VELAN	Technical Memo No. 319

Over-Pressurization, Pressure Locking, Thermal Binding in Wedge Gate and Parallel Slide Gate Valves

The failure of gate valves, wedge and parallel slide, to open under critical process conditions can be attributed to a large increase in unwedging thrust due to the following phenomenon:

(1) Over-pressurization
(2) Pressure-locking
(3) Thermal-binding

1. Over-Pressurization is usually caused when liquid trapped between the seats in the valve cavity (valve closed) of a double-seated valve is subsequently heated. The trapped fluid expands, due to increase in temperature. The resultant increase of pressure can cause a **breach of the pressure boundary**. Figure 1 illustrates a typical situation.

1.1) For each 1°F rise of temperature, a pressure increase of 150 psi can occur.

1.2) Over-pressurization can occur in both pressure-seal and bolted-bonnet type valves. Although in bolted-bonnet valves the gasket may leak and release the pressure, very rapid temperature transients could conceivably cause pressure boundary failure. Small leakage does not always relieve the pressure.

1.3) This phenomenon is not restricted by size. Usually, equalization provisions are requested on sizes NPS 6 and above. On some occasions a request has been made on NPS 4.

1.4) Note that a length of pipe isolated at both ends by a valve may also suffer from over-pressurization.

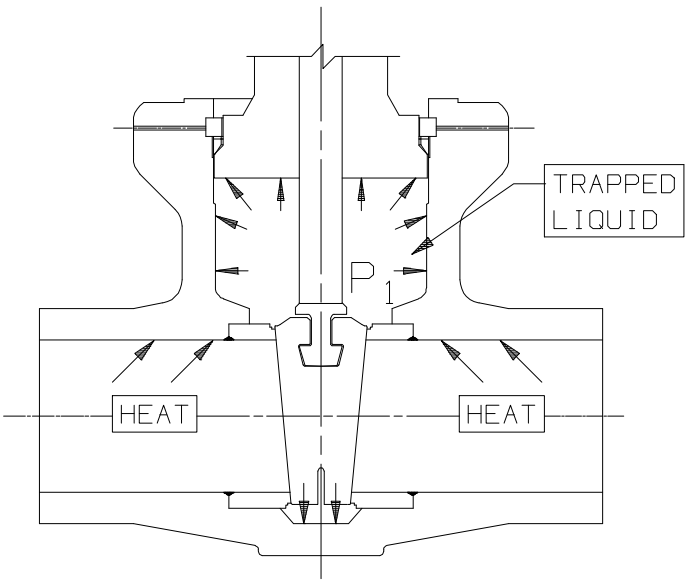

FIGURE 1: OVER-PRESSURIZATION

P_1: PRESSURE OF TRAPPED LIQUID BETWEEN SEATS

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2. Pressure Locking occurs when the pressure in the body cavity (valve closed) increases, or when the line pressure decreases without decrease in the body cavity pressure. This can cause **inoperability** of the valve closure member. Figure 2 illustrates a typical situation.

2.1) The effect of Pressure-locking is much greater in parallel-slide valves than wedge gate valves because of the effective area that the trapped pressure is exposed to. This is also known as double disc drag.

2.2) Items 1.1 to 1.3 apply to pressure-locking as well.

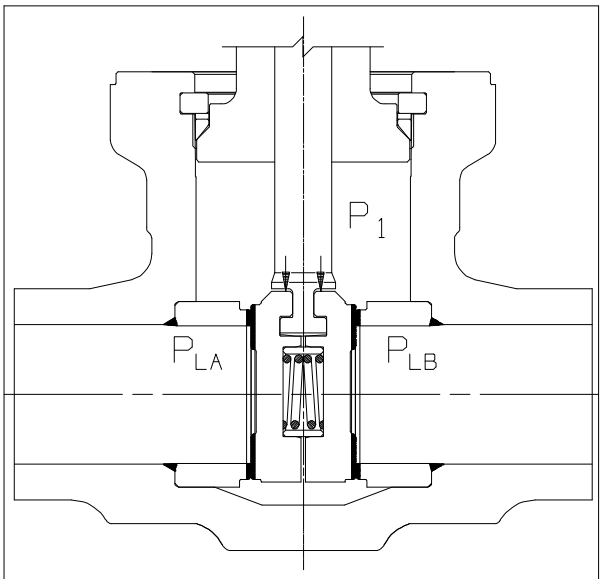

FIGURE 2: PRESSURE LOCKING
P_1: PRESSURE OF TRAPPED FLUID BETWEEN SEATS
P_{LA}/P_{LB}: LINE PRESSURE

3. Thermal Binding: In wedge type gate valves, (whether solid or flexible wedge) thermal binding is caused by dimensional interference between wedge and seat, due to temperature differences and/or thermal - expansion - coefficient differences. This can cause **inoperability** of the valve closure member. Figure 3 illustrates a typical case.

In addition, stem expansion and piping stresses (mechanical & thermal) can conceivably contribute to thermal binding as valve bodies are not fully rigid.

Therefore:

3.1) Wedge gate valves are subject to thermal binding and the severity of the binding depends upon the specific magnitude of change in the operating conditions.

3.2) Parallel slide gate valves are not subject to thermal binding.

3.3) Thermal binding is more common at high temperature operation.

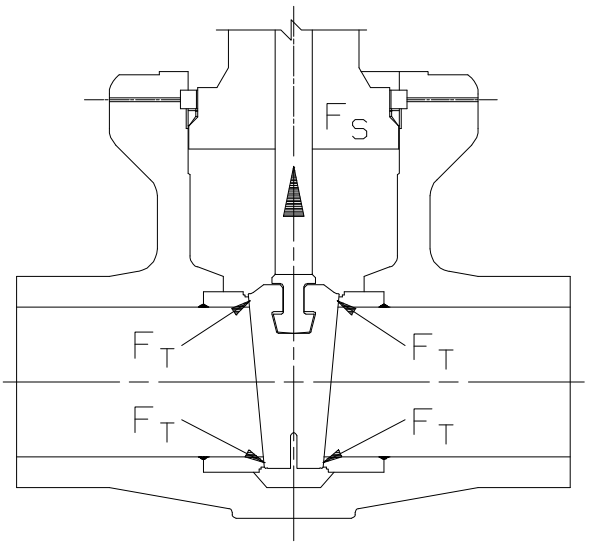

FIGURE 3: THERMAL BINDING
F_S: THRUST REQUIRED TO LIFT WEDGE
F_T: THERMAL BINDING LOAD

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4. Solutions for Over-Pressurization & Pressure-locking:
After evaluating and determining that the potential for a problem exists, the solution for over-pressurization and pressure locking is to provide pressure relief to the body cavity. This can be done in the following ways.

4.1) An internal hole in one of the wedge faces (Fig 4A), connecting the body cavity to the high pressure side of the valve. The valve will only seal in one direction.

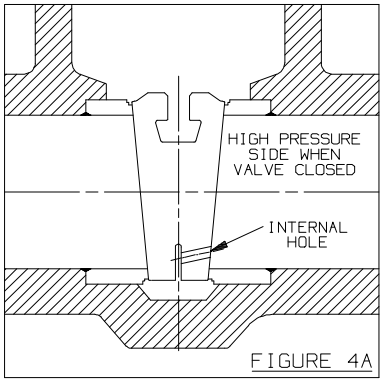

FIGURE 4A

4.2) An equalizing-pipe, connecting the body cavity to one side of the valve (Fig 4B). The valve will only seal in one direction, i.e. high pressure must be on the side of the equalizing-pipe when valve closed.

4.3) Adding an equalizing-pipe and equalizing-valve (Fig 4C). The valve can seal from both sides, when the equalizing-valve is closed. Note however body cavity pressure relief, is not available when the equalizing-valve is closed.

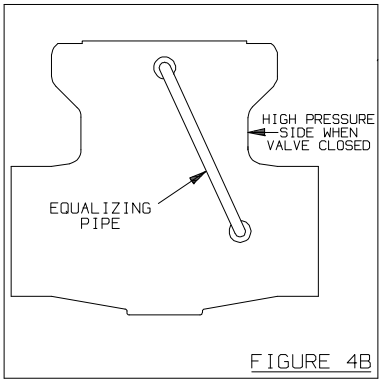

FIGURE 4B

4.4) Relief valve (Fig 4D & 4E), connecting the body cavity to the atmosphere, is another way to provide pressure relief. However the exhaust from the self-activating type relief-valve must be piped to a safe location. Caution must be used when opening the drain type relief-valve.

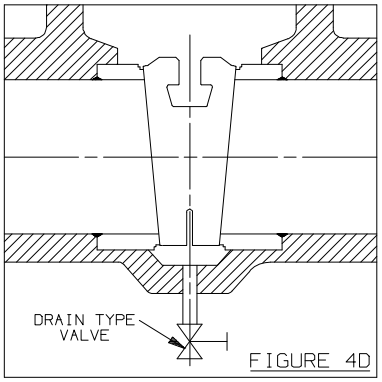

FIGURE 4D

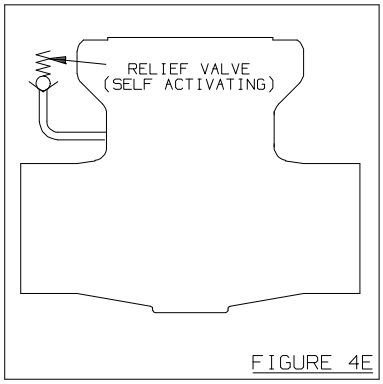

FIGURE 4E

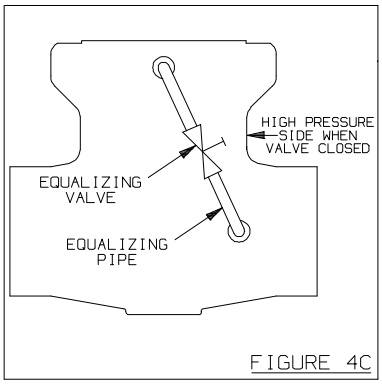

FIGURE 4C

4.5) Note that equalization and drain valves should be motorized for safer and efficient control.

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5. Solutions for Thermal-binding: After evaluating and determining that the potential for a problem exists, the following are solutions, which will reduce or eliminate thermal binding effect.

5.1) A bypass-pipe & bypass-valve (Fig 5) will allow warm up of both sides of the wedge. Note that warm-up lines located far away from the valve do not have a significant impact on thermal equalization.

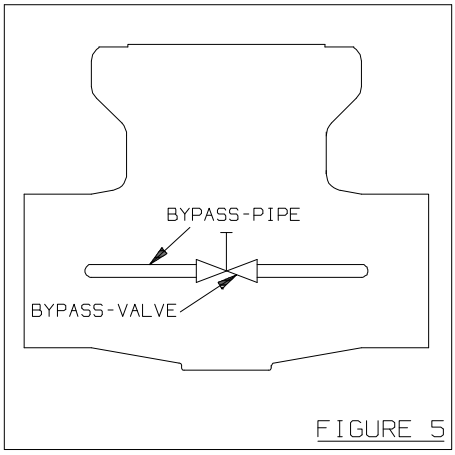

FIGURE 5

5.2) Verify the process to see if ΔT between closing and opening can be reduced.

5.3) Contact Velan Engineering Department for specific design solutions.

5.4) After closing wedge type gate valve, back up the stem (50% of backlash) to allow room for stem expansion. This is only practical in manual valves or electronically controlled motor operated valves.

5.5) Adequate pipe supports can reduce piping stresses.

5.6) Evaluate the use of parallel slide gate valves, which are not subject to thermal binding. However, it is important to consider that they are more susceptible to pressure locking, higher seat wear, as well as difficulties in positive sealing at low pressures.

5.7) Stroke the valves a few times, immediately after closure, if practical, to allow for wedge to warm up, or close valve slowly to allow for the same.

5.8) Under exceptional circumstances opt for position seating instead of torque seating on closure. Must discuss with Velan Engineering Department for warranty considerations.

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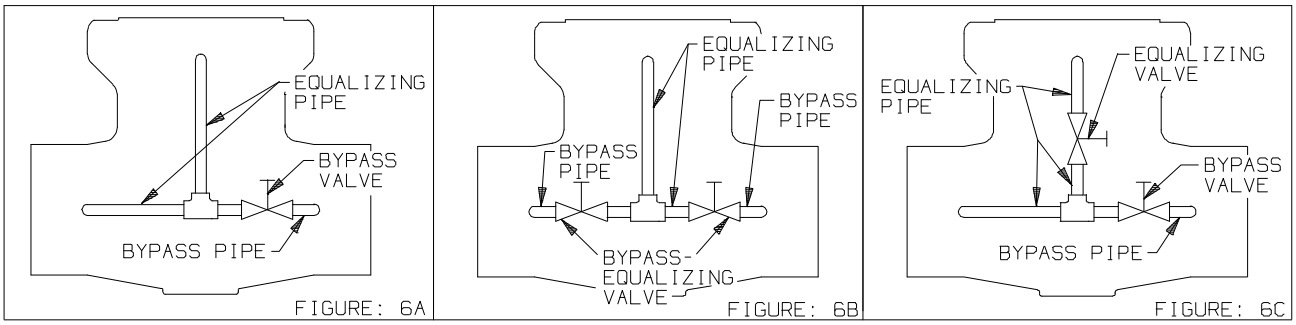
6. Solutions for Combined Effects: When evaluation determines that thermal binding may exist in combination with over-pressurization and/or pressure locking, the solution will require combination of both equalizing and bypass pipe/valve. Figures 6A to 6C show some common combinations, others are also available. The particular choice will depend on actual process, as well as requirements for bi-directionality.



7. Responsibility: The decision on bypass and equalization pipe/valve requirements is based on design process and valve application (as well as experience), the details of which are known to piping/process engineers or end users. This is clearly reflected in ASME B16.34 paragraph 2.3.3 (also ASME B31.1) i.e. it requires that the user determine if the valve requires overpressure protection. The valve manufacturer will help in evaluating situations based on his knowledge of his product. Please feel free to contact Velan Engineering, to resolve specific application questions.

8. References:

(8.1) Velan Technical Memo No. 313 by J.M. Farrell, [1993]
(8.2) J.M. Farrell NUREG/CP-0146, [1994]
(8.3) EPRI NP-6516 [1990]
(8.4) Velan Application Notes No. APS-DB1 by Don Bowers [1994]
(8.5) Paper by Mirek Hubacek, from Valve World Conference [2000]
(8.6) US NRC Generic Letter 95-07 [August 17, 1995]
(8.7) US-NRC NUREG-1275 Vol. 9 [March 1993]