Valve Selection Guide

API RECOMMENDED PRACTICE 615
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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, 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.

While 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 an 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 guidance on the selection of common types of valves used by the petroleum refining, chemical, petrochemical and associated industries. These include gate, ball, plug, butterfly, check, and globe valves covered by API and ASME Standards.

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

Installation issues are discussed briefly for a few valve types.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 594, *Check Valves: Flanged, Lug, Wafer, and Butt-welding*

API Standard 598, *Valve Inspection and Testing*

API Standard 599, *Metal Plug Valves—Flanged, Threaded, and Welding Ends*

API Standard 600, *Steel Gate Valves—Flanged and Butt-welding Ends, Bolted Bonnets*

API Standard 602, *Steel Gate, Globe and Check Valves for Sizes NPS 4 and Smaller*

API Standard 603, *Corrosion-resistant, Bolted Bonnet Gate Valves—Flanged and Butt-welding Ends*

API Standard 607, *Fire Testing for Soft-seated Quarter-turn Valves*

API Standard 608, *Metal Ball Valves—Flanged, Threaded, and Welding Ends*

API Standard 609, *Butterfly Valves—Double Flanged, Lug- and Wafer-Type*

API RP 622, *Type Testing of Process Valve Packing for Fugitive Emissions*

API Recommended Practice 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*

ASME B16.1 [1], *Gray Iron Pipe Flanges and Flanged Fittings*

ASME B16.24, *Cast Copper Alloy Pipe Flanges and Flanged Fittings*

ASME B16.34, *Valves—Flanged, Threaded, and Welding End*

ASME B16.42, *Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300*

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[1] ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

CGA G4.1 [2], *Cleaning Equipment for Oxygen Service*

CGA G4.4, *Oxygen Pipeline Systems*

Chlorine Institute Pamphlet No. 6 [3], *Piping Systems for Dry Chlorine*

MSS SP-120 [4], *Flexible Graphite Packing Systems for Rising Stem Steel Valves—Design Requirements*

MSS SP-134, *Valves for Cryogenic Service Including Requirements for Body/Bonnet Extensions*

NACE MR0103 [5], *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

3 Terms and Definitions

For the purposes of this document the following definitions apply.

3.1
abrasive service
Abrasive service is a term used to identify fluids containing abrasive particulate in piping systems including pipe rust, scale, welding slag, sand, catalyst fines, grit and hydrocarbon particles such as coke.

3.2
bellows stem seal
A flexible metal bellows is used in addition to valve stem packing to provide a positive seal against leakage past the stem packing.

3.3
chlorine service
Services containing liquid or vapor chlorine in concentrations higher than 1 ppm (OSHA PEL). This does not include water services containing chlorine for pH balancing or as a biocide.

3.4
clean service
Clean service is a term used to identify fluids free from solids or contaminants. Clean fluids include most light hydrocarbons, instrument air, nitrogen, water, steam, lube oil, diesel oil, methanol, etc.

3.5
closure member
This refers to the component in the valve that serves to stop flow (gate, ball, and plug, for example). Known as the obturator in some international valve standards.

3.6
cryogenic (low temperature) service
Cryogenic service is generally defined in the process industry as services that are lower than minus 101 °C (minus 150 °F). These services, which are comparatively clean, include LNG liquefaction and gasification, NGL production, ethylene production, etc.

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[2] Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, Virginia 20151, www.cganet.com.
[3] The Chlorine Institute—Headquarters Office 1300 Wilson Blvd., Arlington, Virginia 22209 USA, www.chlorineinstitute.org.
[4] Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.
[5] NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.

3.7
dirty service
Dirty service is a general term used to identify fluids with suspended solids that may seriously impair the performance of valves unless the correct valve type and trim are selected.

3.8
double block and bleed (DB&B) valves
A bleed valve is located in the body to vent the cavity between the seats. Venting the cavity will help to reduce the pressure acting on the downstream seat, which will help minimize any leakage.

3.9
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 build up.

3.10
fugitive emissions
Leakage of volatile organic compounds (VOCs) typically from valve stem seals and gasketed joints.

3.11
hardfacing
Hardfacing refers to the use of a high-hardness material such as Co-Cr A applied to the seating surfaces of valves to provide for longer life and improved resistance to galling of the contacting parts.

3.12
high temperature service
High temperature service, as it relates to valves, is typically defined as a service with temperature higher than 400 °C (750 °F).

3.13
hydrogen service
Services containing hydrogen at partial pressure with a temperature above the carbon steel curve in API 941.

3.14
hydrofluoric acid (HFA) service
Service involving the use of the toxic hydrofluoric (HF) acid . This acid in the presence of water and carbon steel forms a scale (iron fluoride) that can block pipes and valve cavities and adhere to the metallic sealing surfaces of valve gates and seats.

3.15
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.

3.16
oxygen service
Streams containing more than 23 % by volume oxygen as defined by CGA G-4.4.

3.17
pulsating flow service
Pulsating flow is the unsteady fluid flow in a piping system resulting from the repeating pressure variations such as occur with a reciprocating pump or compressor within the system. This flow results in a periodic increase and decrease of flow and pressure in the pipe.

3.18
pressure seal bonnet
The pressure seal bonnet design is one that features a special compact body-bonnet joint rather than a flange. This body-bonnet joint is pressure-assisted so that with increasing pressure the joint seals more tightly.

3.19
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 heat tracing (e.g. steam-jacketed design) to maintain temperature and valve operability.

3.20
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 primarily the means of transportation, e.g. coal slurries and catalyst services.

3.21
stress cracking
Material failure resulting from exposure to aggressive environments, such as sour or wet H_2S exposure, chlorides, hydrogen, and amines, for example.

3.22
sour (wet H_2S) service
Wet H_2S service is defined as having greater than ≥ 50 wppm of H_2S in a water phase (determined by using the total amount of sulfide in the water phase) or ≥ 0.05 psia H_2S partial pressure in the gas phase with liquid water present.

3.23
utility service
Generally considered to include air, water, nitrogen, and steam not exceeding Class 150.

3.24
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.

4 Considerations for Valve Selection

4.1 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).

4.2 Valve Types

Consideration of 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 valves (API 602).

4.3 Other Considerations

Other considerations to take into account:

— pressure class and size;

— fluid service;

— materials of construction;

— valve trim selection;

— valve special features such as fire testing, cavity venting, purge connections, etc.;

— flow capacity and pressure loss.

5 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.

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

5.1.1 Gate Valves

5.1.1.1 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.

5.1.1.2 API 600 Gate Valves

API 600 on gate valves covers sizes from NPS 1 up to NPS 24 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). 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 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 Figure A.1 for a typical API 600 gate valve.

5.1.1.3 API 602 Gate Valves

API 602 covers the smaller size gate valves in sizes up to NPS 4 for pressure classes from Class 150 to Class 1500 including the special 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 Figures A.2 and A.3 for typical examples of API 602 gate valves.

5.1.1.4 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 $^1/_2$ through NPS 24. The wedge design is typically solid or flexible although split wedge and parallel-sided double disc gates are covered in the standard. Hardfacing may be specified to reduce galling tendency of stainless wedge seat faces to stainless body seat faces. See Figure A.4 for an example of a gate valve from API 603.

5.1.1.5 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.

5.1.1.6 Orientation Considerations

While somewhat dependent on pressure class, gate valves larger than about NPS 8 oriented in any 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 and not be operable. Special attention to guiding details including clearances, avoidance of sharp corners on the disc leading edge, and the possible 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 may be considered to address this potential build-up.

5.1.1.7 Other Gate Valve Designs

Other gate valve designs used in process plants that are less common include double disc designs, “knife gate” designs sometimes used in water service and special design “slide valves” used in high temperature, highly erosive fluid solids service such as in fluid coker units.

5.1.2 Ball Valves

5.1.2.1 General

Ball valves are another valve type designed 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.

5.1.2.2 API 608 Ball Valves

API 608 covers ball valves in sizes NPS $^{1}/_{2}$ through 20 for flanged and butt-welded ends in pressure classes 150 through 600 and NPS $^{1}/_{4}$ through 2 for socket welded and threaded ends in classes 150 through 800. Three port sizes are covered: full bore, single reduced bore, and double reduced bore.

Ball valves are available in two design options: "floating ball" and "trunnion" mounted ball. In floating ball designs the ball is held between fixed, resilient upstream and downstream seats. Trunnion designs are usually found in higher pressure and larger applications where the top and bottom of the ball are held in position in the valve body by means of a short shaft or other means and the seat rings are spring loaded against the ball. See Figure A.5 and Figure A.6 for examples of API 608 ball valve designs.

5.1.2.3 Soft Seated Ball Valves

Ball valves in API 608 are available with soft seats of a type of Polytetrafluoroethylene (PTFE) to provide for tight shutoff and reasonable turning torque requirements but with a pressure-temperature limitation due to the soft seat material. API 608 defines seat material pressure-temperature limitations of 177 °C (350 °F) for PTFE and 205 °C (400 °F) for reinforced PTFE.

5.1.2.4 Metal Seated Ball Valves

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.

5.1.3 Plug Valves

5.1.3.1 General

Plug valves are designed for on-off service using a truncated cone-sealing element that is typically supported either by a thin grease film (lubricated plug) or by a polymer sleeve (sleeved plug). Some plug valve designs are metal seated to provide for higher temperature service. Plug valves are useful for tight shutoff applications and for highly corrosive/erosive services because of its large sealing area. Common plug valve types are covered in API 599, but there are other plug-type designs used for special applications. Plug valves are not recommended for throttling service.

5.1.3.2 API 599 Plug Valves

Sizes covered in API 599 are NPS $^{1}/_{2}$ through 24 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. This pressure-temperature limit is to be marked on the valve nameplate. API 599 requires a temperature capability for lubricants and stem seals or packing to have a minimum temperature range of –29 °C (–20 °F) through 107 °C

(225 °F). Nonlubricated plug valves may use metal seats as sealing elements or hydrocarbon-resistant plastic of elastomer sleeve linings. See Figure A.7, Figure A.8, and Figure A.9 for examples of API 599 Plug Valves.

5.1.3.3 Gear Operation

API 599 defines gear operation as standard for NPS 8 and larger in Class 150 and 300 and for smaller sizes for higher-pressure classes.

5.1.4 API 609 Butterfly Valves

5.1.4.1 General

Butterfly valves covered by API 609 are available in several configurations including double flanged, and lug/wafer types that provide tight shutoff in the closed position but are also suitable for flow regulation. Materials available include gray iron, ductile iron, bronze, steel, nickel-base alloy, and special alloys. These valves are intended for installation between flanges. Butterfly valves are defined in API 609 as two major types, Category A (see 5.1.4.2) and Category B (see 5.1.4.3).

5.1.4.2 Category A Butterfly Valves

Manufacturer's rated cold working pressure (CWP) butterfly valves, usually with a concentric disc and seat configuration. Sizes covered are NPS 2 through NPS 48 for valves having ASME Class 125 or Class 150 flange bolting patterns. These valves are often lined with a nonmetallic material that may extend over the flange faces to serve as a gasket material. See Figure A.10 for a typical Category A Butterfly Valve.

5.1.4.3 Category B Butterfly Valves

Pressure-temperature-rated butterfly valves that have an offset seat and either an eccentric or a concentric disc configuration are 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), B16.42 for ductile iron, or B16.24 for cast copper alloys depending on the body material. Category B butterfly valves are specified in sizes up to NPS 48 for double flanged designs and up to NPS 24 for lug and wafer designs. The lug type or "single flanged" has bolting lugs provided threaded as standard but optionally may be ordered drilled through. Category B valves are known as "high performance" butterfly valves. See Figure A.11 for a typical category B Butterfly Valve.

5.1.4.4 Triple Offset Designs

In addition to the double offset disc designs, there is also the triple offset design, which uses an angled-seat geometry to allow shaft closing torque to compress the sealing element more tightly to provide for a better seal. Since the body seat has a complex geometry, repair or replacement of a damaged seat may require special equipment. See Figure A.12 for an example of a triple offset design.

5.1.4.5 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 and bearing wear that may occur with the stem vertical.

5.1.5 Globe Valves

Although mainly considered for throttling service, globe valves are another valve type that may be used as a block valve. These will be discussed in more detail in 5.3.

5.2 Valves for Preventing Flow Reversal—Check Valves

5.2.1 General

Check valves prevent undesirable backflow without any outside intervention. A typical example is to prevent backflow into a pump either when the pump is shutdown or from the discharge side of a pump installed in parallel. Pump damage could occur if such backflow was not prevented.

Except in the smaller sizes, check valves should be properly sized for the flow conditions to avoid mechanical damage resulting from the disc opening and closing against the seats if the flow is not sufficient to keep the disc fully open. Check valves having the same NPS as the line size may be too large.

Since for typical designs the closing force on check valve seats results from a combination of pressure differential, gravity and closing spring force (where provided), typical metal-seated check valves may not provide for fully tight shutoff. On the other hand, they may provide tight shutoff in some situations even if not intended. Resilient seated check valves are available for improved tight shutoff performance.

5.2.2 API 594 Check Valves

Check valves covered by API 594 include:

— Type A—single or dual plate in wafer, lug, or double flanged designs; and

— 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 Figures A.13 and 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 in the full open position. See 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.

5.2.3 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 Figure A.16 and Figure A.17 for examples of API 602 ball and piston check valves.

5.2.4 Stop-check Valves

A special case is the "stop-check" design where the piston-type disc can be closed against the seat by mechanical means similar to a globe valve operation. These valves, often used in steam service, serve dual functionality; acting like a check valve in normal operation and providing block valve capability when needed. Some designs have a space above the disc that can trap fluid and retard the opening movement of the disc. To permit unrestrained valve opening some form of pressure equalization from above the disc to the downstream may be required to relieve pressure caused by the fluid trapped above the disc. The need for pressure equalization also applies to some piston check designs. The manufacturer should be consulted for need and proper sizing. Stop-check valves are available in T-pattern, Y-pattern, and angle pattern.

5.2.5 Orientation Considerations

Proper orientation of a check valve is essential for correct operation. Check valves with a bolted or welded cover in horizontal lines should always be oriented with the cover upwards, because the valves internal check element is designed to function as intended in this orientation. Check valves installed with the cover turned to the side will probably not operate properly unless spring loaded by the manufacturer for this purpose. Double plate valves in horizontal flow should be installed with the pins vertical. Some types of check valves, notably the double plate, spring assisted and swing-type, will also work in vertical lines with the flow upward. Y-pattern check valves, which could be lift type or modified swing type (tilt disc) internals, can usually be used in either horizontal or vertical-up lines with flow upward equally well. If in doubt, check with the manufacturer.

5.2.6 Location Considerations

To minimize wear or damage to internal parts, check valves should not be located in areas of turbulent flow; such as adjacent to changes in direction or pump discharges. Consult the manufacturer for recommendations when in doubt.

5.2.7 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 momentum of the stream acting against the closed valve. Typically check valve designs that close quickly can minimize the adverse effect of the flow reversal by preventing the build-up of a rapid reverse flow. Typical applications are at pump discharges. Fast acting check valves are the ones with a small 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).

Although not in common use, some large check valve designs may be fitted with an optional external device attached to the closure element to assist in its 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.

5.3 Valves for Throttling (Controlling) Flow—Globe Valves

5.3.1 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. See Figure A.18 and Figure A.19 for examples of globe valve designs.

5.3.2 Typical Sizes Available

While 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.

5.3.3 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. Typically, a bypass valve is too large if it is the same NPS size as the control valve it bypasses. 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.

5.3.4 Disc Guiding

For larger size and higher-pressure class valves, a provision to guide the disc throughout its travel should be considered. A guided disc ensures that the disc will not deflect or cock during travel, resulting in uneven seat wear and leakage. The disc may be guided in a cage, at a single location near the stem, on one or more outside diameters on the disc, or by machined body-guide ribs.

5.3.5 Non-Rotating Disc

Where conditions require the valve to be less than 20 % open, the use of a nonrotating 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.

6 Service Considerations

6.1 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, dirty, or abrasive (slurry service) depending on the amount and type of suspended solids materials that could lead to valve plugging or erosion damage. In addition, the presence of sulfur and other compounds in the streams in combination with elevated temperatures contribute to corrosive environments. Such streams require careful selection of materials to provide adequate service life. Corrosion engineers continue to study and develop materials to address these concerns.

6.2 Chlorine Service

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

Chlorine gas or liquid service is highly corrosive, especially if water is present in the gas or fluid. Water combines with the chlorine and forms HCl (hydrochloric acid), which may corrode body and trim materials. 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.

6.3 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, which distances the packing and operating mechanism from the cryogenic fluid, to permit stem packing to operate at a higher temperature and to help ensure that the valve operator will not be encased in ice when in service. MSS SP-134 provides additional details covering bonnet extension design.

6.4 Hydrofluoric Acid Service

Valves in Hydrofluoric (HF) acid service should be restricted to those types that have been demonstrated in service or by test to handle this service successfully. Generally, valve types that do not provide opportunities for the accumulation of solid matter are preferred. HF acid processes are operated under license from the technology owners who place strict controls on listed valves. The design and material requirements for these valves (typically carbon steel with special Monel trim or solid Monel) as well as details of internal geometry are very specific and are designed to resist the specific characteristics of HF acid corrosion. Valves for this service are inspected and tested to a higher standard than those for typical process applications.

6.5 Hydrogen Service

Valves in this service are typically provided with a higher casting quality as compared to commodity castings. As hydrogen is an extremely permeable fluid, the use of weld-end valves in Class 600 and higher should be considered where practical to reduce the number of potential leak sources.

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

6.6 Oxygen Service

Valves in oxygen service should comply with CGA G4.4, *Oxygen Pipeline Systems*, as applicable. Valves for this service should be thoroughly degreased, cleaned, assembled in clean conditions and properly packaged and sealed as oils and greases are highly combustible in the presence of oxygen. Guidance is given in CGA G 4.1, *Cleaning Equipment for Oxygen Service*. Proper handling and storage prior to installation is essential.

For oxygen service Bronze or Monel body and trim materials are often recommended to prevent sparking and ignition as a result of high-energy mechanical impact. There are silicon-based lubricants specifically formulated for oxygen service, since standard hydrocarbon lubricants should never be used in the presence of oxygen.

6.7 Pulsating or Unstable Flow

The selection of check valves needs special consideration when used in pulsating 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. Some difference of opinion exists on this subject, but generally dual plate, tilting disc, and axial flow (nozzle) type check valves are the types suggested for pulsating/unstable flow.

6.8 Sour Service (Wet H_2S Service)

Valve materials for sour service should comply with NACE MR0103. This document, specific to downstream HPI processes, limits the hardness of all steels; 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.

It should be noted that NACE MR0103 places the responsibility on the user to specify whether bolts will be exposed to H_2S environment. Unless so specified by the user, bolts such as bonnet bolting that are not internal to the valve will typically conform to the product standard without sour service compliance. This is because valve body-bonnet bolting need not meet the requirements of NACE in cases where the material is not directly subjected to the process fluid. If any leakage of sour product is not able to drain away or evaporate (e.g., insulated valves) then bolting should be in accordance with NACE standard.

Particular attention should be given to the bolting if a NACE-compliant material is deemed necessary. The imposition of a hardness limitation will result in reduced strength. Reduced strength bonnet bolting may not be suitable for the same design conditions as the standard bolting material.

6.9 Viscous or Solidifying Service

Valves in viscous fluid service or solidifying fluid service, such as liquid sulfur or heavy fuel oil, often require steam trace heating or steam jackets to maintain a sufficient temperature for valve operability. Special attention should be given to check valves in which sluggish response may cause operating difficulties.

7 Valve Material Selection

7.1 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 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.

7.2 Valve Trim Selection

7.2.1 General

Valve trim materials include more than just the valve seating surfaces as is well defined in trim tables contained in API 600 and 602. In general for all valve types the trim includes all internal parts in contact with the process fluid. If specific requirements are not defined, API standards require that trim materials must be at least as corrosion resistant as the body material.

7.2.2 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. As pointed out in API standards, a key consideration to avoid galling of valve seats is to provide a difference in hardness between the mating seating surfaces except when both surfaces are hardfaced. Trim tables are provided in the referenced standards. Several of the available trims provide for hardfacing of one or both seating surfaces to better ensure long-term abrasion, corrosion, and wear resistance.

7.2.3 Trim for Other Valves

For check valves, trim is defined as the seating surfaces of the closure member and body seat. Trim tables are provided in the referenced standards. Several of the available trims provide for hardfacing of one or both seating surfaces to better ensure long-term abrasion, corrosion, and wear resistance.

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. Shaft and bushing materials are to have similar corrosion properties as the trim materials.

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.

For globe valves, the trim is as defined in API 602.

7.3 Seating Surfaces—Soft Seats

Ball valves and butterfly valves are often used with resilient, nonmetallic seats to provide for leak tightness. 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 by agreement with purchaser and manufacturer. With PTFE material the service temperature limit is typically 177 °C to 205 °C (350 °F to 400 °F). The need for pressure relief of the body cavity should be considered for some soft-seated ball valves in liquid service.

7.4 Stem Sealing—Fugitive Emissions

A common valve stem packing material used in process piping is a form of flexible graphite. A typical packing design for new valves is several rings of die-formed packing with one ring of braided material on top and one on the bottom of the packing stack. The braided material "wiper rings" helps to resist extrusion of the die-formed rings out of the stuffing box. Current valve packing technology offers a significant resistance to light hydrocarbon packing leaks (fugitive emissions) compared to the previous use of asbestos packing materials. Key materials factors that affect graphite packing performance are percent carbon content, density of the packing, and corrosion/oxidation inhibitors. MSS SP-120 has a good discussion on flexible graphite packing systems for rising stem valves. API 622 qualified packing should be considered.

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 538 °C (1000 °F) and higher.

Live Loading—Over time, packing sealing performance may degrade due to "packing consolidation". This results in the loss of gland load leading to packing leakage. The process of "Live Loading", which may be optionally available, involves spring loading the gland follower with conical disc washers that provide a means to maintain a gland load on the packing and helps to extend the amount of time over which the packing remains effective.

Some quarter-turn valves may use elastomeric O-Rings for stem seals. These seals may have a service temperature limitation lower than PTFE.

Valves with a "bellows seal" on the stem have been used in steam service, as well as in certain hazardous/toxic applications to reduce potential for packing leakage. This design is covered in API 602 for sizes NPS $^{1}/_{2}$ to NPS 2. API 602 includes design and testing details for bonnets with bellows stem seals in addition to conventional packing. See Figure A.20 for an example design of a bellows stem seal from API 602.

7.5 Valve Bonnet Gaskets

API 600 offers 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), and reinforced flexible graphite sheet for Class 150 only (when approved by the purchaser). The bonnet gasket shall be suitable for a service temperature range of –29 °C to 538 °C (–20 °F to 1000 °F).

API 602 requires that the bonnet flange gaskets be spiral wound with flexible graphite filler, unless specified otherwise. The required design confines the gasket to prevent over-compression.

API 603 bonnet gasket requirements are similar to those in API 600. Spiral wound gaskets (Class 300 and higher) with controlled compression and flexible graphite filler are permitted. API 603 does not define an upper temperature requirement.

8 Valve Specific Features and Options

8.1 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. These 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 in order. 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.

Metal seated ball valves especially those in high-pressure service frequently need gear or power operators to deal with the high closing/opening torque requirements involved.

8.2 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.

8.3 Hot Tap Valves

Valves used for hot-tapping warrant some special consideration. Two key requirements are that the valve port be 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.

8.4 Double Block Valves for Positive Isolation

When positive process stream isolation is needed for equipment maintenance, or other reasons, the use of soft-seated valves is effective if the seat material is adequate for the service temperature. Otherwise, for applications to avoid product contamination or for safety reasons, it is sometimes recommended to use two block valves in series with a bleeder between the valves vented to a safe location. The use of two valves in series may be needed as typical refinery 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). With two valves in series any small leakage passing the first valve may be vented away. With the pressure between these block valves reduced to a low level the second valve is able to provide a good seal with minimum leakage. The need for this arrangement increases at higher pressures in vapor service.

8.5 Double Block and Bleed (DB&B) Valves

Block valves with upstream and downstream seats like gate, ball, and plug valves could possibly perform the function of the two block valves described above by providing a vent connection between the valve body seats with each of the seats serving as one of the block valves. In theory if the leakage past the upstream seat was not too great, it could be vented away by the bleed valve thereby reducing the pressure against the downstream seat so it could provide for minimal leakage. API 598 includes a special high-pressure closure test to confirm double block and bleed capability in a single valve. Testing has shown that current API 600 gate valves are not designed to provide this performance at full rated pressure.

8.6 "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 has been developed to provide a type test for valve designs with such nonmetallic or nongraphitic materials to confirm that adequate resistance to a fire condition is provided. Valves that successfully pass this test are considered "Fire Tested" and are marked accordingly.

8.7 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, the use of butt-weld end valves should be considered in high pressure, hazardous services to minimize leak potential. Valves NPS 2 and smaller are furnished with socket welded, threaded, butt-welded, or flanged ends. For threaded end connections, the use of seal-welding for hydrocarbon and certain other services helps to provide better assurance against leaks in service.

8.8 Cavity Overpressure

Double-seated 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 and consequent expansion of the trapped liquid medium could result in an excessive pressure build-up in the cavity sufficient to cause failure of the pressure boundary. A temperature increase caused by ambient heating could be sufficient to result in a failure and release of contents.

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. Note that use of a drilled vent may render the valve to be unidirectional and therefore appropriate marking is required.

8.9 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 a potential for bolt failure under exposure to fire conditions due to thermal expansion of the exposed bolts. This is a particular concern in hydrocarbon service where the intensity of a fire may be increased due to leaking material. The use of flange shields consisting of 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, the double flanged design is the preferred alternative.

8.10 Valve Purge Connections

Gate valves 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 can be more susceptible to this. A NPS $^3/_4$ valved connection installed between the seats in position G (see Figure 1 in ASME B16.34) will permit use of a purge to help clear the obstruction.

9 Steps for Valve Selection and Procurement

It is recommended, that at a minimum, the following suggested steps be considered to determine and select a suitable valve for the intended service.

1) Determine required valve size and maximum design pressure and temperature for the process.

2) Select valve type based on required function.

3) Select body material based on design temperature and corrosion resistance needs from a material listed in applicable ASME standard.

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 due to soft seat material.

6) Consider special packing needs.

7) Select valve end design (flanged, threaded, or welded).

8) Define venting if needed to avoid cavity overpressure from trapped liquids.

9) Determine need for assisted operation (gear operator, motor drive, etc.).

10) Specify fire testing to API 607 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) Prepare a detailed purchase description to address supplemental items in “Notes to Purchaser” in API standards.

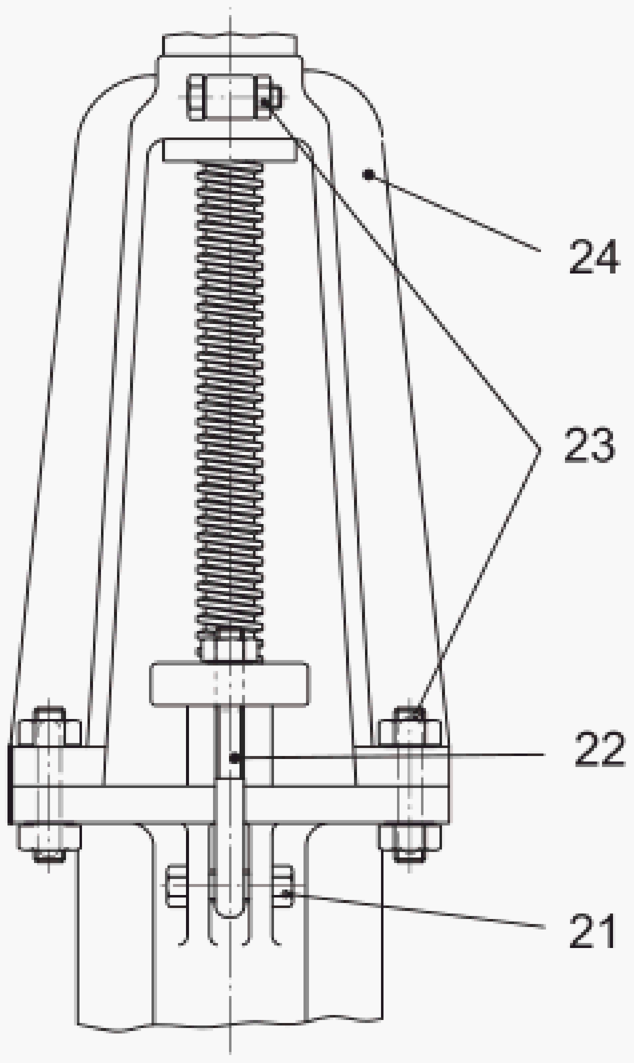
NOTE Annex B contains examples of typical purchase descriptions for reference.

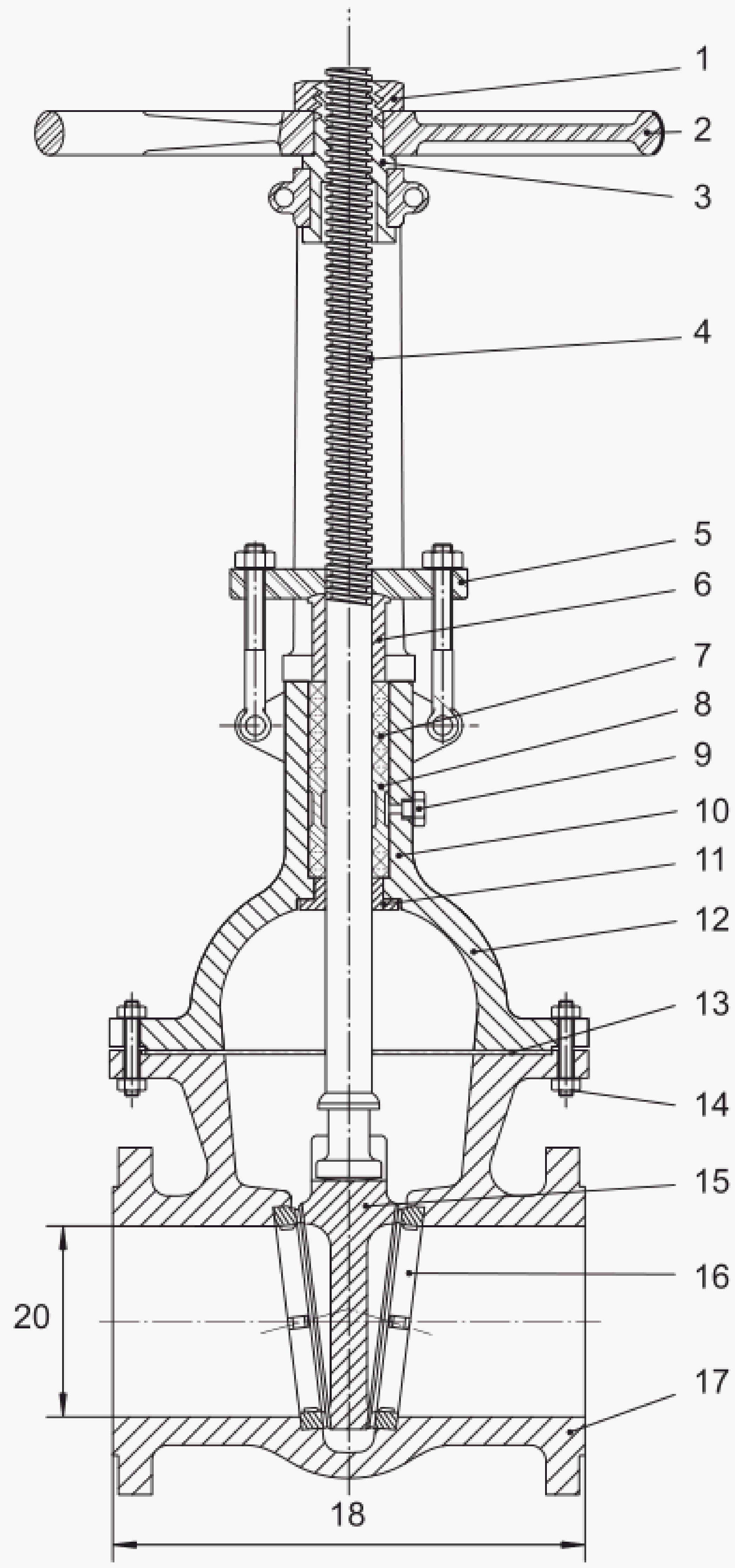
14) For critical valves discuss with selected manufacturer for suggestions or options to consider.

NOTE Some steps may need to be recycled to address temperature or materials selection limits.

Annex A
(informative)

Schematic Drawings for Typical Valve Types





Key

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

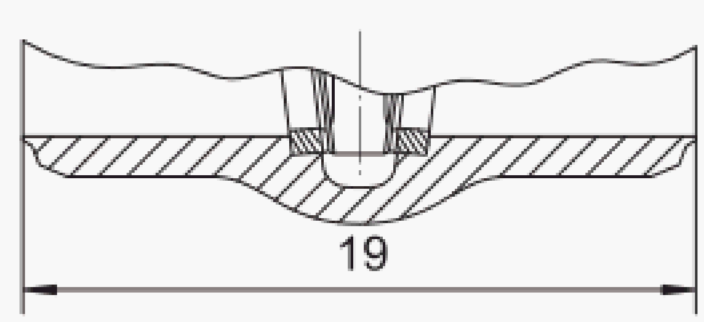


Figure A.1—Typical API 600 Bolted Bonnet Gate Valve—Outside Screw and Yoke

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

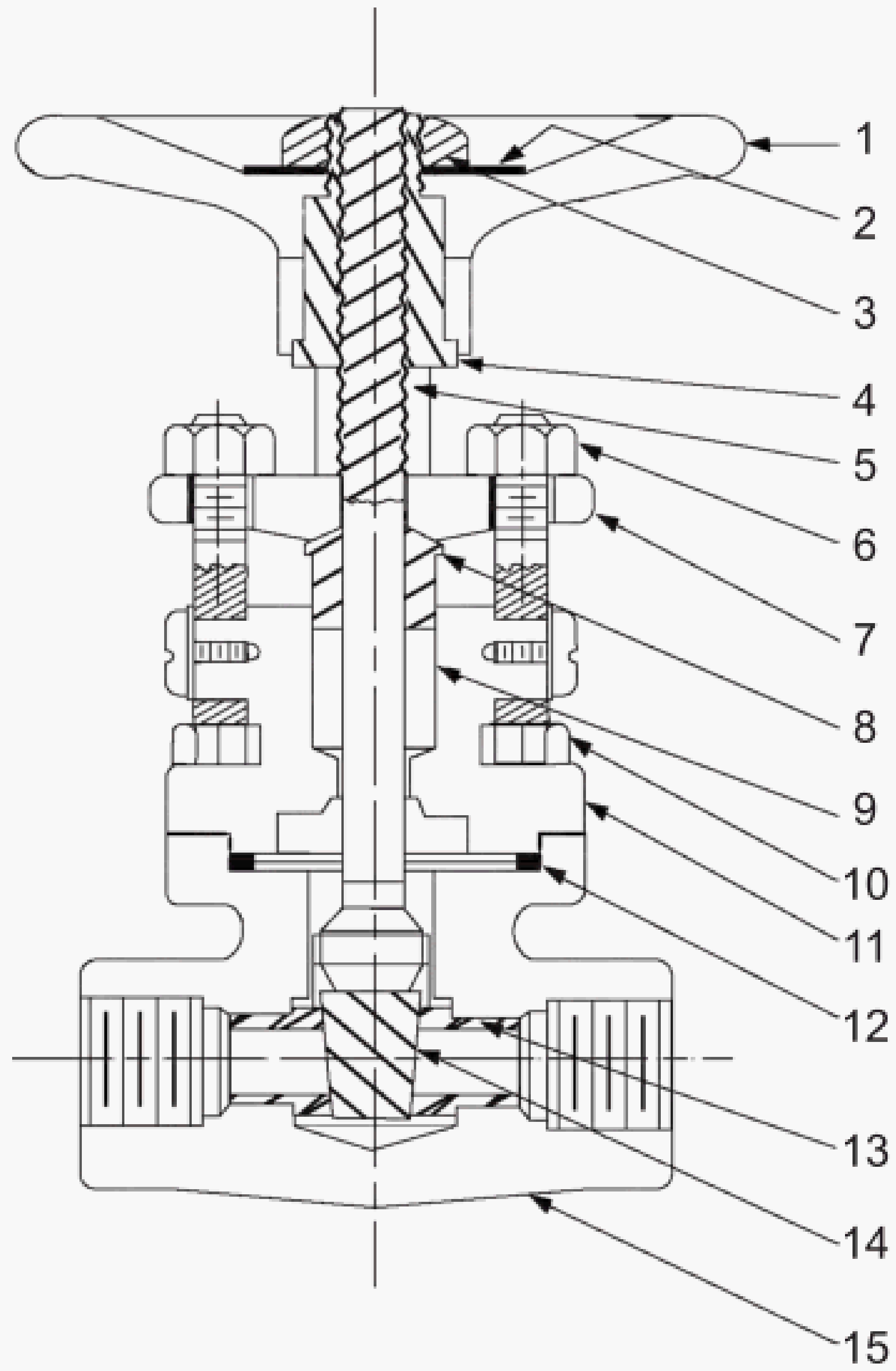


Figure A.2—Typical API 602 Bolted Bonnet Gate Valve

Key

1 jam nut
2 identification disc
3 handwheel
4 yoke nut
5 bearing ring for yoke nut
6 yoke
7 gland bolting
8 packing gland
9 packing
10 stem
11 bonnet
12 solid wedge
13 body
14 seats

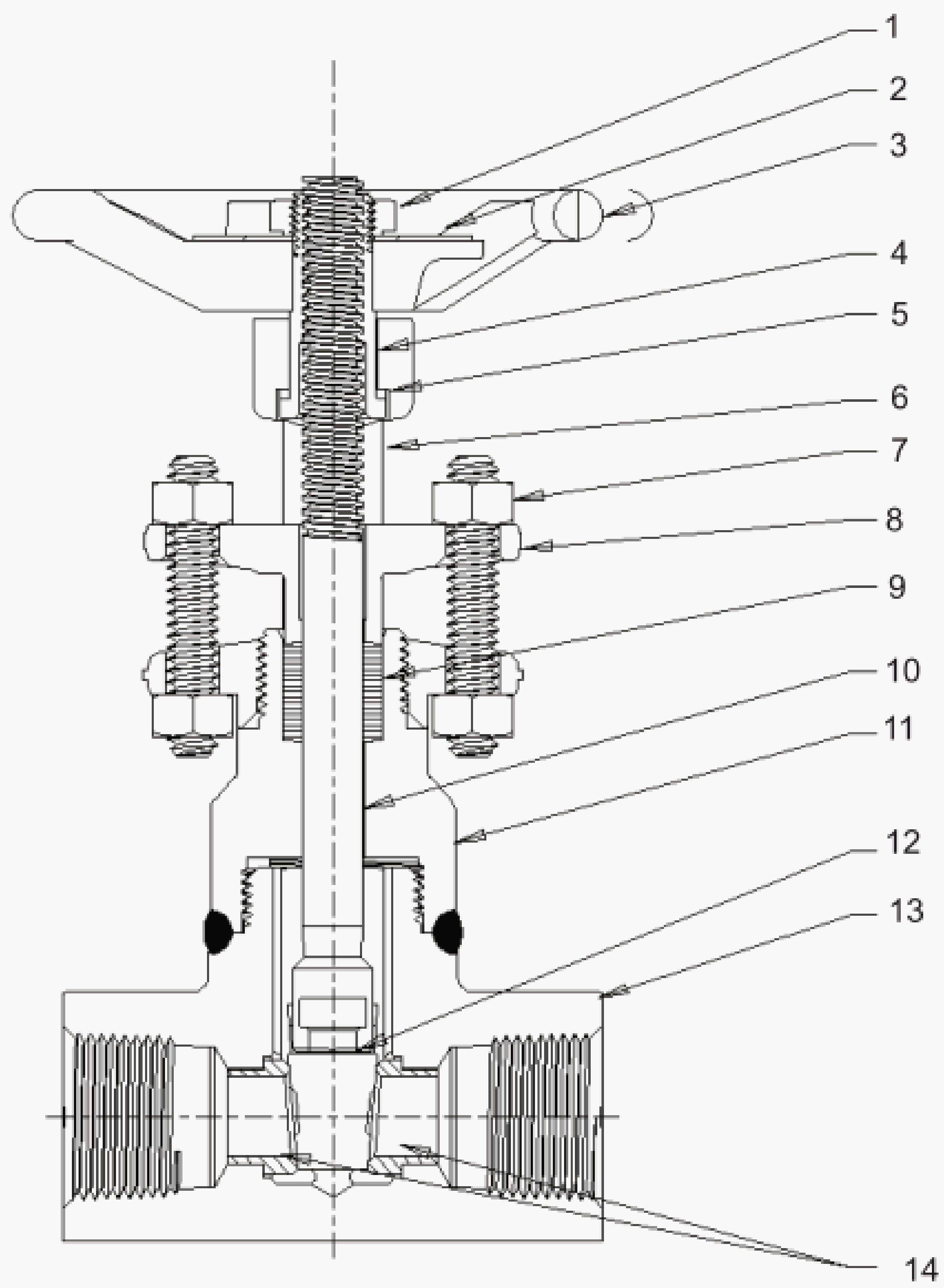


Figure A.3—Typical API 602 Welded Bonnet Gate Valve

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

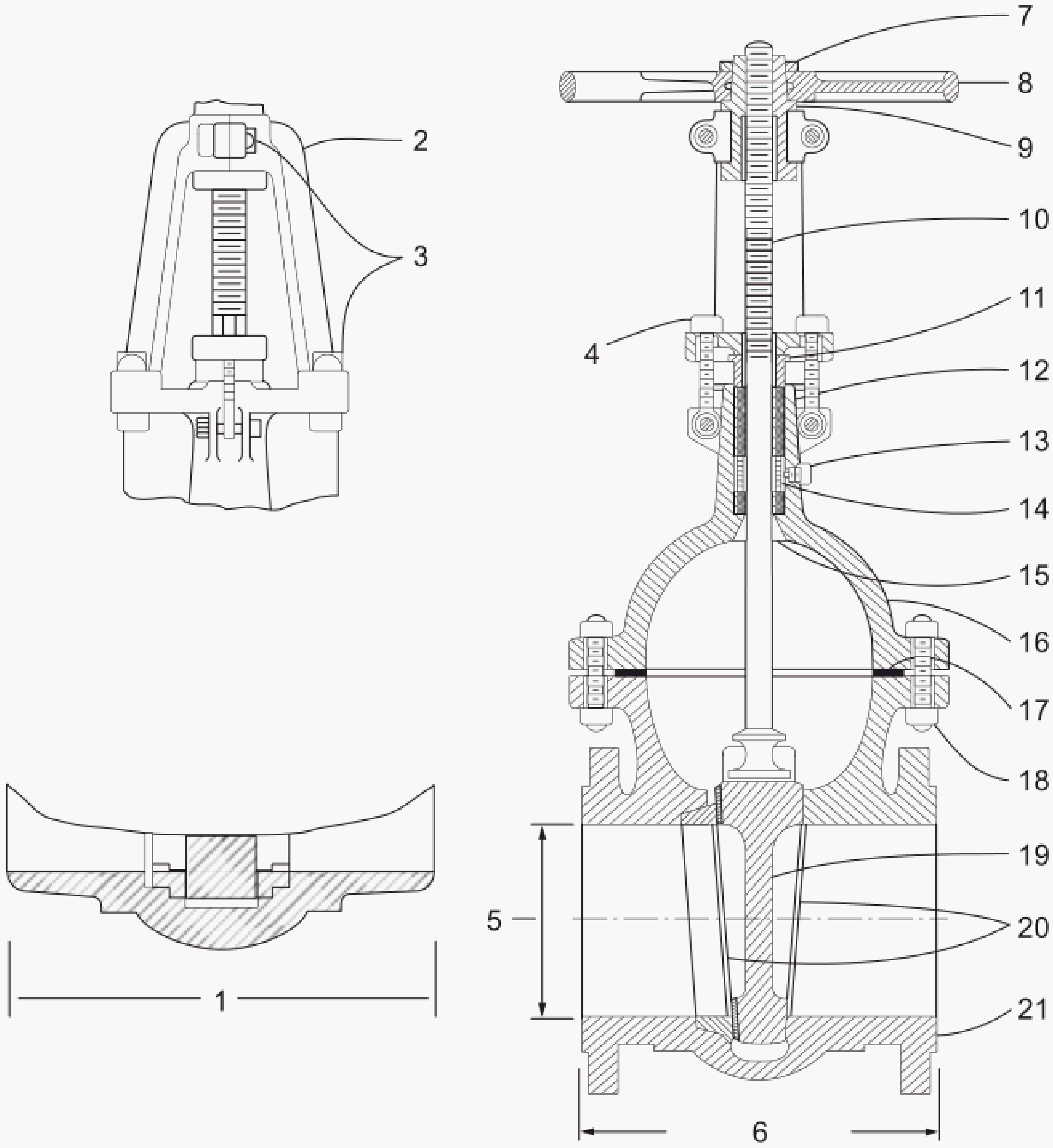
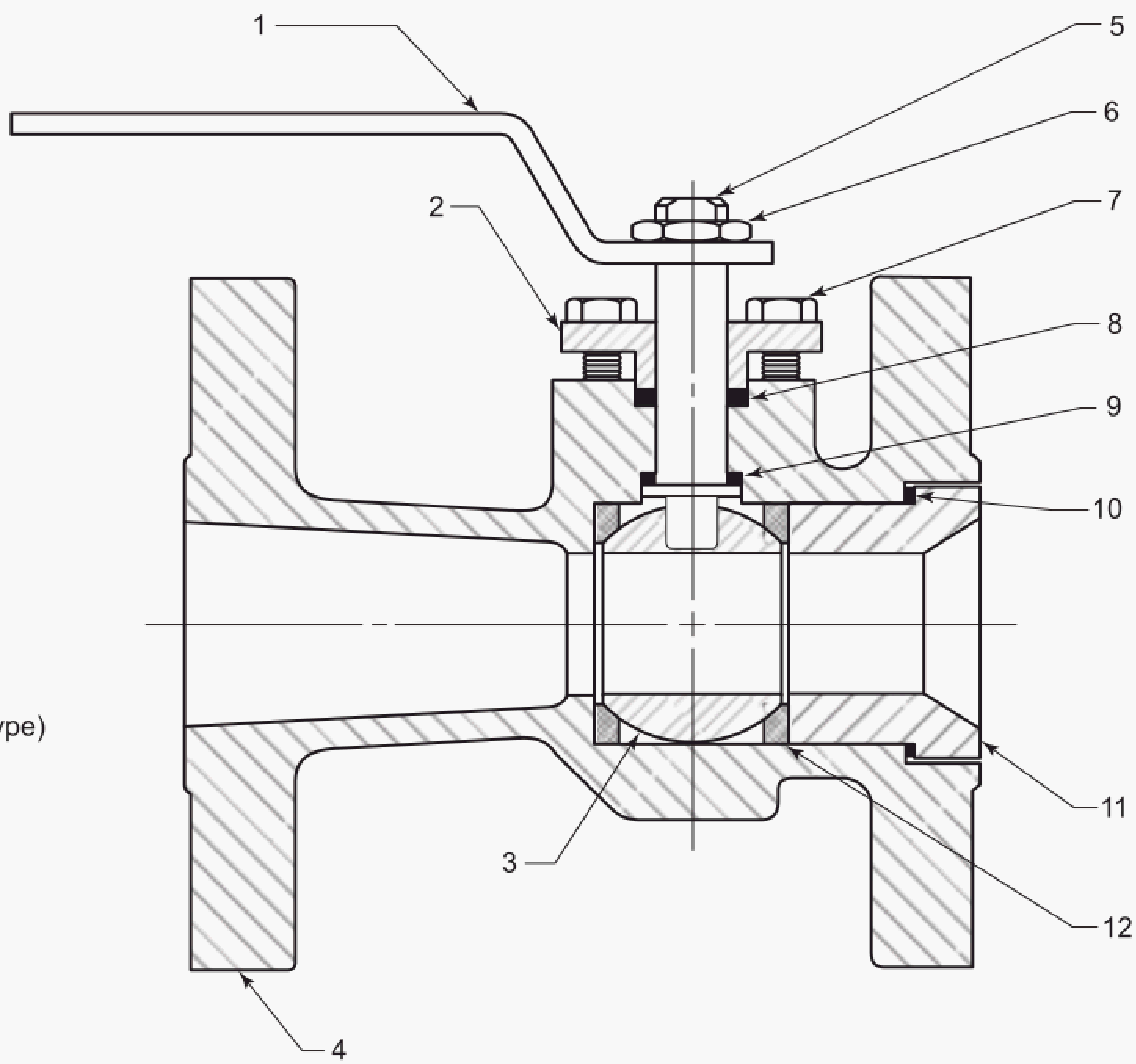


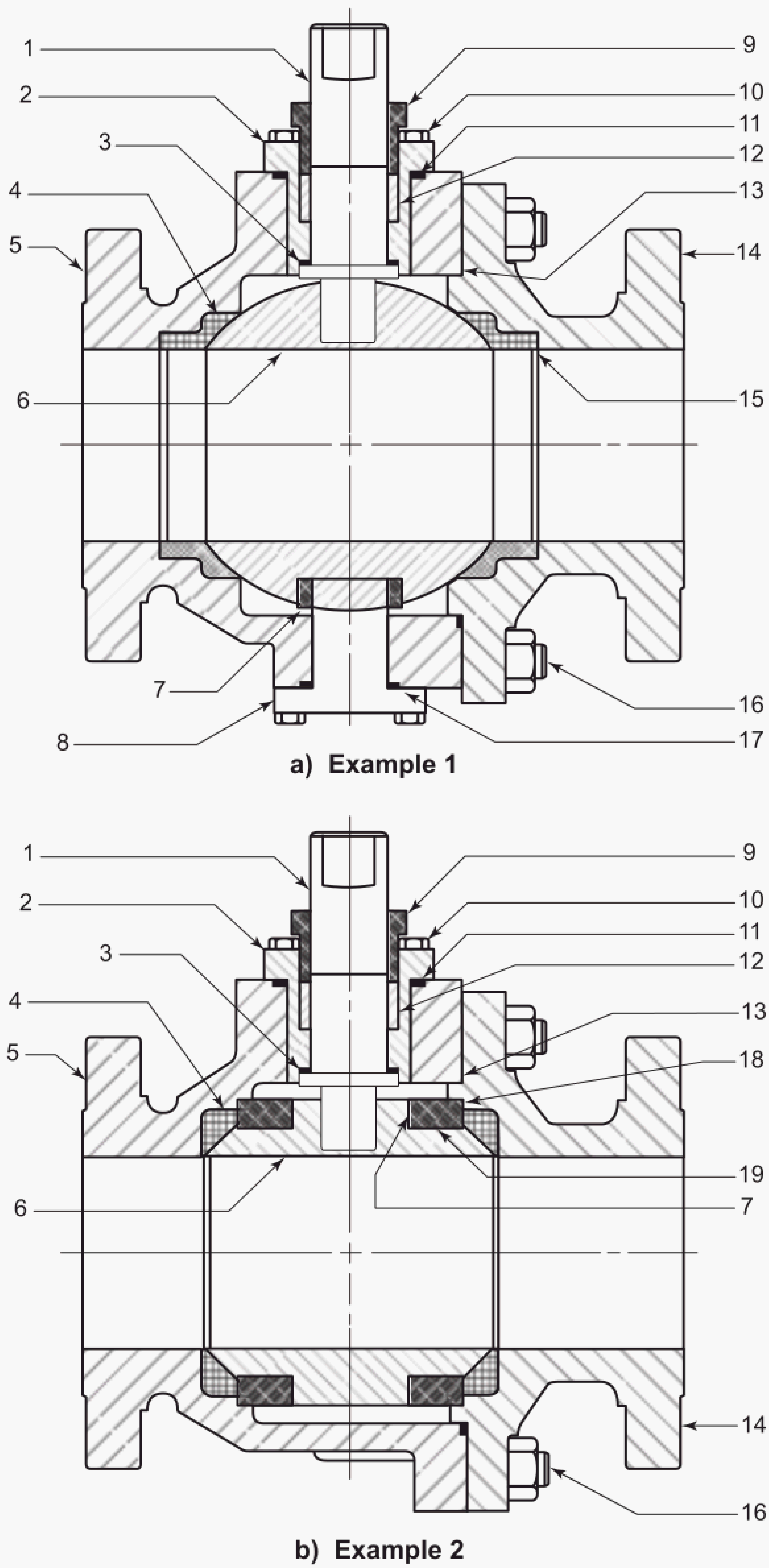
Figure A.4—Typical Valve Nomenclature Example from API 603



Key

1 handle (lever type)
2 gland flange
3 ball
4 body
5 stem
6 stem nut
7 gland bolting
8 stem seal
9 thrust washer
10 body seal
11 body insert
12 seat

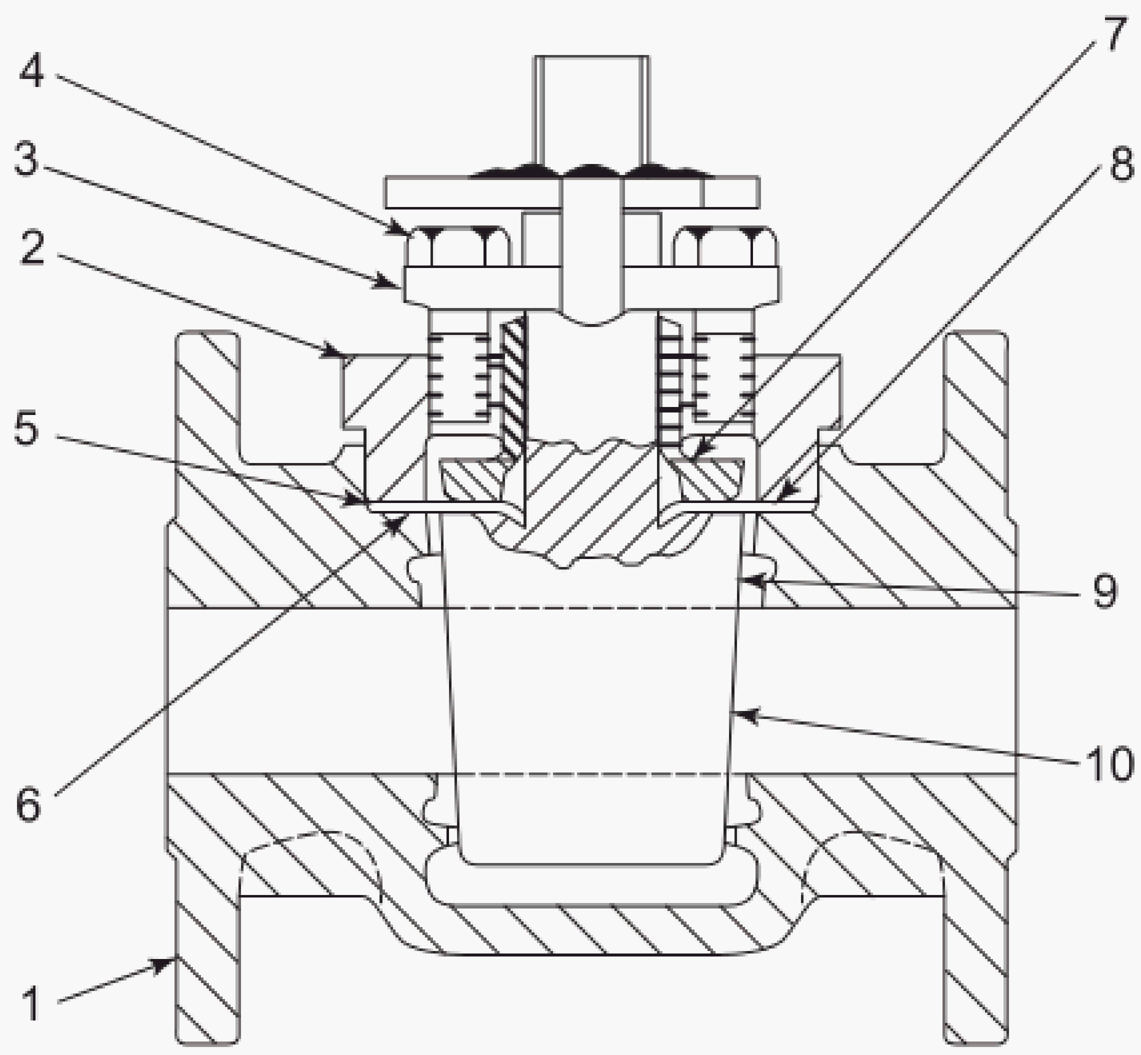
Figure A.5—Typical Example of Floating Ball Valve—One Piece Body Design Illustrated



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

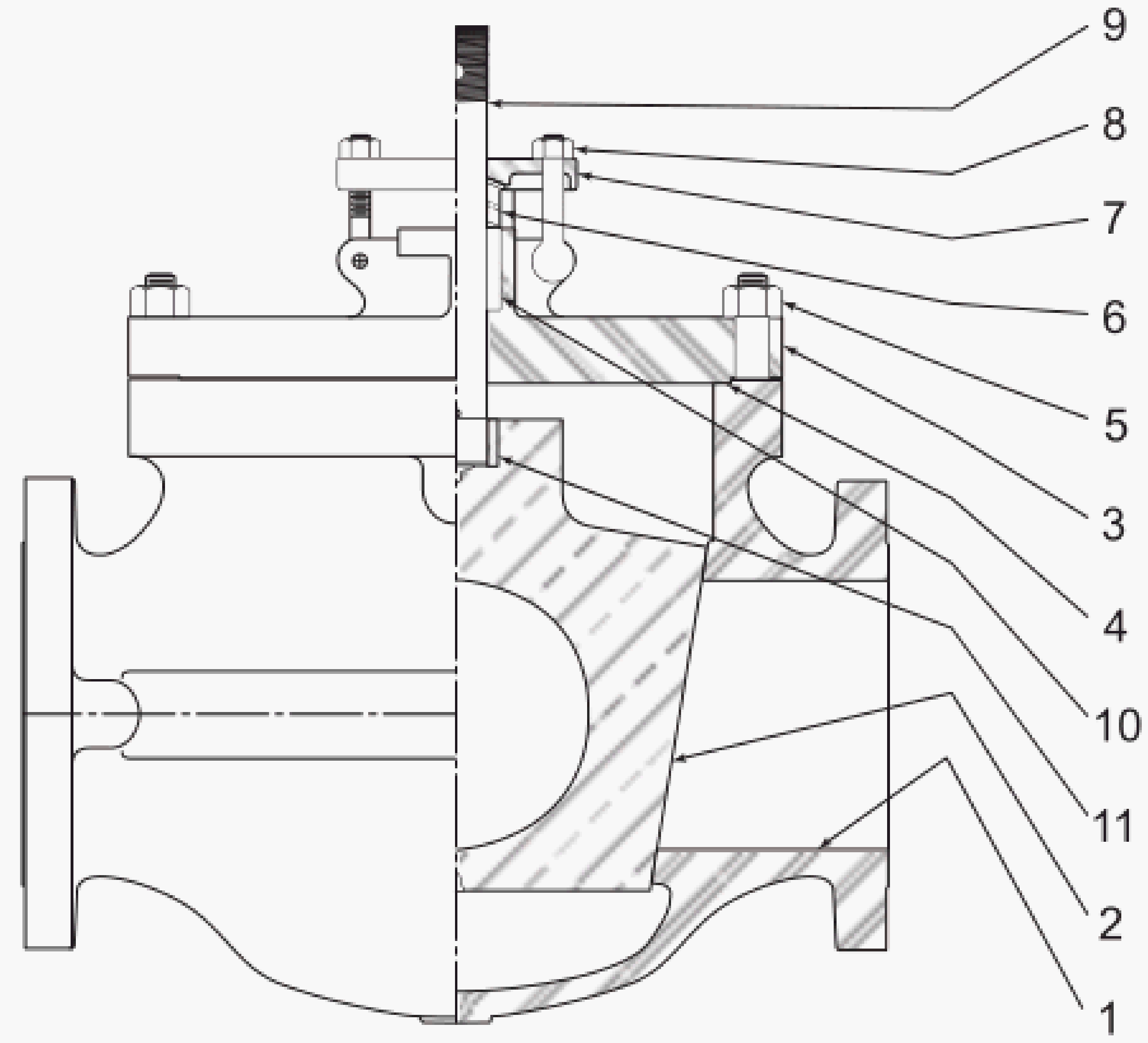
Figure A.6—Typical Trunnion Mounted Ball Valves—Two Examples of Split Body Designs



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

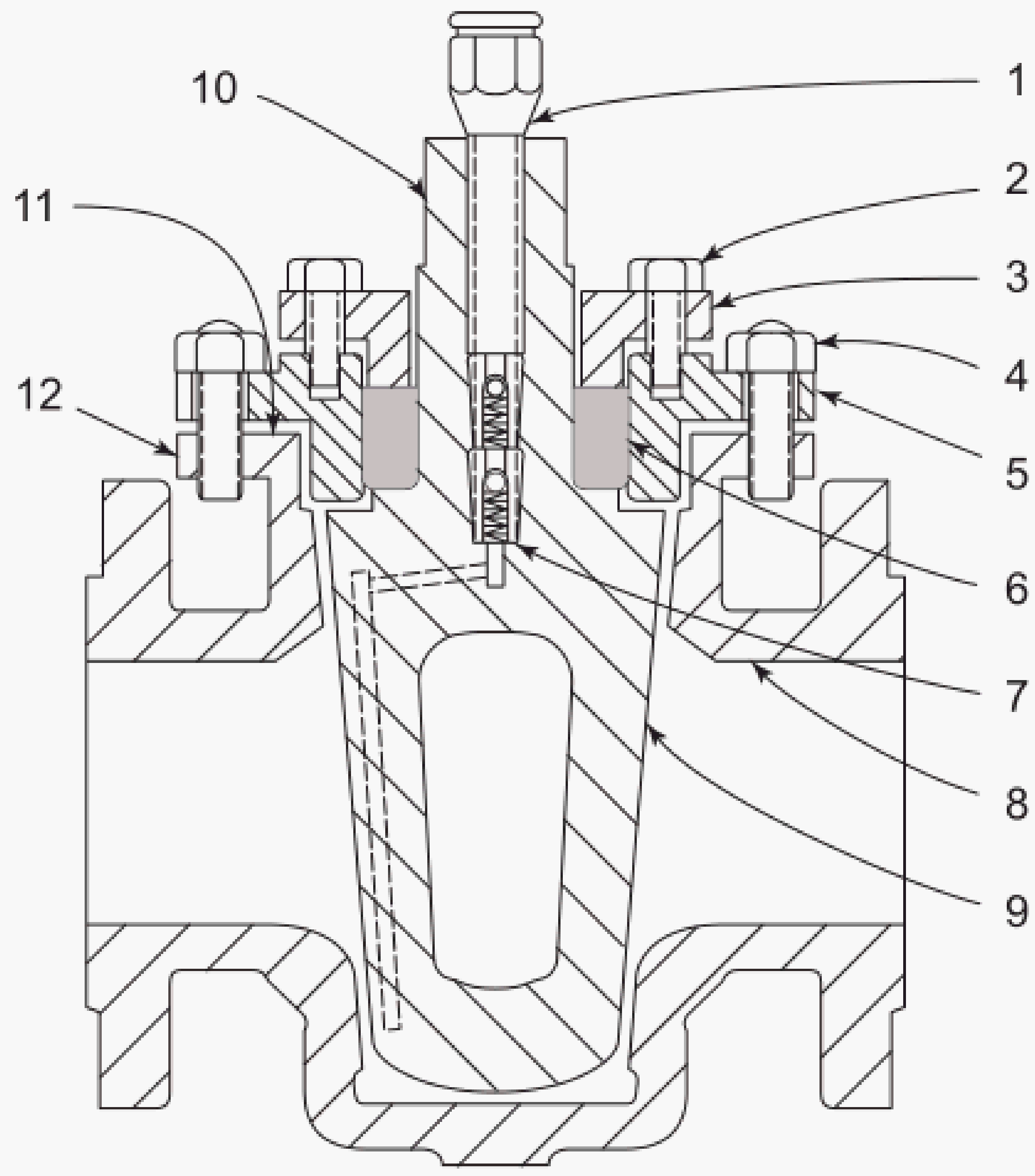
Figure A.7—Typical Sleeve Lined Plug Valve



Key

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

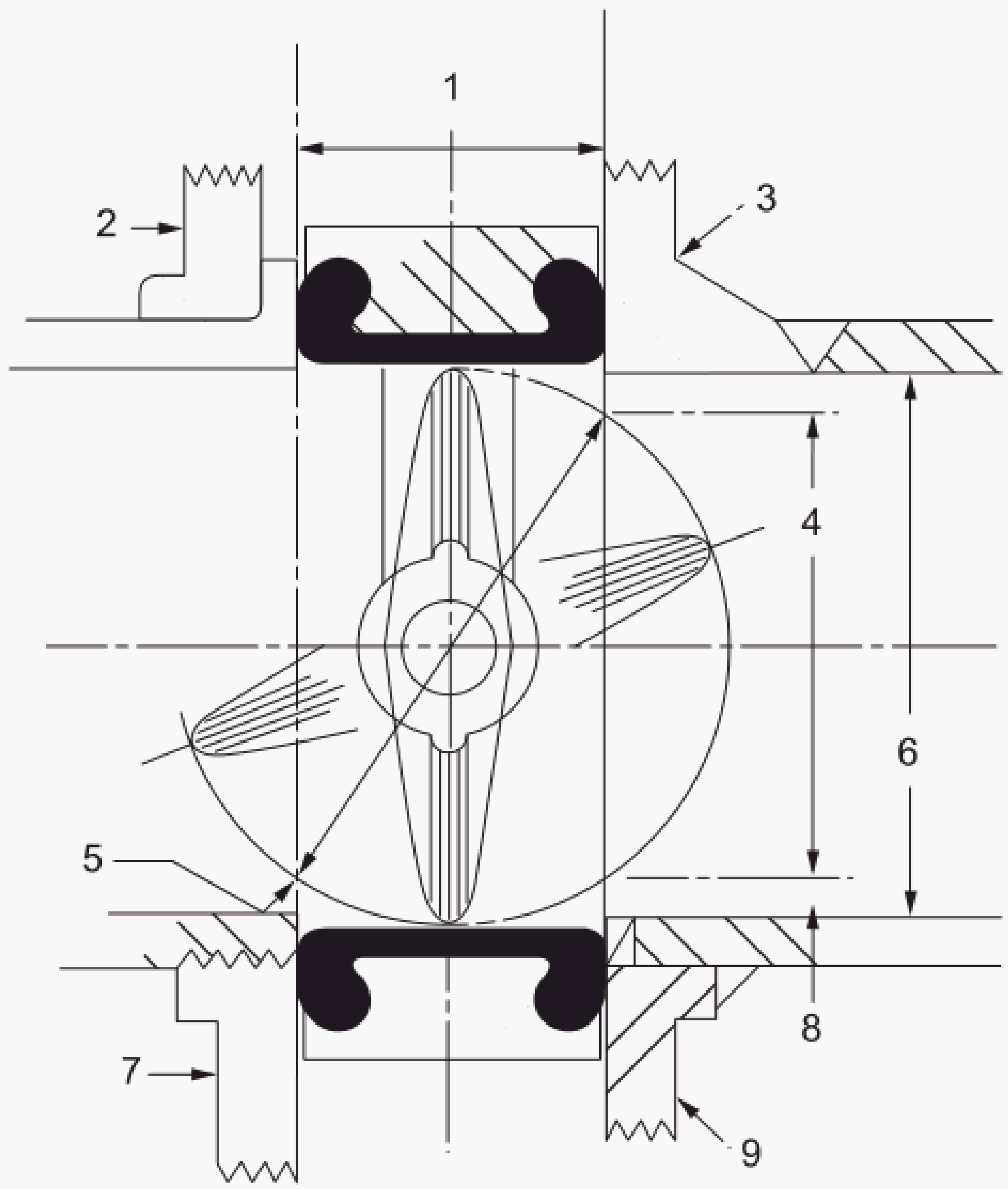
Figure A.8—Typical Nonlubricated Plug Valve



Key

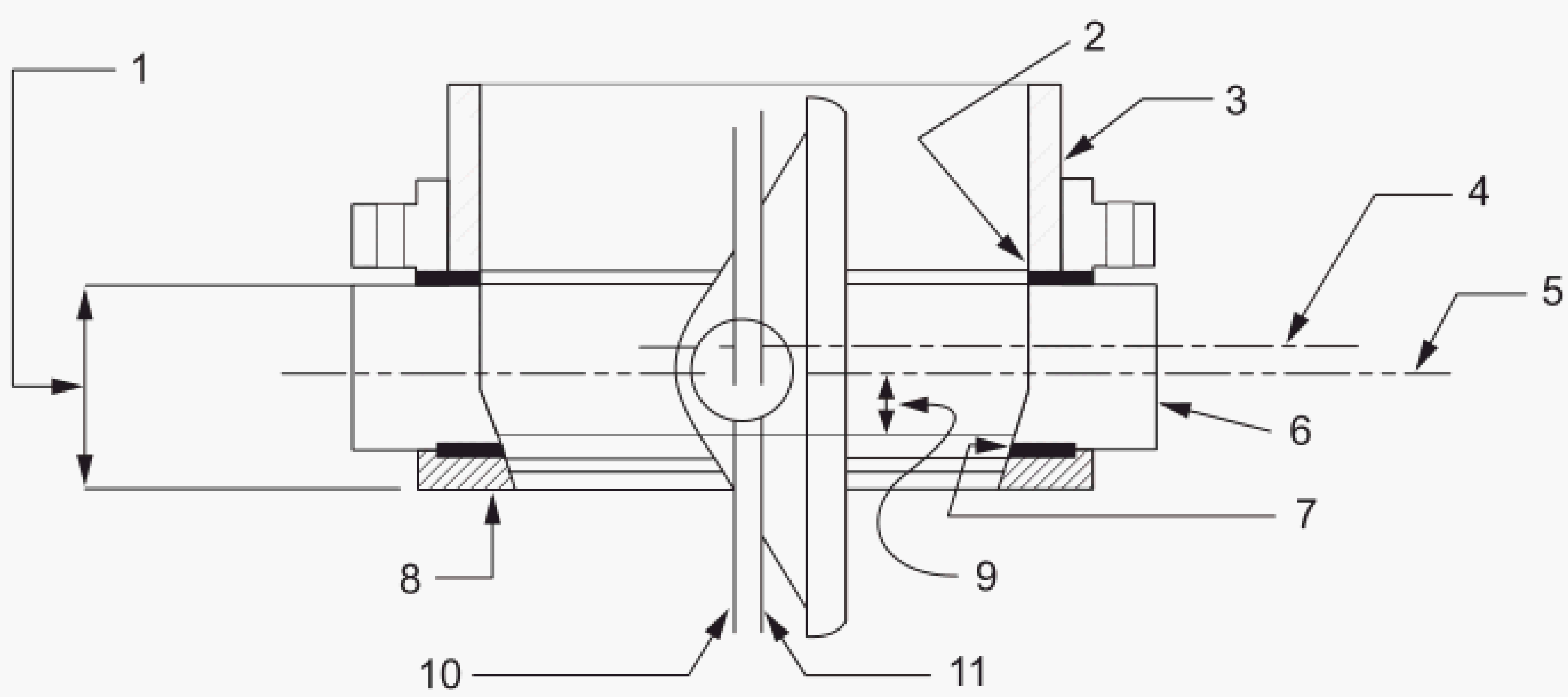
1 lubricant fitting
2 gland bolting
3 gland
4 cover bolting
5 cover
6 stem packing
7 lubricant check valves
8 body
9 plug
10 stem
11 cover gasket
12 cover flange

Figure A.9—Typical Lubricated Plug Valve



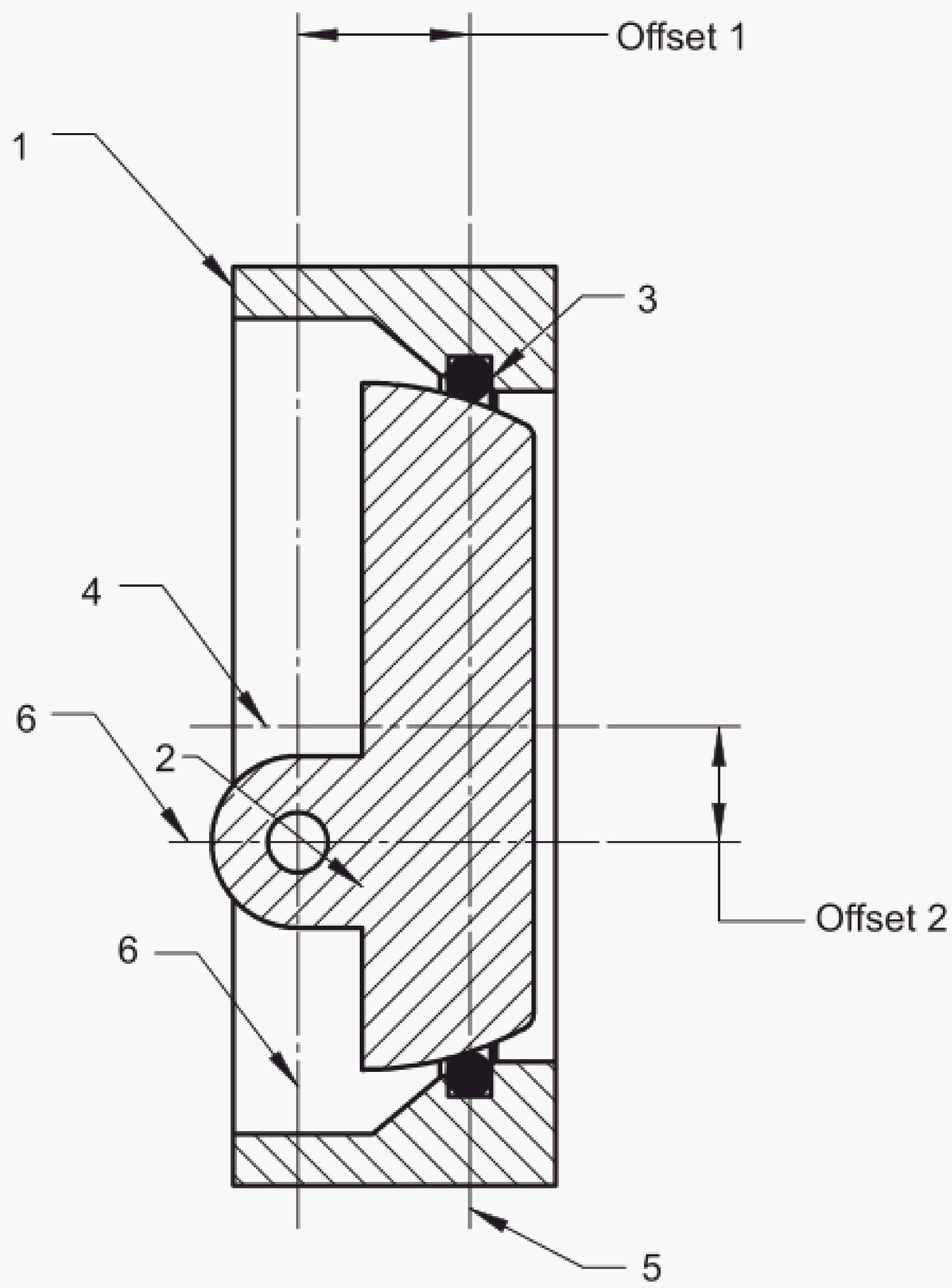
Key
1 minimum installed face-to-face dimension, *W*
2 lap-joint flange
3 welding-neck flange
4 chord of disc, *a*
5 maximum disc diameter, *D*
6 pipe inside diameter, *d*
7 threaded flange
8 nominal radial clearance, *c*
9 slip-on flange

Figure A.10—Typical Category A Butterfly Valve



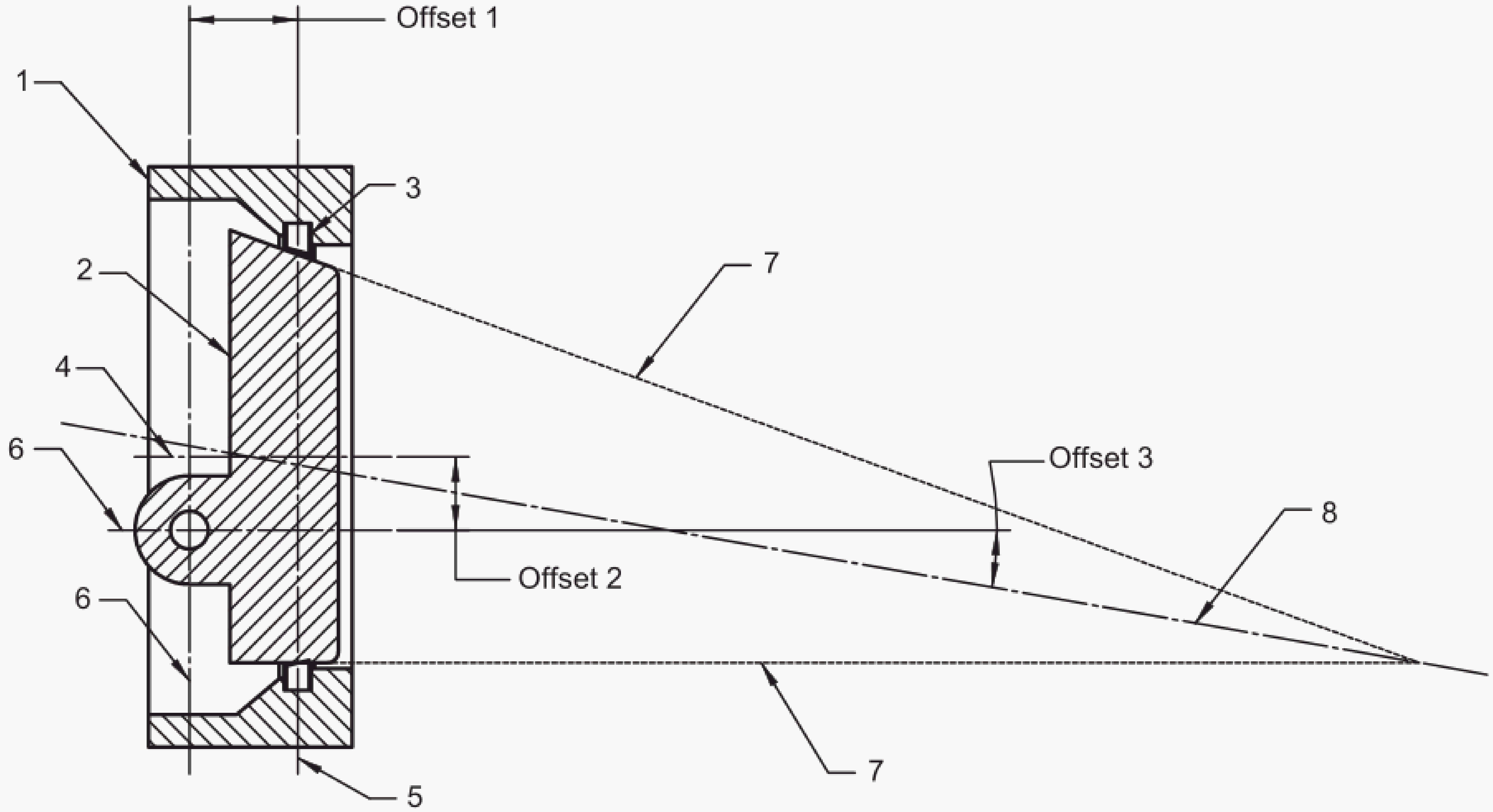
Key
1 valve face-to-face dimension (metal)
2 flange gasket
3 pipe
4 disc centerline
5 shaft centerline
6 body
7 seat
8 seat retainer plate
9 seat offset
10 shaft centerline (axis of rotation)
11 pipe centerline

Figure A.11a—Typical Category B Butterfly Valve—Double Offset Type



Key
1 body
2 disc
3 seal
4 pipe centerline
5 seal centerline
6 shaft centerlines

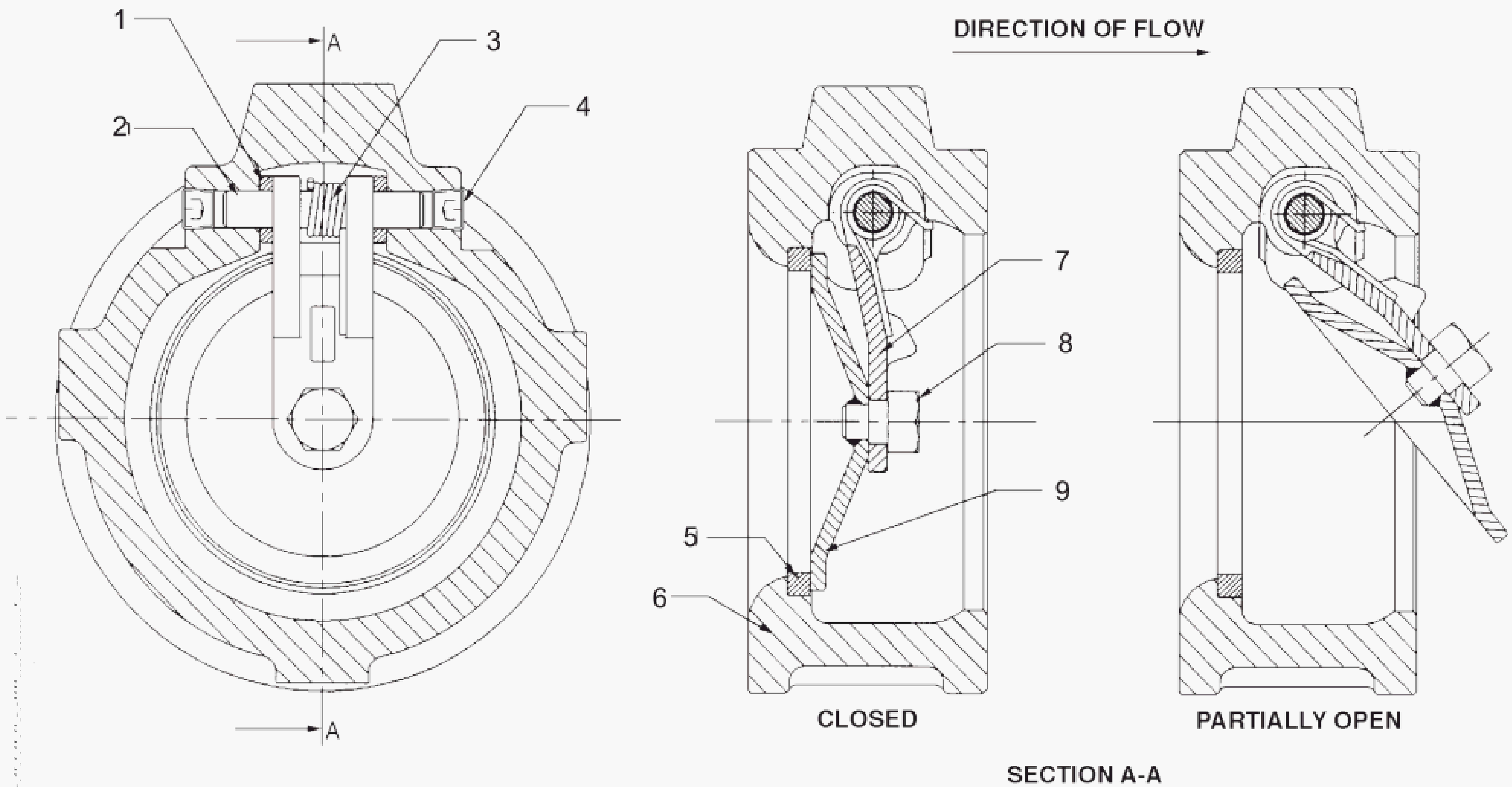
Figure A.11b—Detail of Double Offset Butterfly Valve—Disc and Seats (Seal)



Key

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

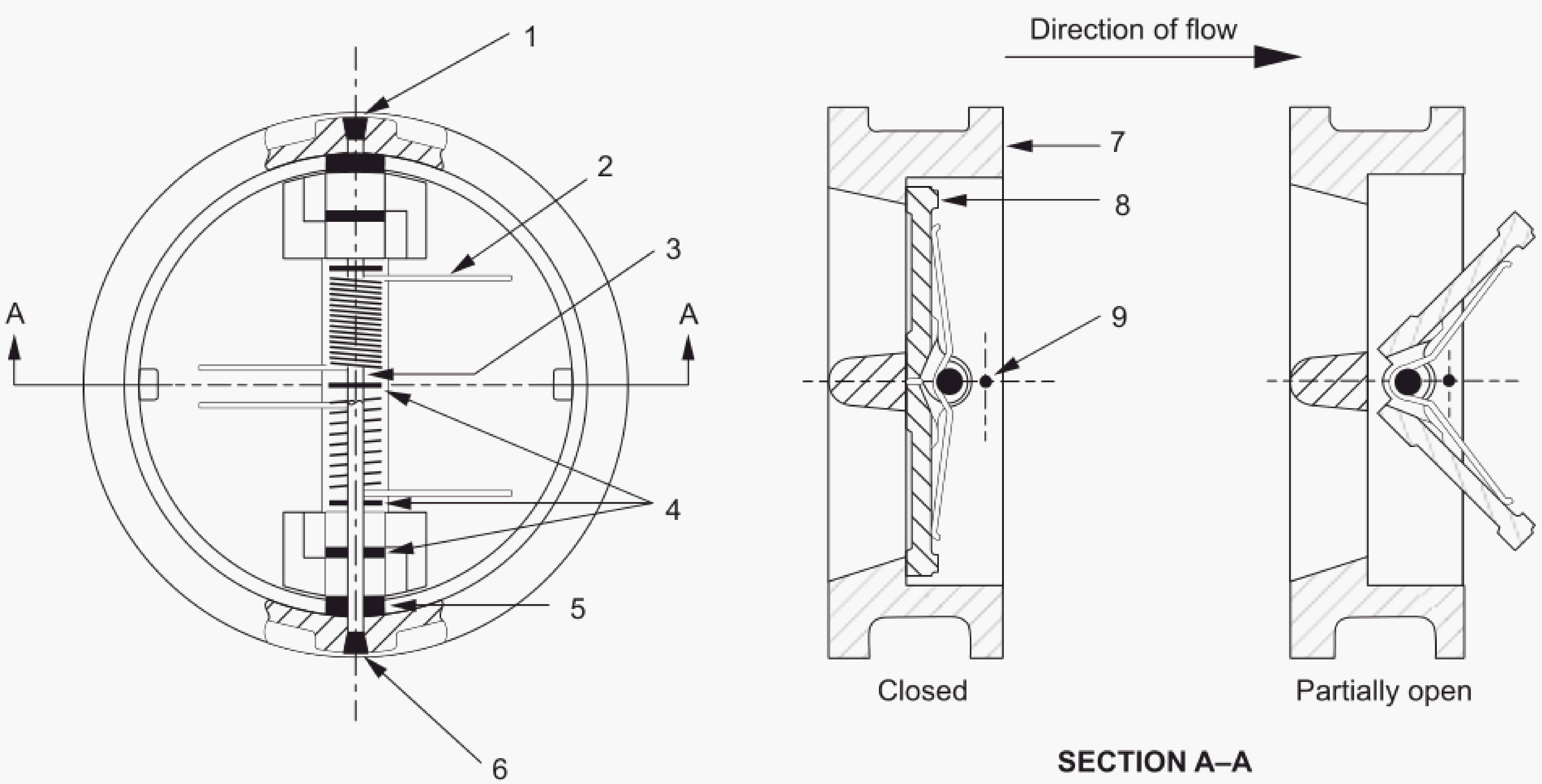
Figure A.12—Detail of Triple Offset Butterfly Valve—Disc and Seats (Seal)



Key

1 bearing spacers
2 hinge pin
3 spring
4 hinge pin retainers
5 seat ring
6 body
7 hinge
8 shoulder pin
9 plate

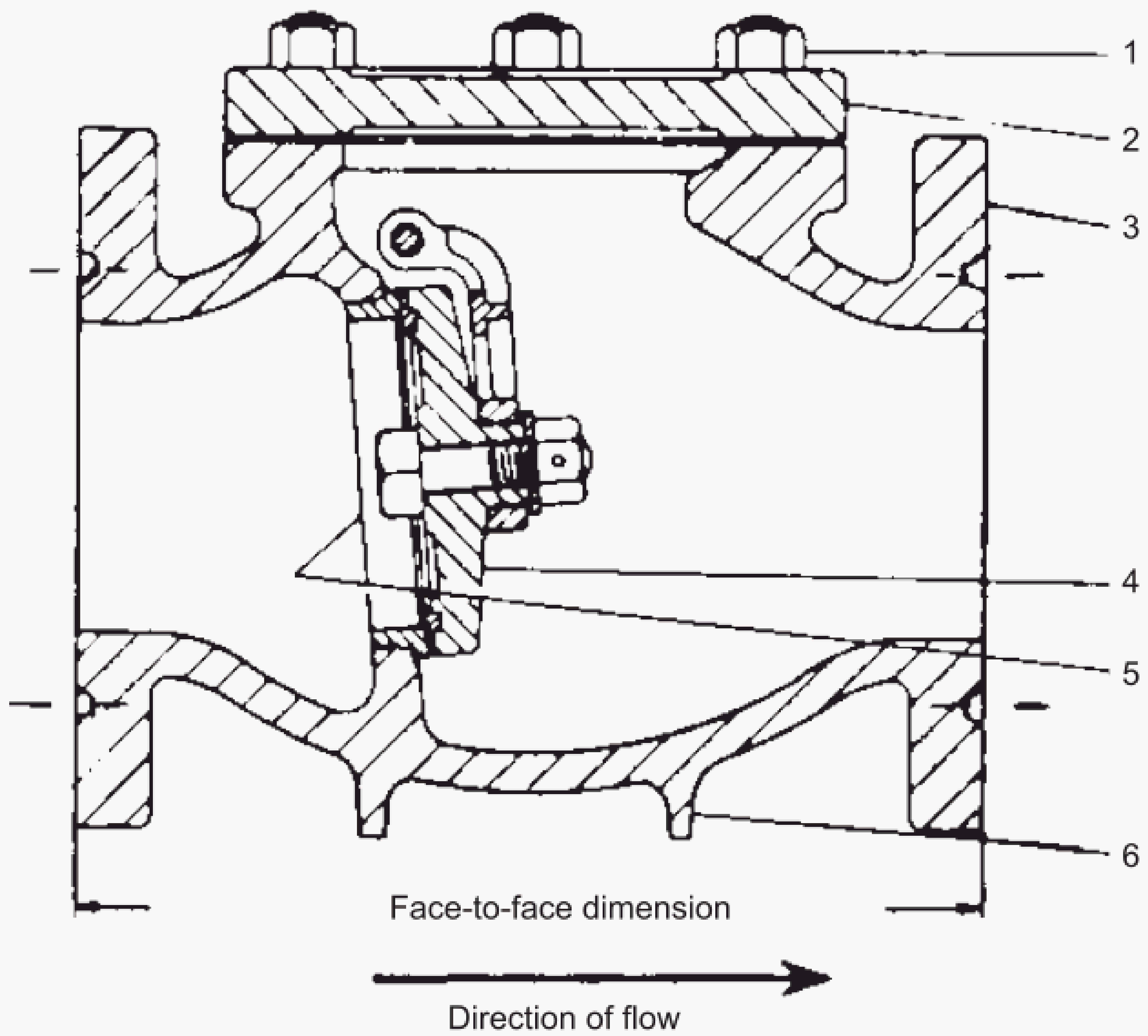
Figure A.13—Typical Single Plate Wafer Check Valve



Key

1 hinge-pin retainers
2 spring
3 hinge pin
4 plate-lug bearings
5 body-lug bearings
6 stop-pin retainers
7 body
8 plates
9 stop pin

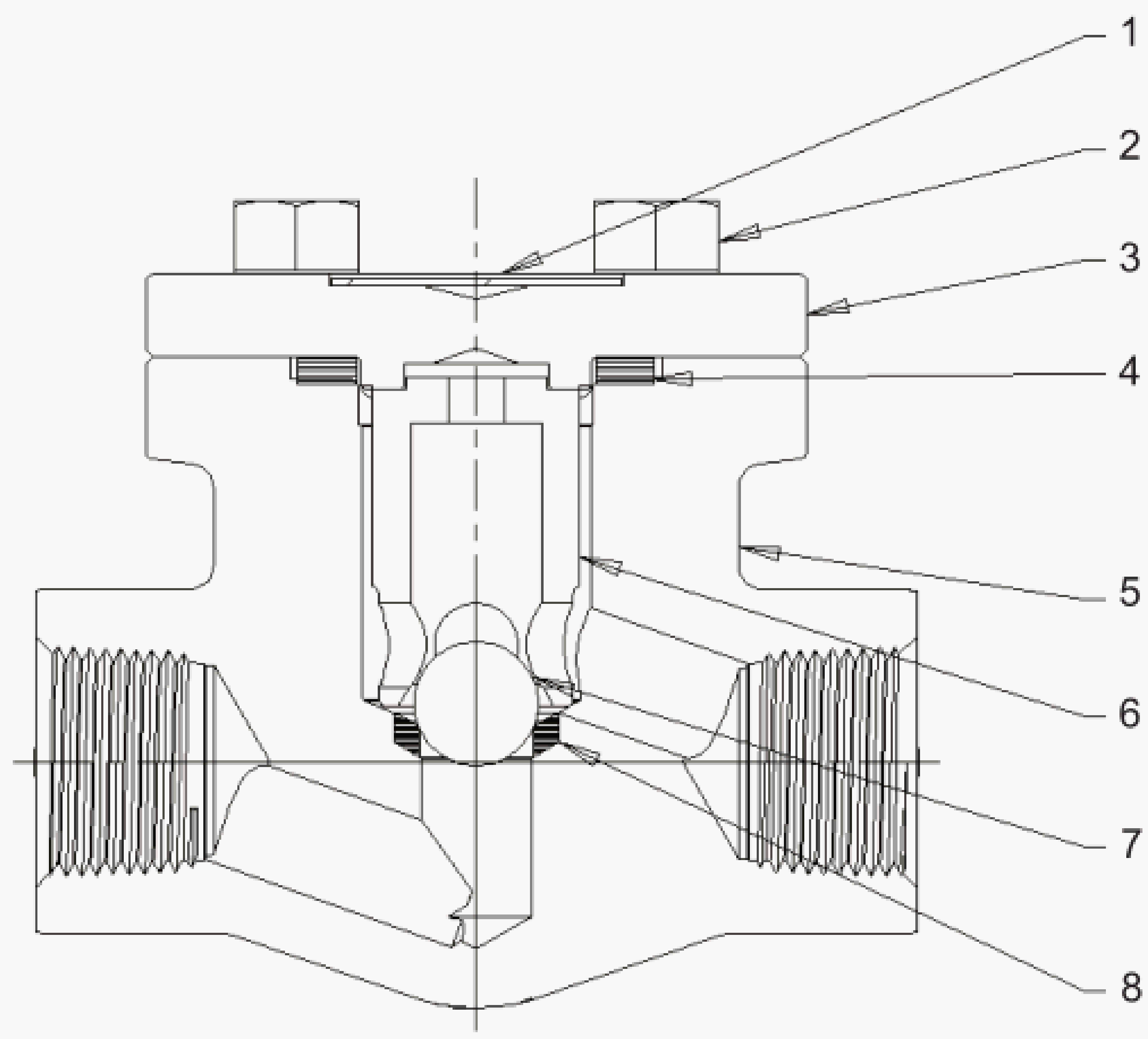
Figure A.14—Typical Dual Plate Wafer Check Valve



Key

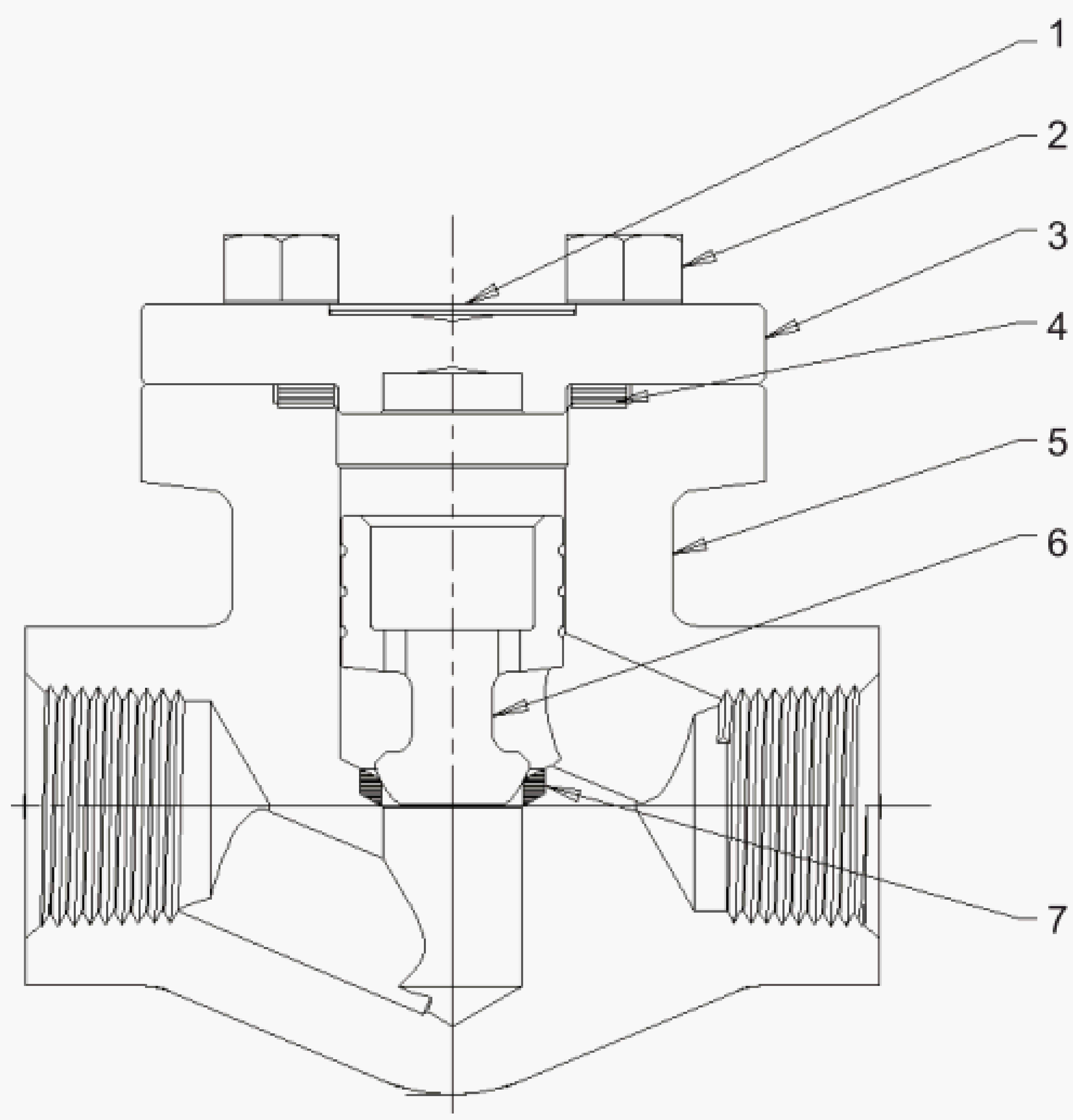
1 cover studs and nuts
2 cover
3 body
4 disc
5 seat ring
6 support ribs or legs

Figure A.15—Typical Flanged Swing Check Valve



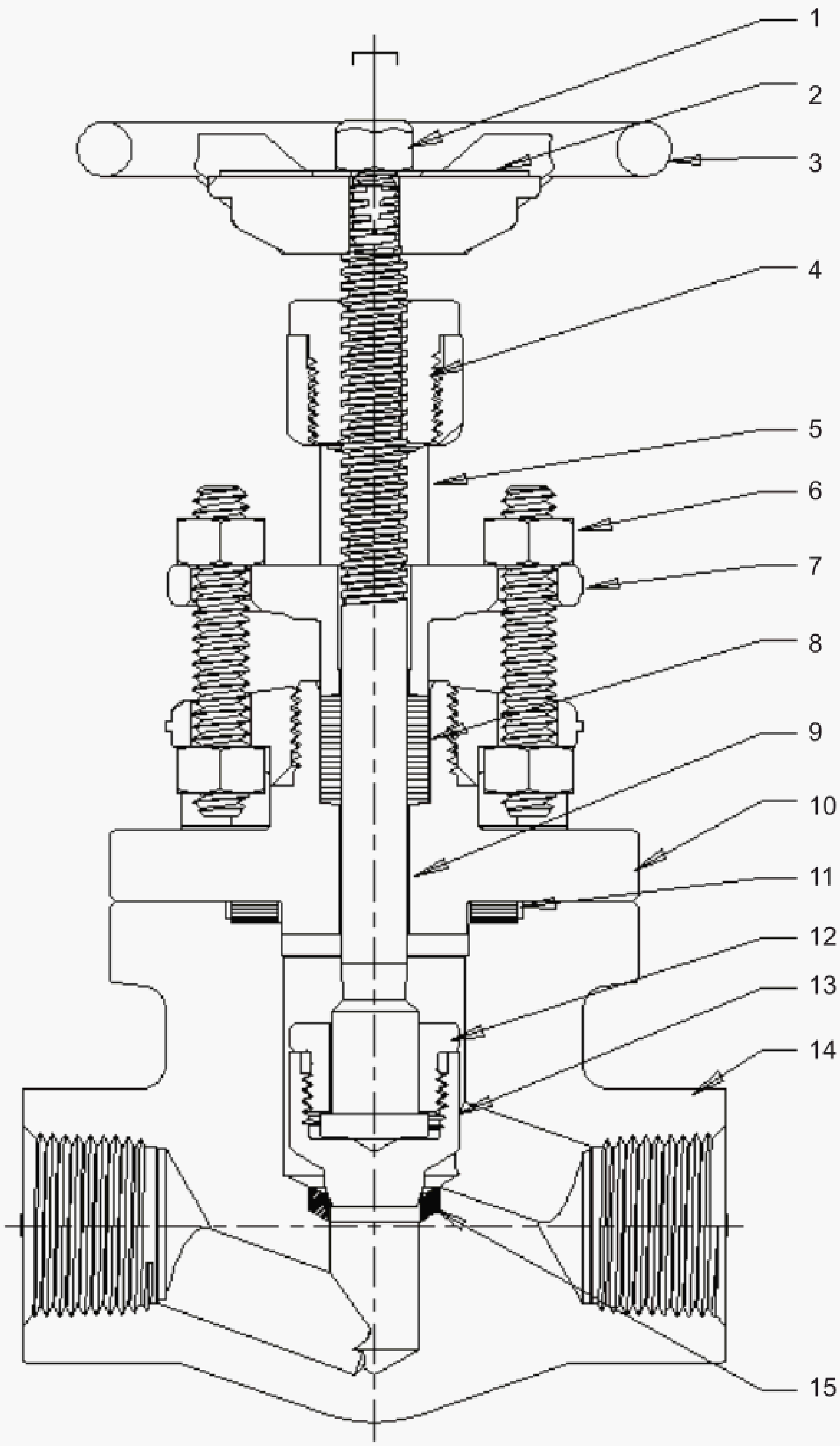
Key
1 identification disc
2 bonnet bolting
3 bonnet
4 gasket
5 body
6 ball guide
7 ball check
8 integral seat

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



Key
1 identification disc
2 bonnet bolting
3 bonnet
4 gasket
5 body
6 disc check
7 integral seat

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

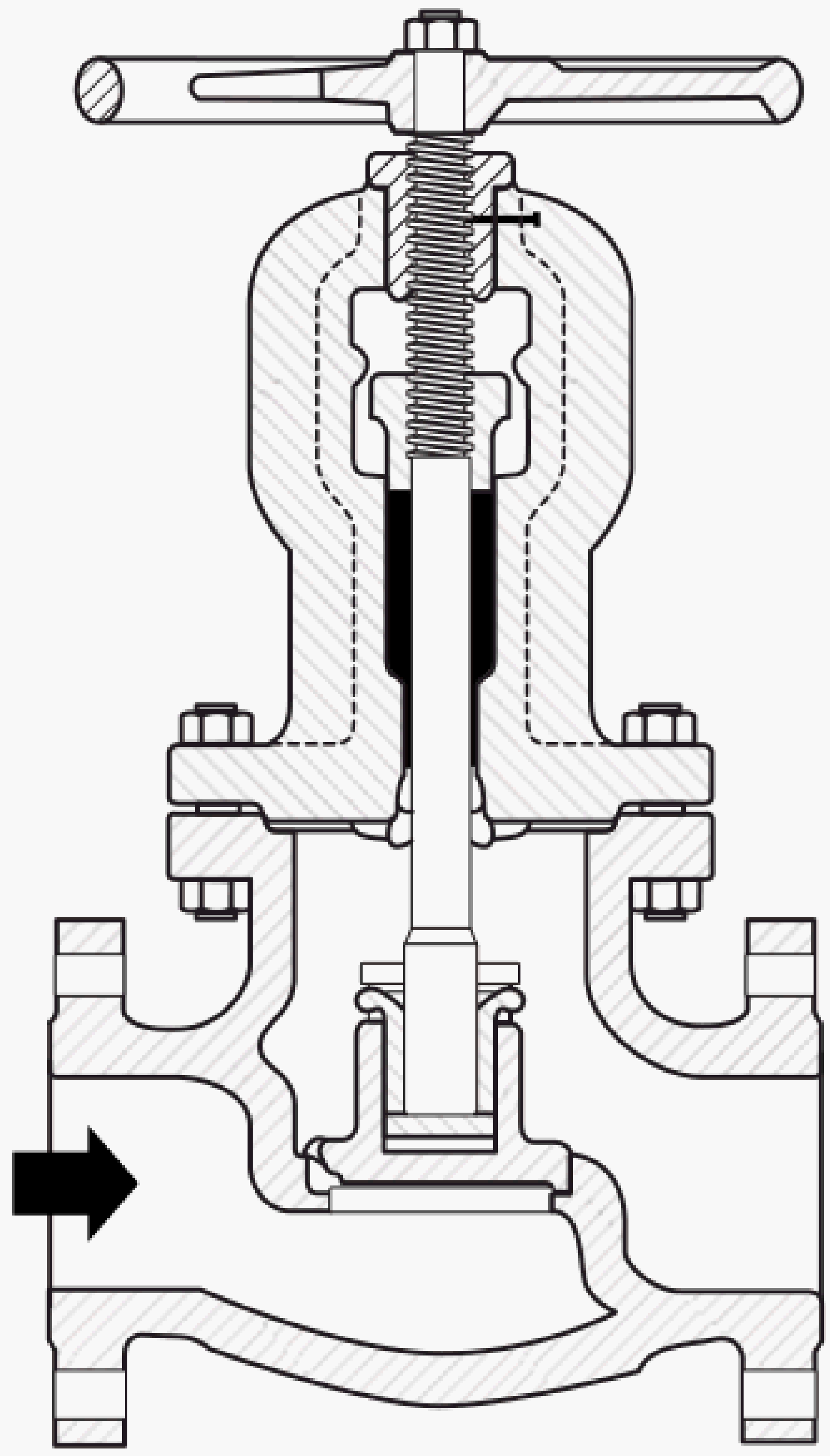
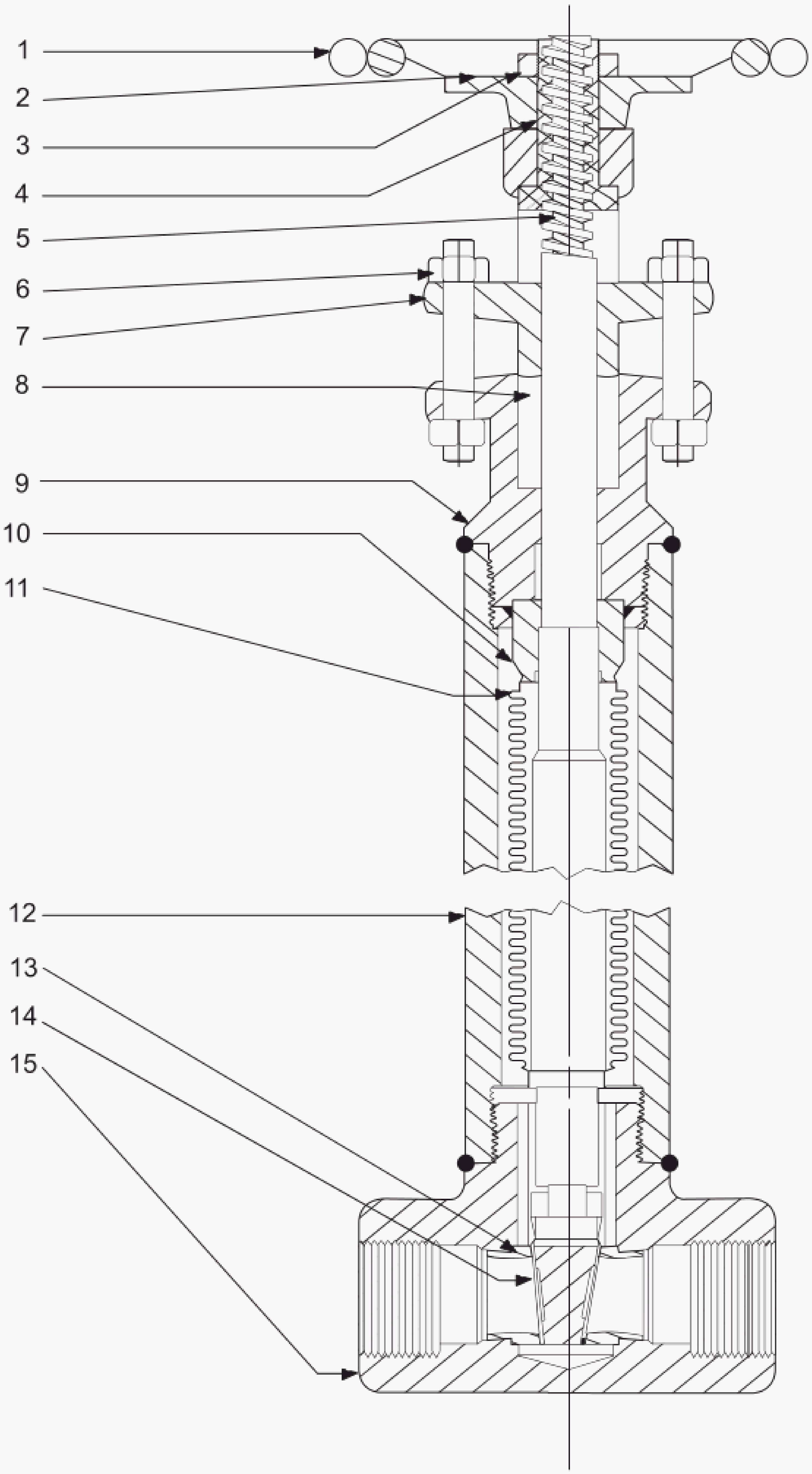


Figure A.19—Typical Flanged Globe Valve



Key

1 handwheel
2 identification plate
3 handwheel nut
4 stem nut
5 stem
6 gland bolting
7 gland
8 packing
9 bonnet
10 bellows end fitting
11 bellows
12 body/bonnet extension
13 seat ring
14 gate
15 body

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

Annex B
(informative)

Examples of Typical Valve Purchase Descriptions

B.1 API 600 Gate Valve

Valve; gate; API 600; NPS 18; Class 300; flanged raised face, carbon steel body; ASTM A 216 WCB; OS&Y; flexible wedge; bolted bonnet with a spiral-wound flexible graphite filled gasket; trim #5; flexible graphite packing; provide gear operation for 400 psig differential; back-up handwheel; NPS $^{3}/_{4}$ NPT drain connection in ASME B16.34 position G; API 598 testing; Inspection by purchaser.

B.2 API 602 Gate Valve

Valve; gate; API 602, NPS 2, Class 800, socket weld ends; forged carbon steel body, ASTM A 105; OS&Y; welded bonnet, or bolted bonnet with flexible graphite filled spiral-wound gasket; trim #8; flexible graphite packing; API 598 testing.

B.3 API 608 Soft-seat Ball Valve

Valve; ball, API 608, NPS 6, Class 300, Soft-seated ball; flanged, RF; fire tested design per API 607; carbon steel body, ASTM A 216 WCB or ASTM A 105; Type 316 SS stem and ball; PTFE or RTFE seats; bidirectional, with body cavity overpressure protection; regular port; gear operator; flexible graphite body seals and gasket; flexible graphite packing, lockable device.

B.4 API 609 Category B Double Flanged Butterfly Valve

Valve; butterfly; API 609 Category B, NPS 10, Class 300, double flanged, RF, long pattern for mating with welding-neck flanges; fire tested design per API 607; carbon steel body, ASTM A 105 or ASTM A 216 WCB; bidirectional flow; 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; Inspection by purchaser.

General Note: Refer to the “Notes to Purchaser” section in API Standards to assure that all the information needed to define valve details is appropriate for the intended service application.

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	Std 609, Butterfly Valves--Double Flanged, Lug- and Wafer-type		$89.00	

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