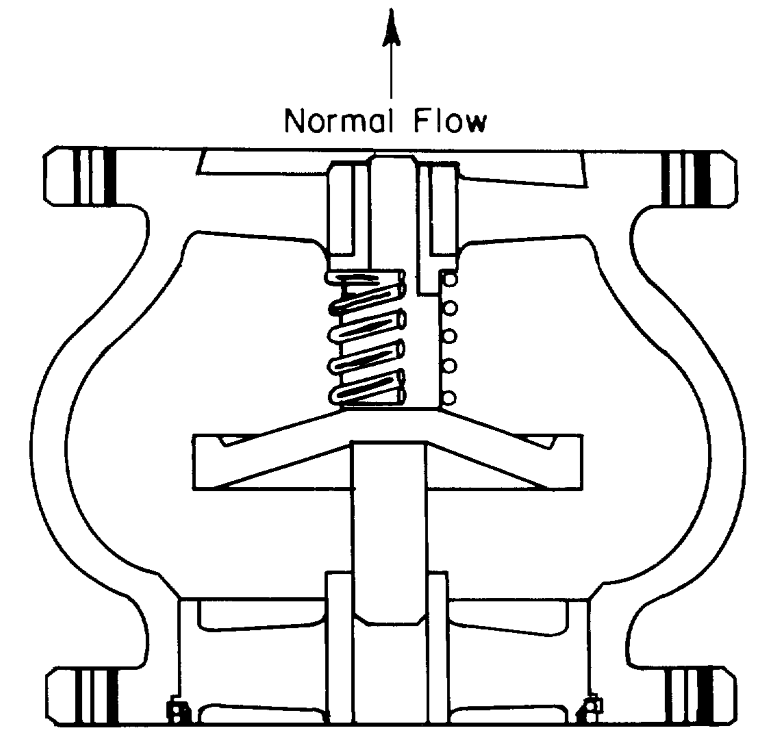


Fig. 3.1.1.3-1. Anti-water hammer check valve

3.1.1.4 Double Check Valves and Backflow Preventers

Cross connections can result in the contamination of the public water sources by the intermixing at the public source of private water supplies and the public water sources. Cross connection control as indicated by water regulatory authorities can be achieved with double check valves (see Fig. 3.1.1.4-1) or reduced pressure principle backflow preventers commonly referred to as RN devices or a double check-detector check valve. Cross connection control is covered in Data Sheet 3-3, *Cross Connections.*

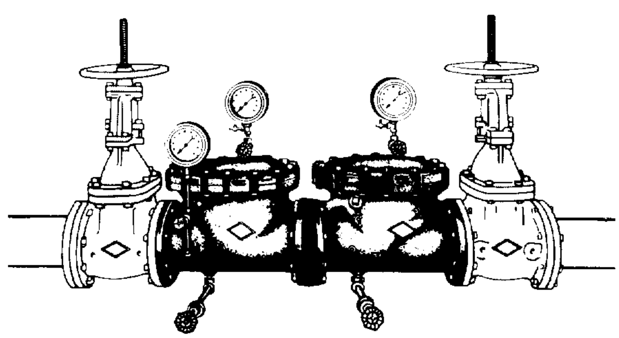


Fig. 3.1.1.4-1. Double check valve

3.1.1.5 Fire Department Pumper Connections

A fire department pumper connection, sometimes referred to as simply ''pumper connection,'' is a connection through which a fire department can pump water into fire service mains or into a sprinkler system, thus raising the water pressure above that normally available. The Approved connections are made of bronze, and consist of two inlet couplings threaded for standard fire hose and joined into the outlet pipe connection. A check valve is provided in each inlet so that either connection may be used separately. The connections are available in straight, 45° or 90° patterns.

Providing one or more pump connections on private fire service systems is particularly important where the public water system is the only source of supply. To prevent loss of system pressure through the pumper connection, install an Approved single check valve in each fire department connection, located as near as practicable to the point where it joins the system.

An Approved automatic drip valve in the pipe is installed between the check valve and the outside hose coupling of the pumper connection so that it discharges to a proper frost-free location.

Other information on the installation of fire department pumper connections and associated hose coupling threads is covered in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers.*

3.1.1.6 Manually Operated Valves

3.1.1.6.1 General

Manually operated valves are used to control individual sources of water supply, isolate equipment such as check valves for maintenance, and allow sectionalizing of water main systems in the event of a break or for the purpose of making repairs or extensions.

3.1.1.6.2 Gate Valves and Butterfly Valves

Gate valves (Fig. 3.1.1.6.2-1) and butterfly valves (Fig. 3.1.1.6.2-2) with associated indicating mechanisms are commonly used in fire service mains. With the gate valve in its fully open position, the disk is lifted completely out of the waterway. Butterfly valves utilize a quarter turn disk to control flow. With the butterfly valve in its open position, the disk sits in the waterway, parallel to the direction of flow.

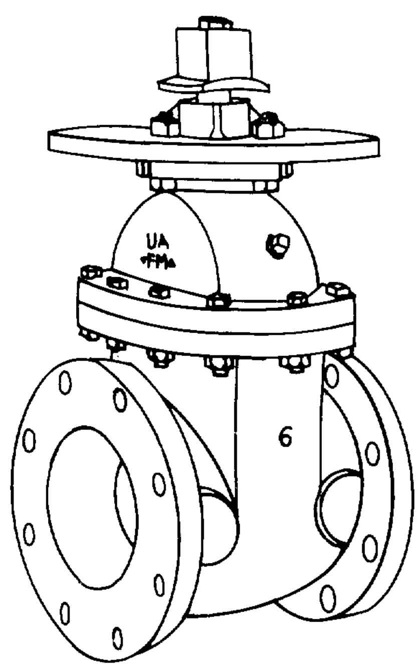


Fig. 3.1.1.6.2-1. Gate valve

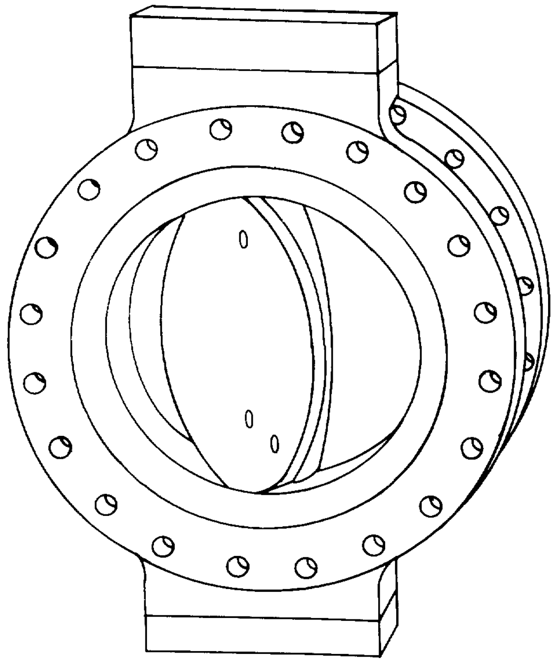


Fig. 3.1.1.6.2-2. Butterfly valve

3.1.1.6.3 Post Indicator Valve Assembly

An Approved post indicator valve (PIV) assembly (Fig. 3.1.1.6.3-1) is available only as a factory assembled unit with true open-shut orientation. The assembly consists of a buried, quarter turn valve and an above-grade indicator operator. If excessive force is applied to the handle, one of the series of successively weaker shear joints incorporated into the drive train will break so as to preserve the correct orientation between indicator and valve position. Parts are so designed that they can be assembled only one way, always to give correct indication. If the post is broken off above grade, failsafe features will keep the valve intact and a spring will hold an open valve open.

3.1.1.6.4 Indicator Posts

Indicator posts are controls that extend above ground for operating underground fire service main valves. As an important feature of their design, a target or indicator, visible through an opening in the post, indicates whether the valve is open or shut.

The indicator post consists of a cast-iron barrel, an extension flange that allows the height of the barrel to be regulated, and a wrought-iron or mild-steel stem that operates the underground valve and simultaneously moves the target (see Fig. 3.1.1.6.4-1). Indicator posts are available for installation on existing gate valves.

3.1.1.6.5 Manually Operated Valves

If a valve must be placed where an indicator post cannot be used, such as in the road, an Approved indicating butterfly valve (IBV, see Fig. 3.1.1.6.5-1) or an outside screw and yoke (OS&Y, see Fig. 3.1.1.6.5-2) may be installed in a watertight, frost-proof concrete or masonry pit.

Nonindicating type underground gate valves are generally limited to branch mains, hydrants and building lead-ins. Such valves are normally non-rising stem type and require a key wrench for operation. A curb box with cover plate at grade level provides access for the wrench to the valve stem nut (see Fig. 3.1.1.6.5-3).

All Approved PIV assemblies, IBV and OS&Y valves open counterclockwise. Currently Approved non-rising stem (NRS) gate valves for operation with key wrenches through curb boxes or with indicator posts are manufactured to open counterclockwise. A sign securely attached to the indicator post that shows the direction

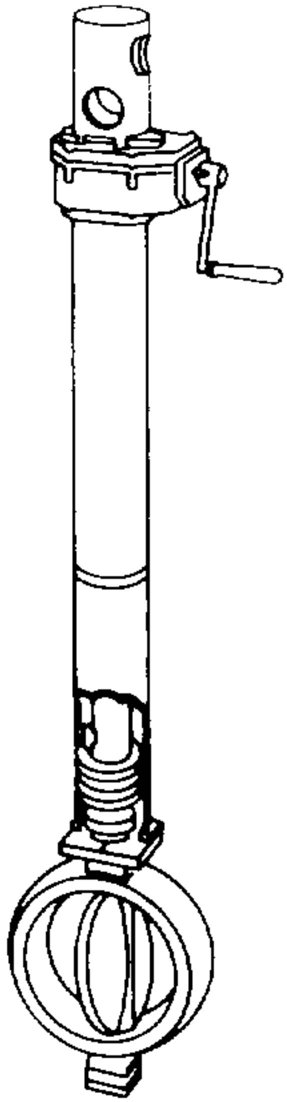


Fig. 3.1.1.6.3-1. Post indicator valve assembly

of opening is an acceptable form of identification. For curb box installations, the cover plate can be appropriately marked or a sign installed on a nearby post or building wall.

3.1.1.6.6 Tapping Valves

The use of a tapping valve allows a new connection to be made to an existing water main without shutting off the water. Tapping valves are covered in this data sheet in Section 2.3.3, *Tapping Machines.*

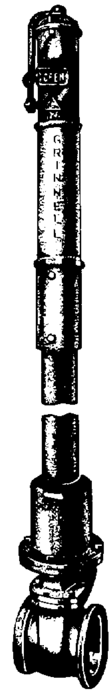


Fig. 3.1.1.6.4-1. Gate valve with indicator post

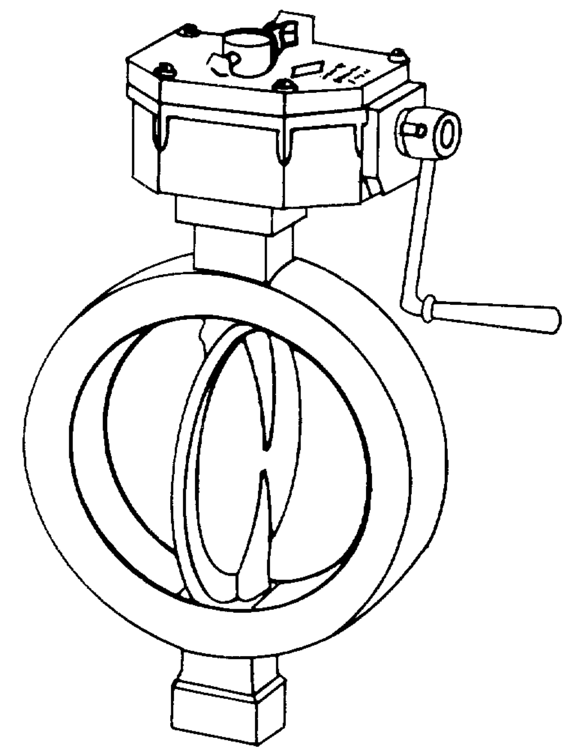


Fig. 3.1.1.6.5-1. Indicating butterfly valve

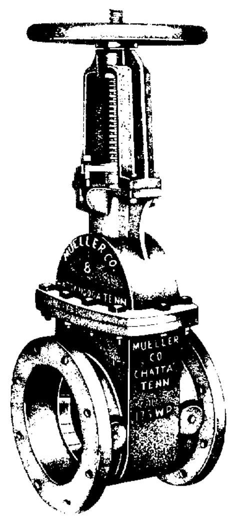


Fig. 3.1.1.6.5-2. Outside screw and yoke gate valve

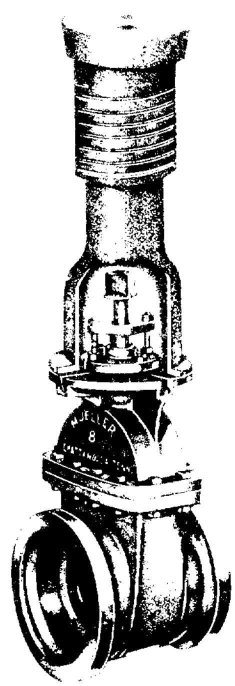


Fig. 3.1.1.6.5-3. Curb box with cover plate at grade level

3.1.1.6.7 Hydrants

Types

Dry-barrel hydrants (see Fig. 3.1.1.6.7-1) are used in areas where freezing temperatures are experienced. Water is admitted into the barrel only when the hydrant valve is opened. To prevent the water that remains in the barrel from freezing after the hydrant is closed, a small drain hole opens as the hydrant valve is closed. ''Traffic'' model hydrants are available incorporating sections of intentional weakness at ground level so that if struck by a vehicle, the hydrant will break off above ground level without the hydrant valve opening. The most common kind of dry-barrel hydrant is the compression type (see Fig. 3.1.1.6.7-1).

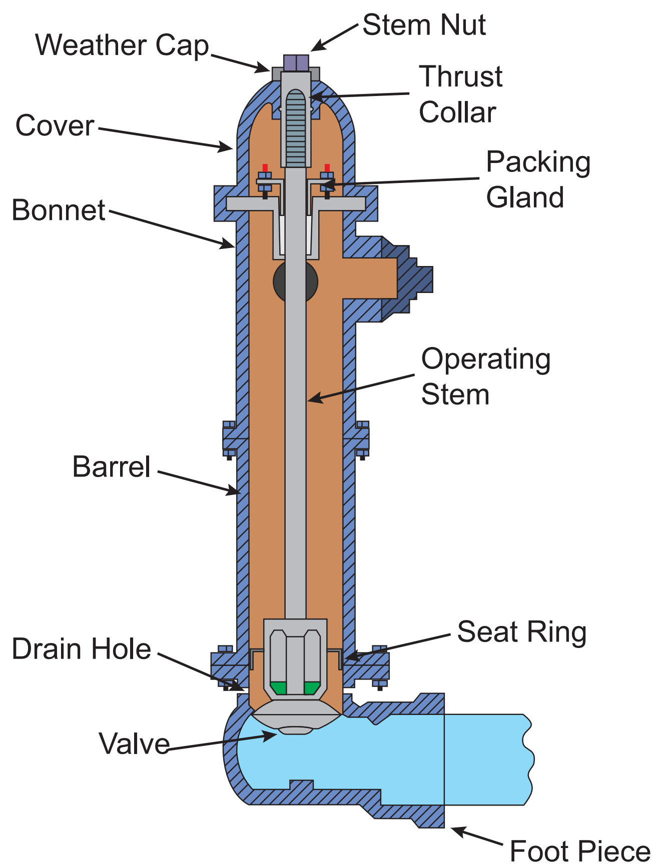


Fig. 3.1.1.6.7-1. Dry barrel hydrant

Wet-barrel hydrants (see Fig. 3.1.1.6.7-2) are used in areas where the temperature remains above freezing. They usually have a compression valve at each outlet, but may have one such valve in the bonnet that controls the flow of water to all outlets.

Approved hydrants have either two or three hose outlets. Installations of hydrants having pumper-suction outlets in private fire protection systems may cause water supply deficiencies. The draft created by pumpers connected to pumper-suction outlets of a hydrant could deplete the water supply to sprinklers.

Uses

Hydrants are used to supply water for manual fire fighting. Outdoor hazards for which hose stream protection is especially needed include storage of combustible materials and equipment, freight cars and loading platforms and aboveground ignitable liquid tanks. Hose streams from hydrants or hose connections on the roof are needed to protect combustible roof structures and equipment such as cooling towers, oil-filled transformer installations, and large areas of smooth-surfaced roof coverings. For unsprinklered buildings, hose streams are usually the main defense against fire.

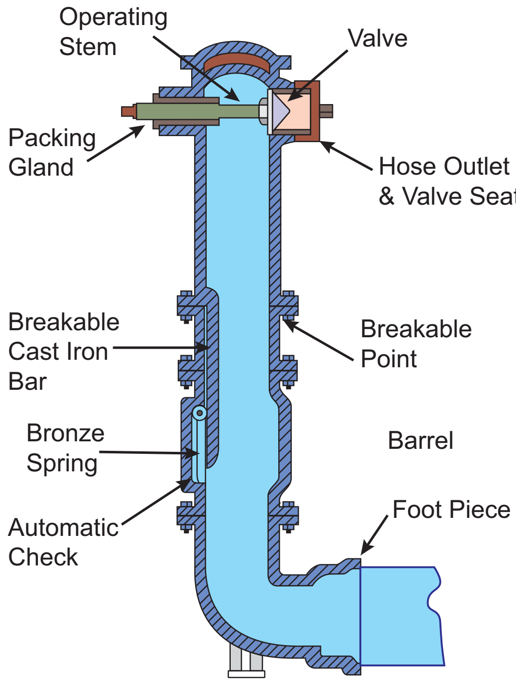


Fig. 3.1.1.6.7-2. Wet barrel hydrant

In sprinklered buildings, occupancies such as those described below need hose streams from hydrants as supplementary protection.

1. *Warehouses and storage areas in manufacturing buildings.* Storages of high piled combustible material and those where smoldering or burrowing fires are persistent, particularly need supplementary protection since reignition is possible after sprinklers are shut off.

2. *Ignitable liquid occupancies.* Hose stream protection is needed to cool exposed, ignitable liquid tanks and their supports, and for use with portable foam generators.

3. *Loading docks.* Hose stream protection is needed to control a fire in a railroad car or trailer that is shielded from sprinkler discharge.

Location

Sufficient public or private hydrants are installed to provide an adequate number of readily available hose streams, as recommended by other FM Global Data Sheets, at any point in the property where fire may occur outdoors. For the protection of buildings and contents, hydrants are located near access openings and at points between, if necessary. This type of installation may result in uneven, though adequate, spacing of hydrants.

3.1.2 Fire Service Mains

3.1.2.1 General

Underground pipe and fittings for fire service mains must be suitable for the working pressures and the conditions under which they are to be installed. The pipe and fittings must be able to withstand the severe conditions that may be imposed by fire pump operation, pressure surges, the use of hose streams or operation of automatic deluge or water spray sprinkler systems.

Low residual pressures, including the vacuum conditions that could realistically exist, will not cause acceptable pipe to collapse or crack. Cast-iron, ductile-iron and asbestos-cement pipe have been tested where the external pressure was raised to 25 psi absolute (172 kPa absolute, 1.7 bar absolute) while the internal pressure was lowered to between 0.2 and 1.0 psi absolute (1.4 and 6.9 kPa absolute). There were no adverse effects on the pipe.

Acceptance of pipe, joints and fittings that are not Approved is based on satisfactory experience and conformity to specifications of recognized engineering bodies.

3.1.2.2 Types of Material

Note: The majority of iron pipe manufactured today is ductile iron. For purposes of this data sheet the term cast-iron refers to cast-gray iron; ductile-iron refers to cast-ductile iron.

3.1.2.2.1 Cast Iron

Cast iron made in accordance with ANSI/AWWA C106/A21.6 or C108/A21.8 (withdrawn in 1982 and 1979 respectively) or equivalent is acceptable. These specification standards give data on pipe sizes, weights, working pressures and thickness classes for various laying conditions. In these specifications the pipe class (150, 200, 250, etc.) represents the maximum working pressure expressed in psi. Select pipe thickness class (wall thickness) on the basis of maximum working pressure and laying condition as described in ANSI/AWWA C101/A21.1 (withdrawn in 1982). The thickness classes are numbered 22 through 28 for pipes up to 12 in. (300 mm nominal) diameter.

Use lined pipe for all new or replacement installations to offset the corrosive action of water. Portland cement is extensively used for lining pipe today. Cement-mortar linings are covered in ANSI A21.4 (AWWA C104). Coal-tar enamel linings are also available but less common.

Select fittings for use with cast-iron pipe that conform to ANSI A21.10 (AWWA C110). Also select fittings appropriate for the same range of working pressures as the pipe with which they are to be used.

Joints may be of several types, including push-on, standardized mechanical and poured-lead bell and spigot. The last type is now rarely used. Special forms of push-on and standardized mechanical joints are Approved. These joints are essentially bell and spigot, and depend on friction between parts and the surrounding earth fill to prevent separation.

The push-on-joint (see Fig. 3.1.2.2.1-1) is made up by seating a circular rubber gasket of special cross section in the bell and then forcing the spigot end of the pipe past the gasket to the bottom of the bell socket. No packing or caulking is required.

The standardized mechanical joint (see Fig. 3.1.2.2.1-2) consists of a single rubber gasket held firmly in place by a follower ring or gland bolted to the bell. The advantages are tightness, flexibility, speed and ease of installation. Care must be taken to assemble the joint correctly. The spigot must be lubricated and the nuts tightened uniformly according to the manufacturer’s instructions. The bolts and nuts must be coated with an asphaltic material to avoid corrosion.

The bells of mechanical joint pipe usually will accommodate straight spigot ends from other cast-iron pipe having the same outside diameter; if not, sleeves and adapters may be needed to connect old and new pipe.

The poured-lead bell and spigot joint (see Fig. 3.1.2.2.1-3) is made by placing a ring of packing material in the bell, filling the joint with molten lead, and caulking the lead for tightness. It is now rarely used.

3.1.2.2.2 Ductile Iron

Ductile iron is a cast-iron material in which a major part of the carbon content (graphite) occurs as free carbon in nodular or spheroidal form instead of the flake form found in cast iron. This carbon form makes ductile-iron pipe less brittle than, and preferable to, gray-cast-iron pipe. Ductile iron has the corrosive resistance of cast iron and approaches the strength and ductility of steel.

Ductile-iron pipe made in accordance with ANSI/AWWA C151/A21.51 is acceptable for fire service use. The ANSI/AWWA specification gives data on pipe sizes, wall thicknesses, weights and working pressures for various laying conditions. Select pipe thickness class (wall thickness) on the basis of working pressure, laying condition, and depth of cover as described in ANSI/AWWA C150/A21.50. The thickness classes are numbered 51 through 56 for 3 and 4 in. (80 and 100 mm) pipe, and 50 through 56 for pipe 6 in. (150 mm) and larger. Class 50 (the thinnest available wall) is satisfactory for working pressures up to 350 psi (2412 kPa, 24 bar) for all laying conditions and depths of cover in pipe sizes 6 through 12 in. (150 through 300 mm).

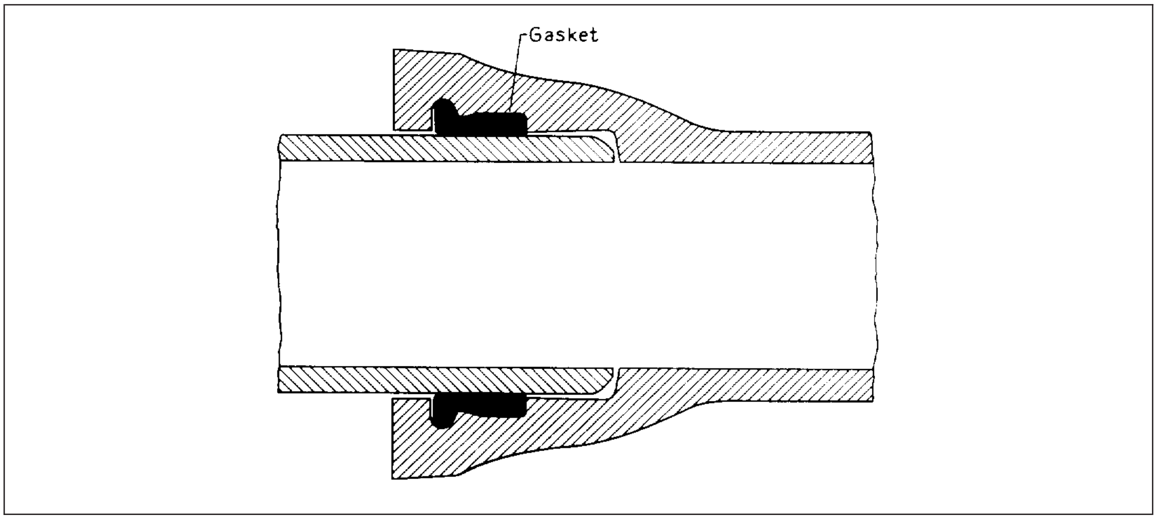


Fig. 3.1.2.2.1-1. Push-on joint

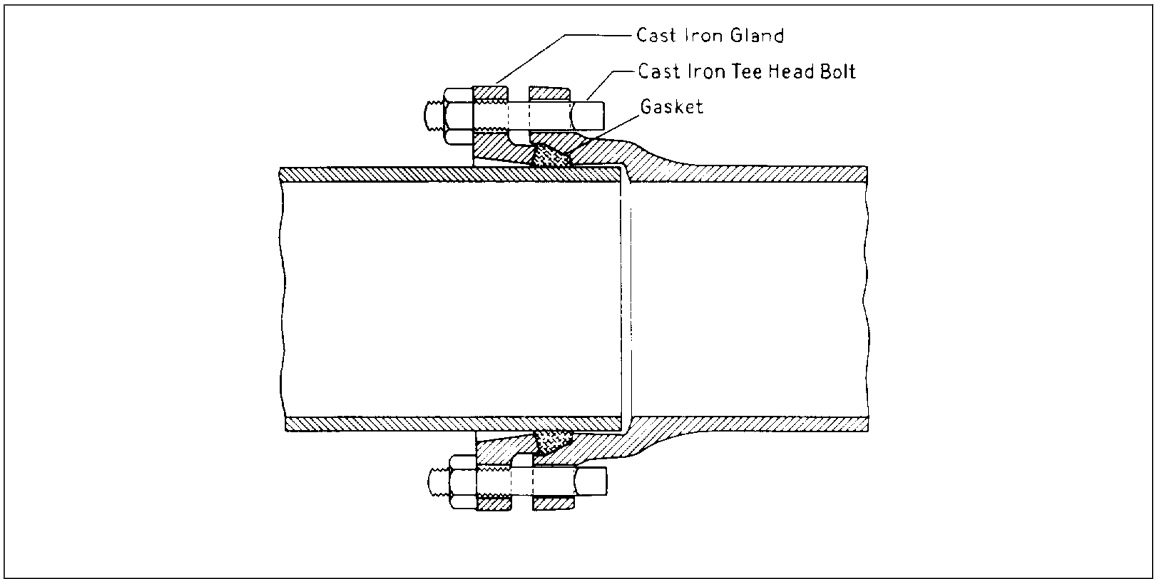


Fig. 3.1.2.2.1-2. Standardized mechanical joint

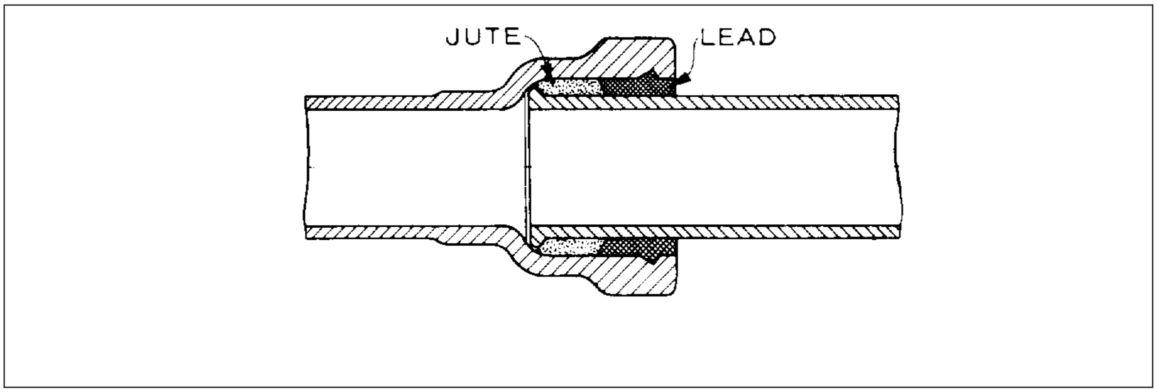


Fig. 3.1.2.2.1-3. Bell and spigot lead joint

Cast-iron or ductile-iron fittings conforming to ANSI/AWWA C110/A21.10 are used with ductile-iron pipe, which is made for use with push-on and standardized mechanical joints.

As with iron pipe, select lined pipe for all new or replacement installations to offset the corrosive action of water. Portland cement is extensively used for lining pipe today. Cement-mortar linings are covered in ANSI/AWWA C104/A21.4. Coal-tar enamel linings are also available but less common.

3.1.2.2.3 Steel

Steel pipe manufactured in accordance with ANSI/AWWA C200 is acceptable for fire service use.

Because of its high strength, steel pipe is particularly suitable for use where it may be exposed to earthquake shock, or to the impact from vehicle loads on railroad tracks, highways and similar locations. Its greater strength is also advantageous in unstable soil or on steep slopes.

Steel pipe for use as buried pipe is lined and coated for corrosion protection. Protective coal-tar enamel and cement-mortar coatings and linings should conform to ANSI/AWWA C203 or C205 respectively. Pipe so protected is available directly from the mill; except for repair, coatings that may be applied in the field are practical only on large jobs. Paint or otherwise protect exposed steel piping, as in pits, against atmospheric conditions.

Steel pipe may be joined by welding, threaded joints or Approved flexible couplings for use with grooved or plain pipe ends. Repair damaged linings and coatings. Do not field weld steel pipe having coal-tar enamel lining, because resulting damage to the lining cannot be effectively repaired. Welding should conform to ANSI/AWWA C206. Suitable precautions against fire are essential when welding in tunnels. Expansion joints may be needed in long tunnels. Hangers and supports should conform to the recommendations of Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

3.1.2.2.4 Asbestos Cement

Asbestos-cement pipe made in accordance with AWWA C400 is acceptable for fire service use. Classes 150 and 200 pipe are used when the maximum working pressures do not exceed 150 and 200 psi (1034 kPa, 10.4 bar and 1378 kPa, 13.8 bar), respectively. AWWA C400 does not cover pipe in classes higher than 200.

Asbestos-cement pipe is composed of a mixture of asbestos fibers and cement. It is particularly well adapted for locations where ferrous pipes, without special protective linings or coverings, would be obstructed or weakened by actively corrosive waters, soil conditions or electrolysis. Where asbestos-cement pipe must be buried in highly acid or alkaline soils, the pipe manufacturer should be consulted as to its suitability. Occasionally coatings can be provided that will protect the pipe from soil conditions.

Joints for asbestos-cement pipe are of the push-on type, and are Approved. The usual joint is a cement asbestos sleeve into which a specially shaped rubber gasket is inserted in a circumferential groove near each end of the sleeve. When making the joint, the tapered ends of the pipe are forced into the sleeve, compressing the rubber gaskets to make a tight joint. Another method of joining is to use an asbestos-cement sleeve, which is forced over roll-on rubber gaskets so arranged that the gaskets, in their final position, are properly located on each side of the joint to form a watertight connection (see Fig. 3.1.2.2.4-1.).

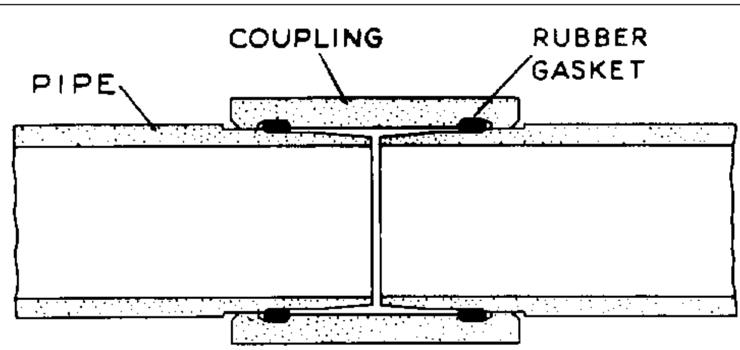


Fig. 3.1.2.2.4-1. Coupling for asbestos cement pipe

Fittings other than couplings are cast iron. Anchorage is by thrust blocks.

3.1.2.2.5 Plastic

When using plastic pipe and fittings for fire service, select Approved products. Use the Approved pipe within the limits of its Approval, and according to the manufacturer's installation instruction. Where plastic pipe may be exposed to a damaging chemical environment, consult the manufacturer. For example, pipe may be exposed to chemical attack as a result of an oil spill on the ground surface above.

Approved plastic pipe is available in various types of material, including polyethylene, polyvinyl chloride and glass fiber-reinforced plastic. All are lightweight and corrosion resistant. Thrust blocks are used for anchorage.

3.1.2.2.6 Polyethylene

Polyethylene pipe exhibits a typical elastic behavior to short-term stress, and its resistance to these stresses is extremely high. It has been successfully used in installations such as river, lake and salt water crossings as well as for underground service mains. Polyethylene pipe is generally chemically inert and is only attacked by certain very strong chemicals. Water does not corrode polyethylene pipe so that the Hazen-Williams flow coefficient, "C", remains practically constant throughout the life of the pipe.

Joints are made by the butt fusion process. The process is based on temperature-induced changes in the crystalline structure of polyethylene. At normal ambient temperatures and elevated temperatures to 200°F (93°C) the crystalline structure of polyethylene is readily recognizable on microscopic examination. As the temperature increases above 200°F (93°C), the structure becomes less distinct, and at 260°F (127°C), it disappears entirely. This point is usually referred to as the crystalline melting point. In the butt fusion process the pipe ends are trimmed and heated to a temperature above the crystalline melting point. The butt ends are brought together under pressure and the material flows and mixes. As the material cools below the crystalline melting point, crystals form across the joining plane, essentially reforming the original material structure (see Figs. 3.1.2.2.6-1 and 3.1.2.2.6-2).

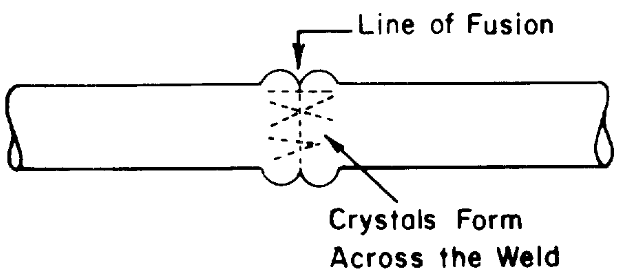


Fig. 3.1.2.2.6-1. Butt fusion joint

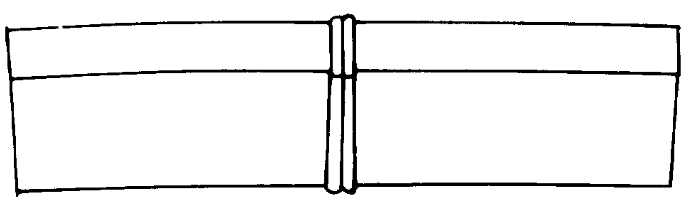


Fig. 3.1.2.2.6-2. Section of polyethylene pipe wall joined by butt fusion

To ensure mixing at the line of fusion, the viscosity of the two pieces must be the same, otherwise, the materials tend to flow at different rates under pressure, with the risk that the plane will not fuse. For this reason, join by fusion only polyethylene materials of the same kind.

Polyethylene pipe may be connected to flanged, cast iron fittings or components with metal flanges. Polyethylene stub ends that are compatible with the metal flanged components are joined to the pipe by the butt fusion process (see Fig. 3.1.2.2.6-3).

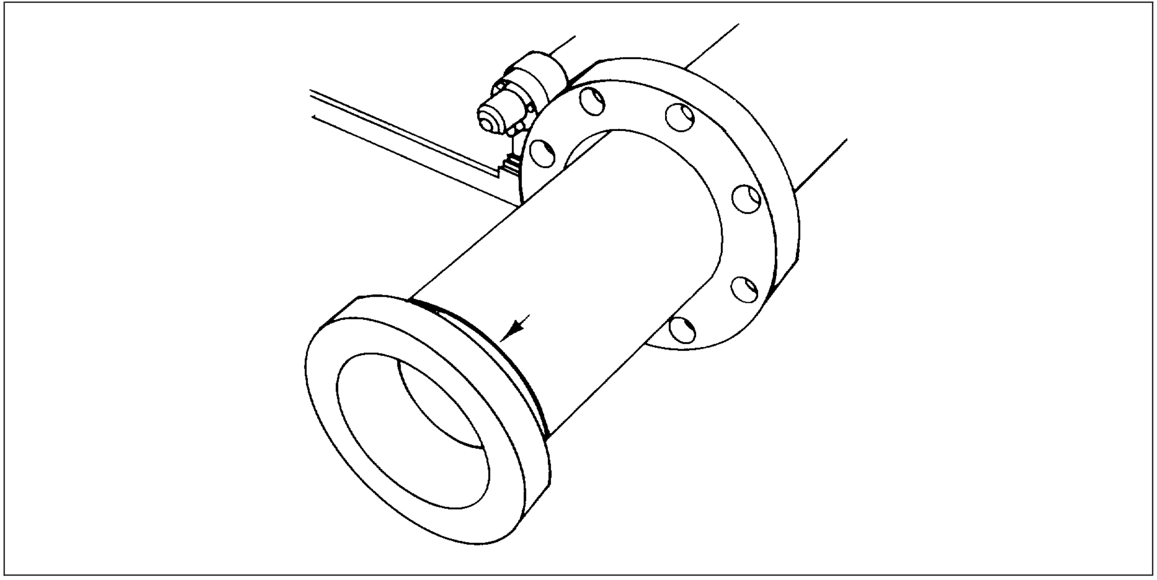


Fig. 3.1.2.2.6-3. Stub end butt fused to polyethylene pipe. Note joining point

3.1.2.2.7 Polyvinyl Chloride (PVC)

Polyvinyl chloride pipe is immune to nearly all types of chemical and electrochemical corrosion that may be experienced in underground piping systems. Since PVC is a nonconductor, galvanic and electrochemical effects may not affect PVC piping systems. Do not use PVC pipe in areas subject to constant spillage of aromatic hydrocarbons.

Some Approved PVC pipe has an integral bell on one end and a spigot on the other end. Thus the typical coupling is by a push-on, bell and spigot joint with a steel band-reinforced elastomeric gasket (see Fig. 3.1.2.2.7-1). Other Approved PVC pipe has plain ends, and is joined by a twin-gasketed coupling.

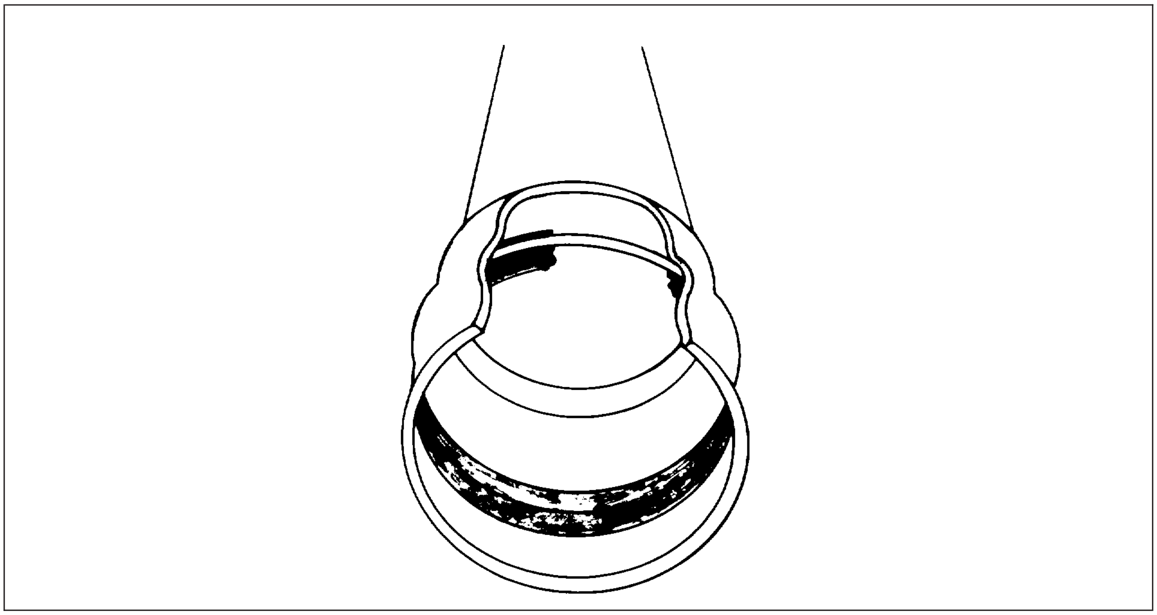


Fig. 3.1.2.2.7-1. PVC pipe end with integral bell and steel-band-reinforced elastomeric gasket

Approved PVC pipe is manufactured with cast iron outside diameter dimensions, and may be joined to standard cast iron belled fittings or other fittings by Approved devices or standardized mechanical joints.

3.1.2.2.8 Glass Fiber-Reinforced Composite

Glass fiber-reinforced composite pipe is immune to most corrosive soils and ground water. Approved pipe is manufactured in various configurations of glass fiber-reinforced composites. Joints are formed by couplings and adhesive, integral flanges, or mechanical couplings (see Fig. 3.1.2.2.8-1). Pipe is joined to cast iron fittings using transition gaskets and Approved devices or standardized mechanical joints (see Fig. 3.1.2.2.8-2). Approved glass fiber-reinforced plastic fittings are available.

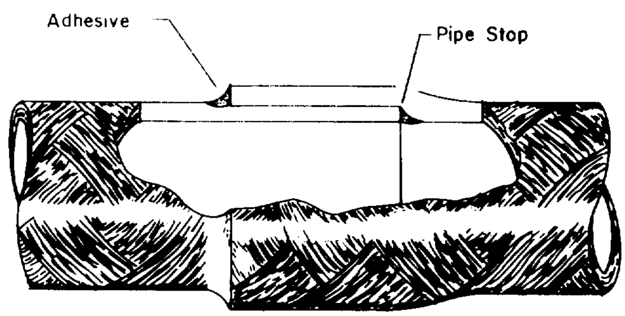


Fig. 3.1.2.2.8-1. Glass fiber-reinforced composite pipe joint formed by integral flanges and adhesive

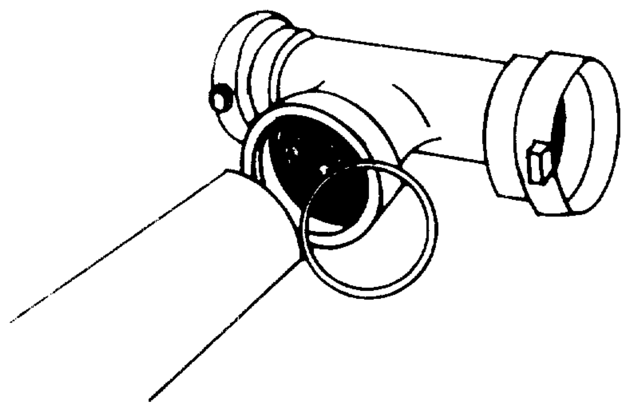


Fig. 3.1.2.2.8-2. Glass fiber-reinforced composite pipe, cast iron fitting and transition gasket

3.1.3 Connections From Water Supplies

3.1.3.1 Size

Connections from water supplies are sized to restrict velocities to less than 20 ft/sec (6.1 m/sec) to prevent damage to fittings and valves. Friction loss at anticipated rates of flow can be minimized by properly sizing the pipe.

3.1.3.2 Arrangement

Figure 3.1.3.2-1 shows some acceptable arrangements of manually operated control and check valves in connections from various water supplies to fire service mains.

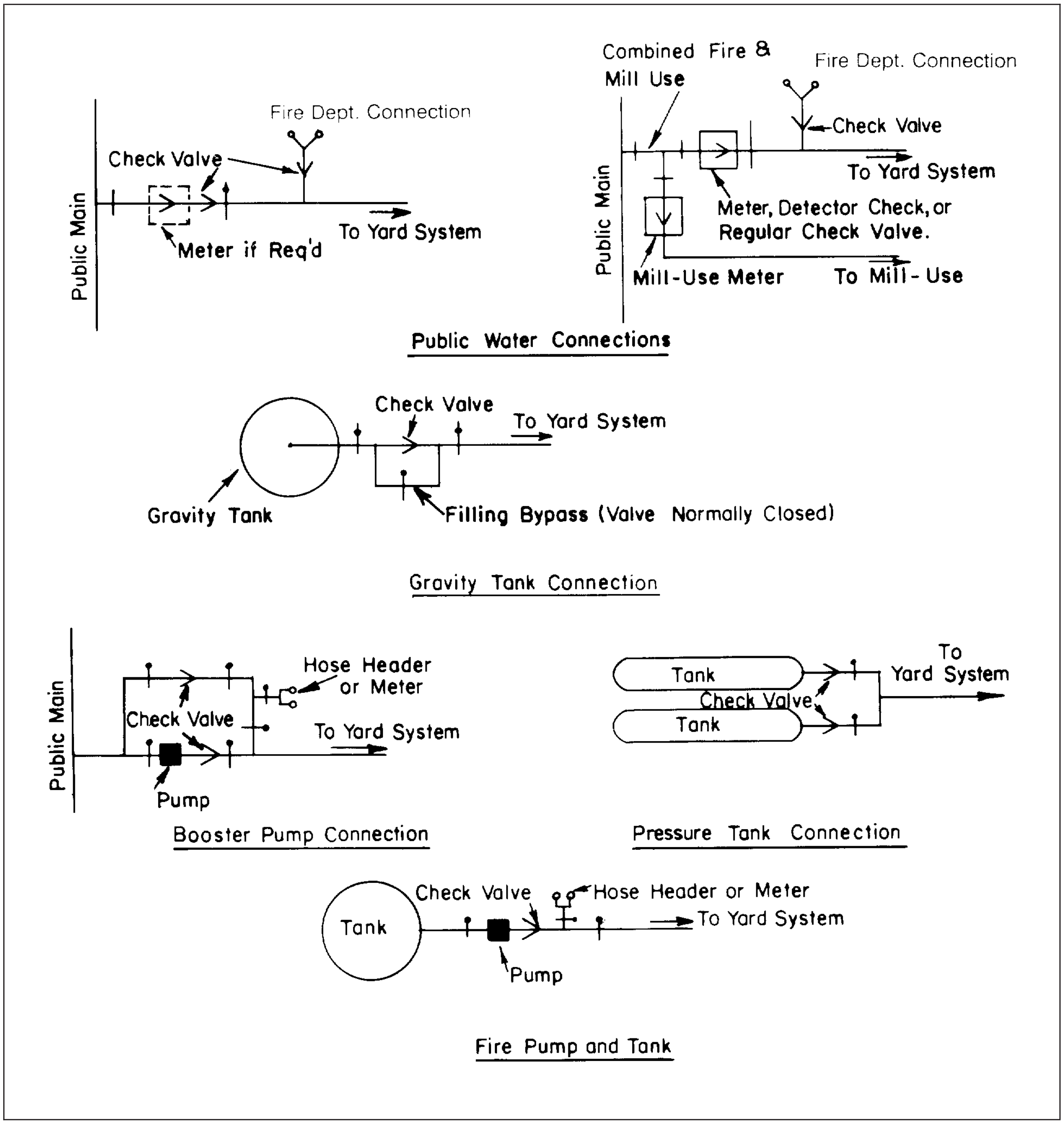


Fig. 3.1.3.2-1. Connections from water supplies

3.1.3.3 Cross Connections

The public health authority determines the acceptability of cross connections. Data Sheet 3-3, *Cross Connections,* details cross-connection control, achieved by backflow prevention devices or by air gaps. The devices required by health authorities can have high head loss.

3.1.4 Arrangement and Location of Fire Service Mains

3.1.4.1 Arrangement

Private fire service mains are arranged so as to minimize, insofar as practical, impairments (loss of protection) in the event the mains or their appurtenances are damaged, or in cases of system shutdown for other reasons. Such damage can include main breaks and leaks, dropped valve gates and damaged valves and hydrants.

The layout of plants varies widely, making it impossible to establish firm rules concerning the arrangement of fire service mains and divisional valves. Judgment is applied to achieve economic but effective arrangements. Underground mains are costly to install, thus making every effort to avoid unnecessary installations is advised. Consider the following items when planning new installations.

1. Rarely is it practical to arrange the mains and division valves so that impairments have little or no effect on the fire protection system. For example, a virtually impairment-free (but impractical) system is shown in Figure 3.1.4.1-1.

The two-riser installation shown in Figure 3.1.4.1-1 is impractical because it requires seven valves in addition to the city gate valve, and an extent of underground main, the cost of which is out of proportion to maximum foreseeable fire loss, with all protection out of service. A more practical arrangement is shown in Figure 3.1.4.1-2.

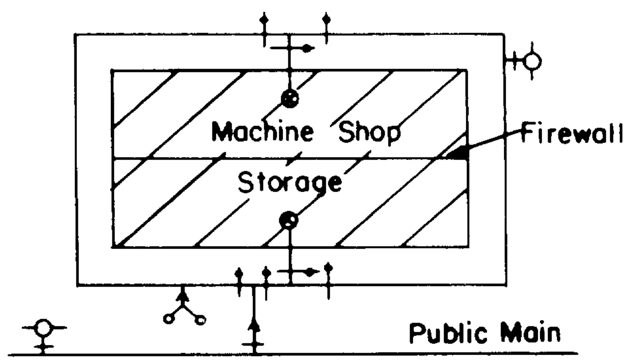


Fig. 3.1.4.1-1. Impairment-free (but impractical) underground system

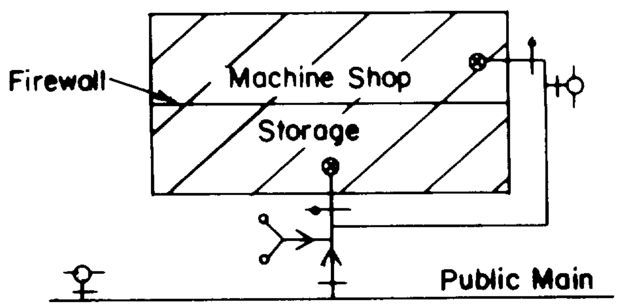


Fig. 3.1.4.1-2. Practical underground system

One-quarter as much underground piping and only two valves are needed. Clearly this system is not as responsive to impairments but with only one-quarter as much underground piping, the exposure to impairments is greatly diminished.

2. Rarely is an underground main necessary solely to supply hydrants. In a case without underground mains in the vicinity of needed hydrants, wall hydrants fed from indoor sprinkler system piping can provide acceptable alternative sources of hose stream supply.

One exception to this is the single-building plant where the hydrants are used to supply water for fighting fires indoors. A wall hydrant cannot be relied upon to be in service for use with hose streams on a fire inside the building, since there is too great a chance that the sprinkler system and therefore the water supply to the wall hydrant will be shut off at a critical moment. Hydrants fed from underground mains may therefore be necessary.

A second exception is where hydrant protection is necessary for yard storage remote from buildings. In this case an underground main system used solely to supply the yard hydrants may be necessary.

3. Where multiple water sources are provided, it is not necessary that they all remain in service in the event of an impairment. Only those (or that one) necessary to meet the total water demand need be available.

4. Where loops are provided so that multiple paths are available for water flow to a single point, the mains forming the legs of the loop need to be sized only to carry that portion of the flow occurring under no-impairment conditions. Where the hazard is such that a deluge system is provided, it may be advisable to size the legs of the loop to carry the total water flow.

5. Arrange systems involving multiple water sources so that an underground main impairment is unlikely to impair all sources (see Fig. 3.1.4.1-3).

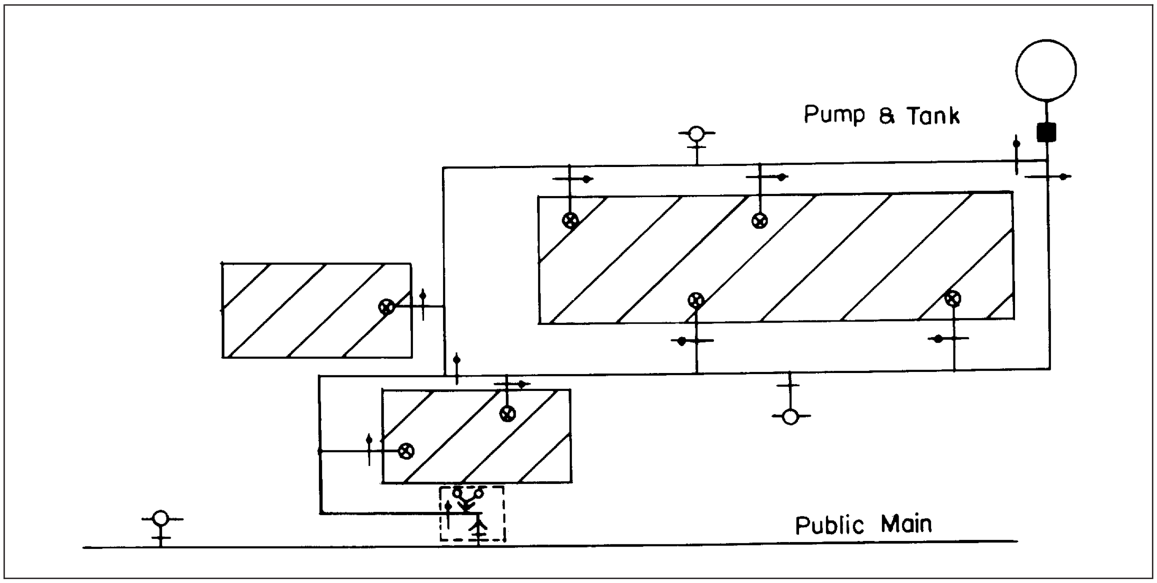


Fig. 3.1.4.1-3. Acceptable arrangement of multiple water sources

6. Manifolded riser arrangements, though generally undesirable (see Data Sheet 2-8N), decrease the need for looped mains (see Figs. 3.1.4.1-4. and 3.1.4.1-5).

In Figure 3.1.4.1-4 a manifolded riser arrangement has been used, and a loop around Building "A" would serve little purpose. In Figure 3.1.4.1-5 the risers are more widely distributed, and the loop around building "A," in addition to judiciously placed divisional valves, allows for some flexibility.

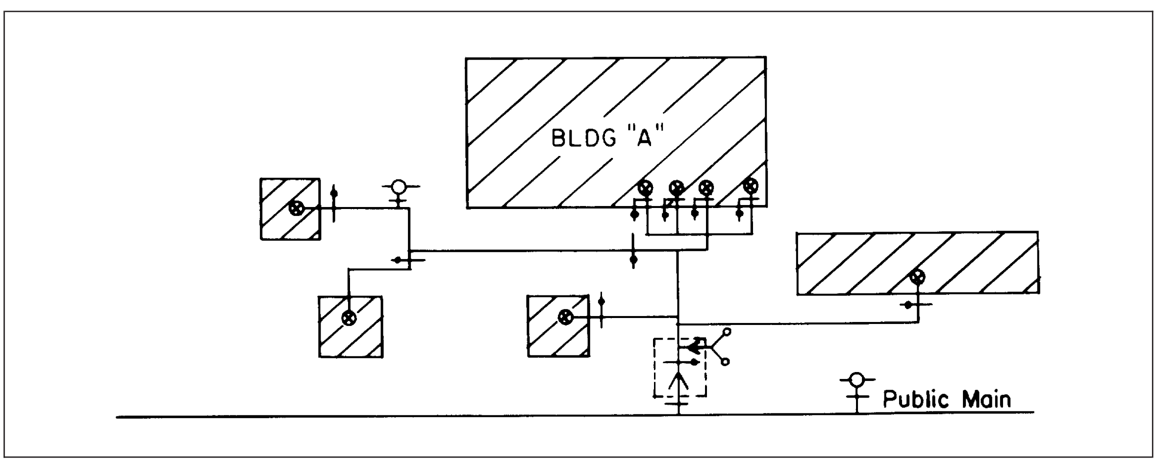


Fig. 3.1.4.1-4. System with manifolded riser arrangement

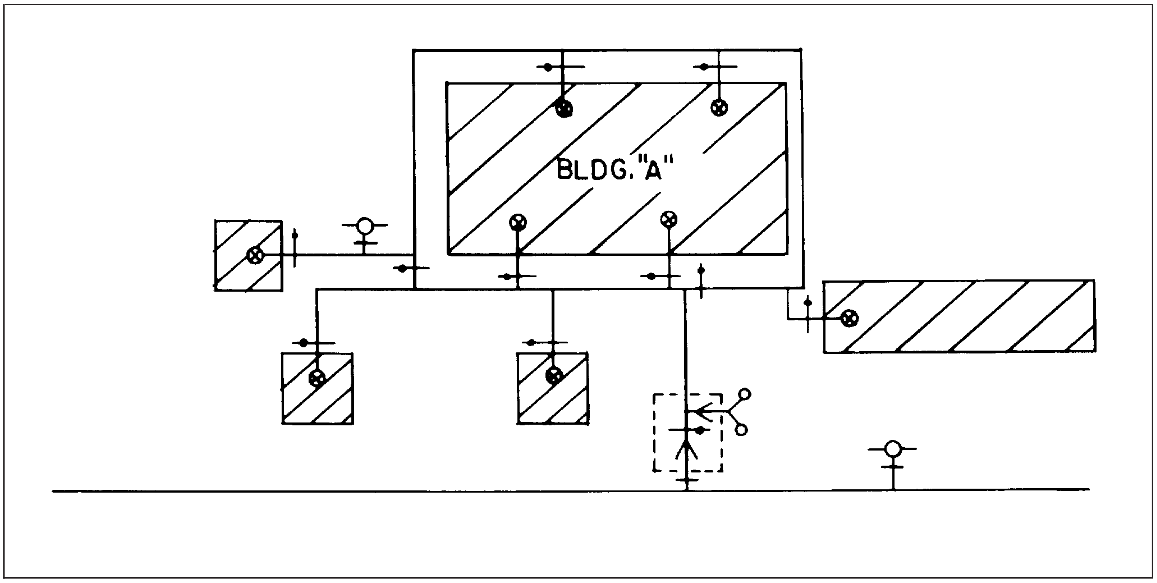


Fig. 3.1.4.1-5. System with looped main substituted for manifolded riser arrangement of Figure 3.1.4.1-4

7. Where looped mains are present, divisional valves are provided so that sections of the loop may be isolated. The maximum number of risers to be impaired simultaneously depends on the values exposed to loss by the impairment, the possibility of temporary water supply connections to the impaired risers from in-service hydrants or other sources, the expected frequency of fires (this may be deduced from the occupancy), and the ease with which the area may be patrolled. As an example of the latter, a large, open building with a mezzanine at one end from which the entire building may be surveyed is easier to patrol than several widely separated smaller buildings.

As a general guideline, limit to about six the number of risers served by one divisional valve. Base the identification of needed valves on the combination of the above guideline and good judgment. If 13 risers are served by two divisional valves, an additional valve is not needed unless judged necessary after careful consideration.

8. Large, multi-riser, multi-source, multi-building plants usually benefit from looped main arrangements. In such plants, extensive main installations are usually necessary, so that completing loops does not add significantly to the cost.

9. Looped main arrangements can be economically advantageous, especially in the case of large buildings. The cost of several long runs of feed main indoors may exceed the cost of providing a looped main to directly feed the risers on the far side of the building (see Fig. 3.1.4.1-6).

10. A major factor in the installation of underground mains is the cost of excavation. This is influenced largely by the ground conditions. Rock formations that require blasting escalate cost, while clay soils, which do not even require shoring, may be more economically excavated.

3.1.4.2 Location

Underground breaks have occurred where the main ran beneath the floor. Floor settlement is a major factor in the breaks. Repair of main breaks below the floor can be a lengthy and costly procedure. In addition, the break can cause much damage, both to the structure (by washouts) and to the building contents.

3.1.5 Pipe Installation

3.1.5.1 Trenching and Laying

Installation of ductile-iron piping is in accordance with ANSI/AWWA C600 and asbestos cement pipe is in accordance with ANSI/AWWA C603. These AWWA standards were written for water utility piping, but the same principles and procedures apply to fire service mains.

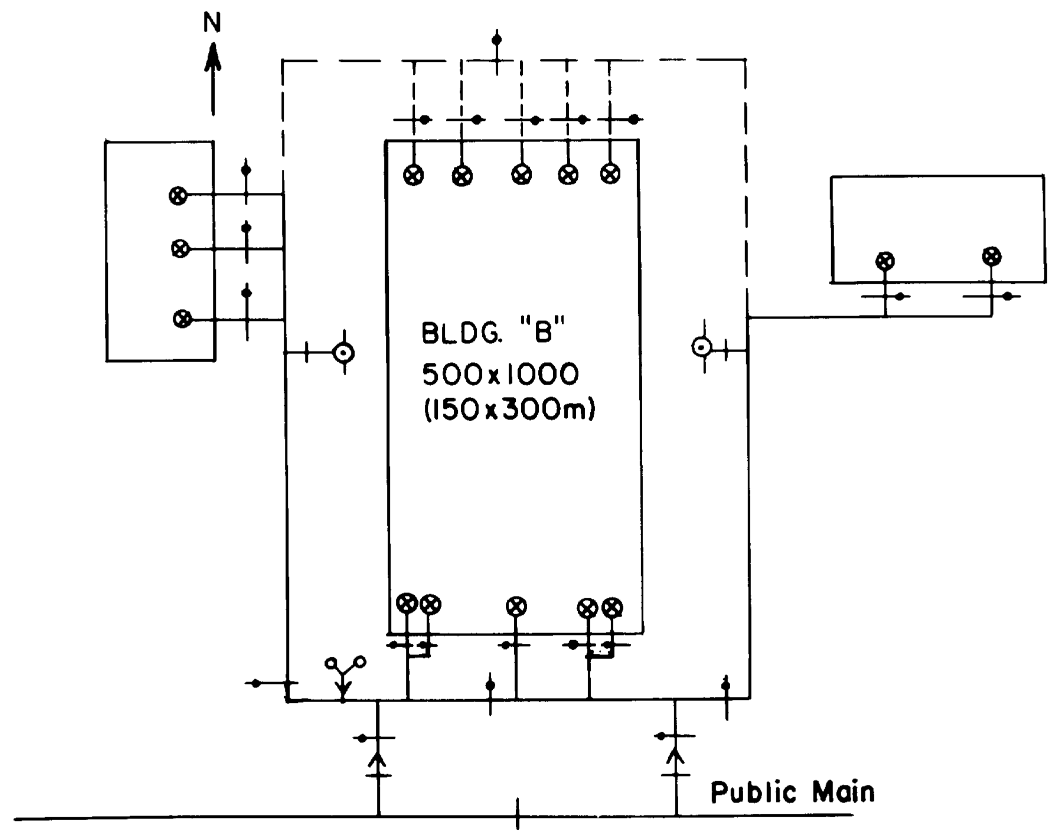


Fig. 3.1.4.1-6. System where completion of underground main loop avoids long runs of indoor feed mains

Figures 3.1.5.1-1 and 3.1.5.1-2 show the pipe laying conditions for ductile-iron and asbestos-cement pipe, respectively.

Bell holes are provided in the trench bottom to allow joint assembly, and to ensure that the pipe barrel will lie flat on the trench bottom.

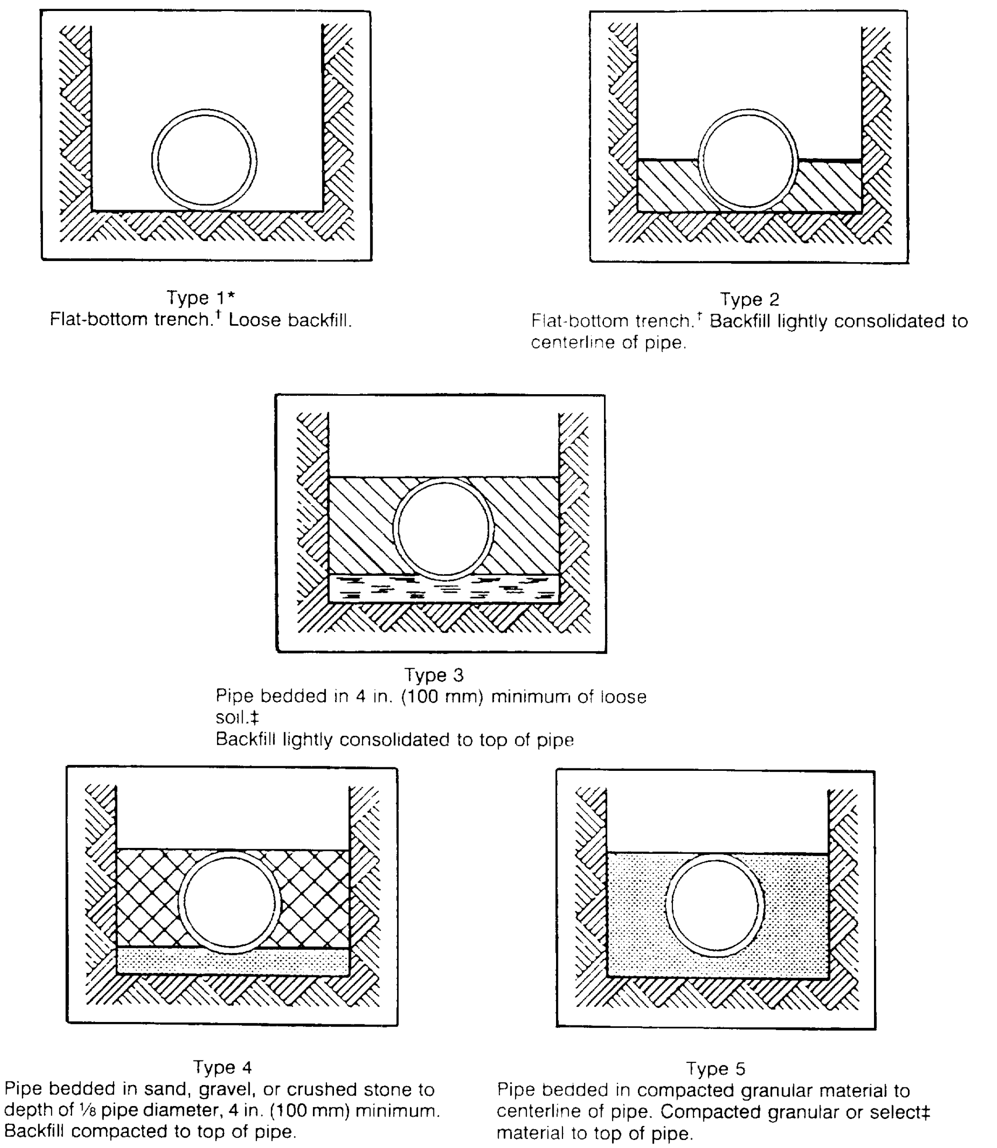
Except for bell holes and coupling holes, a level trench bottom is maintained so that the pipe is supported along its full length.

3.1.5.2 Protection Against External Corrosion

Metallic salts, acids or other substances in the soil combine with moisture, resulting in an electrochemical reaction, which causes iron ions to separate from the pipe. The mass of the metal at the pipe's surface is diminished, and it becomes pitted or corroded.

External corrosion occurs if iron or steel pipe is installed under coal piles, in cinder fill or wherever acids, alkalis, pickling liquors, etc., can penetrate the soil.

Loose polyethylene encasement used according to ANSI/AWWA C105/A21.5 affords good protection to iron pipe exposed to corrosive soil conditions. The polyethylene encasement provides a high degree of protection, and results in minimal and generally insignificant exterior surface corrosion of iron thus protected. Also, the dielectric capability of polyethylene provides shielding against stray direct current at most levels encountered in the field. Tests on polyethylene used in the protection of cast- and ductile-iron pipes have shown that after 20 years of exposure to corrosive soils, the polyethylene strength loss and elongation reduction are insignificant. The polyethylene is also highly resistant to bacteriological deterioration.

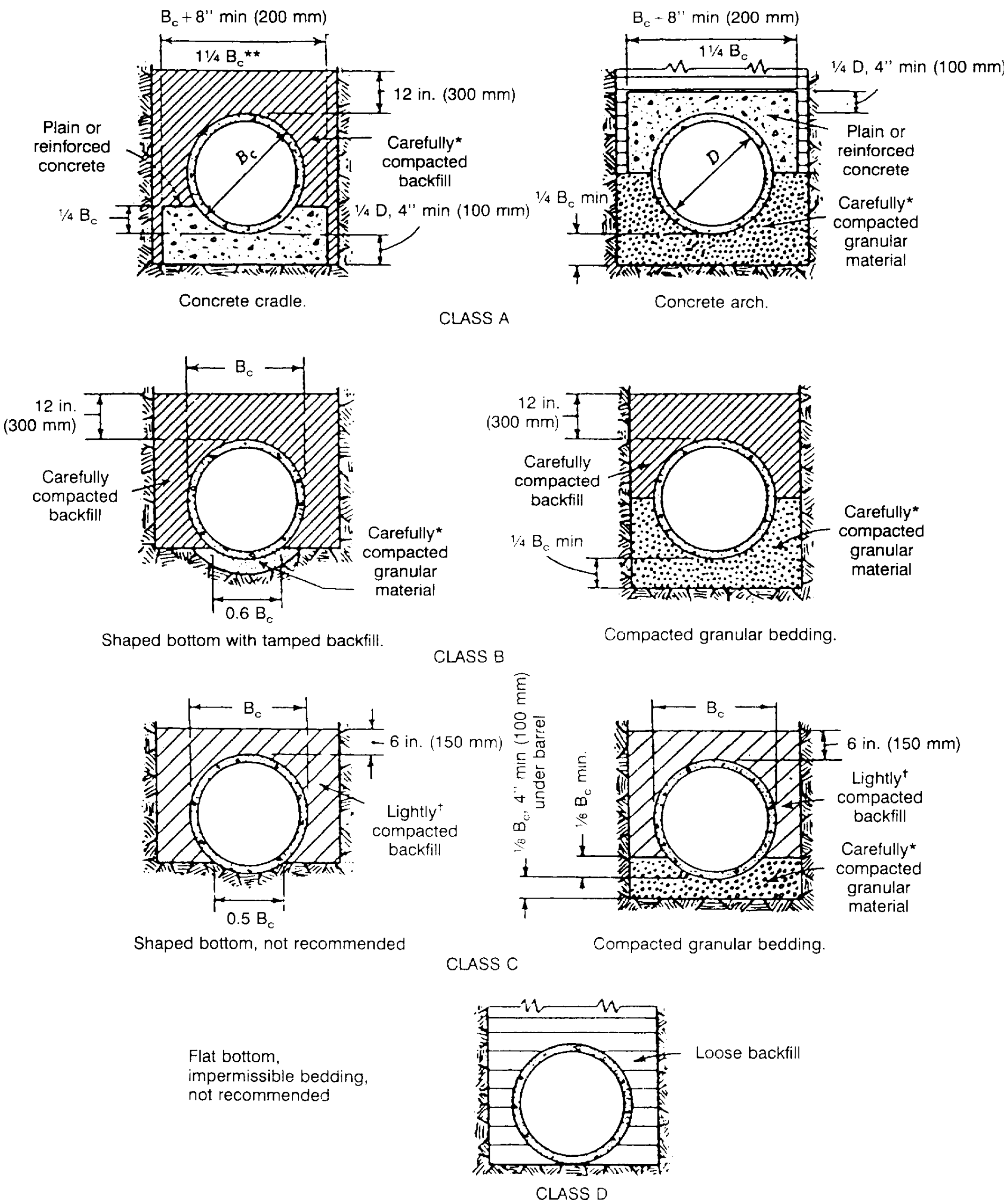


NOTE: Reprinted from AWWA Standard C600 by permission. Copyright 1987, American Water Works Association.
*For 14 in. and larger pipe, consideration should be given to the use of laying conditions other than type 1.
†"Flat-bottom" is defined as undisturbed earth.
‡"Loose soil" or "select material" is defined as native soil excavated from the trench, free of rocks, foreign materials, and frozen earth.

Fig. 3.1.5.1-1. Laying conditions for ductile-iron pipe

Asbestos-cement pipe is particularly suitable for locations where ferrous pipe would be subjected to attack by actively corrosive water, soil conditions or electrolysis. Where asbestos-cement pipe must be buried in highly acid or alkaline soils, the manufacturer should be consulted. Protective coatings are sometimes available.

Stray electric current from an external source may follow a buried main until it reaches a location where the resistance to ground is lower. Ionization occurs at these points where the current leaves the main, producing an effect similar to that of soil corrosion.



NOTE: 1. Reprinted from AWWA Standard C403 by permission. Copyright 1989, American Water Works Association.
2. In rock trench, excavate at least 6 in. (150 mm) below the coupling of the pipe except where concrete cradle is used.

*Carefully compacted backfill or granular material
†Lightly compacted backfill
**B_c = Outside Diameter of Pipe

Fig. 3.1.5.1-2. Laying conditions for asbestos-cement pipe

When stray electric currents are suspected, the extent and origin can be determined by professional ground surveys. If the stray currents cannot be eliminated or diverted, and the main is not yet seriously corroded, it can be protected by bonding all the joints and providing direct low resistance metallic ground connections. Cathodic protection is sometimes used. This technique imposes direct electric current from a galvanic anode to the buried main. Cathodic protection is also effective against soil corrosion, but is rarely used in fire protection installations due to the costs of installation and maintenance.

3.1.5.3 Protection Against Freezing

Local soil conditions and elevation will affect the depth of frost cover. Frost penetrates deeper in soils on hillsides with northern exposure than those with southern exposure. Frost penetration has been found to be 1.5 times as deep in sand as in clay. Frost penetration is significantly greater in disturbed soil than in undisturbed soil. Based on these examples, local officials should be consulted for recommended frost depth levels. Relying on generalized maps for a specific location is not recommended. For areas where frost is a factor, bury fire service mains at least 6 in. (150 mm) deeper than municipal water works piping. The additional depth of cover is necessary because of the lack of water circulation in fire service mains. Figure 3.1.5.3-1 shows a generalized recommended depth of cover in the United States.

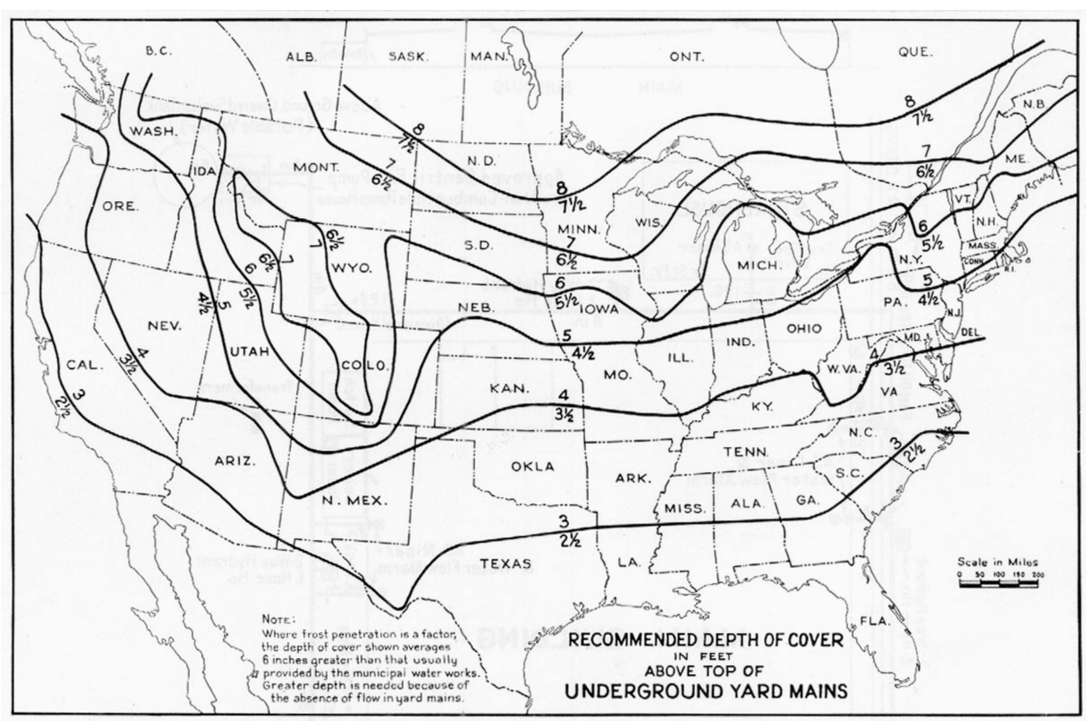


Fig. 3.1.5.3-1. Recommended depth of cover (ft) above underground mains (1 ft=0.3 m)

3.1.5.4 Restraining

Unbalanced thrust forces occur in the water main where the piping stops or changes cross-sectional area or direction. At bends, hydrants, reducers, tees, valves, wyes, dead-ends and offsets on pipe systems, these unbalanced forces must be overcome to prevent the joints from separating. For example, a resultant force of 43,500 lbs (193,500 N) can act on a 90° bend on a 12 in. (305 mm) pipe at a water pressure of 225 psi (1550 kPa). Technical information on thrust restraint can be found in AWWA Manual M11, *Steel Pipe*—A Guide for Design and Installation and AWWA Manual M23, *PVC Pipe-Design and Installation.* Figure 3.1.5.4-1 shows examples of joint restraint.

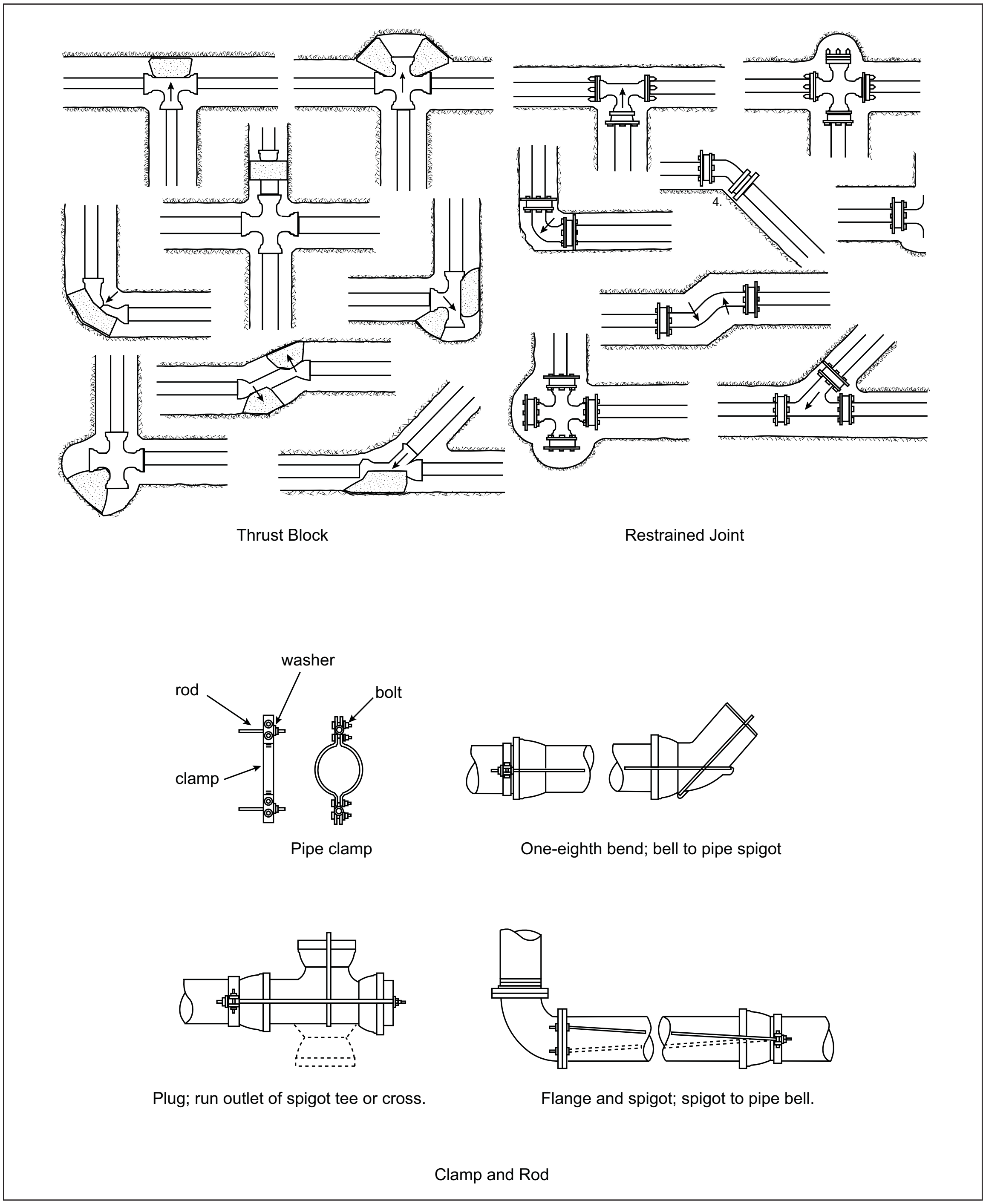


Fig. 3.1.5.4-1. Various methods of joint restraint

3.1.5.5 Hydrostatic Leakage Testing

New mains are hydrostatically tested to determine if the joints are tight and to ensure that there are no defective pipes or fittings. Large installations may be tested in their entirety, or sections between valves may be tested individually. In some cases, it may be necessary to include older pipe within the test section.

A "Contractor's Material and Test Certificate" as shown in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, is signed by the contractor's and management's representatives upon inspection.

3.1.6 Tapping Machines

3.1.6.1 Purpose

Major impairments of fire protection, and therefore the potential for very serious fires, can occur when water is shut off to make new connections to existing water mains. Tapping machines are valuable tools that permit such connections to be made without shutting off the water. Use of this equipment, in addition to maintaining normal protection, avoids postponing the work until periods of facility shutdown. Connections can be made in any size not larger than the nominal diameter of the main to be tapped, and preferably one size smaller.

Tapping tools are available for use with cast- and ductile-iron, asbestos-cement and some types of plastic pipe. The components for tapping are a split sleeve with a side outlet and a special tapping valve. The tapping valve is similar to a gate valve, but the seat opening is larger, to allow clearance for the cutter. The outlet has a bell end with a special flange for bolting onto the tapping machine.

Knowledge of the size and class, or the outside diameter, of the pipe and the diameter of the tap is required when ordering tapping sleeves and valves. Make certain that the contractor or local water department has suitable tapping equipment.

3.1.6.2 Operation

To make a tap, the split sleeve is assembled on the main with the face of the side outlet in the proper direction, and end joints are made watertight. The tapping valve is then attached (see Fig. 3.1.6.2-1) and the tapping machine bolted to the discharge side of the valve. A tapping drill and shell cutter are attached to a shaft that is inserted through the wide open gate until contact is made with the main. The drilling operation bores and threads a center hole, and the cutter takes a disk from the pipe wall. When the cut is complete, the shaft holding the cutter, the threaded drill and the disk are withdrawn far enough to allow the tapping valve to be closed. The machine is then unbolted and removed so that the branch main can be connected to the valve outlet.

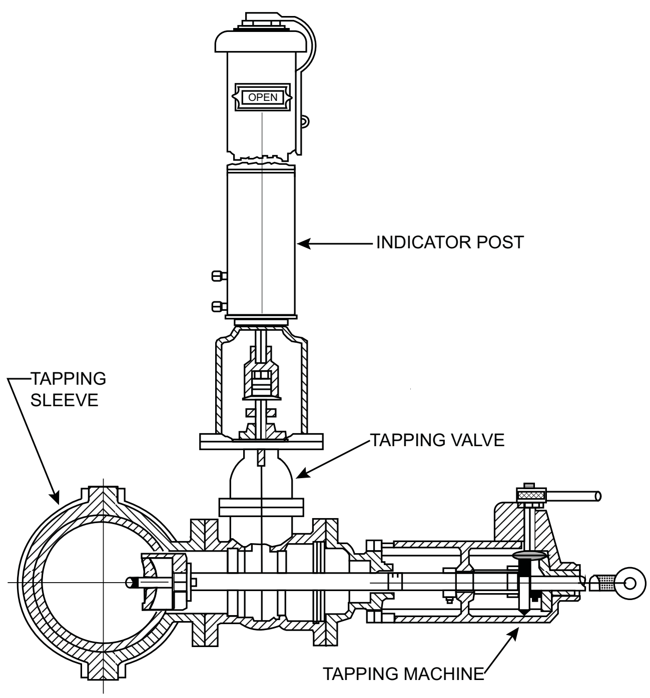


Fig. 3.1.6.2-1. Application of tapping machines to pipe under pressure

It is vital that the disk be removed. Care must be taken in operating a tapping machine not to withdraw the shaft until the cut is completed. Otherwise, the retaining thread may be stripped and the disk not withdrawn with the cutter. If this does occur, a brief shutdown will be necessary and the disk can readily be recovered by reaching through the open valve.

Approved tapping valves have flanges to accommodate indicator posts.

3.1.7 Fire Hose and Equipment for Private Hydrants

3.1.7.1 General

Fire hose is important in all types of occupancies when sprinkler systems are impaired, particularly while sprinklers are shut off immediately following a fire. Charged lines with shutoff nozzles are needed for prompt application of water in the affected areas. The fire hose also can be used to temporarily provide water to sprinkler system risers from nearby hydrants or other risers in the event of an impairment.

Hose streams from hydrants should be available as standby protection in case the sprinkler system is unable, for any reason, to cope with the fire.

For hydrants to be used effectively, sufficient hose and accessory equipment must be quickly available. The equipment needed and its use depend on local facility conditions. Both should reflect the facility's location and size, and the probable needs of the Emergency Organization or public fire department.

Most public fire departments will not use hose provided by the facility, so it is not usually necessary to store hose for their use. Underwriter playpipes for hoses are generally supplied to permit adequate flow testing of the fire protection water supplies if meters are not used for flow testing.

Hose connections above roofs or at the tops of stairs to the roofs of large buildings may need the same hose and accessory equipment as yard hydrants.

3.1.7.2 Size of Hose and Type of Nozzle

Approved 1-½ in. (40 mm) hose with combination spray and solid-stream shutoff nozzles keeps water damage at a minimum and is easy to handle. A gated wye-and-adapter fitting will permit an extension of small hose lines directly from the hydrant or from a lead line of 2-½ in. (60 mm) hose.

The necessary amount and arrangement of small hose, in hose houses or cabinets at hydrants, will depend on the layout of small hose stations within the building.

The type of nozzle will depend on the specific occupancy and protection requirements.

3.1.7.3 Storing and Transporting Hose

At the large facility with a well trained, centralized fire department and motorized equipment, fire hose and accessory equipment are usually carried on a fire truck or other motorized vehicles.

Hand-drawn hose carts or hose reels, each provided with 400 or 500 ft (120 or 150 m) of hose and accessory equipment, are commonly used, acceptable methods of storing hose at both large and small plants. One such cart or reel kept in a strategically located hose reel house or other suitable place can serve three or four hydrants.

Some hose houses or outdoor hose cabinets may be needed at locations that are inaccessible to vehicles, and at concentrated local hazards in the yard or on roofs.

Facilities that have no mobile equipment may have hose houses at most yard hydrants. It is desirable to connect two or three lengths of hose to the hydrant outlet, ready for quick use.

Approved types of hose houses have been in use for many years and are available in knockdown form. Approved hose cabinets are suitable where plant yard space is limited or where the usual hose house would not be desirable for other reasons. They are often useful for storage of hose at a roof hydrant location. They can be attached to a building wall, or placed on angle-iron legs or a concrete foundation near a hydrant.

Hose houses may be designed of masonry or other materials to match the architecture of plant buildings. Hose houses should be constructed to provide good inside air circulation. Provide roofs that are substantial and watertight. Provide screening for protection against vermin

Install foundations that are above the yard level to ensure good drainage. Provide at least 6 in. (152 mm) between swinging door bottom and the ground. Arrange doors and shelves to permit easy operation of the hydrant and attachment of the hose.

The type and amount of equipment needed for individual hose houses or cabinets depends on the needs of the immediate area. Individual requirements may call for all 1-½ in. (40 mm) hose, all 2-½ in. (60 mm) hose, or some of each.

3.1.8 Cleaning and Lining of Fire Service Mains

3.1.8.1 Reason for Cleaning and Lining

The carrying capacity of unlined, cast iron, ductile iron and steel water mains decreases with age because of corrosion. The inside surface is roughened by the formation of tubercles or rusting and the effective diameter also may be reduced by chemical deposits, silt or organic growths.

Practical methods are available for cleaning and lining buried water mains and the cost is usually less than that for replacement with new pipe of the same size.

Cleaning should restore old iron and steel mains to 80% or more of new pipe capacity, but improvement is temporary unless the main is also lined. Lined mains retain their capacity for many years. Negotiate contracts for cleaning that guarantee a Hazen-Williams ''C'' of not less than 90.

3.1.8.2 Methods of Cleaning

3.1.8.2.1 General

There are two basic cleaning methods: mechanical and chemical. Mechanical methods are used most frequently. Lining materials include cement mortar, plastic (epoxy resin), and bituminous compounds. For cleaning or lining, the run of pipe must be isolated. This may require the installation of temporary valves.

Impairment of sprinklers or other protective equipment during these operations must be handled according to recommended procedures. Piping connected to a public water system must usually be disinfected after the work is completed, and before service is restored. Verify the result of the cleaning and lining by conducting waterflow tests.

3.1.8.2.2 Mechanical Cleaning

Mechanical cleaning consists of cutting, scraping and brushing off deposits with special tools, which are forced through the pipe. Loosened material is then flushed out with water. The choice of tools and method depends on the type and hardness of the scale, piping layout and water pressure.

Mechanical cleaning methods vary considerably, but usually involve the following steps:

1. A length of main is excavated at each end.

2. Valves controlling sprinkler systems and branch mains are closed.

3. Control valves at each end of the main are closed and water is removed from the main.

4. Butterfly valves within the length of main are removed.

5. A section of pipe is removed from each end.

6. A 45° elbow and a piece of pipe are attached to the downstream end for discharging water and debris above ground level.

7. A tool is put in the upstream opening and run through the pipe.

8. After the tool is removed, the pipe is reconnected at the upstream end and water is run until clear. The pipe must then be drained and dried, and the lining done immediately.

9. The discharge pipe and elbow are removed, and the pipe reconnected. All divisional valves are opened. The sprinkler control valves are slowly opened (with the sprinkler drains open) and left open until water runs clear so that debris from the lead-ins is flushed from the sprinkler drains rather than entering overhead piping.

The hydraulic method uses water pressure to force the cleaning tool through the pipe. The tool consists of a series of overlapping steel blades and wire brushes mounted at the front end. A series of loosely fitting, flexible cups is mounted behind the cutters, and water pressure against them forces the assembly through the pipe.

Pipes 4 in. (100 mm) nominal diameter and larger can be cleaned by this method. Runs up to several thousand feet can be cleaned in one pass, and bends of 90° can be negotiated.

The procedure is to insert the cleaning tool at the upstream opening and reconnect the pipe using mechanical joints. The upstream valve is opened and pressure applied to push the tool through the main. The course and progress of the tool can usually be followed by sound. An appropriate method of cleaning the pipes should be chosen to minimize the impact on pipe components, such as pipe joints.

Another hydraulic method using a plastic sponge can be used to advantage in runs of pipe with many turns and fittings. This method removes softer deposits by propelling a bullet-shaped cylinder of polyurethane sponge through the pipe by water pressure. The sponges are available with various abrasive surfaces.

The rotating cutting tool method uses powered, rotating cutters or reamers, driven through a rotating, flexible spring-steel cable. This method is used where pipe deposits are too dense or hard for successful removal by the hydraulic method. Single runs are limited to about 300 ft (90 m) but complex piping layouts and 90° bends can be negotiated.

The cable-and-winch method is often used for relatively short runs of pipe where water pressure is too low or deposits too hard for the hydraulic method. The cleaning tool is pulled through the pipe by cable attached to a power winch.

3.1.8.2.3 Chemical Cleaning

Chemical methods of cleaning pipe use weak solutions of hydrochloric acid or other chemicals. These methods are most advantageous for complex piping layouts with many elbows.

The choice of chemicals depends on the nature of the scale. For example, inhibitors may be added to reduce reaction with the metal pipe. The solution may be circulated continuously through the pipe during cleaning or allowed to stand until cleaning is completed. Supplemental mechanical methods may be used.

3.1.8.3 Methods of Lining

Pipe lining is a method used to rehabilitate existing pipes and underground mains. The most common methods of pipe rehabilitation are:

- Centrifugally cast concrete pipe (CCCP)
- Cured-in-place pipe (CIPP)
- High-density polyethylene sliplining (HDPE)

For all methods, prior to starting any pipe rehabilitation or relining, the existing pipe is measured using a small camera to map the interior of the piping and the locations of any branch or tap lines.

The piping is then cleaned to remove any deposits or material before the relining operation commences.

Centrifugally cast concrete pipe (CCCP) is a type of spin-in-place pipe lining that uses a spinning head to apply thin coats of a cementitious material (e.g. Portland cement or Permacast mortar) to the inside of the pipe. These thin coasts may also contain other material such as fiber reinforcement and rust inhibitors to increase erosion resistance and prevent corrosion. The number of applied coats determines the thickness of the lining and is determined during the initial examination phase. This type of lining is typically seen in large concrete pipes and culverts.

Cure-In-Place Pipe (CIPP) uses an epoxy resin to line existing pipe and is the most common type of pipe rehabilitation seen today. After inspection, cleaning and measurement of the existing pipe, a special liner is prepared and soaked with epoxy resin. The resin-impregnated liner is then inserted or pulled into the existing pipe, in an inverted condition, positioning the resin between the liner and the existing internal pipe wall. A special bladder is then inserted into the liner and inflated, using air or water, pressing the epoxy resin against the internal surface of the existing pipe. The resin is then dried and cured using UV light, heat or steam Branch lines and taps can also be coated using this method. The lining is thin and smooth, therefore the flow in the newly relined pipe is not noticeably reduced and this method can be applied to pipes with a wide range of pipe diameters.

High-density polyethylene sliplining does not involve adding a new liner, but instead involves pulling a new polyethylene pipe inside the old existing pipe. Sections of piping are grouted together prior to being pulled into the existing piping. One disadvantage of this method is that the flow capacity of the pipe is noticeably reduced due to the addition of the HDPE pipe.

Because any relining operation will impact the internal properties of the pipe, a calculation of these impacts should be conducted. An example of this is seen when a pipe is relined using the CIPP epoxy resin. While the resin lining does reduce the internal diameter of the pipe, and thereby reducing the flow slightly, the new epoxy lining is smoother and therefore reduces the C-factor. This reduction on C-factor reduces frictional losses, with the overall effect being no real reduction in flows through the relined pipe.

Cured-in-place pipe (CIPP) and high-density polyethylene (HDPE) sliplining pipe rehabilitation systems are covered under FM Approval Standard 1616 Underground Pipe Rehabilitation Systems.

The products that have passed the requirements for Approval Standard 1616 are listed in the *Approval Guide* under the section: Automatic Sprinkler Systems / Pipe, Fittings and Pipe Joints for Underground Fire Service Mains / Underground Pipe Rehabilitation Systems.

As part of the Approval process, the rehabilitation system undergoes a series of tests to ensure its suitability for use in existing mains.

The tests conducted include:

- Determining the lining material is suitable for use within the existing main. This includes ensuring the liner is suitable for the defects seen and can withstand the water conditions (e.g., pH).
- Hydrostatic strength testing to ensure the rehabilitation system does not leak under the normal rated working pressures seen in the underground mains.
- A vacuum test to show the rehabilitation system can withstand the conditions that can occur when mains are drained for maintenance.
- A flow test to ensure the pipe liner does not detach from the existing pipe once it is in place.

3.1.9 Breakage of Underground Fire Service Mains

3.1.9.1 Reason for Breaks

Underground water mains may fail because of corrosion, external loading or water pressure surges (water hammer). Joints may separate as a result of inadequate anchorage at bends and tees. Manufacturing defects are rarely responsible, and defective pipes are usually detected by inspection prior to installation.

Excessive stresses in piping are caused by uneven movement or settlement in unstable soil, or by external loading from above. Such loading can be due to building walls and foundations, heavy floor loads, and vehicle or rail traffic.

Hydrostatic tests are frequently used to determine the condition of underground piping. The tests are made at 150 psi (1034 kPa, 10.3 bar) minimum pressure, but at least 50 psi (345 kPa, 3.5 bar) above the normal static pressure. Such tests merely indicate whether or not the yard system will withstand that pressure at that time, and do not necessarily indicate the system's true condition.

3.1.9.2 Investigating Breaks

Note: Figures 3.1.9.2.1-1 through 3.1.9.2.4-1 picture asbestos-cement pipe. Similar pipe failures are common with cast-iron and ductile-iron pipe.

3.1.9.2.1 Hydrostatic Failures

"Hydro breaks" occur when a complete section of pipe wall is blown off by internal pressure. Hydro breaks are of two types, low pressure and high pressure.

In a low pressure hydro break (Fig. 3.1.9.2.1-1) a section of pipe, starting at or near a coupling, is lifted out of the pipe wall. Invariably there is a crack running out to the end of the pipe.

Fig. 3.1.9.2.1-1. Examples of low pressure hydro breaks

Cause of failure is probably a crack in the pipe end caused by rough handling after hydrostatic testing at the pipe manufacturing plant. The crack is usually not severe enough to show up as a leak. When pressure is increased, or water hammer is encountered in the system, the weakened section blows out.

In a high pressure hydro break (Fig. 3.1.9.2.1-2) the break occurs in the center of the pipe, and has the appearance of resulting from an explosion. A section of the pipe will be lifted out of the barrel of the pipe. A crack out to the end of the pipe is possible.

Cause of failure is probably water hammer from air present in the pipe, in combination with high water pressure.

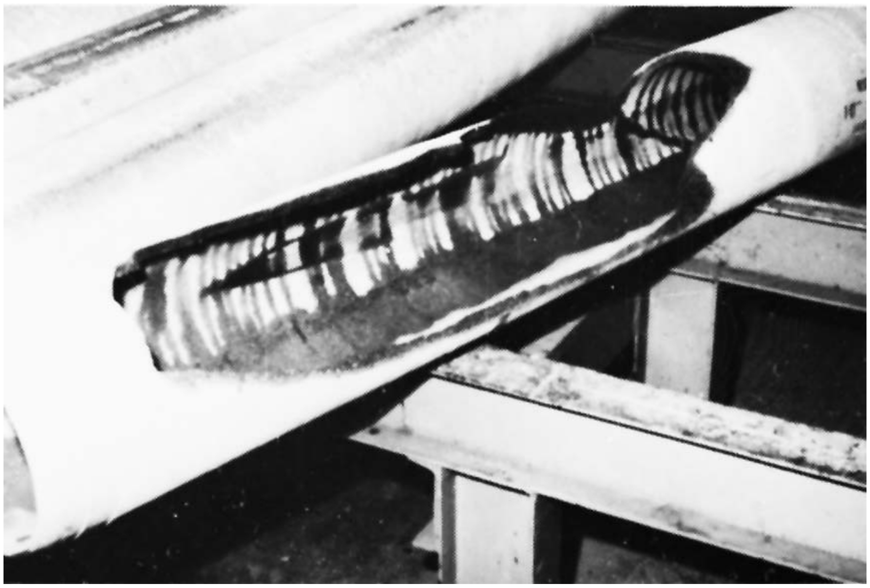


Fig. 3.1.9.2.1-2. High pressure hydro break

3.1.9.2.2 Crush Failure

Crush failure is characterized by a crack of the horizontal axis of the pipe usually down both sides. It is due to loads applied above the crush limits of the pipe. The excess loads can result from excessive depth of bury and/or live loads.

3.1.9.2.3 Shear Failure

Shear failure has the appearance of having been cut straight across the pipe diameter. It is common for pipe ends to be substantially offset in profile. Pipe ends, although straight, have rough and irregular surfaces and can be accompanied by a small lip and companion cavity.

The failure is caused by shear conditions that exceed the pipe strength. Often caused by pipe being laid on a trench bottom that goes from one type soil to another, e.g., hard stable trench bottom to soft yielding type of soil conditions. It also can be caused by hillside movement or slipping, as when a pipe section enters a structure without adequate flexibility provisions.

3.1.9.2.4 Flex Failure

Flex failure (Fig. 3.1.9.2.4-1) has the general appearance of having been cut straight across the pipe diameter similar to a shear failure, except that the pipe ends are not offset. Pipe ends are open on the top or bottom, thus indicting how the pipe was bent. For example, a rock under the crack would result in the top being open more than the bottom. The pipe ends have the same general appearance of those resulting from shear failure.

The failure is caused by the pipe having been forced to bend to the breaking point.

Fig. 3.1.9.2.4-1. Flex failure. Break offset to show crack

3.1.9.2.5 Corrosion

Corrosion of pipes is the deterioration of pipe material due to a reaction with the environment. Three general types of corrosion are recognized: galvanic, electrolytic and biological. Soil corrosion or metallurgical investigations may be required to determine the cause and type of corrosion.

3.1.9.3 Repairing Breaks

Breaks in underground mains may be repaired quickly by bolting split sleeves. Long breaks, however, may require replacement of the pipe. For short or cirumferential breaks, special saddles and clamps are available.

3.1.10 Investigating Breakage of Underground Fire Service Mains

3.1.10.1 The following steps are recommended in investigating breaks:

1. Determine the type and class of the pipe.

2. Determine the faulty condition or combination of conditions that caused the break.

3. When corrosion is a factor, arrange to have parts of the yard system uncovered to determine the extent of the corrosion. If it has not advanced to a dangerous degree, the pipe may be protected by coating and wrapping. It is recommended that cinder fill, one of the most common causes of pipe corrosion, should be removed and replaced with clean soil, or the main should be relocated. Take whatever other steps are necessary to discover and correct the cause if the corrosion is excessive.

4. If hydrostatic tests are to be made, section the mains by shutting division valves and apply the pressure through small connections around the shut valves. With this procedure, failure of a main under test will cause only minor discharge and prevent the excessive damage that might occur if fire pump pressure were applied to an entire system through larger sized valves. As an alternative, a small pump may be used. Take particular care when testing mains located under plant buildings.

5. Where pipes under buildings are in poor condition and require replacement, locate the new pipes in the yard away from foundations and other structures, or indoors in a trench.

6. If excessive pressure surging (water hammer) is suspected as the cause of the breaks, try to discover the source and take steps to eliminate or minimize the effects, as achieved through the installation of anti-water hammer check valves or suitable pressure relief valves. Ridding the system of air, by flowing water, may reduce the occurrence of water hammer.

3.1.11 Leakage From Underground Fire Service Mains

3.1.11.1 General

Unusually large water bills, loss of water from a gravity tank or frequent automatic fire pump start-ups usually indicate leaks in underground fire service mains.

3.1.11.1.1 Determine that there is no obvious leakage through sprinkler drain valves or hydrants, no tank overflows, nor any backup through pump suction lines. Make sure that the unaccounted water from the fire service system is not being used for industrial purposes.

3.1.11.2 Locating Leaks

3.1.11.2.1 In attempting to locate leaks, study the location and arrangement of the underground mains shown on the original plans. Look for surface depressions in driveways or railroad sidings where mains cross. Unusual surface loadings or heavy vehicle traffic occasionally causes yard mains to settle with resultant joint leakage or cracks. Clumps of grass that are taller than surrounding growth are sometimes a sign of water leakage. Inadequate anchorage at dead ends and blow-off connections are often the source of leaks. Look for signs of moisture where mains pass under or through building foundations.

3.1.11.2.2 Isolate the leak systematically by closing divisional and sprinkler-riser control valves, and by noting whether the pressure at sprinkler-riser gauges or hydrants remains constant. Any unusual drops in pressure on gauges will indicate that the leak is within the closed off section of the yard main. If the rate of leakage is abnormal, the leak can usually be located by one of the following methods:

1. Listening device. After the leak has been isolated in one pipe or section, it can often be found by using a listening device. Listening involves the use of sound-intensifying equipment in a systematic fashion to locate leaks. When escaping through a pipe wall, all leaks lose energy to the wall and the surrounding area, and the energy is then converted to audible sound waves. These sound waves can be picked up by sensitive instruments and amplified so the user can hear them. In the hands of an experienced operator these instruments can help locate a leak with remarkable accuracy.

Sound-intensifying equipment in common use today is either mechanical or electronic. The two most widely used mechanical devices are the aquaphone and the geophone. The aquaphone resembles an old-fashioned telephone receiver with a metal spike protruding where the telephone wire would go. The listening end of the geophone looks like a doctor’s stethoscope but the listening tubes are connected to two diaphragms, which give the operator the desired “stereo” effect to indicate the direction of the leak.

The listening device should preferably be used when the plant is shut down and all is quiet. Leaks are common in hydrants and stuffing boxes of indicator post gate valves, so listen at these points first. Leaks in underground pipes in swampy or porous fill, or where sewers or other pipes run nearby, are difficult to locate with listening devices.

2. Rods. Leakage from yard mains can sometimes be located by driving rods through the soil along the run of main where the leak is suspected, and listening at the exposed end of the rods. The sound of escaping water will increase as the point of leakage is approached. Note whether the rod is wet when withdrawn and whether it drives easily when nearing pipe depth.

3. Electronic instruments. Electronic instruments are more delicate, yet are capable of filtering out unwanted background noise. They need a power source and require more care in handling and storing than the mechanical instruments. All the newer devices can be easily carried by the operator. One system is hooked up to an electronic console and housed in a truck or “mobile” laboratory.

3.1.11.2.3 Rate of leakage can be determined by one of the following recommended methods:

1. Meter readings. Measure all water delivered to the section under test by reading the meter (if any) on the public water connection or by using a small domestic water meter attached to a hydrant. Any draft of mill-use water through connections to the yard system will usually be detected by an irregular meter reading. If a booster pump maintains pressure on the fire system, operate it and use the small meter to obtain the rate of leakage.

Figure 3.1.11.2.3-1 shows a water meter attached to a hydrant. The meter is used to measure all water delivered to the test section.

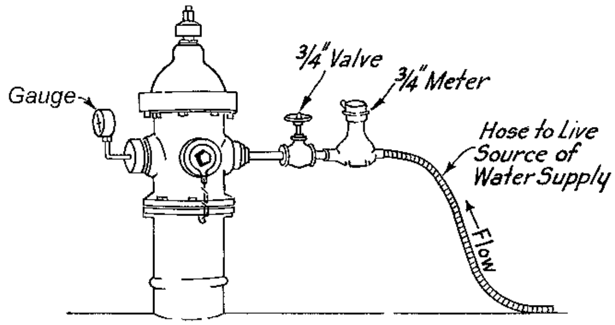


Fig. 3.1.11.2.3-1. Metering method of leak detection

2. Drop in water level. Measure the drop in level in a gravity tank. If the fire service system is also supplied by one or more connections to public water, close the control valves in these connections during measurements so that all water flowing to leakage will come from the gravity tank.

3.1.12 Maintenance

3.1.12.1 Maintenance of Single Check Valves

Single check valves on public water connections to private fire systems need internal inspection and cleaning at least once every five years.

Check valves in poor condition may remain partly open and leak. Any fluctuations in pressure in the public main would then cause similar variations of pressure within the plant system, resulting in false waterflow alarms.

Occasionally, it is necessary to shut off public mains for repairs or changes, and sometimes public water pressure is reduced by heavy drafts or breaks in mains. In systems where public water and gravity tank pressures are about the same, or where the public water pressure is less, good check valve maintenance is especially needed to safeguard the tank supply.

When fire department pumper connections provide the only supplementary water supply, regular internal examination and cleaning of the check valves is essential so that pressure added by the fire department pump is not lost by leaking check valves.

The modern, Approved check valve is well designed but needs periodic attention. The body is of iron, and enough tubercles may build up on the interior of the valve to interfere with the free movement of the clapper and clapper arm or prevent tightness of the clapper seat.

3.1.12.2 Maintenance of Double Check Valves and Reduced Pressure Backflow Preventers

Details of testing and maintenance of double check valves, and of testing of reduced pressure backflow preventers are given in Data Sheet 3-3, Cross Connections. Maintain reduced pressure backflow preventers according to the manufacturer’s instructions.

3.1.12.3 Maintenance of Manually Operated Valves

Yearly, all valves should be operated to full travel of their mechanism to make sure they can be operated easily when necessary. Records should be maintained of the number of turns required to operate each valve from the fully open to the fully shut position. This is valuable later in determining whether a valve has jammed partially open.

3.1.12.4 Maintenance of Hydrants

To ensure that a hydrant will work correctly when it is needed, a periodic testing and maintenance program should be followed. AWWA Manual M17, Installation, Field Testing, and Maintenance of Fire Hydrants, outlines various points to check, lubrication repairs and record keeping procedures to carry out a meaningful inspection. Hydrants should be inspected yearly, and in locations of freezing climates, two inspections per year may be appropriate.

3.1.12.5 Maintenance of Fire Hose for Use Outdoors

Mildew may attack untreated hose fabric containing cotton or linen if the hose is stored in a damp location or not thoroughly dried after wetting. Fire hose is available with chemically treated fabric for protection against mildew and rot. Treated jackets also absorb less water and, therefore, dry more quickly. The resistance to dampness and mildew is not 100% effective even when the treatment is new, and it deteriorates with age.

It is just as important to carefully dry hose with jackets made from a combination of cotton and synthetic yarns.

4.0 REFERENCES

4.1 FM Global

Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-81, *Fire Safety Inspections and Sprinkler System Maintenance*
Data Sheet 3-0, *Hydraulics of Fire Protection Systems*
Data Sheet 3-2, *Water Tanks for Fire Protection*
Data Sheet 3-3, *Cross Connections*
Data Sheet 3-11, *Flow and Pressure Regulating Devices for Fire Protection Service*
Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*

FM Approvals *Approval Guide*

4.2 NFPA Standards

NFPA 24, *Installation of Private Fire Service Mains and Their Appurtenances.*

NFPA 1962, *Care, Use and Service Testing of Fire Hose Including Connections and Nozzles.*

4.3 Others

ANSI/AWWA C101/A21.1, *American Standard Practice—Manual for the Computation of Strength and Thickness of Cast Iron Pipe* (Standard withdrawn in 1982).

ANSI/AWWA C104/A21.4, *American National Standard for Cement Mortar Lining for Cast Iron Pipe and Fittings for Water.*

ANSI/AWWA C105/A21.5, *American National Standard for Polyethylene Encasement for Gray and Ductile Cast Iron Piping for Water and Other Liquids.*

ANSI/AWWA C106/A21.6, *American National Standard for Cast Iron Pipe Centrifugally Cast in Metal Models, for Water or Other Liquids* (Standard withdrawn in 1982).

ANSI/AWWA C108/A21.8, *American National Standard for Cast Iron Pipe Centrifugally Cast in Sand-Lined Molds, for Water or Other Liquids* (Standard withdrawn in 1979).

ANSI/AWWA C110/A21.10, *American National Standard for Gray Iron and Ductile Iron Fittings, 2 in. through 48 in., for Water and Other Liquids.*

ANSI/AWWA C150/A21.50, *American National Standard for the Thickness Design of Ductile Iron Pipe.*

ANSI/AWWA C151/A21.51, *American National Standard for Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.*

ANSI/ASTM A-333, *Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service.*

ANSI/AWWA C200, *AWWA Standard for Steel Water Pipe 6 in. and Larger.*

ANSI/AWWA C203, *AWWA Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.*

ANSI/AWWA C205, *AWWA Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe—4 in. and Larger—Shop Applied.*

ANSI/AWWA C206, *AWWA Standard for Field Welding of Steel Water Pipe.*

ANSI/AWWA C400, *AWWA Standard for Asbestos-Cement Distribution Pipe, 4 in. through 16 in. (100 mm through 400 mm), for Water and Other Liquids.*

ANSI/AWWA C600, *AWWA Standard for the Installation of Ductile-Iron Water Mains and Their Appurtenances.*

ANSI/AWWA C603, *AWWA Standard for the Installation of Asbestos Cement Pressure Pipe.*

AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water and Other Liquids.*

AWWA Manual M6, *Water Meters-Selection, Installation, Testing and Maintenance.*

AWWA Manual M17, *Installation, Field Testing and Maintenance of Fire Hydrants.*

AWWA Manual M11, *Steel Pipe—A guide for Design and Installation.*

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

ANSI/ASME A112.26.1, *Water Hammer Arresters.*

Cast Iron Pipe News, Fall 1975, *Thrust Restraint for Underground Piping Systems*, Carlson, R.J.

Ductile Iron Pipe Research Institute, Second Edition 1989, *Thrust Restraint Design for Ductile Iron Pipe.*

APPENDIX A GLOSSARY OF TERMS

FM Approved: Product and services that have satisfied the criteria for FM Approval. Refer to the *Approval Guide*, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Refer to Section 3.0, *Support for Recommendations* for descriptions of system components.

APPENDIX B DOCUMENT REVISION HISTORY

January 2022. Interim revision. The following significant changes were made:

A. Added Section 2.1 on using FM Approved equipment and services. Removed all subsequent redundant iterations of this language in the document.

B. Added guidance for the new FM Approved pipe rehabilitation system in Section 2.0.

C. Updated explanatory text on pipe rehabilitation systems in Section 3.0 to support the new Section 2.0 guidance on FM Approved pipe rehabilitation systems.

D. Updated guidance on thrust block areas in Table 2.

E. Relocated information on leak detection methods and equipment to Section 3.0. This material contains no recommendations.

F. Replaced unreadable figures in the document.

G. Updated references and terminology to current FM Global and FM Approval brand assurance standards.

September 2000. Reorganized to provide a consistent format.

June 1992. First issued.

APPENDIX C UNDERGROUND MAIN INSTALLATION CHECKLIST

The following checklist is designed to allow on-site checks during actual underground installations. The items that are included in the checklist are those that are often performed poorly, leading to underground breaks, leaks and impairments to the fire protection system. It is assumed that before underground main installation begins, plans have been reviewed and accepted to ensure that all aspects of design and material selection are in accordance with requirements.

The purpose of the checklist is to allow a person to ensure that the actual physical installation of the underground mains is done in a proper manner. Any problems that are identified during the actual installation should be corrected immediately, or work should be suspended until corrections are made. Since problems are far less likely to be recognized or resolved after the trench has been back filled, the importance of a corrective resolution to problems cannot be overemphasized.

Checklist

This checklist is designed to allow an on-site person to witness an underground main installation, and easily determine whether important installation practices are being followed. The checklist is divided into three parts: 1) Trench Preparation, 2) Pipe Installation, and 3) Acceptance Testing. It is assumed that all details of design and materials selection have previously been reviewed and accepted. References to sections or figures pertain to this data sheet.

C.1 Trench Preparation

C.1.1 Compare, by measurement, the actual versus specified depth of trench when trench is dug.

Actual depth of trench is ________ ft (________ m).

Specified depth of trench is ________ ft (________ m).

(Check one)

_____ Actual depth is greater than or equal to specified depth— *work may continue,* go to item C.1.2.

_____ Actual depth is less than specified depth— *stop,* and make sure correct depth is provided.

Comment: If bury depth is inadequate, water in the pipe may freeze during the winter, impairing protection and causing pipe breakage.

C.1.2 Confirm, by inspection, that the trench contains clean fill only.

Important: Laying pipe on any material other than clean fill may cause pipe breakage or pipe decay after the trench is back filled!

(Check one)

_____ Trench contains *only* clean fill— *work may continue.*

_____ Trench contains materials other than clean fill— *correct as follows:*

If the Trench Bed Contains	*And:*	*Then:*
Rocks, boulders *or* any exposed rock surface	They cannot be removed	Construct a foundation for the pipe using suitable material.
	They can be removed	Remove all rocks, etc. to provide a clearance at least 6 in. (152 mm) below and on each side of all pipe, valves and fittings. Replace removed material with a bed of sand, crushed stone or earth that is free from stones, large clods or frozen earth, on the bottom of the trench to a minimum depth of 6 in. (152 mm) level and tamp the bedding material.
Unstable material	Which cannot be removed	Construct a foundation for the pipe using suitable material
	It can be removed	Remove unstable material and replace it with clean stable backfill material.
Ash, cinders, refuse or other organic material	It cannot be removed and it is unstable:	Construct a foundation for the pipe using suitable material and protect the pipe against corrosion
	It can be removed	Remove material to a minimum of at least 3 in. (76 mm) below intended pipe elevation and replace with clean, stable backfill material.

C.2 Pipe Installation and Testing

C.2.1 Pipe Material

Check that the type of pipe being used is the same as that specified on plans.

(Check one)

_____ Pipe material is the same; *go to C.2.2.*

_____ Pipe material is not the same; *stop and determine why.*

C.2.2 Pipe Joints

Make sure all joints between pipe, valves and fittings are properly installed in the manner required for the type of pipe being used.

(Check one)

_____ All joints are proper for the type of pipe being used; go to C.2.3.

_____ All joints are not proper for the type of pipe being used— *stop and resolve.*

C.2.3 Pipe Restraint

Generally, restraining is required at all bends, tees, plugs and hydrant lines, unless Approved devices specifically designed for this purpose are used

(Check one)

_____ Pipe restraint *is provided at all bends, tees, plugs and hydrants;* go to C.2.4.

_____ Pipe restraint *is not provided at all bends, tees, plugs and hydrants— stop and determine* if other means are used to eliminate the need for pipe restraint. *If so, continue. If not, stop and resolve.*

C.2.4 Corrosion Protection

Corrosion protection is needed for pipe restraining devices (such as rods, nuts, bolts, washers, clamps and for iron or steel pipe. Corrosion may occur when corrosive soil conditions exist or when galvanic action occurs due to stray electrical currents.

(Answer ''Yes'' or ''No'')

_____ All rods, nuts, bolts, washers, clamps and other restraining devices (except thrust blocks) have been cleaned and thoroughly coated with a bituminous or other acceptable corrosion-retarding material.

If Yes, continue.

If No, stop, and ensure that proper corrosion protection is provided.

(Answer ''Yes'' or ''No'')

_____ Suitable pipe materials are used, or proper corrosion protection is provided for iron or steel pipe based on the corrosiveness of the soil.

If Yes, continue.

If No, stop and ensure that proper corrosion protection is provided.

(Answer ''Yes'' or ''Does Not Apply'')

_____ Suitable protection is provided against galvanic corrosion to ferrous pipe materials due to stray electrical currents.

If Yes or Does Not Apply, continue to C.2.5.

If No, stop and ensure that proper corrosion protection is provided.

C.2.5 Hydrostatic Leakage Testing

Hydrostatic leakage testing ensures that all joints are tight, and that pipe and fittings are not defective. Partially backfill over pipe before testing in accordance with test guidelines.

(Answer ''Yes'' or ''No'')

_____ Hydrostatic testing indicates that the amount of leakage does not exceed that allowable.

If Yes, continue to C.2.6.

If No, stop, correct deficiencies, and re-test.

C.2.6 Backfilling

Backfilling using suitable fill material to the correct depth to prevent freezing will help ensure suitable long term underground main performance.

(Answer ‘‘Yes’’ or ‘‘No’’)

_____ Suitable fill material is used for backfilling.

If Yes, continue to C.2.6.1.

If No, stop and make sure suitable fill material is used.

(Answer ‘‘Yes’’ or ‘‘No’’)

C.2.6.1 Depth of Backfill

_____ Depth of backfill is sufficient for freeze protection for the geographic location involved.

If Yes, continue to C.2.7.

If No, stop and make sure that pipe is buried to the proper depth.

C.2.7 Flushing

Make sure that proper flushing of all underground piping is conducted to ensure that foreign materials are removed.

(Answer ‘‘Yes’’ or ‘‘No’’)

_____ Flushing completed per accepted practices.

If Yes, continue to C.3.

If No, make sure flushing is completed and foreign materials are removed.

C.3 Acceptance Testing and Documentation

C.3.1 Contractor’s material and test certificate for underground piping. Make sure that the certificate is completely filled out, that the results indicated on the certificate agree with the actual results obtained, and that the certificate is signed and dated by a suitable person.

(Answer ‘‘Yes’’ or ‘‘No’’)

_____ Certificate properly prepared and signed.

If Yes, stop.

If No, make sure certificate is completed and signed.