

# Pulsation Dampeners for smooth flow in pipes

Written by  
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Stopping and starting is expensive. Cars last longer and get better mileage with freeway rather than city driving. Corporations leave computers running 24/7 to extend their life. Industrial gas turbine maintenance schedules are determined as much by number of starts as number of operating hours.

But there is something that stops and starts more often than rush hour traffic in Los Angeles – the water or oil coursing through a hydraulic system. Each pump piston stroke sends a shockwave through the system at the speed of sound, hammering the fittings and lowering the life expectancy of equipment. Unless, that is, one uses a pulsation dampener to provide a constant pressure and smooth the fluid flow.

## The K Factor

In most liquid handling systems, the primary source of pulsations is the pump. This applies to both hydraulic motion systems as well as chemical injection pumps. With any type of positive displacement pump - whether it uses a diaphragm, gear, piston or vane – the pump breaks down the inlet flow into a series of discrete parts. The pump then applies energy to each of these discrete parts, raising its pressure and then releasing it into the general high-pressure flow.

Since piston-type pumps are most commonly used, we will look at these in more depth, recognizing that the same principle applies to other types of pumps. Reciprocating piston pumps are an efficient means of achieving high pressures, however they also tend to produce the strongest output pulsations. While the average pressure and flow rate of the fluid remains relatively constant, it is subject to wide fluctuations, particularly in the area immediately following the pump output. The pump operates by taking a finite amount of fluid into its chamber and then rapidly compressing it. This action produces a sinusoidal pattern of fluid pressure and speed fluctuating around the average pressure and speed of the system.

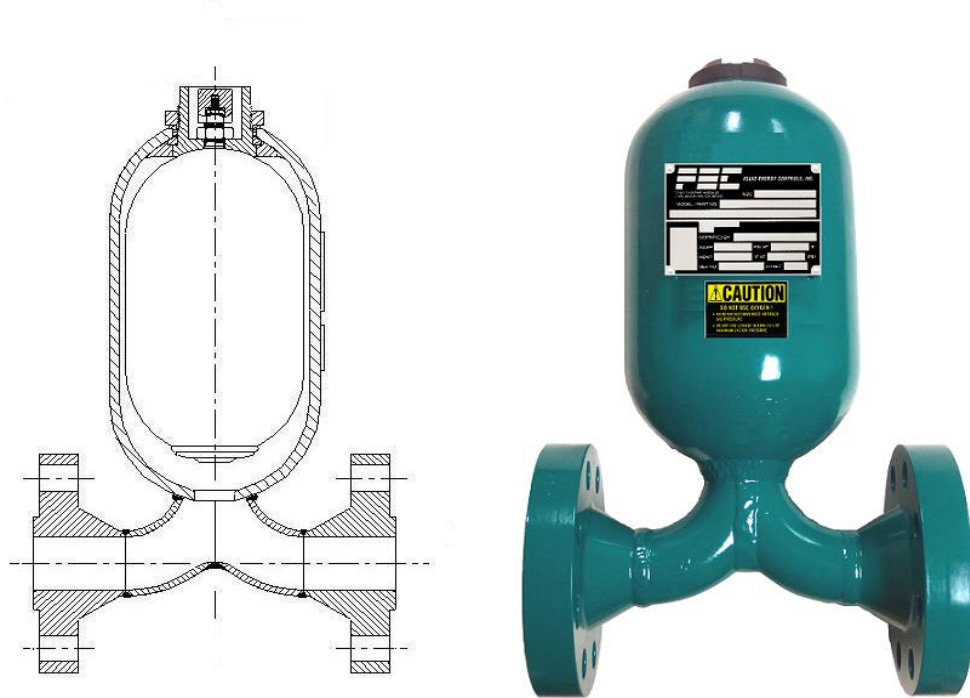
As the high-speed, high-pressure fluid exits the discharge port on the pump, it creates a compression wave. That wave travels through the fluid at the speed of sound until it reaches a bend or restriction in the pipe. At that point, the joint or restriction absorbs some of the compression wave's energy, while the rest is reflected back against the flow coming from the pump. This back-and-forth hammering the compression wave causes lowers the lifetime of the pump and the plumbing.

One way to smooth out the flow is to use a double-acting pump or one with multiple pistons. Since each piston stroke reaches its maximum at a different point in time, this smoothes out the pressure highs and lows the same way a 12-cylinder Jaguar engine runs much smoother than a single piston lawnmower. The K Factor of a pump is a figure showing how much the flow volume varies from the average flow volume at different points of the piston stroke. A simplex, single-acting pump has a K Factor of .60, meaning the fluid volume at the discharge port varies 60% above and below the average flow. Adding more pistons lowers the K Factor to the point where, with seven pistons, the

K Factor drops to only 0.02. Of course, not many septuplex pumps are in use. The more typical simplex, duplex and triplex pumps require pulsation dampeners to bring their pulsation problems under control.

### Smooth Strokes

Pulsation dampeners are devices attached to the pump output that moderate the pump's pressure and volume fluctuations. They can be attached on a nipple off the outlet line, or they can sit inline. There are numerous designs available, but the basic elements consist of a sphere containing a diaphragm or a cylinder containing a bladder. With the first design, the diaphragm is held in place by the two halves of the sphere. The diaphragm splits the interior of the sphere into two halves - one contains nitrogen and the other the fluid being pumped. A charging valve and pressure meter sits on the gas side of the sphere, and the other side connects to the plumbing. The cylindrical design is similar in operation, but a bladder is attached to the charging valve, and the fluid flows in around the bladder.



**A 2.5 gallon flow-thru pulsation dampener, design for a fast response to absorb fast pressure pulses caused by positive displacement pump**

In both cases, the gas side of the dampener is pre-charged to about 70-80% of the minimum allowable system pressure, so there will always be some liquid within the dampener. Then, when the fluid is pressurized, since the nitrogen is more compressible than the hydraulic fluid, most of the fluid above the average system flow goes into the pulsation dampener, rather than creating a compression wave. Then, during the low pressure portion of the piston stroke, the gas expands to force the fluid back out of the dampener into the system, maintaining the mean flow and pressure.

## Pressure Drop

The elasticity of the rubber and the compressibility of the gas work together to eliminate greater than 95 percent of the flow and pressure variations, prolonging the life of the equipment. This does require, however, that the system be properly designed, installed and maintained. To begin with, the right materials must be selected for the diaphragm/bladder and the vessel. The diaphragm or bladder is typically made using Buna-N, however other materials such as Neoprene, EPR, Butyl, Viton, Hypalon, Silicon and Teflon are also available depending on the material being pumped. 304 or 316 stainless steel is normally used for the vessel, though other materials - including Alloy 20, Hastelloy C, polypropylene, PVDF, Teflon and Nylon - can also be used as appropriate.

Next is properly sizing the dampener. On a piston pump, the formula is to multiply together four factors: the area of the plunger face in square inches (A), the stroke length of the piston in inches (L), the K Factor of the pump as discussed earlier (K), and the pressure factor (e.g. a pressure factor of 50 would give approximately a  $\pm 5\%$  pulsation control).  $A \times L \times K \times 50 =$  size of dampener in cubic inches. So if you have a simplex pump (K Factor = 0.60) with a 3" diameter piston ( $A = 7"$ ) and a five inch stroke ( $L = 6$ ), then your minimum size for a dampener is 1050 cubic inches. You would then select the next larger size dampener – a 5-gallon (1155 cu. in.) model.

Next is installation. The dampener should be placed as close to the pump outlet as possible. Depending on design constrictions, the dampener can either sit in line, or off to the side, connected by a nipple. If using a nipple, be sure to select the shortest possible nipple diameter and the dampener inlet should be no smaller than the pump outlet pipe diameter or they will restrict the flow into and out of the dampener, reducing its effectiveness. The dampener should be pre-charged with nitrogen to 70-80% of the system mean operating pressure.

Finally, be sure to check the nitrogen pressure on a regular basis to ensure it is still at the pressure needed. Shut off the pump before checking the pressure, otherwise you will a fluctuating reading closer to the mean operating pressure of the system, rather than the pre-charge pressure.

With these steps in place, you can rest assured that the fluid will flow smoothly, reducing vibration, extending pump and plumbing life, and eliminating costly downtime. At least that is one less thing you will have to worry about, though you will still have to watch your blood pressure in the morning commute.

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