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# Pressure surges; how to check and cure them!

Hydraulic shock or water hammer is a momentary pressure rise resulting when the velocity of the liquid flow is abruptly changed. The longer the pipeline and higher the liquid velocity, the greater the shock load from the surge. For the piping system to keep its integrity, the surge pressure plus the working pressure in the piping system must not exceed 1½ times the recommended working pressure rating of the piping system.

- The six factors that influence the severity of water hammer are:
- Liquid Velocity
- Length of Pipe Run
- Modulus of Elasticity of Piping Material
- Inside Diameter of Pipe
- Pipe Wall Thickness
- Valve Closing Time

First, we must find the speed a surge wave travels through the piping system. Since the pressure wave travels at different speeds through each piping materials, it is necessary to compute the speed of sound in the water as it is changed by the pipe material.

$$a = \frac{4600}{\left[1 + \frac{k}{E}\left(D_R - 2\right)\right]^{1/2}}$$

Where:

a = wave velocity, ft./sec.
k = Fluid bulk modulus, 300,000 psi for water
E = Modulus of elasticity of pipe, 400,000 for PVC
DR = Dimension ratio of pipe, OD/t

Example: What is the wave velocity for water with 2-inch DR 21 PVC pipe?

$$a = \frac{4600}{[1+.75(21-2)]^{1/2}} = 1177.9 \text{ ft./sec.}$$

The pressure surge in water system can be calculated using the change in flow rate or system velocity and the speed of the pressure.

Where:

P = Pressure surge, psi.
V = Velocity change, ft./sec.
g = Acceleration of gravity, 32.2 ft./sec.

Example: The peak pressure surge can be calculated.

$$P = \frac{aV}{2.31\ g}$$

This calculated surge pressure is added to the line pressure to realize the peak pressure the system undergoes. To lower or keep the peak surge within reasonable limits it is necessary to extend the velocity change time. It is common practice to increase, or slow, the valve closing time to exceed the critical close time (Tc) of a system.

$$P = \frac{1178 \times 12}{2.31 \times 32.2} = 190.0 \text{ psi}$$

Example: What is the shortest valve closing time for a 100-foot run of 2-inch DR 21 pipe?

$$T_C > \frac{2 \times L}{a}$$

Where:

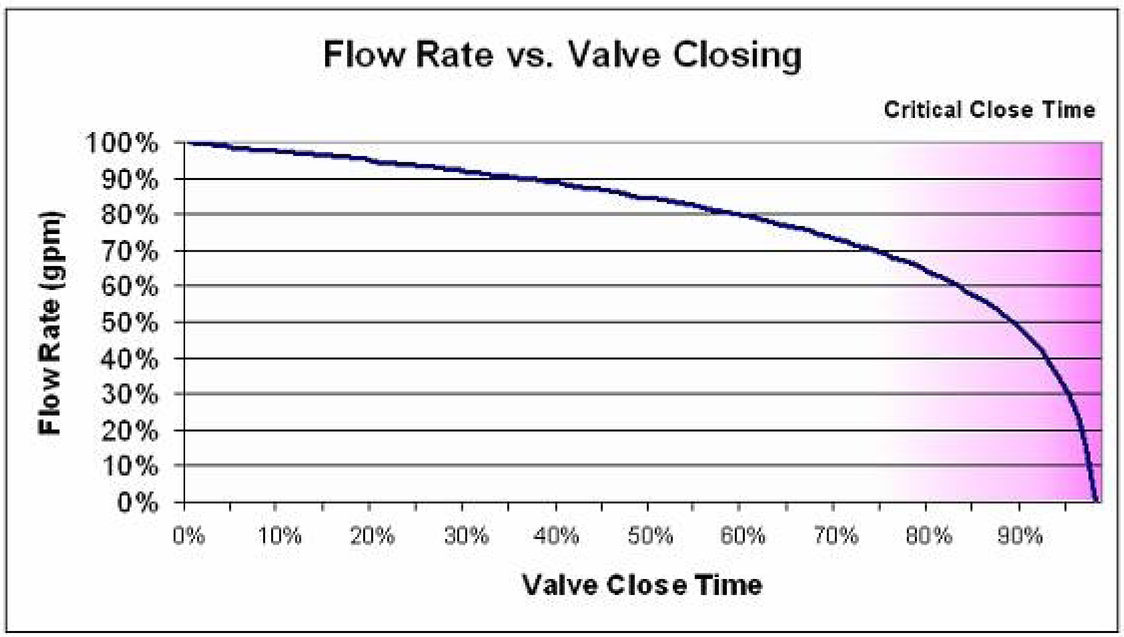
Tc = Valve Closure Time, (sec.)
L = Length of pipe run, (ft.)
c = Sonic velocity of the pressure wave (1178 ft./sec.)

Example: What is the shortest valve closing time for 100-foot run of 2-inch DR 21 pipe?

$$T_C > \frac{2 \times 100}{1178} = 0.17 \text{ sec.}$$

Most solenoid controlled diaphragm valves will close or open more rapidly the greater the difference between the upstream and the downstream pressure. This means that most of the flow (gallons per minute) is closed off in the last 25% of the valve operation. Conversely, the bulk of the flow comes about during the first 25% of opening.

These sudden, quick, and repeated changes in flow during system operation produce repeated cyclic pressure fluctuations. These are the fatigue-causing culprits that can weaken and will then destroy any irrigation system.




A common cause of water hammer, often overlooked, is the air slug, which is nothing more than a bubble or air pocket within the system. When this bubble is traveling through the piping at the velocity of the water, there is no real problem.

Yet, when that air slug gets to the sprinkler, or opening, the air escapes through the nozzle at roughly five times faster than would water, so the upstream water velocity suddenly increases. When the air slug is gone, the system velocity is suddenly decreased to the original value. For example if the normal velocity is only three feet per second, the system can increase to fifteen feet per second during the air escape, and can be instantly cut by twelve feet per second to the original speed. The twelve foot per second change in velocity will create a pressure spike of over 190-psi in a two-inch system. The addition of the surge to the working pressure of 150-psi unite to 340-psi which surpasses the pressure rating of a Class 200 or DR 21 pipe.

The 200-psi surge will only last about one-third of a second, a short time, only enough to cause the gage to flicker. Most gages and pressure recorders will only reflect, or show, less than one-half of the peak surge pressure because their mechanisms cannot react quickly enough. Many times an oil-filled gauge will be installed to provide a steady needle for easy reading; but the dampening of the needle movement hides the surges and damage that is being done to the system. Since PVC is a visco-elastic material and sudden changes cannot be tolerated effectively, the surges may lead to broken piping and components.

Therefore, to effectively remove or eliminate pressure surges it is essential to make sure to manage the causes. For PVC piping systems the conditions that can be controlled are:

- Control the velocity of fluid in the system. The slower (lower) the fluid travels through the system reduces the chance of damaging pressure surges. The industry recommends flows below 5 feet per second for PVC piping.
- Shorter pipe runs (spans) will reduce the chances of a reflective pressure wave which can damage the system.
- It is important to realize that the “effective valve close time” is about ¼ of the time lag between when the valve is signaled to close and when the flow actually stops.

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