

Valve Selection Guide

API RECOMMENDED PRACTICE 615
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Introduction

This recommended practice (RP) aids in selection of valves for the hydrocarbon processing industry (HPI) and may also 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 composed 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 Annex B 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, petrochemical, chemical, liquefied natural gas (LNG) plants and their various associated processes. Selection guidance is provided for valve types covered by ASME B16.34^[19] 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 Normative References

There are no normative references in this document.

3 Terms and Definitions

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

3.1

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.

3.2

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.

3.3

chlorine service

Services containing liquid or vapor chlorine in concentrations higher than 1 ppm as defined in 29 *CFR* 1910^[26]. 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 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.

3.5

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.

3.6

CWP (cold working pressure)

The maximum fluid pressure at which a valve or fitting is allowed to be used at ambient temperature.

3.7

cryogenic service

The lower end of low-temperature service (such as liquefied gas) typically between $-73\text{ }^{\circ}\text{C}$ to $-254\text{ }^{\circ}\text{C}$ ($-100\text{ }^{\circ}\text{F}$ to $-425\text{ }^{\circ}\text{F}$).

3.8

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.

3.9

double-block-and-bleed (DB&B) valve

Valve with two or more seating surfaces that in the closed position provides a seal against pressure from both ends of the valve with a means of venting/bleeding the cavity between the seating surfaces.

3.10

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.

3.11

fugitive emissions

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

3.12

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.

3.13

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.

3.14

hydrofluoric (HF) acid service

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

3.15

hydrogen service

Services containing hydrogen at partial pressure with a temperature above the carbon steel curves in API Recommended Practice 941^[16].

3.16

low-temperature service

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

3.17

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.

3.18

oxygen service

Fluid streams containing more than 23 % by volume oxygen as defined by CGA G4.4^[24].

3.19**potable water**

Water suitable for human consumption.

3.20**pressure seal bonnet**

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

3.21**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.

3.22**severe service valves**

A valve that is specifically engineered for crucial applications where the service conditions are severe, harsh, critical, and challenging.

3.23**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).

3.24**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.

3.25**sour (wet H₂S) service**

Services with greater than ≥ 50 ppm of H₂S in a water phase (determined by using the total amount of sulfide in the water phase) or ≥ 0.05 psia H₂S partial pressure in the gas phase with liquid water present.

3.26**stress cracking**

Material failure resulting from exposure to aggressive environments, such as wet H₂S exposure, chlorides, hydrogen, ammonia, or amines.

3.27**type testing**

A test performed to assess the performance of a specific valve design under controlled conditions.

3.28**utility service**

Services generally limited to air, water, nitrogen, and steam at pressures below 150 psi (1035 kPa) and at temperatures between -29°C to 186°C (-20°F to 366°F).

3.29**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".

3.30

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

- 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

- gate valves (API 600^[5], API 602^[6], API 603^[7]);
- ball valves (API 608^[9]);
- plug valves (API 599^[4]);
- butterfly valves (API 609^[10]);
- check valves (API 594,^[2] API 602^[6]);
- globe/stop-check valves (API 602^[6], API 623^[12]).

4.3 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.

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^[5], API 602^[6], and API 603^[7]. Gate valves are typically not recommended for throttling service.

5.1.1.2 API 600 Gate Valves

API 600^[5] 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-duty valve where corrosion, erosion, and other service conditions would indicate a need for full port opening, heavy wall section, and large stem diameters. Pressure/temperature ratings for these valves are given in ASME B16.34^[19] (Standard Class) for the listed materials. Body and bonnet wall thickness specified in API 600^[5] are greater than those in ASME B16.34^[19] thereby providing for an additional corrosion allowance capability. Stem diameters are also specified. The standard gate in API 600^[5] 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 Figure A.1 for a typical API 600^[5] gate valve.

5.1.1.3 API 602^[6] Gate Valves

API 602^[6] 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^[6] gate valves are commonly used in process plants in sizes from NPS ½ 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-welding end valves are available where use of socket-welding or threaded ends may not be desired, for example, in compressor lube oil service. See Figure A.2, and Figure A.3 for typical examples of API 602^[6] gate valves.

5.1.1.4 API 603^[7] Gate Valves

API 603^[7] was developed to provide a lower-cost alternative to API 600^[5] 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^[5] valves. API 603^[7] specifies wall thicknesses comparable to those in ASME B16.34^[19]. Like API 600^[5], API 603^[7] specifies minimum stem diameters. These valves are available in flanged or butt-welding ends in pressure classes 150, 300, and 600 and in sizes NPS ½ 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 Figure A.4 for an example of a gate valve from API 603^[7].

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. To avoid damage to the pressure seal element, the use of this design should be restricted to services that are not highly corrosive. 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]; however, it is covered in MSS SP-144^[35].

5.1.1.6 Orientation Considerations

Although somewhat depending on pressure class and size, larger gate valves (typically NPS 24 and larger) oriented in a position other than with the stem vertical may result with the gate 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 gate 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.

5.1.1.7 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 dimensions; and
- lower cost for high alloys due to reduced size/weight.

Knife gate designs are used in the following:

- environmental wastewater systems (rain and effluent collection);
- sludge and other services with a high concentration of particulates;
- wet scrubber systems associated with flue gas discharge from fluidized catalytic cracking unit (FCCU) and continuous catalytic reformer (CCR);
- petrochemical pellet and dry material handling systems for high-density polyethylene and polypropylene pellets and powders; and
- flare isolation applications.

See Figure 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.

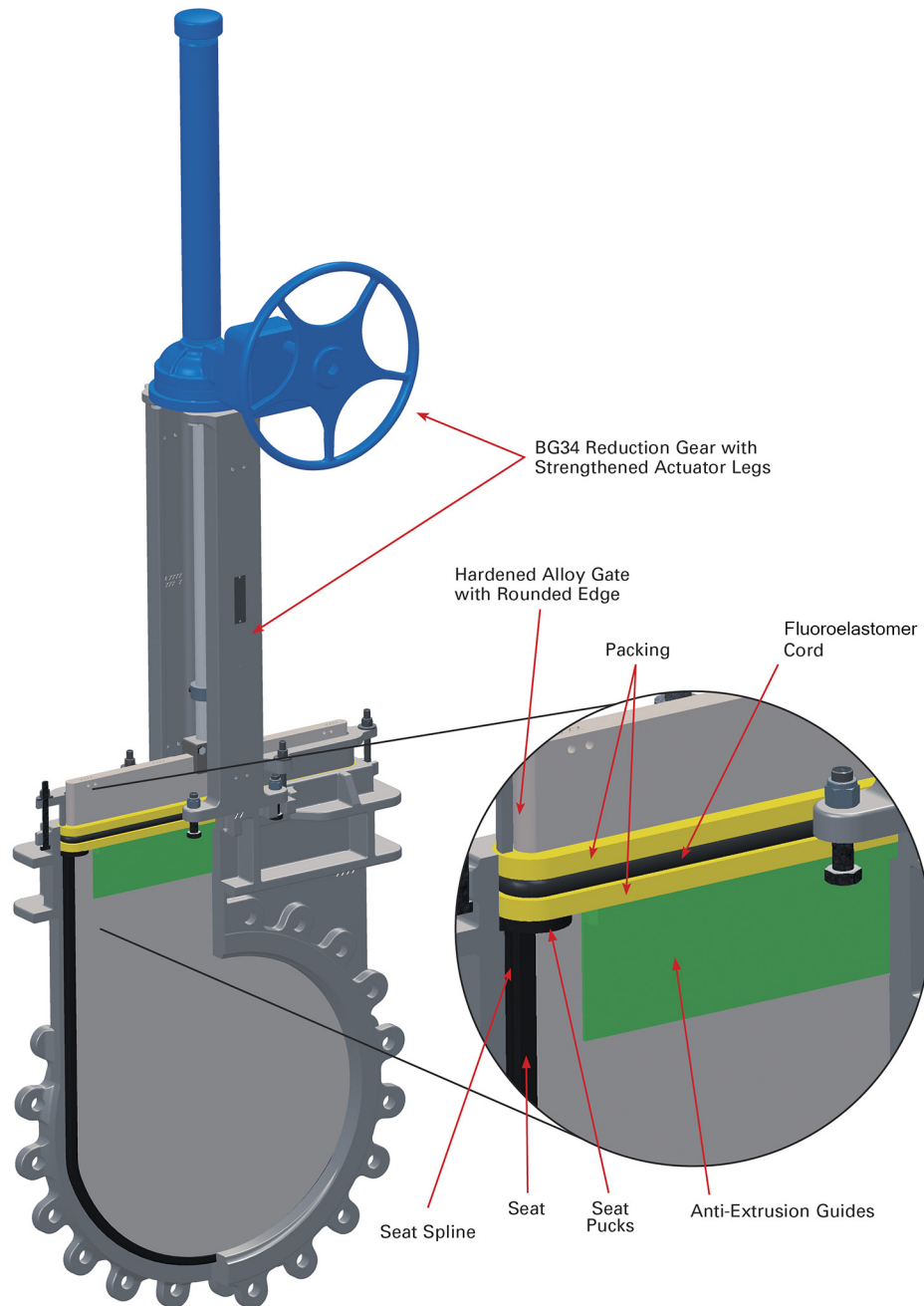


Figure 1—Bidirectional Knife Gate for Wet Scrubber Applications

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 low-alloy chrome of carbon steel and use a cold wall design that uses a thermal refractory material. Sometimes erosion-resistant lining materials are also used.

5.1.2 Ball Valves

5.1.2.1 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.

Ball valves are provided with threaded, welded, or flanged end connections. Threaded are used on NPS 2 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-welding end connections are typical for NPS 2 and smaller. Ball valves with weld ends may have extended weld ends (sometimes called pipe or transition pups) that can be applied to either socket-welding or butt-welding end valves and are used to permit welding of valves without damaging soft seats.

5.1.2.2 API 608^[9] Ball Valves

API 608^[9] covers ball valves for flanged and butt-welding ends in sizes NPS ½ through 24 in pressure Classes 150 through 600 and NPS ¼ through 2 socket-welding and threaded ends in Classes 150 through 800. Port sizes covered include full bore, single-reduced bore, and double-reduced bore. Reduced bore ball valves are not suitable for most pigging operations. If there is a requirement for free-draining of a line, reduced bore valves may not be suitable. Reduced bore valves may reduce the flow capacity of a line. Ball valves are categorized as either “floating ball” or “trunnion-mounted” ball.

5.1.2.2.1 Floating 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 line pressure forces the ball against the downstream seat to form a tight seal. Generally, floating ball valves are used in sizes NPS 12 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 7.1 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 bidirectional, bidirectional with a preferred high-pressure end, or unidirectional, depending on design and manufacturer. One-piece and two-piece body design ball valves are usually 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.

5.1.2.2 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 with 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.

See Figure A.5 and Figure A.6 for examples of API 608^[9] ball valve designs.

5.1.2.3 API Std Ball Valves

Besides API 608^[9], there is also the Upstream publication API 6D^[11] 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^[9], as well as ones that require complex double-isolation or double-block performance.

5.1.2.4 Ball Valve Seats

API 608^[9] 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^[9] defines minimum seat material pressure/temperature ratings for polytetrafluoroethylene (PTFE) and for reinforced PTFE. API 608, Sixth Edition—Tables 1 and 2 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^[19]. 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 with 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^[3], Tenth Edition—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^[9] valves can be specified as a “fire safe” or “fire tested” design. API 607^[8] 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 in recent years it has become the norm to use them in 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 8.6 for further discussion for the implications of fire tested designs.

5.1.2.5 Rising Stem Ball Valves

Rising stem ball valves use 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. Rising stem ball valves may have a preferred sealing direction and can be unidirectional. 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 as special.