

# Valve Selection Guide

API RP 615

DRAFT THIRD EDITION

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## Introduction

API Recommended Practice (RP) 615 was developed to aid in the selection of valves for the hydrocarbon processing industry (HPI), which includes refineries and petrochemical and chemical plants and the various processes associated with them. This RP may assist in the selection of valves for other industrial processes, such as power or general industry process applications. The task force members who developed this document represent many years of experience in the design and selection of valves and are comprised of professionals from manufacturing, engineering contractors, and end users.

The objective of this RP is to disseminate suggested information on valve selection recommendations as an aid to reduce operational problems and maintenance costs.

Although this RP provides guidance on the selection of valves, the valve specifier or end user is required to pay particular attention to, and is ultimately responsible for, all aspects of the application involving process, metallurgical, and mechanical considerations.

Typical purchase descriptions are provided in the Annex to assist in the complete definition of valve details to help ensure that the correct product is specified for the intended application.

Of prime importance, however, is that this RP is a general guideline for valve selection; the final responsibility is that of the user of this document.

# Valve Selection Guide

## 1 Scope

This Recommended Practice (RP) provides general guidance on valve selection for the hydrocarbon processing industry (HPI), which includes refineries and petrochemical, chemical, and liquefied natural gas (LNG) plants and their various associated processes. Selection guidance is provided for valve types covered by ASME B16.34 and API Valve Standards for the Downstream Segment, which include gate, ball, plug, butterfly, check, and globe valves.

Modulating control valves and pressure relief valves are outside the scope of this RP.

## 2 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

### 2.1

#### **abrasive service**

Abrasive service is a term used to identify fluids containing particulates that are likely to damage a valve's pressure boundary or internals through erosion. Fluids containing rust, scale, welding slag, sand, catalyst fines, grit, and hydrocarbon particles (coke) may fall in this category.

### 2.2

#### **bellows seal**

A flexible metal bellows used in place of or in addition to valve stem packing to provide a positive seal against leakage to atmosphere.

### 2.3

#### **chlorine service**

Services containing liquid or vapor chlorine in concentrations higher than 1 ppm as defined in 29 *CFR* 1910. This does not include water services containing chlorine for pH balancing or as a biocide.

### 2.4

#### **clean service**

Clean service is a term used to identify fluids free from solids or contaminants that could interfere with proper valve operation and/or closure. Clean fluids include most light hydrocarbons, instrument air, nitrogen, water, steam, lube oil, diesel oil, methanol, etc.

### 2.5

#### **closure member**

This refers to the component in the valve that serves to stop flow (internal disc, ball, and plug, for example). A closure member may also be referred to as the valve obturator.

### 2.6

#### **cryogenic service**

The lower end of low temperature service (such as liquefied gas) typically between  $-73\text{ }^{\circ}\text{C}$  to  $-196\text{ }^{\circ}\text{C}$  ( $-100\text{ }^{\circ}\text{F}$  to  $-320\text{ }^{\circ}\text{F}$ ).

### 2.7

#### **dirty service**

Dirty service is a general term used to identify fluids with suspended solids that may impair the proper performance of a valve. Detrimental effects of suspended solids on valve performance can be mitigated by minimizing or purging dead zones where suspended solids may accumulate. Dirty service can also be an abrasive service.

**2.8****double block and bleed (DB&B) valve**

A valve equipped with both upstream and downstream seats as well as a bleed valve to vent the body cavity between the seats. The bleed valve can be used to confirm that the valve seats are holding from either direction, or in the case of upstream seat leakage, to reduce or eliminate any upstream pressure acting on the downstream seat.

**2.9****fouling/scaling service**

Fouling or scaling services are general terms used to identify liquids or elements of liquids that form a deposit on surfaces. Such deposits may vary widely in nature, with varying hardness, strength of adhesion and rates of buildup.

**2.10****fugitive emissions**

Leakage of volatile organic compounds (VOCs) typically from valve stem seals and bolted or threaded joints.

**2.11****hardfacing**

Hardfacing refers to the use of a high-hardness material such as CoCr-A applied to the seating surfaces of valves to provide for longer life and improved resistance to erosion and galling of the contacting parts.

**2.12****high-temperature service**

High-temperature service, as it relates to valves, is typically defined as a service with temperature higher than 205 °C (400 °F) for soft seated valves and 400 °C (750 °F) for metal seated valves.

**2.13****hydrogen service**

Services containing hydrogen at partial pressure with a temperature above the carbon steel curve in API RP 941.

**2.14****hydrofluoric acid (HF) service**

Fluid streams containing dilute or concentrated amounts of corrosive and toxic hydrofluoric (HF) acid.

**2.15****low-temperature service**

Low-temperature service is generally defined in the process industry as services that range from -73 °C (-100 °F) up to -30 °C (-21 °F).

**2.16****non-Newtonian fluid**

A non-Newtonian fluid is a fluid whose flow properties are not described by a single constant value of viscosity. For a non-Newtonian fluid, the relation between the shear stress and the strain rate (viscosity) is nonlinear, and can even be time-dependent.

**2.17****oxygen service**

Fluid streams containing more than 23 % by volume oxygen as defined by CGA G4.4.

**2.18****pulsating flow service**

Unsteady fluid flow in a piping system resulting from repeating pressure variations such as occur with a reciprocating pump or compressor. This unsteady flow creates a periodic increase and decrease of flow and pressure in the pipe.

**2.19****pressure seal bonnet**

A removable valve bonnet design which makes use of internal valve pressure to provide for a tight seal and eliminates the need for a bonnet flange.

**2.20****solidifying service**

Solidifying service is a general term used to identify fluids that change from liquid to solid unless maintained at certain conditions of temperature, pressure, and flow. It is a term generally associated with fluids such as liquid sulfur and heavy fuel oil in which valves often require external heat input (e.g. steam-jacketing) or purging to prevent the fluid from solidifying and affecting valve operability.

**2.21****slurry service**

Slurry service is a general term used to define liquids with substantial solids in suspension. Often the solid is the product and the fluid is simply used to facilitate flow (e.g., coal slurries and catalyst services).

**2.22****stress cracking**

Material failure resulting from exposure to aggressive environments, such as wet H<sub>2</sub>S exposure, chlorides, hydrogen, ammonia, or amines.

**2.23****sour (wet H<sub>2</sub>S) service**

Services with greater than  $\geq 50$  wppm of H<sub>2</sub>S in a water phase (determined by using the total amount of sulfide in the water phase) or  $\geq 0.05$  psia H<sub>2</sub>S partial pressure in the gas phase with liquid water present.

**2.24****utility service**

Services generally limited to air, water, nitrogen, and steam at pressures below 150 psi (1035 kPa) and at temperatures between  $-29^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$ ) and  $186^{\circ}\text{C}$  ( $366^{\circ}\text{F}$ ).

**2.25****viscous service**

Viscous service is a term that generally identifies a wide range of fluids with pronounced thickness and adhesive properties. Fluids include high-viscosity oils (lube and heavy fuel oil) and non-Newtonian fluids such as waxy crude, gels, and pastes.

**2.26****vacuum service**

Vacuum service is a term that generally identifies a service that occasionally or always operates below atmospheric pressure. The absolute pressure could be any value down to near zero, sometimes referred to as "full vacuum".

**2.27****potable water**

Quite simply, it is water suitable for human consumption.

**2.28****severe service valves**

A valve that is specifically engineered for a specific application.

### **3 Considerations for Valve Selection**

#### **3.1 Valve Functions**

Consideration of valve function:

- stop flow (on-off or isolation valves referred to as block valves),
- prevent flow reversal (check valves including stop-check valves),



- regulate flow (control flow rate by throttling flow),
- prevent overpressure in piping system (pressure relief valves—not in scope of this RP).

### 3.2 Valve Types

Consideration of primary valve types:

- gate valves (API 600, API 602, API 603),
- ball valves (API 608),
- plug valves (API 599),
- butterfly valves (API 609),
- check valves (API 594, API 602),
- globe/stop check valves (API 602, API 623).

### 3.3 Other Considerations

Other considerations to take into account:

- pressure class and size;
- fluid service;
- materials of construction;
- valve trim selection;
- acceptable leakage rate;
- valve special features such as fire testing, cavity venting, purge connections, etc.;
- flow capacity and pressure loss;
- service variables such as multiphase flow, velocity, corrosivity, toxicity, combustibility, temperature, pressure.
- cycle frequency.

## 4 Primary Valve Types

**NOTE** Some valve types are capable of performing multiple functions. If not used for their primary intended function, they may not perform well or may experience a premature failure.

### 4.1 Valves to Stop Flow or to Provide for Equipment Isolation (Block Valves)

#### 4.1.1 Gate Valves

##### 4.1.1.1 General

The gate valve is a common type of block valve for on-off service. The gate valve's closure member (gate) moves out of the flow stream perpendicular to the flow path. Typical process gate valves use a wedge type gate. Upon closing the gate to effect shutoff, the two faces of the gate engage the matching angle of the valve body seats. Turning the handwheel forces the disc firmly into the seats, which, assisted by line pressure, provides for shutoff of

flow. The API standards covering gate valves are API 600, API 602, and API 603. Gate valves are typically not recommended for throttling service.

#### 4.1.1.2 API 600 Gate Valves

API 600 covers sizes from NPS 1 and larger in pressure classes from Class 150 to Class 2500 with flanged or butt-welding ends. This standard was developed for refinery applications to provide a robust, heavy wall design suitable for service up to 538 °C (1000 °F) *(this temperature may need to be lowered to 800°F due to Low-E packing temperature limits and changes in design documents. As of this publication, testing to determine this temperature is underway.)* Pressure-temperature ratings for these valves are given in ASME B16.34 (standard class) for the listed materials. Body and bonnet wall thickness specified in API 600 are greater than those in ASME B16.34 thereby providing for an additional corrosion allowance capability. Stem diameters are also specified. The standard gate in API 600 is a one-piece, wedge-shaped, either solid or flexible wedge. The “flexible” wedge design provides for a small amount of angular deflection of the disc faces to provide for a better engagement with the body seats. This allows the wedge to accommodate some deviation from the ideal seat position caused by deflection of the valve body due to line stresses or thermal expansion, thereby resulting in improved seat tightness and reduced potential for gate binding in the closed position. See Annex A, Figure A.1 for a typical API 600 gate valve.

#### 4.1.1.3 API 602 Gate Valves

API 602 covers the smaller gate valves in sizes up to NPS 4 for pressure classes from Class 150 to Class 1500 including Class 800. API 602 gate valves are commonly used in process plants in sizes from NPS 1/2 to NPS 2 in Class 800 with threaded or socket-welding ends. The standard port size is smaller than the line size but full port is an available option. These small valves are usually made from forgings. Flanged-end and butt-weld end valves are available where use of socket weld or threaded ends may not be desired, for example, in compressor lube oil service. See Annex A, Figure A.2 and Figure A.3 for typical examples of API 602 gate valves.

#### 4.1.1.4 API 603 Gate Valves

API 603 was developed to provide a lower cost alternative to API 600 valves in corrosive, lower pressure services. They provide a lighter-weight, corrosion-resistant design made of a stainless or nickel alloy with a thinner body wall than API 600 valves. API 603 specifies wall thicknesses comparable to those in ASME B16.34. Like API 600, API 603 specifies minimum stem diameters. These valves are available in flanged or butt-weld ends in pressure Classes 150, 300, and 600 and in sizes NPS 1/2 and larger. The wedge design is typically solid or flexible although split wedge and parallel-sided double disc gates are covered in the standard. Seat hardfacing may be desirable to reduce the galling tendency of stainless wedge seat faces to stainless body seat faces. See Annex A, Figure A.4 for an example of a gate valve from API 603.

#### 4.1.1.5 Pressure Seal Bonnet Gate Valves

Gate valves with a special “pressure seal” bonnet closure design that avoids bonnet flanges are available from several manufacturers for Class 600 and higher and may typically be used in hydrogen service. The pressure seal bonnet design uses a compact body-bonnet joint that is pressure-assisted so that with increasing pressure the bonnet seals more tightly. The use of this design should be restricted to services that are not highly corrosive to avoid damage to the pressure seal element. Maintenance that involves reassembly of the pressure seal should be done with the help of a manufacturer’s representative or a qualified valve repair organization to ensure proper assembly, testing, and preloading of the seal ring. Replacement seal rings may be available only from the original manufacturer. These valves are often supplied with weld ends thereby eliminating heavy line flanges. This valve design is not covered in API 600; however, it is covered in MSS SP-144.

#### 4.1.1.6 Orientation Considerations

Although somewhat depending on pressure class and size, larger gate valves oriented in a position other than with the stem vertical may result with the disc getting hung up against the inside body guides such that the valve may get stuck, thereby rendering the valve inoperable. Special attention to guiding details including clearances, avoidance of sharp corners on the disc leading edge, and the use of machining/hardfacing on the guides is

recommended. Even with the stem vertical, there may be an accumulation of dirt and other deposits between the seats such that the valve may not close fully. Installation of a bleed valve between the body seats to provide a purge connection can help remove such deposits.

#### **4.1.1.7 Other Gate Valve Designs**

Other gate valve designs used in process plants that are less common include “knife gate,” double-disc, and “slide valve” designs.

The primary features of knife gates include the ability to cut through media isolating capability, full port design, low head loss, compact face to face, and low cost for high alloys. “Knife gate” designs are used in environmental waste water systems (rain and effluent collection); sludge and other services with a high concentration of particulates; flue gas discharge, wet scrubbers on FCCU (Fluidized Catalytic Cracking Unit) and CCR (Continuous Catalytic Reformer), petrochemical pellet and dry material handling systems for high density polyethylene and polypropylene pellets and powders; and flare isolation applications. See Fig 1 below for an example of a bidirectional knife gate used for a wet scrubber application. MSS and AWWA standards cover various knife gate valve pressure-temperature ratings, materials, and testing requirements, including double block and bleed.

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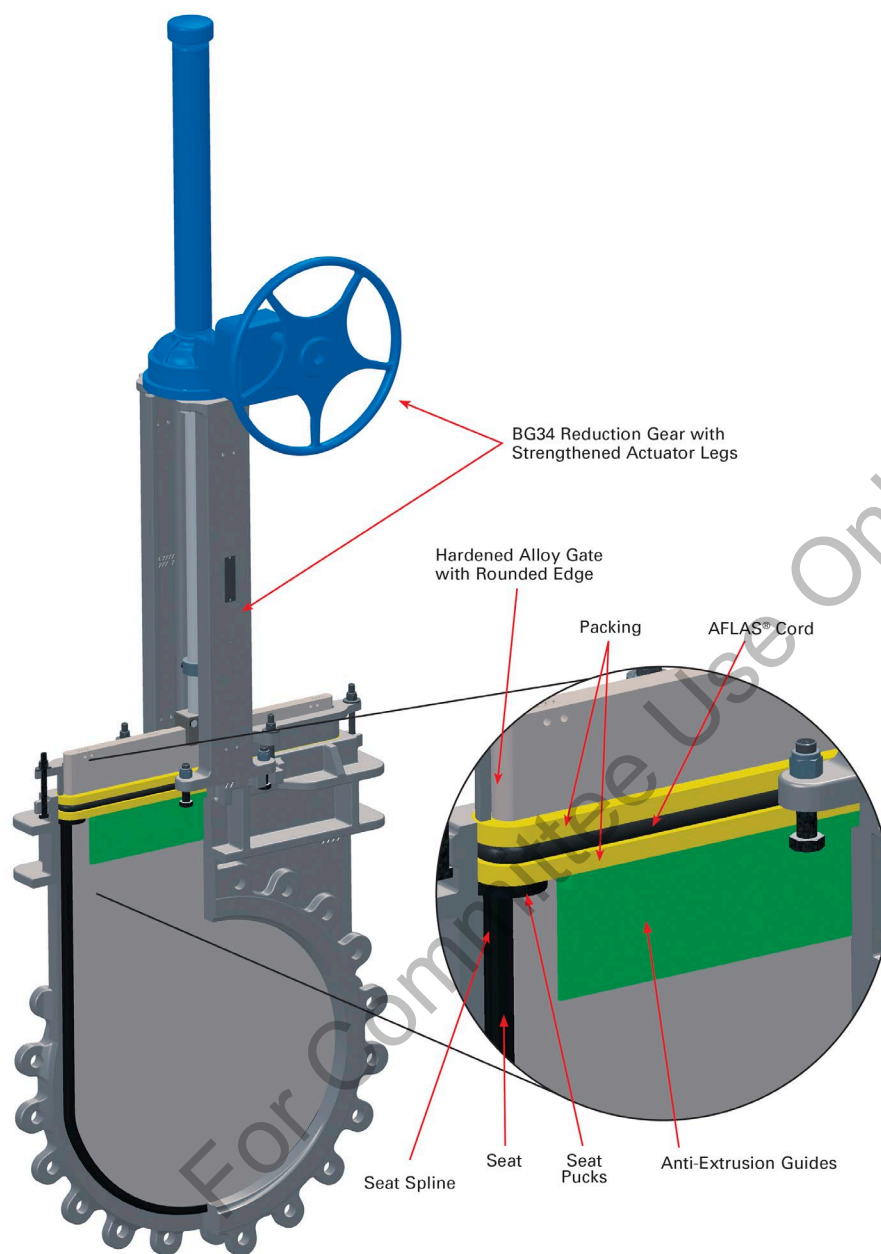


Figure 1

Bidirectional Knife Gate for Wet Scrubber Applications (courtesy of DeZURIK, Inc.)

Double-disc designs are used for double block and bleed applications.

“Slide valve” designs are highly engineered valves typically used in high temperature, highly erosive fluid solids service such as in fluid cokers and catalytic cracking units. These valves are often made of alloy steels for higher temperatures and are also sometimes lined with erosion resistant materials.

## 4.1.2 Ball Valves

### 4.1.2.1 General

Ball valves are another valve type designed primarily for on-off block valve operation. They are known as “quarter turn” valves, as a 90° turn (quarter turn) of the stem provides for full open to full closed position. Ball valves are typically not recommended for throttling service. Ball valves are available with both metallic and nonmetallic seats. Nonmetallic seats and seals can limit the pressure–temperature rating of the valve. “V-port”, notched, or segmented ball valves are available for control applications.

### 4.1.2.2 API 608 Ball Valves

API 608 covers ball valves for flanged and butt-welded ends in pressure Classes 150 through 600 and socket welded and threaded ends in Classes 150 through 800. Port sizes covered include full bore, single reduced bore, and double reduced bore. Ball valves are provided in either full-port (or full-bore) or reduced-port (or reduced-bore). Reduced-port ball valves are not suitable for most pigging operations. If there is a requirement for free-draining of a line, reduced port valves may not be suitable. Reduced port valves may reduce the flow capacity of a line.

#### 4.1.2.2.1 Floating Ball

Ball valves are categorized as either “floating ball” or “trunnion mounted” ball. In floating ball designs the ball is supported by the seats so that it is held in position (floats) between the upstream and downstream seats. Upstream pressure on the ball is the primary means of providing the seal by forcing the ball on the downstream seat. Floating ball valves have a top stem that rotates the ball, but do not have a bottom stem. The ball moves with line pressure and deforms a downstream seat to affect shutoff. Generally, floating ball valves are utilized in sizes 10-12 NPS and smaller and Class 150, 300, and in some cases 600 due to the force exerted by the ball on the downstream seat

Floating ball valves may have a one-piece, two-piece, or three-piece body design. A one-piece body design ball valve has the ball installed and retained from one end of the valve with an insert and is generally not repairable. One-piece body design ball valves are commonly used in chemical applications to avoid having additional body gaskets. A variant of the one-piece design is the top-entry, in which the body is one integral piece with a top cover similar to the bonnet on gate valves. The floating ball valve is also available in the resilient lined design. See section 6.1 for more details.

A two-piece body design ball valve has a body with an end-piece on one end to install or access ball and seats. Two-piece body design ball valves may be bi-directional, bi-directional with a preferred high-pressure end, or uni-directional, depending on design and manufacturer. One-piece and two-piece body design ball valves must be removed from service for repair.

Three-piece body design ball valves have a center body section with end caps on each end. Some small-size three-piece body design ball valves can have the center section removed or swing out, and are often used in welded piping systems and automated valves to reduce maintenance time. Some of these three-piece body design ball valves have exposed thread body bolts holding the end caps to the body, and these valves are generally not installed in applications requiring a fire-safe design.

#### 4.1.2.2.2 Trunnion Ball

In a trunnion mounted design, the ball is held in a fixed position in the valve body via a top and bottom stem connected to the ball. Seat springs are used to load the seats against the ball, and line pressure also supplements the spring forces, which push the seats on to the ball. Trunnion designs are typically found in higher pressure and larger bore applications. Trunnion mounted ball valves typically have lower operating torques compared to floating ball valves, particularly in larger sizes. Wear to the stem and seats are reduced due to the trunnion support and uniform loading which results in longer cycle life of the valves. Trunnion-mounted ball valves are often used for bidirectional sealing requirements and for double-isolation block and double block-and-bleed applications. Trunnion-mounted valves are primarily three-piece design, but can be two-piece split body.

#### 4.1.2.2.3 End Connections

Ball valves are provided with threaded, welded or flanged end connections. Threaded are used on 2 NPS and smaller and eliminate the need for welding. Generally, threaded end ball valves are used in clean, lower temperature, and lower pressure applications. They are more prone to leakage at the connections in high temperature services, cyclic operation, and high bending stress installations. Ball valves with welded ends are used in high temperature, high pressure, and buried applications, but most designs (not having a top entry) must be cut from the lines to repair. Ball valves with socket weld end connections are typical for 2 NPS and smaller. Ball valves with weld ends may have extended weld ends (sometimes called pipe or transition pups) are applied to both socket weld and butt weld end valves, are used to permit welding of valves without damaging soft seats.

See Annex A, Figure A.5 and Figure A.6 for examples of API 608 ball valve designs.

#### 4.1.2.3 API-6D Ball Valves

Besides API 608, there is also the Upstream Standard API-6D for pipeline ball valves. This is used for valves that are larger or of higher pressure classes that are beyond the scope of API 608, as well as ones that require complex double-isolation or double-block performance. Beyond those differences, the two are broadly similar and API 608 is a much less complicated standard.

#### 4.1.2.4 Ball Valve Seats

API 608 ball valves are available with either soft or metallic seats, depending on service needs and temperature. At lower-temperature applications, soft seats are preferred when tight closure is required. Seat and gasket material selection is determined by the service fluid, pressure, temperature, velocity and frequency of operation of the valve, and many material options are available. API 608 defines minimum seat material pressure-temperature ratings for polytetrafluoroethylene (PTFE) and for reinforced PTFE. Tables 1 and 2 of API 608 provide minimum seat pressure-temperature ratings. Depending on valve size (NPS), the seat pressure-temperature ratings can be significantly different for floating and trunnion mounted ball valves, and significantly lower than the shell rating in ASME B16.34. This is an important consideration when selecting floating and trunnion-mounted ball valves for process conditions. For other soft seat materials, the manufacturer should be consulted for the applicable pressure-temperature limits.

Metal seated ball valves, often with a hardfacing on the seating surfaces, have been widely used in high temperature-pressure service as well as applications exhibiting erosive/abrasive characteristics. In the case of manual operation, a gear operator is usually needed. Consideration should be given for the significantly higher torque requirements of metal seated ball valves compared to soft seated valves. Gear operators or actuators are commonly specified for valves > NPS 3. Metal-seated ball valves generally incur seat leakage, and API 598 Table 5 provides maximum allowable leakage rates for liquid and gas closure tests. Metal seated ball valves should be used when soft seated ball valves cannot handle the process conditions. Soft and metal seated API 608 valves can be specified as a "fire safe" or "fire tested" design. API 607 provides specific test requirements that would need to be satisfied to meet such specification, including subjecting a test valve to controlled fire conditions and measuring the leakage performance both during and after the burn. Fire-tested designs used to be considered special, but many users in recent years have standardized on fire-tested valve designs for almost all hydrocarbon services. These valves typically have graphite body seals and packing, and typically have a secondary metal sealing element that comes into play when the resilient seat is completely or partially melted away in a fire. See paragraph 7.6 for further discussion for the implications of fire tested designs.

#### 4.1.2.5 Rising Stem Ball Valves

Rising stem ball valves utilize a rising or rising-rotating stem to rotate a ball a quarter turn and mechanically wedge the ball against a single seat to provide shutoff. They are either provided with manual operators or are automated with linear actuators. Rising stem ball valves may be used in molecular sieve switching; isomerization; thermal oil; and abrasive, dirty, and high-temperature services. This type of valve is primarily used where tight shutoff or zero leakage is required, and is generally considered a special.

### 4.1.3 Plug Valves

#### 4.1.3.1 General

Plug valves are quarter turn valves designed with a truncated cone-sealing element that is rotated 90° to move the plug from the open-closed and closed-open positions. The plug port opening is typically rectangular in shape and has a reduced area vs. the corresponding pipe size. Full, round bore and full flow area plug valves are available as optional configurations. The plug is typically supported either by a thin grease film (lubricated plug) or by a polymer sleeve (sleeved plug), a molded polymer body liner (fully lined plug), or slip seals (lift and turn plug). Other plug valve designs are metal seated to provide for higher temperature service. Plug valves are available in 2-way, 3-way, and 4-way configurations. See section 6.1 for more details.

Lubricated plug valves use a sealant to prevent in-line leakage, reduce friction, and provide for smooth operation. Lubricated plug valves must be greased on a regular basis to ensure optimum performance. It is important that the lubrication grease be compatible with the process fluid. Non-lubricated sleeved plug valves utilize a tapered polymer tube which is compressed between the body and plug to achieve a seal. The sleeve acts as a bearing for the plug to rotate in and provides the needed lubricity to ensure reasonable operating torque and smooth operation. Non-lubricated fully lined plug valves have all wetted surfaces of the body and plug plastic lined to provide corrosion resistance in chemical applications. Fully lined plug valves utilize the compression of the body & plug liners to achieve a seal. MSS SP-155 details the typical requirements for plastic lined metal valves. Lift-type non-lubricated plug valves utilize a mechanism which lifts the plug and slips off the seating surface and rotates it to the open-closed and closed-open positions. This action extends the life of the slip seals and permits a double-block-and-bleed operation.

Plug valves are typically used for tight, bi-directional shutoff in corrosive applications because of their large in-line sealing surfaces. Sleeved and fully lined plug valves also provide for in-line seal adjustments to stop an in-line leak. Plug valves can be used in applications which contain solids as they are cavity free and their seating surfaces are not directly in the flow path. Wedge type plug valves can be supplied with purge connections to clean seating surfaces in fouling applications such as in delayed coker service. Stem sealing is usually accomplished via o-rings, a series of metal/plastic diaphragms, or standard packing sets. Plug valves are available as fire-tested to API 607; however, soft seated sleeved plug valves only meet the external leakage requirements. For fugitive emission applications valves with live loaded stem packing which meet API 641 are available. Plug valves are generally used for on/off service but with modifications can be used in basic control applications. Common plug valve types are covered in API 599, but there are other plug-type designs used for special applications

#### 4.1.3.2 API 599 Plug Valves

Sizes covered in API 599 are NPS 1/2 through 36 for flanged and butt-welding ends and NPS 1/2 through 2 for threaded and socket-welding ends. This standard covers valves that have pressure-temperature ratings in accordance with ASME B16.34 Standard Class for steel and nickel-alloy body and cover materials, and ASME B16.42 for ductile iron. Lubricated plug valves and designs with nonmetallic components such as: seals, sleeves, liners, diaphragms, seats, and sealants may limit the applications of valves to more restricted pressures and temperatures. See Annex A, Figure A.7, Figure A.8, and Figure A.9 for examples of API 599 plug valves.

### 4.1.4 API 609 Butterfly Valves

#### 4.1.4.1 General

Butterfly valves are defined in API 609 as two major types, Category A (see 4.1.4.2) and Category B (see 4.1.4.3). They are available in various designs and body/end configurations, including double-flanged, butt-welding, and lug/wafer types. In addition to providing on-off isolation, butterfly valves may also be suitable for flow regulation. Typical materials of construction include gray iron, ductile iron, bronze, steel, nickel-based alloys, and special alloys. These valves are intended for installation between flanges. For many butterfly valves, it is normal for the disc to protrude past the valve ends when in the open position. This may impact proper valve operation if the connecting

piping is internally lined. Refer to API 609 for figures and further guidance on disc-to-pipe clearance calculations for Category A and Category B butterfly valves.

For both Category A and B valves, AWWA Manual M49 (Quarter-turn Valves: Head Loss, Torque, and Cavitation) provides recommended methods for calculating operating torque, head loss, and cavitation for quarter-turn valves.

See Annex A, Figures A.10a and A.10b for typical Category A and B Butterfly Valves, respectively.

#### **4.1.4.2 Category A Butterfly Valves**

##### **4.1.4.2.1 General**

Category A butterfly valves have pressure–temperature ratings at temperatures up to and including 366 °F assigned by the manufacturer known as Cold Working Pressure (CWP). CWP rating is the lesser of its shell rating, seat rating, or differential pressure rating. These valves typically have a concentric disc and seat configuration. Sizes covered include NPS 2 to NPS 60 for valves having ASME Class 125 or Class 150 flange bolting patterns. Frequently specified for water and other utility services such as environmental wastewater and cooling water systems, etc., these valves may be lined with a nonmetallic material that may also extend over the flange faces to serve as a gasket material.

See Annex A, Figure A.10a for a typical Category A and B Butterfly Valves respectively.

##### **4.1.4.2.2 Major Features**

The body material of Category A valves is typically ductile iron but may be cast iron, carbon steel or stainless steel and, for many designs, is not in contact with the service fluid. Common disc materials are polyamide-coated ductile iron, plastic-coated ductile iron or stainless steel, and solid corrosion-resistant alloys compatible with the service conditions.

Body end connections of Category A valves are either wafer-type or lug-type, but double flanged are also manufactured.

The seal on the seat relies on elastic deformation of the resilient seats as it closes. These valves are position seated meaning the valve does not seal tighter by increasing the applied torque to the closure member at the seated position. Increasing the applied torque may actually allow the closure member to rotate through the seated position making the leak worse or possibly damaging the valve. A position-seated valve relies on adjustable stops in the actuator to properly close/seal or open.

Due to concentric disc and seat configuration of Category A valves, closure is bi-directional, and seat closure testing is required only in one direction. Lug-type and double-flanged valves may be used in dead end services when designated or rated for this service by the manufacturer. The dead-end rating may be lower than the standard shutoff rating.

Smaller valves are equipped with lever operators for quarter-turn operation and larger valves use gear operators as required within API 609.

##### **4.1.4.2.3 Applications**

Category A valves with elastomeric seats (also called resilient seats and liners) are used in potable water, non-potable water, seawater, mild chemicals and caustics for both isolation block and flow control applications. Some common elastomeric seats used are EPDM, NBR and FKM, depending on compatibility with the service fluid. Polyurethane and UHMWPE are used in abrasive fluid applications. Seats may be either bonded or unbonded to the bodies, depending on whether repairability is required.

Plastic-lined Category A butterfly valves are generally used in low-pressure, low-temperature chemical services, with PTFE and PFA liners being the most common. The purpose of the liner is to completely isolate the body from corrosive acids and other fluids and avoid using more costly corrosion-resistant body materials. Liners generally limit the operating temperature to the maximum rating of the liner material. MSS SP-155 (Plastic-lined Metal Valves) addresses temperature limits of common liner materials. See Section 6.1 for further details.



#### 4.1.4.3 Category B Butterfly Valves

##### 4.1.4.3.1 General

Category B butterfly valves have pre-established pressure-temperature ratings designated by ASME Class depending on the valve's body material as discussed later under 4.1.4.3.3. These valves have various offsets involving the shaft, disc, and seat. to help minimize rubbing and wear of the seating surfaces and improve sealing.

Category B butterfly valves are typically used in several ASME pressure classes, end-conditions, and sizes up to NPS 60. For lugged and wafer designs, sizes covered include NPS 2 to NPS 60 for Class 150 and 300 and NPS 3 to NPS 60 for Class 600. For double-flanged (short and long pattern) and buttwelding end designs, sizes covered include NPS 3 to NPS 60 for Classes 150, 300, and 600. Larger sizes are used in LNG and high-pressure utility water services. The lug type or "single flanged" design has threaded bolting lugs as standard but optionally may be supplied with drilled through lugs. Double-flanged and gate-valve face-to-face dimension options are also manufactured.

Category B valves handle everything from general applications as in Category A valves to viscous and corrosive liquids; corrosive gases; and steam.

##### 4.1.4.3.2 Major Features

A single offset **butterfly valve** is a concentric valve whose seat plane is offset parallel from the plane of the shaft centerline along the pipe/valve body/disc axial centerline. A double offset **butterfly** is a single offset design whose shaft centerline has been further offset perpendicular from its pipe/valve body/disc axial centerline. A triple offset **butterfly** is a double offset design whose seat sealing angle is offset from the pipe/valve body/disc axial centerline to create an inclined seat and seal. See Annex A, Figure 10.b for a typical Category B butterfly valve. See Figures A.11b. - A.11d for examples of a single, double, and triple offset designs, respectively, relative to that of a concentric Category A valve as shown in Figure A.11a.

Single, double, and triple offset designs are commonly referred to as "high performance" types due to the higher pressures, temperatures, and velocities over the above Category A valves. Single and double offset designs are position seated while the triple offset is torque seated. Position-seating was previously discussed above in Category A valves. A torque-seated valve differs from a position-seated valve as it will seal tighter by applying more torque to the closure member against the seat but will generally not go through the seated position.

Category B butterfly valves have a preferred seating direction dictated by the specific valve design. Single and double offset designs are typically soft seated. Triple offset designs help category B butterfly valves achieve tight closures. Depending on service requirements, they may be equipped with a resilient metal/graphite seat.

##### 4.1.4.3.3 Applications

Single and double offset butterfly valves are commonly used at Class 150 and 300 pressures. Seats are generally resilient, often PTFE or RPTFE, with minimum seat pressure-temperature ratings in accordance with Table 1 of API 609. Metal backup seats are used for fire-safety requirements. Metal seats are used for high temperature and erosive or abrasive services. Services and applications that use single and double offset butterfly valves are liquid and gas hydrocarbons, steam, chemicals, high pressure water, seawater, high cycle, low emissions, fast operation, medium vacuum, cryogenic, air separation, and applications requiring tight shutoff and flow control.

Triple offset butterfly valves are used for services requiring a tight metal-to-metal shutoff, cryogenic, and higher pressures including Class 600 and 900 and higher temperatures (up to 1200 °F) than single or double offset butterfly valves. Some designs use overlays on the body for seating surfaces and others use hard-surfaced independent seats for field replacement. Services and applications include process isolation, tank switching, separators, gas dryer switching, butadiene, plastics processing, isocyanates, ethanol production, light slurries, ethanol production, steam distribution systems, oil and gas production manifolds, and cryogenic applications including LNG and NGL. Triple offset valves are used for isolation, including low emissions and fast operation, and are infrequently used for flow control.

#### 4.1.4.3.4 Pressure–Temperature Rating

Pressure–temperature-rated butterfly valves that have an offset seat and either an eccentric or concentric disc configuration are typically available in Class 150, 300, and 600. These valves may have a seat rating less than the body rating. API 609 lists the minimum seat pressure–temperature ratings for PTFE and reinforced PTFE materials. Seat rating for other materials is determined by agreement with the manufacturer. The body rating is determined from ASME Standards B16.34 (standard class) for steel, nickel alloy, or special alloy material, B16.42 for ductile iron material, or B16.24 for cast copper alloys depending on the body material.

#### 4.1.4.4 Orientation Considerations

Although butterfly valves are operable in any orientation, the preferred orientation for butterfly valves is with the stem horizontal to avoid debris collection leading to bearing contamination that may occur with the stem vertical.

### 4.2 Valves for Preventing Flow Reversal (Check Valves)

#### 4.2.1 General

Check valves (also called non-return valves) prevent undesirable backflow without any outside intervention. A typical application is for preventing backflow into a pump when the pump is shut down. Backflow could occur as a result of fluid pressure generated from the discharge side of another pump installed in parallel. Pump damage due to reverse flow could occur if such backflow is not prevented.

Check valves should be properly sized for the flow conditions to avoid mechanical damage resulting from continuous disc movement (opening and closing against the seats), which can occur if the flow is not sufficient to keep the disc fully open. This is more likely to be of concern with larger check valves (greater than NPS 2) having the same NPS as the line. To minimize wear or damage to internal parts, check valves should also not be located in areas of disturbed flow, such as adjacent to changes in pipe direction or near pump discharges. The manufacturer should be consulted for sizing guidance in low flow applications and for spacing guidance (both upstream and downstream) where turbulent flow is a concern.

Check valves may rely on any combination of (a) flow reversal, (b) gravity, (c) springs, or (d) an external force to close. They are typically metal seated and normally do not provide (and are not intended for) tight shutoff. However, some designs are more suitable for providing a tighter seal, particularly those that are also equipped with soft or resilient seats or lapped metal seat surfaces capable of achieving no leakage in the reverse direction.

The selection of check valves needs special consideration when used in pulsating flow service or unstable flow such as in reciprocating compressor service as they may open and shut rapidly as the flow rate changes. This may lead to hammering and valve damage. In such services, tilting disc, and axial flow (nozzle) type check valves or swing check valves with external dampening may provide some advantage over conventional swing type because of their shorter stroke and typically lower mass of the closure element.

#### 4.2.2 API 594 Check Valves

Check valves covered by API 594 include:

- Type A—single or dual plate in wafer, lug, or double flanged designs;
- Type B—bolted bonnet, swing check valves with flanged or butt-welding ends.

Type A wafer, lug, or double flanged check valves include gray iron (ASME B16.1, Class 125 and 250), ductile iron (ASME B16.42, Class 150 and 300), and ASME B16.34 materials, Class 150 to 2500. These are available up to NPS 48 for Class 300 and lower. See Annex A, Figure A.13 and Figure A.14 for examples of Type A check valves.

Type B swing check valves include ASME B16.34 materials in sizes up to NPS 24. These check valves provide for minimal pressure drop and turbulence as the disc is almost fully out of the flow stream when sized for velocity high

enough to keep the disc in the full open position. See Annex A, Figure A.15 for an example of a Type B swing check valve.

Body wall thickness for gray iron, ductile iron and ASME B16.34, Table 1, Group I materials are specified in API 594. These wall thicknesses match those in API 600 for gate valves. Wall thickness for materials in ASME B16.34, Groups 2 and 3 are as defined in B16.34. Certain types of check valves are also available in the plastic lined design. See section 6.1 for more details.

#### 4.2.3 API 602 Check Valves

API 602 covers check valves in the smaller sizes up to NPS 4 (piston, ball, and swing). Wall thicknesses are defined for pressure classes up to Class 1500. See Annex A, Figure A.16 and Figure A.17 for examples of API 602 ball-and-piston check valves.

Some piston check designs (including stop check type) may have a space above the disc that can trap fluid and retard the opening movement of the disc. To permit unrestrained valve opening, pressure equalization from above the disc to the downstream end may be required to relieve pressure caused by the trapped fluid.

#### 4.2.4 Stop-check Valves

Stop-check provide both check valve and globe valve functionality in one design where the piston-type disc can also be closed against the seat by mechanical means similar to that of a globe valve. Available in T-pattern, Y-pattern, and angle pattern, these valves function like a check valve in normal operation but can provide block valve capability when necessary.

#### 4.2.5 Orientation Considerations

Proper orientation of a check valve is essential for correct operation. Most check valve designs are well suited for horizontal line installation. Swing-check valves with a bolted or welded cover in horizontal lines rely on gravity for the closure force, and thus should be oriented with the cover upwards. The valve's closure mechanism is designed to function as intended in this orientation. Swing-check valves installed with the cover turned to the side will not operate properly unless spring loaded by the manufacturer for this purpose. Likewise, dual-plate check valves in horizontal flow should be installed with the pins vertical.

Vertical line installation may require additional considerations. Downward flow vertical line orientation of API 594/API 602 type check valves should be avoided except when used with an internal or external spring or counterweight properly designed to handle the required cracking pressure. Single or dual-plate check valves are well suited for upward flow vertical line installation, as both gravity and the internal spring assists closure. Similarly, Y-pattern as well as ball and piston type check valves that rely on an internal spring to close may be used for vertical lines with upward flow. Swing-type and tilt disc-type check valves may also be used in vertical lines with the flow upward, but their closure responses may be affected since the closing force due to gravity is reduced when the valves are in the open position.

#### 4.2.6 Non-slam Check Valves

When a check valve closes on flow reversal, it is possible for a large surge force to develop due to the rapid momentum change of the stream acting against the closed valve. Fast-acting non-slam check valve designs are often specified in pulsating flow service for pump discharge applications so as to minimize the adverse effect of reverse fluid flow. Fast-acting check valves are ones with minimal closure member travel (e.g., the aerodynamic axial flow check valves, also known as nozzle check valves), small mass of the closure member (e.g., dual-plate check valves), and short distance between the center of rotation and center of the closure member (e.g., tilting disc types).

Some API 594 single plate check valve designs may be fitted with an optional external device attached to the closure element to either assist or (in the case of large valves) dampen the effects of closure. Numerical simulations are

sometimes used to predict the magnitude of a fluid surge pressure rise as affected by valve closure time to help determine the need for such devices.

### **4.3 Valves for Throttling (Controlling) Flow—Globe Valves**

#### **4.3.1 General**

The globe valve design is intended to control flow and may also be used as an isolation valve. The globe valve design minimizes seat wear during valve opening and closing as the disc moves toward and away from the body seat providing a uniform clearance and flow around the disc edge. Globe valves are typically used as manual bypass valves around engineered control valves to control flow when the control valve is blocked in and removed for repair. Globe valves are also used to take pressure drop in the system. Globe valves are covered in API 602 in sizes up to NPS 4 and in API 623 for sizes NPS 2 up to NPS 24. See Annex A, Figure A.18 and Figure A.19 for examples of globe valve designs.

#### **4.3.2 Typical Sizes Available**

Although larger sizes and higher-pressure ratings may be available, standard globe valves are typically available in sizes up to NPS 12 in Class 150, NPS 10 in Class 300, and NPS 8 in Class 600. Very large low-pressure globe valves are usually impractical because the force on the disc can cause the body to flex, causing the disc to rise slightly, resulting in leakage.

#### **4.3.3 API 623 Steel Globe Valves**

API 623 covers globe valves from NPS 2-24 and pressure classes from 150-2500. The minimum wall thickness in API 623 is the same as API 600. It also establishes minimum stem and seat diameters. The standard requires that the disc be guided throughout its full travel range by guides built into the body, not just by the stem. This gives the disc stability while in throttling service. Additionally, it helps ensure that the disc will not deflect or cock during travel, which could result in leakage and uneven seat wear.

#### **4.3.4 Globe Valve Sizing**

Globe valves are suitable for throttling, ideally when the disc is at least 20 % open; otherwise flow-induced vibration may result, leading to valve damage. For this reason, valve sizing is important to ensure that the valve is not too large for the intended flow condition. One major use for globe valves is as the manual bypass around a control valve. Typically, a bypass valve is too large if it is the same NPS size as the control valve it bypasses, and the globe valve should ideally be sized based on the Cv required, rather than just matching the Cv of the control valve. For high differential pressure or critical throttling, a standard globe valve in bypass applications may not be suitable. An engineered control valve design should be considered in such applications.

#### **4.3.5 Nonrotating Disc**

Where conditions require the valve to be less than 20 % open, the use of a nonrotating or integral disc rather than the standard swivel disc should be considered as an option. This is to reduce harmful disc and stem vibration, but may result in accelerated seat wear and leakage.

## **5 Service Considerations**

### **5.1 General**

The majority of fluid services applicable to the process industry involve hydrocarbon streams of varying levels of corrosivity. These include streams that are considered to be either clean service, dirty service, or abrasive service, depending on the amount and type of suspended solids materials that could lead to valve plugging or erosion damage. Many of these streams also involve elevated temperatures. The presence of sulfur and other compounds

in the streams in combination with elevated temperatures further contribute to a corrosive environment. Such streams require careful selection of materials to provide adequate service life. Corrosion engineers continue to study and develop materials to address these concerns.

## 5.2 Chlorine Service

Valves for chlorine service should be selected in accordance with the Chlorine Institute Pamphlet No. 6 "Piping Systems for Dry Chlorine."

Chlorine is highly corrosive, especially if water is present. Water combines with chlorine to form hydrochloric acid (HCL), which may corrode body and trim materials. Valves in chlorine gas or liquid service should be thoroughly cleaned and degreased to prevent the introduction of water, greases and oils, and other foreign material that could react with the process stream.

Chlorine has a high coefficient of thermal expansion that may result in a high increase in internal pressure if a liquid is trapped in the valve cavity between the valve closure member and the body seats. Valves in this service should incorporate a positive body cavity pressure relief feature.

## 5.3 Cryogenic (Low-temperature) Service

Valves used for cryogenic service are based on ASME B16.34 and API product standards, but with additional design features to ensure reliable operation at low temperatures. Such valves may also incorporate bonnet extensions to distance the packing and operating mechanism from the cryogenic fluid. This allows the stem packing to operate at a higher temperature and helps ensure that the valve operator is not exposed to severe cold or the hand wheel is not encased in ice while in service. MSS SP-134 provides additional details covering bonnet extension design and is now mandatory for valves designated for cryogenic service. ISO 28921-1 provides both design details and testing requirements for low-temperature applications.

Materials of construction for valve components exposed to low temperatures must be chosen in accordance with ASME B31T, which defines the requirements for suitability of piping materials for low temperatures and the required testing and acceptance criteria for these materials. Minimum temperatures are defined for most categories of material and conditions of heat treat and with or without impact testing (T-numbers).

Selection of valves must take in consideration sealing and seating material limitation at low temperature: for this reason, metal seated triple offset butterfly valves, gate, globe and check valves are preferred. Ball valves require special seal and seating materials.

When valves are sealing in both directions, a cavity vent designed to handle the potential excessive pressure caused by thermal expansion of the fluid in the body cavity when the valve is closed is required.

Butt weld and flanged connections are preferred. The main pressure classes are 150, 300 and 600. The most common materials of construction are austenitic stainless steels. Cryogenic valves for LNG are either used in liquefaction, LNG ships or regasification facilities.

## 5.4 Hydrofluoric Acid Service

In refinery HF Alkylation Units, hydrofluoric acid processes are operated under license from technology owners (such as UOP) who place strict controls on valves listed for use. Valves HF acid service should be restricted to those types and manufacturers that have demonstrated the ability to perform as expected in this service. Hydrofluoric acid is used as a catalyst in the HF Alkylation Unit to convert isobutane and alkenes into alkylate, which is used to make gasoline.

In the presence of water, HF acid and carbon steel react to form an iron fluoride scale which can accumulate in the piping system on carbon steel, Monel, and Hastelloy-C surfaces. The iron fluoride scale can build up and foul small

diameter piping and can adhere to metallic valve seal surfaces, valve seats, valve stems, and valve closure members. Scale build-up on valve stems can prevent proper valve stroking while scale build up on valve seats and closure members can cause through valve leakage. Cavity free valves and valve types that have minimal cavities and/or dead spaces are preferred.

The materials of construction for valves used in HF acid service are usually carbon steel or solid Monel, with Monel or Hastelloy-C trim). When fluoropolymers such as PTFE are used for seals, they must be unfilled as HF acid will attack the fiberglass in reinforced PTFE. The completed valve assembly is painted with acid detection paint to provide an immediate visual indication of acid leakage to atmosphere.

Valves for HF acid service are normally inspected and tested to a higher standard than those for typical process applications. Additional non-destructive testing includes radiography of the valve body casting, magnetic particle inspection, liquid penetrant inspection, helium shell testing, and pressure testing with kerosene or mineral oil.

API Recommended Practice 751 "Safe Operation Of Hydrofluoric Acid Alkylation Units" provides additional guidance for HF acid service.

## 5.5 Hydrogen Service

Valves in hydrogen service may be forged or cast. Because hydrogen is an extremely permeable fluid and hydrogen service typically involves elevated temperatures, even small imperfections in the body casting may become a source of potential leakage. When cast, they are typically supplied with a higher casting quality as compared to commodity cast valves.

The selection and limitation of materials in hydrogen service is covered in API RP 941.

For high pressure (Class 600, 900, 1500, and 2500) valves used in hydrocrackers and similar hydrogen applications, weld end connections, additional non-destructive examinations of castings, and high pressure gas testing of valves prior to installation are frequently applied to help assure the integrity of the pressure shell of the valve.

## 5.6 Oxygen Service

Valves in oxygen service should comply with CGA G4.4, "Oxygen Pipeline and Piping Systems", as applicable. Valves for this service need to be thoroughly degreased, cleaned, assembled in clean conditions, and hermetically packaged and sealed. This is necessary to minimize accidental contamination during handling, transport and storage, as hydrocarbon-based oils and greases are highly combustible in the presence of oxygen. For internal lubrication, silicon-based lubricants specifically formulated for oxygen service should be used. Additional guidance is available in CGA G4.1, "Cleaning Equipment for Oxygen Service" and MSS SP138, "Quality Standard for Oxygen Cleaning of Valves and Fittings."

Important considerations in the selection of materials include auto-ignition, flammability, and flame propagation. For oxygen service, valve body material selection is based on velocity and impingement considerations, and is typically carbon steel, stainless steel, or Alloy 400. Bronze or Monel trim materials are also recommended to prevent sparking and ignition as a result of high-energy mechanical impact.

Gaskets and stem packing materials are to be given careful consideration. Graphitic and PTFE packings are both used but have different compatibility depending on pressures, concentrations and other variables.

Additional references that are useful for valves designed, selected and applied to oxygen services are ASTM G93 (Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments, ASTM G88 (Guide for Designing Systems for Oxygen Service), ASTM G94 (Guide for Evaluating Metals for Oxygen Service) and ASTM G63 (Standard Guide for Evaluating Nonmetallic Materials for Oxygen Service).

## 5.7 Sour Service (Wet H<sub>2</sub>S Service)

Valve materials for sour service should comply with NACE MR0103. This document, specific to downstream HPI processes, limits the hardness of metals; requires austenitic steels to be solution annealed; proscribes the use of certain materials for pressure retaining boundary parts (including valve stems); and provides special requirements for bolting, welding, etc.

NACE MR0103 places the responsibility on the user to specify whether bolts will be exposed to a H<sub>2</sub>S environment. Unless specified, external bolting may not be suitable for sour service. Where leakage of sour product is a concern, external bolting should also be in accordance with NACE MR0103. NACE compliant bolting is typically of lower strength than standard bolting. This may be a consideration when determining suitability of a valve for the design conditions, particularly if the original valve bolting is being replaced.

## 5.8 Severe Service

Valves designed for “severe service” are specifically engineered to be used in extreme applications. Severe service applications can include those in which the valve is exposed to one or more of the following conditions: aggressive corrosion, high solids content, abrasion, propensity to scale, high velocity, extreme high / low temperatures, large temperature gradients, high pressure and/or high pressure drop, toxicity, flammability, high cycling frequency, etc.

Severe service valves for corrosive applications may be standard valves constructed of a special alloy, may have corrosion resistant alloys weld-deposited over critical interior surfaces, or may have corrosion resistant liners molded onto all wetted surfaces. Valves for abrasive applications and applications with high solid content may have hard facing applied to critical surfaces or may utilize components made of ceramics or other high hardness materials. Valves for applications with high velocities or high-pressure drops may include sacrificial components which are designed to absorb the majority of the wear and damage.

Valves for high/low temperatures are designed with special tolerances to account for the expansion and/or contraction of the materials due to the operating temperature. They often include extended bonnets to move the atmospheric seals away from the extreme temperature so the seals will function as expected. Valves exposed to large thermal gradients typically require the use of live loaded stem packing. Valves in toxic applications often utilize live loaded stem packing, double packed stems, or bellows sealing to prevent emissions.

## 5.9 Viscous or Solidifying Service

Valves in viscous fluid service or solidifying fluid service, such as liquid sulfur or heavy fuel oil, often require external heating or steam jackets to maintain a sufficient temperature for valve operability. This is of particular importance with check valves, where sluggish response may be a concern.

### 5.9 Sea Water & Brine Service (Brackish Water)

Valves in sea water & brine service require proper selection of wetted area materials of construction. Of particular concern in these services is metallic material compatibility (resistance to galvanic corrosion, pitting & crevice corrosion) and graphitic seal compatibility. Selecting the appropriate valve materials of construction requires an understanding of salt / chloride concentration and how seawater reacts with valve materials, as well as materials used in adjacent piping / equipment. PTFE is preferred seal material as graphite may not be compatible in sea water and brine services. Due to the high probability of galvanic corrosion, it is important to understand metals galvanic properties in seawater environment. Of particular concern with respect to galvanic corrosion should be the use of dissimilar materials (especially when in direct contact with each other) where the greater the difference in corrosion potential the greater the severity of corrosion which will occur.

## 6 Valve Material Selection

### 6.1 Body Material Selection

Material selection for valve body and bonnet for steel and nickel alloys are listed in Table 1 of ASME B16.34. This table is organized into three groups: Group 1 being ferrous materials, Group 2 austenitic stainless materials, and Group 3 nickel alloys relating to specific tables of pressure–temperature ratings. Other materials are covered in ASME B16.1 (cast iron), B16.24 (copper alloys), and B16.42 (ductile iron).

Particular attention needs to be given to the notes in these tables for limits concerning temperature and heat treatment. Reference to these pressure–temperature (P–T) tables provides the basis for selecting the proper pressure class to meet mechanical strength requirements. However, in addition material selection needs to consider resistance to the many material degradation mechanisms present in process flow streams such as general corrosion, stress cracking, low- and high-temperature effects, hydrogen service effects, etc.

If temperature, flow, and corrosivity conditions are not excessive, certain valves can be built with plastic linings. These linings allow a less corrosion resistant material such as ductile iron to be used for the pressure retaining components, while the lining provides resistance to the fluid's corrosivity. Plug, ball, butterfly and certain types of check valve can be equipped with these linings. The linings are typically molded in place, and made from PTFE or injection-moldable plastics like PFA. This lining typically also covers the closure element, and often also covers the flange face. MSS SP-155 and ISO 19240 cover these linings and their design.

### 6.2 Valve Trim Selection

#### 6.2.1 General

Valve trim materials include more than just the valve seating surfaces as is well defined in trim tables contained in several API valve standards. In general, trim typically includes all internal parts in contact with the process fluid. If specific requirements are not defined, API standards require that trim materials shall be at least as corrosion resistant as the body material.

#### 6.2.2 Gate Valves

For gate valves, trim is defined as the seating surfaces of the closure member and body seats as well as the material of the stem and backseat bushing. A key consideration to avoid galling of valve seats is to provide either a difference in hardness between the mating seating surfaces or to provide hardfacing to both seating surfaces. Trim tables with various hardfacing options are provided in API 600 and API 602. Several of the available trims provide for hardfacing of one or both seating surfaces to better ensure long-term abrasion, corrosion, and wear resistance.

#### 6.2.3 Trim for Other Valves

Globe valve trim is very similar to that of gate valves, with some parts not found in gate valves such as the disc retainer and (in some valves) a guide pin or guide rings. The same considerations of galling still apply. API 623 uses a similar trim table as API 600, and for small valves, API 602 covers both globe valves as well as gate valves.

For check valves, trim is defined as the seating surfaces of the closure member and body seat. A listing of acceptable trims is included in the API 594 trim table. Several of the available trims provide for hardfacing of one or both seating surfaces to better ensure long-term abrasion and corrosion. Most check valve designs do not experience significant sliding wear between seating surfaces, so the need for hardfacing both seating surfaces for wear resistance is not as critical as with other valve types.

For ball valves, trim is defined as the internal metal parts of the valve, such as the ball, stem, and metal seats or seat retainers. These are to be of the same nominal chemical composition as the shell and have mechanical and corrosion-resistance properties similar to those of the shell.



For butterfly valves, all materials in contact with the process fluid are to be the manufacturer's standard unless specified otherwise. Trim is defined as the seating surfaces of the body, disc, disc to shaft connection hardware (e.g., keys, pins, screws, etc.), and any internal fasteners that are in contact with the process fluid. However, trim material requirements are not explicitly specified. Shaft and bushing materials are also determined by the manufacturer taking into account the corrosion properties of the other trim components. Selection of sealing materials should take into account chemical compatibility, resistance to corrosion from the process media, resistance to galling (particularly for metal-to-metal seals). The trim materials exposed to process media should also consider the potential for galvanic corrosion and materials selected to best suit the purpose of each component and the compatibility with the process.

For plug valves, the corrosion resistance of the plug and stem material is required to be at least equal to that of the body material.

### 6.3 Seating Surfaces—Soft Seats

Ball valves and butterfly valves are often provided with resilient, nonmetallic seats to provide for zero leakage. To avoid the build-up of excessive body cavity pressures, pressure relief of the body cavity should be considered for soft-seated ball valves in liquid service.

API 608 and API 609 cover PTFE and reinforced PTFE materials with P–T ratings defined. Other soft seat materials are available with P–T ratings established by agreement between the purchaser and manufacturer. With PTFE material, the service temperature limit is typically 177 °C to 205 °C (350 °F to 400 °F).

### 6.4 Stem Sealing—Fugitive Emissions

Flexible graphite valve stem packing material is normally used in downstream process applications where high temperature and fire resistance is often a primary consideration. Although graphite material is susceptible to oxidation at temperatures above 343 °C (650 °F), it has been used with success in valves with service temperatures up to 427 °C (800 °F) and even higher in non-oxidizing environments.

A typical flexible graphite packing design for gate valves is comprised of two to four rings of die-formed packing with one ring of reinforced braided material on top and one on the bottom of the packing stack. The braided material “wiper rings” help resist extrusion of the die-formed rings out of the stuffing box. Key material factors that affect flexible graphite packing performance are: percent carbon content, density of the packing, extent of impurities, and presence of corrosion/oxidation inhibitors. MSS SP-120 includes additional considerations for flexible graphite packing systems used in rising stem valves. To ensure the quality of flexible graphite packing and minimize the risk of excessive fugitive emissions, API 622 provides a type-testing procedure for packing qualification and API 624 provides a type-testing procedure for rising stem valves equipped with flexible graphite packing.

Over time, packing sealing performance may degrade due to “packing consolidation.” This results in the loss of gland load, leading to packing leakage. To minimize the potential for this to occur, the packing gland can be “live loaded” with conical washers on the gland bolting. When compressed, the conical disc washers can provide a means to maintain a gland load on the packing and help extend the amount of time over which the packing maintains an effective seal. MSS SP-143 provides guidance on proper design for live load packing arrangements.

Some quarter-turn valves may use elastomeric rings for stem seals. These seals may have a service temperature limitation lower than PTFE and are usually nonadjustable.

To further improve on fugitive emission performance, valves can also be supplied with a “bellows seal” on the stem in addition to a back-up packing gland. Bellows sealed valves are frequently used in steam service, as well as in certain hazardous/toxic applications. This packing design option is covered in API 602 for sizes NPS 1/2 to NPS 2. See Annex A, Figure A.20 for an illustration of a bellows stem seal from API 602.

## 6.5 Valve Bonnet Gaskets

For gate valves, API 600 and API 603 offer several options for bonnet gasket types: solid metal, jacketed metal, corrugated metal insert with graphite facings (Class 150 only), ring joint, spiral wound (Class 300 and higher), as well as a reinforced flexible graphite sheet for (Class 150 only) when approved by the purchaser. In all cases, the bonnet gasket is required to be suitable for a service temperature range of  $-29^{\circ}\text{C}$  to  $538^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$  to  $1000^{\circ}\text{F}$ ).

API 602 restricts the bonnet flange gasket to a spiral wound type with flexible graphite filler, unless specified otherwise. The design requirement confines the gasket to prevent overcompression and extrusion.

For globe valves, API 623 requirements are similar to API 600, except that only round bonnets are permitted. Flexible graphite sheet is not allowed, since the flat bonnet face permitted in API 600 is not used in API 623.

## 7 Valve Specific Features and Options

### 7.1 Valve Operation

Gate and globe valve operation is normally by means of a handwheel while quarter-turn valves have operating handles or levers in the smaller sizes. Quarter-turn valves with oval handles are available to prevent accidental operation that could occur if a lever was caught by loose clothing. Levers or handles are usually adequate for small, quarter-turn valves less than NPS 4, for example, but for larger valves, a means of assisted operation is often required. The number of times per year that a gate or globe valve is opened and closed should be considered as well. Valves larger than NPS 6 that are operated frequently would benefit from a gear operator installed. An important factor affecting the need for assisted operation (gear or power) is a limit on maximum rim pull force for ergonomic considerations.

Some valves such as metal-seated ball valves, triple offset valves, valves in high-pressure service, or valves operated frequently may necessitate gear or power actuation to assist with the high torque requirements. Installation of a bypass system can facilitate valve operation by reducing the effects of thermal shock or high differential pressures.

### 7.2 Position Indication

Whether a rising stem gate valve is open or closed is usually easily noted from the position of the stem relative to the yoke. Quarter-turn valves with operating handles properly mounted also provide a good visual indication. When gear drives are mounted on quarter-turn valves, it is important that the open and closed positions are clearly indicated with proper markings.

### 7.3 Hot Tap Valves

Valves used for hot-tapping warrant some special consideration. Two key requirements are that the valve port is large enough to pass the hot-tap cutter and that they are properly leak-tested in accordance with API 598 prior to installation. This is to ensure that the seat tightness is adequate to minimize leakage when the valve is closed and the cutting device removed.

### 7.4 Double Block Valves for Positive Isolation

Metal-seated valves in sizes larger than NPS 2 may not seal "bubble tight" when closed (as evidenced by the allowable leakage rates for new valves in API 598). When positive process stream isolation is needed for product segregation, the use of soft-seated valves is an effective solution, provided the seat material is adequate for the service temperature. For higher-temperature applications and for safety reasons, it may be necessary to use two block valves in series, with a bleeder between the valves. With two valves in series, any small leakage passing the first valve can be vented away with the bleeder to a safe location. When vented, the pressure between the two block valves is reduced to a low level, and the second valve is then likely to provide a good seal with little or no leakage. The need for this arrangement increases at higher pressures and with larger diameter valves.

## 7.5 Double Block-and-Bleed (DB&B) Valves (Single Valve)

Double-seated block valves may also provide the function of two block valves in series as described above when a vent connection is added between the upstream and downstream valve body seats. Leakage past the upstream seat can then be vented away by the bleed valve, thereby reducing the potential for downstream seat leakage.

Certain plug and ball valve designs are capable of providing double block-and-bleed functionality in a single valve configuration. Double block-and-bleed plug valves utilize two mechanically wedged resilient seals and a bleed system between the upstream and downstream seals to provide positive isolation and verification of positive isolation. They are often used for product segregation, tank storage isolation, and metering.

Standard API 600 gate valves are normally not designed to provide double block-and-bleed performance at full rated pressure, particularly in larger sizes and where a flexible wedge gate is provided. Other gate configurations, such as a solid- or split-wedge type, can improve the performance of the upstream seat. API 598 includes a special high-pressure closure test to confirm double block-and-bleed capability in a single valve.

## 7.6 “Fire Tested” Valves

Valves with seats, stem seals, or gaskets that are not capable of withstanding exposure to fire without failure could contribute to the severity of a fire by leaking flammable material. API 607 provides a type test for quarter turn valves and valves equipped with nonmetallic seats to confirm that adequate fire resistance is provided. Valves that successfully pass this test are considered “Fire Tested” and are marked accordingly.

## 7.7 Valve End Connections

Valves larger than NPS 2 are typically furnished with flanged ends. This permits convenient installation and removal for maintenance or replacement. Since every flanged joint is a potential leak source, the use of butt-weld end valves should be considered in high pressure or hazardous services such as high pressure hydrogen or lethal fluids and gases, to minimize leak potential. Valves with weld ends may have extended ends (sometimes called pipe or transition pups) applied to both socket weld and butt weld ends to permit welding to valves without damaging soft seats. Valves NPS 2 and smaller can be furnished with ends that are socket welded, threaded, butt-welded or flanged. For threaded end connections, the use of seal-welding for hydrocarbon and certain other services helps to provide better assurance against leaks in service.

## 7.8 Cavity Overpressure

Valves in the closed position may cause liquid to be trapped in the cavity between the seats. This could result from being in liquid service, condensation, or other means. Subsequent exposure to a temperature increase as a result of ambient heating or process conditions and the consequent expansion of the trapped liquid medium could result in an excessive pressure buildup in the cavity sufficient to cause failure of the pressure boundary. Over pressurization can occur in low temperature and cryogenic services and certain chemical processes such as chlorine.

A positive body cavity relief feature, such as self-relieving seats or a vent hole drilled through the high-pressure side should be considered for such valves. Use of a drilled vent may render the valve to be unidirectional and therefore appropriate marking is required.

For wedge (flexible or solid) gate valves with metal seats, seat supported (floating) ball valves with spring energized soft seats or seat supported (floating) ball valves with cantilevered (soft) seats, a positive body cavity relief feature such as a vent (equalizing) hole with a diameter of at least 3 mm drilled through the high-pressure side outside of the seat facing area should be considered. Use of a drilled vent may make the valve unidirectional, therefore requiring directional pressure marking.

Spring energized (single or double) self-relieving seat configurations (“soft, metal and integral fire safe”), used in ball valves with seat supported (floating) ball and/or ball valves with a trunnion supported ball are acceptable, provided the manufacturer can confirm the correct cavity relieving function,

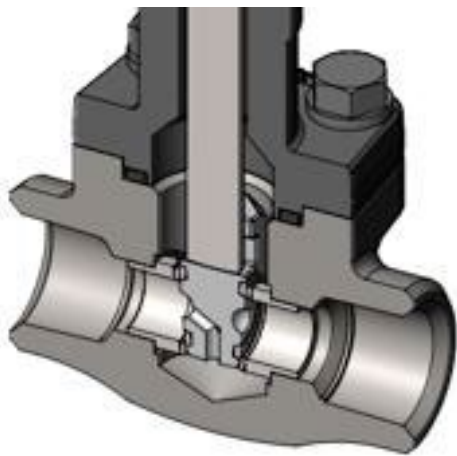
In trunnion supported ball valves which have self-relieving seats configurations, venting can be directed by selecting a single piston effect by double piston effect design which will result in venting excess pressure in the single piston effect side. Appropriate marking is required to indicate the venting side.

A double self relieving seat design prevents the risk of installing the valve incorrectly and eliminates the need for control and identification marking.

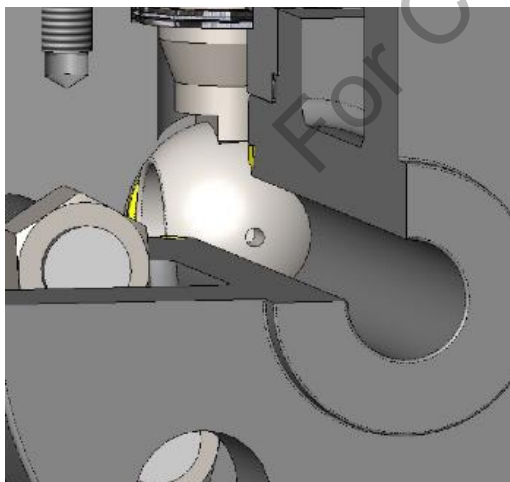
**Note- Further enhancements to the illustrations will be available in further drafts**

#### Examples

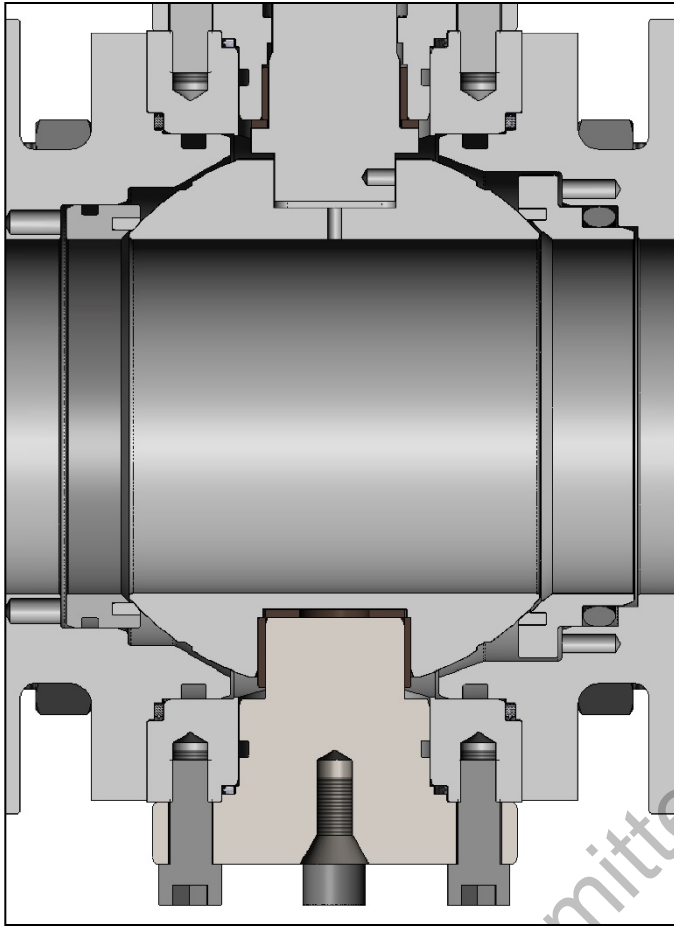
1-Vent hole in API602 Gate Valve: *(Replace image with higher resolution image)*



2- Vent hole in API608 Floating type Ball Valve: *(Replace image with higher resolution image)*



### 3- Single Piston Effect x Double Piston Effect Seat in API608 Trunnion type Ball Valve: *(add arrows)*



## 7.9 Flange Shields

Wafer valves (butterfly and check, for example) installed between a pair of flanges offer advantages in terms of cost and weight savings, but they have an increased potential for flange leakage. When exposed to fire conditions, differential expansion of the exposed bolts relative to the valve body may result in loss of gasket compression on the joint. This is a particular concern in hydrocarbon service where the leaking fluid can further intensify the fire. The use of flange shields, such as a stainless steel band around the flanges to cover the exposed bolts, will provide some degree of protection. Use of lug-type designs is an improvement; however, a double-flanged valve design is the preferred alternative as it minimizes the overall length of the individual bolts.

## 7.10 Valve Purge Connections

Gate valves in fouling/scaling service may accumulate dirt or debris between the seat rings preventing full disc closure. Large gate valves (NPS 12 and up), as well as valves installed with the stem vertical are particularly susceptible to such accumulation. NPS  $\frac{3}{4}$  or larger valved connection installed between the seats in position G (see Figure 1 in ASME B16.34) will permit the use of a purge to help clear the obstruction.

Ball valves are also susceptible to the accumulation of dirt, debris, or particles such as coke in the valve cavity that can cause the valve to bind up or not seal. Ball valves can be provided with one or multiple purge connections (as recommended by the valve manufacturer.)

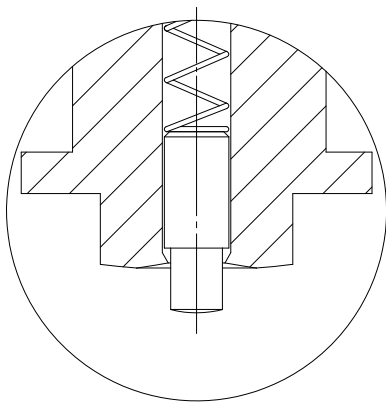
## 7.11 Electrical Continuity

In soft seated valves (ball, gate, butterfly and plug) static electricity can build up between seating surfaces (seat and obturator) as thermoplastic materials are not conductive. To avert such possibility an antistatic feature should be required to provide electrical continuity from the obturator to the body. Ball, gate and plug valves shall have electrical resistance not to exceed 10  $\Omega$ .

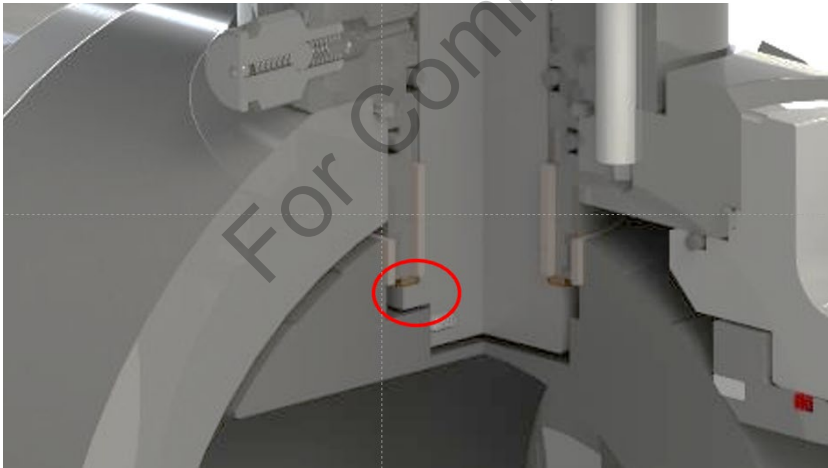
The purchaser may specify when the electrical resistance between the closure member and the valve body/bonnet and between the stem/shaft and the valve, body/bonnet shall not exceed 12 V when measured using a direct current power source. The resistance shall be measured on dry valves before pressure testing and shall not exceed 10  $\Omega$ .

### Example

- 1- Floating ball valve stem spring assisted antistatic device



- 2- Trunnion mounted ball valves *(add arrow or other identification)*



## 8 Steps for Valve Selection and Procurement

The following steps are recommended for consideration when selecting and procuring a valve appropriate for the intended service. Some steps may need to be recycled to address temperature or materials selection limits.

- 1) Determine required valve size and maximum design pressure and temperature for the process.
- 2) Select body material based on design temperature and corrosion resistance needs. (Materials are normally selected from a material listed in the applicable ASME standard.)
- 3) Select valve type and governing API standard (API 600, 602, 603, etc.) based on required function.
- 4) Determine valve Class from pressure-temperature rating tables in ASME B16.34 (standard class), B16.1, B16.24, B16.42, or applicable API standard, depending on the material and valve type.
- 5) Consider the need for special trim and temperature limits associated with nonmetallic seat materials.
- 6) Consider special packing needs.
- 7) Select desired valve end design (flanged, threaded, or welded).
- 8) For double-seated valves, define venting if needed to avoid cavity overpressure from trapped liquids.
- 9) Determine need for assisted operation (gear operator, motor drive, etc.).
- 10) Specify API 607 fire testing certification for valves with nonmetallic seats or seals in hydrocarbon service.
- 11) Determine the need for special testing requirements to API 598 (DB&B or Hot Tap Valves).
- 12) Review any special needs with company valve and materials specialists.
- 13) For critical valves, consider additional features, options, and suggested improvements with potential manufacturers.
- 14) Prepare a detailed purchase description to address purchaser specified requirements in accordance with the corresponding API standard. Annex B provides examples of typical purchase descriptions.

## 9 Testing and Inspection of Valves

### 9.1 Hydrostatic Testing

Hydrostatic testing is the most common test used to verify valve operability and integrity. All valves used in refinery service are hydrostatically tested at the factory as part of the manufacturing process. Additional post-manufacture testing is often requested for valves that have been in storage for long periods of time or require additional verification. Production hydrostatic tests are useful to verify closure & seal efficacy as well as detect gross pressure retaining component leakage.

API 598 is the primary testing specification for refinery valves. Additional pressure testing specifications are found in MSS SP-61, ANSI/FSA 70-2, and API 6D. It is important to note that the test durations in all these standards are short and may not detect all leakage, particularly microscopic casting defects.

MSS SP-61 is similar to API 598, although some test durations and allowable leakage rates are different. SP-61 is specified for testing of non-API valves. ANSI/FSA 70-2 is a control valve leakage standard that has leakage rates segregated by various classes from class I to class VI. API 6D is the design and testing standard for pipeline valves. The test pressures are close to API 598, although the test durations are much longer.

## 9.2 Fugitive Emissions Testing

Fugitive Emissions testing is useful for confirming that the packing and seals in a valve are capable of retaining fugitive emissions. A type test is used to confirm initial designs of the packing system, while production tests are utilized to confirm a degree of FE containment integrity on specific valves.

## 9.3 Non-destructive Testing (NDT)

Most NDT of valves is performed on valve components in the factory, if required, prior to final assembly. Additional post-manufacturing NDT may be requested by the user if the service conditions merit. Proper NDT on assembled valves may require disassembly, re-assembly and hydrostatic testing.

method	defect location	defect types or usage	limitations	applicable valve-related standards
Dye Penetrant (PT)	surface	cracks, casting defects	surface only	ANSI B16.34, MSS SP-93
Hardness testing	surface	verify successful heat treatment, assist in confirming material type, determining strength of carbon steel	Not accurate for determining strength of many steels. Some electronic test equipment not accurate on thin sections	NACE MR0175, NACE MR0103
Magnetic particle (MT)	surface & slight subsurface	cracks, casting defects, hot tear confirmation	cannot be used on non-magnetic materials	ANSI B16.34, MSS SP-53
PMI	surface	verification of material	Should not be used to provide precise chemistry of materials	API RP578, MSS SP-137
Radiography (RT)	volumetric	casting defects, welding defects	some defects (hot tears) may require confirmation by other NDT methods	ANSI B16.34, MSS SP-54
Ultrasonic (UT)	volumetric	welding defects, forging defects	not accurate for castings	ANSI B16.34, MSS SP-94

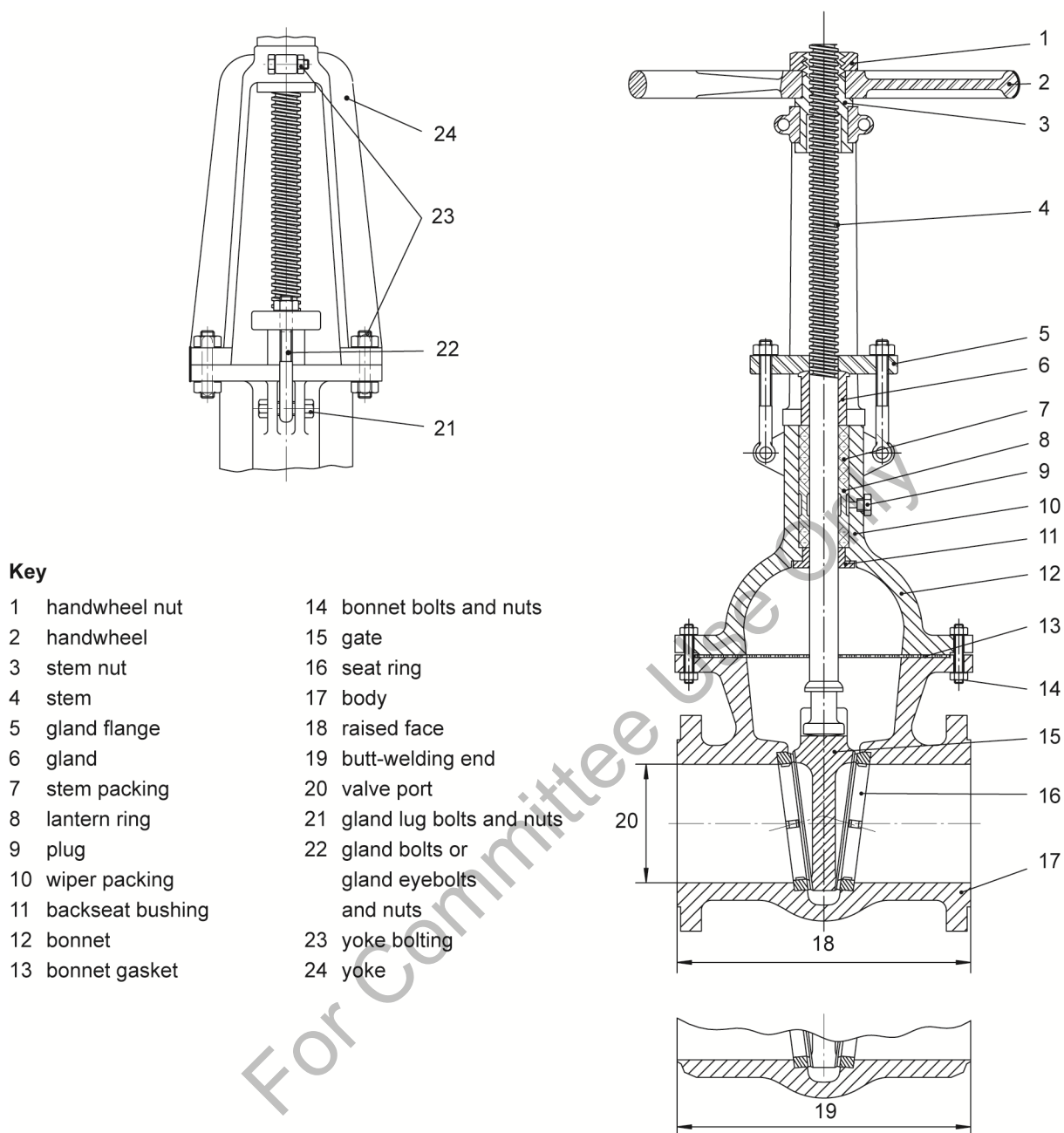


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## **Annex A** (informative)

### **Schematic Drawings for Typical Valve Types**

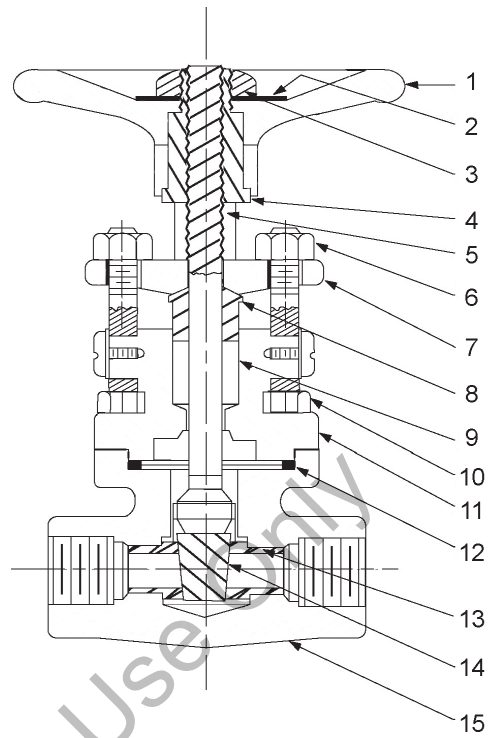
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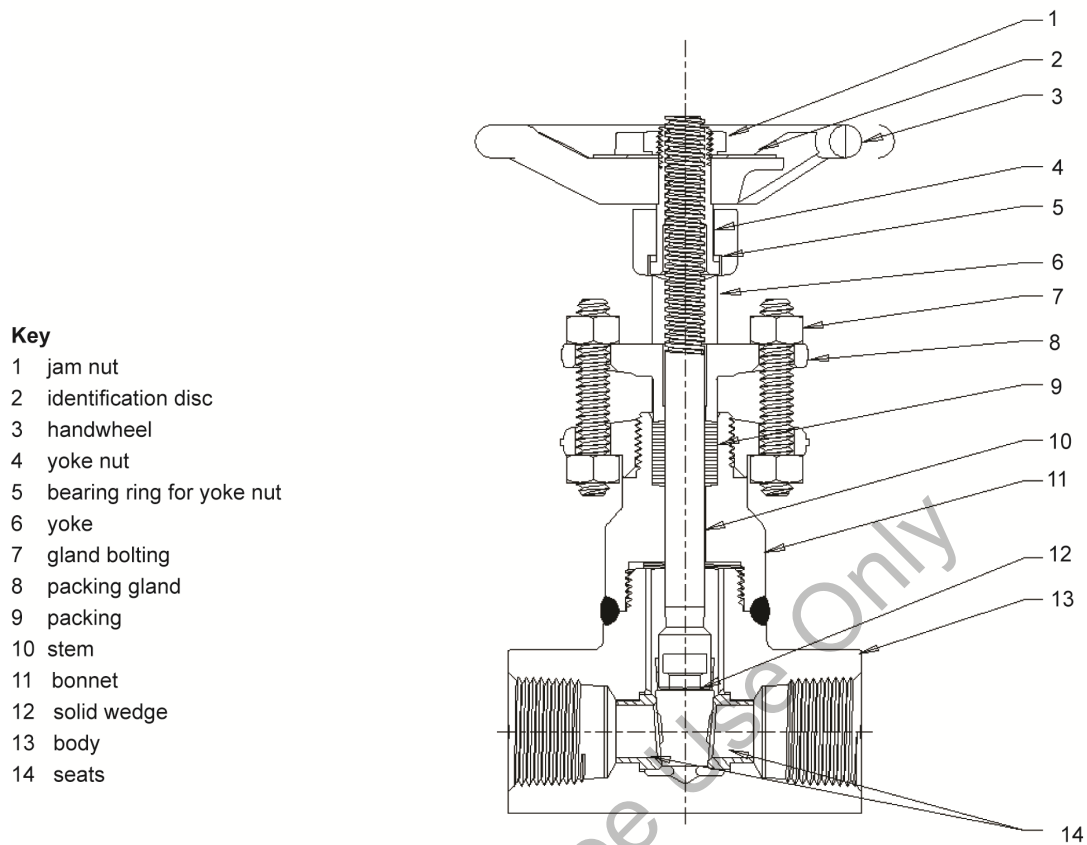
**Figure A.1—Typical API 600 Bolted Bonnet Gate Valve—Outside Screw and Yoke**

**Key**

- 1 handwheel
- 2 identification plate
- 3 handwheel nut
- 4 stem nut
- 5 stem
- 6 gland bolting
- 7 gland flange
- 8 gland
- 9 packing
- 10 bonnet bolting
- 11 bonnet
- 12 gasket
- 13 seat ring
- 14 gate
- 15 body



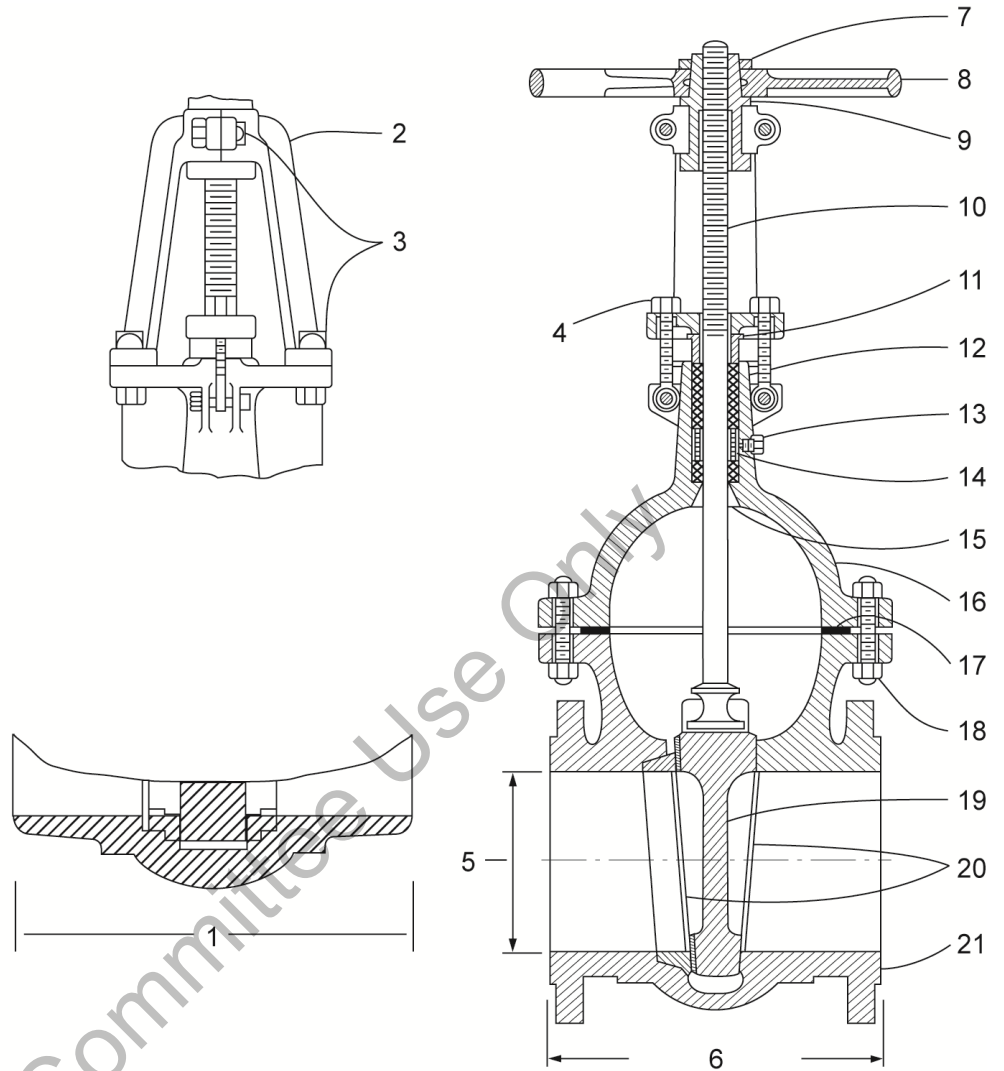
**Figure A.2—Typical API 602 Bolted Bonnet Gate Valve**



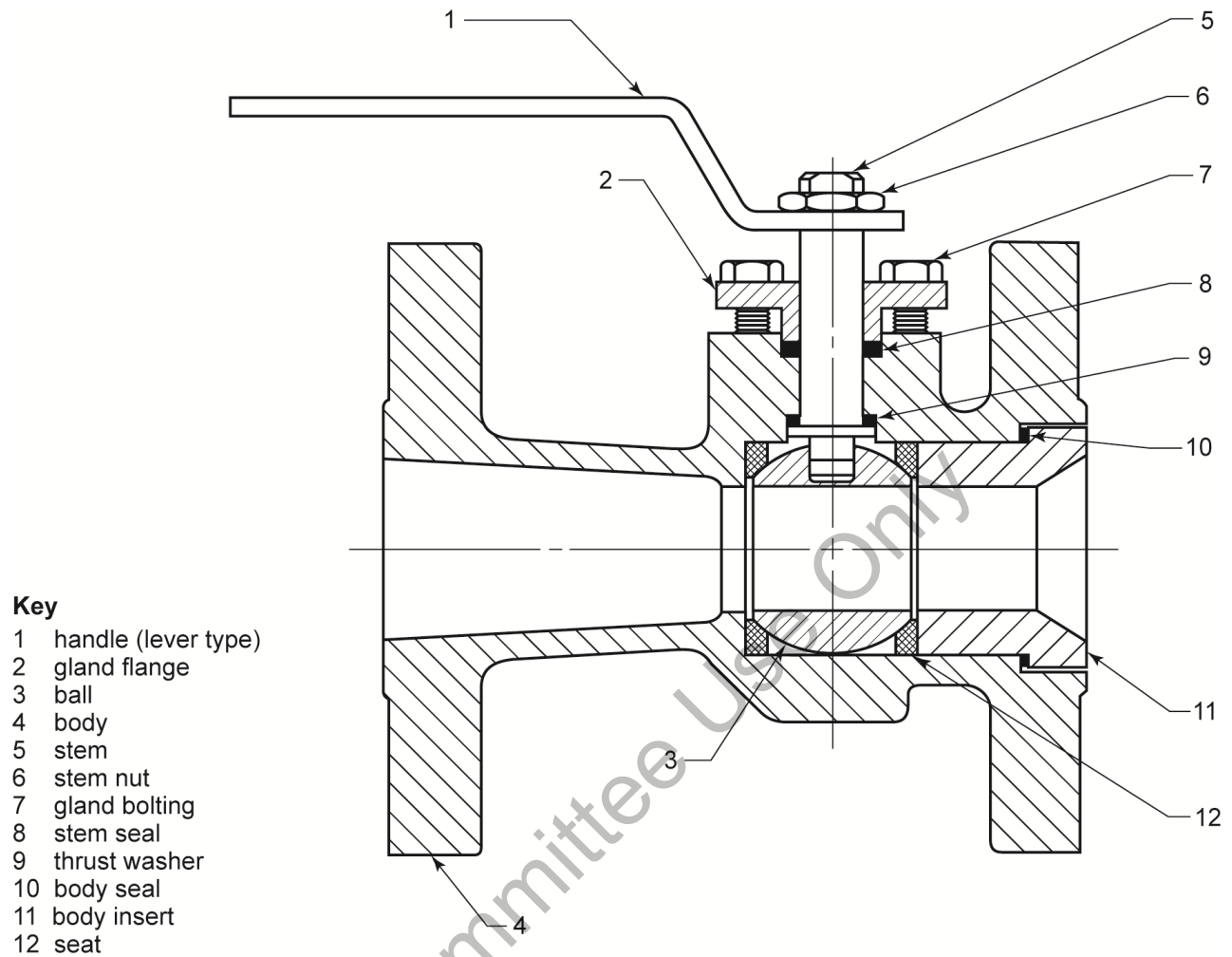
**Figure A.3—Typical API 602 Welded Bonnet Gate Valve**

**Key**

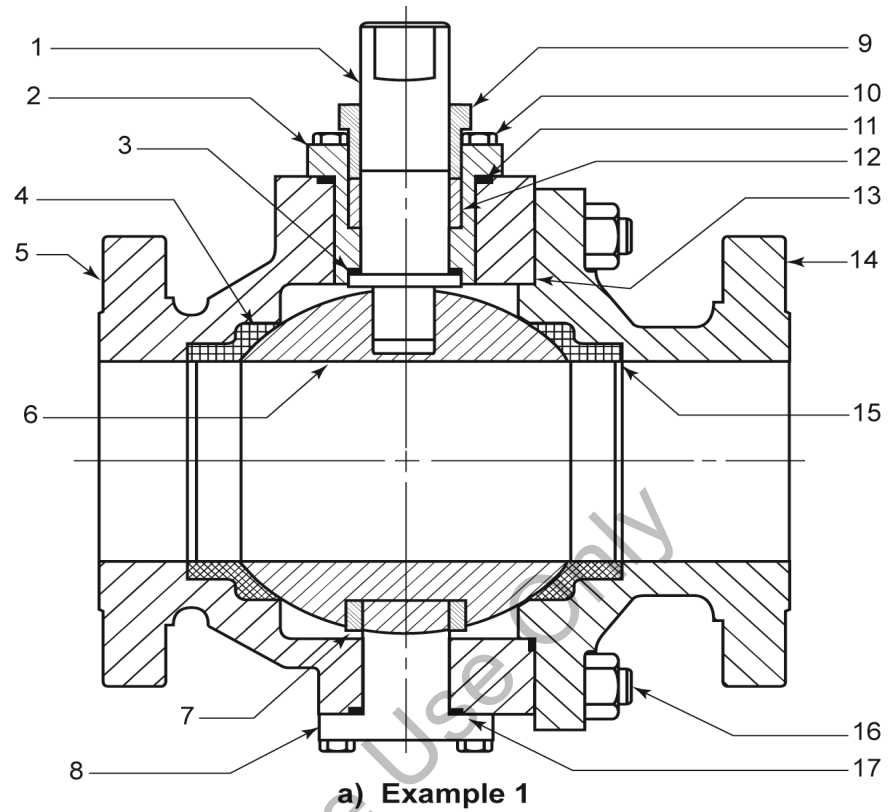
- 1 butt-welding end
- 2 yoke
- 3 yoke bolting
- 4 gland bolts or gland eyebolts and nuts
- 5 valve port
- 6 face to face
- 7 handwheel nut
- 8 handwheel
- 9 stem nut
- 10 stem
- 11 gland
- 12 stem packing
- 13 plug
- 14 lantern ring
- 15 backseat
- 16 bonnet
- 17 bonnet gasket
- 18 bonnet bolts and nuts
- 19 gate
- 20 separate or integral seat
- 21 body



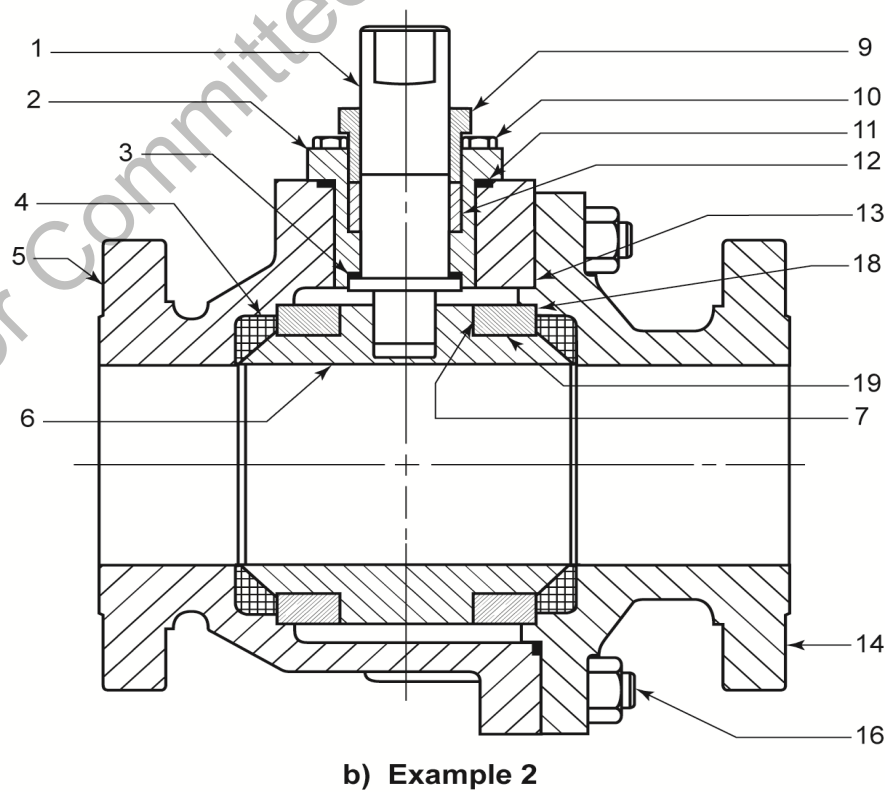
**Figure A.4—Typical Valve Nomenclature Example from API 603**



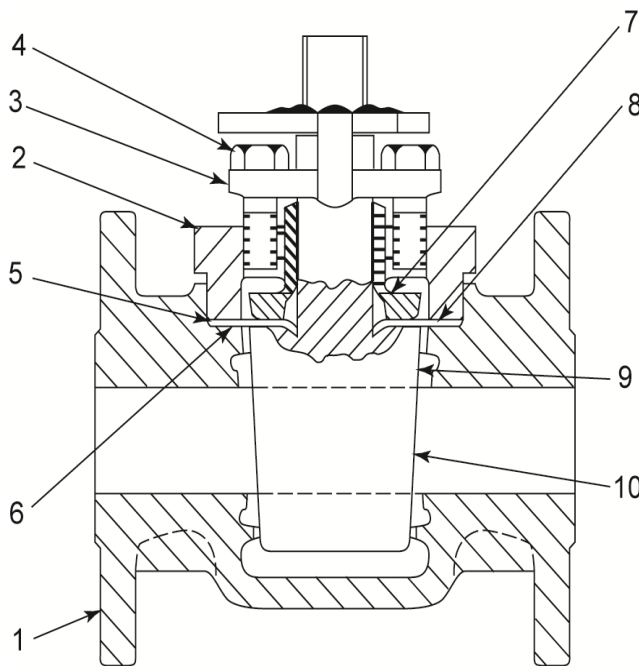
**Figure A.5—Typical Example of Floating Ball Valve—One Piece Body Design Illustrated**

**Key**

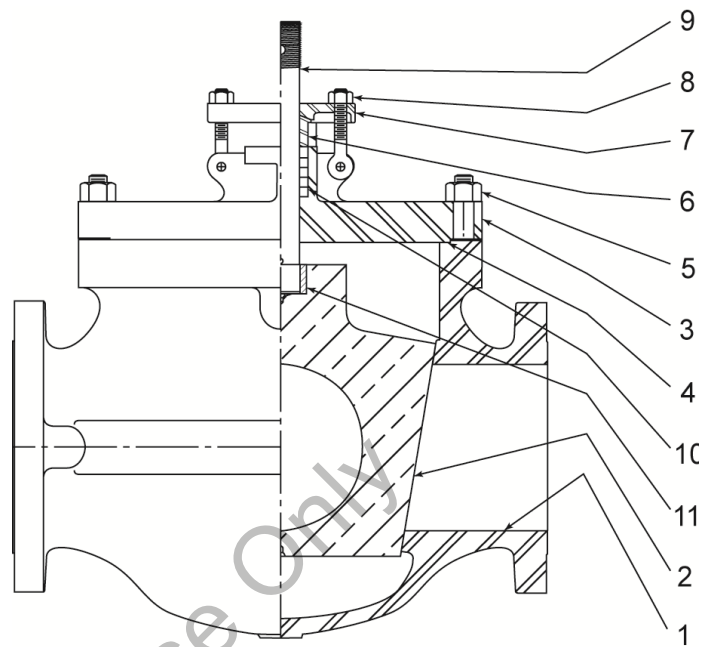
- 1 stem
- 2 cover
- 3 thrust washer
- 4 seat
- 5 body
- 6 ball
- 7 trunnion bearing
- 8 trunnion
- 9 gland
- 10 cover bolting
- 11 cover seal
- 12 stem seal
- 13 body seal
- 14 body cap
- 15 seat spring
- 16 body bolting
- 17 trunnion seal
- 18 trunnion plate
- 19 bearing spacer



**Figure A.6—Typical Trunnion Mounted Ball Valves—Two Examples of Split Body Designs**

**Key**

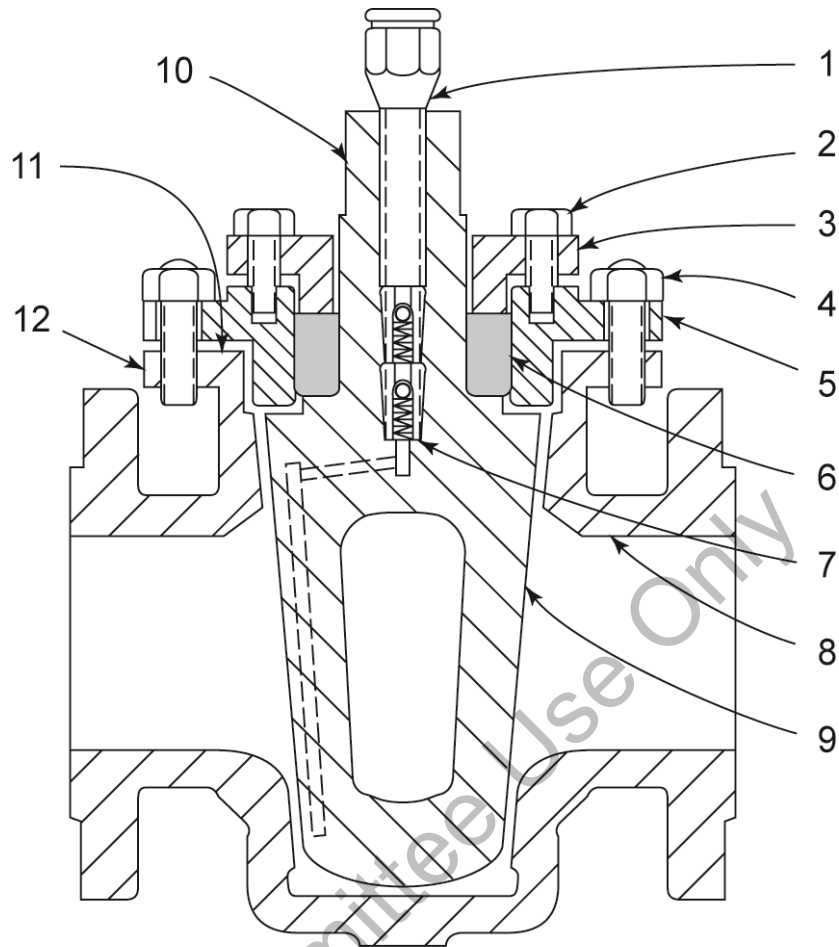
- 1 body
- 2 cover
- 3 adjuster
- 4 adjuster bolting
- 5 cover gasket or seal
- 6 nonmetallic diaphragm
- 7 stem seal or packing
- 8 metallic diaphragm
- 9 sleeve
- 10 plug

**Key**

- 1 body
- 2 plug
- 3 bonnet
- 4 gasket, bonnet
- 5 bonnet bolting
- 6 packing gland
- 7 packing gland flange
- 8 packing gland bolting
- 9 stem
- 10 packing
- 11 stem connection

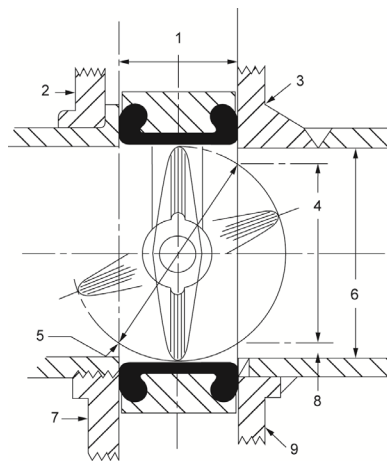
**Figure A.7—Typical Sleeve Lined Plug Valve****Figure A.8—Typical Nonlubricated Plug Valve**



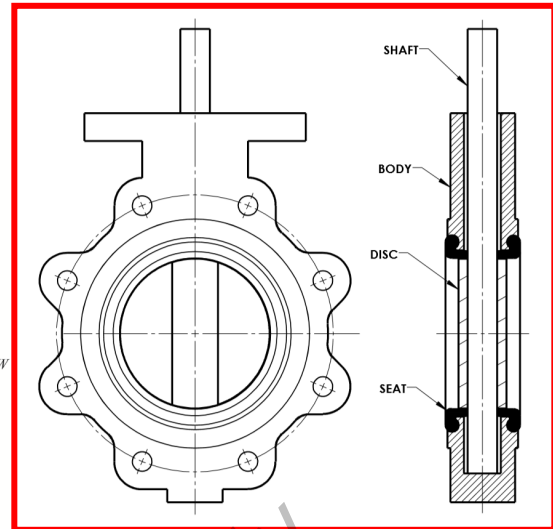
**Key**

- 1 lubricant fitting
- 2 gland bolting
- 3 gland
- 4 cover bolting
- 5 cover
- 6 stem packing
- 7 lubricant check valves
- 8 body
- 9 plug
- 10 stem
- 11 cover gasket
- 12 cover flange

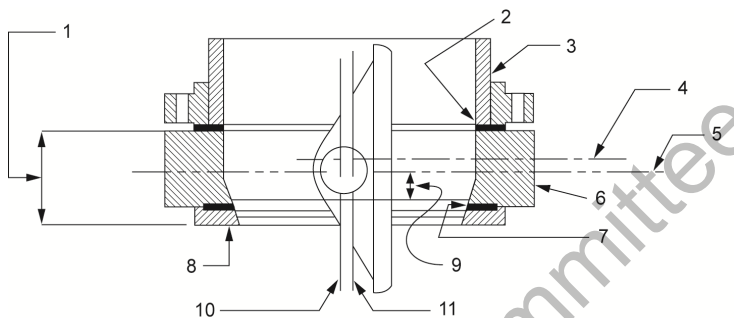
**Figure A.9—Typical Lubricated Plug Valve**

**Existing**

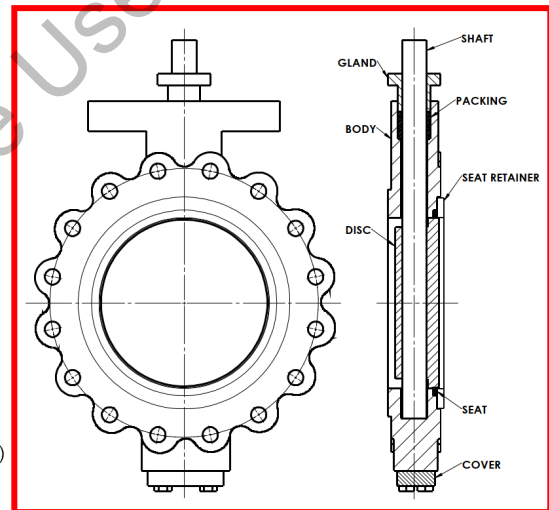
- Key**
- 1 minimum installed face-to-face dimension,  $W$
  - 2 lap-joint flange
  - 3 welding-neck flange
  - 4 chord of disc,  $a$
  - 5 maximum disc diameter,  $D$
  - 6 pipe inside diameter,  $d$
  - 7 threaded flange
  - 8 nominal radial clearance,  $c$
  - 9 slip-on flange

**Proposed (API 609\_e9 Draft 16)**

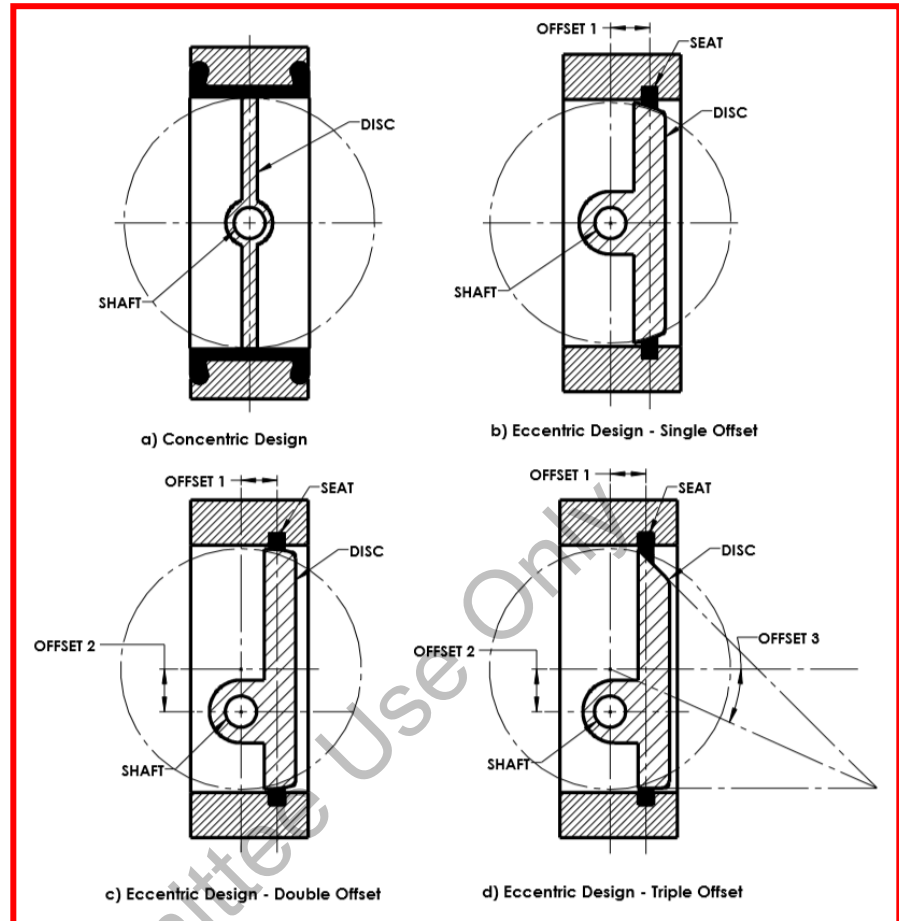
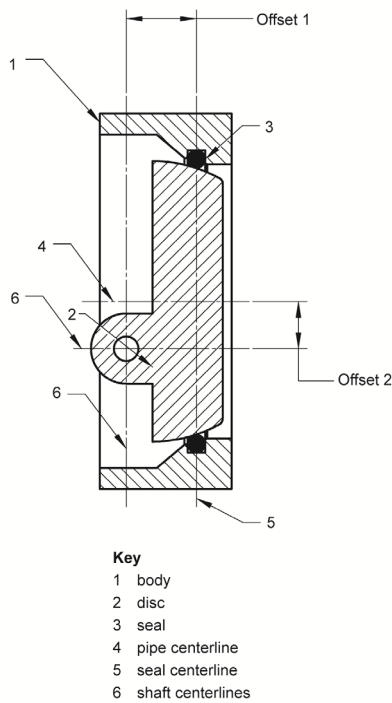
**Figure A.10a— Typical Part Nomenclature for Category A Concentric Disc Type (Matches latest API 609 9<sup>th</sup> Edition Fig. C.1 for consistency.)**



- Key**
- 1 valve face-to-face dimension (metal)
  - 2 flange gasket
  - 3 pipe
  - 4 disc centerline
  - 5 shaft centerline
  - 6 body
  - 7 seat
  - 8 seat retainer plate
  - 9 seat offset
  - 10 shaft centerline (axis of rotation)
  - 11 pipe centerline

**Existing****Proposed (API 609\_e9 Draft 16)**

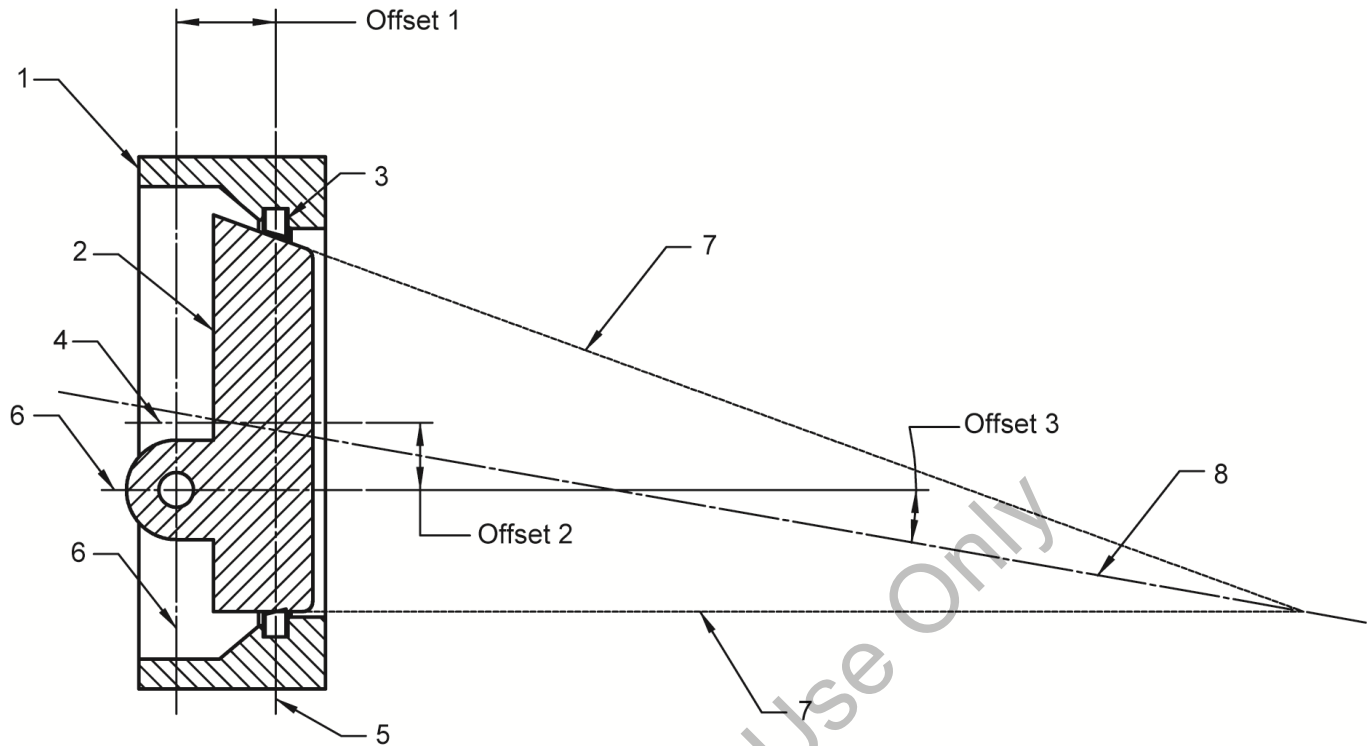
**Figure A.10b— Typical Part Nomenclature for Category B Offset Disc Type (Matches latest API 609 9<sup>th</sup> Edition Fig. C.2 for consistency.)**



Existing

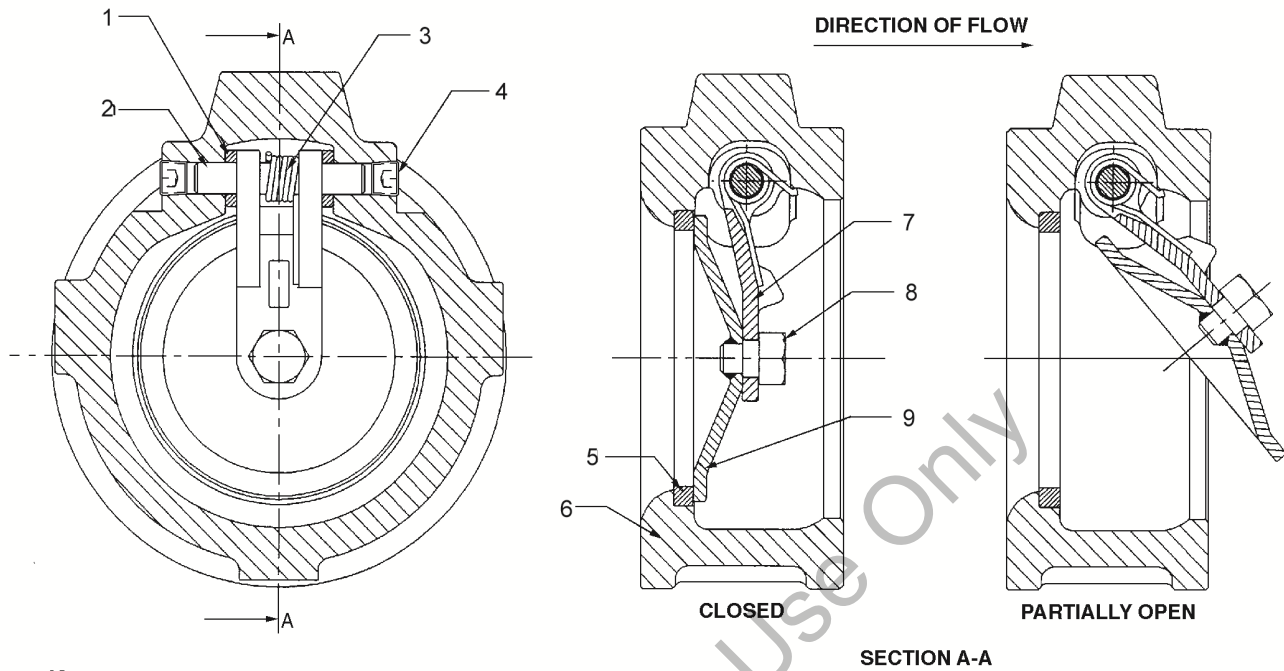
Proposed (API 609\_e9 Draft 16)

Figure A. 11a-11d—Typical Offset Type Constructions (Matches latest API 609\_e9 Draft 16 for consistency.)

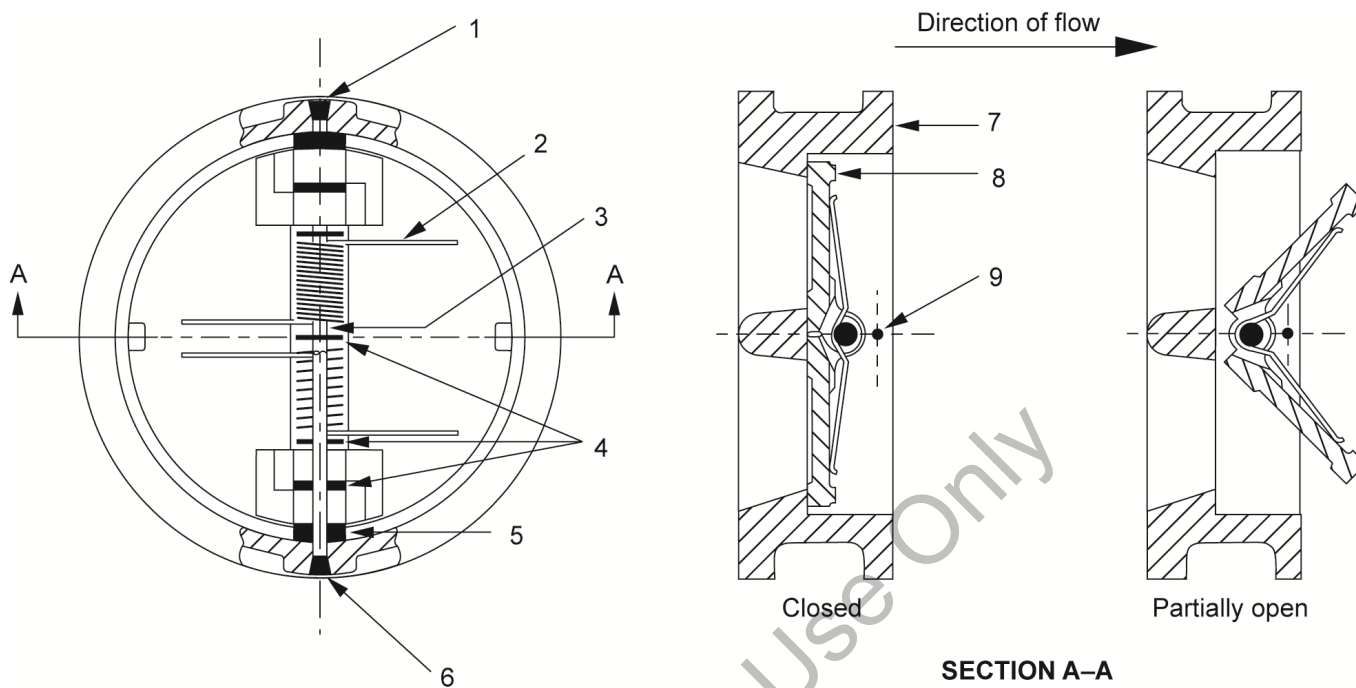
**Key**

- 1 body
- 2 disc
- 3 seal
- 4 pipe centerline
- 5 seal centerline
- 6 shaft centerlines
- 7 cone outer edge
- 8 cone centerline

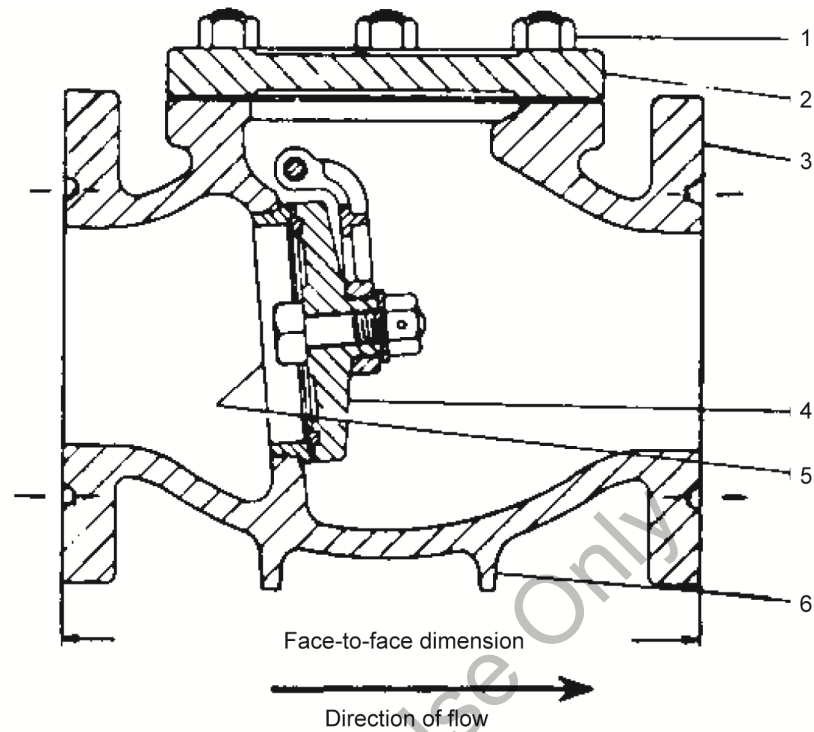
*Delete since triple offset covered by new Fig A.11d above*



**Figure A.13—Typical Single-plate Wafer Check Valve**

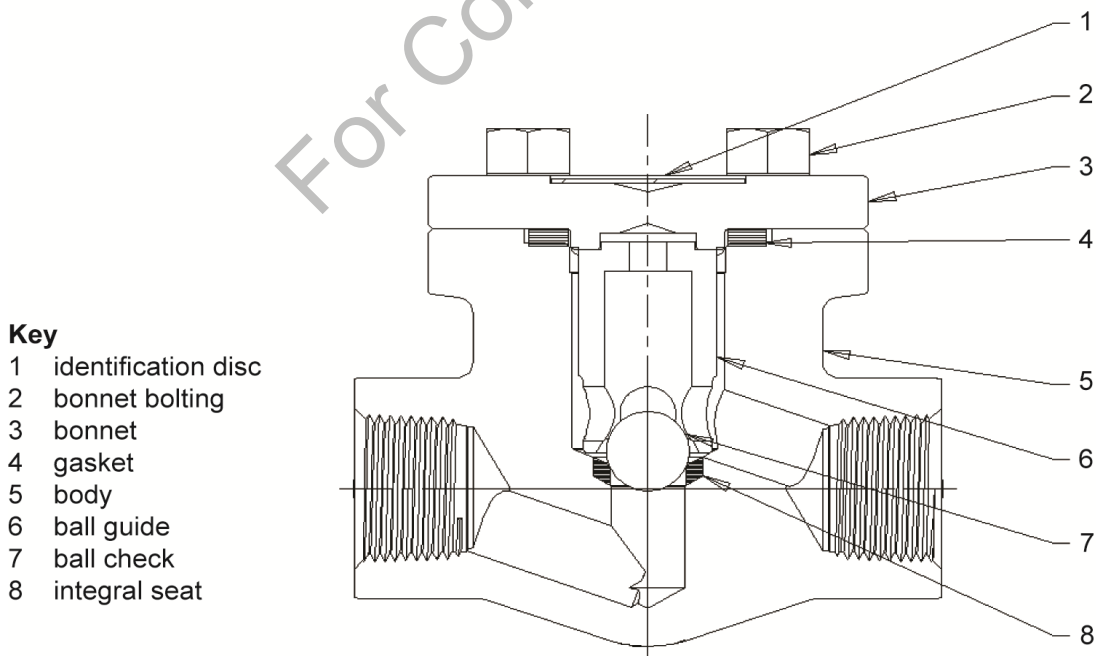


**Figure A.14—Typical Dual-plate Wafer Check Valve**

**Key**

- 1 cover studs and nuts
- 2 cover
- 3 body
- 4 disc
- 5 seat ring
- 6 support ribs or legs

**Figure A.15—Typical Flanged Swing Check Valve** *(drawing will be replaced [GJJ])*

**Key**

- 1 identification disc
- 2 bonnet bolting
- 3 bonnet
- 4 gasket
- 5 body
- 6 ball guide
- 7 ball check
- 8 integral seat

**Figure A.16—Typical Ball Check Valve—Threaded End**

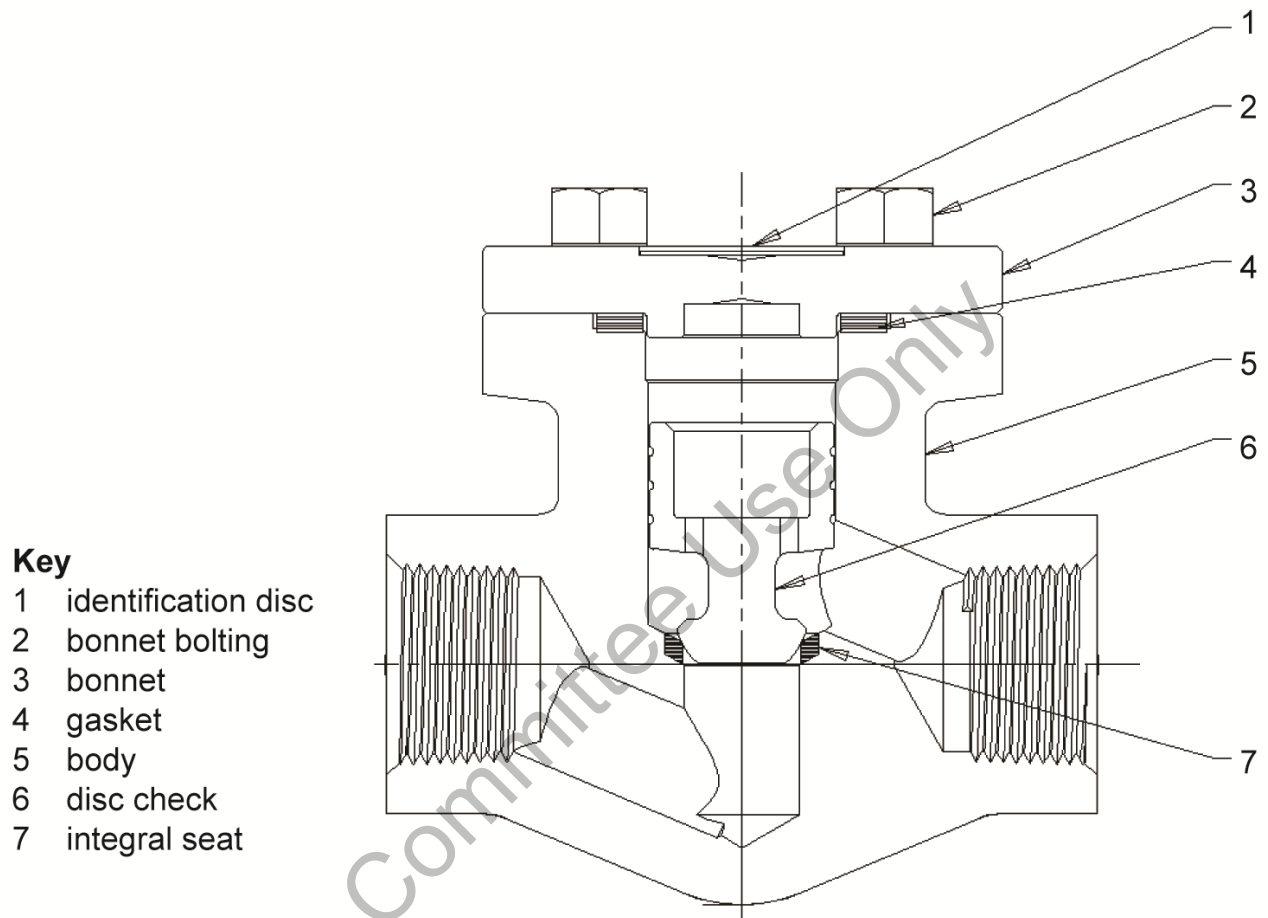
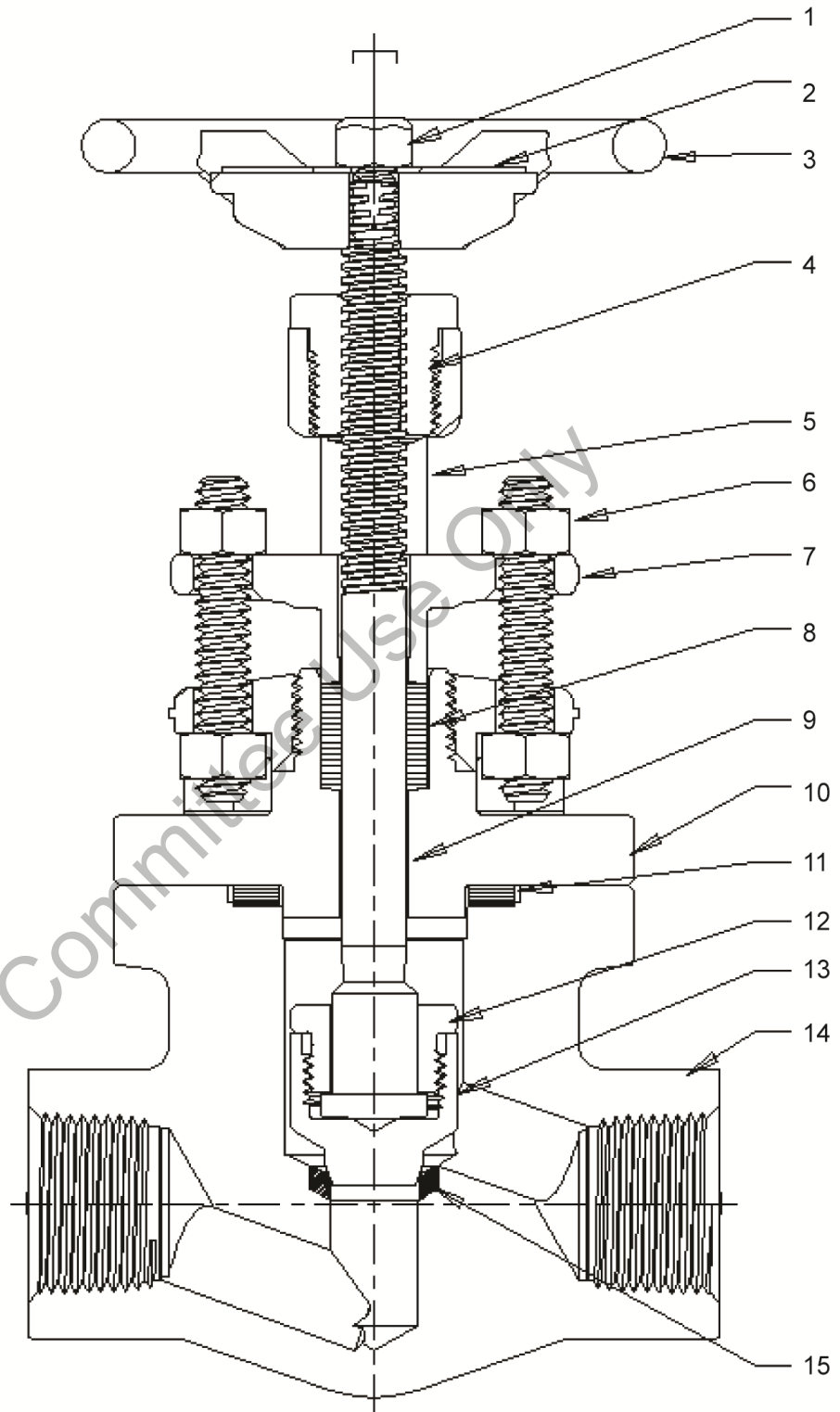


Figure A.17—Typical Piston Check Valve—Threaded End



**Key**

- 1 jam nut
- 2 identification disc
- 3 handwheel
- 4 yoke nut
- 5 yoke
- 6 gland bolting
- 7 packing gland
- 8 packing
- 9 stem
- 10 bonnet
- 11 gasket
- 12 disc nut
- 13 disc
- 14 body
- 15 integral seat

**Figure A.18—Typical Threaded Globe Valve**

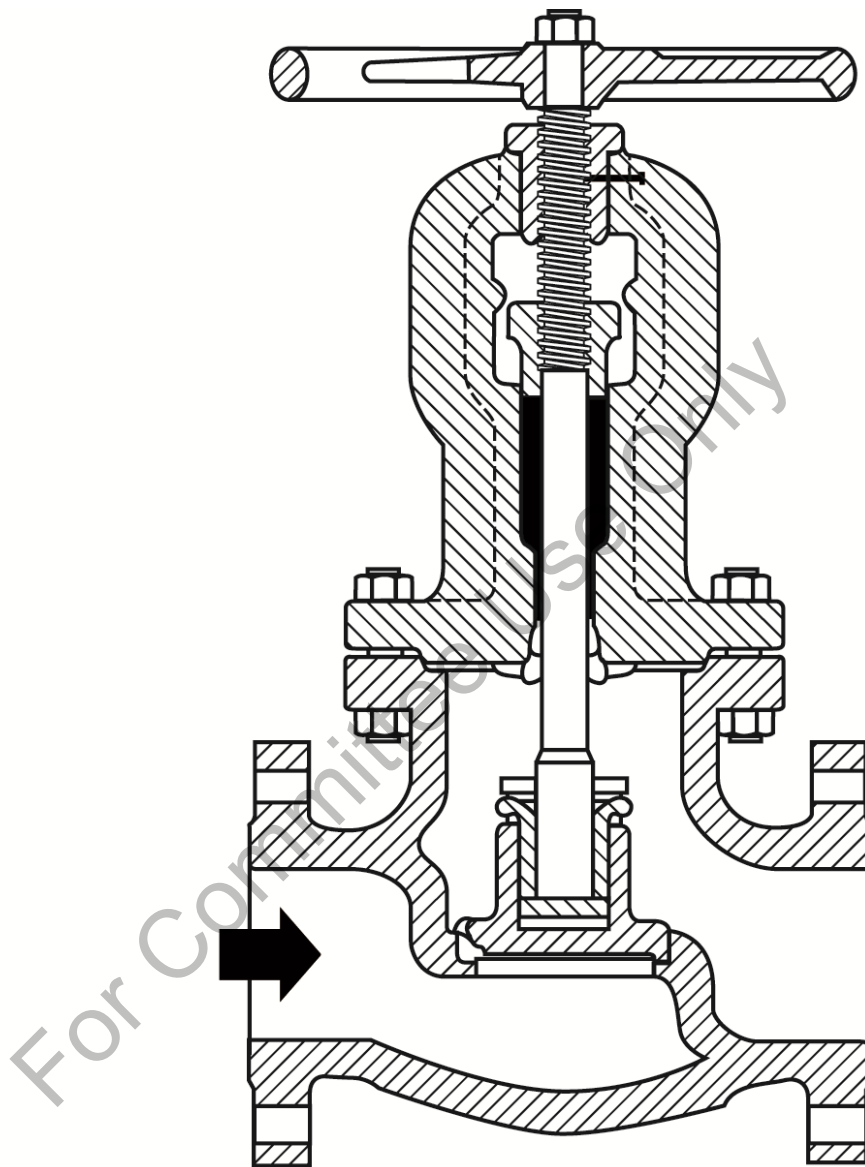
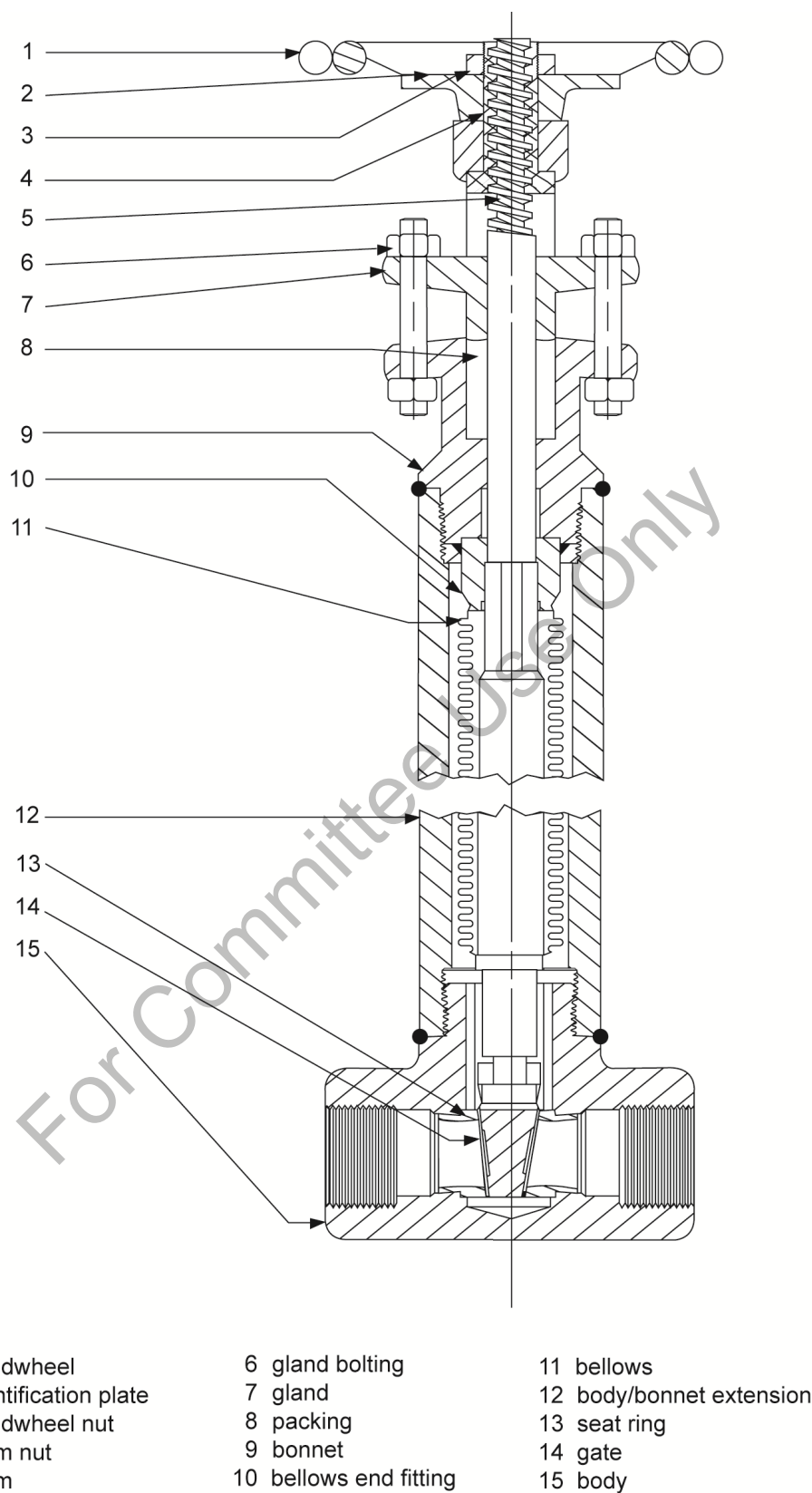


Figure A.19—Typical Flanged Globe Valve

For Committee Use Only



**Figure A.20—Example of API 602 Bellows Stem Seal**

## Annex B

(informative)

### Examples of Typical Valve Purchase Descriptions

API valve standards specify information that needs to be provided by the purchaser to fully define valve details required for the intended service.

#### B.1 API 600 Gate Valve

Gate valve (API 600); NPS 18, Class 300; raised face flanged ends; ASTM A216 WCB body; bolted bonnet, OS&Y, with flexible wedge; spiral-wound flexible graphite filled gasket, flexible graphite packing; trim #5; gear operation for 400 psig pressure differential; NPS 3/4 NPT drain connection in position G (per ASME B16.34); third-party inspection by purchaser.

#### B.2 API 600 Gate Valve (Cryogenic Service)

Gate valve (API 600) for cryogenic service from -320 °F (-196 °C); NPS 6, Class 150; raised face flanged ends; ASTM A351 CF8M or ASTM A182 F316/316L (casting to have Ferrite Number of 8 or less per ASTM A800); Mill Test Report required; stainless steel yoke and bonnet bolting, ASTM A320 Gr. B8 Cl. 2; bolted bonnet, OS&Y, solid or flexible wedge; trim #12; flexible graphite packing; extended bonnet and cryogenic design/testing requirements per ISO 28921-1; witnessed cryogenic testing and inspection by purchaser.

#### B.3 API 602 Gate Valve

Gate valve (API 602); NPS 2, Class 800; socket weld ends; ASTM A105 body; welded bonnet, OS&Y; flexible graphite packing; trim #8.

#### B.4 API 608 Ball Valve

Ball valve (API 608); NPS 6, Class 300; raised face flanged ends; ASTM A216 WCB or ASTM A105; Type 316 stainless steel stem and ball; PTFE or RTFE seats, reduced bore; bidirectional with body cavity overpressure protection; gear operator; flexible graphite body seals, gasket, and packing; lockable device; fire tested design per API 607.

#### B.5 API 623 Globe Valve

Globe valve (API 623); NPS 3, Class 600, raised face flanged ends; ASTM A216 WCB; bolted bonnet, OS&Y, swivel disc; stainless steel reinforced flexible graphite or stainless steel spiral-wound flexible graphite filled gasket; flexible graphite packing; trim #8.

#### B.6 API 609 Butterfly Valve

Butterfly valve (API 609 Category B, triple offset type); NPS 10, Class 300; raised face double flanged, long pattern; ASTM A105 or ASTM A216 WCB; bidirectional flow for on-off service; graphite laminated stainless steel seal ring; graphite seals; flexible graphite packing; gear operated; API 598 testing with leak rates for resilient seated valves; fire tested design per API 607.

#### B.7 API 599 Sleeved Plug Valve

Plug Valve (API 599); sleeve-lined type, full bore; NPS 2, Class 300; raised face flanged ends; ASTM A216 WCB body; ASTM A351 CF8M plug; PTFE sleeve with PTFE stem seals; wrench operated (included), with lockable device.

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- [3] API Standard 598, *Valve Inspection and Testing*
- [4] API Standard 599, *Metal Plug Valves—Flanged, Threaded, and Welding Ends*
- [5] API Standard 600, *Steel Gate Valves—Flanged and Butt-welding Ends, Bolted Bonnets*
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- [12] API Standard 623, *Steel Globe Valves – Flanged and Butt-welding Ends, Bolted Bonnets*
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- [15] API RP 751, *Safe Operation Of Hydrofluoric Acid Alkylation Units*
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- [17] ASME B16.1 <sup>1</sup>, *Gray Iron Pipe Flanges and Flanged Fittings*
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- [22] AWWA Manual M49 <sup>2</sup>, *Quarter-turn Valves: Head Loss, Torque, And Cavitation Analysis*
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- [24] CGA G4.4, *Oxygen Pipeline and Piping Systems*
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- [27] ISO 19240<sup>5</sup>, *Industrial Valves—Lined metal quarter-turn and check valves for chemical process and related industries*
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<sup>2</sup> American Water Works Association, 6666 W. Quincy Ave., Denver, Colorado 80235, [www.awwa.org](http://www.awwa.org)

<sup>3</sup> Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, Virginia 20151, [www.cganet.com](http://www.cganet.com).

<sup>4</sup> The Chlorine Institute—Headquarters Office 1300 Wilson Blvd., Arlington, Virginia 22209, [www.chlorineinstitute.org](http://www.chlorineinstitute.org).

<sup>5</sup> International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

<sup>6</sup> Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, [www.mss-hq.com](http://www.mss-hq.com).

<sup>7</sup> NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, [www.nace.org](http://www.nace.org).