

VALVE & TESTING

What is a valve?

Valve (valv/)

Noun: a device for controlling the passage of fluid or air through a pipe, duct, etc., especially an automatic device allowing movement in one direction only.

Reference Codes and Standards

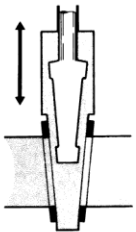
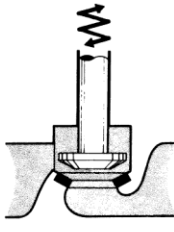
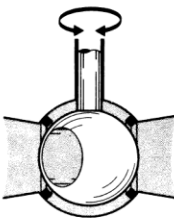
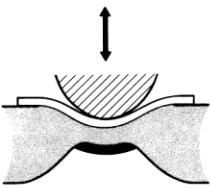
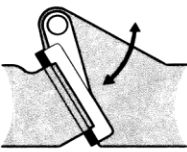
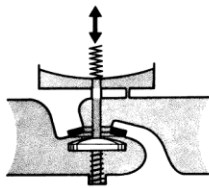
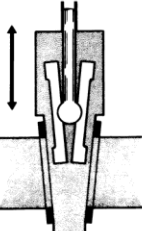
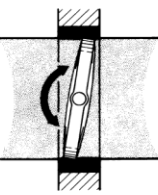
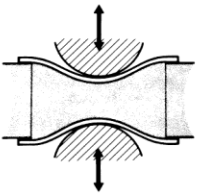
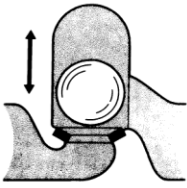
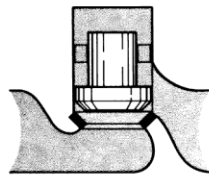
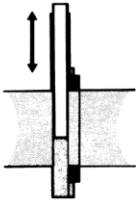
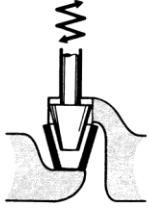
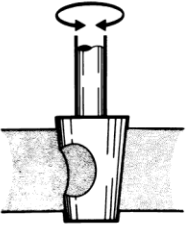
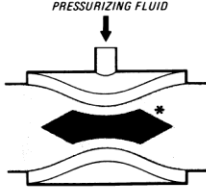
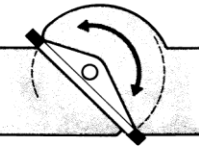
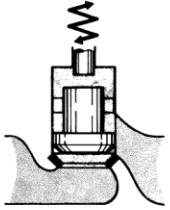
- API STD 598: Valve inspection and testing
- API STD 600: Steel gate valve
- API STD 594: Check valve
- API 608: Ball valve
- API 609: Butterfly valve
- API RP 621: Valve repair
- ASME 16.34: Valves (flanged, threaded and welding end)

Classification by Mechanism

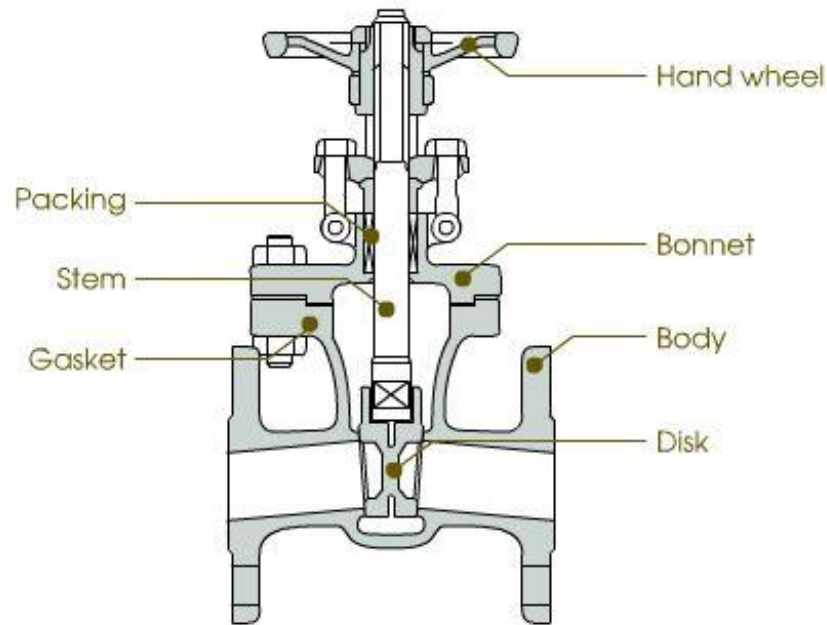
BASIC VALVE MECHANISMS FLUID CONTROL ELEMENTS (DISCS)

CHART 3.1

IN THESE SCHEMATIC DIAGRAMS, THE DISC IS SHOWN WHITE, THE SEAT IN SOLID COLOR, & THE CONVEYED FLUID SHADED.

OPERATED VALVES				SELF-OPERATED VALVES	
GATE	GLOBE	ROTARY	DIAPHRAGM	CHECK	REGULATING
 SOLID-WEDGE GATE	 GLOBE	 ROTARY-BALL	 DIAPHRAGM (SAUNDERS TYPE)	 SWING CHECK	 PRESSURE REGULATOR
 SPLIT-WEDGE GATE	 ANGLE GLOBE	 BUTTERFLY	 PINCH	 BALL CHECK	 PISTON CHECK
 SINGLE-DISC SINGLE-SEAT GATE	 NEEDLE	 PLUG or COCK	 PRESSURIZING FLUID *Central seat is optional SQUEEZE	 TILTING DISC CHECK	 STOP CHECK

Gate Valve



- A gate valve consists of a body that contains a gate that interrupts flow. This type of valve is normally used in a fully open or fully closed position. Gate valves are generally used in systems where low flow resistance for a fully open valve is desired and there is no need to throttle the flow.

Gate Valve

■ Advantages:

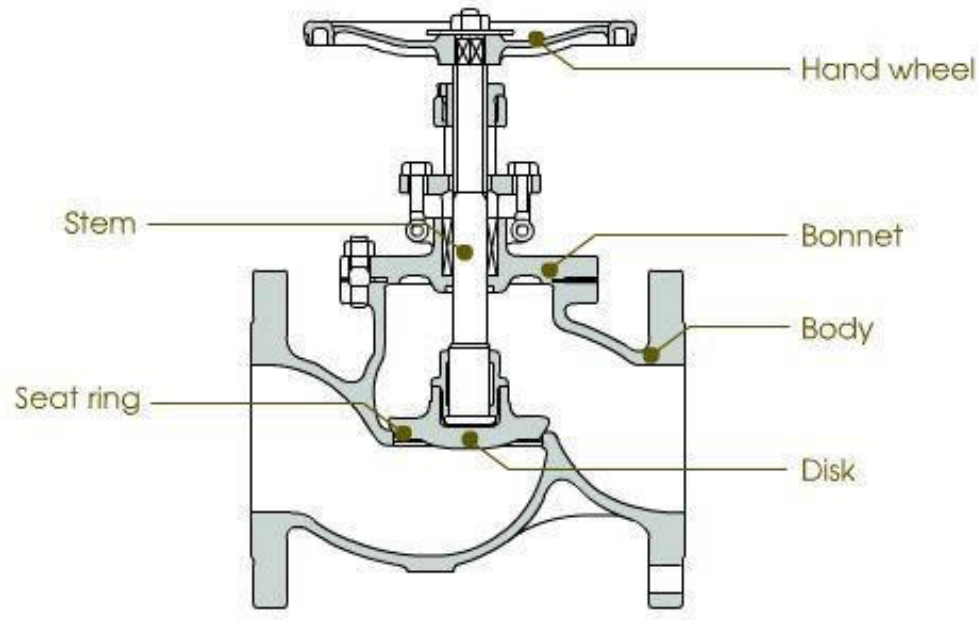
- It has ***good shutoff*** characteristics.
- The ***pressure loss*** through the valve is ***minimal***.

Gate Valve

■ Disadvantage

- It is ***not suitable for throttling applications.***
- It is ***prone to vibration*** in the partially open state.
- It is ***more subject to seat and disk wear*** than a globe valve.
- ***Repairs***, such as lapping and grinding, are generally ***more difficult*** to accomplish.

Globe Valve



- A globe valve, which is commonly used to regulate fluid flow, consists of a valve body that contains a circular disc that moves parallel to the disc axis and contacts the seat. The stream flows upward generally, except for vacuum service or when required by system design (e.g. fail closed), through the seat area against the disc, and then changes direction to flow through the body to the outlet disc. The seating surface can be flat or tapered.

Globe Valve

■ Advantages:

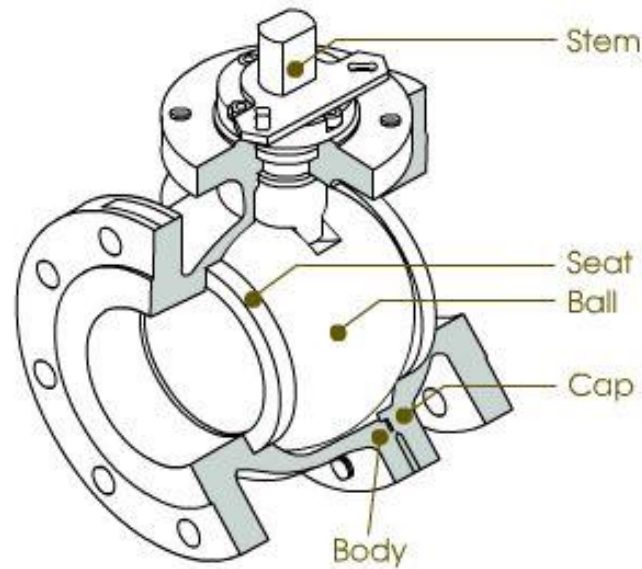
- ***Good shut-off*** capability.
- ***Moderate to good throttling*** capability.
- ***Shorter stroke*** (compared to a gate valve)
- Available in tee, wye, and angle patterns, each offering unique capabilities
- ***Easy*** to machine or ***resurface the seats***

Globe Valve

■ Disadvantages:

- ***Higher pressure drop*** (compared to a gate valve)
- ***Requires greater force*** or a larger actuator ***to seat*** the valve (with pressure under the seat)

Ball Valve



- A ball valve is another one-quarter turn valve similar to a plug valve except that the plug in a ball valve is spherical instead of tapered or cylindrical. Ball valves usually function as block valves to close off flow. They are well suited for conditions that require quick on/off or bubble tight service. A ball valve is typically equipped with an elastomeric seating material that provides good shut off characteristics; however, all-metal, high-pressure ball valves are available.

Ball Valve

■ Advantages:

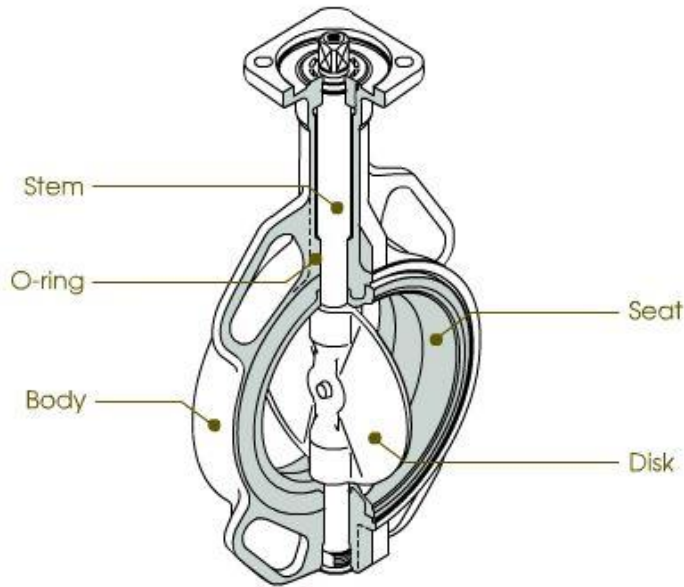
- ***Quick*** to ***open*** and ***close***.
- ***Smaller*** in size than a gate valve.
- ***Several designs*** of ball valves offer flexibility of selection.
- High-quality ball valves provide ***reliable service*** in high-pressure and high-temperature applications.
- ***Force*** required ***to actuate*** the valve is ***smaller*** than that required for a gate or a globe valve.

Ball Valve

■ Disadvantages:

- Conventional ball valves have relatively ***poor throttling*** characteristics. In a ***throttling position***, the partially exposed seat ***rapidly erodes because*** of the ***impingement*** of high velocity flow.

Butterfly Valve



- A butterfly valve consists of a disc mounted on a stem in the flow path within the valve body. The body is usually flanged and of the lug or wafer type. A one-quarter turn of the stem changes the valve from fully closed to completely open. Butterfly valves are most often used in low-pressure service for coarse flow control.

Butterfly Valve

■ Advantage

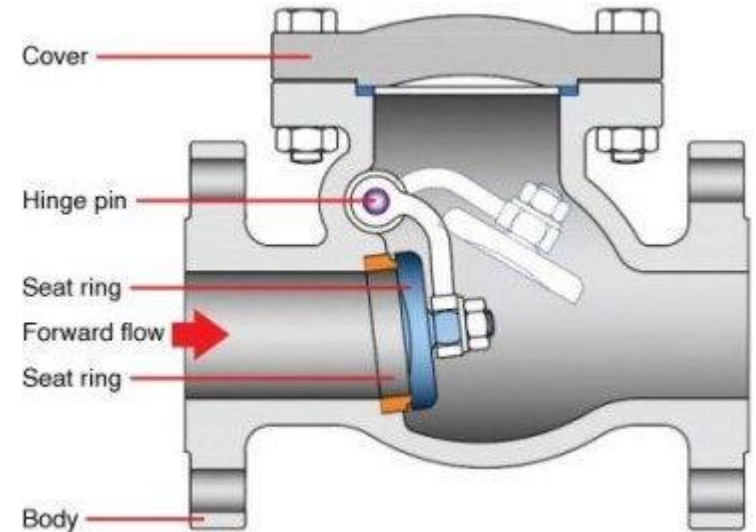
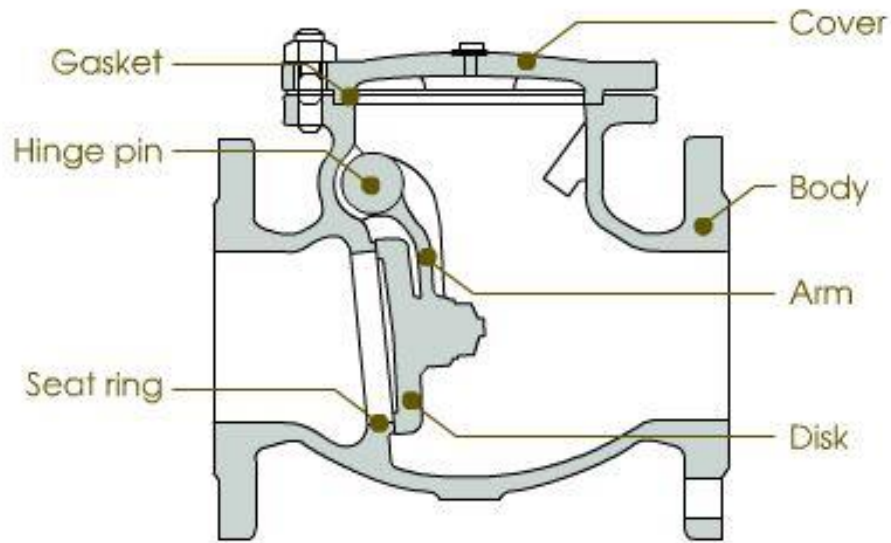
- The compact design requires considerably ***less space***, compared to gate, globe, or other valves.
- ***Light*** in weight.
- ***Quick acting***, as a quarter-turn valve, it requires less time to open or close.
- It is ***available in large sizes***, ranging from NPS 1¹/₂ (DN 40) to over NPS 200 (DN 5000).
- It has ***low-pressure drop*** and high-pressure recovery.

Butterfly Valve

■ Disadvantage

- ***Throttling service*** is limited to ***low differential pressure***.
- ***Cavitation and choked flow*** are two potential concerns.
- The ***disc movement*** is unguided and affected by ***flow turbulence***.

Check Valve



- Check valves are designed to prevent the reversal of flow in a piping system. These valves are activated by the flowing material in the pipeline. The pressure of the fluid passing through the system opens the valve, while any reversal of flow will close the valve. Closure is accomplished by the weight of the check mechanism, by back pressure, by a spring, or by a combination of these means.

Check Valve

■ Advantages:

- It is ***self-actuated*** and requires no external means to actuate the valve either to open or close. It is ***fast acting***.
- It allows flow in one direction only
- Pressure drop is very low

Check Valve

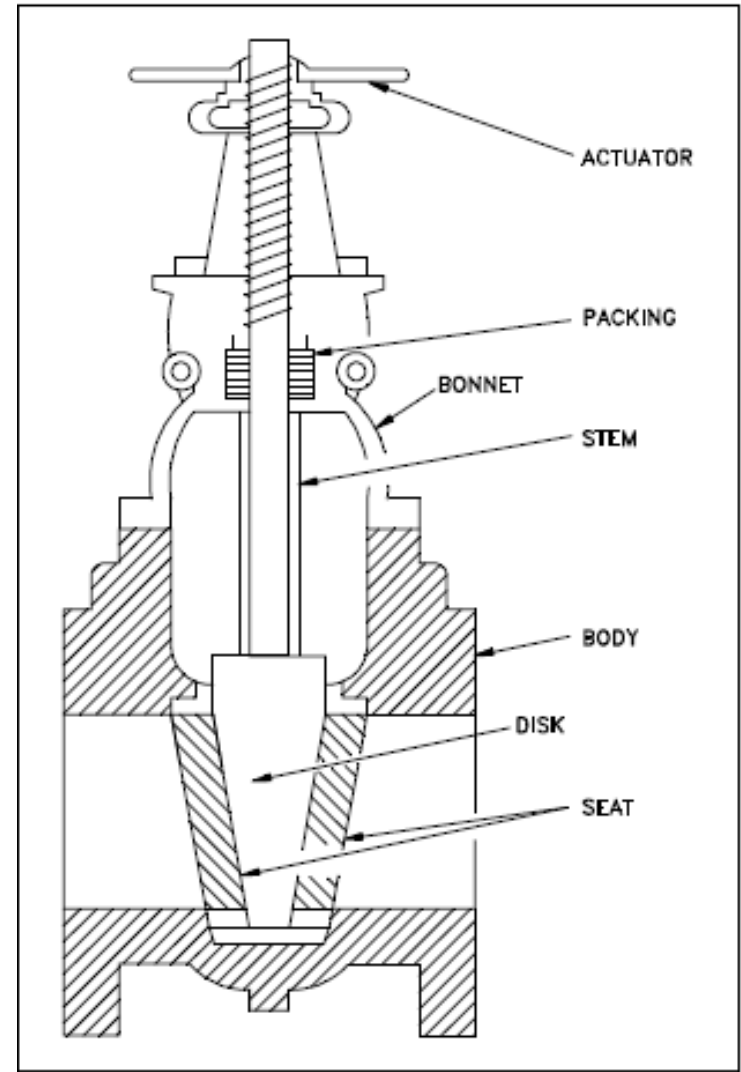
■ Disadvantage

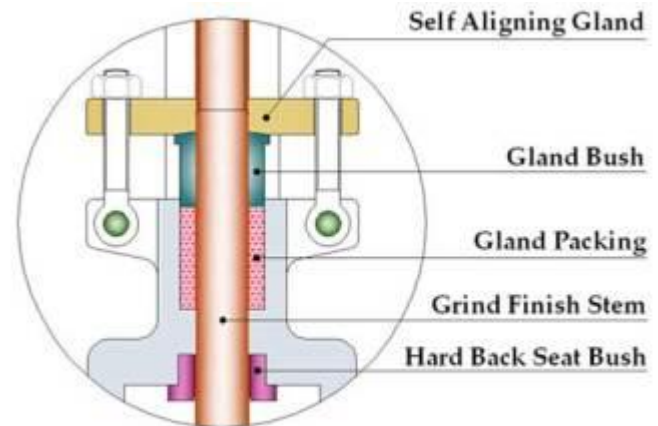
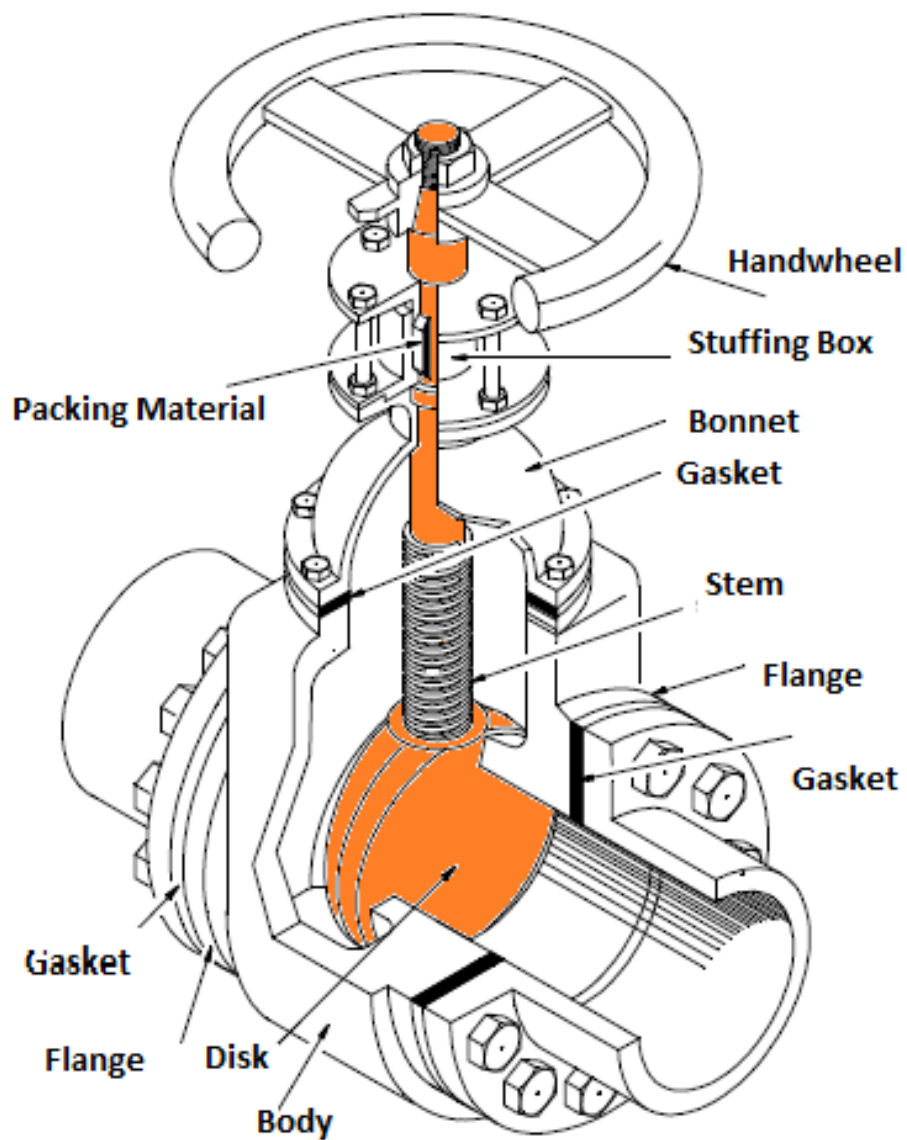
The major disadvantages to the use of a check valve are:

- Since all moving parts are enclosed, it is ***difficult to determine*** whether the valve is ***open or closed***. Furthermore, the condition of internal parts cannot be assessed.
- Each type of check valve has ***limitations on its installation*** configurations.
- Valve ***disc*** can ***stick in open position***.

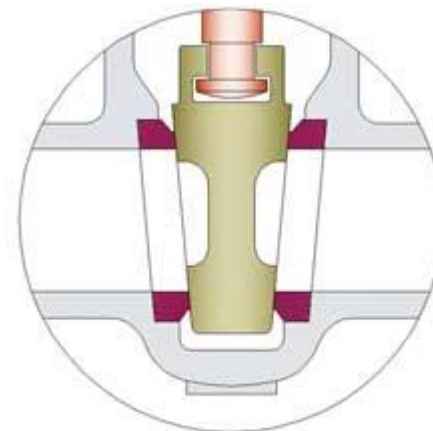
Valve Component

- **Body** : is the primary pressure boundary of a valve. It serves as the principal element of a valve assembly because it is the framework that holds everything together.
- **Bonnet** : A valve body closure component that contains an opening for the stem.
- **Trim** : The internal elements of a valve are collectively referred to as a valve's trim. The trim typically includes
 - **Disc** : The part of the valve which is positioned in the flow stream to permit or to obstruct flow
 - **Seat** : The portion of the valve against which the closure member presses to effect shutoff.
 - **Stem** : which connects the actuator and disk, is responsible for positioning the disk.
- **Actuator** : A device that operates a valve by utilizing electricity, pneumatics, hydraulics, or a combination of one or more of these energies.
- **Packing** : to prevent leakage from the space between the stem and the bonnet.





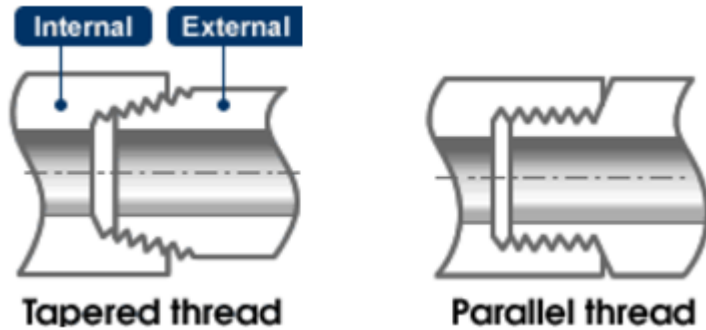
Bonnet Assembly



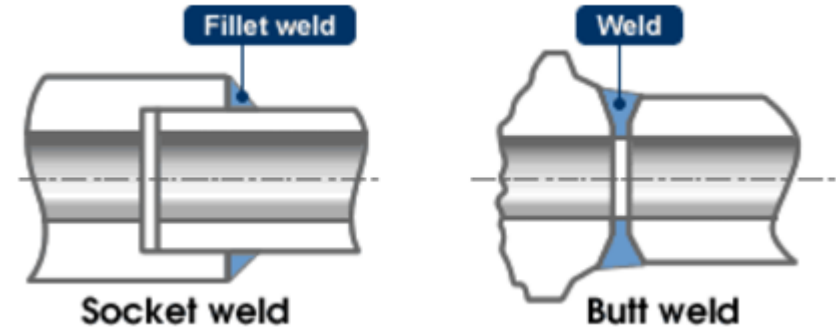
Solid Wedge Gate

Common valve connections

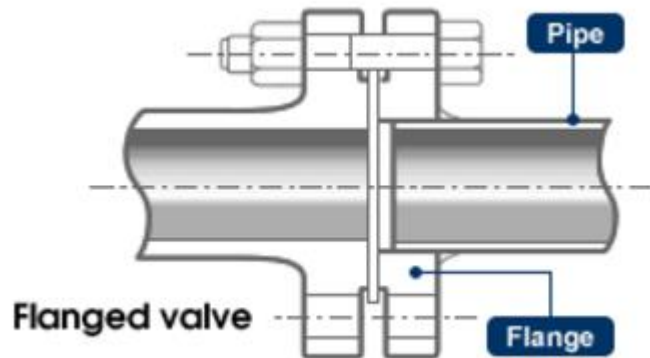
■ Threaded Connection



■ Welded Connection



■ Flanged Connection



Trim Chart

Trim Number	Nominal Trim	Seat Surface Hardness (HB) Minimum ^a	Seat Surface Material Type ^b	Seat Surface Typical Specifications Grade			Stem/Bushing		Stem Hardness (HB)	Backseat Bushing Hardness (HB)
				Cast	Forged	Welded ^m	Material Type ^b	Typical Specifications Type		
1	F6	Note ^c	13Cr	ASTM A217(CA15)	ASTM A105 (F6a)	AWS A5.9 ER410	13Cr	ASTM A276-T410 or T420	200 min 275 max	250 min.
2	304	Note ^d	18Cr-8Ni	ASTM A351 (CF8)	ASTM A182 (F304)	AWS A5.9 ER308	18Cr-8Ni	ASTM A276-T304	Note ^d	Note ^d
3	F310	Note ^d	25Cr-20Ni	NA	ASTM A182 (F310)	AWS A5.9 ER310	25Cr-20Ni	ASTM A276-T310	Note ^d	Note ^d
4	Hard F6	750 ^e	Hard 13Cr	NA	Note ^f	NA	13Cr	ASTM A276-T410 or T420	200 min 275 max	250 min.
5	Hardfaced	350 ^e	Co-Cr A ^g	NA	NA	AWS A5.13 E or R CoCrA	13Cr	ASTM A276 T410 or T420	200 min 275 max	250 min.
5A	Hardfaced	350 ^e	Ni-Cr	NA	NA	Note ^h	13Cr	ASTM A276 T410 or T420	200 min 275 max	250 min.
6	F6 and Cu-Ni	250 ⁱ 175 ⁱ	13Cr and Cu-Ni	ASTM A 217 (CA 15) NA	ASTM A182 (F6a) Note ^k	AWS A5.9 ER410 NA	13Cr NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA
7	F6 and Hard F6	250 ⁱ 750 ⁱ	13Cr and Hard 13Cr	ASTM A 217 (CA 15) NA	ASTM A182 (F6a) Note ^f	AWS A5.9 ER410 NA	13Cr NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA
8	F6 and Hardfaced	250 ⁱ 350 ⁱ	13Cr and Co-Cr A ^g	ASTM A 217 (CA 15) NA	ASTM A182 (F6a) NA	AWS A5.9 ER410 AWS A5.13 E or R CoCrA	NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA
8A	F6 and Hardfaced	250 ⁱ 350 ⁱ	13Cr and Ni-Cr	ASTM A 217 (CA 15) NA	ASTM A182 (F6a) NA	AWS A5.9 ER410 Note ^h	13Cr NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA
9	Monel	Note ^d	Ni-Cu Alloy	NA	MFG Standard	NA	Ni-Cu Alloy	MFG Standard	Note ^d	Note ^d
10	316	Note ^d	18Cr-8Ni	ASTM A351 (CF8M)	ASTM A182 (F316)	AWS A5.9 ER316	18Cr-8Ni-Mo	ASTM A276-T316	Note ^d	Note ^d
11	Monel and Hardfaced	Note ^d 350 ⁱ	Ni-Cu Alloy and Trim 5 or 5A	NA	MFG Standard	NA See Trim 5 or 5A	Ni-Cu Alloy NA	MFG Standard NA	Note ^d NA	Note ^d NA
12	316 and Hardfaced	Note ^d 350 ⁱ	18Cr-8Ni-Mo Trim 5 or 5A	ASTM A351 (CF8M)	ASTM A182 (F316)	AWS A5.9 ER316 See Trim 5 or 5A	18Cr-8Ni-Mo NA	ASTM A276-T316 NA	Note ^d NA	Note ^d NA
13	Alloy 20	Note ^d	19Cr-29Ni	ASTM A351 (CN7M)	ASTM B473	AWS A5.9 ER320	19Cr-29Ni	ASTM B473	Note ^d	Note ^d
14	Alloy 20 and Hardfaced	Note ^d 350 ⁱ	19Cr-29Ni and Trim 5 or 5A	ASTM A351 (CN7M) NA	ASTM B473 NA	AWS A5.9 ER320 See Trim 5 or 5A	19Cr-29Ni NA	ASTM B473 NA	Note ^d NA	Note ^d NA
15	Hardfaced	350 ^e	Co-Cr A ^g	NA	NA	AWS A5.13 E or R CoCrA	18Cr-8Ni	ASTM A276-T304	Note ^d	Note ⁿ
16	Hardfaced	350 ^e	Co-Cr A ^g	NA	NA	AWS A5.13 E or R CoCrA	18Cr-8Ni-Mo	ASTM A276-T316	Note ^d	Note ⁿ
17	Hardfaced	350 ^e	Co-Cr A ^g	NA	NA	AWS A5.13 E or R CoCrA	18Cr-10Ni-Cb	ASTM A276-T347	Note ^d	Note ⁿ
18	Hardfaced	350 ^e	Co-Cr A ^g	NA	NA	AWS A5.13 E or R CoCrA	19Cr-29Ni	ASTM B473	Note ^d	Note ⁿ

NOTE Cr = Chromium; Ni = Nickel; Co = Cobalt; Cu = Copper; NA = Not Applicable.

Trim Chart

Trim Number	Nominal Trim	Seat Surface Hardness (HB) Minimum ^a	Seat Surface Material Type ^b	Seat Surface Typical Specifications Grade			Stem/Bushing		Stem Hardness (HB)	Backseat Bushing Hardness (HB)
				Cast	Forged	Welded ^m	Material Type ^b	Typical Specifications Type		
8	F6 and Hardfaced	250 ⁱ 350 ⁱ	13Cr and Co-Cr A ^g	ASTM A 217 (CA 15) NA	ASTM A182 (F6a) NA	AWS A5.9 ER410 AWS A5.13 E or R CoCrA	NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA

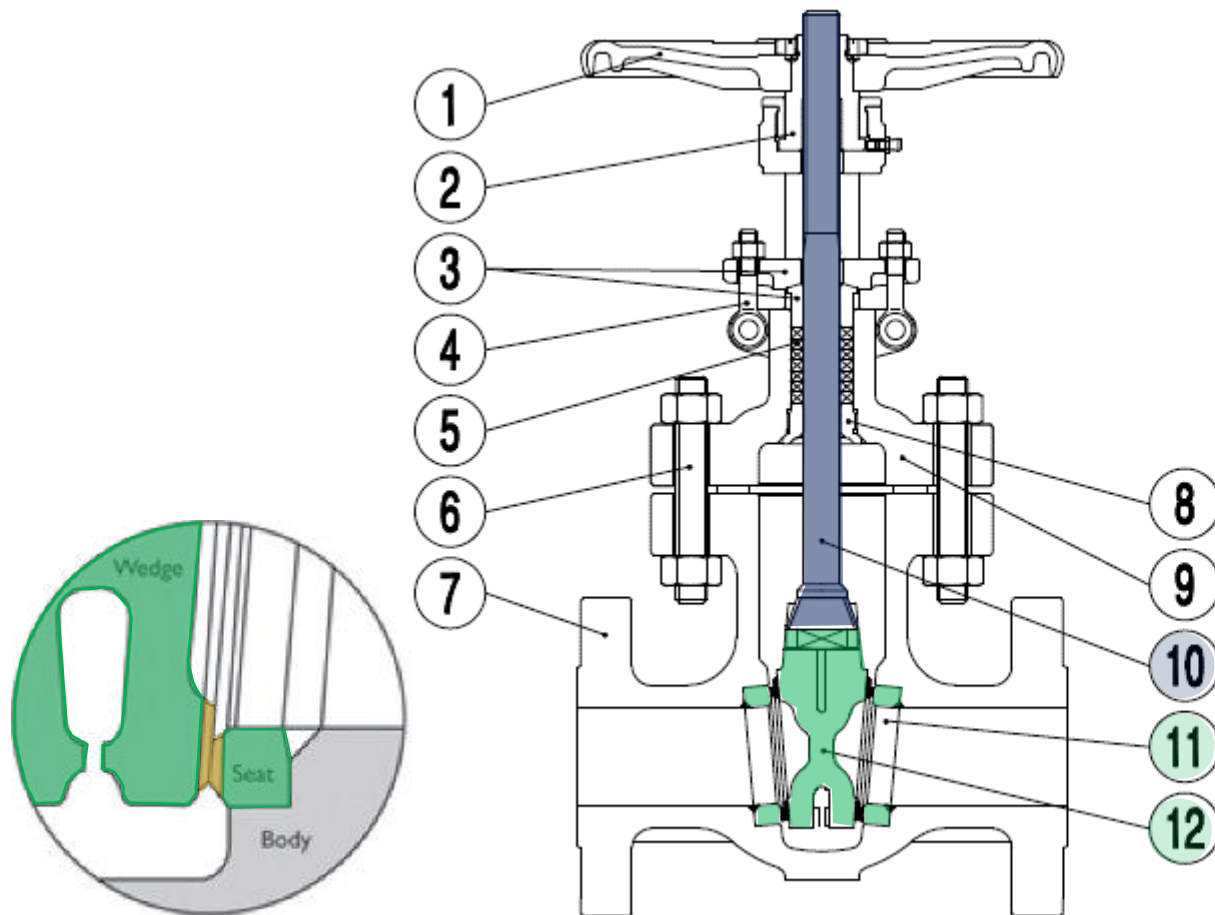
■ Example:

■ Trim #8

- Nominal trim: F6 (SS410) + Hard Faced
- Seat surface material: F6 (SS410) + Co-Cr-A(Stellite)
- Stem: F6 (SS410)
- Disc: F6 (SS410)
- Application: General service up to 593C, medium pressure and more corrosive service

Valve Trim

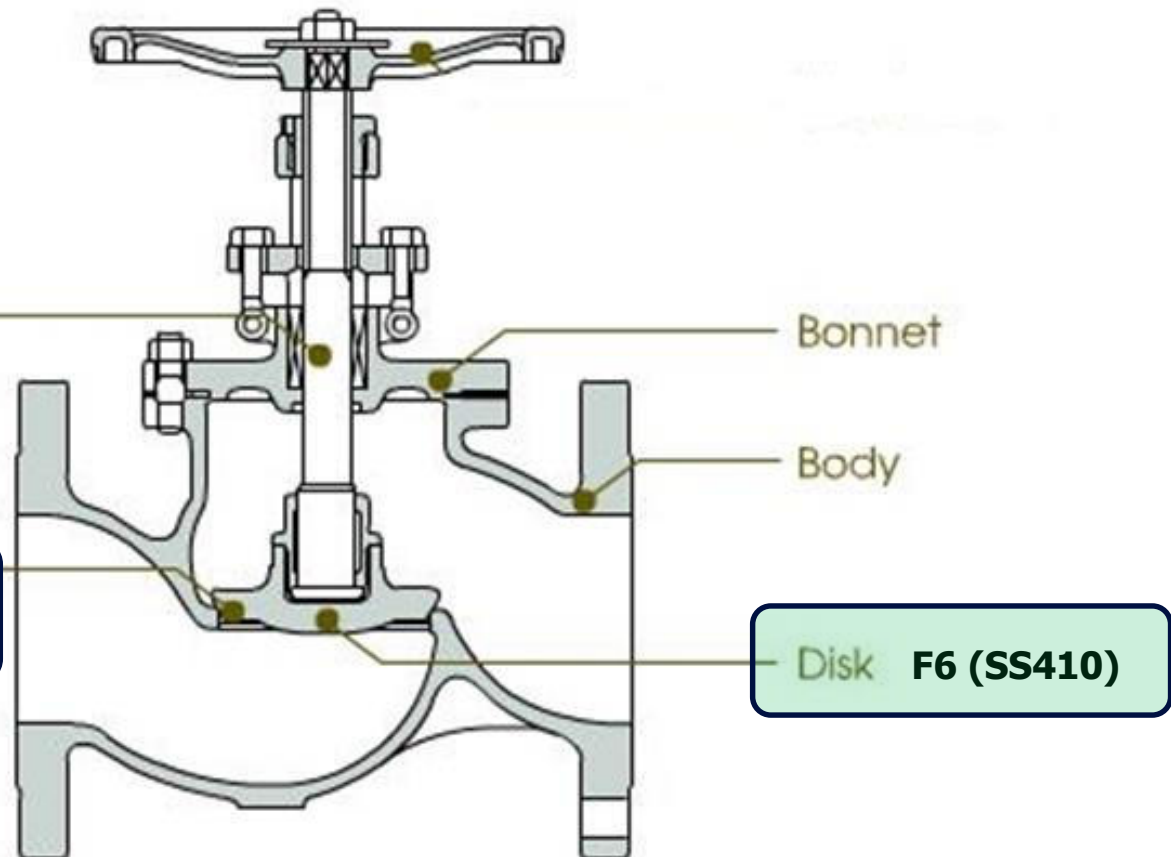
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8	F6 and Hardfaced	250 ^l 350 ^l	13Cr and Co-Cr A ^g	ASTM A 217 (CA 15) NA	ASTM A 182 (F6a) NA	AWS A5.9 ER410 AWS A5.13 E or R CoCrA	NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA



IT.	DESCRIPTION
1	HANDWHEEL
2	YOKE SLEEVE
3	GLAND FLANGE
4	GLAND EYE BOLT
5	PACKING
6	BONNET BOLT
7	BODY
8	BONNET
9	BACK SEAT
10	STEM
11	SEAT RING
12	WEDGE

Valve Trim

Trim Number	Nominal Trim	Seat Surface Hardness (HB) Minimum ^a	Seat Surface Material Type ^b	Seat Surface Typical Specifications Grade			Stem/Bushing		Stem Hardness (HB)	Backseat Bushing Hardness (HB)
				Cast	Forged	Welded ^m	Material Type ^b	Typical Specifications Type		
8	F6 and Hardfaced	250 ⁱ 350 ⁱ	13Cr and Co-Cr A ^g	ASTM A 217 (CA 15) NA	ASTM A182 (F6a) NA	AWS A5.9 ER410 AWS A5.13 E or R CoCrA	NA	ASTM A276 T410 or T420 NA	200 min 275 max NA	250 min. NA



Valve Testing

- API 598 Valve inspection and testing

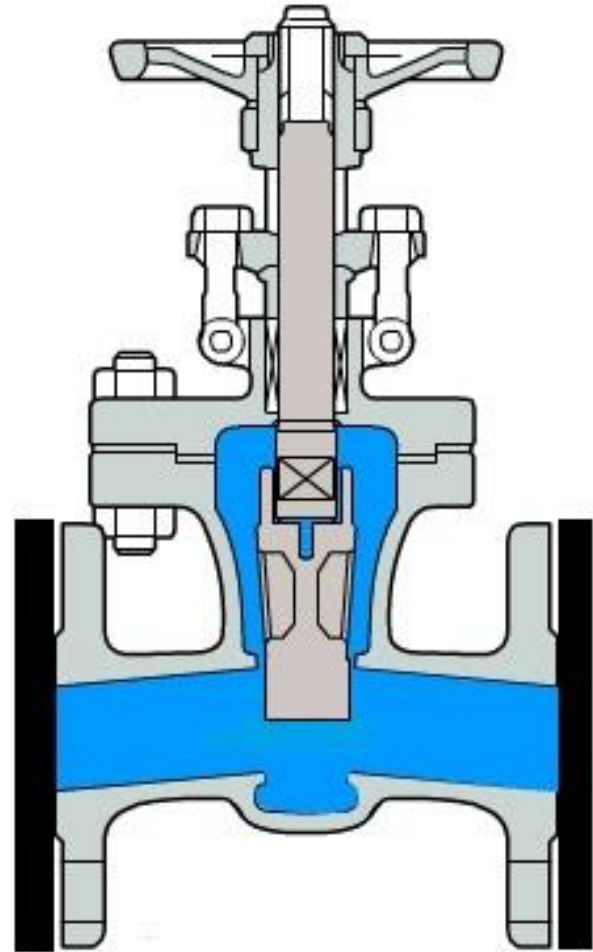
- Pressure Tests

- Shell test
- Backseat test
- Low pressure closure
- High pressure closure

- Requirement of each pressure test is varied by type of valve, size, and flange rating

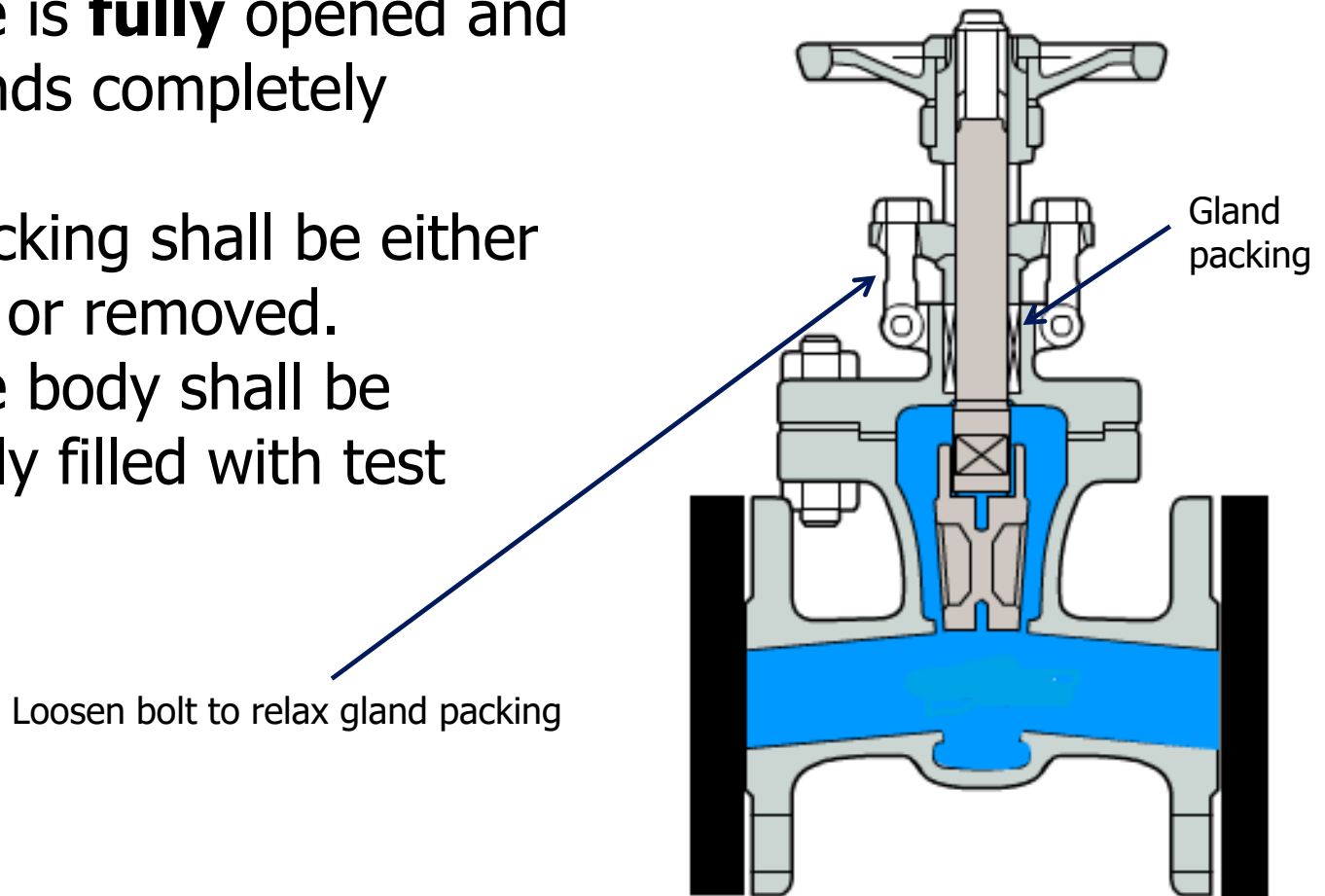
Shell Test

- The valve is **partially** opened and valve's ends completely closed.
- Not a single valve component shall be removed.
- The valve body shall be completely filled with test fluid.



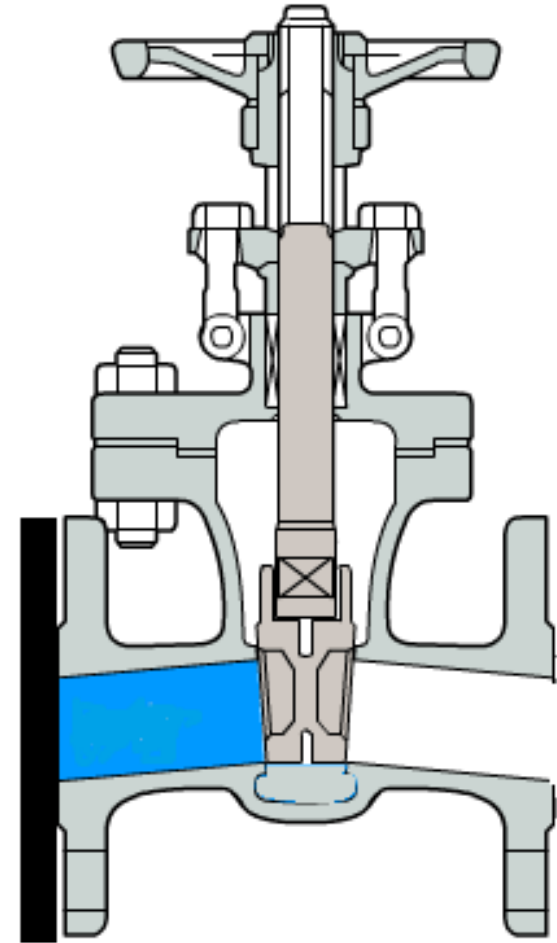
Backseat Test

- The valve is **fully** opened and valve's ends completely closed.
- Gland packing shall be either loosened or removed.
- The valve body shall be completely filled with test fluid.



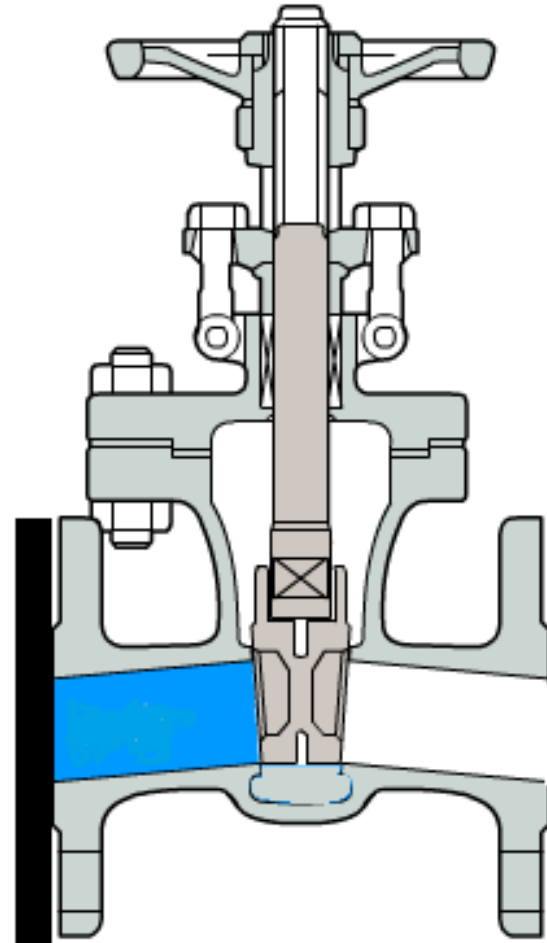
Low Pressure Closure

- The valve is fully closed with one end subjected for testing and the other end opened for detection of leakage
- Not a single valve component shall be removed.
- Both ends shall be subjected for testing



High Pressure Closure

- Same as Low Pressure Closure, **except** that in the case of a liquid test, leakage shall be detected when drops, not bubbles
- Both ends shall be subjected for testing



Tests Required

Table 1—Pressure Tests

Valves: DN (NPS) $\leq$ DN 100 (NPS 4) and ASME Class $\leq$ 1500
 DN (NPS) $>$ DN 100 (NPS 4) and ASME Class $\leq$ 600

Test Description	Valve Type					
	Gate	Globe	Plug	Check	Floating Ball	Butterfly and Trunnion Mounted Ball
shell	required	required	required	required	required	required
backseat ^a	required	required	NA	NA	NA	NA
low-pressure closure	required	optional ^c	required ^b	optional ^c	required	required
high-pressure closure ^d	optional ^{c f}	required ^e	optional ^{b c f}	required	optional ^{c f}	optional ^{c f}
NOTE NA = Not applicable.						

Tests Required

Table 2—Pressure Tests

Valves: DN (NPS) $\leq$ DN 100 (NPS 4) and ASME Class > 1500
 DN (NPS) $>$ DN 100 (NPS 4) and ASME Class > 600

Test Description	Valve Type					
	Gate	Globe	Plug	Check	Floating Ball	Butterfly and Trunnion Mounted Ball
shell	required	required	required	required	required	required
backseat ^a	required	required	NA	NA	NA	NA
low-pressure closure	optional ^b	optional ^b	optional ^b	optional ^b	required	optional ^b
high-pressure closure ^c	required	required ^d	required	required	optional ^{b e}	required
NOTE NA = Not applicable.						

Test Pressure

Table 3—Shell Test Pressures

Valve Type	Class	Shell Test Pressure (Minimum)	
		Bar Gauge	Pounds per Square Inch Gauge (psig)
ductile iron	150	26	400
	300	66	975
cast iron	125		
DN 50 to 300 (NPS 2 to 12)		25	350
DN 350 to 1200 (NPS 14 to 48)		19	265
cast iron	250		
DN 50 to 300 (NPS 2 to 12)		61	875
DN 350 to 600 (NPS 14 to 24)		37	525
steel			
flanged	150 to 2500	b	b
butt weld	150 to 4500	b	b
threaded ^a and socket weld	800	c	c
	150 to 4500	b	b

For other materials, the test pressure shall be 1.5 times of the working pressure varying by class (ASME B16.34).

Test Fluid

- The test fluid shall be done with water or with other suitable fluid.
- For testing of austenitic stainless steel valves, water with chloride content not exceeding 30 ppm shall be used

Test Duration

Table 5—Duration of Required Test Pressure

Valve Size		Minimum Test Duration (Seconds) ^a			
DN	NPS	Shell	Backseat (for Valves with Backseat Feature)	Closure Check Valves (API 594)	Closure Other Valves
≤ 50	≤ (2)	15	15	60	15
65 to 150	(2 1/2 to 6)	60	60	60	60
200 to 300	(8 to 12)	120	60	120	120
≥ 350	≥ (14)	300	60	120	120
^a The test duration is the period of inspection after the valve is fully prepared and is under full pressure.					

Acceptance Criteria

- The valve shall be visually examined for leakage after it has been fully prepared and is under full test pressure.
- No leakage or pressure drop.
- For valves with **adjustable** stem seals, leakage through the stem seals or stem packing shall not be cause for rejection.

Allowable Leakage Rates

The following table shows maximum allowable leakage rates for closure tests

Valve Size		Metal Seated Valves
DN (mm)	NPS (in.)	Liquid Test (drops/minute)
≤ 50	≤ 2	0
65	2 1/2	5
80	3	6
100	4	8
125	5	10
150	6	12
200	8	16
250	10	20
300	12	24
350	14	28
400	16	32
450	18	26
500	20	40
600	24	48
650	26	52
700	28	56
750	30	60
800	32	64
900	36	72
1000	40	80
1050	42	84
1200	48	96