# Pulsation: Cause and Solution

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**This primer on pulsation reviews pump design and its relationship to pulsation, the problems created by pulsation, and the different types of pulsation dampeners and their effectiveness.**

Changes in fluid discharge are inherent in all positive displacement pumps. These changes will subsequently form systematic pressure fluctuations, commonly known as *pulsation*.

Positive displacement pumps – such as piston, diaphragm, vane, gear and screw pumps – discharge discrete amounts of fluids into downstream piping. Each chamber (such as a piston or single vane) therefore creates a pressure rise and fall in the system piping. When plotted on a flow vs. time chart, these pressure changes form a sine wave, as shown in Diagram A.

This sine wave represents the instantaneous flow rate of a single chambered or simplex pump. The mean flow rate of this pump is the average discharge per revolution and is also the flow rating of the pump.

As we increase the number of chambers of a pump (duplex, triplex etc.) we create additional sinusoidal waves offset by time. This means a double diaphragm, or two-piston, pump will create a wave offset in time by half in relationship to the first wave. As a result, the pressure fluctuations are reduced, as shown in Diagram B.

As you may surmise, the increasing number of chambers will produce a decreasing amplitude of pressure pulsation. Theoretically, an infinite number of chambers will completely eliminate discharge pulsation.

Practically speaking, the number of chambers varies by the type of pump construction. We commonly deal with piston pumps between one and eleven pistons, diaphragm pumps with one to four chambers, vane pumps with approximately 11 vanes, and gear pumps having even more chambers.

Since the severity of the amplitude decreases as the frequency increases, we are more apt to have system damage with pumps designed with fewer chambers.

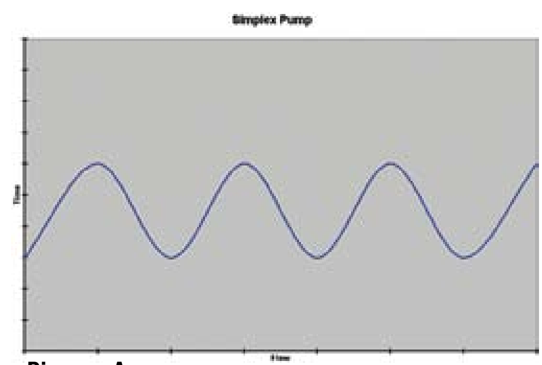



Diagram A

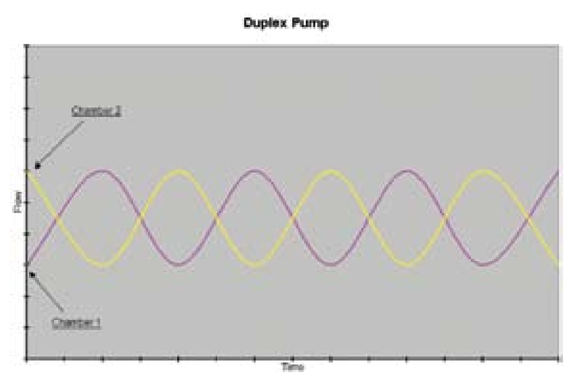



Diagram B

## Problems Created by Pulsation

Pulsation can cause a variation of problems to the piping system. Vibration is the most common problem, as the pipe system reacts to frequency of the pump. Damage may happen to various components, such as fittings, pipe hangers, gauges, transducers and valves.

As each pulse reaches the end of the piping system it produces shock, which reflects back down the system.

Additionally, the frequency created by the pump creates hydraulic noise in the system. This noise can actually become more troublesome in the higher frequencies caused by the higher number of chambers. Even screw pumps can produce problems in noise-sensitive environments.

## Types of Pulsation Dampeners

Remediation of these problems can be accomplished thru various types of pulsation dampeners. Generally these dampeners fit into two categories: liquid dampeners or gas-filled dampeners.

Liquid dampeners function as acoustic isolators. These devices must be custom designed to meet each individual application and are therefore used only where either gas units cannot be used, or where a pump and system may be duplicated.

Gas dampeners are manufactured as either bladder, diaphragm, metal bellows, or piston designs. They function by compensating for fluid reduction below the mean as the pump strokes, and by absorbing the addition volume produced above the mean when the flow increases. This device then produces an effect analogous with a capacitor in an electrical system.

The dampening effectiveness of the device is directly related to the size of the gas chambers and the gas charge pressure as it relates to the output and pressure of the specific pump. The formula for determining the gas volume necessary takes these factors into consideration and looks like this:

$$V = \frac{Vc \times K \times (P_2 \div P_1)^{1/N}}{1 - (P_2 \div P_3)^{1/N}}$$

Where:

V = size of pulsation dampener (cubic displacement). This is the maximum volume occupied by the gas in the dampener.

$P_1$ = Minimum system pressure (PSIA)

$P_2$ = Mean line pressure (PSIA) or system pressure

$P_3$ = Maximum system pressure (PSIA) – is the mean pressure + the percentage of allowable pressure fluctuation.

Vc = Volume of each chamber

N = Gas constant (nitrogen = 1.4)

K = Constant for type of pump

Constants (K) based on pump type:

| PUMP TYPE | (K) CONSTANT |
|---|---|
| Simplex | 0.6 |
| Duplex or double acting simplex | 0.25 |
| Duplex double acting | 0.15 |
| Triplex | 0.13 |
| Quadrauplex | 0.10 |
| Quintuplex | 0.06 |

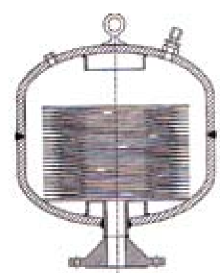
**Since the severity of the amplitude decreases as the frequency increases, system damage is more apt to occur with pumps designed with fewer chambers.**

As the number of chambers increases, the drop of the constant produces reductions in dampener volume such that the flow into and out of the dampener becomes more of a consideration than the volume of the dampener. Port size then becomes the determining factor. You may prefer to have the pulsation dampener or pump manufacturer do this sizing for you. This enables you to pass the responsibility on to them.

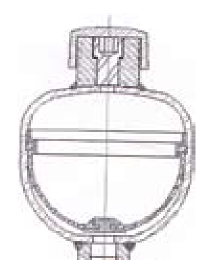
Typically the cost of metal bellow type dampeners is relatively high, so they are used for very high temperatures or extreme compatibility applications.

Piston accumulators are not as well suited because the continuous movement, or dither, of the piston over a small stroke causes premature wear. The weight of the piston also reduces effectiveness as the frequency increases.

The pliability of the bladder (or diaphragm) makes it an ideal membrane between fluid and gas for more efficient dampening. Bladder-type dampeners come in very small sizes (down to 1-cu in), up to large sizes (20-gal), and many different pipe connections, including most flange types.



**Because metal bellow type dampeners are relatively expensive, they are used for very high temperatures or extreme compatibility applications, such as those in the pharmaceutical industry.**



**The bladder-type dampener is an ideal solution because it is pliable, available in a wide range of sizes, and works with a many different pipe connections.**

**The applications for piston accumulators are rather limited due to premature wear issues.**

## Location, Location, Location

Location of the dampener is important when installing a pulsation dampener. The dampener should be placed as close as possible downstream of the pump.

The effectiveness can also be increased by using flow thru dampeners rather than appendage type units. Again cost is a consideration, since flow thru units can cost as much as 80 percent more than appendage units. That's why these types of units are usually used only when maximum reduction of pulsation is required.

## When to Use Dampeners

The inevitable question then becomes, "When do I need a pulsation dampener?"

Aside from the criteria discussed earlier about pump types, this is usually an application-based decision. Typical areas where dampeners may be required are:

- Metering pumps where exact flows are required, such as the food industry and petrochemical plants.
- Oil field high pressure pumps, where simplex, duplex and triplex pumps are common.
- Industrial high pressure, high flow applications.
- High pressure washer pumps.
- RO water purification systems.
- Anywhere a positive displacement pump is already causing damaging pulsation.

Other application insights to consider for possibly using a dampener: When designing or installing a fluid system that incorporates positive displacement pumps, will the pulsation generated cause system component damage and subsequent downtime? Will this vibration and noise generated become a hazard?

Of course, the best time to consider all these factors is *before* the system is installed.

**P&S**

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