Check your check valve

Selecting the correct size and type of check valve for applications can help reduce failure

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Check valves, unlike isolation valves, have to dynamically respond to flow conditions and deliver long-term, trouble-free performance. The correct selection and sizing of swing check valves based on application and line parameters is vital to system reliability.

Check valves are probably the most misunderstood valves in a flow control system. In simple terms, a check valve allows the flow of gas, liquid or steam in one direction and automatically prevents backflow in the reverse direction. All check valves are flow sensitive and rely on fluid pressure to open and use internal spring/hinge force to close. Check valves come in various types depending on construction and application, including swing check, lift check, tilting disc check, ball check, axial-flow check, stop check and poppet check.

Selection and sizing

For long-term, trouble-free performance, check valves must be selected to suit the application. Sizing and selection of a check valve for critical applications and large sizes should be treated with as much importance as sizing of a control valve. Incorrect selection and sizing can result in premature failures.

The focus of this article is on the prevention of premature failures through correct sizing, as well as correct selection of valve type and material to suit the application.

Typical swing check valve issues include disc chattering, slamming, tapping against the seat, cavitation, water hammer, wear, erosion, etc. These phenomena can cause mechanical failure of internal parts and cause dislocation of the disc from its hinge, hinge pin damage, dislocation of hinge arrangement, shearing of disc shaft and damage to seat surfaces. These failures can develop prematurely or over a period of time, depending on the operating conditions.

Chattering of disc

Repeated opening and closing of the disc is known as chattering and is one of the most common causes of swing check valve failure. Chattering occurs when the valve is oversized for the application and the disc is not firmly held against the body stop. Chattering is associated with noise generation and repeated chattering of the disc can lead to premature wear of internals such as the hinge pin, shearing of disc stud, spring failure, poppet damage or seat damage.

A check valve must be sized for a flow rate that will keep the disc in a stable position against the internal stop, in fully open position. Each size of check valve has a critical velocity VMin, which is the minimum velocity required across the valve to keep the disc in fully open position. VMin depends on various parameters like flow medium (gas or liquid), density, temperature, disc weight and moment arm distance, etc. When a valve is sized to deliver a velocity of flow more than VMin, chattering (fluttering or excess vibration) can be avoided.

However, it may not always be possible to ensure a constant velocity above VMin, as flow conditions alternate from maximum to normal to minimum. Modern power plants have high turndown ratio (the ratio of maximum flow to minimum

Figure 1. Swing check valve disc stud failure caused by chattering

Figure 2. Seat damage caused by chattering

flow) and in such cases ideal sizing should ensure disc opening angle greater than 25° with minimum flow. Furthermore, care should be taken to ensure that there are no flow disturbances in the upstream side of the check valve and that entry flow into the check valve is stable and uniform.

The wear of the hinge pin in Figure 3 was noticed before it caused any mechanical failure. This highlights the need to monitor the condition of check valves in critical services at regular intervals, where the flow velocity cannot be maintained above VMin.

Figure 3. Undue wear of hinge pin in a swing check valve due to chattering

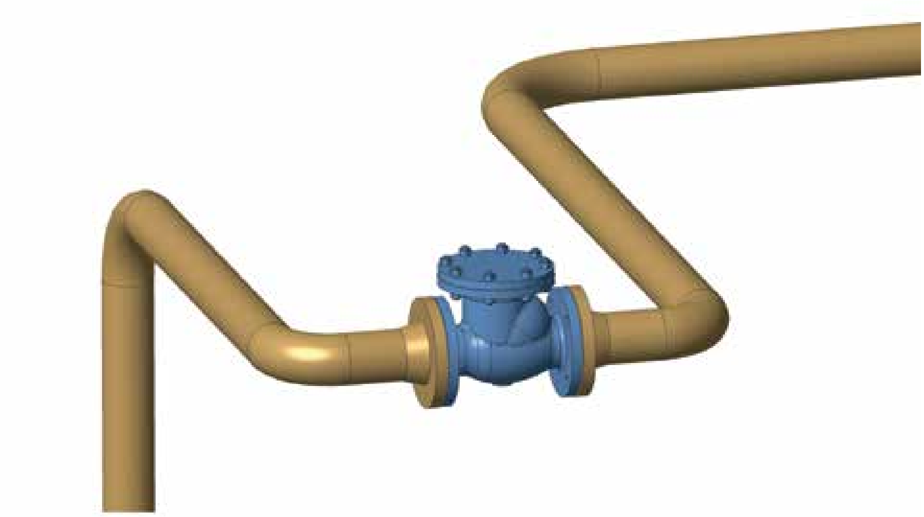

Figure. 5 Typical pipe layout of a swing check valve in a refinery

Wrong selection of disc material

In applications where fatigue loading is expected, the correct selection of disc and hinge assembly materials is of paramount importance. For multiphase and unstable flow conditions experienced in industries such as oil exploration, the disc material should have high fatigue resistance to withstand dynamic loadings.

In a 12-inch Class 900 check valve installed in an offshore platform, the disc stud got sheared due to repeated contact of the disc against the stopper (see Figure 4). The analysis revealed that the disc material selected for the check valve was a martensitic stainless steel (CA15), which has low impact strength and could not withstand the impact loading. Here, the CA15 disc was replaced with carbon steel material, which is more ductile than C15, extending the life of the check valve.

Figure 4. Disc stud damage

Flow disturbances: upstream and downstream placement

The placement and positioning of upstream and downstream equipment also plays an important role in ability of the check valve to function without chattering. Upstream of the check valve should have a minimum 5D (D = pipe diameter) straight pipe length to ensure uniform flow. Presence of any control valve at a shorter distance upstream will lead to non-uniform and even turbulent flow, which in turn could result in chattering. Similarly, bends and reducers placed upstream can create non-uniform flow. The downstream section of the check valve should have a straight pipe length of at least 10D, since bends can cause back pressure.

Figure 5 shows a check valve with upstream and downstream bends, where space constraints defy piping conventions. In this case, the line fluid from the bend enters the check valve in swirling streams, causing disc chattering and excessive noise.

"Using the wrong type or size of check valve can lead to valve slamming issues due to pressure pulsations"

Slamming of the disc

Using the wrong type or size of check valve can lead to valve slamming issues due to pressure pulsations. Fast closing of the disc due to backflow pressure or pressure surge can have devastating effects on valve internals. Swing check valves that have a longer travel distance from a closed to open position are more prone to slam than lift check or tiling disc check valves.

Disc tapping

When the flow velocity through a swing check valve is too low due to oversizing, and when the disc angle of opening is less than 20°, there is a tendency for the disc to tap against the valve seat and bounce back. This tapping is magnified in the case of gas applications with flow fluctuations.

In a recent example, for a gas pipeline with a flow rate of 281 kg/h, the disc opening angle for the 3-inch swing check valve was only 15°. Since there was a strong tendency for disc tapping, the size was changed to 2 inches and the opening angle increased to 25°.

Parameters		3-inch SCV	2-inch SCV
Flow medium		gas	
Flow rate	kg/h	281	
Actual flow velocity	m/s	4.1	9.10
V-Min (to keep disc fully open)	m/s	29	32.7
Disc open angle for the actual flow	degree	15	25

Table 1. Comparison of disc opening angles in 3-inch and 2-inch swing check valves

Application	Swing check	Tilting disc	Lift check
Fast opening and fast closing	3	1	1
Variable flow conditions	3	2	1
Low pressure drop	1	2	2
Disc stability at low flow velocity and pulsating flow	3	1	1
1 – Excellent, 2 – Good/Fair, 3 – Fair/Not Recommended			

Table 2. Guidelines for the selection of check valve type

Selecting a check valve size

Performance of a check valve depends greatly on selection and sizing based upon its application and operating parameters.

Guidelines for the selection of check valve type can be seen in Table 2.

In choosing the size of the valve, the following basic parameters need to be considered (list not comprehensive):

- Line fluid and density
- Single-phase/multiphase
- Fluid pressure and temperature
- Minimum/maximum and normal flow rates
- Upstream and downstream equipment

Swing check valves should be sized to obtain flow velocity sufficient to hold the disc firmly in open position. Valve manufacturers will have data on VMin for each valve size, which can be used for sizing.

Although it is preferable to operate under a fully open position, the actual flow conditions in the plant may vary from low to high flow rates. In such cases, a tilting disc check valve will perform better even when the flow velocities are below VMin.

If piping specification calls for a swing check valve and the flow velocity ranges from low to high, an appropriate sized valve should be selected so that the disc open position with low velocity flow is greater than 20° to avoid disc tapping. Valve performance should be monitored during regular maintenance to avoid sudden failures.

Ensure that entry into the check valve is uniform and stable by adhering to conventional straight pipe lengths of 5D (minimum) on the upstream side and 10D on the downstream side.

Conclusions

Check valves should be sized and selected for the application they are to be used in. Proper check valve sizing will enhance system reliability and provide long-term, trouble-free service.

An oversized valve can lead to premature wear and failure of the valve internals due to chattering or excessive disc movement. An undersized valve will cause higher pressure losses and create excessive noise and vibration. Maintaining uniform flow by adhering to straight pipe distance guidelines will enhance valve performance, even if flow velocity is less than VMin.

Choosing a valve with a short travel distance, for example a tilting disc check valve, can help to avoid slamming.

For more information
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