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The Misunderstood Check Valve

Too often this valve is unjustly blamed when problems occur, but the real culprit is its use in the wrong applications.

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Check valves may be 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 utilizing check valves. In other words, these valves may be 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 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 as found with on/off control or other valves. Unlike other valves, they continue to work even if the plant facility loses air, electricity or hydraulic pressure, 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, various grades of stainless steel and alloys such as Hastelloy, Inconel, Monel and titanium. End connections include threaded, socket weld, butt weld, flanged, grooved, wafer and insert type.

Check valves are found everywhere including in 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 desalination, water and waste, chemical, food and beverage, geothermal, mining, oil and gas, power, pulp and paper, refining and more.

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Like other valves, check valves are used with a variety of media: liquids, air, other gases, steam, condensate, and in some cases liquids with particulate or slurries. Applications include pump and compressor discharge, header lines, vacuum breakers, non-code pressure relief, 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 pressure and flow 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 the 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 control valves. Because of this, allowable seat leakage rates are greater for check valves than with on/off control 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, media, and what the seat material is made of (such as metal or an elastomer). Metal and PTFE seating 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 media.

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 necessarily the line size. Ideally, the disc is stable against the internal stop in the open position when flowing or fully closed when no flow or checking. When these conditions are met, no chattering of the disc will occur, thereby preventing premature valve failure. Unfortunately, most check valves are selected in the same way on/off control valves are selected, by line size and the desire for the largest Cv available. This ignores the fact that unlike on/off control valves that have actuation (manual, pneumatic, hydraulic or electronic), only the flow conditions determine the internal performance of the check valve.

Check valve internals are flow sensitive, unlike on/off control valves. If there is not enough flow and pressure to fully open the check valve, trim chatter occurs inside the valve. This results in premature wear, potential for failure and a higher pressure drop than calculated.

Whenever a metal part rubs against another metal part, wear is a result. That leads to eventual failure of the component itself. 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(s) 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 control valves. However, if the flow is not sufficient to achieve full open and the check valve is only partially open, the pressure drop will be higher than what's calculated. This is due to the effective Cv of the valve being less than maximum when the check valve is partially open. In this situation, a large rated Cv actually becomes detrimental to the check valve (unlike with on/off control valves). This results in chattering of the disc and eventual failure. Such is not the case with some other valves. For example, with a gate valve that is fully open, the wedge is out of the flow path. Therefore, 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 unique 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. This is especially true if you are having problems with whatever type of check valve is presently installed.

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 should only be installed in a horizontal flow position. This is because they will not operate properly in the vertical flow positions. They also don't tend to seal well in low backpressure applications.



Illustration of a typical swing check valve.
Photo Credit: All photos courtesy Check-All Valve.

These check valves range in size from ½ 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. This means they are highly susceptible to water hammer issues. Most swing check valves meet ANSI B16.10 face-to-face dimensions and will permit pigging of the line. There is a variation of the swing check called the tilting disc check. However, that version does not permit line pigging.

Piston/Poppet Check

Piston or poppet style check valves are available as inline, inclined (Y-pattern), or conventional (90 degree T-pattern) body designs. All types are considered a silent check valve style that prevent water hammer and reverse flow. It does this by using a spring-assisted disc in line with the flow that 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 designs can be installed in any position, including flow down if the proper spring is installed. Piston/poppet check valves are available from 1/4 inch to 24 inches and larger. The body design selected will determine the pressure drop; inline designs will provide the best flow performance. Piston/poppet check valves are available with multiple different end connections including threaded, flanged, weldable, etc. Special end connections are available, but you would need to consult with the check valve manufacturer. Some of these check valves can be inspected and repaired in line. Ideally, this style of check valve should only be used for clean media service with no particulate.



Illustration of inclined, y-pattern poppet style check valve.

Flange Insert Check

Flange insert check valves are an extremely compact, wafer-style check valve for flanged piping. They are commonly used in-line and vary from 1/2 inch to 20 inches in size. This style is also considered a type of silent check that help prevent water hammer.

Accordingly, they will have an internal spring that assists with closing of the valve. The flange insert check and its compact design allow it to be added to

an existing system with minimum piping alteration required.



Flange insert check valve with compact wafer design.

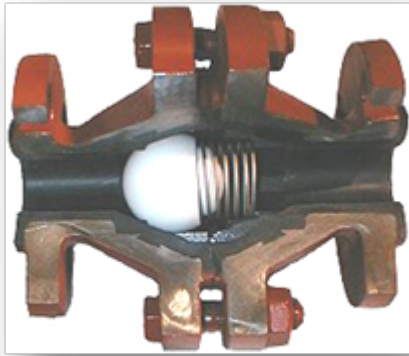
Center Guided Check

Center guided check valves are another type of silent check valve. They are also designed to prevent water hammer as well as reverse flow. This style is similar to the piston/poppet. It also falls under MSS SP125 & 126 for specifications. They are available in flanged styles with sizes from 2 to 24 inches and sometimes larger. Similarly, this style is best suited for clean media with no particulate.

Ball Checks

Ball check valves use a ball inside the body to control the movement of flow. This style is also considered a type of silent check. 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



Ball-style check valve, or silent check, is useful for viscous media applications.

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.

Selection

Among the many factors to consider when selecting a check valve are material compatibility with the medium, valve pressure rating (ANSI), line size,

application data (flow, design/operating conditions), installation (horizontal, flow up, or flow 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.

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

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/chattering, reverse flow, sticking, leakage, missing internals, component wear or damage. However, it is worth mentioning that normally the real cause is the wrong size, spring, and/or style for the check valve application. In such cases, the problem is the application, not the check valve.

Two of the most common problems with check valves are incorrect sizing or incorrect installation. Incorrect sizing comes in one of two forms. If the valve Cv is too small for the application, you would see a very high pressure drop which could lead to premature valve wear because of the high velocities involved. More commonly, if the valve Cv is too large for the application, there will not be enough pressure drop created across the check valve to fully open it. Any check valve that is not fully open has a high probability of chatter which will lead to premature valve failure. Incorrect installation involves not having the proper amount of straight pipe upstream of the check valve. Ideally a minimum of 10 pipe diameters of straight pipe upstream of the check valve is desired. This is to ensure a nice laminar flow going through the check valve. Shorter distances can cause flow turbulence and spin that can prematurely wear any style of check valve.

Examples of some other problems for check valves include 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 pipes and damage equipment and pipe supports.

If the internals are missing or exhibiting excessive 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 chatter of the internals. Second, if the check valve is used at the discharge of a reciprocating air or gas compressor, a specialty 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 intended 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 T-pattern 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. As we discussed earlier if possible, install the check valve a minimum of 10 pipe diameters downstream of any fitting or other piping system component that could cause turbulence. Notice, I said “if it’s 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 specific applications. Line size does not necessarily equal check valve size. 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 check 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 and options are selected.

NOAH MILLER is the worldwide applications/engineered sales manager for Check-All Valve Manufacturing Company. With the company since 2010, he’s been assisting customers with proper check valve installation, check valve sizing, troubleshooting, and custom check valve designs. He regularly works with customers in the industries of oil and gas, steam, pharmaceutical, food and beverage, etc. He’s considered the expert on check valve capabilities and is relied upon by engineers, field personnel, and purchasers to assist them with their check valve needs.

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