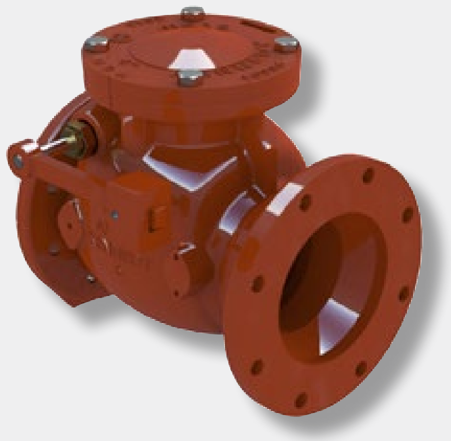
Understanding Swing Check Valves

***By:* Matt Binsfeld, Application Engineer**

Swing check valves are probably the most misunderstood valve in the municipal water works industry. What causes a check valve to slam? How can we prevent it? How does the design of a swing check valve make it susceptible to slam? Why are there so many closure devices available?

To answer those questions, we need to understand the problems of water hammer and valve slamming, the general design of a swing check valve, and the pros and cons of each type of closure device available on the market.



POTENTIAL PROBLEMS

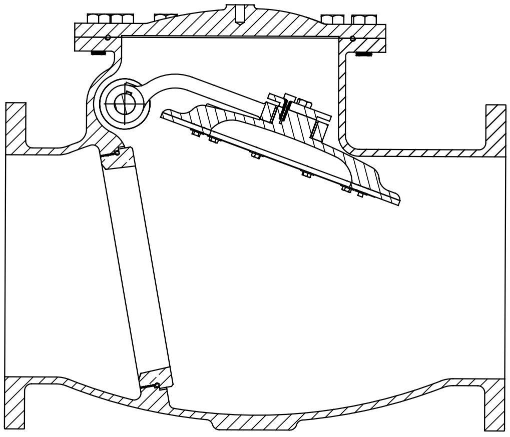
Water and wastewater treatment plants are demanding applications for all types of valves, and swing check valves are no exception. Two critical issues that can be prevented by the proper selection of swing check valves – the related problems of water hammer and valves slamming shut – are described below.

Water Hammer

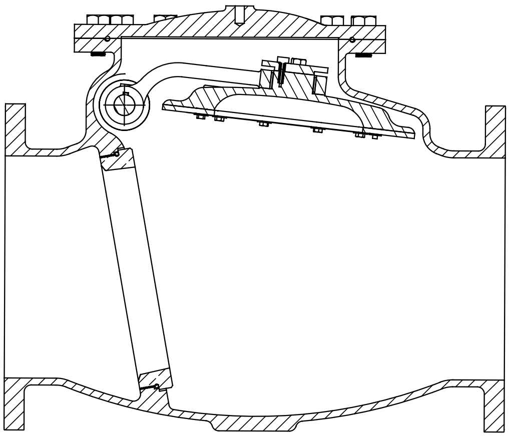
Ask Google A.I. and it will tell you "Water hammer occurs when there is a sudden increase or decrease in the rate of flow and pressure of a fluid in a piping system with the most frequent cause being an abruptly closed valve stopping the flow of liquid." The simplest example of this is when a valve at one end of a system is shut abruptly and the check valve on the other end slams shut due to the reverse flow. This bounces a shock wave back and forth between those valves, traveling at the speed of sound, until it dissipates over time. This shock wave can be so powerful that it bursts fittings or valves in the system.

Slamming

The design of a swing check valve, with up to 90 degrees of disc swing as it closes, makes it susceptible to slamming much more than other designs of check valves that require less movement to close. Most swing check valve slamming can be prevented with the proper application of a closure device. Check valve closure devices can be added to a standard check valve to provide either a fast closure or a controlled, slow closure. Fast and immediate closure is typically needed with pumps that will be damaged by any backflow. However, in systems that can tolerate backflow, slow-acting closure devices are the easiest way to ensure the check valve will not slam.



Full Waterway



Through Waterway

THE BASICS OF SWING CHECK VALVE DESIGN

While all swing check valves feature a swinging disc that opens and closes to control flow and prevent backflow, there are several different design features to consider when choosing these valves for municipal water and wastewater applications.

Full Waterway vs. Through Waterway

Most swing check valves on the market are of the "Full Waterway" design, also referred to as "Full Port". This means the waterway of the valve (or "Port") maintains at least the same area as the pipe it is sized for. A "Through Waterway" design maintains a straight, line of sight, full pipe diameter through the valve. A through waterway swing check valve design typically requires more angle of swing from open to close, increasing the likelihood of slamming.

Self-Aligning Disk

Swing check valves typically are designed with a disc mounting arm that does not hold the disc rigidly but allows the disc to float and self-align to the body seat ring. This design relies on the disc being held against the upper part of the valve body when the check valve is in the open position, to prevent the disc from fluttering in the flow of media. This adds complexity to the application of a swing check valve when it comes to both flow requirements and turbulence.*

*Most manufacturers require flow to be in the range of 5 to 15 FPS. With flow less than 5 feet per second, the disc will not be held against the body and can shake in the flow causing premature wear to the disc and mounting components. Flow above 15 FPS is beyond the upper flow limit of standard check valves and requires a high-flow design like a slanted check valve.

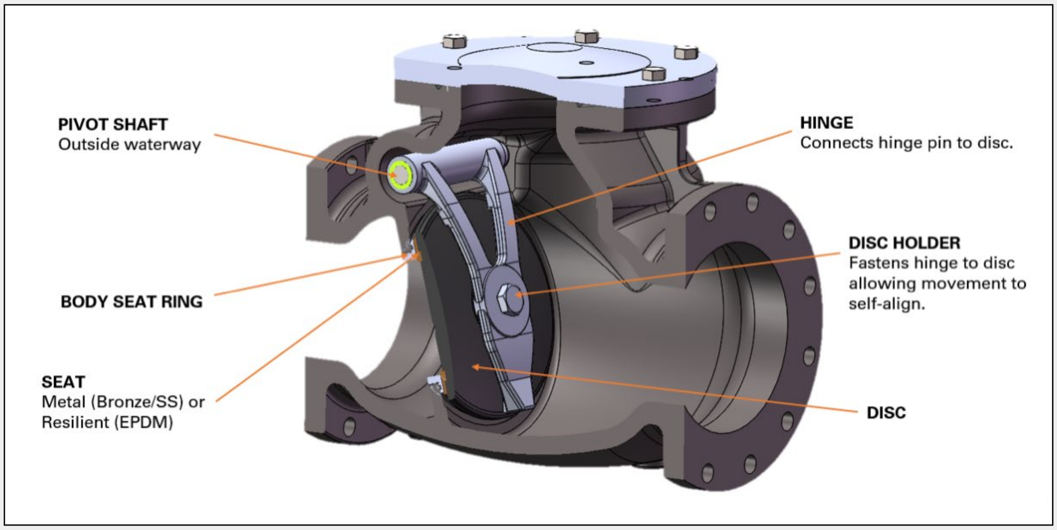
*This same shaking of the disc can be caused by turbulent flow if the check valve is placed immediately downstream of an elbow, reducer, pump, or other component that disrupts the flow. Most manufacturers require a swing check to have a minimum straight pipe length of 5 to 10 pipe diameters upstream of the valve to create a more laminar flow past the disc.

Seat Materials

Body seat ring and disc seat materials are offered in elastomers, bronze, and stainless-steel to accommodate a wide range of media, temperature, chemicals, and abrasives that may flow through a swing check valve. Per AWWA standards, elastomers form a drip-tight seal while metal seats are allowed a certain amount of leakage.

Removable Internals

Common swing check valve designs allow a main cover to be removed and all internals to be replaced without removing the valve body from the pipeline.



SWING CHECK VALVE CLOSURE METHODS

There are several check valve closure methods to consider, from a simple lever and spring all the way to a complex hydraulic speed control. Most closure devices connect to the pivot shaft of the valve and control the swing rate of the disc. Let's review each method starting with a plain check valve.

Plain Swing Check Valve (without closure device)

A swing check valve can be used without any closure device if the application does not require controlling the closing time and slamming is not a concern. The lack of closure device allows the least amount of headloss as the disc is free to swing with no resistance against the flow other than its own weight. However, without a closure device there is no way to control slamming.

PROS	CONS
Low headloss	Slow closure rate
	Slams with reverse flow

Lever and Weight

Adding a lever with weight to a swing check valve speeds up the closing time due to the weight pushing the disc against the flow. In applications where the flow stops gradually, this can prevent the disc from slamming by closing the valve at the exact moment the flow stops. However, if the flow stops abruptly, using only a lever and weight closure device will likely result in slamming since there is no control over the closing rate.

A lever and weight will cause slightly higher headloss than a plain check valve, but the additional force will also assist a pump in building pressure on start-up. Caution should be used when adding large amounts of weight to the swing arm, as excessive weight can damage the pivot shaft if slamming occurs.

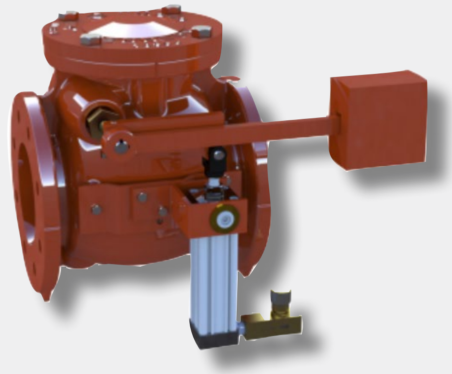
PROS	CONS
Faster closure rate	Slams on abrupt reverse flow
Prevents backflow	Risk of shaft damage

Lever and Spring

A lever and spring closure device is very similar to a lever and weight device. It speeds up the closing time even faster than the lever and weight due to the spring(s) pushing the disc against the flow. In applications where the flow stops gradually, this can also prevent the disc from slamming.

Typically, the spring tension can be increased by a threaded tensioner or more springs being added to the device. With more tension, the disc closes earlier in the process of losing line pressure. However, more tension increases headloss. Like the lever and weight, slamming in an abrupt loss of flow is a concern.

PROS	CONS
Faster closure rate	Slams on abrupt reverse flow
Prevents backflow	Higher headloss



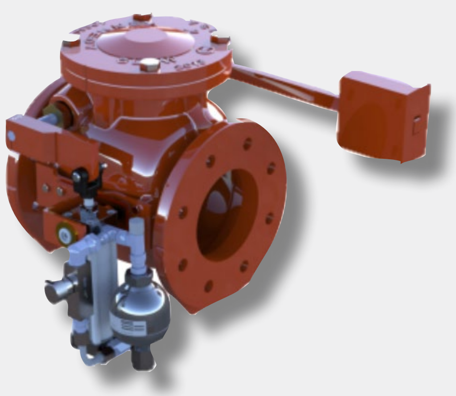
Air Cushioned Lever and Weight

An air cushioning accessory can be added to a lever and weight closure device. The air cushion consists of an air cylinder and a flow control restricting the release of air as the cylinder is compressed by the swing arm during valve closure.

This allows all the advantages of having the lever and weight system with the addition of partial control over the closing rate and protection against a large amount of weight damaging the pivot shaft*. However, due to the compressibility of air, this system will not prevent slamming if there is still significant reverse flow when the disc nears the closed position.

*The air cushion accessory was originally designed to prevent large weights from damaging the pivot shaft when a swing check valve slammed shut. After introducing this system, it was discovered that the air cushion's flow control could be set slow enough (in some cases) to delay the closing of the valve until the shock wave returned through the valve - eliminating the potential water hammer.

PROS	CONS
Partial control over closure rate	Allows backflow
Shaft damage protection	Still slams in certain situations



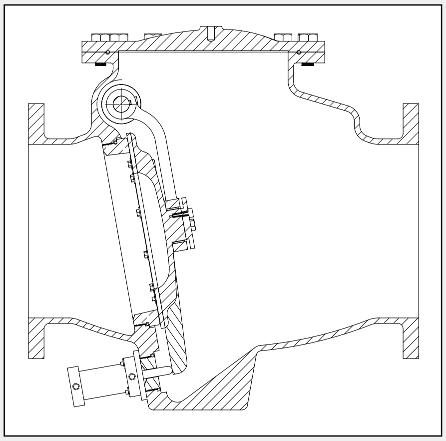
Oil Cushioned Lever and Weight

Adding an oil cushioning accessory to a lever and weight closure device is one of only a few options effective at preventing slamming. The oil cushion consists of an oil cylinder and flow control(s) that restrict the flow of oil through the cylinder as it's compressed by the swing arm during valve closure.

This provides complete control over the closing rate, protection against a large amount of weight damaging the pivot shaft, and protection against slamming. The oil cushion is much more effective than an air cushion at preventing slamming because the oil is not compressible. This allows the flow control to maintain the desired closing rate all the way to disc closure.

PROS	CONS
Full control over closure rate	Allows backflow
Shaft damage protection	

Bottom Mounted Buffer

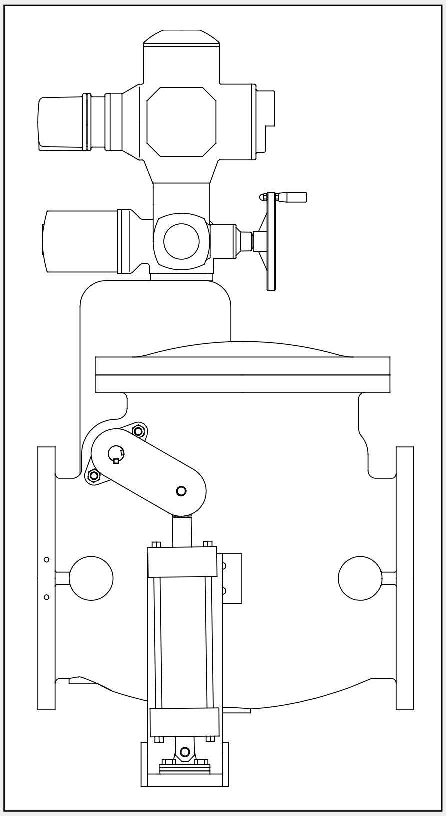


Much like an oil cushioning accessory, a bottom mounted buffer is also very effective at preventing slamming. This system consists of a plunger protruding into the final portion of the disc path. The plunger is attached to an oil cylinder with flow control(s), just like the side mounted oil cushioning device. The buffer's flow controls restrict the flow of oil through the cylinder as it's compressed by the disc just prior to closure.

This provides good slam control and shaft damage prevention but does not give complete control over the closing rate, as the disc only contacts the plunger at the very end of its travel. A bottom mounted buffer is a good choice when headloss is a concern because it can be used without any other closure device, allowing the disc to open unrestricted. The risk of debris or corrosion collecting on the plunger needs to be considered since the plunger is extended into the bottom of the valve body and, in some designs, directly into the flow path.

PROS	CONS
Full slam prevention	Only minimal control over closure rate
Low headloss	Allows backflow
	Additional components exposed to media

Pumpcheck



In situations involving a pump where there can be zero chance of slamming and there can be zero back-flow, a "Pumpcheck" or motorized pump control swing check valve is utilized. A Pumpcheck uses both a standard swing check valve with a cylinder closure control and an electric motor operator (EMO). In normal operation, the EMO receives its signals from either the same controller as the pump or from pressure switch(es) in the line.

On pump shutdown, the EMO closes the valve slightly ahead of when the pump stops. On start-up, the EMO opens the check valve slightly after the pump starts. In both pump shut-down and start-up there is zero chance of slamming or back-flow because there is still pressure in the line ahead of the check valve when it is closed. In the case of power failure, the swing check is allowed to operate normally with a standard closure device, preventing slamming. However, with just the cylinder closure control, some back-flow will occur.

PROS	CONS
Full slam prevention	Requires automation
Prevents backflow	Expensive
Precise control over closure rate	Large footprint

ADDITIONAL FACTORS

More than just the basics of closure devices need to be considered when designing a system with swing check valves in water and wastewater treatment plants. Some of the many factors involved when selecting the proper check valve and closure device are head pressure, length of line, back-flow tolerance, and manifold designs. Also, proper placement of swing check valves in relation to other components can be easily overlooked while designing a system, resulting in a dramatic reduction in the lifespan of the valve's internal components. The technical sales support team at McWane Plant and Industrial (MPI) is ready to assist you in the selection of the proper closure device for any scenario.