Triangle Pump Components Incorporated

Understanding Water Hammer

Created in partnership with DFT® INC

What is Water Hammer?

Water hammer is a shock wave that is transmitted through the fluid contained in a piping system. The most basic explanation is that water hammer occurs when a fluid in motion is suddenly forced to stop moving. The momentum of the fluid abruptly stopping creates a pressure wave that travels through the media within the pipe system, subjecting everything in that closed system to significant forces. Normally the pressure wave is dampened or dissipated in a very short amount of time, but the pressure spikes can do enormous damage in that short time.

Water hammer is a common issue in households and industrial plants alike, and is evidenced by a thumping or banging sound that, in extreme cases, can result in extensive and costly damage to expansion joints, pressure sensors, flow meters and pipe walls. In the home, water hammer can originate from any action that causes water to move through the pipes, such as taking a shower, washing your hands, or running the dishwasher. When the flow of water is brought to a quick halt, a shock wave can be created within that pipe. At home, halting the flow slowly, however, will prevent water hammer.

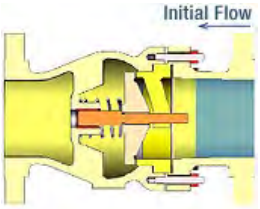
In an industrial setting, water hammer can result from improper valve selection, improper valve location and sometimes poor maintenance practices. Certain valves, such as swing check valves, tilting disc checks and double door check valves can contribute to water hammer problems. These types of check valves are prone to slamming because they rely on reversing flow and backpressure to push the disc back onto the seat, to close the valve. If the reverse flow is forceful as in a vertical line with normal flow upwards, the disc is likely to slam with a great deal of force. The resulting shock can damage the alignment of the disc so that it no longer makes full 360 degree contact with the seat.

What is Water Hammer? (Cont.)

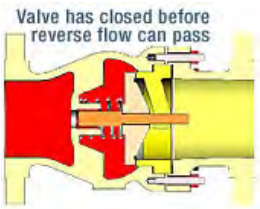
This leads to leaks that, in the best case undermine the efficiency of the system and in the worst case could do damage to other components.

Localized, abrupt pressure drops are annoyance at the least and a serious problem at the most. You can take steps to prevent or mitigate water hammer by studying its causes, consequences and solutions.

Triangle Pump Components, Inc. (TPCI) is an expert on all things fluid handling systems. We have nearly a century of experience serving a variety of processing industries and combatting common pump suction problems. Though we specialize in pump cavitation issues, water hammer is a residual effect that we often see in overall systems – even after cavitation problems are resolved. In this eBook we will examine some of the common causes and symptoms of water hammer, as well as what you can do to investigate and alleviate them in your system.



Initial flow moves through the check valve, opening the valve.



The spring closes the disc when pressure is reduced, ahead of the reverse flow.

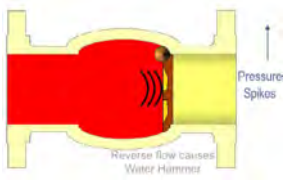
Causes and Conditions of Water Hammer

Hydraulic Shock

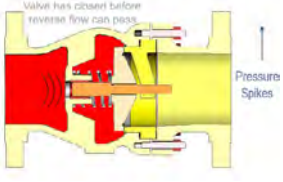
The most common cause of water hammer is either a valve closing too quickly or a pump shutting down suddenly. Hydraulic shock is in fact the momentary rise in fluid pressure in a piping system when the fluid is suddenly stopped. As Sir Isaac Newton observed an object in motion tends to stay in motion unless acted on by another force. The momentum of the fluid traveling in its forward direction will work to keep the fluid moving in that direction. When a valve suddenly closes the fluid after that valve will be elastically stretched until the momentum of the fluid is arrested. The fluid then wants to snap back to its normal, unstressed condition, much like an extended spring being released, causing liquid to travel back through the pipe. The back flowing fluid then encounters the closed valve, potentially with significant destructive force. The reflection of this fluid pressure wave is the loud bang (and there could be more than one pressure pulse) that is observed.

The actual force of water hammer depends on the flow rate of fluid when it is stopped and the length of time over which that flow is stopped. For example, consider 100 gallons of water flowing in a 2" pipe at a velocity of 10 feet per second. When the flow is quickly brought to a halt by a fast closing valve, the effect is equivalent to that of an 835 pound hammer slamming into a barrier. If the flow is stopped in a half second (which is to say the closing speed of the valve), then a pressure spike of over 100 psi can be generated.

Water hammer is obviously a serious issue in industrial settings, such as at a wastewater plant or municipal water system. In contrast to the example above, the average bathroom faucet is usually based on a ½" nominal line size and has a water pressure that ranges between 60-80 psi and delivers about 8-10 gallons per minute. A 6" line in a water treatment plant would deliver 900 gallons per minute with a velocity of 10 feet per second. A 24" water main could be delivering over 12,000 gallons of water per minute, enough to fill your average back yard swimming pool in less than two minutes.



Reverse flow causes Water Hammer.



Valve has closed before reverse flow can pass.

Causes and Conditions of Water Hammer (Cont.)

Consequences of Water Hammer

The consequences of water hammer can range from mild to severe. A common sign of water hammer is a loud banging or hammering sound emanating from the pipes, especially after a water source is shut off quickly. This is the sound of the pressure shock wave hitting a closed valve, joint or other blockage at a high force. This sometimes deafening noise can be a source of great distress and concern, especially if people are working close by.

Repeated occurrences of water hammer aren't just an annoyance, however. Water hammer also seriously damages pipelines, pipe joints gaskets and all the other components of the system (flow meters, pressure gauges, etc.). The pressure spikes can easily exceed five to ten times the working pressure of the system; upon impact, thereby placing a great deal of stress on the system. Water hammer causes leaks at the joints in the system, as well as pipe wall cracks and deformation of piping support systems. Repairing or replacing damaged pipeline components and equipment can be quite costly. If the spill results in an environmental issue, the costs can be staggering.

In most situations, water hammer is considered to be a safety hazard. The extreme pressure of water hammer can blow out gaskets and cause pipes to rupture suddenly. People in the vicinity of such an event can be seriously injured.

Figure 1

In the first graph, pressure spikes from reverse flow in a conventional swing check valve are shown over time.

In the second graph, a silent check valve reduces the pressure spike by closing before the reverse flow can pass.

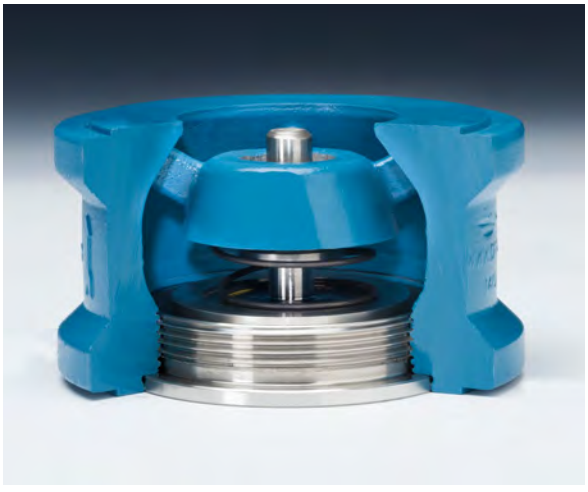
Causes and Conditions of Water Hammer (Cont.)

Solutions to Water Hammer

There are many ways to mitigate the effects of water hammer, depending on its cause. One of the simplest ways to minimize water hammer caused by hydraulic shock is to train and educate operators. Operators who learn the importance of opening and closing manual or actuated valves properly can take care to minimize its effects. This is particularly true for quarter turn valves like ball valves, butterfly valves and plug valves.

Water hammer arrestors provide a point of relief for pressure spikes caused by water hammer. These piping system components reduce the characteristic noise and resultant stress on the pipeline system by acting like a shock absorber. When sized and installed properly, water hammer arrestors can be an effective solution for water hammer.

Another area to look at is check valves installed in vertical pipe lines. Swing checks, Tilting discs and Double Door valves can be made to operate in a vertical line, but they will not prevent reversing flow in this orientation. Only a Silent Check Valve can work in this orientation.



Hydraulic shock resulting from the sudden closure of swing check, tilting disc and double door check valves can be remedied by changing these valves with silent or non-slam check valves. Silent check valves close upon the decrease of the differential pressure across the closure member of the valve, rather than reverse flow and are thus far less likely to slam shut which induces water hammer. When the differential pressure across the disc approaches the cracking pressure of the valve, the valve has fully closed. This allows the fluid flow to decelerate, which allows the momentum of the fluid to decrease before the valve is fully shut, while still ensuring that the fluid flow does not reverse direction.

Conclusion

System designers must be familiar with the best practices and industry standards for minimizing water hammer, such as using slow-closing valves when appropriate, optimal valve locations within a piping system and special piping design considerations for high operating pressure systems.

When piping systems are properly engineered, you can reduce the likelihood of water hammer or even eliminate it completely. In existing systems, the damaging effects of water hammer can be limited in a number of significant ways, such as installing water hammer arrestors, making sure that operating procedures for quarter turn valves insures a slow closing rate, relocating check valves out of vertical lines and installing silent check valves as a primary line of defense.

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About Triangle Pump

For almost 100 years, Triangle Pump Components Inc. has been an industry leader in durable, dependable pump components. From our patented World War II-era **Durabla®** valve to our plate valves, **Resista™** abrasion resistant valves, plungers, packing, and **DynaRod™** extension rods, our entire product line is equipped to mitigate suction system failures for your pump.

We manufacture and sell reciprocal pump valves, plungers, packing, and a full line of stuffing box components. Our dependable products and dedicated staff are here to help resolve any suction system problems you may be experiencing.

To learn more about our diverse product line and how we can optimize your pump suction system, contact us today to speak with a Triangle Pump representative.

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