



Distribution System Operation

The proper operation of the distribution system is equal in importance as the operation of a water treatment plant. The distribution system delivers the water from the source to the customer.

PIPING MATERIALS

Of the many types of pipe in use today, no one type fits all conditions of service. Knowledge of the different types of pipe will allow the operator to select the one that best fits the installation.

CAST IRON PIPE

In the United States today there are more miles of cast iron pipe in service than any other type of pipe. Cast iron enjoys this distinction because it has been used as a piping material for centuries and it provides long, useful life in underground piping service. It is available in diameters from 2 to 48 inches and in individual lengths from 18 to 20 feet.

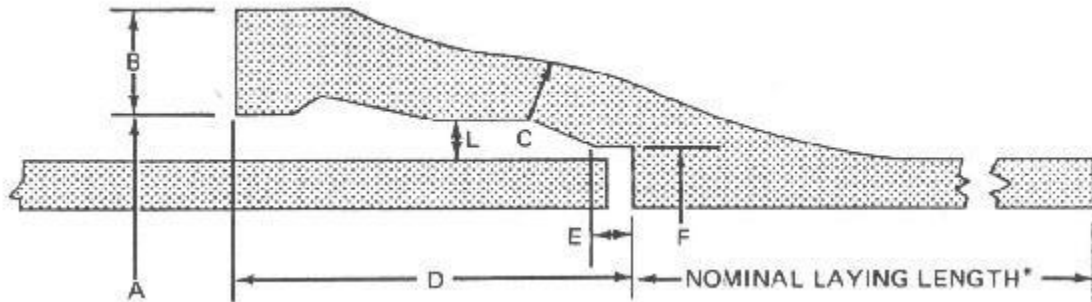
Interior corrosion and the formation of tubercles that reduce the carrying capacity of the pipe are major problems in iron (ferrous) piping materials. Most cast iron pipe used today has its interior lined with a thin coating of Portland cement, which greatly reduces the corrosion as well as friction losses.

Although many miles of the older type “pit cast” or “sand cast” iron pipe is still in service, centrifugal cast iron pipe is more common. The thickness of the pipe is dictated by the depth of bury and the pressure that will be applied. Class 50 to Class 54 is the most common pipe classes in Minnesota.

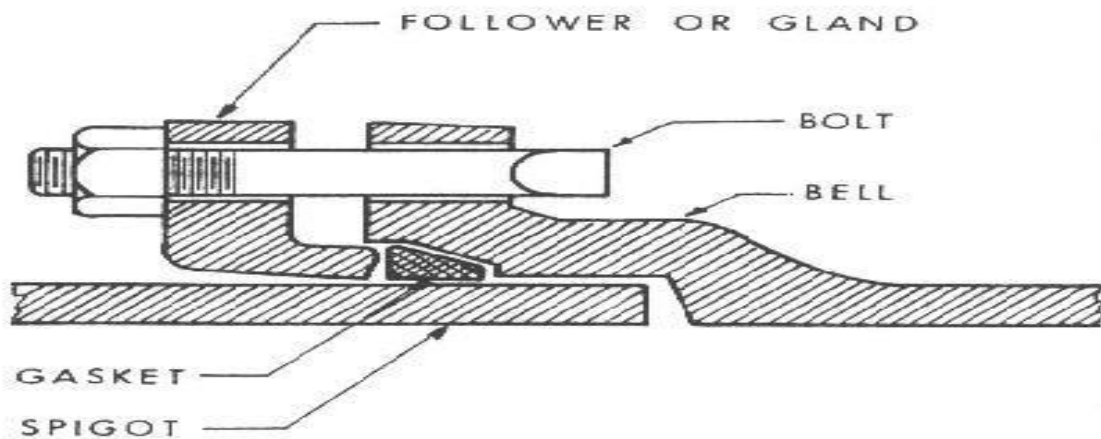
Cast iron pipe is adaptable to most service conditions. However, the pipe is subject to excessive outside corrosion in a highly acidic soil, where the carbon dioxide content is high. Under these conditions, a pipe material other than cast iron may be a better choice.

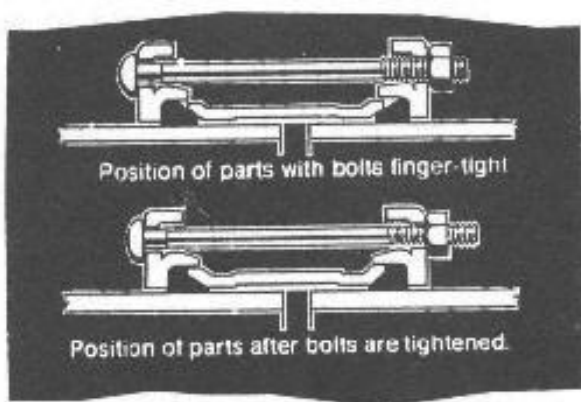
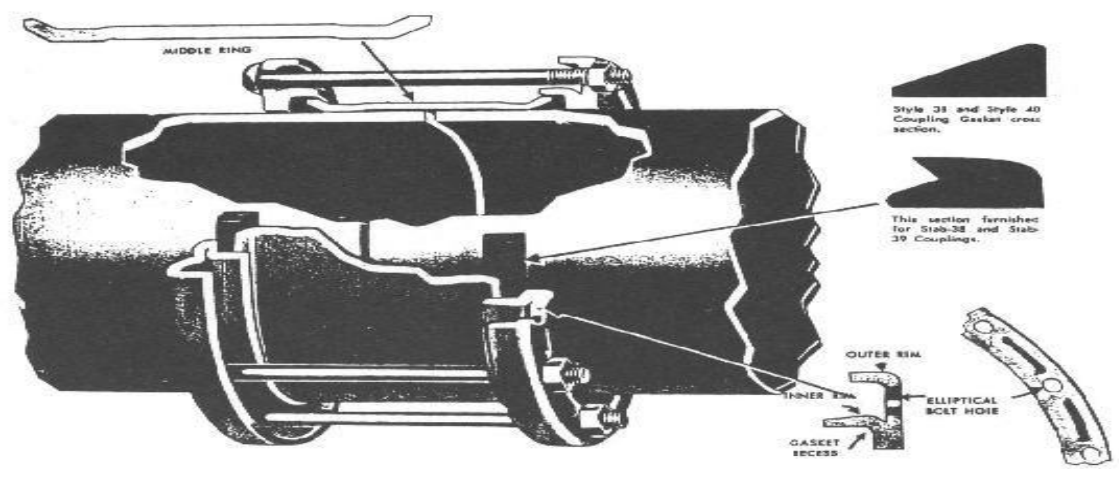
Pipe Joints

Until around 1950, a lead joint was commonly used on cast iron pipe. In this joint, the bell and spigot are put together with a yarning material which is chalked into the joint to prevent leakage. Molten lead is then poured into the joint to provide the strength needed to hold the pressure of the water. The lead will have to be chalked after it has cooled to make the joint watertight. In many utilities it was common practice to use a sulphur material that required no chalking in place of the lead. The use of lead joints is now prohibited.

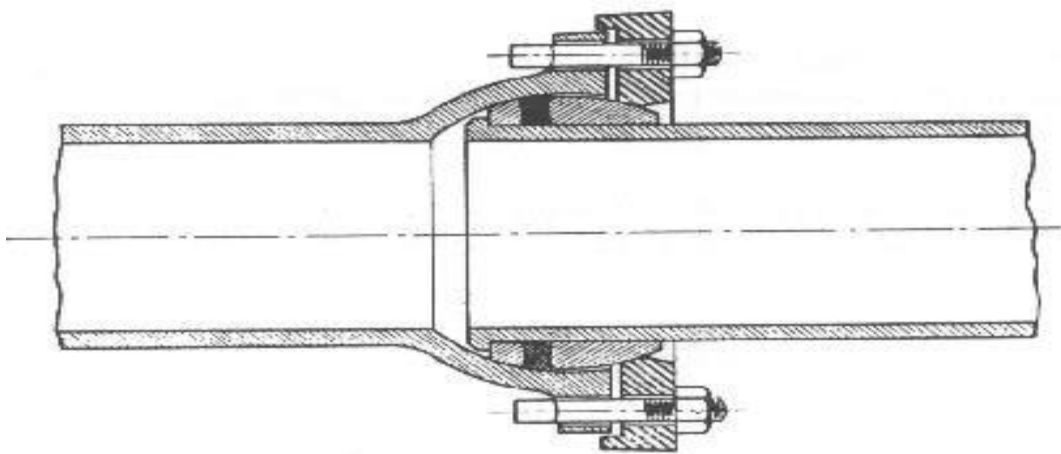


About 40 years ago the mechanical joint replaced the bell and spigot joint as the most popular method of joining cast iron pipe. The mechanical joint is made watertight by wedging a rubber gasket into a tapered groove formed by the bell of the previously laid pipe and the spigot of the pipe being laid. Wedging is accomplished by drawing bolts between the bell flange and the follower ring or gland. The mechanical joint is used on slip joint pipe and on hydrants that are joined to the pipe. A dresser coupling is a special type of mechanical joint.

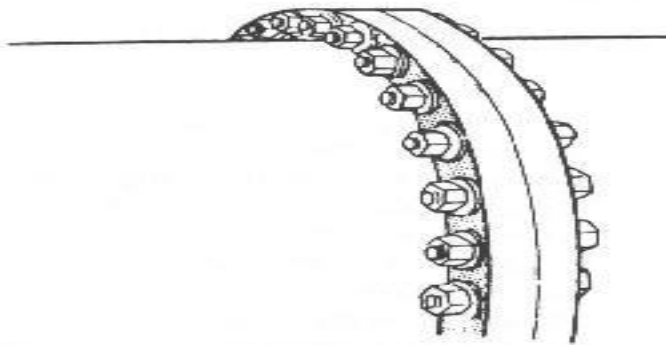
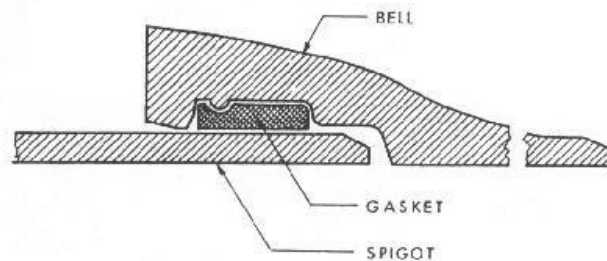




Ball joint pipe provides a simple, rugged type flexible joint for cast iron and ductile iron pipe and is ideally suited for underwater installation where the cost of equipment and labor require a speedy and reliable assembly. Pipes connected with ball joints may be pulled across streams with a cable as the joints are positively locked together. They may also be laid directly from a barge. The lengths of pipe and joints are sufficiently strong to support their own weight safely in the water. They may be laid without diver in deep water as long as they are filled with water, which displaces the air in the pipe.



A joint with a bell and spigot, similar to a lead joint, has become the standard joint for construction of pipelines that use cast iron or ductile iron pipe today. This joint is called a compression push on a slip joint. It uses rubber or composition gaskets which fit into the bell end of the pipe with the spigot end being shoved into the bell to compress the gasket. The rubber gaskets are sold under trade names, such as Tyton or Bell Tite.



Another common joint is the flanged joint. It is made by threading plain-end pipe and screwing it on flanges that are faced and drilled to permit being bolted together.

DUCTILE IRON PIPE

Ductile iron pipe was introduced in the mid-1950s as a replacement for cast iron pipes. It resembles cast iron pipe in appearance and has many of the characteristics of cast iron although it is less brittle, more flexible, and will not break as easily as the cast iron pipe.

Ductile iron is particularly suited to bridge crossings, installations supported on piers or piling, areas under deep fills, and in conditions where differential pressure may cause breakage of other pipe materials.



Joints used on ductile iron are the same as the ones described for cast iron pipe with the slip joint being the most common today. Fittings for ductile iron have the same outside diameter as cast iron; as a result, fittings are interchangeable between the two types of pipe.

The preferred method of cutting ductile pipe is sawing rather than snapping it, as is often done with cast iron pipe.

STEEL PIPE

Steel pipe, along with lead, was used extensively for service lines in the early part of the century. Some of this type of pipe is still in service.

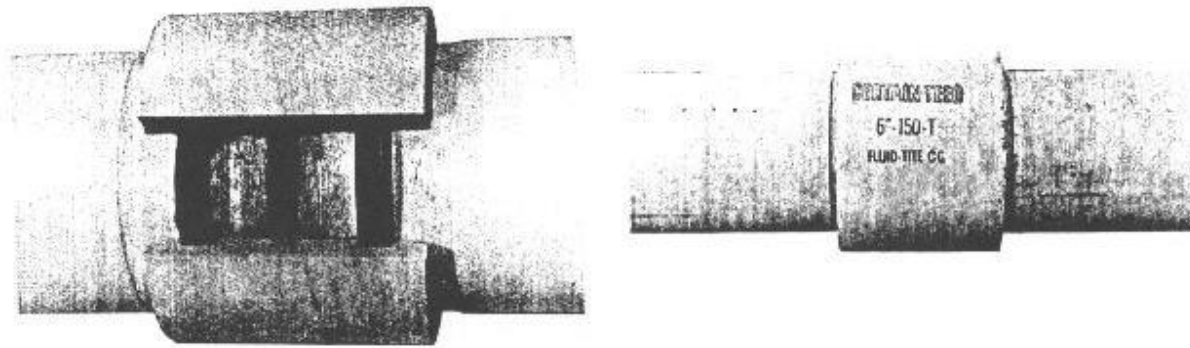
Standard steel pipe is used in large diameter pipe, primarily transmission pipe. This pipe needs to be wrapped in materials that will control the outside corrosion. The inside of the pipe is usually coated with Portland cement to prevent corrosion on the inside of the pipe.

Thin wall steel pipe is usually furnished in 40-foot lengths. Thickness ranges from 14 gage to 3/8 inch or larger, depending on the service conditions. Ten gage is generally the thinnest material used in waterworks service.

Standard steel pipe is designed to be joined by slip joints or dresser couplings. It is easily installed, reasonably flexible, and can be designed to withstand severe conditions. Service taps into thin wall steel pipe can only be done in relatively low pressure areas unless the pipe is reinforced in some way. Service saddles are usually used for service taps. Because it is more prone to corrosion, steel pipe can be expected to fail earlier than cast iron or ductile pipe. Large diameter steel pipe can be cheaper to install than the other types.

ASBESTOS CEMENT PIPE

Asbestos cement pipe is a highly corrosion-resistant formulation of asbestos, silica, and Portland cement. Under most service conditions, its smooth interior and resistance to interior corrosion sustain high water carrying capacities throughout its life. The major disadvantage of asbestos cement pipe is its limited beam strength and its low resistance to being bent. The pipe must be handled, installed, and bedded more carefully than some other types of pipe. Ends of the pipe are machined to allow joining in a type of slip joint in which the two ends of the pipe are inserted into an asbestos coupling. Rubber gaskets compressed in the coupling form a watertight seal. Cast iron fittings are normally used along with asbestos cement pipe. Recently there have been concerns of asbestos fibers separating from the pipe and entering the water being carried in the pipe.



PLASTIC PIPE

The use of plastic has increased dramatically as a water-supply pipe. It is resistant to corrosion yet remains flexible after construction. The joints on the pipe are generally of the slip joint construction and the fittings generally of the cast iron variety although fittings made of plastic are also available. Services may be tapped directly into the pipe, but most utilities use service saddles to make service connections.

Plastic pipe has good corrosion resistance, is easy to install, handle, and connect and has a good flow characteristic. It has now been used for several decades and has proven to provide good service. A disadvantage is that, being non-metallic, it cannot be thawed by electric resistance methods if frozen nor can it be located underground with electronic pipe locators unless a tracer wire is provided with the pipe installation. PVC pipe must be able to be located, such as with a copper tracer wire.

SERVICE PIPE

Pipe used in service connections is generally copper up to two inches in thickness or else ductile iron or cast iron above that width. Copper pipe is readily available in widths from one-half to two inches and in rolls up to 60 feet. For underground service, copper pipe is often flared and joined with threaded couplings.

Plastic pipe is gaining popularity for use in services because of copper's higher cost as well as lead and copper regulations. Plastic pipe comes in rolls usually 100 feet in length; the fittings are similar to the ones used on copper. The pipe may be flared, but the most common fitting is the wedge lock.

PIPE SIZE AND LOCATION FOR MAINS

Water mains should be placed in the public right of way or easements must be obtained if it becomes necessary to cross private property. The overall pattern of the system should provide for as many closed loops as possible. Long isolated lines terminating in dead ends without interconnections should be avoided.



The locations should be selected to:

- Provide a straight-line alignment where possible.
- Match a standard pattern applicable to the entire system, such as the water main being located on the north or east sides of the street and the sewers on the south or west sides.
- Be readily accessible for maintenance, repair, or replacement with minimum damage to existing streets and other underground utilities.
- Avoid conflict, contamination, and possible cross connection with the sanitary sewers. The water main must be ten feet from a sanitary sewer when they are running parallel. If they come closer than 18 inches when crossing, the sewer must meet water-main standards.
- Provide protection from physical damage due to freezing and other weather conditions. In Minnesota, the pipe should be buried seven feet below the ground surface to prevent it from freezing.

PIPE SIZE

The size of the water main will depend on what services it will supply and the flow expected. When determining the water demand, pressure losses have to be taken into consideration. If fire protection is required, the minimum size of a water main must be six inches in diameter. Some utilities have adopted an eight-inch minimum size for the main network.

Testing and Disinfecting

All new mains must be pressure tested and disinfected. Pressure testing will determine if the installation has been installed correctly and if the main is ready for service. Disinfection will ensure that the water delivered through the main is safe to use.

Pressure Testing

Pressure testing is done by filling the water lines under test pressure and noting the amount of leakage, if any, that takes place. Hydrostatic (water) testing is by far the most common and logical for water mains.

Pressures for testing are normally $2\frac{1}{2}$ times the normal operating pressure or at least 150 pounds per square inch (psi). This will disclose faulty pipes, bad joints, breaks, and other major defects. All pressures are to be measured at the lowest point in the system under test. The duration of the test should be no less than two hours and need not exceed 24 hours. If the utility is testing a fire service, the pressure is expected to be 200 psi for at least one hour.

All new mains are allowed some leakage, which is computed from the following formula (for mechanical joint pipe or slip joint pipe):



$$L = \frac{N \times D \times P}{3700}$$

where

- L = Allowable leakage per hour in gallons
- N = Number of joints in the test section
- D = Nominal pipe diameter in inches
- P = Average pressure during the test in psi

When the leakage test reveals an excessive loss of water, the source of the leakage must be found and corrected. Additional tests and repairs should be made until the leakage is brought to within the allowable limits.

The procedure for making a leakage test is quite simple. The test section is isolated in a suitable manner. All bends and dead ends shall be blocked against movement. Water is introduced into the low point through taps or fittings on the pipe. Hydrants, blowoffs, or air release valves along the pipe should be opened to allow the air in the pipe to be expelled. If suitable taps or connections are not available to expel the air, the main must be tapped at the high points to allow the air to escape. These taps will have to be removed and plugged after the test is complete.

After the air in the pipe has been expelled, the line is filled by pumping to sufficient pressure, as measured by a calibrated test gauge located at the low point. A hand-operated positive displacement pump is satisfactory for the purpose. At the end of the test, or hourly if the test is longer, the pump is again operated to restore the test pressure. Leakage is determined by the amount of makeup water required to restore the pressure. Most manufacturers of pipe provide a table of maximum leakage allowance per 100 couplings per hour at the selected test pressure.

Disinfecting

All new mains must be disinfected in accordance with American Water Works Association (AWWA) Standard C651 before being placed into service. The problems encountered in disinfection will be lessened, and the likelihood of satisfactory results will be increased, if proper precautions are taken during pipe installation to prevent dirt, trench water, and other foreign material from entering the pipe. The disinfection procedure consists of three operations: preliminary flushing, chlorination, and final flushing and testing.

Preliminary flushing is done prior to chemical disinfection. Mains must be flushed by running a sufficient amount of water through them. A velocity of 2½ feet per second is considered minimum for flushing. High velocities will do a better job. Even velocities of four to five feet per second may not remove the heavier material. However, if proper precautions are taken to prevent entry of the heavier material during construction, a flushing velocity of 2½ feet per second will produce satisfactory results.

The only disinfecting agents in general use for water mains are chlorine compounds. They are fed directly into the line as a water solution of liquid or gas chlorine, placed in the pipe as tablets prior to the pipe being filled with water, or injected as chlorine gas.



A liquid or gas chlorine water mixture is fed with a solution feed chlorinator. Dry gas may be fed directly through proper devices that regulate the flow rate and provide effective diffusion of the gas into the water.

The following types of chlorine compounds are used:

- Calcium Hypochlorite—available as a commercial product under such trade names as HTH, Perchloron, and Pittchlor.
- Chlorinated lime—also called chloride of lime or bleaching powder.
- Sodium hypochlorite—also known as liquid bleach.

These compounds are prepared for feeding into the main as a one-percent water solution (10,000 parts per million [ppm]). The amount of the compounds required to make a one-percent solution depends on the chlorine content of the compound.

The disinfecting agent should be introduced into the main through a corporation stop at the top of the pipe at the beginning of the new line. Water from the existing system or another suitable source should flow into the new pipeline during the application of the chlorine. The flow of water and chlorine mixture should be proportioned so that the chlorine dosage will be no less than 50 ppm. The chlorinated water should be held in the main for at least 24 hours and must have 10 ppm free chlorine residual at the end of the 24-hour period.

Treated water should stand in the pipeline at least 24 hours. During this time, all newly installed valves should be operated. Circumstances may preclude a 24-hour retention period. In these cases, the chlorine concentration may be increased and the retention time reduced. For example, a 100 ppm chlorine concentration could be used for a period of 12 hours. Consult AWWA Standard C651 for the approved ways of disinfecting the water mains.

The final operation in the procedure is the removal of the chlorine compound from the pipe line by flushing. This flushing should continue until the water in the pipeline has the same chlorine residual as the water in the rest of the water system. Before the pipe can be put into service, total coliform samples should be taken at several points in the new system, usually with one sample taken per block, plus one from each dead end. These samples must be taken on two consecutive days and the test results must be negative.

SERVICE LINE DESIGN

The condition of the service lines is often an overlooked part of the water system. In most systems, the total length of service lines may nearly equal and sometimes even exceed the total length of the mains.



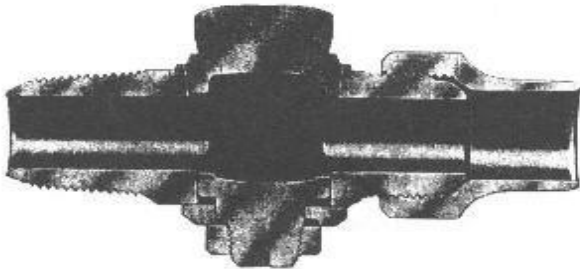
Service lines consist of two parts: the service connection that extends from the main in the street to the property line or curb stop; and the portion of the pipe that runs from the curb stop to the building. In most cities, the water operator needs to be concerned only with size, selection of pipe materials, and installation of the service connection.

Materials and installation practices apply equally to that portion of the service line located on the customer's property. Every water utility should have regulations consistent with the Minnesota Plumbing Code requirements. These regulations shall cover such items as approved materials, depth of lines, installation procedures, inspections, responsibility for the work, responsibility for payment of costs, and other information necessary to provide an understanding of the requirements.

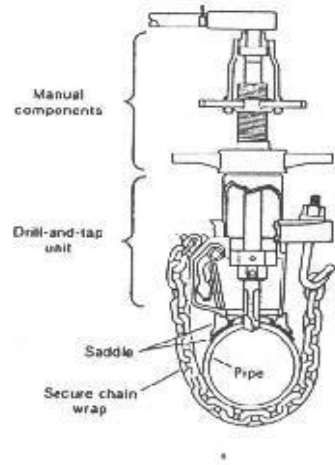
SERVICE LINE PARTS

Each service connection consists of:

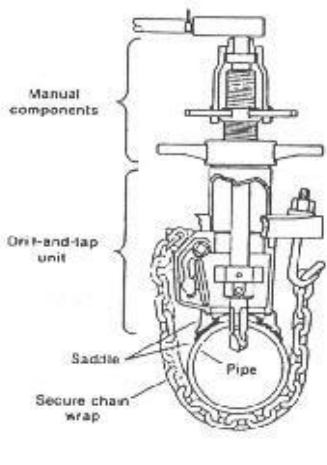
- 1) The connection at the main, which is made with the use of a corporation stop or valve to control the pressure during installation. This valve will generally be installed by a tapping machine and with the main pressurized.



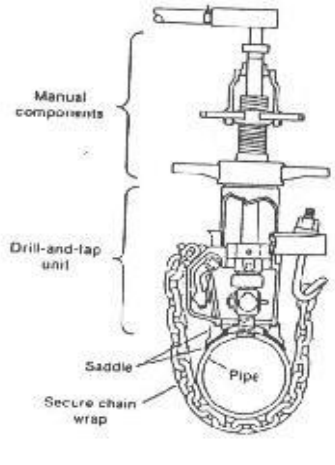
- 2) A length of pipe long enough to reach from the water main to the property line, where another valve is installed to control the water service.
- 3) A shutoff valve at the property line to allow the water to be shutoff without having to dig in the street. In most cases, this valve remains the property of the utility. The shutoff valve can be operated only with a special wrench, preventing the property owner from operating the valve.
- 4) Meters installed to measure the amount of water supplied to the customer. In some cases, the meter is installed at the curb line, but in Minnesota the normal location of the meter is inside the customer's premises.



a. With the combined drill-and-tap unit, first drill a hole into the main.

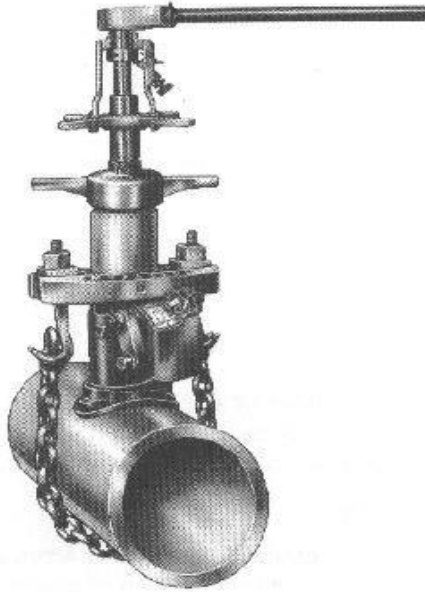


b. After the hole is drilled, insert the tap.



c. Again, with the drill-and-tap unit, insert the threaded inlet of a corporation cock. The service can then be activated.

Wet Tapping



**Manual Tapping Machine
SERVICE**



Manual Drilling Machine SIZE OF

Pressure losses in the service line can be substantial. If care is not taken in the sizing of the service parts, pressure losses can result in operating pressure that is too low even though the main pressure is maintained at satisfactory levels. The size and length of pipe and the number of stops, valves, fittings, and meters, as well as the demand rate, influence the amount of pressure loss in the service line. Losses can be calculated by using a set of pressure loss charts.

In the small-size pipe usually found in service lines, these losses are not minor. In fact, they may be greater than the total losses in the remainder of the pipe. As previously noted, a typical service connection consists of a corporation stop, curb stop, meter valve, and meter. The common fittings, along with the service pipe, create the pressure losses between the water main and the point of the water use.

A normal household instantaneous demand is in the 6 to 15 gallons per minute (gpm) range. The demand comes from the simultaneous use of plumbing fixtures and appliances in the building.

Demand Rates for Household Fixtures

Fixture Demand Rate (GPM)

Bathtub	4
Dishwasher.....	3 – 5
Disposal Unit.....	2 – 3
Laundry Tub.....	5
Lawn Sprinkler.....	5
Shower.....	3
Toilet.....	4
Washing Machine.....	3 – 7

VALVES

Valve Selection

Valve placement depends on the layout of the system, location of the customers, location of points susceptible to damage, and cost factors. The Ten State Standards adopted by the Minnesota Department of Health call for valve spacing of every 500 feet in commercial districts and 800 to 1,000 feet in other sections.

Valves are installed at enough points on a water system to minimize loss of water service during repairs. It is common to place valves at street intersections or at the extension of property lines. Valves are supplied with valve boxes or pits for maintenance. Many types of valve are used in the water industry, but all have basically the same function—to control or to stop the flow in pipes.

Gate Valves

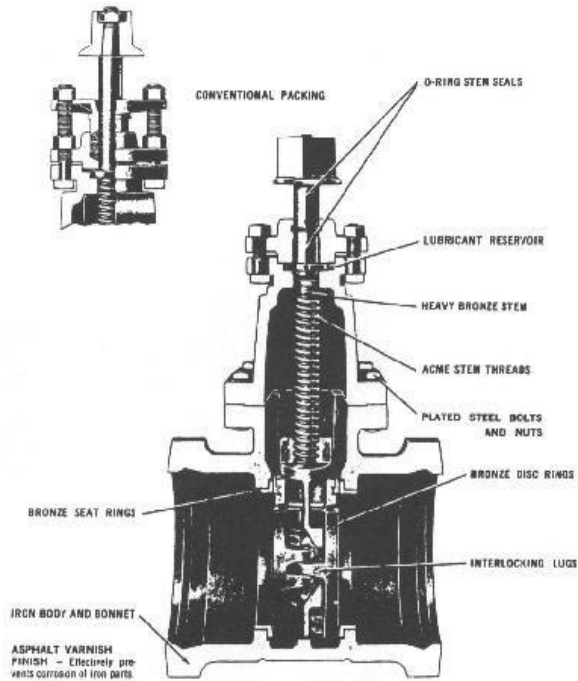
The most common type of valve used in a water distribution system is the gate valve. The main gate valve type is one with a non-rising stem, a valve in which the stem does not rise as the valve is opened. This valve is reasonably dependable, has an almost unobstructed waterway when open, is very economical in smaller sizes, and can be installed underground with a minimum cost. A photo of a valve riser is shown at right. It is important that the riser is installed correctly. Also, rods now are used so that the long shut off wrench isn't needed.



A gate valve is not well adapted for throttling flow or for frequent operation. Either will cause excessive wear on the seating edges of the discs and guides. Infrequent operation may cause the vulva to freeze in one position or become difficult to operate. Where the water carries small amounts of sand or silt, the valve seats may fill with deposited material unless operated at regular intervals to keep the valve seat clear.

The gates or wedges that provide the means of closing the line are forced into the flow line by the stem until the wedges reach the bottom of the valve. At this point, additional pressure on the stem will force a wedge out between the discs and the side of the valve seats to seal the valve.

Another type is the resilient seat gate valve, which is basically the same as a gate valve with one important difference. It does not have a depression in the bottom of the valve to collect debris and prevent the valve from closing. The valve plug will push into the flow and seal on the sides of the valve seats without the wedges to force the seal.



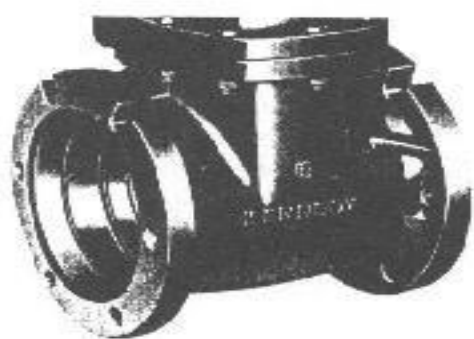
For 12-inch and smaller lines, gate valves are the most common type of valve used in underground application. Large gate valves, 14 inches and above, are installed with a smaller bypass valve to reduce the pressure differential when opening or closing the valve. It may be impractical to install larger gate valves in a vertical position due to height limitations. In such cases, gate valves are installed with their stems horizontal and the valves geared so the axis of the operating nut is vertical. A gate valve to be installed in a horizontal position should be equipped with rollers and tracks to carry the weight of the discs.

Until the introduction of the O-ring seal, the seal between the operating stem of the valve and the valve bonnet was accomplished with a packing held tight with a bolted connection. Leakage around the packing was common, particularly after the valve had been in service for several years. Tightening the packing nuts or replacing the packing was difficult and often costly, as excavation was normally necessary. The O-ring seal is a definite improvement.

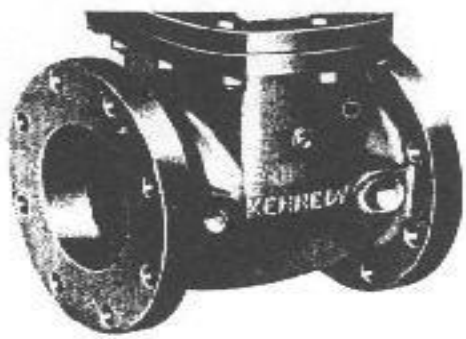
Gate valves are available with bell and spigot, flanged, mechanical joint or slip-on ends and can, through special orders, be furnished with different types of connections on each end of the valve.



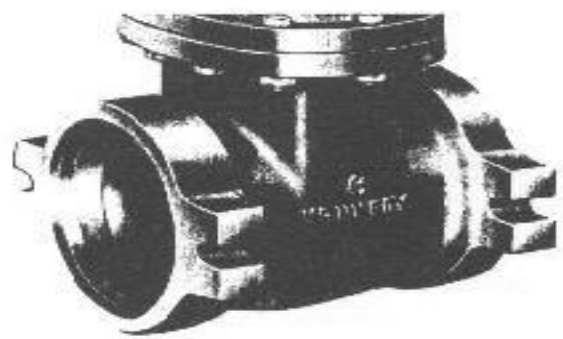
BELL ENDS



MECHANICAL JOINT



FLANGED JOINT



ASBESTOS-CEMENT JOINT

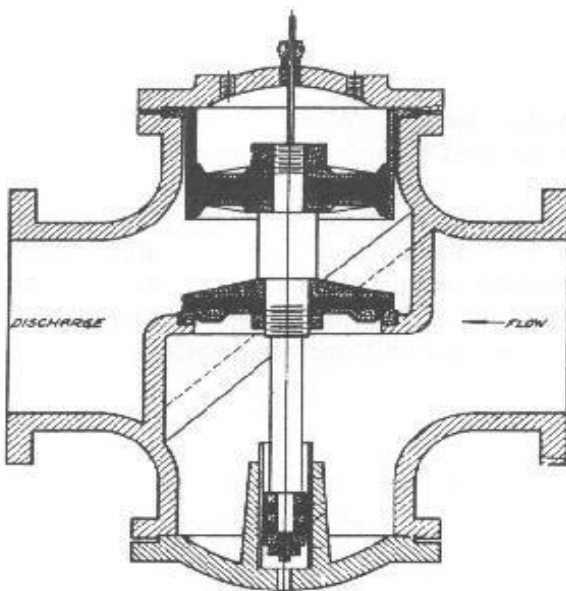
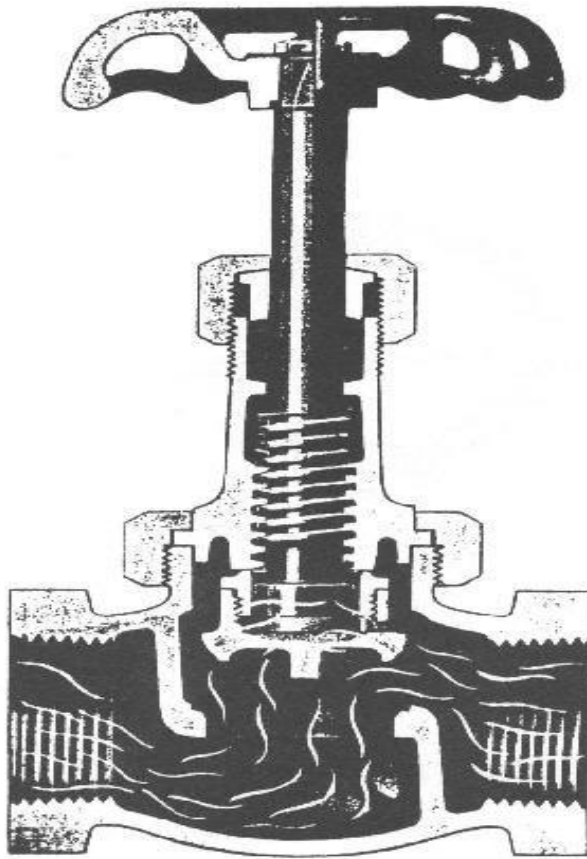
Joints Used to Install Valves

Globe Valves and Angle Valves

Except for some special service applications, the globe valves used in water systems are generally three inches or smaller. The high-pressure loss in this valve limits it to smaller sizes. The globe valve operates by forcing a tapered plug into the port through which the water flows.

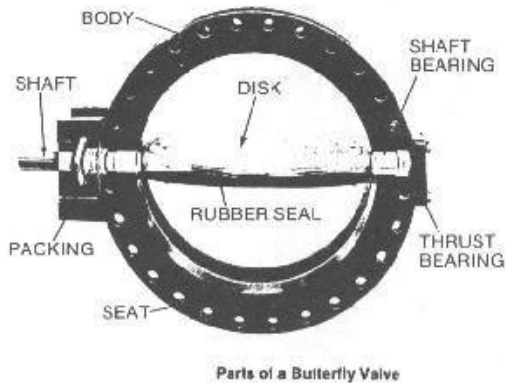
An angle valve is a globe valve in which the entrance and exit from the valve are at right angles from each other. This type of valve is frequently used before a meter installation at a residential service.

Large globe valves are used frequently for throttling and control applications such as pressure reducing, altitude valves, check valves, and other special purpose applications. The larger globe valves are normally joined by flanged connections.



Butterfly Valves

Rubber-seated butterfly valves are particularly adapted to certain service conditions in the water industry.



The butterfly valve consists of a shaft-mounted disc that rotates in a 90-degree arc from full open to full closed. When the disc is rotated into the closed position, it compresses the rubber seat, which is slightly smaller in diameter than the disc, and a tight seal is made. Since the valve shaft rotates only 90 degrees from the open to the closed position, some type of gear or lever is used to control the speed of operation and aid in maintaining a partially open or closed position. For buried service, the gear assembly must be enclosed.

Although butterfly valves are frequently used in place of gate valves to shut off services, the butterfly is also used in throttling or in automatic control of the flow of water. The valve will open, close, or throttle on command from a controller. Electric motors or hydraulic or pneumatic cylinders are the most common types of power sources for these automatic operations.

VALVE MAINTENANCE

Valves are one of the most important parts of a distribution system. When the utility has a break in a water main, its crews need to find the valve quickly and be able to operate it.

Therefore, the location of each valve should be recorded on a set of as-builds plans that are accessible to utility operators at all times. However, it is not unusual to find a valve that has been covered by street work or that has had its box damaged during construction to the point that the valve wrench can no longer be put on the operating nut of the valve. Pipe locators help in finding the valve boxes, but they do not insure that the valves will operate properly.

Inspection

A well-organized valve inspection program is essential for proper maintenance. Each valve in the system should be operated at least once a year to make sure that it can be located and that it works.

Valves in a distribution system allow small areas to be isolated for emergency maintenance. This means that most valves suffer from lack of operation, not wear. No definitive rules exist as to how



often a valve should be operated, but an annual check is common. The type of water in the system, the location of valves, and their size all have a bearing on the frequency.

The following procedures should be followed in a proper valve inspection program:

1. The location of each valve should be checked along with measurements to record reference points.
2. Valves should be operated in both directions, fully closed and fully opened, and the number of turns should be recorded. Any valves that operated in the opposite direction from the normal should be noted. Valves should be left in a position one-half turn from the normal position for fully opened or fully closed.
3. Valves should normally be left in the open position, but valves that are normally left closed should be noted.
4. Badly corroded valves should be operated several times, and, if necessary, a flow should be introduced to clean the valve seat.
5. The condition of the valve packing, stem nut, and gears should be checked.
6. Valve boxes should be checked, cleaned out, and raised, lowered, or replaced as required.

Most water systems number the valves for quick identification; all systems must keep a record of the location, type, and time of installation.

MINNESOTA RURAL WATER ASSOCIATION VALVE RECORD

No. _____ **Location** _____

Type _____ **Make** _____

Type of Jointing _____ **Sizing** _____ **Operating Nut** _____

Opens Left _____ **Opens Right** _____ **No. of Turns** _____

Valve In _____ **Route No.** _____

Comments:

Date	Opens	No. of Turns	Stem	Packing	Nut	Box or Manhole	Lid	Checked By	Remarks

Y= Yes N= No NR= Need Repair R= Repaired
 O= Open C= Closed

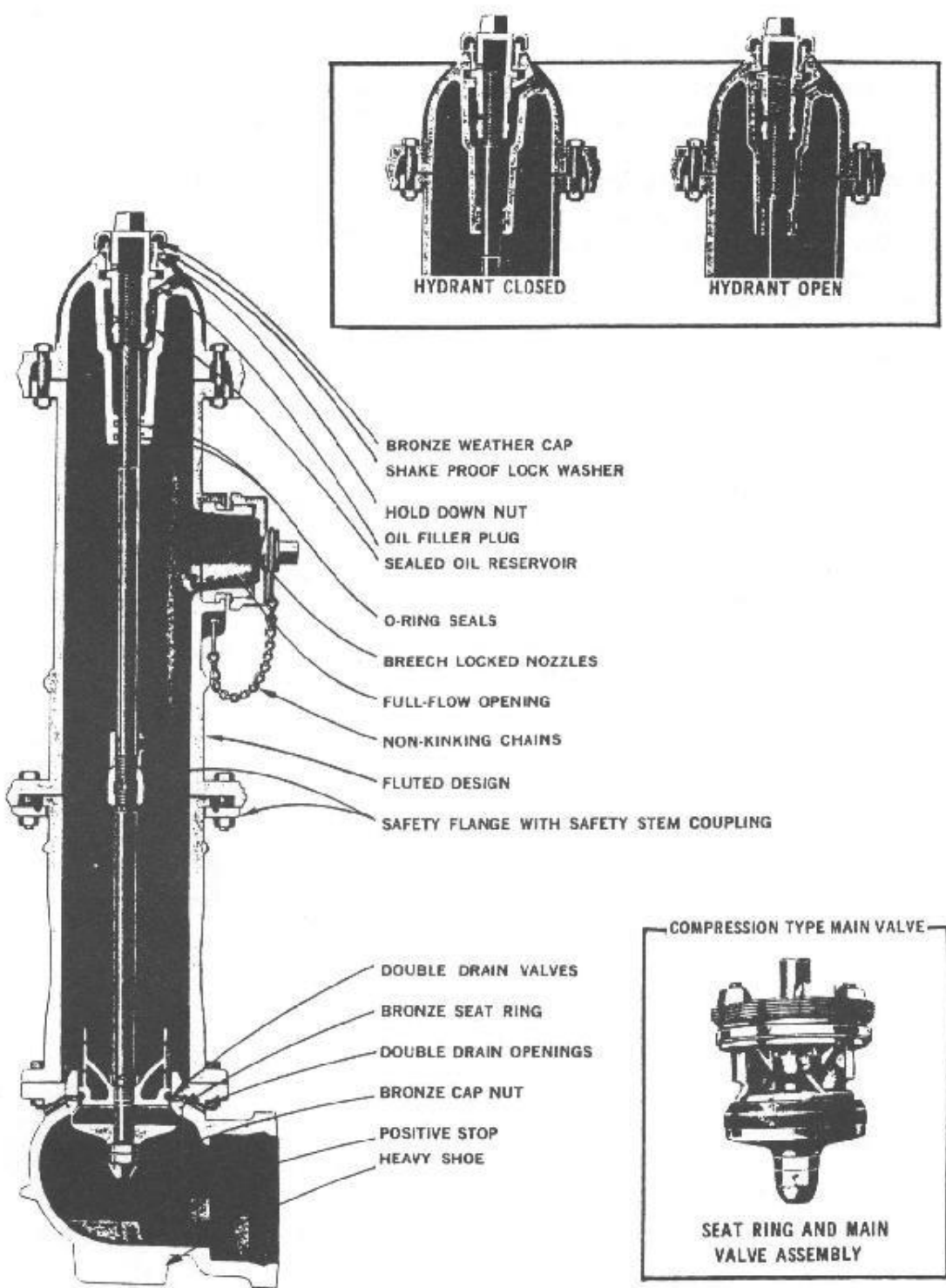
HYDRANTS

Hydrant Selection

Hydrants are located throughout the water system to provide for fire protection but they also provide a means of assessing the condition of the water system. Spacing of hydrants varies slightly with the design of the water system, value of the surrounding property, and area served, but they are usually found at intersections in areas that are not subject to traffic damage. The outlets of the hydrant should face the street. In general, hydrants should be spaced at 500-to-600 foot intervals in average-value areas and at 300-foot intervals in high value areas.

The purpose of a hydrant is to provide a quick, simple, and dependable method of connecting a fire hose to a source of water under pressure. Hydrants used in Minnesota are of two different basic types: the compression type, which opens against the flow and the corey or toggle type, which opens with the flow. The pipe connection for the compression type is at the bottom of the hydrant; the connection for the corey type is about one foot from the bottom. The two can be distinguished by the operating-nut location. The compression hydrant has its operating-nut in the center of the bonnet; the corey hydrant operating-nut is offset to the back of the hydrant bonnet.

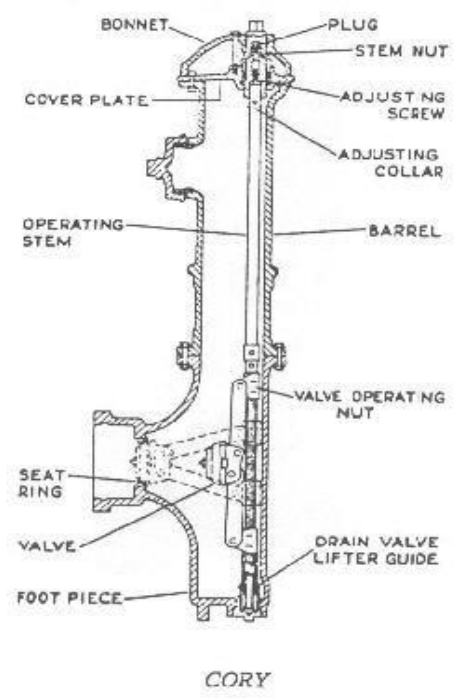
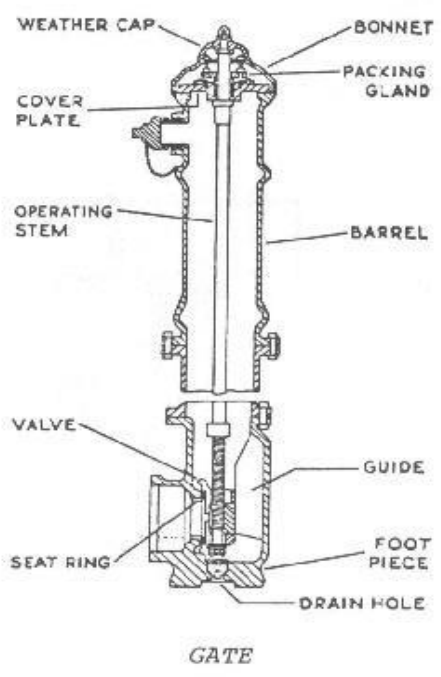
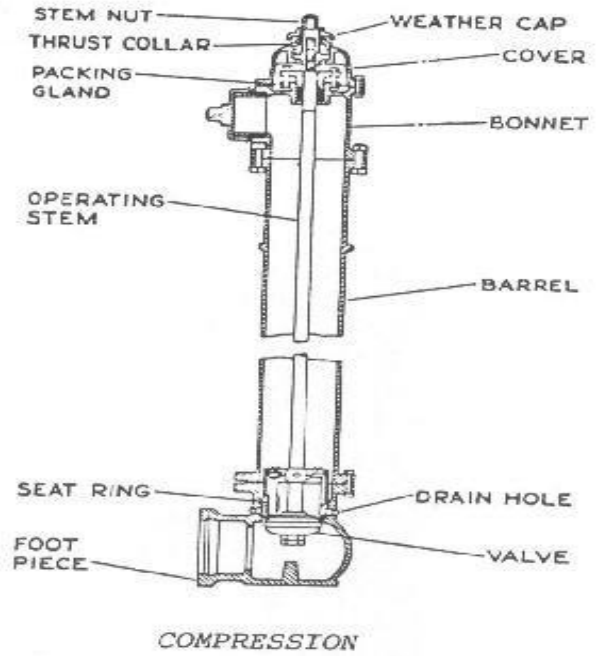
The size of the hydrant refers to the size of the opening in the valve. For example, a four-inch hydrant has a four-inch valve. Hydrants can be furnished with one to four 2.5-inch nozzles and one or two four-inch steamer nozzles. The most common combination is two 2.5-inch nozzles and one steamer nozzle. The length of the hydrant is referred to as the depth of bury and is the distance from the surface of the ground to the bottom of the inlet pipe.



The hydrant barrel is cast iron and the wear points are bronze. Hydrants normally are manufactured so that the main valve remains closed if the hydrant barrel is broken off. Most hydrants today are provided with break-away parts at or near the surface so that a broken hydrant can be repaired without having to dig to the base of the hydrant.

Hydrants are furnished with bell, mechanical joint, or flanged-bottom connections. The type of connection is dictated by the type of pipe that is used. If the hydrant is to be furnished with its own hydrant valve, the flanged connection would possibly be best. Nozzles provided should correspond to the type used by the fire department. The most common threads used in Minnesota are the National Standard threads.

wear points are bronze. Hydrants normally are





HYDRANT MAINTENANCE

Fire hydrants are installed for emergency use and should be inspected at least once per year to ensure their correct operation. Their exposure to the elements makes them prone to damage and failure. Inspection is often performed in conjunction with a flushing program.

The correct inspection procedure is as follows:

1. The hydrant should be sounded for leaks.
2. It should be operated and flushed, its ease or difficulty of operation noted, and any worn parts fixed.
3. The condition of the drain valve, operating nut, nozzles, nozzle caps, chains, packing, and paint should be noted.
4. After operation and closure, the interior should be observed to see if the barrel drains properly.
5. The setting of the hydrant and the distance of the nozzles from the ground and the curb line should be noted and, if needed, fixed.
6. The hydrant should be lubricated if needed.
7. The accessibility of the hydrant, its ground clearance, and its interference from poles or other objects should be noted and corrected if necessary.

Frequent painting of hydrants is an excellent public-relations tool as hydrants are usually the only element of the distribution system seen by the general public.

Hydrants are designed for emergency use. Therefore, they are not suited to continuous use as a water supply. Hydrants should not be regularly used to fill tanks and should never be used with the valve partially opened for throttling. A hydrant should be opened slowly and fully and then closed fully. After the hydrant is closed, the operating nut should be turned back enough to free it from any tension (about $\frac{1}{2}$ turn). When hydrants are used for filling tanks, proper backflow equipment should be used.

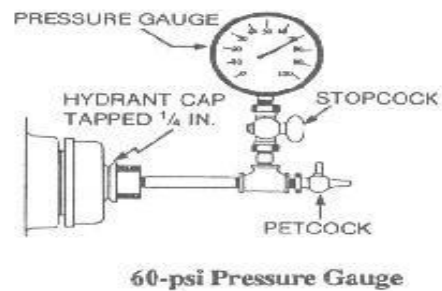
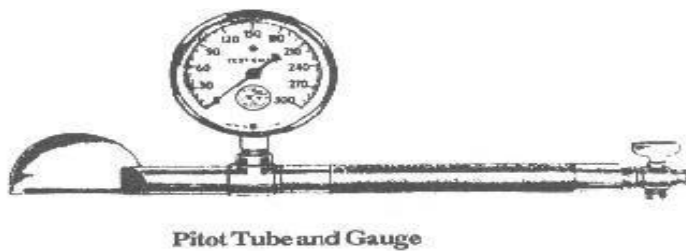
Flushing

Regular flushing of hydrants is important to ensure that it works and is in operational condition at all times. In addition, flushing can reveal information about the condition of the water system itself.

When a water system is flushed, the velocity has to be high enough—at least 2.5 feet per second—to sweep out any material accumulated in the system. If the necessary velocity cannot be obtained, the system should be valved to allow it to short circuit and induce the velocities needed. Flushing begins closest to the water source or treatment plant and working downstream in the distribution system.

Flow Tests

Flow tests from hydrants are important to determine the condition of the distribution system, particularly during peak-demand days. These tests also determine the amount of water available for firefighting. The tests are performed by opening one or more hydrants and measuring the flow, noting also a change in pressure at a nearby hydrant. A pitot gauge—an instrument with a tube having a small hole in one end, centered in the stream flowing from the hydrant nozzle—may be used to determine flows from the hydrant. The velocity of the water flow is transmitted as pressure to a pressure gauge attached to the tube.



From the pitot or pressure gauge reading, the flow can be calculated using a chart. The hydrant flow is expressed as gallons per minute. The standards used for hydrants express the flow as gpm at 20 psi.



MINNESOTA RURAL WATER ASSOCIATION HYDRANT RECORD

No. _____ Location _____

Make _____ Model _____

Type _____ No. Outlets _____ 2 1/2" _____ 4 1/2" _____ Other

Size of Main _____ Date Installed _____

Size of Riser _____ Size of Lead Line _____

Static Pressure _____ Flow Pressure _____

Connected to a looped Systems? _____ Discharge _____

(gallons per minutes) Provided with Street Gate

Valve? _____ Give Location Diagram

Remarks _____

Date	Flushed	Lubricated	Painted	Repaired	Pentagon	Cap & Chain	Checked By	Remarks

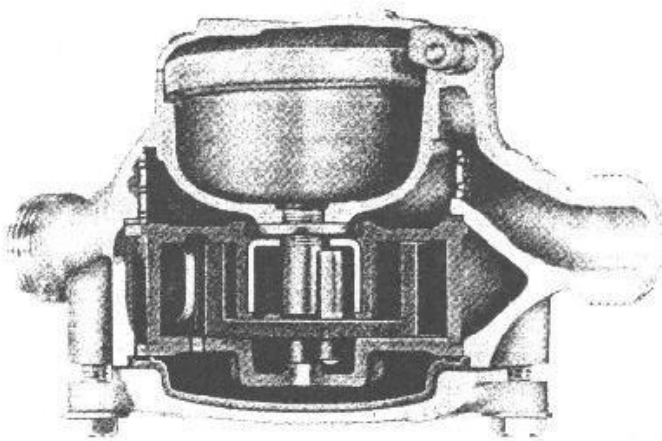
METERS

Service Meter Selection

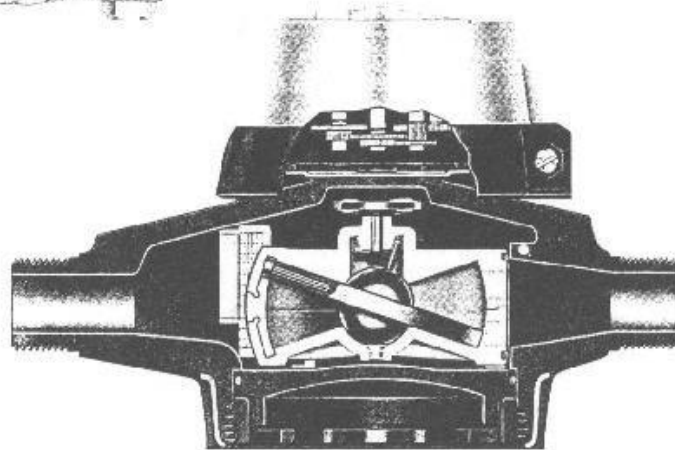
A water meter measures the amount of water passing through it and determines the amount a customer is charged. Two basic types of meters are used in the water industry: the displacement meter and the velocity meter.

Displacement Meters

The common small diameter service meter is of the displacement type. Displacement meters are capable of measuring small flows with relatively high accuracy. Water flowing through the meter is measured by counting the number of times the chamber is filled and emptied.



Piston Meter



Nutating-Disc Meter



A displacement meter has either a nutating disc or a piston meter as its measuring device. Water flowing into the chamber causes the disc or piston to pivot, transferring the pulses to a gear train and, from there, to the dials on the register.

The displacement meter is limited to use with comparatively low flow rates associated with normal domestic service. Excessive wear and inaccurate registration occur when displacement meters are operated in excess of their capacities.

RECOMMENDED CAPACITIES OF DISPLACEMENT METERS

<i>Size</i>	<i>Minimum Capacity gpm</i>	<i>Average Capacity gpm</i>	<i>Maximum Capacity gpm</i>
5/8 by 3/4	1/4	4	20
3/4	1/2	6	30
1	3/4	10	50
2	2	32	160
3	4-1/2	60	300
4	8	100	500
6	14	200	1,000

Velocity or Current Meters

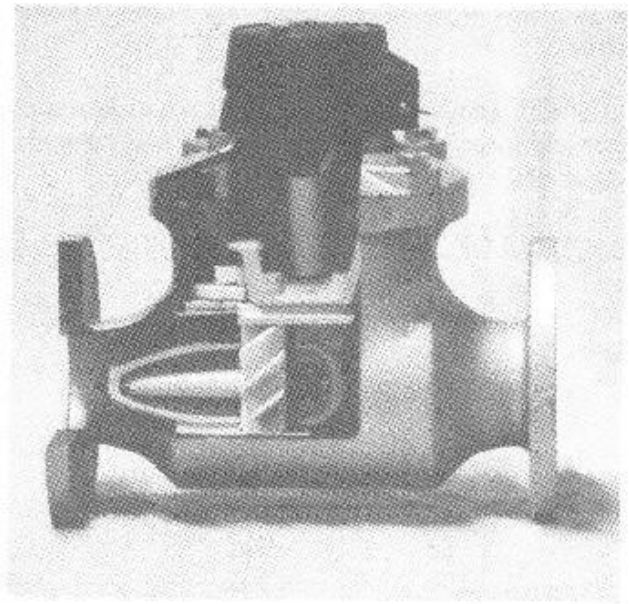
A velocity meter, or current meter as it is more commonly called, registers the volume of water passing through it by measuring the velocity of the flow within a known cross-section area. The two basic current-meter types in use are the turbine and the propeller meters.

The basic operating principle of a turbine meter is the same as that of the hydraulic turbine. A bladed rotor is mounted in a special passage, through which the stream of water is directed. The reaction of the water against the blades of the rotor causes it to rotate at a speed proportional to the velocity of the flow. The rotating movement is transferred through a gear train to the meter register.

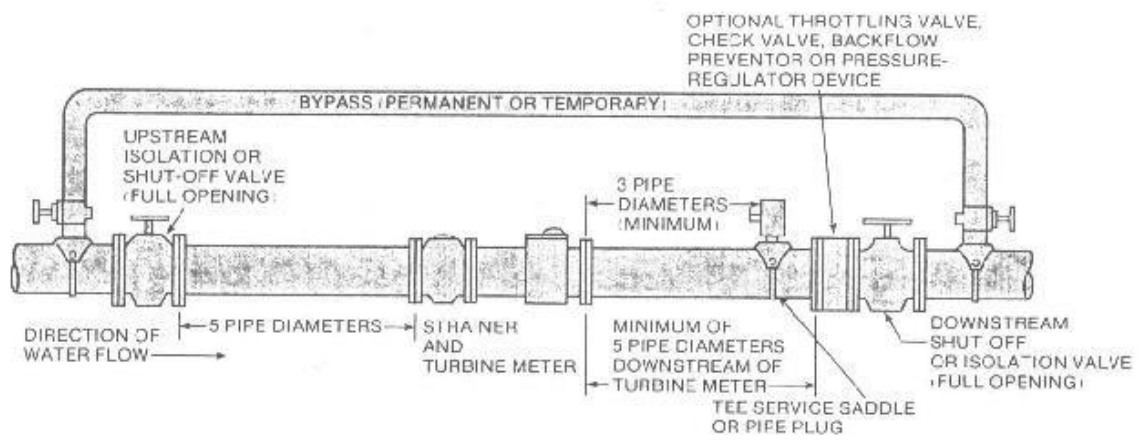
There are three general designs of turbine rotors. In the first, the water flows through the rotor blades at a right angle to the blades. The term “turbine meter” was formerly applied to this design. In the second design, called helical or axial flow type, the flow is parallel to the rotor axis. In the third type, called a mixed-flow turbine meter, the flow is part axial and part radial.

Turbine meters are used to measure relatively high flows and where there is sufficient head to overcome the friction loss through the meter.

The location of the meter in relationship to elbows or fittings is very important. The meter should be located five straight pipe diameters, upstream and downstream, from the nearest valve or fitting.



Turbine Meter



Optimum Turbine Meter Installation



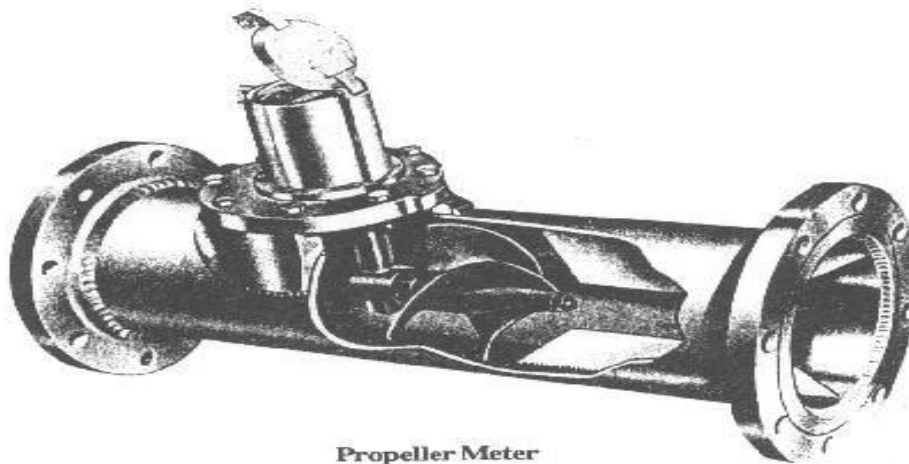
The following table provides a suggested volume comparison to use in selecting a turbine meter:

RECOMMENDED CAPACITIES FOR TURBINE METERS

<i>Size</i>	<i>Minimum Capacity gpm</i>	<i>Average Capacity gpm</i>	<i>Maximum Capacity gpm</i>
1 – ½.....	5	25	75
2.....	10	53	160
3.....	15	133	400
4.....	20	233	700
8.....	30	533	1,600
10.....	75	1,267	3,800
12.....	100	1,933	5,800
16.....	200	3,833	11,500

A turbine meter has a much larger range of flow than a displacement meter. During the selection of a meter, the average flow should be used to size the meter. Flow in the low range should be infrequent, and it is expected that some water loss would result if the flow remains in that range.

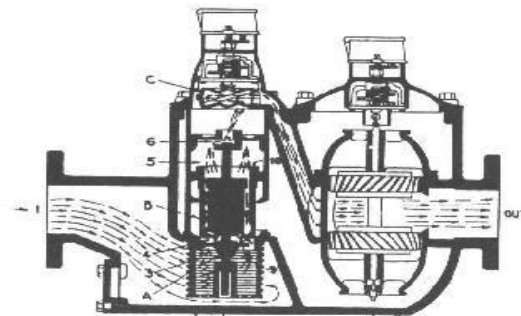
The propeller meter is a special type of axial flow turbine meter. In contrast to the turbine, where the direction of water flow changes while passing through the meter, the water flows straight through the propeller meter. The friction losses in a propeller meter are lower than in the same size turbine meter at the same flow. Propeller meters are generally less accurate than turbine meters at the lower rates of flow. Propeller meters are particularly adaptable to metering in mains where it is desirable to keep the friction loss at a minimum, where a high degree of accuracy is not needed, and where the flow range is relatively limited. A propeller meter is generally less expensive than a turbine meter of the same size.



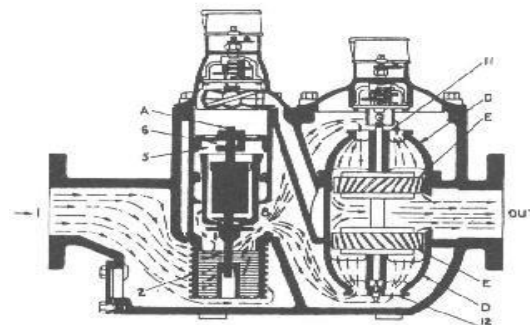
Propeller Meter

Compound Meters

In situations in which a customer's water use fluctuates regularly over a wide range, compound meters are used to accurately measure the water consumption. A compound meter is a combination meter with a turbine section for high flows and a displacement section for low flows. In normal operation, the low flows pass through the displacement section until the friction loss is so great that the valve opens, allowing the water to flow through the turbine section of the meter. A compound meter in good repair is capable of measuring flow with 98 percent accuracy over a wide range of flow conditions. There are other ways to read meters such as AMR (Automatic Meter Reading), telephone radio read, etc.



Compound Meter with Vertical Lift Check at Low Flow Rates



Compound Meter with Vertical Lift Check at High Flow Rates

METER MAINTENANCE

Having meters installed at the customers' locations provides the only fair and equitable method of charging for water. This is one of the most economical means of reducing water waste. They usually pay for themselves through a reduction in plant size. Meters are the "cash registers" of the water system and should be maintained in proper working order.

The accuracy of customers' meters should be checked regularly. The benefits of a scheduled meter maintenance program include increased revenue and a uniform work load. Large losses of revenue result from the practice of removing a meter only when a service is disconnected or when the meter has stopped. The cost of meter removal and repair is minor when compared with revenue lost by low or no registration. A metered system allows for the equitable distribution of the cost of water



service. Serious inequities and injustices can result unless the meters are maintained at a high, uniform level of efficiency and unless every reasonable effort is made to see that inequities do not occur.

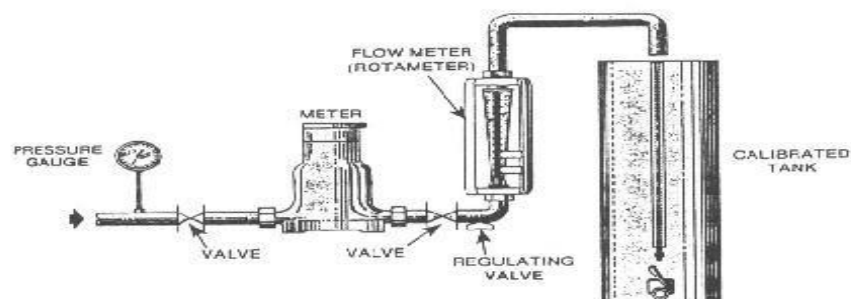
Basic Maintenance and Repair

The maintenance of positive displacement meters consists of temporarily removing them from the customer's service, taking them apart, and thoroughly cleaning and inspecting all parts. After the meter is dismantled, the measuring chamber should be carefully inspected for pitting. The moving parts, such as the disc, thrust rollers, and slots should be checked for excessive wear and corrosion. The disc should be checked with a straight edge and examined for swelling and distortion caused by freezing, heat, or hot water.

After defective and badly worn parts have been replaced, the disc should be reassembled in the chamber. Proper clearances should be provided and shims should be inserted if required.

Some important steps to follow in meter maintenance:

1. Clean all meter parts thoroughly
2. Check the action of the disc in the chamber before and after assembly in the main casing.
3. Remember that friction is just as detrimental as slippage to correct registration.
4. Store meters away from heat sources.
5. Use a new meter as a standard of comparison for tolerances and clearances.
6. Retest the meter for accuracy after repair. Special test benches are available for that purpose.
7. If necessary, call upon the manufacturer for advice and help.





Meter Testing Equipment

All meter repairs follow essentially the same procedures.

METER RECORDS

A suitable meter record provides full and complete information about the installation repair and testing of each meter. The time devoted to maintaining complete records is considerable because of the number of units involved and the probability that they will not remain at one location during their lifetime. Any record system should provide such basic data as the date of purchase, size, make, type, location of meter, and the data on all tests and repairs. A meter history card can be used for maintaining such records.

WATER DEPT.		SERVICE RECORD		ACCOUNT NO. _____
ADDRESS _____	DATE INSTALLED _____			
LOCATION OF TAP _____	SIDE OF _____	MAIN _____	FT. _____	OF _____
SIZE OF TAP _____	TYPE _____		DEPTH _____	
SERVICE LINE: SIZE _____	MATL _____		LENGTH _____	
BOX: TYPE _____	SIZE _____	STOP: TYPE _____	SIZE _____	
REMARKS _____				
DATE	METER NO.	WORK PERFORMED		BY