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THE MISUNDERSTOOD CHECK VALVE

TOO OFTEN THIS VALVE IS UNJUSTLY BLAMED WHEN PROBLEMS OCCUR, BUT THE REAL CULPRIT IS THE APPLICATION.

BY MIKE JOHNSON

Check valves are probably the most misunderstood valves ever invented. If you mention check valves to most plant personnel, the typical response is "they don't work." In fact, those personnel may well have taken out the internals or repiped the system to avoid check valves. In other words, these valves are the least popular valve in use today.

This article will explore the basics of check valves, how they work, what types there are, how to select and install them, how to solve their problems, and, finally, why they are not always the cause of the problem.

Simply put, a check valve allows flow in one direction and automatically prevents back flow (reverse flow) when fluid in the line reverses direction. They are one of the few self-automated valves that do not require assistance to open and close. While some can be fitted with externally weighted and dampened devices for special circumstances, the majority do not have any outside assistance, such as that found with on/off or other valves. Unlike other valves, they continue to work even if the plant facility loses air, electricity, or the human being that might manually cycle them.

As with other types of valves, check valves are found in a full range of sizes, materials, and end connections. The line sizes range from 1/8 inch or smaller to 50 inches and larger. They are made of bronze, cast iron, plastics, carbon steel, and various grades of stainless steel, alloys such as Hastelloy, Inconel, Monel, and titanium. End connections include threaded, socket weld, butt weld, flanged, Victaulic, wafer, and insert type.

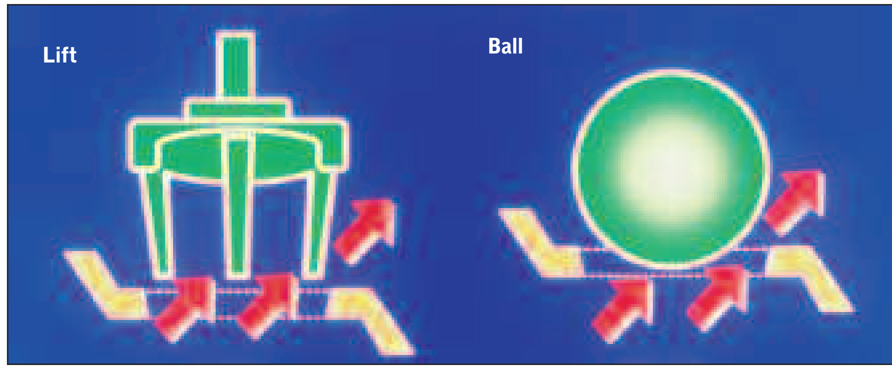
Check valves are found everywhere, including the home. If you have a sump pump in the basement, a check valve is probably in the discharge line of the pump. Outside the home they are found in industries such as automotive, desalination, aviation, commercial construction, water and waste, chemical, colleges and universities, food and beverage, geothermal, hospitals, mining, oil and gas, pharmaceutical, power, pulp and paper, refining, sanitary, marine, steel, tire, and ultrapure water.

Like other valves, check valves are used with a variety of media: liquids, air, other gases, steam, condensate, and in some cases, liquids with fines or slurries. Applications include pump and compressor discharge, header lines, vacuum breakers, steam lines, condensate lines, chemical feed pumps, cooling towers, loading racks, nitrogen purge lines, boilers, HVAC systems, utilities, pressure pumps, sump pumps, wash-down stations, and injection lines.

How They Operate

Check valves are flow sensitive and rely on the line fluid to open and close. The internal disc allows flow to pass forward, which opens the valve. The disc begins closing the valve as forward flow decreases or is reversed, depending on the design. The function or purpose of a check valve is to prevent reverse flow. Construction is normally simple with only a few components such as the body, seat, disc, and cover. Depending on design, there may be other items such as a stem, hinge pin, disc arm, spring, ball, elastomers, and bearings.

Internal sealing of the check valve disc and seat relies on "reverse" line pressure as opposed to the mechanical force used for on/off valves. Because of this, allowable seat leakage rates are greater for check valves than with on/off valves. MSS SP-61 "Pressure Testing of Steel Valves," published by the Manufacturers Standardization Society, is one standard used by manufacturers to perform seat and shell closure tests for check valves (as well as other valves). Factors affecting check valve seat leakage include reverse pressure, medium, and what the seat material is made of, such as metal or elastomer. Metal sealing surfaces generally will allow some leakage while elastomers such as Buna-N and Viton provide bubble-tight shutoff (zero leakage). Because of this, elastomers should be considered for air/gas media and low-pressure sealing. Important considerations when using elastomers for such valves are service temperature and compatibility of the elastomer with the medium.



The ball check valve is similar to the lift check, but uses a ball instead of a guided disc.

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So what is the ideal check valve? Regardless of type or style of valve, the longest trouble-free service will come from valves sized for the application, not the line size, whereby the disc is stable against the internal stop in the open position or fully closed. When these conditions are met, no fluttering of the disc will occur, resulting in premature failure. Unfortunately, most check valves are selected in the same way on/off valves are selected—based on line size and the desire for the largest Cv available. This ignores the fact that, unlike on/off valves, the flow conditions determine the internal performance of the check valve since its disc is always in the flow stream.

As mentioned earlier, unlike on/off valves, check valve internals are flow sensitive. If there is not enough flow, disc movement occurs inside the valve, since the disc is always in the flow path. This results in wear, potential for failure, and a higher pressure drop than calculated.

Whenever a metal part rubs against another metal part, wear is a result, which leads to eventual failure of the component. A component failure can result in the valve not performing its function, which in the case of a check valve, is to prevent reverse flow. In extreme cases, failure could result in the component or components escaping into the line, causing failure or nonperformance of other valves or equipment in the line.

Typically, pressure drop is calculated based on the check valve being 100% open as with on/off valves. However, if the flow is not sufficient to achieve full opening, but instead, the check valve is only partially open, the pressure drop will be greater than calculated since the flow passage is restricted by the disc being in the flow path. In this situation, a large rated Cv actually becomes detrimental to the check valve (unlike with on/off valves), resulting in fluttering of the disc and eventual failure. Such is not the case with some other valves. With a gate valve, for example, if the valve is fully open, the wedge is out of the flow path and the flow through the valve does not affect the performance of the wedge whether that flow is low, medium, or high.

Various types of check valves are available. Some of the more popular types are included below. All these can be used for clean media. As with other types of valves, specialty check valves can be found for special applications. While no one type of valve is good for all applications, each has its advantages. Taking time to contact the manufacturer to assist in selection can help you find the best fit, especially if you are incurring problems with whatever type of check valve is presently installed.

Ball Checks

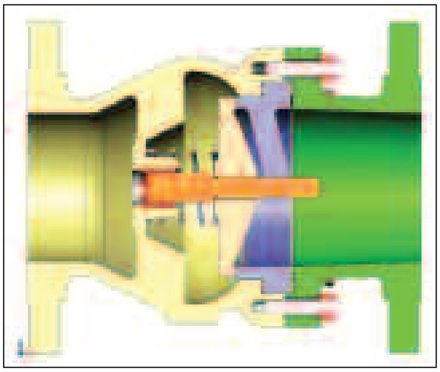
Ball check valves use a "ball" inside the body to control the movement of flow. The ball is free to rotate, resulting in even wear and a wiping action between the ball and seat. This feature makes ball checks useful for viscous media. Ball checks are typically found in smaller sizes of 2 inches and less. Some designs include a spring to assist in closing and for use in 90-degree styles installed in vertical lines. Depending on the body design, pressure drops with ball types can be higher than with other types of check valves. Ball checks are available in various end connections including threaded and socket weld. Some body designs permit in-line repair/inspection.

Dual Plate

Dual plate, or double-door, check valves consist of two plates hinged in the center and spring loaded to assist in closing. They can be used for most media and possess good flow capacity. Sizes range from 2 inches to 60 inches and larger. Because of their design, dual plate check valves are lightweight and have compact face-to-face dimensions. As with butterfly valves, the compact design of dual plate types can require less support and shrink the needed size for a mechanical room. Dual plate valves are available in various body styles that include wafer, lug, and flanged; some meet the popular API 594 face-to-face dimensions. Dual plate valves require removal from the line to perform inspection or repair.

Spring Assisted In-Line/ Nozzle Check

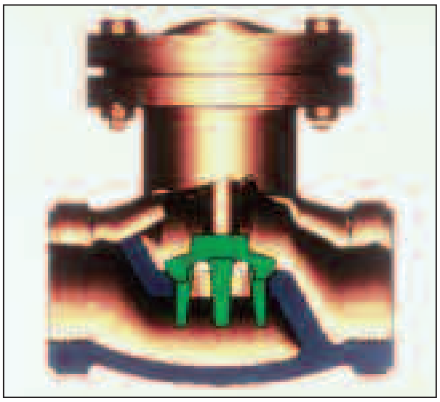
In-line check valves are also known as nozzle checks or silent check valves. They are designed to prevent water hammer as well as reverse flow. The design uses a spring-assisted disc in line with the flow and has a short travel distance, resulting in a fast closing valve. As forward velocity begins to slow, the spring assist starts to close the disc. By the time the forward velocity reaches zero, the valve disc is closed against the seat before reverse flow can occur, preventing pressure surges in the line and thus preventing water hammer. Most in-line designs can be installed in any position, including flow down if the proper spring is installed. As with other check valves, spring-assisted valves can be used for most media. Line sizes range from 1/4 inch and smaller to 30 inches and larger. They are available in various styles including globe, wafer, insert, and threaded/socket weld. Some designs meet API 594 and ANSI B16.10 face-to-face dimensions. End connections include threaded, socket weld, flanged, wafer, and butt weld. In-line check valves have to be removed from the line to perform internal inspections or repair.



Shown here is an example of an in-line check valve. This valve is also known as a nozzle check or silent check valve.

Piston Check

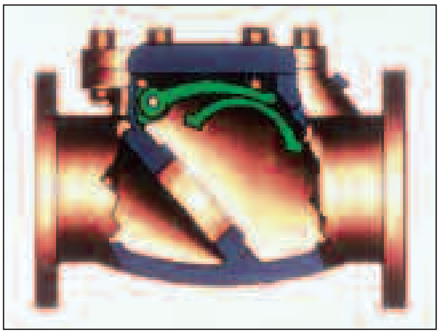
Piston, or lift, check valves are available as inclined (Y pattern) or conventional (90 degree) body designs. In either case, a body-guided disc moves within the body bore. The body guide ensures alignment of the seat and disc when the valve closes. Piston check valves are available from 1/4 inch to 24 inches and larger. Smaller valves, 1/4 inch to 2 inches, are normally provided with a spring to assist in closing and to ensure the disc slides back to the seat when installed in vertical lines. The body design selected will determine the pressure drop; inclined designs will provide the best flow performance. Piston check valves are available with threaded or socket weld ends for 2 inches and smaller. Larger valves are available with flanged or butt weld ends. Special end connections are available, but you should consult the valve manufacturer. Piston check valves can normally be inspected and repaired in line. Exercise caution when these valves are used for dirty media because that media could cause the disc to stick inside the body bore.



A lift check valve has a guided disc that is raised from the seat by upward flow pressure.

Swing Check

Swing checks are a simple design using a disc attached to an arm that is hinged at the top of the valve (at the 12 o'clock position). Reverse flow and gravity assist the valve in closing. Swing checks can be used for most media and generally provide good flow capacity. They range in size from 1/2 inch and smaller to 50 inches and larger, and are available with threaded, socket weld, flanged, or butt weld end connections. Swing checks are typically easy to inspect and maintain. In most cases, repairs can be performed with the valve in the line. Because of their design, swing checks are not fast-closing valves due to the travel distance from full open to close. Most swing check valves meet ANSI B16.10 face-to-face dimensions, and will permit pigging of the line.



There are many different check valve designs, with the oldest and most common being the swing check.

Selection

Among the many factors to consider when selecting a check valve are material compatibility with the medium; valve rating (ANSI); line size; application data—flow, design/operating conditions; installation—horizontal, vertical flow up or down; end connection; envelope dimensions, especially if replacing an existing valve to avoid pipe modifications; leakage requirements; and special requirements such as oxygen cleaning, NACE, CE Mark, etc.

Problem Solving

When replacing a check valve it helps to ask the following simple questions:

- "Why am I replacing this valve?"
- "What was the problem?

Sometimes we get so busy or absorbed in other things, we forget the cause can help with the solution. Common check valve problems include noise (water hammer), vibration, reverse flow, sticking, leakage, missing internals, component wear, or damage. However, it is worth mentioning that normally the real cause is the wrong style check valve for the application. In such cases, the problem is the ***application***, ***not*** the check valve.

Two of the most common problems with check valves are reverse flow and water hammer. In both situations, a fast-closing valve is desired. Reverse flow can be costly, especially if it occurs at the discharge of a pump and the pump spins backwards. The cost to repair or replace the pump, plus the plant downtime far exceeds the cost of installing the right check valve in the first place. With water hammer, you need a faster-closing check valve to prevent pressure surges and resulting shock waves that occur when the disc slams into the seat, sending noise, vibration, and hammering sounds that can rupture pipelines and damage equipment and pipe supports.

If the internals are missing or exhibiting wear, two factors may be occurring. First, if the check valve selected does not have enough flow passing through to keep it against its stop, a valve with a lower Cv is needed to prevent the moving/fluttering of the internals. Second, if the check valve is used at the discharge of a reciprocating air or gas compressor, a valve with a damped design or dashpot to handle high-frequency cycling is needed.

Sticking can occur when scale or dirt is trapped between the disc and body bore. Leakage can happen from damage to the seat or disc or simple trash in the line. An elastomer is needed to provide zero leakage.

Installation

When installing check valves, point the "flow arrow" in the direction of the flow to allow the valve to perform its function. The flow arrow can be found on the body or tag. Make sure the valve type will work in the installed position. For example, not all check valves will work in a vertical line with flow down, nor will conventional or 90-degree piston check valves perform in a vertical line without a spring to push the disc back into the flow path. The disc in some check valves extends into the pipeline when the valves are fully open. This could interfere with the performance of another valve bolted directly to the check valve. If possible, install the check valve a minimum of five pipe diameters downstream of any fitting that could cause turbulence. Notice, I said "if possible." After all, how many check valves have you seen bolted to the discharge of a pump? Many! A good source of reference for installing check and other styles of valves is MSS SP-92 "Valve Users Guide," published by the Manufacturers Standardization Society.

How Are Check Valves Like Doors?

Lastly, I like to compare check valves to doors—whether that door is to your office or home. Typically, you open your office door at the start of the day and close it at the end, which is similar to what happens when a pump is cycled on and off. However, if someone stands at your door and constantly cycles it open and closed, what could happen? In most cases, the hinge pins would fail, since they are the weak link in the operation of your door.

Check valves face a similar situation. Pins, stems, springs, or other components that are constantly cycled can fail. That is why it is important to properly select check valves for their possible applications. A check valve with a high Cv in a low flow application is doomed from the start. It is not the check valve's fault; it is the fault of the wrong selection for the application. The selected valve would have worked fine in proper flow conditions. Unfortunately, the installed check valve is blamed for the failure, when in reality the culprit was the application. It is always best to review the application and service conditions with the manufacturer before purchasing a check valve to make sure the correct style is selected. **VM**

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