Pressure Locking & Thermal Binding In Wedge Gate & Parallel Slide Gate Valves

CRANE Energy Flow Solutions™

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Crane Energy Flow Solutions™

Resolution Made By Richard Teller Crane
Founder Of Crane Co., On July 4, 1855

"I am resolved to conduct my business in the strictest honesty and fairness; to avoid all deception and trickery; to deal fairly with both customers and competitors; to be liberal and just toward employees; and to put my whole mind upon the business."

The Essence Of This Resolution Is
The Business Policy Of Crane Co. Today

Crane Co.

- **Tradition of quality, innovation, and leadership, SINCE 1855**
- **Listed on the New York Stock Exchange SINCE 1936**
- **12,000 employees, across 25 countries**
- **Integrity, performance with trust and respect, are the basis for our business system**
- **Committed to lean, operational excellence**

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Crane Co.

Crane is a global leader within the fields of:

AEROSPACE — $566 million

ENGINEERED MATERIALS — $309 million

MERCHANDISING — $258 million

FLUID HANDLING — $1000 million

CONTROLS — $124 million

brands you trust

CRANE ENERGY & CRANE CHEMPHARMA

Background:

- The thermal binding and pressure locking phenomena are based on well-known concepts. The determination of when the phenomena might occur requires a thorough knowledge of systems and plant operations. Pressure locking or thermal binding occurs as a result of the valve design characteristics (seating designs, body configuration and material of construction thermal coefficients) when the valve is subject to specific pressures and temperatures during the plant operation. The other factor for these phenomena indicates that situations were not always considered as part of the design basis for valves in many plants

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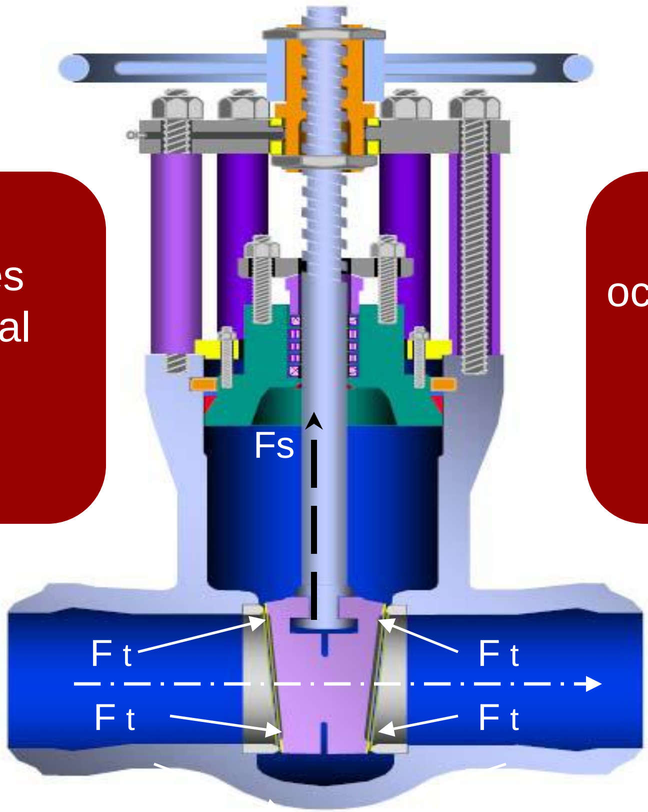
Thermal Binding

- Thermal binding is generally associated with a wedge gate valve that is closed while the system is hot and then allowed to cool before attempting to open the valve.
- In a Wedge Gate the wedge is generally cast and has machined seating surfaces on both sides at an angle of 5° from vertical.
- Thermal binding is more common at high temperature conditions.
- A wedge type gate valve has a mechanical interference between the gate and the seating surfaces
- Due to the difference in expansion and contraction the reopening of the valve might be prevented until the valve and disc are reheated.

Flex Wedge Gate Valve in Closed Position

Parallel slide gate valves are not subject to thermal binding.

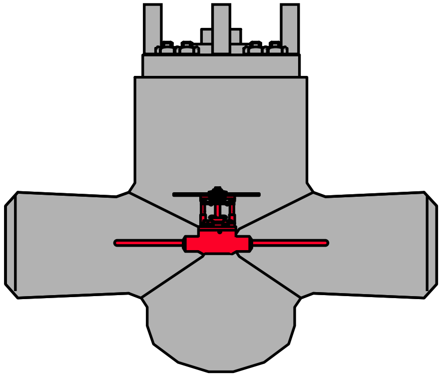


When thermal binding has occurred the valve can remain unserviceable until high temperature is re-obtained (recommended $\Delta T \leq 150$)

Thermal Binding
F s: Thrust required to lift wedge
F t: Thermal binding load

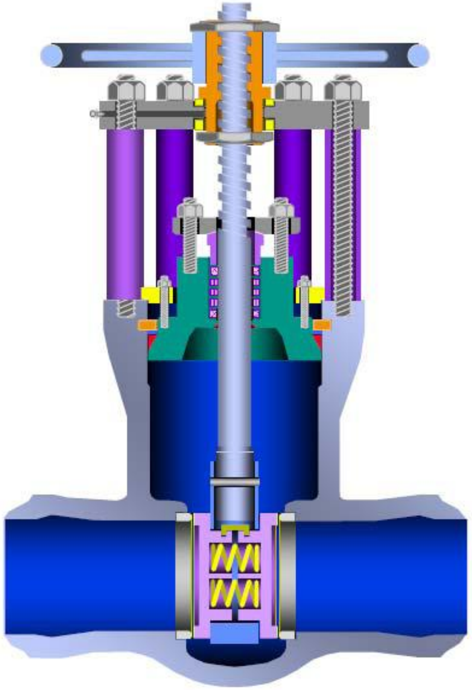
Thermal Binding Solutions

- After closing the valve, back off the stem a ¼ of a turn to allow for stem expansion.
- Install a bypass pipe and valve on the inlet and outlet sides of the body. This will allow warm up of both sides of the wedge.



Thermal Binding Solutions

- The Parallel Slide Valve is preferred over the Flex Wedge in high temperature applications as there is <u>no possibility</u> for Thermal Locking and because seat integrity increases with increasing pressure.



The higher the process pressure the higher the seating force

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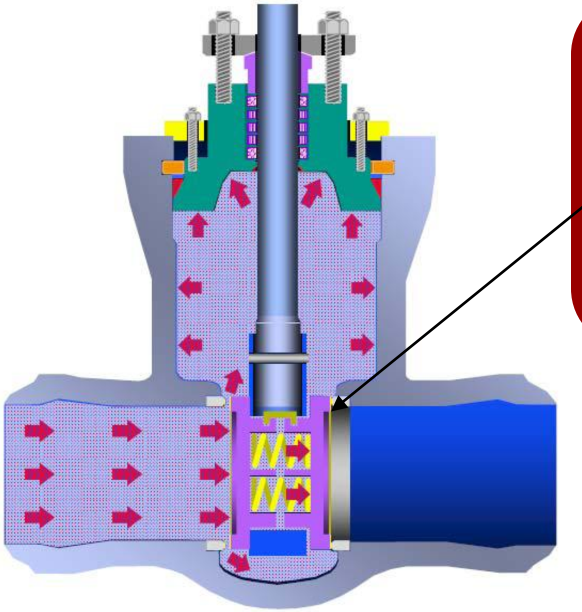
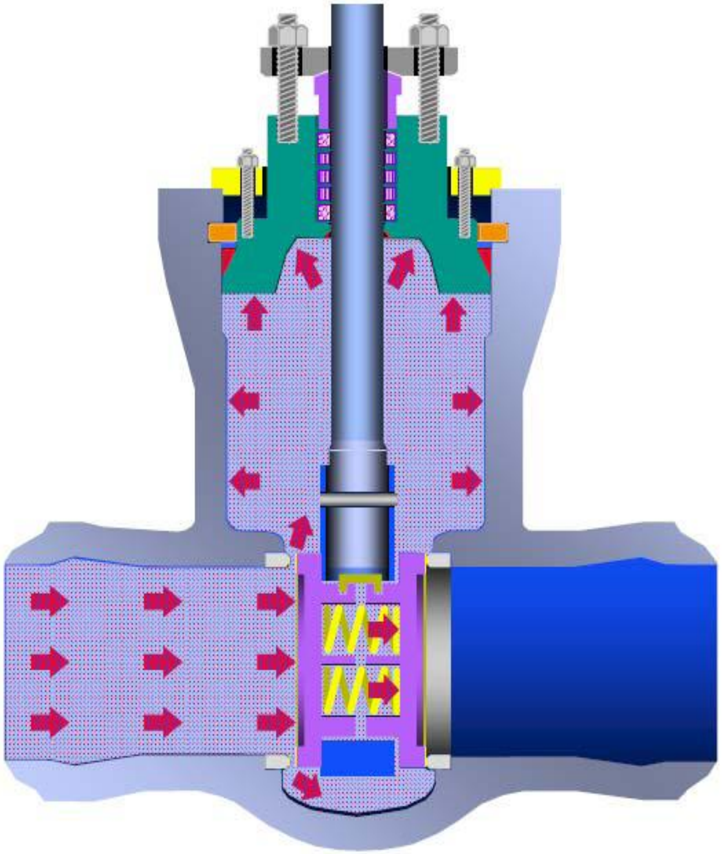
Thermal Binding Solutions

- The Parallel Slide Valve is a dynamically energized valve. It uses the process pressure to press the disc against the seat.
- As the process pressure rises it will overcome the upstream disc spring force and push the disc away from the seat thereby permitting process pressure into the body cavity.



This pressure is immediately seen by the downstream disc and forces it against the downstream body seat

Thermal Binding Solutions



- The stem thrust required for seating and unseating the valve is calculated from the Seating Force + Stem Load + Stem Packing Friction.
- Seating Force is calculated from the Valve Seat Area x Max Differential x Valve Factor.

Seating forces are calculated for only one seat being pressure energized at a time.

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Pressure Locking

- Pressure Locking occurs when the pressure in the body cavity, when the valve is closed increases, or when the line pressure decreases without decreases in the body bonnet area.
- Temperature in the valve bonnet might increase in response to heat up during plant operation, ambient air temperature rise due to leaking components or pipe breaks.
- The bonnet pressure could decrease by leakage past the seating surfaces or stem packing. If this does not occur, the depressurization time may be longer than the needed time to operate the valve.

Pressure Locking

- Pressure Locking is due to condensate being trapped in the bottom pocket (belly) of the valve body. This may be the result residual condensate being present in the valve from the cooling process during shutdown or it may be condensate that is driven into the valve during the initial warm up. The warm-up of the process line and of the valve body will produce condensate. This condensate will drain into the valve belly. This described in ASME under paragraph 2.3.3. Fluid Thermal Expansion.

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Pressure Locking

Over pressurization could occur in both pressure seal and bolted bonnet valve designs.

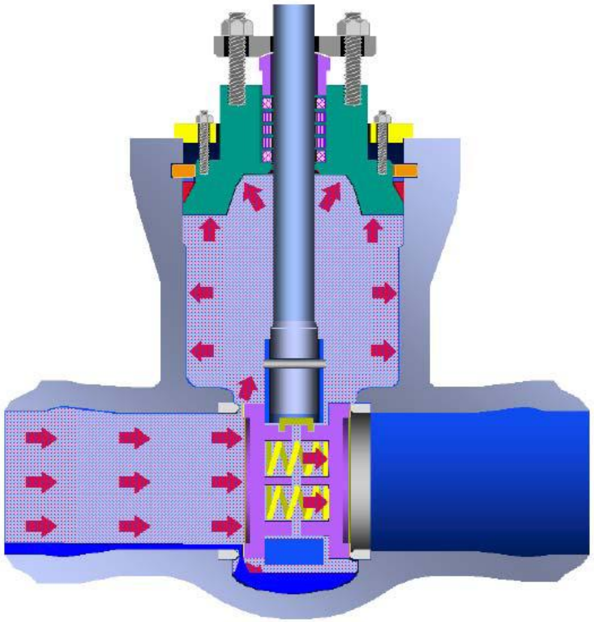

Figure 1.
Normal parallel slide gate valve operation.
Note: Seated on downstream seat
as designed

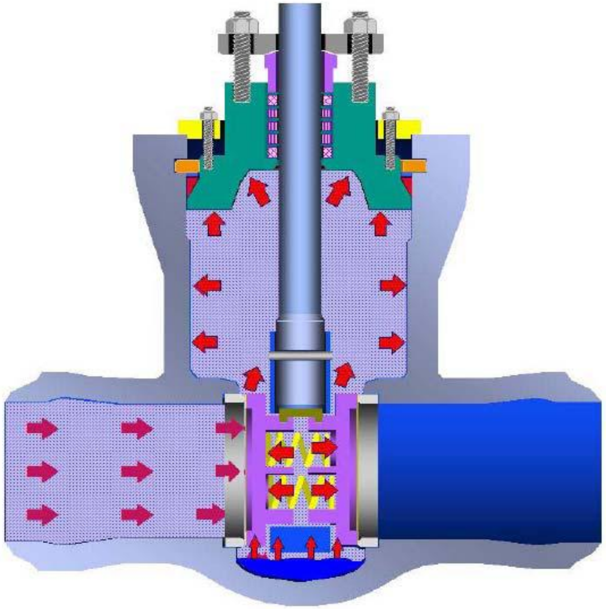

Figure 2.
Trapped condensate in valve.
Note: Pressure of trapped fluid between seats.

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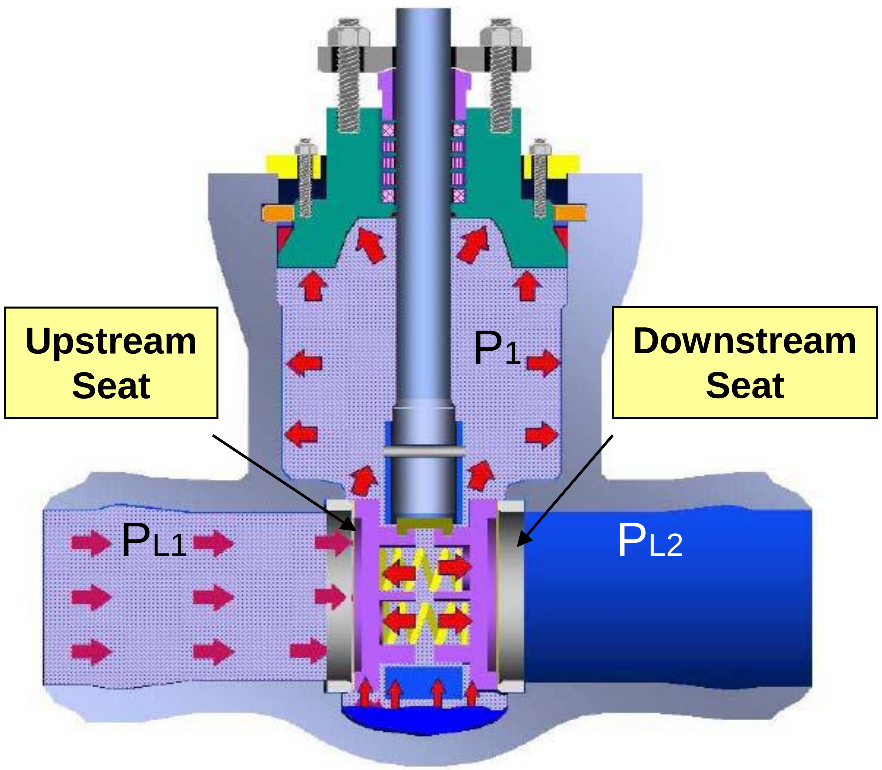
Pressure Locking



P1: Pressure of trapped fluid between seats
PL1/PL2: Line pressure

- The trapped fluid expands (P1), due to increase in temperature.
- Typically, for each 1° F rise of temperature, a pressure increase of 150 psi occurs.
- Not restricted to valve size.
- Actuator sizing is normally based on stated torques of a normal operating Parallel Slide Valve sealing on the downstream body seat. During over pressurization the dynamic seating force is doubled because both discs are loaded from the internal pressure. End result is the actuator cannot operate the valve.

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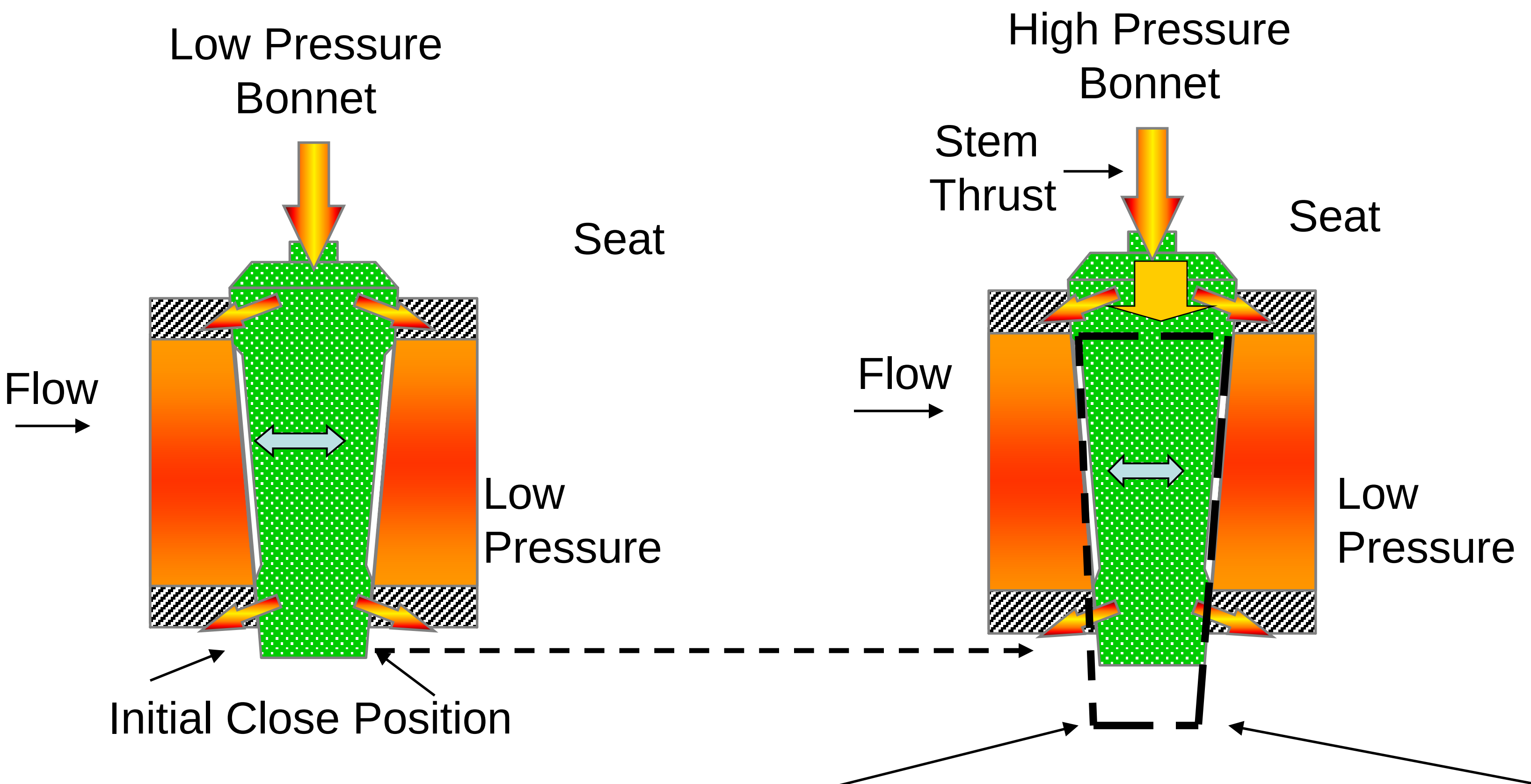
Wedgegate



The higher bonnet pressure causes the body to expand, thus moving the seats apart. The stem pushes the disc further down.

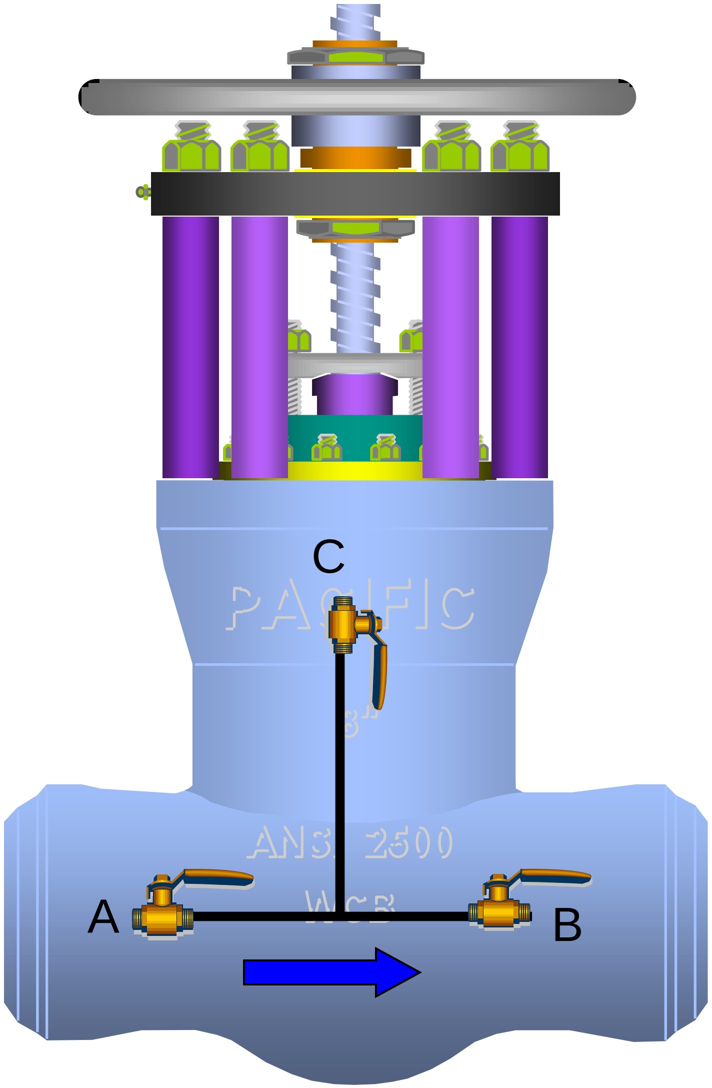
Pressure Locking Solutions

- Cycling the valve during start-up. The trapped condensate in the body cavity will be either flashed or siphoned away.
- Installing a pressure release system of the body cavity. This can be accomplished by an equalizing pipe from the bonnet to the high pressure side of the valve (the valve will only seal in one direction when the valve is closed).
- Installing a automatic relief valve or a manual drain valve to exhaust to the atmosphere (safety is suggested for both applications).
- Drilling an internal hole in the wedge face to the high pressure side of the valve.

THREE LEGGED BYPASS SOLUTIONS

- With the **A & B** valves open the valve seats are fully bypassed, and typical warm up or pressure equalization process can occur. The **C** valve can be open, or left closed for the typical bypass/warm up operation.

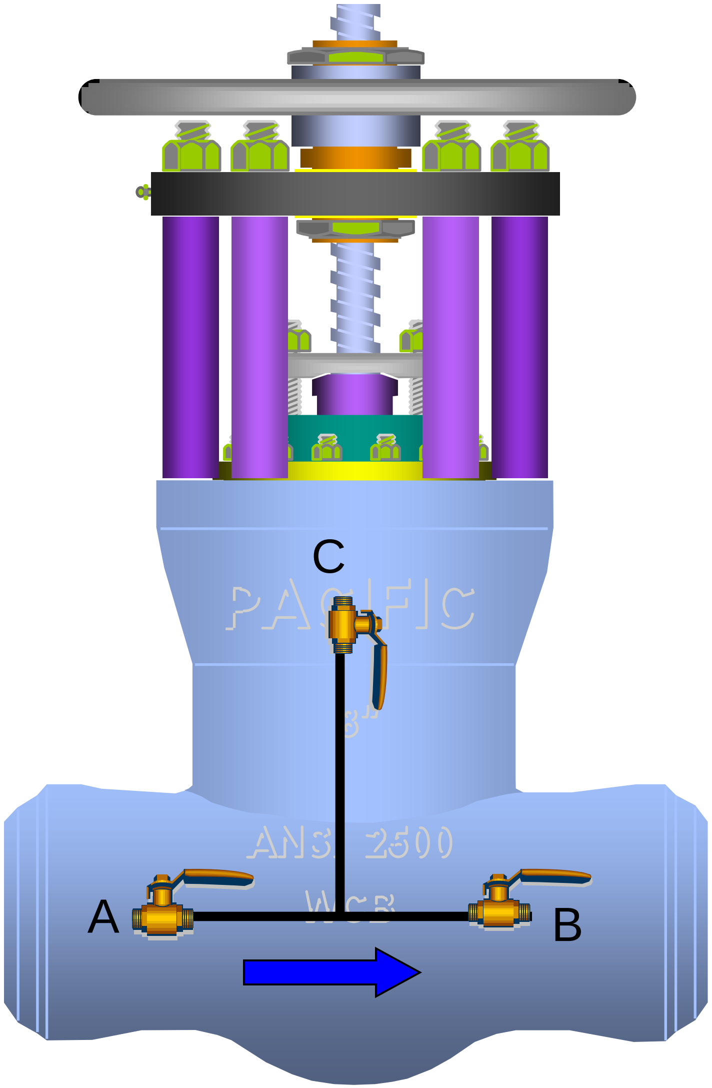
- If all **three valves** are left continuously open, the system will constantly be equalized. However the valve is not capable of shutoff in this condition.



THREE LEGGED BYPASS SOLUTIONS

- If all **three valves** are closed the valve becomes bidirectional as opposed to unidirectional, but no bonnet venting will take place.

- With the **C** valve left open, when bonnet over pressurization occurs then either the single **A** or **B** valve, or both, can be opened to relieve pressure in the bonnet. It is recommended that only the **A** or **B** valve aligned with the HIGH PRESSURE SIDE be opened in this circumstance.



Conclusion

- The valve manufacturer needs to be consulted to evaluate the situation of Pressure Locking or Thermal Binding based on the knowledge of the product and design conditions. Their trained service departments and engineering staffs can possibly prevent damage to the valve or harm to the valve operator.