

# **Operational Cost Saving in Water Injection Pump Systems Through Pulsation Control**

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DECEMBER 1984

VOL. 76, NO. 12

The use of high pressure positive displacement pumps has long been an acceptable means of increasing well production by water injection. Positive displacement pumps are normally used rather than centrifugal pumps because of their high volumetric and mechanical efficiency above 2000 psig. Unfortunately all positive displacement pumps have an inherent problem of producing pressure variations or pulsations on both the suction and discharge side of the pump. We discuss here these problems and suggest some possible solutions and recommended design practices.

A properly designed suction system can increase the efficiency of the positive displacement pump by providing an ample suction pressure of net positive suction head available (NPSHA) to completely fill each cylinder during suction stroke. Pumps with long suction piping and a torturous flow path from the supply reservoir can have severe pressure pulsations and resulting inlet cavitation. This can lead to increased pump maintenance and loss of pump operating time.

Suction pulsations are basically created by the acceleration and deceleration of the fluid from the reciprocating action of the pump stroke. The pressure loss from variation is called "Acceleration Head". The total pressure available to the pump (NPSHA) is a sum of the following terms:

$$NPSHA = H_s + H_b + H_t - H_a - H_f$$

$H_s$  = Static Head

$H_b$  = Atmospheric or Barometric Pressure

$H_t$  = Tank or Reservoir Pressure

$H_a$  = Acceleration Head

$H_f$  = Suction Friction Losses

If the total suction head available (NPSHA) drops below the fluid vapor pressure, the liquid will begin to vaporize or cavitate and generate severe suction pressure pulsations. Addition cavitation can lead to excessive wear of the suction fluid end and cylinders, plungers, and other pump parts. Plunger pitting from cavitation increases packing wear and can result in premature seal replacement.

The use of a Suction Stabilizer increases the NPSHA by minimizing the "Acceleration Head". As the pump demands varying flow-rates, the Suction Stabilizer provides or accepts the additional fluid by the expansion and contraction of the gas charge in the Suction Stabilizer.

A properly installed Suction Stabilizer can substantially reduce "Acceleration Head", but it cannot solve all suction design problems. The following is a list of good design practices for a sound suction system:

- 1) Reduce the fluid velocity to less than 2 ft per second to minimize fluid friction losses.

- 2) Piping should be as short and as direct as possible with the number of bends and turns minimized. All elbows should be long radius type.
- 3) Keep the line diameter constant throughout the suction piping to reduce the flow disturbances and pressure losses.
- 4) Install a Suction Stabilizer just upstream of the pump inlet to improve NPSHA and eliminate "Acceleration Head".
- 5) Avoid using a common suction manifold on more than one operating pump. If this cannot be avoided, a Suction Stabilizer on each pump is needed to prevent pump interaction.

A Suction Stabilizer will not only increase the NPSHA to the pump, but also reduce the amount of entrained gas in the operating fluid. This increases the volumetric efficiency of the pump by separating the gases from the liquid before entering the pump.

There are a number of Suction Stabilizers available in today's market and each basically functions in the same way. To prevent waterlogging or loss of the gas precharge, the Suction Stabilizer should have a flexible separator between the gas and operating fluid. This also eliminates the sudden influx of gas into the pump inlet if the suction pressure suddenly drops. The separator membrane should be very flexible to provide good response to high frequency flow variations.

The unit should be a flowthrough design for maximum operating efficiency. A typical gas loaded Suction Stabilizer is shown in figures 1, 2, 3, and 4.

All positive displacement pumps generate pressure pulsation on the discharge which may cause serious damage to the pump and discharge piping. The pressure pulsations are created by the flow variations generated by the reciprocating pump stroke. The

smoothest flow with the least pressure variations will be produced utilizing many rather than a few pistons or plungers on a single crankshaft. Discharge Dampeners are generally hard to reduce the flow and pressure variations and to "quiet" the pump operation.

A correctly installed Discharge Dampener will not only reduce the pressure variations in the discharge piping, but will also decrease the hydraulic load on the pump. Pressure variations will cause excessive wear of the pump's moving parts from the uneven loading condition. A more even discharge flow will prolong the life of pump parts, decrease untimely maintenance and down time.

The discharge piping also benefits from the use of a Pulsation Dampener. The pressure pulsations and resulting mechanical vibrations from an unprotected discharge will eventually cause metal fatigue failure of the piping. As the pulsations pound away on the discharge piping, the metal will harden and fracture from cyclic stressing. It is for this reason that most discharge piping is oversized, but may still eventually succumb to failure from pump pulsations.

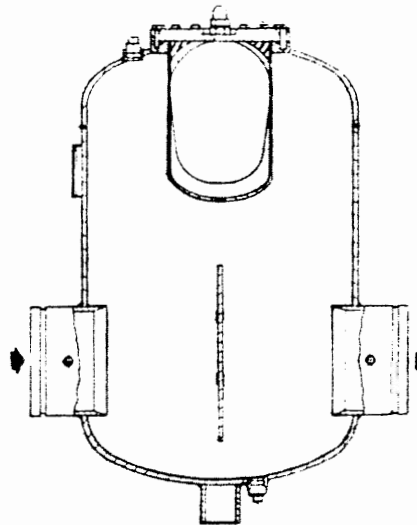


Figure 1



Actual oscillograph traces illustrate dramatic improvement of suction pressure conditions with Suction Stabilizer.

Figure 2

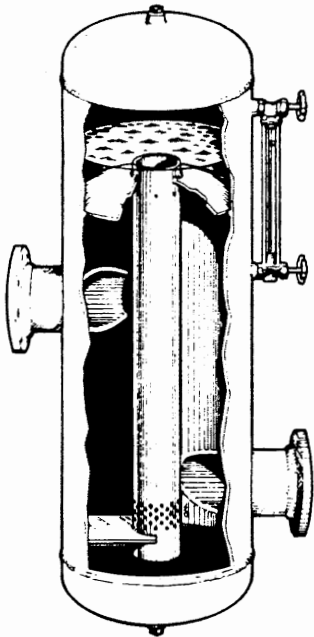
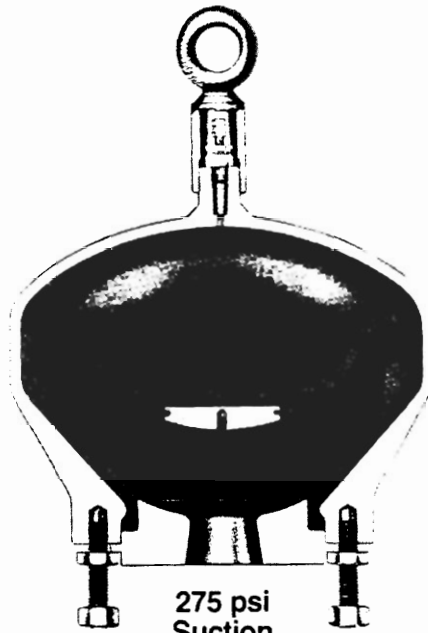


Figure 3

A duplex-single-acting pump, operating at 200 RPM without a Pulsation Dampener, can theoretically produce a pressure swing of 54% above and 48% below the mean operating pressure. This cyclic loading on the discharge piping will be produced at a rate of 24,000 cycles per hour or 576,000 cycles per 24-hour day. Within a month of continuous operation, the piping can be subject to over 10 million pressure cycles.

Most discharge Dampeners will reduce the pressure variation to 5-10% above and below the mean operating pressure. This amplitude reduction of the pressure variation and resulting reduced stresses will prolong the life of the discharge system. This means less repairs and less replacement of discharge



275 psi  
Suction  
Stabilizer  
Figure 4

components and piping.

There are a number of Discharge Dampener designs available today. The majority can be classed into three groups: (1) Bladder type, (2) Diaphragm type, and (3) Acoustic or noncharged type. Each of these types will reduce the pressure pulsation in the discharge piping, but certain key design features will increase the performance and efficiency of the dampener.

The best performing Discharge Dampener is a gas precharged unit which is designed with flowthrough capacity. A gas charged Dampener is shown in figures 5 and 6. The unit should be repairable and have a flexible lightweight separator.

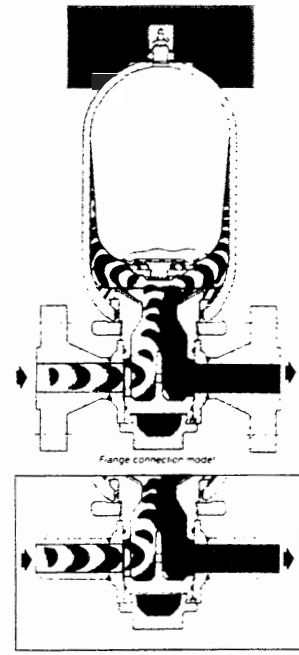


Figure 5

The noncharged acoustic dampeners are not as efficient in pulsation reduction performance, but are convenient because of their minimal maintenance requirements. Acoustic dampeners also apply more of a hydraulic load on the pump than the gas charged types (see figure 7).

In conclusion, with the proper care in designing a positive displacement pump system, one can avoid pressure pulsation, cavitation, and mechanical vibration from seriously hampering the pump operation. Suction Stabilizers and Discharge Dampeners should always be considered to maximize a pump's efficiency and for a smooth operation.

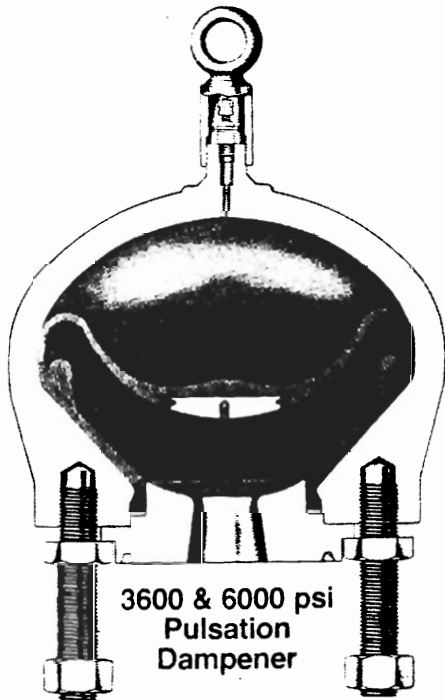


Figure 6



Figure 7

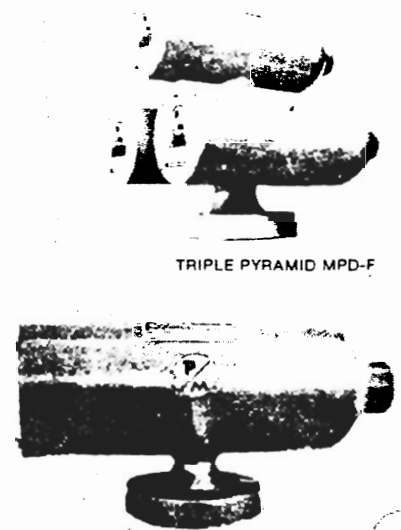


Figure 8