CHAPTER 5

DISTRIBUTION SYSTEM EQUIPMENT

5-1. Valves. The types of valves most frequently used in water distribution are gate, butterfly, ball, plug, globe, and check valves. Valves of the 150 psi class should be the minimum pressure class considered. Applications of the various types of valves and the standards to be used for these valves are given in table 5-1. All valves should have the direction to open shown on their operators.

Table 5-1. Valve Applications

Type	Applications	Sizes to be Used (diameter, inches)
Gate	Sectionalizing distribution mains. Isolating fire-hydrant branches.	3 or larger
Butterfly, rubber seated	Mains with water pressures less than 150 psi	3 or larger
Ball	Applications involving throttling or frequent operation. Water service lines.	6 or less*
Plug	Applications involving throttling or frequent operation. Water service lines.	6 or less
Globe	Throttling operations. Water service lines.	2 or less

*Ball valves larger than 6 inches may be used if gate valves or butterfly valves are not available.

a. Gate valves. Gate valves may have either a single solid wedge gate or double disc. Solid wedge gates are satisfactory in sizes up to 6 inches, but double disc gates should be used for larger sizes. Because of the excessive wear and leakage of the gates and seats which may result, gate valves should not be used where frequent operation is required. If gate valves are left open for long periods, debris may accumulate in the seat and prevent complete closure, but if left closed for long periods, deposits may prevent opening. Gate valves should be operated periodically to break loose any deposits which might have formed. Large gate valves should be geared to make operation easier.

b. Butterfly valves. The advantages of butterfly valves include easy operation, small space requirement, low cost, minimum maintenance, low head loss, driptight shutoff, suitability for throttling, and reliability. A disadvantage is that main cleaning and lining equipment cannot be used in lines containing butterfly valves without removing the valves. Mechanical valve operators will be designed to restrict the rate of closure so that water hammer will not occur in the system on which the valve is installed.

c. Ball valves. Ball valves have the advantage of ease of operation, reliability, durability, and capability of withstanding high pressures, but they are usually expensive.

d. Plug valves. Lubricated and eccentric plug valves are the types of plug valves commonly used. Lubricated plug valves normally have a cylindrical or tapered plug, intersecting the flow, with a rectangular port opening. Round ports can be obtained in the smaller sizes. Specially formulated greases are used both for lubrication and sealing of lubricated plug valves. When operated periodically, these valves are relatively easy to operate and provide a tight shutoff, but the plugs may freeze if not operated for a long period of time. Plug valves are especially good for high pressure applications. Eccentric plug valves are preferable to lubricated plug valves because of greater ease of operation and reduced maintenance requirements; eccentric plug valves are also less prone to freeze. Ball and plug valves will not be used on buried pipelines, except when installed in a valve pit. The basic application for the eccentric plug valves is normally on small service lines.

e. Globe valves. Globe valves are particularly well suited to throttling operations, and most plumbing fixtures are normally equipped with these valves. Small globe valves normally have rubber discs and metal seats to provide driptight shutoff, but special discs and seats are available for more severe conditions and may be used on water service lines 2 inches or less in diameter.

f. Check valves. Any valve used to prevent the reversal of flow is considered a check valve. Most check valves are equipped with plugs or hinged discs which close flow openings when flow is reversed. Rapid and complete valve closing is often insured by the addition of special weights or springs to the plugs or discs. A newer type of check valve has spring-loaded, wafer-style, semicircular plates mounted on a vertical pivot through a flow reversal. This wafer-style check valve has the disadvantage of producing relatively high head losses and of showing excessive wear under some operating conditions.

g. Air release and vacuum relief valves. Air release valves are required to evacuate air from the main at high points in the line when it is filled with water and to allow the discharge of air accumulated under pressure. Excess air allowed to accumulate at high points creates a resistance to flow, and an increase in pumping power requirements results. Vacuum relief valves are needed to permit air to enter a line when it is being emptied of water or subjected to vacuum. Special valves are available to perform either or both of these functions. Air release and vacuum relief valves should be installed at high points in the line or where a long line changes slope.

h. Valve location.

(1) Shutoff valves. The purpose of installing shutoff valves in water mains at various locations within the distribution system is to allow sections of the system to be taken out of service for repairs or maintenance without significantly curtailing service over large areas. Valves should be installed at intervals not greater than 5,000 feet in long supply lines and 2,400 feet in main distribution loops or feeders. All branch mains connecting to feeder mains or feeder loops should be valved as closely to the feeders as practicable so that the branch mains can be taken out of service without interrupting the supply to other locations. In the areas of greatest water demand, or where the dependability of the distribution system is particularly important, maximum valve spacings of 1,000 feet may be appropriate. At intersections of distribution mains, the number of valves required will normally be one less than the number of radiating mains; the one valve will be omitted from the line which principally supplies flow to the intersection. Valves are not usually installed on branches serving fire hydrants on Army installations. As far as practicable, shutoff valves should be installed in standardized locations (e.g., the northeast corner of intersections or a certain distance from the centerline of streets) so they can easily be found in emergencies. For large shutoff valves (approximately 30-inch diameter and larger), it may be necessary to surround the valve operator or entire valve with a vault to allow for repair or replacement. In important installations and for deep pipe cover, pipe entrance access manholes should be provided so that valve internal parts can be serviced. If valve vaults or access manholes are not provided, all buried valves, regardless of size, should be installed with special valve boxes over the operating nut in order to permit operation from ground level by the insertion of a special long wrench into the box.

(2) Blowoff valves. Blowoff valves or fire hydrants should be installed at the ends of dead-end mains to allow periodic flushing of the mains. However, if time and materials become critically short, these valves may be deleted. Primary feeder mains and larger distribution mains should have a blowoff valve in each valved section which should be installed at low points in the mains where the flushing water can be readily discharged to natural drainage channels. Blowoff valves should be designed so that operation will not result in erosion. Special care must be taken to eliminate the possibility of contaminated water entering the distribution system through blowoff valves which have not been tightly closed.

5-2. Fire hydrants.

a. Dry- and wet-barrel hydrants. The most common types of fire hydrants are the dry- and wet-barrel varieties. They are similar in configuration and operation, but in the dry-barrel hydrant, provision is made for draining water from the barrel after the hydrant is shut off. This is normally accomplished by gravity drainage through special drain outlets in the base or barrel of the fire hydrant. Wet-barrel hydrants can be used in areas where the temperature is always above freezing.

b. Safety hydrants. Barrel-type hydrants extending aboveground are available in models which can be damaged by automobiles or trucks without disturbing the main valve. These are the "safety" or "traffic" fire hydrants and should be used near heavily traveled roads or intersections where adequate protection of the hydrant cannot be provided.

c. Flush-top hydrants. In cases where the barrel-type aboveground hydrant would interfere with necessary traffic, a flush-top hydrant can be utilized. In this type of hydrant, the operating nut and hose nozzles are located in a cast-iron box below ground level. The top of the box has a horizontal lid which is flush with the adjacent ground surface. However, flush-top hydrants are more difficult to locate than barrel-type hydrants, especially in areas subject to heavy snows, and once located are awkward to uncover and put into operation. Barrel-type hydrants are preferable to flush-top hydrants. Hydrants of all types should have the direction to open shown on their operators.

d. Hydrant nozzles. Nozzles on fire hydrants are either 2-1/2 or 4-1/2 inches in diameter. The 2-1/2 inch nozzle is for direct connection to fire hoses and the 4-1/2 inch nozzle is for use with mobile fire pumper units. Unless unusual conditions dictate otherwise, hydrants with two fire hose nozzles and one pumper should be used. The outlet nozzles on most hydrants are located at 90-degree angles to each other. The pumper outlet should normally face the street or intersection, and the two fire hose nozzles should face opposite directions, 90 degrees from the pumper nozzle. Hydrants with either more or less than three nozzles should be alined so that the nozzles are readily accessible from the street.

e. Hydrant spacing.

(1) General. Hydrant distributions will conform to the standards shown in table 5-2 and as demonstrated in appendix B.

(2) Troop housing areas. The preferred location for fire hydrants in troop housing areas is at street intersections. Where additional hydrants are required because of the above hydrant distributions, these additional hydrants will normally be located

adjacent to streets approximately halfway between intersections. Each unit will have at least one hydrant within 300 feet and a second hydrant within 500 feet.

Table 5-2. Hydrant Distribution

Required Fire Flow, gpm	Average Area per Hydrant, square feet
1,000 or less	160,000
1,500	150,000
2,000	140,000
2,500	130,000
3,000	120,000
3,500	110,000
4,000	100,000
4,500	95,000
5,000	90,000
5,500	85,000
6,000	80,000
6,500	75,000
7,000	70,000
7,500	65,000
8,000	60,000
8,500	57,500
9,000	55,000
10,000	50,000
11,000	45,000
12,000	40,000

(3) Airfields. For airfield hangar areas, hydrants will be spaced approximately 300 feet apart and where economically feasible will be connected to the base distribution system and not to the special system serving deluge sprinkler systems in the hangars. At double cantilever hangar areas, hydrants will be connected only to the base water distribution system. For aircraft fueling, mass parking, servicing, and maintenance areas, the fire hydrants will be installed along the edge of aircraft parking and servicing aprons. Hydrants will be spaced approximately 300 feet apart, and hose will be provided in sufficient length so that every part of the apron may be reached by approximately 500 feet of hose. One or more hydrants will be located within 300 feet of all operational service points.

(4) Remote fuel storage areas. Army fuel storage facilities that are remotely located with relation to the public or post water systems will generally not have fire hydrant protection. However, where the facility is of a critical nature or is of a high strategic or monetary value that would justify some degree of fire protection and the materials are available, fire hydrants will be installed.

f. Hydrant location.

(1) Proper clearance should be maintained between hydrants and poles, buildings, or other obstructions so that hose lines can be readily attached and extended. Generally, hydrants will be located at least 50 feet from the buildings protected, and in no case will hydrants be located closer than 25 feet to a building except where building walls are blank fire walls.

(2) Street intersections are usually the best locations for fire hydrants because fire hoses can then be laid along any of the radiating streets. However, the likelihood of vehicular damage to hydrants is greatest at intersections, so the hydrants must be carefully located to reduce the possibility of damage. Hydrants should not be located less than 6 feet from the edge of a paved roadway surface, nor more than 7 feet. If hydrants are located more than 7 feet from the edge of the paved roadway surface and if the shoulders are such that the pumper cannot be placed within 7 feet of the hydrant, consideration may be given to stabilizing or surfacing a portion of wide shoulders adjacent to hydrants to permit the connection of the hydrant and pumper with a single 10-foot length of suction hose. In exceptional circumstances, it may not be practical to meet these criteria, and hydrants may be located to permit connection to the pumper using two lengths of suction hose (a distance not to exceed 16 feet).

(3) Hydrants should not be placed closer than 3 feet to any obstruction nor in front of any entranceways. The center of the lower outlet should not be less than 18 inches above the surrounding grade, and the operating nut should not be more than 4 feet above the surrounding grade.

(4) In aircraft fueling, mass parking, servicing, and maintenance areas, the tops of hydrants will not be higher than 24 inches above the ground with the center of lowest outlet not less than 18 inches above the ground. The pumper nozzle will face the nearest roadway.

g. Hydrant installation. Many problems of hydrant operation and maintenance can be avoided if the hydrant is properly installed. All hydrants should be installed on firm footings such as stone slabs or concrete bases to prevent settling and strains on line joints. Separation of the pipe joints in the elbow beneath the hydrant is sometimes a problem because of forces created by the water pressure across the joint through the elbow. This problem can be alleviated by placing thrust blocks between the elbow and supporting undisturbed soil or by tying the joint.

h. Hydrant markings. All hydrants at Army mobilization facilities will be marked in accordance with NFPA 291.

5-3. Water pipe materials. Water distribution pipes are available in a variety of materials. Those most commonly used, and most suitable for use at Army installations, are asbestos-cement, ductile iron, reinforced concrete, steel, and plastic. All water mains and service lines should be designed for a minimum normal internal working pressure of 150 psi plus appropriate allowances for water hammer. Internal working pressure as well as external stresses due to earthfill and superimposed loadings will be calculated in accordance with the applicable standards of the American Water Works Association for each kind of pipe.

a. Selection of materials. In selecting the material to be used for a particular application, the following items should be considered:

(1) Availability of the material and its ability to be delivered within the time frame allotted.

(2) Ability to withstand maximum anticipated internal pressures and external loads or the most severe combination thereof.

(3) Ease of installation. This involves the unit weight of the pipe, type of joints used, type of bedding required, and whether or not thrust blocking is required.

(4) Resistance to external and internal corrosion.

(5) Joint tightness.

(6) Durability.

(7) Ease of tapping for service connections.

(8) Cost.

b. Types of materials.

(1) Asbestos-cement pipe.

(a) This pipe is usually unaffected by aggressive soil conditions and is installed in many locations where unprotected ductile-iron or steel pipe would suffer excessive corrosion. Standard lengths of asbestos-cement pipe are 13 feet for pipe 8 inches or larger in diameter and either 10 or 13 feet for pipe 4 or 6 inches in diameter. The three classes of asbestos-cement pipe are: Class 100, Class 150, and Class 200 for pipe 4 inches through 16 inches and Class 30, Class 35, Class 40, etc. for pipe 18 inches through 42 inches. These refer to the maximum anticipated internal working pressure, not including sudden surges, to which the pipe is to be subjected. A factor of safety of 4.0 has been used in the design and manufacture of these pipes. They should theoretically be capable of withstanding internal bursting pressures of at least 400 psi (Class 100), 600 psi (Class 150), and 800 psi (Class 200). Techniques for evaluating both internal and external loads are given in AWWA C401. External loads include both weight of the backfill supported by the pipe and the weight of superimposed loads, static or dynamic, on the pipe. A factor of safety of 2.5 is used in designing for external loads. Asbestos-cement pipe is not readily available in sizes greater than 24 inches so its use should be restricted to smaller distribution lines.

(b) Asbestos-cement pipe is also grouped into two categories according to the percentage of uncombined calcium hydroxide in the pipe. Type I has no limit on the uncombined calcium hydroxide; Type II has 1.0 percent or less. Inasmuch as the uncombined calcium hydroxide may be leached from the walls of a pipe, thereby reducing the strength of the pipe, Type II pipe will be considered in all mobilization construction, but when supplies become short, an allowance for Type I should be made.

(c) Fittings and specials are not made of asbestos-cement for pressure pipe so other types of materials must be used. The recommended material is cast iron, but adapters must be used to make a correct fit. Information on the details for fittings and specials should be sought from the pipe manufacturer.

(d) Couplings for asbestos-cement pipe usually come with the pipe. They are of the slip-on variety and come with rubber gaskets. Curves and bends in this type water line can be made by deflecting the joints. However, joint deflection should not exceed manufacturer's recommendations.

(e) Installation of asbestos-cement pipe will be in accordance with the provisions of AWWA C603. Tapping of asbestos-cement pipe can be achieved by the following methods:

- Employing a special coupling with a brass insert. This is usually factory installed.

- Directly tapping the pipe, similar to ductile iron pipe.

- Strapping on a tapping saddle.

(2) Ductile iron pipe.

(a) Ductile iron pipe of equivalent thickness is stronger, tougher, and more durable than other kinds of water pipe. The prescribed method of determining the required thickness of ductile iron pipe is given in AWWA C150. Ductile iron is preferred in situations where some pipe deflection may occur, such as in earthquake-prone areas or in soil conditions where settling of the pipe may occur.

(b) Ductile-iron pipes are frequently lined with coal-tar enamel or cement mortar to reduce corrosion of interior surfaces. Cleaning and lining of corroded ductile-iron pipe can substantially reduce the head losses in the pipe; pipeline cleaning without lining is not permitted unless the line has been relegated to short term duty (less than 1 year) and will be abandoned.

(c) Fittings and specials for ductile-iron pipe must be suitable for the pressure ranges anticipated. The occurrence of water main failure is most probable at fittings' and specials' joints, so particular attention must be given to restraining them.

(d) Joints available for ductile iron pipe include the push-on, mechanical joint and flanged types. Push-on type joints are preferable in most situations because of ease of installation. Mechanical joints are desirable where a more positive type water seal is required. Flanged connections are usually employed in open areas such as meter pits or plants and are seldom used in buried areas.

(e) Methods for tapping ductile-iron pipe include integral tapping bosses, tapping saddles, direct bore and thread taps, and actual insertion of a tee into a water main. Methods are available which allow tapping under pressure with relative ease.

(3) Concrete pipe. Concrete pipe is strong, durable, corrosion-resistant, and has a smooth interior which allows high flow velocities with minimal head losses. Concrete pipe should be used for larger sized mains (greater than 24 inches) for cost-effectiveness, material savings, and relative ease of installation.

(a) The type of concrete pipe to be considered for mobilization work is prestressed concrete cylinder pipe. There are two types of prestressed concrete cylinder pipe available. They are the lined-cylinder type with concrete cast inside the steel cylinder, wire wrapped under tension around the steel cylinder, and a concrete or mortar covering over the wire and cylinder; and the embedded-cylinder type with the steel cylinder encased in concrete, wire wrapped on the outer concrete surface, and the wire covered with a coating of cement or mortar. Both types are characterized by high strength and relatively light weight as compared to other kinds of concrete pipe. The lined-cylinder type is used for pressures up to 250 psi and the embedded-cylinder type for pressures up to 350 psi. Diameters of the pipe range from 16 to 48 inches for the lined-cylinder type and from 24 to 144 inches for the embedded-cylinder type. The design and manufacture of both types of prestressed concrete cylinder pipes are covered in AWWA C301.

(b) Fittings and specials for concrete pipe include bends, tees, wyes, connections to valves, closures, curves, and pipes with outlets for air valves and blowoffs. Details of these items should be presented on the construction drawings to expedite fabrication.

(c) Joints for concrete pipe usually consist of two steel rings, one in the spigot end of one pipe section, the other in the bell end of another pipe section. The spigot ring has a seat which contains a rubber gasket. This gasket is compressed against the ring in the bell end when the two pipe sections are joined. Operating experience has shown that rubber-gasketed bell-and-spigot joints provide a long-lasting, watertight seal when proper installation procedures are followed. Subsequent coating of the joint with mortar insures watertightness.

(d) Tapping of concrete pipe without special equipment or expertise is more difficult than other types of pipe and it should not be used where multiple future tapping for building service may be required. If tapping of concrete pipe is anticipated, service connections should be built into the pipe at the factory or fabrication point.

(4) Steel pipe.

(a) The properties of steel pipe favoring its use are high strength, ability to yield or deflect under a load while still resisting the load, the capability of bending without breaking, and the ability to resist shock. Like ductile-iron, steel pipe is susceptible to corrosion if effective coatings and linings are not applied and maintained. Inasmuch as corrosion products do not adhere to steel pipe, they are continually sloughed off, thus allowing further corrosion. By contrast, corrosion products adhere to ductile-iron pipe and offer some protection against further corrosion. Steel pipe is generally available in diameters ranging to 144 inches and greater. Maximum allowable working pressures depend on pipe wall thicknesses and may be selected for the entire range of waterworks applications. In designing steel pipe to withstand internal pressures, a factor of safety of 2.0 is generally used; a factor of safety of 1.5 or 2.0 is recommended in designing for external loads. Steel pipe may be used for transmission lines and service lines with adequate protective coatings and linings and cathodic protection as determined necessary by site conditions. Steel pipe should not be used for distribution mains. The basics of steel pipe waterlines are covered in AWWA C200.

(b) Fittings and specials for pipe 3 inches and under may be flanged, screwed, or mechanically jointed (dresser-type coupling). All fittings and specials must be galvanized. Fittings and specials for larger sized steel pipe are not, in general, stock items. Therefore, these items must be specifically made for each project. Detailed information as to spatial limitations, size, pressure requirements, angles, etc., must be provided for fabrication.

(c) Several options are open to the designer for steel pipe joints. Steel pipe may be welded, flanged, or connected by a mechanical coupling. Threaded couplings are also available for pipe sizes 3 inches and under.

(d) Steel pipe may be tapped in a manner similar to ductile-iron pipe except that welding service connections or couplings onto steel pipe may be more advantageous on steel pipe than on ductile-iron pipe.

(5) Plastic pipe.

(a) Plastic pipe. Several different types of plastic have been used in the manufacture of water distribution pipes. The most commonly used plastic pipes include polyvinyl chloride pipe (PVC) and two closely related types: reinforced thermosetting-resin pipe (RTRP) and reinforced plastic mortar pipe (RPMP). These materials are described in this section.

(b) Other types of plastic pipes. Numerous other types of plastic pipes have been developed mainly to provide resistance to corrosive liquids. Thus, these materials are adequate for potable water and should be given consideration especially if supplies are readily available. Such materials include polymers of acrylonitrile, butadiene, and styrene (ABS); polyethylene (PE) and high-density polyethylene (HDPE); polybutylene (PB); and polypropylene (PP).

(c) The advantages and disadvantages of plastic pipe. The advantages of plastic pipe are that it has a very low resistance to flow, it is somewhat flexible and can deflect under earth or superimposed loadings, it does not corrode from electrical or microbial action, and it is relatively lightweight and easy to install. Disadvantages are that it suffers a permanent loss of tensile strength with time, and that the tensile strength of the pipe at any time is decreased by temperature increases. Plastic pipe also undergoes significant expansions and contractions with temperature changes, necessitating the use of gasket couplers. Tapping could be difficult - care must be exercised to prevent the pipe from splitting. Plastic pipe materials are vulnerable to heat and ultra-violet radiation so care must be taken during transportation and storage of these materials to insure that they neither deform under heat nor deteriorate in sunlight.

(d) PVC pipe. PVC pipe is used in sizes of 4 to 12 inches inside diameter for distribution lines. It is available in pressure classes of 100, 150, and 200 psi, which correspond to the maximum anticipated internal working pressure for the pipe. A factor of safety of approximately 3.0 is used in the design of PVC pipe for sustained internal pressures, and a factor of safety of 4.0 is used for sudden pressure surges. However, due to the loss of tensile strength with time, these factors of safety decrease correspondingly. Pipe conforming to AWWA C900 with elastomeric gasket bell and spigot joints in 4-inch diameter through 12-inch diameter size, is acceptable for transmission, distribution, and service lines. Transmission, distribution, and service lines less than 4-inch diameter will require Schedule 80 pipe with threaded joints or Schedule 40 pipe with elastomeric gasket bell joints.

(e) RTRP and RPMP. Reinforced thermosetting-resin pipe (RTRP) and reinforced plastic mortar pipe (RPMP) are products belonging to the glass-fiber-reinforced thermosetting-resin pressure pipe family. These pipes are usually unaffected by aggresive soil conditions and have excellent resistance to corrosivity found in the water carried by these pipes. Common laying lengths of RTRP and RPMP are 10, 20, 40, or 60 feet, although other lengths can be provided. Diameters vary from 1 inch to 144 inches. For water, the standard pressure classes of up to 250 psi are available. The plastic pipe described herein is available in two types depending on the method of manufacture: Type I is filament wound; Type II is centrifugally cast. RTRP is the same as RPMP except the RPMP contains aggregate in the base material whereas the RTRP does not. Four grades are available depending on the materials incorporated in the pipe.

- Grade 1 - RTRP epoxy
- Grade 2 - RTRP polyester
- Grade 3 - RPMP epoxy
- Grade 4 - RPMP polyester

The differing grades generate differing resistances to salts, chemicals, and chemical solvents but are not affected by potable water. Selection of a particular grade and type for potable water use should be based on material availability and delivery time.

(f) Fittings and specials for plastic pipe. Cast-fittings for plastic pipe may be made of iron or of the same material as the pipe. If cast-iron fittings are used, consideration must be given to the use of adapters whenever plastic pipe joints with cast-iron fittings.

(g) Joints and couplings for plastic pipe. Joints for plastic pipe may be threaded, solvent welded, or push-on type with elastomeric gaskets. Fiberglass pipe may be joined by overlapping the joint with material similar to the pipe material.

(h) Tapping plastic pipe. Plastic pipe requires more expertise for tapping, especially in cold weather, since this pipe has a greater tendency to crack over other types of pipe material. The piping manufacturer's recommendations should be followed for details on tapping before work is started on plastic pipe.