Distribution Valves: Selection, Installation, Field Testing, and Maintenance

AWWA MANUAL M44
Second Edition

American Water Works Association

Science and Technology

AWWA unites the entire water community by developing and distributing authoritative scientific and technological knowledge. Through its members, AWWA develops industry standards for products and processes that advance public health and safety. AWWA also provides quality improvement programs for water and wastewater utilities.
List of Figures, v
Preface, vii
Acknowledgments, ix

Chapter 1 History and Design Considerations .......................... 1
  History, 1
  Design Considerations, 3

Chapter 2 Types and Selection of Valves ................................. 9
  Valves Used for On–Off Operation and Flow Control, 10
  Valves Used Primarily For On–Off Control, 16
  Special-Purpose Valves, 19
  Actuators, 23
  Valve End Connections, 24

Chapter 3 Valve Tests, Unloading, Inspection, and Storage ........... 27
  Manufacturing Plant Valve Tests, 27
  Manufacturer’s Documents, 28
  Unloading at the Utility, 32
  Inspection After Unloading, 32
  Storage, 33
  Bolts, 33

Chapter 4 Installation .................................................... 35
  Inspection Before Installation, 35
  Installation, 36
  Testing After Installation, 37

Chapter 5 Operation and Maintenance .................................... 45
  Planning a Maintenance Schedule, 46
  Reactive Versus Preventative Maintenance, 46
  Valve Maintenance Procedures, 47
  Record Keeping, 47

Chapter 6 Distribution Valves Emergency Response Planning .......... 53
  Planning a Response, 54
  During an Emergency or Event, 54
  After the Event, 54
  Post-incident Review, 55

Bibliography, 57

Index, 59

List of AWWA Manuals, 61
Figures

1–1 A historical timeline for valve development, 2
1–2 Valve elements (rectangular butterfly valve), 4
1–3 Eccentric plug valve with handwheel actuator, 5
1–4 Eccentric plug valve with hydraulic actuator, 6
2–1 Globe valve, 11
2–2 Butterfly valve, 12
2–3 Plug valve, 13
2–4 Cone valve, 14
2–5 Ball valve, 15
2–6 Pinch valve, 16
2–7 Diaphragm valve, 17
2–8 Control valve, 17
2–9 Gate valve, 18
2–10 Resilient-seated gate valve, 18
2–11 Swing-type check valve, 20
2–12 Pressure relief valve, 21
2–13 Inserting valve, 23
2–14 Pneumatic actuator, 24
2–15 Valve end connections, 25
3–1 Sample shop drawing, 29
3–2 Information from a maintenance manual, 31
4–1 Crossover tighten method, 36
4–2 Drawing of a typical valve casing, 38
4–3 Drawing of a typical valve casing extension and plug, 39
4–4 Drawing of a typical valve casing top section, 40
4–5 Drawing of a typical valve casing bottom section, 41
4–6 Drawing of a typical valve bonnet, 42
4–7 Valve vault cross section, 43
5–1 Sample valve report, 49
Preface

This manual is a guide to the selection, installation, field testing, and maintenance of water distribution valves. Although the manual focuses on distribution valves, other valves, primarily used in plant operations, are also discussed. The manual provides a history of valves and a brief overview of the theory and flow characteristics of valves. It is a discussion of recommended practice, not an AWWA standard calling for compliance with certain specifications. It provides guidance on generally available valve alternatives. Questions about specific situations or applicability of specific valves should be directed to the manufacturer or supplier.

Information contained in this manual is useful for operators, technicians, and engineers for all size utilities, but it is particularly useful for small- and medium-sized organizations. The manual deals only with the more commonly used valves, including the following:

- globe
- butterfly
- plug
- ball
- cone
- gate
- check

Special-use valves are also discussed, but the intent here is only to introduce their availability and applications. Over the years, a wide variety of valves have been developed for specialized purposes. Fire hydrants, though technically considered valves, are not covered in this manual. The reader is referred to AWWA Manual M17, *Installation, Field Testing, and Maintenance of Fire Hydrants*. This manual refers to AWWA standards for various types of valves. Copies of those standards may be purchased from the AWWA Bookstore.

Several manufacturers graciously provided valve illustrations and other documentation. AWWA does not endorse any manufacturer's products, and the names of the manufacturers have been removed from the material provided. Kanwal Oberoi, Charleston Commissioners of Public Works, Charleston, SC, has provided the drawings for Figures 4-2 through 4-6 and 5-1.

Metrication note: Valve sizes are listed in their current US designation, i.e., nominal pipe sizes in inches. To obtain an exact metric equivalent use a conversion factor of 25.4 mm/in.
Acknowledgments

This manual was developed by the AWWA Distribution Operations and Maintenance Committee. AWWA staff providing publication assistance: Beth Behner, Manuals Coordinator and William C. Lauer, Technical Advisor. The membership of the committee at the time it approved this manual was as follows:

Greg Ramon, Chair
Frank J. Moritz Jr., Vice Chair

Larry L. Bittle Jr., Bexar Metropolitan Water District,
San Antonio, Texas (AWWA)

James M. Brady, Philadelphia Water Department, Philadelphia, Pa. (AWWA)

Michael E. Grahek, Los Angeles Department of Water,
Los Angeles, Calif. (AWWA)

Ken S. Hall, Petaluma, Calif. (AWWA)

George C. Mallakis, Simi Valley, Calif. (AWWA)

Kenneth C. Morgan, Charlotte-Mecklenburg Utilities, Charlotte, N.C. (AWWA)

Frank J. Moritz Jr., Ridgewood Water Department, Ridgewood, N.J. (AWWA)

William G. Mowell, Ridgewood Water Department, Ridgewood, N.J. (AWWA)

Michael J. O'Connell, Burns & McDonnell Engineering Inc.,
Kansas City, Mo. (AWWA)

Greg Ramon, City of Phoenix Water Services Department,
Phoenix, Ariz. (AWWA)

Patrick J. Staskiewicz, Ottawa County Road Commission,
Grand Haven, Mich. (AWWA)

Henry Young Jr., Denver Water, Denver, Colo. (AWWA)

This edition was reviewed and approved by the AWWA Distribution and Plant Operations Division Board of Trustees and the AWWA Technical Educational Council. The Distribution and Plant Operations Division had the following personnel at the time of approval:

Kanwal Oberoi, Chair
Kenneth C. Morgan, Vice Chair

Jerry L. Anderson, CH2M Hill, Louisville, Ky. (AWWA)

Robert L. Gardner, Wannacomet Water Company, Nantucket, Mass. (AWWA)

Rhonda E. Harris, Pro-Ops Inc., Dallas, Texas (AWWA)

George A. Kunkel Jr., Philadelphia Water Department, Philadelphia, Pa. (AWWA)

Bill C. Lauer, American Water Works Association, Denver, Colo. (AWWA)

Kenneth C. Morgan, Charlotte-Mecklenburg Utilities, Charlotte, N.C. (AWWA)

Kanwal Oberoi, Charleston Commissioners of Public Works,
Charleston, S.C. (AWWA)

Nicholas G. Pizzi, Environmental Engineering & Technology,
Twinsburg, Ohio (AWWA)

Melinda L. Raimann, Cleveland Division of Water, Cleveland, Ohio (AWWA)

Lois M. Sherry, American Water Works Association, Denver, Colo. (AWWA)
This page intentionally blank
A distribution system is a piping system that delivers water at service pressure from the pressure source to the end user connection. Generally, the system originates at a treatment plant or pumping station and ends at a residential, industrial, or commercial service connection. The system may also terminate at a fire hydrant or connect to a subordinate system. Valves are a significant component of any water distribution system and are most commonly used in the system for isolating a section of a flow line, controlling the flow, releasing air, and preventing backflow.

The topics in this introductory chapter include a brief historical review of valves and major design considerations, such as flow resistance, flow control elements, and sealing mechanisms.

HISTORY

From the water systems of Greece in 600 BC, which used flap valves to control water for showers, to the London Water Works and the first practical gate valve in the 1800s, to the most modern distribution systems used today, valves have been a vital component of every system. What is believed to be the earliest form of the mechanical valve, the bellows, is shown in hieroglyphs on the wall of an Egyptian tomb built 3,500 years ago. These wall paintings depict a bellows with bamboo piping used to smelt ore. Ever since, people have been refining and designing valves to fit different applications.

As water distribution systems became larger and more complex, particularly after the development of cast-iron pipe, designers met the challenges of water flow regulation with improved valve designs. However, many of the valve types currently used in water utility systems were developed in the 1800s and are still used with little change in their basic features. Nonetheless, there are hundreds of new designs and refinements of old designs available to system planners. Figure 1-1 shows a historical timeline for valve development.
600 BC
Grecian illustrations show evidence of a flap-type valve used in showers for bathing.

400 BC
Plug-type valves are used by both the Greeks and Romans in water mains and supply pipes.

250 BC
Greeks develop a two-cylinder pump that employs a valve in each cylinder.

100 BC
Hero of Alexandria develops the first workable hinged valve. He advises that the seat facings should be smooth and polished to ensure a reasonably tight closure.

1400s
Leonardo da Vinci draws valve constructions, including a multiport check valve with four pairs of hinged gates.

1455
First cast-iron pipe is manufactured in Viegerland, Germany, for installation at Dillenburg Castle.

1600s
King Louis XIV of France orders a cast-iron distribution system to supply water to Versailles.

1700s
Pressure conduits are in general use.

1795
Joseph Bramah designs the first screw-thread valve stem. It is used to open and close sluice-type valves.

1800s
The designs of most commonly used valves are developed during this century. Solid wedge, taper seat valves are introduced in the United States, and most of the changes and refinements take place before 1900.

1839
James Nasmyth designs the first practical metal gate valve, which consists of a cast-iron body and bonnet, a threaded valve stem, and a solid tapered plug. It is immediately employed in England by the East London Water Works.

1875
S.J. Peet patents the double-disc, parallel-seat, bottom-wedge-type gate valve.

1900s
The butterfly, ball, and diaphragm valves are designed and their use becomes common.

Figure 1–1  A historical timeline for valve development
System designers have many choices when they select valves for use in the distribution system. Making the right valve choice depends on many factors, including the size of the pipeline, the hydraulic pressures the valve will control, the material the valve is made from, the material it will come in contact with, what it will be used for and costs. The following section describes basic design considerations when selecting a valve.

**DESIGN CONSIDERATIONS**

This section discusses important factors to consider when selecting valves. The first factor discussed is flow resistance, or friction, which causes head loss (loss of pressure) as the water flows through the system. The other factors discussed are general valve elements involved in flow control, such as the mechanism for adjusting the flow and the sealing mechanism.

**Flow Resistance**

The term flow resistance refers to a fluid's resistance to moving through the piping system. Flow resistance plays an important role in decisions about flow pressure, pumping requirements, and pipe size, as well as in the selection of an appropriate valve for a specific application. A pressure drop caused by friction always accompanies the flow of liquid in a pipe and through valves; this drop is caused by fluid particles rubbing against each other and against the pipe. One can observe the effect of friction by connecting pressure gauges to a pipe system at both the beginning (upstream) and the end (downstream) of the system; with gauges at the same elevation, the upstream gauge will show higher pressure than the downstream gauge.

Different pipe materials experience different levels of friction and so are said to have different friction factors. For example, a copper pipe is smoother than an iron pipe, and water flowing through it will encounter less friction. In addition, for a given nominal diameter, the inside actual diameter may vary depending on pipe material. Flow is affected not only by the roughness of the pipe but also by the pipe diameter; friction increases as the diameter of the pipe decreases. The pressure drop associated with flow through a valve, i.e., the friction loss in the valve, depends on the type of valve.

There are many equations that allow planners to calculate the pressure drop in a given system. System planners can calculate average flow resistance based on the turbulence of the flow, the roughness of the pipe, pipe diameter, valve and bend types, and other factors. Generally, the flow resistance of a valve is expressed in terms of the length of straight-steel pipe that would have an equivalent resistance. For example, a 12-in. gate valve is rated at about a 13.2-ft (4-m) equivalent length of clean schedule-40 steel pipe, and a 12-in. globe valve is rated at about 340 ft (100 m). The relative resistance of PVC is about half that of steel. Therefore, the equivalent length of PVC would be double that of steel.

The considerable complexity of the flow resistance of valves is beyond the scope of this manual. For more information, consult the references listed in the bibliography and manufacturers' technical data.

**Flow Control Elements**

The many different types of valves have basic functions and elements that are similar. This section will discuss those basics. Figure 1-2 shows the basic valve elements.
Flow control. A valve controls flow through one of four basic closure methods:

- A disc or plug moves against or into an opening.
- A flat, cylindrical, or spherical surface slides across an opening.
- A disc or ellipse rotates across the diameter of a pipe or circular element.
- A flexible material moves into a flow passage.

The valve parts that control the flow element, or closure member, are the stem and the operating mechanism (generally a handwheel, lever, or key that attaches to the operating nut).

Stems. Most valves employ a threaded stem to move the flow element. Although there are exceptions, such as safety valves and check valves, most valves have stems that extend to the outside of the valve. A rotating stem provides movement for nonrising-stem gate valves, ball valves, rotating-disc gate valves, butterfly valves, and most plug valves. Quick-opening gate valves, rising-stem gate valves, globe and diaphragm valves, and outside-spring safety and relief valves operate with a stem that moves axially but does not rotate. Some stems both rotate

---

Figure 1–2 Valve elements (rectangular butterfly valve)
Valve operation mechanisms. Most valves are operated with a handwheel (Figure 1-3), operating nut, or lever. Not every application lends itself to such a simple solution, so designers have devised a variety of methods for both manual and automatic valve operation. Special methods are usually needed when special conditions exist:

- The valve must be operated remotely.
- The valve is inoperable using normal methods.
- The size of the valve makes it impossible for one person to operate the valve.

The bury depth of valves may vary. Stem extensions or adjustable valve keys have been designed to operate most valves. Stem extensions usually consist of a steel rod and a coupling that attaches to the valve stem. If the extension must be very long to reach a valve, extra support is provided to keep the extension rigid and to prevent bending or breaking. Operators can use adjustable shafts or steel rods and universal joints to reach valves in difficult locations.

Figure 1–3  Eccentric plug valve with handwheel actuator
Floor stands, gear operators, and wheel operators give personnel a mechanical advantage in opening or closing valves that are inconvenient to reach or are large and difficult to operate. Position indicators may be installed on nonrising stem valves to show how far the valve is open.

Accessories for automatic operation are also available. They can be used simply to open or close a valve or to throttle flows. Hydraulic or pneumatic operators, which operate with a diaphragm or piston construction, are common. In a piston type, two chambers in a cylinder are isolated from each other by a piston. The valve stem is connected to the piston. As hydraulic fluid or air is pumped to one side or the other of the piston, the piston is forced back and forth inside the cylinder, which operates the valve. Electric motors are also used to operate valves. A typical hydraulic operator installation is shown in Figure 1-4.

Sealing Mechanisms

Valves are employed to control the flow of fluid through a piping system. Valve seatings are the portions of the valve that contact the valve body to form a seal that stops or diminishes the flow of liquid. Because they undergo wear and tear during the sealing process, they will become less effective over time. Valve-sealing mechanisms used in water distribution systems are usually metal seatings or soft seatings. Another sealing mechanism involves using a sealant such as that used in a lubricated plug valve.

Figure 1–4 Eccentric plug valve with hydraulic actuator
**Metal seatings.** The material for metal seatings should be carefully chosen because the seatings are prone to damage by corrosion, erosion, abrasion, and deformation. The type of metal chosen for an application should be considered in relation to the types of fluids it will come in contact with, replacement capabilities, how often it will be operated, and other factors that may cause damage or wear to the sealing mechanism. Different metals offer various sealing abilities and resistance to damage. System designers should choose a valve that has seatings offering the best compromise between sealing ability and wearability.

**Soft seatings.** Soft seatings are sealing mechanisms generally made from various natural or synthetic rubbers or plastics. The soft material readily conforms to the mating surface, creating an effective seal. This type of seating should be designed to prevent the seating material from being moved or deformed by fluid pressure. Presently there are limitations on the use of soft seatings on large valves.

**Sealant.** Valve passageways can be sealed by a substance (the sealant) injected into the space between the seatings after the valve is closed. The sealant fills any spaces that might be left open by the seatings and thus prevents leakage. Sealant is also used in emergencies to provide a seal when the original seal has failed.
This chapter introduces the major types of valves and the parameters that should be considered when selecting a valve. These parameters include the purpose of the valve, size, operation, and joint type.

Although certain valve types can be used for many different applications, operators should choose a valve that carefully balances efficiency and cost for the specific application. For example, butterfly valves in sizes 12 in. and larger are less costly than gate valves but have more flow resistance. Factors to be considered in the valve selection and specifying process include

- the requirement that the valve either control or shut off the flow in the manner demanded by service conditions;
- conformance to appropriate American Water Works Association (AWWA), American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI), and other product standards;
- ability of the valve to withstand maximum working or test pressures;
- the need for an unobstructed waterway to maximize flow or accommodate cleaning operations such as “pigging”;
- ability of the valve to resist attack by corrosion and erosion;
- actuator requirements (if any); and
- installation requirements such as weight and accessibility.

This chapter will cover only the most common types of valves and their functions as previously listed.
Valves can be grouped based on their method of flow regulation. The general types of flow regulation and the common valves for those types are as follows:

- closing down
  - globe
  - piston
- sliding
  - gate
- rotating
  - plug
  - ball
  - butterfly
  - cone
- flexing
  - diaphragm
  - pinch

Valves may also be grouped based on the uses for which they are most adaptable. The most common uses are for opening and closing a flow (on-off operation), and for flow control (throttling or controlling the amount of liquid and the direction entering a system or diverting the flow). Valves are used for special purposes as well, such as pressure relief, air release, and pressure control.

**VALVES USED FOR ON-OFF OPERATION AND FLOW CONTROL**

Some valves can be used for both on-off operation and flow control. Other valves are more efficient for throttling operations (butterfly, ball, cone, and globe valves). Still others, such as plug valves, are more effective for on-off operations but can also be used in some throttling operations. The following paragraphs describe the major types of valves and list their best applications. The advantages and disadvantages are somewhat subjective and may not strictly apply in all situations; the information should be used together with engineering data and operational judgment.

**Globe Valves**

**Advantages:**
- suitability for flow regulation
- high sealing capacity
- resistance to wear

**Disadvantages:**
- high flow resistance
- possibility of sediment being trapped by seating

**Description.** Globe valves are closing-down valves where the closure member is moved directly on or off the seat, generally by a rotating threaded stem. The closure member is commonly referred to as a disc. This valve is well suited for flow regulation because of the short distance between the open and closed positions. It also has a high sealing capacity. Because there is little friction encountered in opening and closing the seats, it is resistant to friction wear. However, globe valves tend to trap particulates in the seat, and the flow resistance is high in these valves. See Figure 2-1.
Piston Valves

**Advantages:**
- suitability for on–off operation
- suitability for some flow regulation

**Disadvantage:**
- high flow resistance

**Description.** Piston valves use a piston-shaped closure member that intrudes into the seat bore. Sealing is achieved between the sides of the piston and the seat bore. Therefore, flow cannot start until the piston is completely withdrawn. This type of valve is effective for on–off operation and is somewhat useful for flow regulation. Solids that might be deposited on the seat tend to be wiped away during closing.

Butterfly Valves

**Advantages:**
- suitability for both on–off and flow control
- ease of operation
- short face-to-face dimension
- light weight as compared to same size gate valves

**Disadvantages:**
- some flow resistance
- incompatibility with “pigging” (described in this section)
- high-velocity limitations

**Description.** A popular type of valve for the distribution system, especially in larger sizes, the rubber-seated (sometimes called resilient-seated) butterfly valve (see Figure 2-2) has been used in distribution systems since the 1950s. In the butterfly valve, a circular disc or vane that has a diameter less than or equal to that of the pipe is fastened to a shaft running through the valve body and extending outside to an actuator. The disc or vane rotates 90° in the waterway. In the full open position, the disc is parallel to the flow. The flow, split by the disc, continues on either side of the disc. In a flow-through disc design, the flow is also directed through openings in the disc. In the closed position, the disc is perpendicular to the flow and stops the flow. The clearance between the disc and the valve body is sealed by a rubber seat.

![Figure 2–1 Globe valve](image-url)
The rubber seat may be attached to either the disc or the valve body. Butterfly valves are covered by ANSI/AWWA C504 Standard for Rubber-Seated Butterfly Valves.

A butterfly valve shuts off pressure as though it were a gasket. The seat holds until the pressure exceeds the seal compression, after which the seal leaks. The valve is set at the factory to hold the rated working pressure (the pressure at which the valve is designed to operate) and should not be expected to seal at higher pressures.

The reduction in flow of the butterfly valve is a function of the angle of the disc opening in the pipe. The valve is generally effective for flow control in the range of 20° to 70° open, depending on the difference in pressure across the valve and other characteristics of the valve. Butterfly valves may be used for throttling in some situations; however, they are not intended for long term throttling. The operator should consult the manufacturer before such applications.

Advantages to butterfly valves are that they provide shutoff capabilities, some throttling capabilities, and ease of operation, particularly in sizes 16 in. and larger. The actuators required by larger valves increase the mechanical advantage to allow for ease of operation. Additionally, butterfly valves that are 12 in. and larger are generally more economical than gate valves.

However, butterfly valves do not provide a clear waterway. Restriction of flow in a fully open butterfly valve is greater than in a fully open gate valve because the disc remains in the waterway. As the valve size increases, the proportion of the open flow area to the cross-sectional area of the disc increases. If a large number of butterfly valves are used, pressure loss in a distribution system can be significant. When flow resistance is critical, other types of valves may be required.

Another disadvantage is that butterfly valves prevent the use of “pigging,” which involves using line pressure to force a bullet-shaped plug through a water line to locate and clean flow restrictions.

### Plug Valves

**Advantage:**
- suitability for both throttling and flow regulation

**Disadvantage:**
- cause some flow resistance

![Figure 2–2 Butterfly valve](image)
Description. Plug valves use a flow control mechanism consisting of a machined plug that has a waterway opening bored through it (see Figure 2-3). Plug valves are manufactured in three basic types: lubricated, nonlubricated, and eccentric.

A lubricated plug uses grease to lubricate the plug motion and to seal the gap between the plug and valve body. Some plug valves use the lubricant to lift the plug before turning. For a nonlubricated plug, the valve is mechanically lifted up from, or pushed down to, the seat in a fully open or fully closed position.

An eccentric plug valve is also nonlubricated. Refer to Figures 1-3 and 1-4 for illustrations of eccentric plug valves. This type of valve operates by rotating the plug 90° and pulling it away from the seat, thereby opening the valve. Some eccentric valves use a resilient-coated plug for tight shutoff.

Flow restriction in a plug valve depends on the size and shape of the plug opening. For example, some plug valves have tapered openings where the opening is smaller at the bottom than at the top. Tapered plugs cause more flow restriction than a rectangular design of the same size because there is more plug area blocking the flow. Flow resistance can range from that of a gate valve to more than that of a butterfly valve. An advantage of the plug valve is that it can be installed in any position without special consideration, and it can also be used in throttling applications.

Larger plug valves require an actuator for 90° rotation. Smaller plug valves may be operated with either a 90° rotating lever handle or actuator. Small rubber-seated plug valves are commonly used in consumer service connections as corporation stops, curb stops, and meter isolation valves.

Cone Valves

Advantages:
- full waterway opening with low flow resistance
- good flow-control characteristics
- suitability for throttling or flow modulation
Disadvantage:
- large physical size and weight requires facility to be preplanned to accommodate the valves
- More costly when compared to gate or butterfly valves

Description. The cone valve (Figure 2-4) is a quarter-turn (90°) rotary valve for which the flow control device is a cone seating in a conically shaped body. The seating surfaces are commonly metal to metal. Cone valves have a tolerance for high velocities. Their port openings are generally the same as the pipe opening but are sometimes downsized.

Ball Valves

Advantages:
- low flow resistance
- suitability for throttling where pressure reduction is important
- high-pressure capability

Disadvantage: 
- very heavy

Description. The flow control mechanism in the ball valve is a sphere that has a waterway opening. The sphere is connected to shafts perpendicular to the waterway, and there is 90° of rotation from the closed to open positions. The seating
surfaces are either resilient on a noncorrosive metal or noncorrosive metal to metal. When ball valves are furnished with port openings of the same size as the pipe opening, they have a very low head loss. See Figure 2-5.

Small rubber-seated ball valves are used in consumer service connections as corporation stops, curb stops, and meter isolation valves. Larger ball valves are generally installed in applications where the pressure or velocity exceeds the capability of a butterfly or gate valve. Ball valves are used extensively for control or throttling service where a moderate reduction in pressure is required. In such service, the actuator is constructed to provide a mechanical advantage so that the valve operates smoothly and easily. Ball valves are covered by ANSI/AWWA C507 Standard for Ball Valves 6 In. Through 48 In., and by ANSI/AWWA C800 Standard for Underground Service Line Valves and Fittings.

Pinch Valves

Advantages:
- ease of operation
- resistance to corrosion

Disadvantage:
- only effective for flow control after 50 percent closed

Description. Pinch valves are economical and simple in design. They shut off flow by pinching and sealing off a synthetic or natural rubber tube. They are similar to the pinch cock used in laboratories. The operating mechanism is separated from the fluid, so these valves are useful where corrosion and contaminated fluids are a problem, which should not be a consideration in water distribution systems. See Figure 2-6.

Diaphragm Valves

Advantages:
- ease of operation
- resistance to corrosion

Disadvantage:
- only effective for flow control after 50 percent closed

Description. Diaphragm valves contain a flexible diaphragm attached to a compressor. The diaphragm is lowered by a valve stem onto a weir, which seals and
shuts off the flow, similar to how a pinch valve operates. Diaphragm valves are easily maintained and are used to handle corrosive, erosive, or contaminated fluids, which should not be a consideration in water distribution systems. See Figure 2-7.

Control Valves

**Advantage:**
- accurate proportioning

**Disadvantage:**
- possible cavitation resulting in excessive wear if wrong type valve used

**Description.** Control valves provide accurate proportioning control by automatically varying the rate of flow that passes through the valve according to signals received from sensing devices. Some valves are designed specifically as control units. Most types of valves, however, can be used as control valves when combined with actuators, positioners, and other accessory devices. See Figure 2-8 for a schematic of a typical control valve. Control valves function very similar to a globe valve.

VALVES USED PRIMARILY FOR ON-OFF CONTROL

The valves discussed in this section are used primarily for on-off control of water, rather than for flow control.

Gate Valves

**Advantages:**
- clear waterway for low flow resistance
- ability to block flow in either direction

**Disadvantage:**
- some designs are not suitable for flow regulation

**Description.** Gate valves are the most commonly used type of valve for isolating portions of the distribution system. Gate valves block the passage of water with a disc sliding perpendicular to the flow. They are best used to completely isolate or open a section of piping, primarily for open or closed service; some designs are not recommended for flow regulation or for throttling because of the valve seat material. Gate valves are not well suited for precise flow control because flow reduction is not proportional to travel (the extent to which the valve is open); very little flow reduction occurs until the valve is about 75 percent closed. In the full open position,
the gate has a clear waterway that keeps flow restriction to a minimum. See Figure 2-9 and Figure 2-10 for illustrations of gate valve operation.

The three commonly used types of gate valves are double-disc, solid-wedge, and resilient-seated gate valves.

**Double-disc gate valves.** Covered by ANSI/AWWA C500 *Standard for Metal-Seated Gate Valves for Water Supply Service*, double-disc valves have been in general use since the early 1900s. The design consists of two relatively loose fitting discs that, when closed, are pressed against metal seats by a wedging mechanism. The pressure is released when the valve is opened. Traditional double-disc valves are not recommended for throttling or flow-control applications. More recent resilient wedge valves do exist for these applications.
With double-disc valves, water pressure pushes past the upstream disc and allows the area between the two discs to become pressurized when the discs are in the closed position. This pressure then forces the downstream disc against the seat. Generally, the higher the pressure, the tighter the seal. Larger valves are usually equipped with a bypass valve for pressure equalization and improved ease of main valve operation. The addition of gearing on the shaft of the valve is common on valves 16 in. and larger to reduce the effort required to operate the valves. If valves 16 in.
and larger are installed horizontally, rollers, tracks, and scrapers should be used to make operation easier. Fluids with any debris (grit or mineral deposits) clog these tracks over time. Gate valves that have revolving discs do not require rollers.

The advantage of double-disc valves is that they are bidirectional, providing flow shutoff in either direction. A principal disadvantage of double-disc valves is the large frictional force that must be overcome to move the downstream disc off the seat. Two people or an actuator may be required to operate the larger valves (more than 12 in. in size). This is because of the extra torque required to operate larger valves. Also, when using an actuator, the operator must be concerned with excessive torque that may damage the valve system. In some waters, corrosion may damage the valve and make it more difficult to operate.

Solid-wedge gate valves. Also covered by ANSI/AWWA C500, the solid-wedge design involves a closure member that is a single wedge guided into fitted, tapered body seats. The wedge seats do not contact the body seats until final closure. High pressure may cause the upstream seat to allow water into the valve body but, as with the double-disc valve, the downstream seat will seal even tighter with additional pressure.

Although this type of valve is best suited for isolation or full open use, the wedge gate may be somewhat more acceptable than the double-disc valve in a throttled position because of the close guiding between the wedge and body. This type of valve also provides a clear waterway that minimizes flow restriction.


In recent years, resilient-seated valves have gained increasing acceptance for use in distribution systems. The resilient-seated gate valve has a closure member consisting of a gate that may be encapsulated with a resilient material (rubber, urethane rubber, or others) or may contain a separate resilient seat that seals against the body of the valve and provides a tight seal. ANSI/AWWA C509 also allows designs for which the resilient seat is attached to the body. See Figure 3-1 for a sample shop drawing of a resilient-seated gate valve with an outside stem and yoke.

These valves are bidirectional and provide a clear waterway when open. Because of their smoother waterway, the head loss associated with them is usually less than for metal-seated gate valves. These valves should not be used for long-term throttling. The resilient seat coating may be damaged with long-term throttling.

SPECIAL-PURPOSE VALVES

For specific system applications, valves are available to make operation simpler, more efficient, or automatic. Special-purpose valves are designed to prevent backflow, automatically control pressure, release air, or allow tapping of water lines without isolating flow.

Check Valves

The check valve is a single-direction valve that allows flow in one direction (forward) and stops reverse flow. See Figure 2-11. It opens under the influence of forward pressure and flow, and it closes automatically when flow ceases or reverses, making operation semiautomatic. In some check valve designs, an external lever with a weight or lever spring helps keep the valve closed. Check valves are also available with internal weights or internal springs to aid in closing. Because check valves cause significant pressure loss through flow restriction, they should be used only in...
applications where operational needs make them necessary.

Many other types of check valves, such as swing-type check valves, ball check valves, and others, are available; but these are considered specialized valves and will not be discussed here. Horizontal swing-check valves are covered by ANSI/AWWA C508 Standard for Swing-Check Valves for Waterworks Service, 2 In. (50mm) Through 24 In. (600 mm) NPS.

Air Release Valves

An air release valve is generally a self-actuated valve that automatically vents small pockets of air that accumulate at the high point in a water distribution system when the system is operating under pressure.

**Small-orifice air release valves.** After an air release valve is installed at the high point in a system, it fills with water and closes. During system operation, small amounts of air enter the valve from the system. As air displaces water within the valve, the water level drops. When the water level falls to the point where the float associated with the valve is no longer buoyant, the float drops. This action opens the valve orifice and allows the air that has accumulated in the upper portion of the valve body to be released into the atmosphere. As this air is released, the water level within the valve rises, lifting the float and closing the valve orifice. This cycle repeats itself whenever air accumulates in the valve.

The ability of the valve to open and release accumulated air under pressure is achieved through the use of a leverage mechanism. As the water level and float drop, the weight of the float acting on the mechanism produces a greater force to open the valve than the system pressure exerts to hold the valve closed. Generally, the higher the system pressure, the smaller the orifice diameter needed in the air release valve.

**Large-orifice air release valves.** A large-orifice air release valve enables trapped air to escape more rapidly when a line is being filled, and if combined with a vacuum relief valve permits sufficient volumes of air to enter the pipe when the line is being emptied. A large orifice-valve will not permit any further escape of air at the pipe working pressure once the valve closes. Once closed, this type of valve will reopen only when the system pressure drops to near atmospheric pressure and the float is no longer buoyant.

An advantage of the large-orifice air release valve is that, because of its large diameter, relatively low pressure (either air or water) on the orifice is sufficient to support the internal float or buoyant element. However, during a high rate of
discharge, the float or buoyant element may be caught up in the escaping air stream and slammed to its seat, sometimes resulting in a collapsed, hollow float, and possible water hammer effect.

**Altitude Valves**

Altitude valves are mostly globe-type body valves normally installed in storage tank inlet–outlet lines; they remain open until the tank is filled. The valves are then closed during normal flow conditions. They open again when the pressure in the distribution system becomes less than the static head of the height of water in the tank. These valves are usually equipped with a hydraulic pilot system that senses pressure and operates the valve.

**Pressure Relief Valves**

Pressure relief valves are used to protect against excess pressure in water lines. They lower the pressure by releasing water when the designated pressure safety limit is exceeded. They close again when the line pressure falls below the safety limit. See Figure 2-12. These types of valves are commonly used on water heaters to relieve high pressure conditions.

**Pressure Reducing Valves**

Pressure reducing valves are used to provide water to a pressure district or (zones) of lower elevation from a district of higher elevation. They are often globe valves equipped with hydraulic pilot systems similar to those of altitude valves. The valves do not close under normal flow conditions, unless doing so is required to shut off flow. Typically, a large volume and small volume valve are used in parallel.

![Figure 2–12 Pressure relief valve](image-url)
Tapping Valves

Valves used for tapping are usually solid-wedge or double-disc gate valves, covered by ANSI/AWWA C500. Resilient-seated gate valves, covered by ANSI/AWWA C509, may be suitable in some circumstances. Tapping valves are designed to be used in conjunction with a tapping sleeve or tapping saddle, and a standard tapping machine. Operators can install the sleeve and valve and make the tap under pressure in a takeoff line from an existing main without shutting down or otherwise interrupting the flow of water in the main.

NOTE: should use updated stainless steel tapping sleeve diagram with the tapping machine attachment or identify where the machine should attach to.

One end of the tapping valve consists of a modified flange with a raised lip. (The flange is a projecting circular rim that adds strength for attachment to another component.) This flange mates with the recess or counterbore in the corresponding flange of the tapping sleeve or saddle. This feature enables proper alignment of the valve on the sleeve or saddle and ensures that the shell cutter of the tapping machine meets no interference as it passes through the valve and saddle. The mating dimensions for 2-in. through 12-in. valves are standardized by the Manufacturing Standardization Society (MSS) in Standard Practice 60, Connecting Flange Joint Between Tapping Sleeves and Tapping Valves. The mating dimensions and configurations are not standardized for valves larger than 12 in.

The other end of a tapping valve attaches to the tapping machine. This end can be furnished with a flange, a standardized mechanical joint, or a proprietary push-on joint. The interface dimensions for tapping valves and tapping machines for nominal sizes up to 48 in. are described in MSS Standard Practice 60. When selecting a tapping valve, operators should determine whether the valve can be closed without the gate striking the retracted pilot drill; they should also make sure the valve is compatible with the tapping machine. The distance from the tapping machine to valve interface to the valve gate is not standardized among valve manufacturers.

Tapping machines are not standardized among manufacturers, but they typically have mating features that interface with tapping valves to ensure proper alignment. When selecting a tapping valve, operators should be sure the selected valve is compatible with the sleeve or saddle to be used. Other pertinent MSS Standard Practices include SP-111, Gray-Iron and Ductile-Iron Tapping Sleeves, and SP-113, Connecting Joint Between Tapping Machines and Tapping Valves.

Inserting Valves

An inserting valve (Figure 2-13) is a specially designed gate valve that, when used with suitable valve-inserting equipment, can be installed in an existing pipe system under full operating pressure without interrupting service. Inserting valves are placed on a previously unvalved line to control flow. Some valve sizes require a companion sleeve. These valves are produced in sizes 4 in. through 54 in. for installation in cast-iron or ductile-iron mains. They may also be used with certain sizes of steel, concrete pressure pipe, and asbestos–cement pipe, depending on the wall thickness and the outside diameters of the pipe. Because of the specialized equipment required to use an inserting valve, many utilities hire a contractor to perform the work.
ACTUATORS

A manual actuator is any lever, gear, or wheel used to facilitate movement of a valve's control element. An automatic power actuator uses an external power source that provides the torque (turning or twisting force) necessary to operate a valve automatically or remotely. Automatic power actuators are often used on valves that are frequently operated; they are a necessity on pipeline valves in remote areas. Certain power actuators can quickly shut down a pipeline in case of an emergency. Figure 1-4 shows a plug valve with an actuator attached.

Hydraulic and Pneumatic Actuators

Hydraulic and pneumatic actuators are often simple devices, with a minimum of mechanical parts, as shown in Figure 2-14. These actuators are used on quarter-turn valves and other rotary devices. Air or fluid pressure provides the required thrust or torque, acting on a piston linked to the valve stem to open or close the valve. Both types of actuators can be supplied with a fail-safe feature that turns the valve on or off as required if there is a sudden drop in operating pressure or a power failure. Because air is compressible, it should not be used on high-torque applications or where smooth operation of the valve is essential. If these actuators are installed underground, a vault should be installed which will allow future maintenance.

Electric Actuators

Electric actuators have motor drives that provide the thrust or torque to operate a valve. Electric actuators are an alternative to air or fluid type. They are most frequently used on multturn valves and on quarter-turn valves.

Finally, the valve actuator may require maintenance or repair periodically. It should be placed in a vault or an easily accessible location.
VALVE END CONNECTIONS

Valve ends of the mechanical joint, proprietary push-on joint, or flanged joint types are commonly available and can be found in combination. Other valve ends such as threaded, caulk hub, shoulder joint, and straight spigot types are typically less available. Valve ends (joints) must be compatible in the adjacent piping component and should be installed properly to achieve a leak-free joint. Figure 2-15 shows some common joint types.

In addition to flanged joint ends, special restrained push-on and mechanical joint designs are available with one or more of their joint components modified to provide mechanical locking between the valve end and the pipeline.

Detailed design information, pressure ratings, and assembly procedures can be obtained from the valve manufacturer. Some joints are proprietary, and the manufacturer has exclusive rights to their design. Other information on joints can be obtained from the appropriate AWWA standard.

Valve body material is typically ductile iron or cast iron. Wall thicknesses vary and should be analyzed. Valve body coatings should also be analyzed for specific use and durability. Bolts and nuts are typically zinc coated mild steel. Many manufacturers will use stainless steel or other types of material for bolts and nuts on valves if specified by the user.

Valves are often covered with poly wrap to reduce corrosion. Bolts and nuts can also be coated with a protective undercoating to further reduce corrosion.
Figure 2–15  Valve end connections
This page intentionally blank
Chapter 3

Valve Tests, Unloading, Inspection, and Storage

Most valve components are manufactured to standards set by the American Water Works Association (AWWA) or other organizations such as the American Society of Mechanical Engineers (ASME) and the American National Standards Institute (ANSI). These standards typically include test requirements or testing procedures to ensure that the valves are manufactured to specifications, and the manufacturer must meet all such requirements and procedures. Valve inspection at the manufacturing facility ensures that valves meet those standards and that the valves are in working order when they are shipped. However, valves should also be tested operationally when they arrive at the utility and before they are installed.

MANUFACTURING PLANT VALVE TESTS

When valves are manufactured, the work is available for inspection and approval by the purchaser’s duly authorized inspector. Notice of this requirement should be in the purchaser’s valve specifications. In-plant inspections provide additional assurance to the purchaser that the valves meet the requirements of the specification. For in-plant inspections, the manufacturer provides full facilities for inspection and observation of tests. The purchaser’s inspector should have access to all places of manufacture where materials are being produced or fabricated or where tests are conducted. An affidavit of compliance with the appropriate product standard may be required from the manufacturer even if the purchaser has an inspector at the plant.

After manufacture, each valve should be subjected to operation and hydrostatic tests (pressure tests of the valve to ensure that there is no leakage) at the manufacturer’s plant as specified in the appropriate product standards. Testing assures the buyer that the valve will perform properly. Tests conducted by the manufacturer vary based on valve type and product standard. Some of those tests are described in the following paragraphs.
Operation Test
Each valve should be operated one or more times in the position for which it was
designed to ensure correct functioning of all parts. If the valve does not meet
standards, it must be rejected. All defects in assembly or materials must be corrected
and the test repeated until satisfactory performance is demonstrated.

Shell Test
With the valve in the open position, a hydrostatic test pressure equal to twice the
rated working pressure (or that specified by the product standard) of the valve should
be applied to the body. No leakage is permitted through the metal, joints, or stem seals.

Seat Test
A test should be made from each direction at the rated working pressure (the
pressure at which the valve is designed to operate) for the time specified by the
standard to prove the sealing ability of each valve from both directions of flow. No
leakage is permitted through the metal, through the seats, or past the seat, unless
otherwise indicated in the specific standard. The seats of check valves are tested in
the stopped-flow direction.

Torque Test
A sample of each valve should be torqued in both the open and closed position to
ensure that there is no stem damage or seating damage and a resulting failure to
seal. The specific product standard for each valve type specifies the amount of torque
that should be applied. Deviations in the methods used in conducting these tests are
specified in the appropriate AWWA standard.

MANUFACTURER’S DOCUMENTS ____________________________
The purchaser may specify that the manufacturer provide documents to help the
buyer properly use the valves. The documents may include an affidavit of compliance
with the appropriate product standards, operation manuals, and shop drawings to
show dimensions, construction, and materials used. This information is vital to the
buyer for properly installing and operating the valves.

Shop Drawings
The buyer may request that the manufacturer provide assembly drawings for all
valves delivered. The drawings should include clearance requirements, dimensions,
and construction type. They should be sufficiently detailed to show that the valve
meets the requirements to comply with standards. Figure 3-1 shows a sample shop
drawing. The drawings are especially important when the number of turns, input
torque, actuator data, and protective coating are not specified in the standard. A
knowledge of the exact number of turns and direction to open or close a valve is
essential to prevent actuator failure.

Installation and Maintenance Manuals
Maintenance manuals from the manufacturer should be provided for each significant
order and for all valves. The manuals should include specific instructions for
assembly, installation, and operation. The manuals should include suggested
maintenance procedures for the operation of valves in service. Proper maintenance
can then be scheduled to maximize the service life of the valve and ensure proper
Resilient Wedge Flanged OS & Y Gate Valves

**GENERAL SPECIFICATIONS:**
- Resilient-Seated Gate Valves to AWWA C509 (OS&Y)
- Flanged Ends to ANSI B16.1-1975 class 125
- Working Pressure 200 psi
- Test Pressure 400 psi

---

**Figure 3–1** Sample shop drawing (continues next page)

<table>
<thead>
<tr>
<th>Ref Nos.</th>
<th>H Size</th>
<th>H open</th>
<th>closed</th>
<th>R</th>
<th>L</th>
<th>E</th>
<th>D</th>
<th>K Holes</th>
<th>F</th>
<th>B</th>
<th>Turns to open</th>
<th>Weight lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-065-46</td>
<td>2.5&quot;</td>
<td>15.66</td>
<td>13.06</td>
<td>9.00</td>
<td>7.50</td>
<td>0.71</td>
<td>7.00</td>
<td>5.50</td>
<td>4</td>
<td>3.94</td>
<td>2.0</td>
<td>17</td>
</tr>
<tr>
<td>25-080-46</td>
<td>3&quot;</td>
<td>16.88</td>
<td>13.78</td>
<td>9.00</td>
<td>8.00</td>
<td>0.79</td>
<td>7.50</td>
<td>6.00</td>
<td>4</td>
<td>4.33</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>25-100-46</td>
<td>4&quot;</td>
<td>20.63</td>
<td>16.53</td>
<td>11.00</td>
<td>9.00</td>
<td>0.98</td>
<td>9.00</td>
<td>7.50</td>
<td>8</td>
<td>4.96</td>
<td>2.0</td>
<td>21</td>
</tr>
<tr>
<td>25-150-46</td>
<td>6&quot;</td>
<td>28.98</td>
<td>22.88</td>
<td>13.00</td>
<td>10.50</td>
<td>1.06</td>
<td>11.00</td>
<td>9.50</td>
<td>8</td>
<td>6.22</td>
<td>2.5</td>
<td>26</td>
</tr>
<tr>
<td>25-200-46</td>
<td>8&quot;</td>
<td>37.10</td>
<td>29.00</td>
<td>14.00</td>
<td>11.50</td>
<td>1.14</td>
<td>13.50</td>
<td>11.75</td>
<td>8</td>
<td>7.13</td>
<td>2.5</td>
<td>35</td>
</tr>
<tr>
<td>25-250-46</td>
<td>10&quot;</td>
<td>44.82</td>
<td>34.72</td>
<td>18.00</td>
<td>13.00</td>
<td>1.22</td>
<td>16.00</td>
<td>14.25</td>
<td>12</td>
<td>7.99</td>
<td>2.5</td>
<td>37</td>
</tr>
<tr>
<td>25-300-46</td>
<td>12&quot;</td>
<td>51.84</td>
<td>39.74</td>
<td>18.00</td>
<td>14.00</td>
<td>1.30</td>
<td>19.00</td>
<td>17.00</td>
<td>12</td>
<td>8.50</td>
<td>3.0</td>
<td>44</td>
</tr>
<tr>
<td>25-350-46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>525</td>
</tr>
</tbody>
</table>

Copyright American Water Works Association
Provided by IHS under license with AWWA
No reproduction or networking permitted without license from IHS
Licensee=ATLATEC S A DE C V/5972499902, User=Yañez, Simon
Not for Resale, 02/13/2009 14:28:35 MST
operation. Many manuals also include troubleshooting tips and repair instructions. Often actuators can be adjusted in the field to improve closure. Actuators can be damaged by over-torquing. This should be a consideration when selecting actuators and valves. Figure 3-2 shows some typical information from a maintenance manual.

Packaging and Marking

The manufacturer is required to package valves for shipment to prevent damage in moving the materials to the utility and to mark valves with information useful to the user. As detailed in the appropriate standards, such markings may include the name of the manufacturer, the rated working pressure, the year of manufacture, and the size of the valve. Serial numbers on large valves should be recorded in utility records to allow parts to be ordered in the future.

---

**Figure 3-1 Sample shop drawing (continued)**

<table>
<thead>
<tr>
<th>No.</th>
<th>Part</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yoke</td>
<td>Ductile iron, ASTM A536</td>
</tr>
<tr>
<td>2</td>
<td>Packing</td>
<td>Asbestos free</td>
</tr>
<tr>
<td>3</td>
<td>Bushing</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>4</td>
<td>O-ring seals</td>
<td>Nitrile rubber, ASTM D2000, BUNA®-N&lt;</td>
</tr>
<tr>
<td>5</td>
<td>Valve bonnet</td>
<td>Gray iron ASTM A126 class B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ductile iron ASTM A536</td>
</tr>
<tr>
<td>6</td>
<td>Bonnet bolt seals</td>
<td>Wax</td>
</tr>
<tr>
<td>7</td>
<td>Bonnet gasket</td>
<td>Nitrile rubber, ASTM D2000, BUNA®-N&lt;</td>
</tr>
<tr>
<td>8</td>
<td>Bonnet bolts</td>
<td>Zinc coated steel, ASTM A164</td>
</tr>
<tr>
<td>9</td>
<td>Stem - A</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>10</td>
<td>Stem - B</td>
<td>ASTM copper alloy no. C99500, low zinc</td>
</tr>
<tr>
<td>11</td>
<td>Stem - C</td>
<td>Stainless steel 13% chromium</td>
</tr>
<tr>
<td>12</td>
<td>Support ring</td>
<td>ASTM copper alloy no. 836, low zinc</td>
</tr>
<tr>
<td>13</td>
<td>Pin</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>14</td>
<td>Stem holder</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>15</td>
<td>Wedge, vulcanized</td>
<td>SBR-rubber compound, AWWA C509</td>
</tr>
<tr>
<td>16</td>
<td>Wedge body</td>
<td>Gray iron, ASTM A126 class B</td>
</tr>
<tr>
<td>17</td>
<td>Nut</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>18</td>
<td>Pin</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>19</td>
<td>Handwheel</td>
<td>Gray iron, ASTM A126 class B</td>
</tr>
<tr>
<td>20</td>
<td>Washer</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>21</td>
<td>Stem nut</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>22</td>
<td>Stud bolt</td>
<td>Zinc coated steel, ASTM A153</td>
</tr>
<tr>
<td>23</td>
<td>Gland follower</td>
<td>Ductile iron, ASTM A536</td>
</tr>
<tr>
<td>24</td>
<td>Gland</td>
<td>ASTM copper alloy no. C35330, CZ 132</td>
</tr>
<tr>
<td>25</td>
<td>Hexagon nut</td>
<td>Stainless steel A320B18</td>
</tr>
<tr>
<td></td>
<td>Washer</td>
<td>Zinc coated steel</td>
</tr>
<tr>
<td></td>
<td>Valve body</td>
<td>Gray iron, ASTM A126 class B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ductile iron ASTM A536</td>
</tr>
</tbody>
</table>
OPERATING INSTRUCTIONS
WATER PRESSURE REDUCING VALVE
FIG. 4500

GENERAL:
The Figure 4500 Valve is designed to maintain a constant delivery pressure regardless of the valve’s inlet pressure. The valve is factory tested and set for the required delivery pressure, but field adjustments can be easily made.

INSTALLATION:
The valve is installed with the inlet pressure entering the main valve in accordance with the arrow indication on the drawing or underneath the main valve piston - part #2. Care should be taken to avoid damage to control piping or valve position indicator rod during installation. If the valve is to be repainted, do not paint the indicator rod as it should be smooth and clean to avoid scoring the indicator packing during operation.

OPERATION:
The main valve operates on the differential piston principle such that the area on the underside of the piston is equal to the pipe area while the area on top of the piston is somewhat greater. When equal pressures are applied to both surfaces of the piston, a closing force results which is greater than the opening force, regardless of the line pressure.

To open the main valve, all that is required is to discharge the pressure on top of the piston to the downstream side of the main valve and the inlet pressure acting on the underside of the piston will force the piston open. Trapping pressure on top of the main valve piston will cause the valve to remain in its present throttled position. The downstream pressure should be less than about 80% of the inlet pressure for good operation.

SEQUENCE OF OPERATION:
Inlet pressure is constantly being admitted to the top of the main valve piston through a needle valve which is the closing speed control.

A downstream pressure sensing pilot controls the main valve position by opening, when necessary, and exhausting the pressure above the piston to the valve’s downstream side more quickly than water can enter the area above the piston through the needle valve. An increase in the downstream pressure will cause the pilot valve to close slightly. The flow through the needle valve will then exceed the exhaust through the pilot valve, resulting in a downward movement of the piston to a new throttling position.

The needle valve must be in some degree of opening at all times. This valve affects the main closing speed, and generally ¼ and ½ turn opening of the needle valve is adequate. A “hunting” tendency of the main valve can usually be dampened by the needle valve. All other hand valves are usually fully open.

ADJUSTMENTS:

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle Valve</td>
<td>— Closing Speed Control</td>
</tr>
<tr>
<td>Hand Valve</td>
<td>— Affects Main Valve Opening Speed If Necessary</td>
</tr>
<tr>
<td>Pilot Handwheel</td>
<td>— Turn Counterclockwise to Lower the Downstream Pressure Setting</td>
</tr>
</tbody>
</table>

MAINTENANCE:
When first installed, a slight drip may appear from the air vent tube. This drip should stop when the seals wear themselves in. Should the leakage become excessive, this usually implies that one or both of the seals needs replacing.

Failing to maintain a constant pressure into a closed system may indicate the main valve piston seat rubber needs replacing or possibly the pilot seat #2 is damaged.

Erratic operation usually implies the pilot seat or seals are worn, or damaged.

If seal replacement seems to occur too frequently on valves 12 in. and larger, the factory can provide different leather seal treatments such as “Thiokol” treated leather seals, which are more abrasive resistant. On valves 2½ in., to 8 in. a high hardness rubber may be tried.

Anytime the valve is dismantled, it is recommended that the piston, liner, and seat crown machined surfaces be sanded shiny with a fine emery cloth. This will prolong seal life significantly. A light film of water proof grease or petroleum jelly should be applied to the leather seals and sliding surfaces.

Periodic inspection of the valve is suggested so that repairs can be anticipated before a malfunction occurs and a system becomes overpressurized.

Figure 3–2  Information from a maintenance manual
UNLOADING AT THE UTILITY

All valves should be unloaded carefully, and lowered gently from the truck to the ground, not dropped. The expanded use of pallets, shrink wrap, side-load trucks, and forklifts have simplified receipt and unloading of large quantities of valves. However, the handling of single valves or uncrated valves is still prevalent and the proper use of rigging (slings, chains, or strapping) is critical. In the case of larger valves, forklifts under the skids or slings around the body of the valve should be used for unloading. Only hoists and slings with adequate load capacity to handle the weight of the valve should be used. Hoists should not be hooked into or chains fastened around stems, by-passes, yokes, gearing, motors, cylinders, or handwheels.

To prevent damaging or chipping special coatings, such as epoxy, valves should be protected from lifting devices with padding. If a special coating is damaged, it should be repaired with the original coating material or a material specified by the coating manufacturer.

Some manufacturers make special lifting devices that minimize valve damage during movement of valves or installation.

INSPECTION AFTER UNLOADING

Inspect valves to verify they are in working order after they are unloaded.

Operation

Large valves should be cycled through one complete opening and closing cycle in the position in which they are to be installed. This process will confirm:

- ease of operation
- complete travel of the shutoff mechanism direction
- correct direction of opening
- required number of turns
- smaller valves may also be cycled, or they can be tested after installation

Specifications

The initial inspection also should verify compliance with specifications, including the following:

- size and pressure class (cast in the valve sides so they can easily be confirmed)
- direction of opening
- size and shape of operating nut
- number of turns to open or close
- type of end connections

Verification of end configuration requires inspection by a person familiar not only with the local specifications and requirements but also with the various end configurations available, such as flanges, mechanical joints, push-on joint ends (various configurations), and combinations of the above. ANSI/AWWA C111/A21.11 Standards for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings, and its references, are invaluable in performing this inspection.

Shipping Damage

Inspectors should also test for shipping damage, such as:

- scoring of the seated surfaces
- bent stems
- broken handwheels
• cracked parts, chipped coatings
• missing parts and accessories
• missing lubrication on exterior actuators
• coating problems can be detected with a simple “holiday detector”

After the valves have been inspected, accurate records must be made. Records should include the size and type of valve, time and date of receipt, where the valves are to be stored, comments on inspection and verification, and any comments about the shipment and the way it was received. Chapter 5 discusses record keeping in more detail.

STORAGE

Once records have been made, valves should then be stored in a way that protects them from the environment.

• large physical size and weight requires facility to be preplanned to accommodate the valves
• Metal-seated valves should be stored in the fully closed position to prevent entry of foreign material that could cause damage to the seating surface.
• Resilient-seated valves should be stored in the nearly closed position (rather than fully closed) to avoid unnecessary compression of the resilient material.
• Resilient seats should be protected from sunlight, ozone, and chemical exposure.
• Whenever practical, valves should be stored indoors. If outside storage is required, the operating mechanisms, such as gears, motor, actuators, and cylinders, should be protected from the weather and foreign elements.
• In colder climates, valves should be drained and left slightly open before storage. Failure to do so may result in a cracked valve casting.
• Valves stored outside in cold climates should be stored with the discs in a vertical position. If the discs are in a horizontal flat position, rainwater can accumulate on top of the top disc, seep into the valve body cavity, and then freeze and fracture the casting.
• Electric motor-operated valves should never be stored outdoors because of the sensitivity of electrical contacts to corrosion.

BOLTS

If experience, tests, or observations indicate bolts may be exposed to corrosive environments, the valve may be wrapped or encased with polyethylene sleeving as detailed in ANSI/AWWA C105/A21.5 Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems. Alternatively, the valve should use specially coated bolting, such as galvanized, cadmium, or special baked-on resin. Stainless-steel bolts may also be used.
Chapter 4

Installation

Many valve problems and failures can be traced to improper installation, operation, or maintenance procedures. Valve failure can result in customer disruptions and extensive and costly unearth operations and repairs. Installation personnel should review instruction manuals supplied by the manufacturer in detail before installing valves.

This chapter presents guidelines for valve installation that usually apply. Of course, each situation is unique and may require special construction techniques or design.

INSPECTION BEFORE INSTALLATION

At the job site, installers should establish a step-by-step routine to ensure that valves are properly inspected before they are installed. The routine should include the following steps:

1. Determine the direction of flow in the line to ensure proper installation. Some valves are not bidirectional. Direction of flow is critical when swing check valves are being installed. Swing check valves can be mounted with flow in the upward (vertical) flow direction (never the downward flow direction); however, with lever and weight valve styles, the configuration of the weights must assist in closing the valve.

2. Visually inspect each valve, and remove any foreign material in the interior portion of the valve. Foreign material left in the valve can damage internal working parts and may create a contamination problem.

3. Conduct a detailed inspection of the valve similar to the one done on receipt, as discussed in chapter 3.

4. Determine the actuator position needed to allow for proper orientation of the ground box or vault as required. A ground box or vault is a protective boxlike structure, usually made of concrete, that surrounds the valve and actuator and protects them from settling earth or other hazards. Valve boxes should be designed so that the load or weight from traffic on top of
the box cannot be transmitted to the valve, and the vault should be large enough to provide access to service the valve. (Additional information regarding the choice of materials for bolts can be found in Valve Handbook, Skousen, Philip L., McGraw-Hill, 2004).

**INSTALLATION**

Once preliminary steps have been completed, proper installation generally involves the following steps:

1. Support piping systems and align components to minimize bending at the valve connections.

2. Install valves in the closed position to prevent any foreign material from entering the valve.

3. Place the valve on firm footing in the trench to prevent settling.

4. Install the valve in alignment with the pipe to prohibit excessive strain on the connection to the pipe. Preventing any strain on the connection is critical in flanged installations. Flange fracture can result from unequal strains set up by improper makeup and tightening of the joints. Figure 4-1 shows the proper technique for installing and tightening flanged valves.
   a. Support and align valves.
   b. Clean dirt and grit particles from all parts.
   c. Insert bolts and nuts and tighten by hand.
   d. Tighten bolts and nuts by using the crossover method shown in Figure 4-1. Tighten the bolts and nuts across the connection from each other in order until the joint is uniformly tight (do not tighten the bolts and nuts in rotation). This crossover method will load both pipe and valve evenly and eliminate any concentrated stresses.

5. Provide a valve box or vault for each valve used in a buried-service application. The valve box should be installed so as not to transmit shock loads or stress to the valve or valve actuator. When valves with exposed gearing or operating mechanisms are installed belowground, a vault must be provided to allow pipe clearance and prevent settling on the pipe.

![Figure 4–1  Crossover tighten method](image-url)
If groundwater or surface water enters the vault, the vault floor should include a recessed drainage area and a pump to remove water from the vault. Figures 4-2 to 4-6 show one utility's drawings of its standard valve casing, extension and plug, top and bottom sections, and bonnet. Figure 4-7 shows a cross section of a valve vault.

6. Center the valve box over the operating nut of the valve. The box cover should be flush with the surface of the finished area. The operating nut should be accessible from the top opening of the vault with a valve key. Valve box should be installed in a manner that will not exert force created from street traffic to the valve.

7. If installing a larger valve that uses smaller bypass valves, install a second valve box over the bypass valve operating nut.

8. If the valves must be buried in an unusually deep trench, install a riser on the stem to permit a normal key to be used, or make a notation in the valve records (discussed later in this chapter) that a long key will be required for operation.

**TESTING AFTER INSTALLATION**

Where possible and to avoid spending valuable time searching for leaks, crews should wait to backfill valve excavations until pressure tests have been made. They should perform tests on newly installed piping sections and conduct valve tests at pressure levels higher than the system design pressure. The manufacturers' recommended testing pressure should be used. Test pressure and allowable leakage for given lengths and types of pipes and joints are given in AWWA standards and manuals.

1. After installation and before pressurization, inspect all pressure-containing bolting (bonnet, seal-plate, bypass, and end connections) for adequate tightness to prevent leakage.

2. Inspect all tapped and plugged openings of the valve interior for adequate tightness. Proper inspection at this time will minimize the possibility of leaks once the piping system is pressurized.

3. The test pressure should not exceed the rated valve pressure when resilient-seated gate valves or butterfly valves are used to isolate a test section.

4. When metal-seated gate valves are being used as closure pieces for a test, the test pressure should not exceed twice the rated valve pressure. Metal-seated valves have an allowable leakage, and this should be determined before the test. For tests at pressures greater than the rated valve pressure, the test setup should include a reduction of the line pressure to the rated valve pressure (independent of the valve) on completion of the test. The valve can then be opened enough to release trapped pressure and equalize it with the line pressure. The valve should not be opened or closed at differential pressures above its rated working pressure.

5. When installation is complete, installers should make complete records of the installation on a permanent record that will serve as a reference during maintenance and repair. Specifics on record keeping are described in chapter 5.
Figure 4-2  Drawing of a typical valve casing

DESIGN SPECIFICATIONS:
TOLERANCES OF ± 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF ± 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS OF 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)
DESIGN SPECIFICATIONS:
TOLERANCES OF ± 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF ± 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)
L (LENGTH) SIZES ARE 450, 600 AND 900mm

NOTE:
DESIGNED TO FIT INSIDE TOP SECTION WITH PLUG HOLDER BROKEN OFF AND REMOVED.

Figure 4–3  Drawing of a typical valve casing extension and plug
DESIGN SPECIFICATIONS:
TOLERANCES OF + 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF + 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS OF 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMAL MATERIAL STRENGTH 207 Mpa (30,000 psi) REFERENCING ASTM Spec. A-48
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)
L (LENGTH) SIZES ARE 600, 900 AND 1200mm

Figure 4–4   Drawing of a typical valve casing top section
DESIGN SPECIFICATIONS:
TOLERANCES OF ± 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF ± 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS OF 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)
L (LENGTH) SIZES ARE 900, 1200 AND 1500mm

Figure 4–5 Drawing of a typical valve casing bottom section
Figure 4-6  Drawing of a typical valve bonnet

**DESIGN SPECIFICATIONS:**
TOLERANCES OF ± 3mm ALLOWED FOR CASTING DIMENSIONS OF 25mm OR LESS.
TOLERANCES OF ± 6mm ALLOWED FOR CASTING DIMENSIONS IN EXCESS OF 25mm.
ALL CASTINGS TO BE IN ACCORDANCE WITH ASTM A48.
MINIMUM TENSILE STRENGTH 207 Mpa (30,000 psi)
Figure 4–7 Valve vault cross section
This page intentionally blank
Chapter 5

Operation and Maintenance

In recent years, much discussion has taken place regarding “Best Management Practices” for distribution system valves. It is difficult for water providers to consider an annual scheduling of the operation and maintenance of each valve in their system. For this reason, it is important to identify the critical valves necessary to maintain the effective provision of service in an emergency or during a crisis. Once selected, it should be the intent of the agency to schedule maintenance and operation on these valves in a manner that can be achieved within a reasonable time frame.

Smaller systems should also identify critical valves within their infrastructure and schedule their operation and maintenance in such a way that can be accomplished within the time parameters established to facilitate their effective availability. One process when establishing a program is to determine the percentage of the total number of valves to be operated, maintained, and/or replaced every year. This number or percentage should be based on the time the agency has established as necessary to operate every valve.

For instance, if it is decided to operate all the valves within the system every five years then the total number of valves should be divided by five and the resulting amount is the goal of the number to be operated each year. It is imperative to start with the critical valves as being part of this number. This same process can be used to maintenance valves but with a lower percentage because of the greater amount of time and often equipment needed to provide that service.

Another approach is to methodically work through the entire network from north to south, east to west, etc., to process each valve targeting the critical valves for the needed attention. This plan has to have goals like the one mentioned above, but are achieved in a different way. It should be understood and cannot be overstated that to develop a process that is both achievable and beneficial to the effective maintenance and operation of the system is the goal.

As the discussion of operation and maintenance ensues, the question arises whether to provide the maintenance of the valve along with its operation or to do
them separately. The response is dependent on the manner in which the agency processes its work.

Some organizations have crews that operate only, or provide maintenance only, or perform replacements only. Other agencies have crews that provide either a combination of these services or all of them during the course of their assigned work. Some valve crews have been known to operate valves in a particular area for three days and provide maintenance the other two. It is important to reiterate that all distribution valves be exercised or operated on a periodic basis to maintain the reliability of their service. If properly operated, most valves tend to require less maintenance and have been known to last a long time.

PLANNING A MAINTENANCE SCHEDULE

Water providers have been challenged to plan their maintenance considering various types of crisis situations and emergencies. This means simply that worst-case scenarios have to be factored into the process of scheduling this effort. As previously mentioned, the critical valves must be identified, but before that, the priorities of the system should be established. The system’s priorities will dictate what the critical valves are. If important customers like hospitals, schools, certain businesses, etc., have been determined to be critical, the selection of the valves associated with these facilities will be identified.

In communities that do not have many commercial and/or industrial customers, or have not deemed those customers as critical, their complexities may relate more to the older portion of their infrastructure versus the newer portion or the higher pressure zone against the lower pressure zone. All these components should be considered when establishing a process to provide maintenance to the valves.

The philosophy of maintenance of most agencies is to fix things that break. This is not wrong in and of itself but leaves the agency in a vulnerable position.

REACTIVE VERSUS PREVENTATIVE MAINTENANCE

Reactive maintenance is typically referred to as the kind performed when a valve’s usefulness has deteriorated or has experienced failure. The major difficulty with reactive maintenance is that one never knows when it will occur. This can be complicated to a greater degree if the parts necessary for repair/replacement are not available at the time they are needed. Reactive maintenance is the most expensive as well as the least efficient.

Preventive maintenance identifies the scheduling of required maintenance. It incorporates having the needed parts, identifying impacted customers, etc., to perform an efficient repair/replacement. Preventive maintenance (PM) is based on trying to repair/replace the valve that is due to fail before it fails. Another aspect is to regularly maintain the valves so that the ability to predict the failure is better enhanced.

One of the major problems in implementing a scheduled preventive maintenance program for valves is the apparent magnitude of the job. There may be hundreds of valves even in a small distribution system. However, if a systematic maintenance schedule is applied, the task becomes less daunting. In general, the following rules for operation, inspection, and maintenance apply:

- Inspections should be made of each valve on a regularly scheduled basis (annually if possible) and at more frequent intervals for valves with a 16-in. diameter and larger or valves deemed critical.
• Inspection should include examining the condition of the valve box or vault, operating the valve several times, and lubricating where required.

• Preventive maintenance should be performed as necessary or as suggested by the manufacturer.

• All gate valves should be cycled from full open to full close and back to open at least once every five years. Caution should be exercised when large valves in critical single-source transmission mains are cycled to the fully closed position. Some valves (such as butterfly valves that have a seating where a resilient coating meets stainless steel, or valves with actuators isolated from the contents of the line) may need less exercise. The manufacturers’ guidelines should be followed.

• Repairs should be made promptly and correctly. Records of all operation and maintenance should be maintained. Computer programs are available for such record keeping.

**VALVE MAINTENANCE PROCEDURES**

Operation and maintenance procedures for various types of valves are detailed in manufacturers’ operation manuals and in the appropriate product standards. The following paragraphs provide guidelines for most situations.

A valve that has not been operated for a number of years needs to be closed by using a series of up and down motions. Crews attempting to close a difficult valve should never use a T-handle and extension to force the valve closed. Such overtorquing to obtain a positive shutoff can cause damage to the valve. Torque-limiting devices are available. Crews should follow the following guidelines to close a valve properly:

1. Begin with a steady amount of torque in the direction necessary to close the valve, moving through 5 to 10 rotations.
2. Reverse for two or three rotations.
3. Reverse again and rotate 5 to 10 more turns in the closing direction.
4. Repeat this procedure until full closure is attained.
5. Once the valve is fully closed, it should be opened a few turns so that high-velocity water flowing under the gates can move the remainder of the sediment downstream with more force and clear the bottom part of the valve body for seating.
6. Fully close the valve again.

The reason for this cautious approach is that debris and sediment often build up on the gates, stem, and slides. If this material is compacted while the valve is being closed, the torque required to close the valve continues to build as the material is loaded. If the procedure previously described is used, the stem and other parts are “scrubbed” by the series of back-and-forth motions, and water in the system can flush the debris that has broken loose away from the stem gate and slides or guides.

**RECORD KEEPING**

Asset management requirements have allowed water providers to do a better job of not only knowing where the valves in their system are but to be more aware of their
condition as well. Accurate and up-to-date valve records are an integral part of an agency’s ability to validate the effectiveness, integrity, and reliability of its system. This information has great value to local fire departments, oversight and/or regulatory agencies, along with organizations providing ratings for insurance purposes to businesses and homes in the impacted areas.

The utilization of GIS/GPS integration into the operation of distribution systems has enhanced a water provider’s ability to locate and maintain their valve infrastructure. Computer programs have been added to assist in determining when valves need maintenance and/or replacement. The record of the valves should be detailed enough to provide information to reflect the history and reliability of the component.

Certain kinds of disasters or emergencies like explosions, floods, or tornadoes make it difficult to locate or access valves at the surface which is one of the reasons why it is important to have the physical location of the valve, its lid or pit identified as part of the record.

Design of Valve Records

A utility using a manual card system should have two sets of cards. One set, in a master file, should be retained in the office at all times. A second file may be used by field crews for operation and inspection of the valves. The valve record card should contain information on valve condition, testing, and maintenance required. Figure 5-1 shows a sample valve record card.

All information should be transferred from the field order to the permanent record as soon as possible after field inspection or maintenance of the valve. Computer programs are available for valve records and are capable of printing cards that can be used for field inspection or maintenance work orders. Computer-generated valve record cards should be designed for easy information entry in the field.

Technology within the industry has advanced to the point that hand-held devices are used to locate valves and report their status. Laptop computers can be installed in valve maintenance vehicles to upgrade the data from the field in a faster manner than before, and modeling programs are often employed to aid in determining their size and location within the system.

Valve records can include the following information:

- **Size of the valve**: 6 in., 8 in., etc.
- **Valve type**: identifies the valve design (gate, butterfly, resilient seat, check, or other design)
- **Function and purpose**: indicates whether the valve is a main line valve, hydrant branch valve, service line valve, bypass valve, division valve, or other such function. Current status should also be listed.
- **Manufacturer**: manufacturer’s name, casting year, model number, and reference shop drawings, if available.
- **Type of access**: valve box or valve pit with lid size. The size of the access opening indicates what maintenance can be done from ground level through the pit or box opening and assists in identifying the casting.
- **Actuator**: indicates the torque required to operate the valve, whether the operating nut is direct to the valve stem or through a gear drive to the valve stem, or if it is a power-operated remote control valve.
**VALVE REPORT**

<table>
<thead>
<tr>
<th>VALVE NUMBER:</th>
<th>VALVE LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STREET: ________ AVENUE: ________</td>
</tr>
<tr>
<td>CADAstral:</td>
<td></td>
</tr>
</tbody>
</table>

**VALVE ALIGNMENT:**

**GPS COORDINATES:**

**WATER MAIN ☐ HYDRANT LEAD ☐ SERVICE LEAD ☐ INFORMATION**

**ALIGNMENT:**

**SIZE:** ________ mm **TYPE:** __________ **MAKE:** __________

**VALVE INFORMATION**

**VALVE SIZE:** ________ mm **TYPE:** __________ **MAKE:** __________

**MODEL:** __________ **CLASS:** __________

**VALVE PURPOSE:**

- MAIN CONTROL ☐
- GEARED: YES ☐
- HYDRANT CONTROL ☐
- NO ☐
- SERVICE CONTROL ☐
- OTHER ☐ __________

**TO OPEN TURN:**

- LEFT ☐
- VALVE STATUS: OPEN ☐
- RIGHT ☐
- CLOSE-STOP ☐
- OTHER ☐ __________

**KEYWAY:** CAST IRON ☐

**ENCASED IN P.V.C. ☐** **VALVE INSTALLATION DATE:** __________ __19__

**PROJECT NUMBER OR W.O. & ACCT.:** __________

**FOREMAN OR CONTRACTOR:** __________ **YARD:** __________

**IN SERVICE DATE:** __________ **APPLICATION NO.:** __________

**REMARKS:**

---

**FIELD SKETCH**

PLEASE INCLUDE COUPLINGS, FITTINGS, CHAMBER, PROP. LINES, CURBLINE, SIDEWALK ETC.

---

*Courtesy: Kanwal Oberoi*

Figure 5–1 Sample valve report
• **Direction of operation:** indicates whether the valve opens right or left.

• **Position:** indicates normal position of the valve (open or closed) in the distribution system.

• **Date installed and maintained:** the installation date enables the valve maintenance crew to make the decision whether to repair or replace a broken valve, and it assists in identifying the parts required for repair. The date of the last preventive maintenance should also be listed.

• **Maximum turns:** the maximum number of revolutions required to close or open the valve completely. This information is very important to the field crew because it reduces the possibility of overtorquing the valve and breaking the stem during operation.

• **Test turns:** the number of revolutions in turning the operating nut when the valve was exercised, last tested, or inspected. Test instructions and comments, such as notes indicating the number of revolutions recommended to exercise the valve, should be included.

• **Distribution map or map quadrant number:** intersection identification that will reference the valve to the distribution map.

• **Location:** the street name and intersection that indicates the location of the valve. The dimension for the valve to the center line of the street and from the center line of an intersecting street or other permanent reference points should be included. Measurements should always be taken from permanent points (not fire hydrants, building corners, or other points that may be lost or moved).

With current global positioning technology, X–Y coordinates should be captured for valve location. Because the X–Y coordinates never change, it is simple to identify the valve location using this equipment. This function is performed using GPS/GIS equipment.

• **Pertinent information:** soil conditions, installation difficulties, cost of installation, keyway material, etc.

• **Other information:** include valve number or asset number for identification purposes.

**Lists of Deficiencies and Repairs**

Two other categories of information often included on valve records are deficiencies and repairs. Items found on a list of deficiencies can include the following:

• inability to locate casing

• incorrect casing measurement

• poor casing accessibility

• poor casing grade

• casing that requires cleanout

• spoils in casing

• water in casing

• frozen casing
• leaking valve
• valve found closed
• valve found open
• poor access to operating nut
• poor operation
• noisy operation
• broken top section
• obstruction
• broken plug
• missing plug

Some tasks found on a list of repairs include:
• inspect
• operate
• lower
• raise
• replace top section
• replace plug
• flush casing
• thaw casing
• pump out casing
This page intentionally blank
Distribution Valves
Emergency Response Planning

The implementation of a well-documented maintenance program for distribution valves will greatly enhance an agency’s ability to prepare for and quickly recover from various emergencies. A distribution system operator is faced with the challenge of restoring service to their customers in a timely manner whether responding to an earthquake, a flood, hurricane, tornado, or a man-made disaster.

This response can be accomplished by the effective utilization of the following:

- Accurate valve maintenance records
- Properly maintained valves and appurtenances
- GIS/GPS integration of system infrastructure
- Hydraulic and water quality modeling programs
- A regularly exercised emergency response plan

The identification of critical valves as part of the required vulnerability assessment* has a greater value than just knowing where these components are located. It provides the ability to isolate sections of the infrastructure using these valves in the repair/replacement process. This information should be updated regularly. Determining the needed equipment, materials, and personnel to restore service can be more effectively planned with this information.

*Public Health Security and Bioterrorism Preparedness and Response Act, signed into law 2002. U.S. Public Law 107-188 requires vulnerability assessments be performed and emergency response plans be created or updated for drinking water systems that serve more than 3,300 people. For more information, please go to http://cfpub.epa.gov/safewater/watersecurity.
PLANNING A RESPONSE

Regardless of the emergency, the distribution system valve must be relied on to restore service. As part of the planning process, various scenarios should be considered to better equip the agency for system recovery. Depending on the situation, there are things that can be done prior to, during, and after the event to help in the process of bringing the system back into service.

Prioritizing levels of service is a vital component when planning a response to emergencies. The needs of critical customers like medical facilities and/or other emergency institutions should be determined to produce an effective response.

The isolation valves can be utilized to separate a portion of the system to reduce the impacted areas in certain disasters. For instance, if the affected area of an emergency or event can be determined prior to its occurrence, specific valves can be operated to lessen the number of customers who may experience a disruption of service. This determination of impact can also be useful during modeling or developing repressurization, chlorinating, and sampling plans.

DURING AN EMERGENCY OR EVENT

Certain hazards have different impacts on the infrastructure based on their severity, type, and the preparedness of the system. Established goals for the system and particularly the operation of valves help to determine the amount of time it will take when the restoration process begins.

Staff knowledge in the following areas will have a direct impact on the recovery of service:

- Proper operational procedures
- Component and/or system capabilities/complexities
- Redundancy and operational flexibility
- Inventory of spare and replacement parts
- The location of repair/replacement parts

The operation of valves to isolate the area impacted by the emergency is essential. This isolation could reduce the portion of the system contaminated as well as lessen the amount of time necessary to get the components fully operational.

AFTER THE EVENT

If the agency has properly planned and practiced its emergency response plan, it will be better prepared to bring the system back on line in a timely manner. This preparation, along with the effective maintenance and operation of infrastructure valves, will allow the agency to provide a quality product to the people it serves as well as to reduce the negative impact of any emergency.

An important part of restoring service is to make an assessment of the condition of the system. As it relates to valves, this assessment entails the following:

- Determining the number of valves impacted
- Evaluating the condition of these valves
- Prioritizing the repair/replacement of valves
- Utilizing the necessary parts and equipment needed
• Documenting the damaged incurred
• Documenting the repair/replacement work completed

POST-INCIDENT REVIEW ________________________________

After fully restoring the system capacity, conduct a post-incident review. Prepare a report documenting the outcome of the review to include:

• A chronology of the event
• A listing of impacted components
• A condition assessment of the components
• The identification of repair/replacement parts used
• The equipment and supplies utilized
• The number of employees used and their hours worked
• An assessment of what worked during the process
• The identification of what did not work throughout the event
• A recommendation of what should have been done differently

This review should incorporate the presentation of the information gathered to all appropriate parties, including agency personnel, elected officials, regulatory agency individuals, and the general public.


Index

NOTE: f. indicates a figure.

Actuators, 23
electric, 23
and ground boxes or vaults, 35–36
hydraulic and pneumatic, 23, 24f.
Air release valves, 20
large-orifice, 20–21
small-orifice, 20
Altitude valves, 21
American National Standards Institute (ANSI), 27
American Society of Mechanical Engineers (ASME), 27
American Water Works Association (AWWA), 27

Ball valves, 14–15, 15f.
Bolts and coating, 33
Bonnet, 37, 42f.
Boxes and vaults, 35–37, 43f.
Butterfly valves, 11–12, 12f.

Casing, 37, 38f.
bottom section, 37, 41f.
extension and plug, 37, 39f.
top section, 37, 40f.
Check valves, 19–20, 20f.
swing-type, 20, 20f., 35
Cone valves, 13–14, 14f.
Control valves, 16, 16f.

Diaphragm valves, 15–16, 17f.

Direction of flow, 35

Distribution system, defined, 1

Documentation, 28
informational markings on valves, 30
installation and maintenance manuals, 28–30, 31f.
shop drawings, 28, 29f.–30f.

Emergency response planning, 54
actions after an incident, 54–55
actions during an incident, 54
and isolation valves, 53, 54
and maintenance program, 53
post-incident review, 55
prioritizing levels of service, 54

Flanged valves, 36
bolt-tightening method, 36, 36f.
Flow control elements, 3–6, 4f.
and actuators, 23
types, 4
Flow regulation methods, 10
Flow resistance, 3
Friction
and pipe diameter, 3
factors, 3
Friction loss, 3

Gate valves, 16–17, 18f.
double-disc, 17–19
resilient-seated, 18f., 19
solid-wedge, 19
Globe valves, 10, 11f.
GPS/GIS systems, 48, 50, 53
Hydraulic operators, 6, 6f.
Hydrostatic test, 27

Inserting valves, 22, 23f.

Inspection, 32
(before installation, 35–36
 operational, 32
 for shipping damage, 32–33
 for specification compliance, 32
Installation, 35
 inspection before, 35–36
 manuals, 28–30, 31f.
 steps, 36–37
 testing after, 37

Isolation valves, 53, 54

Lifting devices, 32

Maintenance. See Operation and maintenance

Manufacturers documents, 28–31, 29f.–30f., 31f.
packaging, 30
plant valve tests, 27–28
Manufacturing Standardization Society (MSS), 22

On–off and flow control valves, 10–16
On–off control valves, 16–19

Operation and maintenance, 45
computers and hand-held devices in information entry, 48
critical valves, 45, 53
determining number of valves to be operated annually, 45
and emergency response planning, 53
and GPS/GIS systems, 48, 50
list of deficiencies, 50–51
list of repairs, 51
maintenance manuals, 28–30, 31f.
maintenance schedule, 46
procedures, 47
reactive vs. preventative maintenance, 46–47
record design, 48–50, 49f.
record keeping, 47–51
separate or combined procedures, 45–46
working through network in geographical order, 45
Operation test, 27, 28
Packaging, 30
Pinch valves, 15, 16f.
Piston valves, 11
Plant valve tests, 27–28
Plug valves, 12–13, 13f.
eccentric, 13
Pneumatic operators, 6
Pressure reducing valves, 21
Pressure relief valves, 21, 21f.
Sealing mechanisms, 6
metal, 6, 7
sealants, 6, 7
soft, 6, 7
Seat test, 28
Shell test, 28
Shop drawings, 28, 29f.–30f.
Special-purpose valves, 19–22
Standards, 27
ball valves, 15
butterfly valves, 12
metal-seated gate valves, 17, 19
organizations, 27
polyethylene encasement for ductile-iron pipe systems, 33
resilient-seated gate valves, 19
rubber-gasket joints for ductile-iron pressure pipe and fittings, 32
swing-type check valves, 20, 20f.
Stems, 4–5
Storage, 33
Tapping valves, 21
mating dimensions, 22
Tests and testing
after installation, 37
manufacturers', 27–28
Torque test, 28
Unloading, 32
Valve boxes and vaults, 35–37, 43f.
Valve end connections, 24, 25f.
Valve operation mechanisms, 5–6, 5f.
Valves
bury depth, 5
closing difficult valves, 47
design considerations, 3–7
for flow control and on–off operation, 10–16
flow regulation methods, 10
function in distribution systems, 1
history, 1, 2f.
for on–off control (primarily), 16–19
selection factors, 9
special-purpose, 19–22
## AWWA Manuals

<table>
<thead>
<tr>
<th>Manual</th>
<th>Title</th>
<th>Edition</th>
<th>Year</th>
<th>ISBN</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Principles of Water Rates, Fees, and Charges</td>
<td>Fifth</td>
<td>2000</td>
<td>#30001PA</td>
</tr>
<tr>
<td>M2</td>
<td>Instrumentation and Control</td>
<td>Third</td>
<td>2001</td>
<td>#30002PA</td>
</tr>
<tr>
<td>M3</td>
<td>Safety Practices for Water Utilities</td>
<td>Sixth</td>
<td>2002</td>
<td>#30003PA</td>
</tr>
<tr>
<td>M4</td>
<td>Water Fluoridation Principles and Practices</td>
<td>Fifth</td>
<td>2004</td>
<td>#30004PA</td>
</tr>
<tr>
<td>M5</td>
<td>Water Utility Management Practices</td>
<td>Second</td>
<td>2006</td>
<td>#30005PA</td>
</tr>
<tr>
<td>M6</td>
<td>Water Meters—Selection, Installation, Testing, and Maintenance</td>
<td>Second</td>
<td>1999</td>
<td>#30006PA</td>
</tr>
<tr>
<td>M7</td>
<td>Problem Organisms in Water: Identification and Treatment</td>
<td>Third</td>
<td>2004</td>
<td>#30007PA</td>
</tr>
<tr>
<td>M9</td>
<td>Concrete Pressure Pipe</td>
<td>Second</td>
<td>1995</td>
<td>#30009PA</td>
</tr>
<tr>
<td>M11</td>
<td>Steel Pipe—A Guide for Design and Installation</td>
<td>Fifth</td>
<td>2004</td>
<td>#30011PA</td>
</tr>
<tr>
<td>M12</td>
<td>Simplified Procedures for Water Examination</td>
<td>Third</td>
<td>2002</td>
<td>#30012PA</td>
</tr>
<tr>
<td>M14</td>
<td>Recommended Practice for Backflow Prevention and Cross-Connection Control</td>
<td>Third</td>
<td>2003</td>
<td>#30014PA</td>
</tr>
<tr>
<td>M17</td>
<td>Installation, Field Testing, and Maintenance of Fire Hydrants</td>
<td>Fourth</td>
<td>2006</td>
<td>#30017PA</td>
</tr>
<tr>
<td>M19</td>
<td>Emergency Planning for Water Utility Management</td>
<td>Fourth</td>
<td>2001</td>
<td>#30019PA</td>
</tr>
<tr>
<td>M20</td>
<td>Water Chlorination/Chloramination Practices and Principles</td>
<td>Second</td>
<td>2006</td>
<td>#30020PA</td>
</tr>
<tr>
<td>M21</td>
<td>Groundwater</td>
<td>Third</td>
<td>2003</td>
<td>#30021PA</td>
</tr>
<tr>
<td>M22</td>
<td>Sizing Water Service Lines and Meters</td>
<td>Second</td>
<td>2004</td>
<td>#30022PA</td>
</tr>
<tr>
<td>M23</td>
<td>PVC Pipe—Design and Installation</td>
<td>Second</td>
<td>2003</td>
<td>#30023PA</td>
</tr>
<tr>
<td>M24</td>
<td>Dual Water Systems</td>
<td>Second</td>
<td>1994</td>
<td>#30024PA</td>
</tr>
<tr>
<td>M25</td>
<td>Flexible-Membrane Covers and Linings for Potable-Water Reservoirs</td>
<td>Third</td>
<td>2000</td>
<td>#30025PA</td>
</tr>
<tr>
<td>M27</td>
<td>External Corrosion—Introduction to Chemistry and Control</td>
<td>Second</td>
<td>2004</td>
<td>#30027PA</td>
</tr>
<tr>
<td>M28</td>
<td>Rehabilitation of Water Mains</td>
<td>Second</td>
<td>2001</td>
<td>#30028PA</td>
</tr>
<tr>
<td>M29</td>
<td>Water Utility Capital Financing</td>
<td>Second</td>
<td>1998</td>
<td>#30029PA</td>
</tr>
<tr>
<td>M30</td>
<td>Precoat Filtration</td>
<td>Second</td>
<td>1995</td>
<td>#30030PA</td>
</tr>
<tr>
<td>M31</td>
<td>Distribution System Requirements for Fire Protection</td>
<td>Third</td>
<td>1998</td>
<td>#30031PA</td>
</tr>
<tr>
<td>M32</td>
<td>Distribution Network Analysis for Water Utilities</td>
<td>Second</td>
<td>2005</td>
<td>#30032PA</td>
</tr>
<tr>
<td>M33</td>
<td>Flowmeters in Water Supply</td>
<td>Second</td>
<td>1997</td>
<td>#30033PA</td>
</tr>
<tr>
<td>M36</td>
<td>Water Audits and Leak Detection</td>
<td>Second</td>
<td>1999</td>
<td>#30036PA</td>
</tr>
<tr>
<td>M37</td>
<td>Operational Control of Coagulation and Filtration Processes</td>
<td>Second</td>
<td>2000</td>
<td>#30037PA</td>
</tr>
<tr>
<td>M38</td>
<td>Electrodialysis and Electrodialysis Reversal</td>
<td>First</td>
<td>1995</td>
<td>#30038PA</td>
</tr>
<tr>
<td>M41</td>
<td>Ductile-Iron Pipe and Fittings</td>
<td>Second</td>
<td>2003</td>
<td>#30041PA</td>
</tr>
<tr>
<td>M42</td>
<td>Steel Water-Storage Tanks</td>
<td>First</td>
<td>1998</td>
<td>#30042PA</td>
</tr>
<tr>
<td>M44</td>
<td>Distribution Valves: Selection, Installation, Field Testing, and Maintenance</td>
<td>First</td>
<td>1996</td>
<td>#30044PA</td>
</tr>
<tr>
<td>M45</td>
<td>Fiberglass Pipe Design</td>
<td>Second</td>
<td>2005</td>
<td>#30045PA</td>
</tr>
<tr>
<td>M46</td>
<td>Reverse Osmosis and Nanofiltration</td>
<td>First</td>
<td>1999</td>
<td>#30046PA</td>
</tr>
</tbody>
</table>

To order any of these manuals or other AWWA publications, call the Bookstore toll-free at 1-(800)-926-7337.
To order any of these manuals or other AWWA publications, call the Bookstore toll-free at 1-(800)-926-7337.