check valve SIZING & SELECTION

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EVEN WITH SUCH VARIETY, THE ULTIMATE DECISION MAY NEED TO BE A COLLABORATIVE COMPROMISE.

For a plant engineer or system engineer, the best check valve is the forgotten one. If a check valve is sized and selected correctly, it should perform flawlessly during its design life and not draw the attention of maintenance, component, system, or plant engineers.

Unfortunately, this is a difficult goal to reach, since numerous system and check valve characteristics must be considered and understood. Improper sizing or selection of check valves leads to decreased system efficiency and increased maintenance, which results in facilities losing both production time and money.

Like most other valve types, proper check valve selection typically involves some compromise. System engineers and valve suppliers can work together to choose the right check valve type and size for their application. This collaboration helps facilities achieve optimal system efficiency and decreases maintenance costs due to check valve wear or failure.

CHECK VALVES: AN OVERVIEW

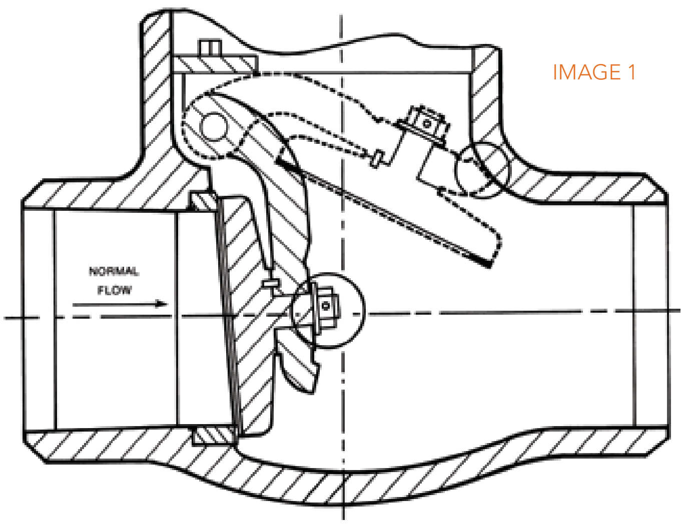
The main function of check valves is to close upon forward-flow stoppage and prevent or minimize the development of reverse flow. This function helps to protect pumps and systems from damage caused by reverse flow. Check valves are also used to isolate areas of plants, such as nuclear power plants, from over-pressurizing or being contaminated.

Several types of check valve designs, each having distinct characteristics, follow.

Swing check valves. Swing check valves are the most common and best check valve for general-purpose use (Image 1). Of all check valve designs, these valves produce the lowest pressure drop, when compared with other check valves of the same size. They feature a simple design that is easy to maintain.

The swing check valve functions by allowing flow forces to move the disc from the closed position to the fully open position in a sweeping arc motion against the hinge-stop inside of the valve body. Due to the weight and center-of-gravity location of the disc and swing-arm assembly, the valve will return to the closed position should flow become interrupted or reversed. External counterweights mounted on the hinge pin are sometimes used to increase or decrease the reaction time and speed of the disc returning to the closed position. Seating surfaces are typically flat, which means the radial disc positioning

IMAGE 1



CROSS-SECTIONAL VIEW OF A TYPICAL SWING CHECK VALVE.

IMAGE 2

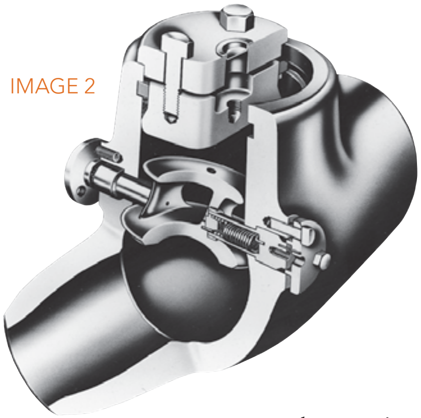
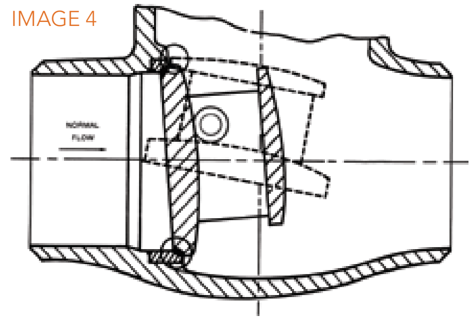


IMAGE 3

IMAGE 4



IMAGES 2 & 3: TYPICAL TILTING DISC CHECK VALVES.

IMAGE 4: CROSS-SECTIONAL VIEW OF TYPICAL TILTING DISC CHECK VALVE.

onto the seat is not critical, except that it must be flat onto the seat. The disc/hinge assembly design differs among manufacturers and application industries, with some designs using separate hinges and discs and others having a single piece.

Swing check valve discs are not stable unless they are in systems with steady flow and are in the fully open position. As the disc/hinge assembly center of rotation is a fair distance from its pivot point, it will take a relatively long period of time for swing check valves to close upon flow stoppage or reversal. During this time, reverse-flow forces may experience a large increase in energy from flow and pressure buildup. This situation can cause high-energy water hammer when the disc slams onto the seat.

Tilting disc check valves. Tilting disc check valves produce slightly more pressure drop than swing check valves of the same size (Images 2, 3, and 4). These check valves have a single-piece disc without a hinge. In response to flow forces, the disc pivots about hinge pins that are located within the geometry of the disc and slightly above the center-line of the valve body. Due to the disc rotating onto the seat, the sealing surfaces must be conical. Most designs of tilting disc check valves include a counterweight on the disc, dramatically increasing the disc stability with lower flow rates.

Tilting disc check valves were designed specifically to minimize the potential for high-energy water hammer. This objective is accomplished by locating the disc center of rotation a short distance from its pivot point, thus allowing the disc to quickly close with flow stoppage or flow reversal. Although it is best to size this valve to be fully open, the disc is reasonably stable under some less than full-open flow conditions.

IMAGE 5

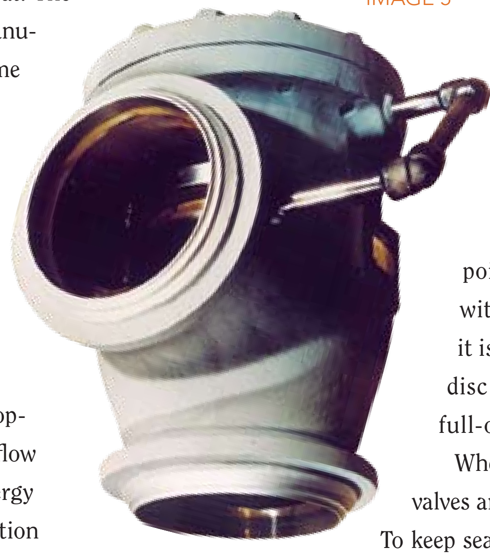


IMAGE 5: TYPICAL ANGLE LIFT CHECK VALVE WITH AN EXTERNAL EQUALIZER PIPE.

When it comes to maintenance, tilting disc check valves are more challenging than swing check valves. To keep seat leakage to a minimum, the conical seating surfaces of the disc and in-body seat must mate well, and the disc pivot location must be precise.

Lift (piston) check valves. Lift check valves are also called piston checks by some manufacturers (Images 5 and 6). They are essentially globe valves without the stem and top works, allowing the disc to respond to flow rates and direction. The disc has linear movement and is typically body-guided with conical seating surfaces. Springs can be added above the disc to provide more closure force when the disc returns to its closed position. Some manufacturers include externally attached equalizer piping to increase the disc opening with lower flows. The equalizer pipe is an open-pressure communication device that maintains equal pressure above the disc and in the piping downstream of the disc.

Depending on the valve body configuration (Y-pattern, angle, or T-pattern), the pressure drop could be close to that of a tilting disc check valve or much higher. The disc of this check valve design is stable in any open position and can be used with a wide range

IMAGE 6

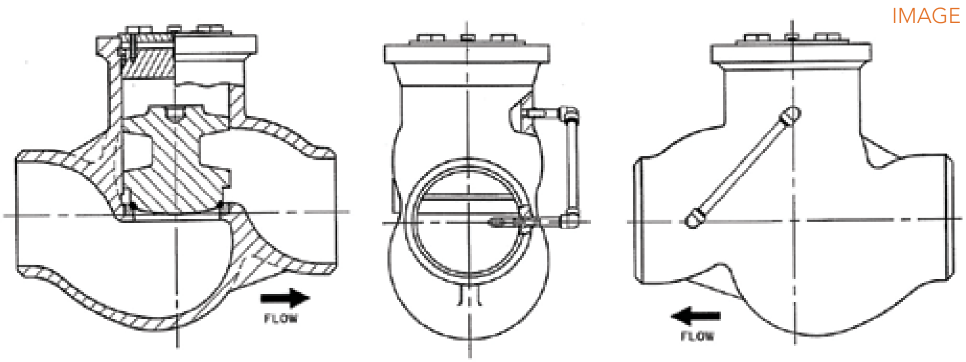


IMAGE 6: CROSS-SECTIONAL VIEW OF A TYPICAL LIFT CHECK VALVE.

of flow rates. Seating surface maintenance is a challenge as it is conical.

Stop-check valves. Stop-check valves are essentially globe valves with a stem that is not attached to the disc (Image 7). With the stem in the fully open position, the valve functions as a lift check valve. With the stem in the closed position, the valve functions as a stop valve to isolate flow in either direction.

IMAGE 7

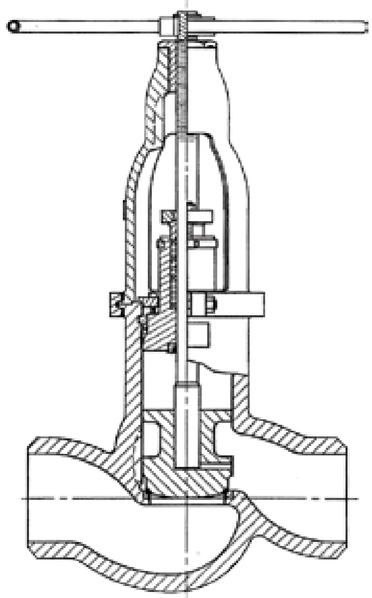


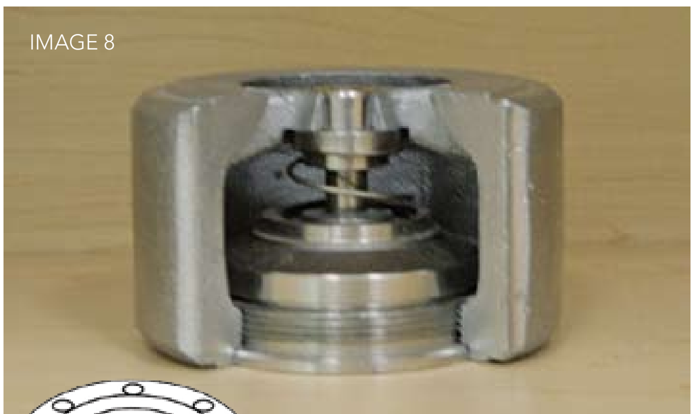
IMAGE 7: CROSS-SECTIONAL VIEW OF A TYPICAL STOP CHECK VALVE.

IMAGE 8: CUTAWAY OF A WAFER STYLE IN-LINE CHECK VALVE.

IMAGE 9: CROSS-SECTIONAL VIEW OF TYPICAL IN-LINE CHECK VALVES.

IMAGE 10: TYPICAL DUAL PLATE CHECK VALVE.

IMAGE 8



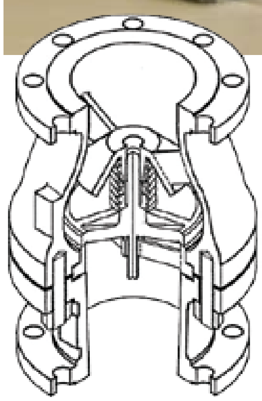


IMAGE 9

All remaining valve characteristics are the same as those of the lift check valve, plus the inclusion of the stem and top works of a globe valve.

In-line check valve. In-line check valves prevent reverse flow with disc movement that is parallel with the flow (Images 8 and 9). With this design, the disc is always in the flow path. The actual designs of these valves vary greatly between design models and manufacturers. Some have flat seats, and others use conical and multiple seats. Most discs are spring-loaded to assist in seating. These check valves are bonnetless and are often installed between flanges (wafer style). The in-line check valve disc has very short disc travel and responds very quickly to flow stoppage or reversal, thus minimizing the potential for water hammer. It is somewhat better than the tilting disc check valve at minimizing potential water hammer, but with a higher pressure drop.

Depending on the design, maintenance effort ranges from relatively simple to extremely difficult. All in-line check valves must be removed from the line to perform maintenance due to the bonnetless design. The in-line check valve produces the most pressure drop when compared to other check valves of the same size.

Dual-plate check valve. Dual-plate check valves are similar to in-line check valves in that they are bonnetless and mounted between pipe flanges (wafer style, Image 10). In this case, the valve includes two spring loaded half-moon shaped discs that rotate about their shaft. The actual designs of these valves vary between design models and manufacturers. Most have multiple flat seats. The dual-plate check valve disc has short rotational disc travel and responds quickly to flow stoppage or reversal, thus the potential for moderate water hammer does exist. It is somewhat better than the swing check valve at minimizing potential water hammer, but with a much higher pressure drop.

Depending on the design, maintenance effort ranges from relatively simple to difficult. All dual-plate check valves must be removed from the line to perform maintenance due to the bonnetless design. The dual-plate check valve also results in a higher pressure drop when compared to a tilting disc check valve of the same size.

PROPER SIZING OF CHECK VALVES

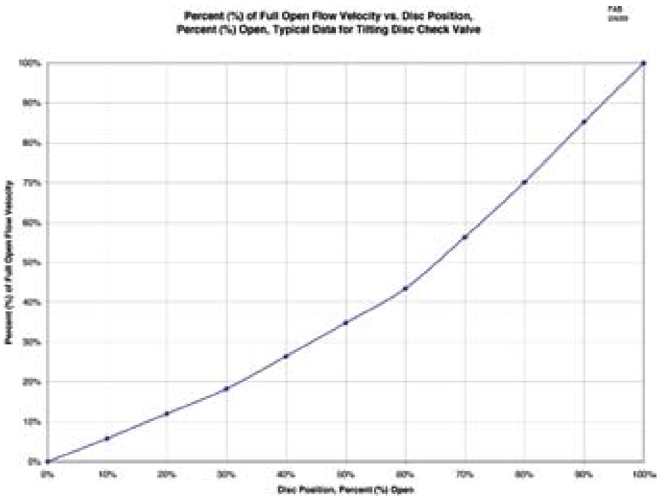
It is very important to optimally size check valves in order to maximize the piping system efficiencies, and minimize or eliminate check valve maintenance. If check valves are sized too small, they produce excessive pressure drop, reduce flow and/or require increased pump energy to allow the piping system to meet its performance requirements.

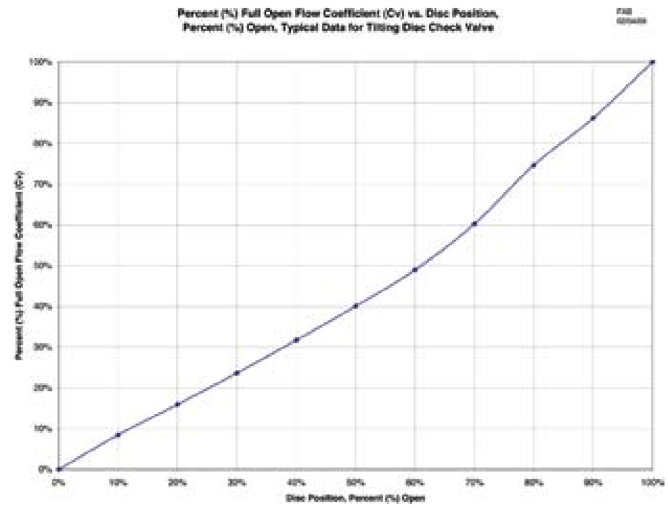
If check valves are sized too large, the disc will not be fully open and, dependent on the check valve type, the disc might be unstable. Disc instability causes valve wear, requiring increased maintenance or even failure of the check valve.

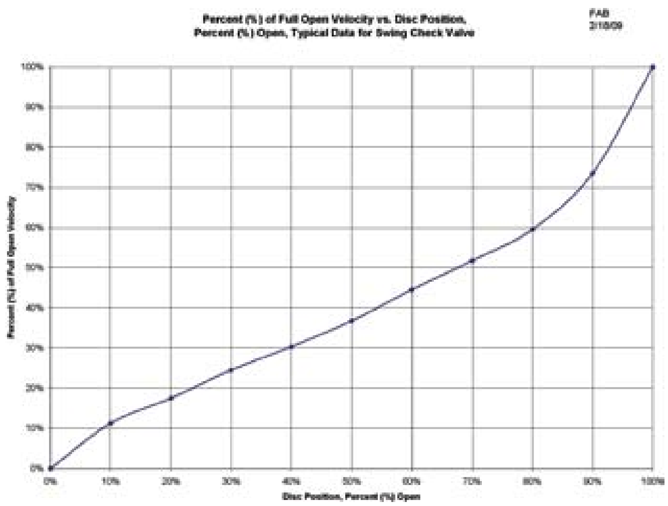
Optimum check valve sizing requires knowledge of all piping system flow conditions (fluid, temperature, pressure, flow rate) and check valve requirements (prevent reverse flow, specified leakage rate at specified pressure, etc.). Sizing the check valve based on the pipe size or the maximum flow conditions is not adequate; all flow conditions must be considered.

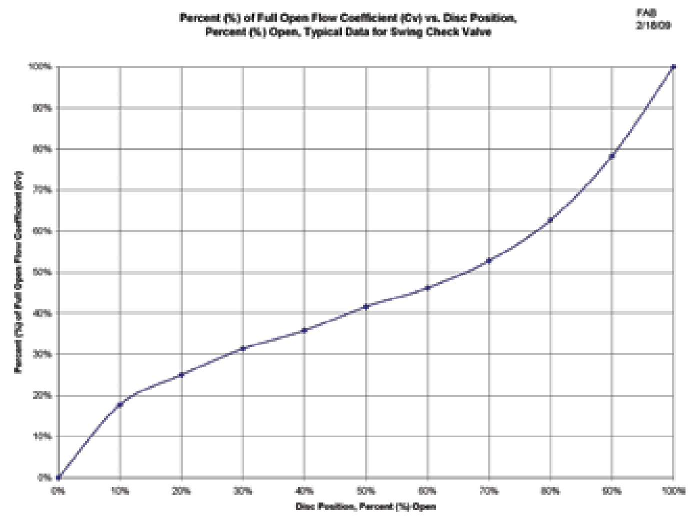
IMAGE 10

The flow coefficient (Cv) listed in supplier catalogs is the check valve flow coefficient with the valve fully open. If the check valve is not fully open, the flow coefficient will be less than that listed in the catalog, and the piping system will have more pressure drop attrib-









uted to the check valve than the catalog value would indicate. The valve supplier should be consulted for assistance to determine the check valve disc position and flow coefficient.

Most reputable check valve suppliers have performed flow tests on their check valve designs to determine the performance characteristics [flow vs. disc position, disc position vs. flow resistance or flow coefficient (K or Cv), disc stability, etc.] (Charts 1 through 4). Based on this performance data and the check valve system conditions, the best check valve size can be determined. The final check valve size selected could be a straight through size or a valve with a reduced seat size to increase the flow velocity at the seat and have the disc fully open.

CHECK VALVE SELECTION

Similar to determining the size of the check valve, selecting the type of check valve requires the knowledge of check valve performance characteristics and all piping system requirements. Each type of check valve has its own set of performance characteristics, which must be matched with the piping system requirements to determine the proper check valve type.

Unfortunately, most check valve applications have multiple requirements, which might not all match with a single type of check valve. Often, the final type of check valve selected is a compromise, driven by the most prevalent requirements.

Proper check valve selection and sizing requires complete knowledge of the piping system conditions and specifications, and the performance characteristics of each type of check valve. The system engineer and supplier must work together to optimize these items to ensure the check valve and the system are a proper match. Without this collaboration, either the system will not perform at optimal efficiency or the check valve will require increased maintenance. TB

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