M49

Quarter-Turn Valves: Head Loss, Torque, and Cavitation Analysis

Third Edition

American Water Works
Association

Manual of Water Supply Practices—M49, Third Edition

Quarter-Turn Valves: Torque, Head Loss, and Cavitation Analysis

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Contents

Preface

The purpose of this manual is to present a recommended method for calculating operating torque, head loss, and cavitation for quarter-turn valves typically used in water works service. It is a discussion of recommended practice, not an American Water Works Association (AWWA) standard. The text provides guidance on generally available methods for using quarter-turn valves as well as their cavitation, flow, and torque characteristics. Questions about specific situations or applicability of specific valves and values should be directed to the manufacturers or suppliers. Information in this manual is useful for technicians and engineers who want a basic understanding of the calculations associated with the use and specification of quarter-turn valves. The valve torque, flow, and cavitation coefficients given are typical but generic values covering a variety of products. Actual flow, cavitation, or torque coefficients for a particular manufacturer's valve should be used in calculations for a specific valve and application to obtain the highest calculation accuracy.

The history of this manual is related to that of American National Standards Institute ANSI/AWWA C504, Standard for Rubber-Seated Butterfly Valves. Until the 1994 edition, ANSI/AWWA C504 included Appendix A, which described a recommended method of calculating torques for butterfly valves. This appendix was deleted from the 1994 and subsequent editions of the standard for several reasons. The AWWA Standards Council directed that standards documents should not contain appendixes; appendix text should either be moved to the main body of the standard or be made into a separate, stand-alone document. Members of the committee for ANSI/AWWA C504 at the time were concerned that the existing text of Appendix A no longer represented the current state of knowledge concerning methods for calculating torques for butterfly valves. In 1993, a subcommittee was established to rewrite Appendix A as a separate manual incorporating the state-of-the-art theory for calculating torque and head loss values for butterfly valves. The second edition of the manual expanded the introduction and some equations, added torque sign conventions, added double-offset disc design variables and calculations, added equations for eccentricity torque, added metric units and equivalents, consolidated the nomenclature, and corrected some errors. This third edition manual broadens the application of these methods to include other quarter-turn valves such as ball, plug, and rotary cone valves.

Manual M49 refers to AWWA standards available for purchase from the AWWA Bookstore. 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.

Chapter 1

Introduction

Head loss, torque, and cavitation are important considerations in the selection and sizing of quarter-turn valves in water systems. Quarter-turn valve components must be able to withstand the forces and torques generated during use, and the actuator must drive and seat the valve. The head loss developed across any valve adds to the energy costs of a pumping system. Cavitation can damage a valve or adjacent piping if not controlled.

The topics in this introductory chapter include an explanation of basic quarter-turn valve design elements and their role in predicting operating head loss, torque, and cavitation. Prior editions limited this manual of standard practice to butterfly valves (BFV). This edition has been expanded to include information on other quarter-turn valves, including ball (BV), rotary cone (RCV), and eccentric plug valves (PV). Many of the included illustrations are targeted toward BFVs but are generally applicable to all the valves of this scope.

Head loss characteristics must be known to predict valve operating torque, and system designers also use these data to size a control valve, calculate pump head requirements, and evaluate the energy costs associated with the head loss across the valve in pumping applications. Valve torque is calculated to allow proper actuator sizing and to provide assurance that the valve components can withstand the internal forces produced by the fluid flow and pressure.

Cavitation is analyzed to avoid undesirable sound and vibration and to prevent damage to the valve and adjacent piping. Cavitation data are determined by flow testing. Values for the range of valve angles are helpful in predicting if cavitation will occur in a given application.

Head loss, torque, and cavitation vary with a valve's position (angle of opening). These characteristics also depend on the geometry of the valve body and closure member as well as the characteristics of the system in which the valve is installed. Flow testing procedures of a valve requires a smooth, undisturbed flow upstream and downstream of the valve, such as that produced by a run of straight, constant-diameter pipe. Although variation from this ideal condition has an effect on valve head loss and torque, these conditions are the benchmark and basis for analysis. Flow disturbances caused by piping configuration, such as elbows, reducers, or other valves within a distance less than eight times the diameter upstream of the valve, may require further review by applying the recommendations given in chapter 6.

Coefficients provided by the quarter-turn valve manufacturer may be used to calculate the head loss and torque as described in this manual of standard practice, provided that the data are determined on the basis of testing methods described in chapter 5. The typical coefficients provided in this manual are presented only for illustrative and approximation purposes. Information from the valve test data or the manufacturer is needed before calculations can be performed for a specific valve in a specific use with high accuracy. However, generalized or typical information will assist in determining the applicability or sensitivity of some characteristics for valve type selection and for most system design considerations.

The closure members of this manual of standard practice are typically referred to as the ball, disc (BFV), cone, or plug. This manual of standard practice may refer to a general closure member or to one specific design. International and European standards will also use the term *obturator* for the closure member.

SCOPE

The fluid flow and torque calculations are based on water or wastewater flow and do not specifically relate to other liquids or gases. The adjustments for application to other fluids can be found in other texts on fluid mechanics. This manual of standard practice covers round or circular BVs and BFVs within the scopes of AWWA and American National Standards Institute (ANSI) standards ANSI/AWWA C504-15, ANSI/AWWA C507-15, and ANSI/AWWA C516-14 with essentially full-ported designs in which the port diameter and closure member diameter are close to the nominal pipe size (NPS) or nominal diameter (in inches or millimeters). This includes BFVs in sizes 3 in. (75 mm) and larger and BVs in sizes 6 in. (150 mm) through 60 in. (1,500 mm).

This manual of standard practice also covers PVs that have round or oblong ports and are available with either full or reduced port areas within the scope of ANSI/AWWA C517-09. Reduced port areas are generally greater than 75 percent of full pipe area.

Rotary cone valves in sizes 6 in. thru 84 in. and pressure ratings of 125 cold working pressure (CWP) or 275 CWP in cast- or ductile-iron construction or ANSI Classes 150 and 300 in steel construction are often used in this industry and referenced in other AWWA manuals of standard practices, such as M44. This valve type does not have an AWWA standard devoted to design and construction. This type of valve is also included in this manual of standard practice.

Some manufacturers produce valves that are configured as three-way and/or four-way valves, which have three or four connection ports and require special considerations not included in this manual of standard practice. The valves covered are of the two-way (two end connections, on-off or throttling) configuration. For all of these valves, it is important to use the matching data for the valve design of interest.

NEW DEFINITIONS, MRST AND AST

For purposes of clarity and understanding, many of the AWWA quarter-turn valve standards are now referring to the operating torque requirements of the valves as two different terms. These are actuator sizing torque (AST) and minimum required shaft torque (MRST), and their definitions appear later in this chapter. These are not to be considered as single values but a series of values (or curves) that vary with valve position. In some cases, one or two (break and/or break and run) conservative or bounding values may be used throughout the entire valve stroke, but in many cases, values at 10°, 5°, or fewer degree increments of valve travel are necessary. The torque predictions of this manual of standard practice provide the most probable operating torque requirements for a valve when operated under the system conditions analyzed. This total operating torque is referred to as the MRST. Depending on the valve type, actuator standard, or manual of standard practice and the valve's application (on-off or modulating), the MRST is multiplied by an application factor (AF) to obtain an AST (AST = MRST × AF). This is also calculated at many valve positions to correctly size the actuator. See the valve or actuator standards for the application factors to be used.

The actuator sizing additional torque margin, allowances for in-service degradation, and/or safety factors for power (i.e., electric motor, cylinder, or vane) actuators are provided in other ANSI/AWWA standards and included in the AFs and other sizing requirements of the product standard.

DIAMETER ASSUMPTIONS

For the valve shaft diameter, valves meeting ANSI/AWWA C504-15 have the minimum shaft diameters given in the standard. ANSI/AWWA C516-14, ANSI/AWWA C507-15, and ANSI/AWWA C517-09 do not provide minimum shaft diameters. It is always best to obtain the shaft diameter by measurement or from the manufacturer's documentation.

Many sources are available for quarter-turn valve flow and torque coefficients. These include valve engineering handbooks; published research papers; and valve supplier manuals, catalogues, or bulletins. The manufacturer generally publishes flow coefficients (i.e., C_v, C_{vm}, or K) for most valves. Some manufacturers consider the torque coefficients (C_t) to be proprietary information and may not publish these data.

Much existing data were developed before published standardization methods, and investigators may have based their calculations on different valve diameter measurements. The major valve diameters include NPS, approach pipe inside diameter, valve port diameter, valve seat diameter, and valve closure member diameter (see Figure 1-1). Also, various publications use slight variations of these first-principles equations or use different units of measure. The user is cautioned to evaluate and convert such data to the proper format and units of measure. For instance, some BFV manufacturers provide a dynamic torque coefficient for use in the formula, $T_d = C_1 \times \Delta P$. When equated to the basic formula used herein, $T_d = C_t \times D_3 \times \Delta P$, it follows that $C_1 = C_t \times D_3$ or $C_t = C_1/D_3$.

If the data were developed on the basis of a BFV disc diameter and the prediction calculations used the nominal diameter, there will be a larger uncertainty in the results than if the disc diameter were used. This manual of standard practice gives direction on what diameter should be used for standardization, consistency, uncertainty, and/or conservatism purposes. However, for many good engineering reasons, much of the older data does not conform to these guidelines. In many instances, the exact approach pipe inside diameter, valve port diameter, and/or valve closure member diameter are not known at the time the calculation is performed. This forces the designer to assume a conservative diameter with greater uncertainty in the results.

For the valves within the scope of this manual of standard practice, the approach pipe inside diameter, valve port diameter, and valve closure member diameter are almost always equal to or less than the valve's nominal diameter when using US customary dimensions. Therefore, the use of the nominal pipe size (NPS) diameter as the diameter in torque prediction calculations will often provide a conservatively high torque value (as the diameter appears in the numerator of the equations). The nominal diameter of the valve may be used in these prediction calculations in lieu of the approach pipe inside diameter, valve port diameter, or valve disc diameter as specified with the understanding that the torque results have a higher uncertainty and are generally greater than a more precise evaluation. In all cases, if the diameter basis on which the data are based is known, the use of the same variable provides the highest-accuracy prediction.

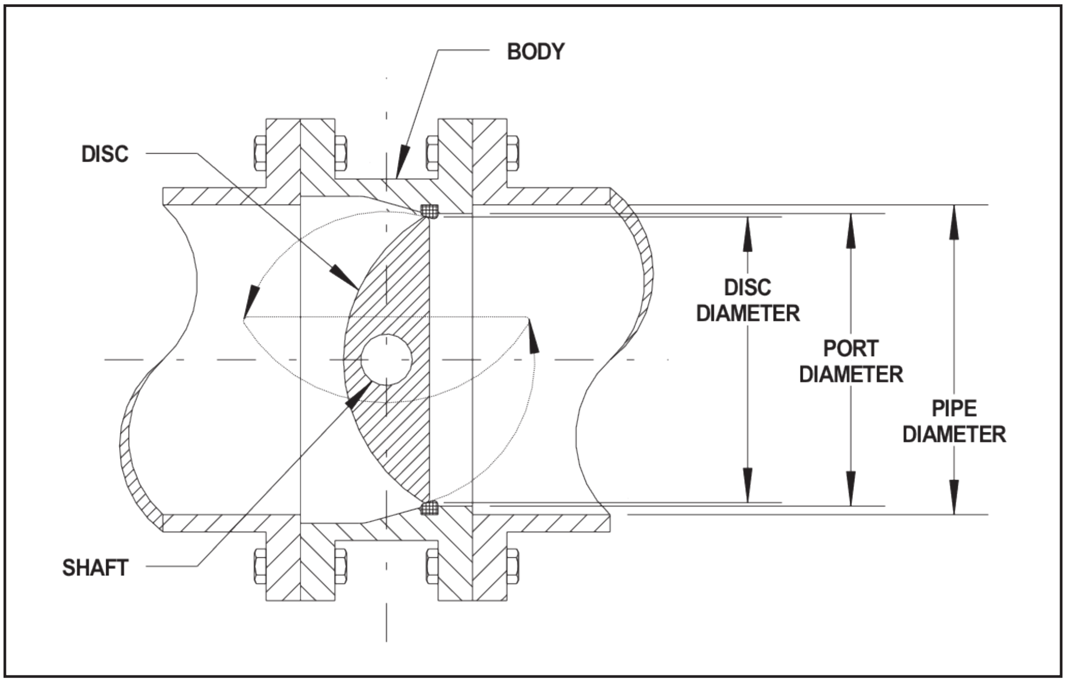


Figure 1-1 Valve disc, port, and pipe diameters

The flow coefficients, C_v and K, and testing and data collection methods that follow are those prescribed in the International Society of Automation (ISA) standard ANSI/ISA S75.02.01-2008, and are based on the test pipe inside diameter. This methodology does use two slight variations from the ANSI/ISA S75.02.01-2008 in that this practice subtracts the piping loss from the test data to obtain net (valve-only) coefficient values versus the gross (as measured, including pipe loss) values and the valve shaft axis orientation during the test. See chapter 5 for more detail.

QUARTER-TURN VALVE DESIGN

In general, valves may be classified as either linear operation or rotary operation. Linear-operating valves include slide gate, gate, globe, needle, and diaphragm valves. Rotary-operation valves include the BVs, BFVs, cone valves, and PVs in this manual of standard practice. As the full travel of many rotary-operation valves approximates a 90° rotation, they are often referred to as quarter-turn valves even though travel may be significantly more or less than 90° or a quarter turn. The quarter-turn valve is a versatile component for use with both shutoff and throttling in water systems. Quarter-turn valves are commonly supplied for the water industry in accordance with ANSI/AWWA C504-15, Standard for Rubber-Seated Butterfly Valves; ANSI/AWWA C507-15, Standard for Rubber-Seated Ball Valves 6 In. Through 60 In. (150 mm Through 1,500 mm); ANSI/AWWA C516-14, Standard for Large-Diameter Rubber-Seated Butterfly Valves Sizes 78 in. (2,000 mm) and Larger; or ANSI/AWWA C517-09, Standard for Resilient-Seated Cast-Iron Eccentric Plug Valves. As shown in Figures 1-2 through 1-5, these valves consist of a ball, cone, disc, or plug (closure member) supported in the body with a shaft, two stub shafts, or closure member trunnions and bearings. The quarter-turn operation is accomplished with a manual or power actuator connected to one shaft that penetrates the valve body and mounts to the exterior. Valves may have either metallic or elastomeric (rubber or plastic) seats.

Flow is controlled by positioning the closure member between 0° (0 percent, closed) to the full open (100 percent to approximately 90°) positions. The approximate effective throttling range for quarter-turn valves is 15° to 75° open (or 15 percent to 85 percent), but the range can vary based on application and valve design. Throttling at the lower angles (<15° or 15 percent) may cause erosion due to excessive local velocities or cavitation. Some valves are available with optional throttling or cavitation-reducing trim to extend the control range. See chapter 4 for discussions of cavitation. Throttling at the higher angles may provide limited control, because the valve has little effect on the system flow in many applications.

AWWA Ball Valve Design

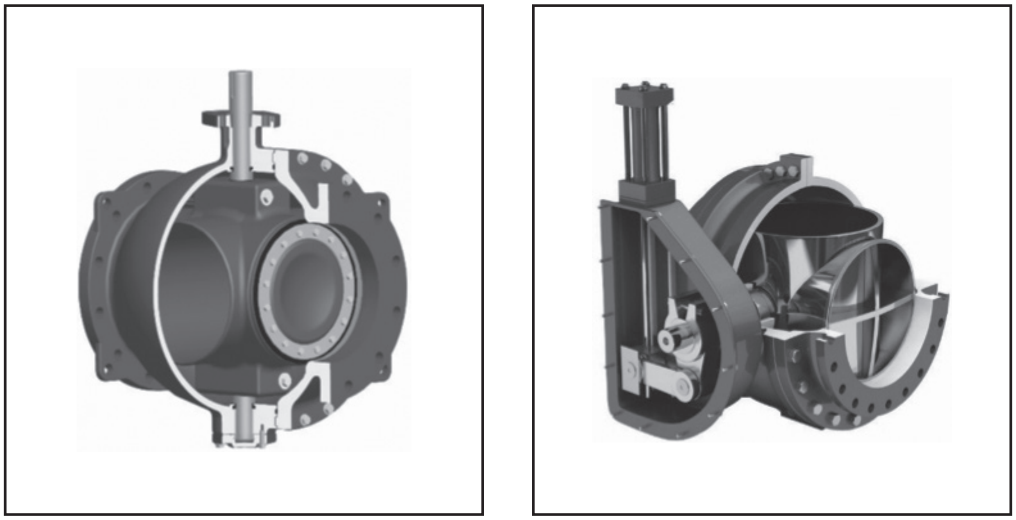
AWWA BVs are characterized by the following design elements (see Figure 1-2):

- They primarily consist of a bored spheroidal closure member (obturator/ball) that rotates roughly a quarter turn on a shaft or trunnion within the valve body.
- Ports are full nominal size (US customary) and unobstructed. (Note: Non-AWWA valves may have reduced ports.)
- Closure member (ball) may be shaft- or trunnion-mounted within the body. (Note: Non-AWWA valves may have a floating ball that is supported by the seats.)
- Closure member (ball), when symmetrically mounted, is position-seated and does not close tighter by increasing the shaft torque at the seated position.
- Closure member (ball), if eccentrically mounted, may be either position- or torque-seated. The seat seal will be tightened by increasing the shaft torque against the seat.
- Bodies may be one-, two-, three-, or four-piece construction.
- Seats may be metallic-to-metallic or metallic-to-elastomeric.
- BVs may be single- or double-seated.
- In double-seated valves, the downstream seat often provides the primary closure seal.
- They are often used in pump control service to control surges and may act as a power-operated check valve.
- In pump control service, a single-seated BV should be installed to seal tightest against system reverse flow, not pumped flow. (This generally places the seat end of the valve toward the pump.)
- They offer good flow control with a near equal percentage inherent valve characteristic.
- The full diameter circular port offers the lowest possible full open head loss.
- The unobstructed full open flow path does not produce cavitation or vibration.

AWWA Butterfly Valve Design

AWWA BFVs are characterized by the following design elements (see Figure 1-3):

- They primarily consist of a circular closure member (obturator/disc) that rotates about a quarter turn on a shaft within the valve body.
- Typically these valves have ports that are relatively close to full nominal size of pipe inside diameter.
- Seats may be metallic-to-elastomeric or metallic-to-metallic.



Two-Piece Body Design Four-Piece Body Design

Courtesy of Val-Matic and DeZURIK

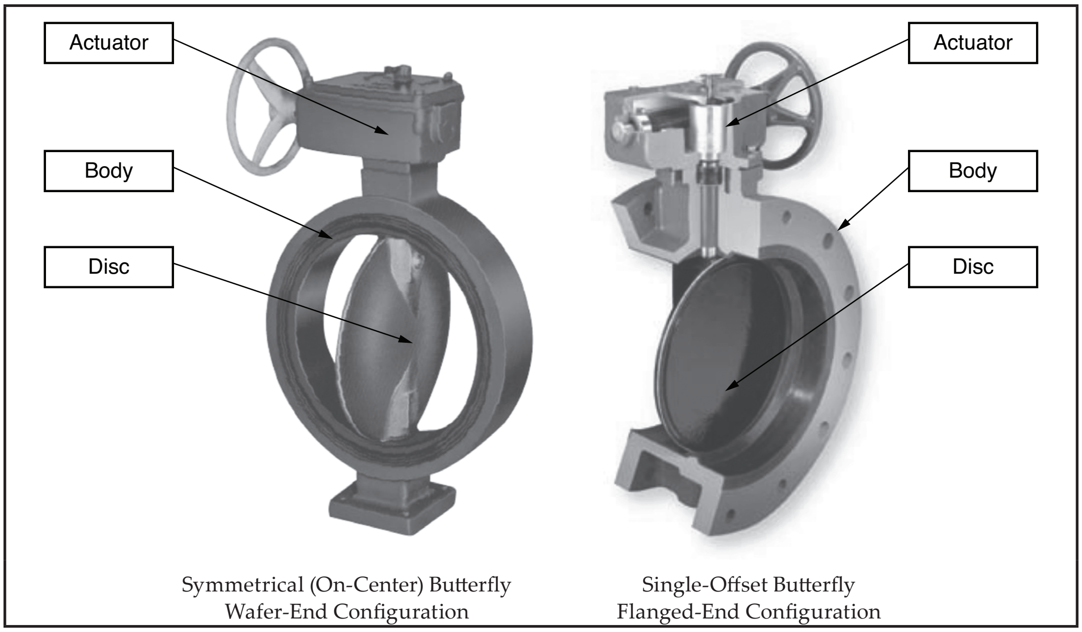
Figure 1-2 Typical ball valve construction

- The disc and seats may be symmetric (on center) design or single-offset, double-offset, or triple-offset designs.
- Symmetric and single-offset designs are position-seated and do not close tighter by increasing the seating shaft torque.
- Double- and triple-offset designs may be either position- or torque-seated. The seat seal will be tightened by increasing the shaft torque against the seat.
- They may be used in pump control service to control surges and may act as a power-operated check valve.
- They offer good flow control with a near equal percentage inherent valve characteristic.
- They offer very low full open head loss.
- Some designs may have a pressure seal direction preference.
- Some designs may have a flow and torque direction preference.

AWWA Plug Valve Design

AWWA PVs are characterized by the following design elements (see Figure 1-4):

- The PV primarily consists of an offset closure member (obturator/plug) that rotates about a quarter turn on a shaft within the valve body.
- Typically these valves have ports that are not circular and may have a full or slightly reduced port area.
- Seats are metallic-to-elastomeric.
- The plug and seat are an eccentric design (e.g., double-offset).
- Materials and construction are designed for both clean-water and wastewater service.
- PVs may be either position- or torque-seated, so the seat seal will be tightened by increasing the shaft torque against the seat.



Courtesy of Pratt and DeZURIK

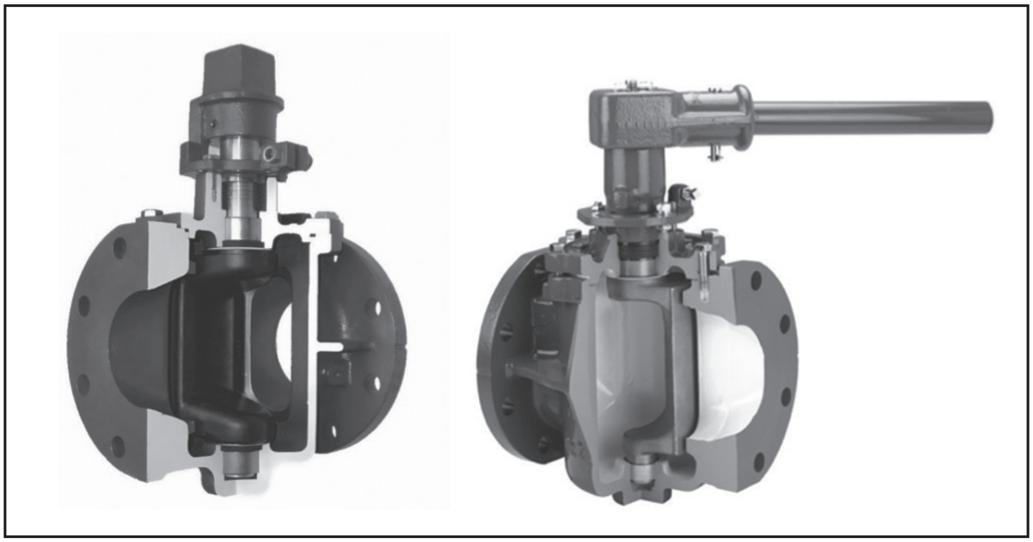
Figure 1-3 Typical butterfly valve construction

- They may be used in pump control service to control surges and may act as a power-operated check valve.
- In pump control service, a PV should be installed to seal tightest against system reverse flow, not pumped flow. (This generally places the seat end of the valve toward the pump.)
- They offer good flow control with a near equal percentage inherent valve characteristic.
- They offer moderate to low full open head loss.
- The normally preferred seal direction installation is the direct pressure orientation.

Rotary Cone Valve Design

Rotary cone valves used in the water and wastewater industry are not covered by an AWWA standard but are typically characterized by the following design elements (see Figure 1-5):

- They primarily consist of a bored and tapered conical closure member (obturator/cone) that rotates a quarter turn on a shaft or trunnion within the valve body and then seals by lowering the tapered cone into the metal seats with an axial movement.
- The actuator provides rotation and torque though the 90° operation and thrust or lift at the end of travel positions.
- Ports are full nominal size and unobstructed.
- Body is one piece with a closure bonnet or cover.
- Closure member (cone) is trunnion-mounted within the body.
- Closure member (cone) is typically symmetrically (concentrically) mounted and lift-seated but does close tighter by increasing the shaft thrust into the seat.
- Seat seals are metallic-to-metallic and generally Monel® for severe flow and corrosion-resistant service.



Courtesy of Val-Matic and DeZURIK

Figure 1-4 Typical plug valve construction

- The seats are precision ground to mate for drip-tight shutoff.
- Shaft axial movement of the cone into the seat provides the primary closure seal.
- They are often used in pump control service to control surges and may act as a power-operated check valve.
- They offer good flow control with an equal percentage inherent valve characteristic.
- The full diameter circular port offers the lowest possible full open head loss.
- Unobstructed flow path does not produce cavitation or vibration.

Butterfly Valve Offset Designs

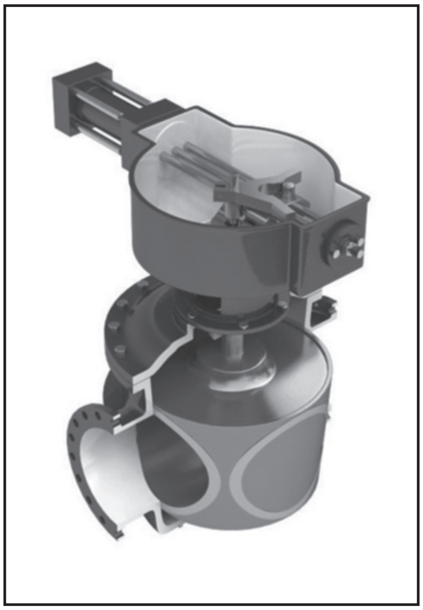
BFVs are available in several different offset designs. The discs, shafts, and seats may be aligned in various relative locations. The popular arrangements are the symmetric (on-center) design and the single-offset, double-offset, or triple-offset design.

In the symmetric (no-offset) design, the disc edge rotates and contacts perpendicularly with a theoretically cylindrical body seat surface (see Figure 1-6). This design is primarily position-seated and does not seat tighter with increased applied seating torque. In this configuration, the shaft intersects the disc's seating contact surface.

The single-offset design adds the seat offset (ε_1) and changes the perpendicular cylindrical contact surface into a theoretical conical body seat surface (see Figure 1-6). This design is also primarily position-seated and does not seat tighter with increased seating torque. In this configuration and the other offset designs, the shaft does not intersect the disc's seating contact surface.

The double-offset design adds the radial shaft offset (ε_2), which, in turn, offsets the centerline of the shaft perpendicular contact surface cone from the body perpendicular contact surface cone, resulting in an eccentric rotation and an eccentric wedge angle (see Figure 1-6). This eccentric action and wedge angle causes the seat load to increase with increased applied seating torque, and these valves may be torque-seated rather than just position-seated.

The triple-offset design rotates the body perpendicular contact surface cone of the double-offset design by the wedge angle offset (ε_3) (see Figure 1-6). This increases the



Courtesy of DeZURIK

Figure 1-5 Typical rotary cone valve construction

eccentric action and wedge angle. Therefore, the seat load increases with increased applied seating torque, and these valves may be torque-seated rather than just position-seated.

Offset valve designs are sensitive to differential pressure or flow direction orientation. Pressure on the shaft side of the disc tends to deflect the disc into the seat, and pressure from the seat side of the disc tends to push the disc away from the seat. Because of the eccentricity torque of the double- and triple-offset designs, the pressure difference in one direction assists seating but opposes unseating. In the opposite orientation, differential pressure opposes seating and assists unseating. Double- and triple-offset valves often have preferred installation orientations typically with the shaft upstream similar to the “direct” pressure installation of the eccentric PV. However, there are other torque-, flow-, and cavitation-related issues and concerns that might override and require a shaft downstream (“reverse”) preferred installation orientation. Always check the flow direction and installation orientation markings on the valve and/or the manufacturer’s drawings and O&M documentation before installing.

SYSTEM CONDITIONS

Analysis requires an understanding of system conditions that affect the head loss, torque, and cavitation calculations for quarter-turn valves, including those conditions on the following list:

1. **Fluid flow rate or velocity:** The maximum anticipated fluid flow rate or flow velocity through the nominal valve size should be determined with consideration of hydraulic design conditions and may include line break or other faulted condition flows when appropriate. The maximum anticipated flow velocity (or flow rate) is needed for the fluid dynamic torque calculations. This is generally at the full open position of the valve. If not at the full open position, then the valve’s differential pressure or the valve’s position when this maximum flow rate occurs must also be known and provided for analysis.

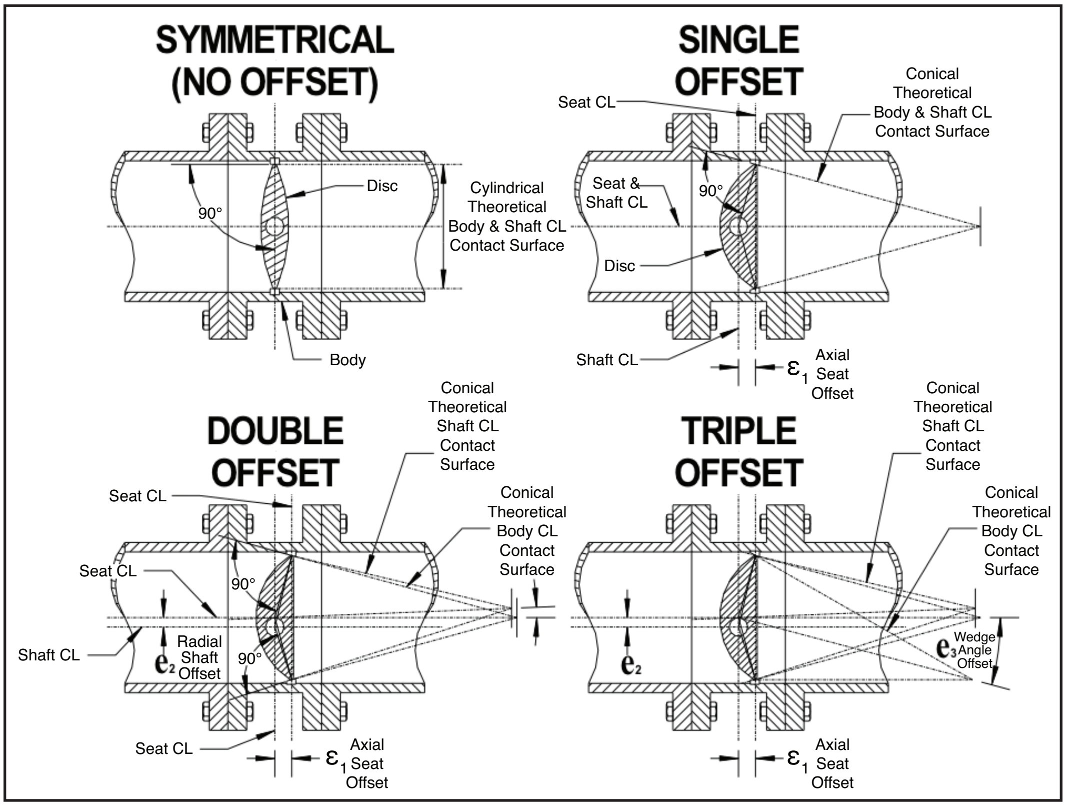


Figure 1-6 Butterfly valve offset designs

2. **Differential pressure:** The maximum (closed) differential pressure is needed for the torque calculations, sealing, and structural considerations. Cavitation calculations also require determination of pressure just upstream and downstream of the valve at the most severe throttling conditions.
3. **Piping installation:** Unless otherwise noted, the valve inlet and outlet are assumed to be straight piped conditions. Free discharge outlet and reservoir inlet installations (illustrated in Figure 1-7) represent unique applications that exceed the scope of this manual of standard practice. These installations affect both the head loss and torque characteristics of a quarter-turn valve. The valve manufacturer should be made aware of these conditions when applicable.
4. **Operating temperature:** Quarter-turn valves and actuators are designed to seat, unseat, control, and rigidly hold the valve closure members under a wide range of operating conditions. Temperature can affect seating torques and friction factors for valve bearings, so it should be considered. The operating temperature of the valves within this scope is 33°F to 125°F (0.6°C to 51.7°C). The valve manufacturer should be advised when operating temperatures are near the extremes or exceed the extremes of this range.
5. **Piping configuration:** Flow turbulence caused by upstream or downstream piping configurations may have a significant effect on valve performance. Nonsymmetrical flow streams or swirling action can magnify the operating torque and head loss of a quarter-turn valve and cause excessive vibration, reducing the valve's useful life. Installation guidelines are presented in chapter 6.

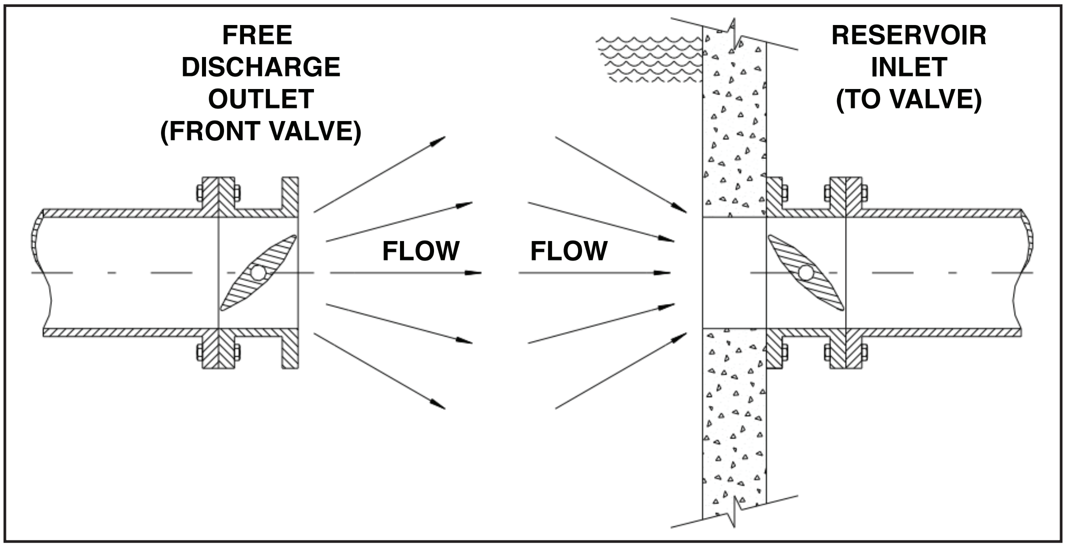


Figure 1-7 Free discharge and reservoir inlet installations of BFVs

DEFINITIONS

The following are definitions used in this manual of standard practice.

Actuator Sizing Torque, AST

The AST is typically calculated by the actuator manufacturer or the firm selecting and mounting the actuator to the valve. The AST is based on the MRST times the AF (AST = MRST × AF). The torque requirements at the seated position (seating or unseating) and the mid-stroke running positions (5° through 90°, opening or closing) should be evaluated. The AST has different values based on valve position. One or two conservative or bounding values may be used for simplicity, but this is not a single value and should normally be considered as a variable or curve of values.

Application Factor, AF

The AF is a multiplier that is used to determine the actuator and power source sizing. The AF is based on the type of actuator as well as the type of service (on-off service or modulating). The AWWA-recommended AF is provided in the valve standard.

Closure Member

This is the generic term for the valve's obturator. This may be a ball, disc, slide gate, gate, needle, plug, or other term for a specific valve design. Also see the obturator definition.

Direct Pressure

Applied pressure direction from which increasing pressure differential causes seat tightness and friction or seat load to increase as in a single-seated BV or eccentric PV. See the chapter 3 section "Flow Direction Through the Valve" and Figure 3-3.

Equal Percentage Inherent Valve Characteristic

A valve flow characteristic wherein a percentage change in valve position is accompanied by an equal percentage change in the inherent flow coefficient.

Minimum Required Shaft Torque, MRST

The MRST is normally provided by the valve manufacturer and is typically determined by the methods of this manual of standard practice. The torque requirements at the seated position (seating or unseating) and the mid-stroke running positions (5° through 90°, opening or closing) should be evaluated. The MRST has different values based on valve position. One or two conservative or bounding values may be used for simplicity, but this is not a single value and should be considered as a variable or curve of values. Note: For linear valves, such as slide gate, gate, and globe, MRST is often an acronym for *minimum required stem thrust* (not *shaft torque*).

Obturator

This is the generic term for the valve's closure member often used in international or European standards. This may be a ball, disc, slide gate, gate, needle, plug, or other term for a specific valve design.

Position Convention

The valve position may be designated in degrees open or percentage open. The fully closed position is referred to as the 0° or the 0% open position. The full open position is always referred to as 100% open and normally corresponds to approximately the 90° open position. Some quarter-turn valves may stroke more or less than 90° for full travel. This manual of standard practice uses degrees open as the position designation and assumes the 90° position and the 100% position are equivalent.

Position Seated

A position-seated quarter-turn valve does not seal tighter on the basis of how much torque is applied to the closure member at the seated position. These valves will often permit the closure member to pass completely through the seated position and start to reopen when passing the fully seated position. These valves are typically concentric in their rotation within and through the body seat. These may include symmetric and single-offset valves.

Reverse Pressure

Applied pressure direction from which the increasing pressure differential causes seat tightness and friction or load to decrease as in a single-seated BV or eccentric PV. See the chapter 3 section "Flow Direction Through the Valve" and Figure 3-3.

Seat Side Flow

This is the fluid flow direction from which the fluid passes the seat centerline before passing the shaft centerline in single-, double-, or triple-offset BFVs, single-seated BVs, and PVs. See the chapter 3 section "Flow Direction Through the Valve" and Figure 3-3.

Shaft-Mounted Closure Member

This closure member support design holds true when a shaft connects to and extends from the closure member directly though a bearing in the valve body. This design has two shaft extensions at diametrically opposed ends of the closure member, and one end penetrates the body for connection to an actuator. The shaft supports the closure member within the valve body and transmits torque for actuation.

Shaft Side Flow

This is the fluid flow direction from which the fluid passes the shaft centerline before passing the seat centerline in single-, double-, or triple-offset BFVs, single-seated BVs, and PVs. See the chapter 3 section "Flow Direction Through the Valve" and Figure 3-3.

Torque Seated

A torque-seated quarter-turn valve seals tighter on the basis of how much torque is applied to the closure member against the seats. These valves will generally not permit the closure member to pass completely through the fully seated position. These valves are typically eccentric in their rotation within and into the body seat. These may include double- and triple-offset BFVs, BVs, and PVs.

Trunnion-Mounted Closure Member

This closure member support design holds true when a shaft connects to and extends from the closure member directly though the valve body. The body bearings directly support the closure member at diametrically opposed closure member trunnions. This design has one shaft extension that penetrates the body for connection to an actuator and transmitting actuation torque. The shaft does not provide support of the closure member within the valve body.

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