FAR-REACHING EFFECTS OF INADEQUATE PULSATION CONTROL

Case study examines slamming check valve far from a reciprocating double diaphragm pump

By Jordan Grose

Pulsations can travel long distances, especially within liquid pumping systems. This article discusses a case where symptoms of problems were first observed more than 650 ft. (200 m) from the source.

Operators of a large refinery first noticed a slamming noise and some broken U-bolt clamps on a pipe five stories up on a pipe rack. The noise came from a banging check valve on a 3 in. (76.2 mm) line among several larger pipes and valves.

Investigations found this was a suction line leading to two reciprocating double diaphragm quadruplex pumps. The pumps were operated in a spared configuration, each powered by an 85 kW electric motor with VFD speed/flow control.

The troubleshooting team took numerous vibration and pulsation measurements around the pump and at the piping check valve. The pulsation levels greatly exceeded pulsation guidelines from API 674 at the check valve and the pumps were confirmed to be the source of the vibration and noise. This was discovered by comparing the frequency of pulsation and vibration to the running speed of the pumps.

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Slamming check valve (center of the photo) due to pulsation.

The only puzzling matter was that the highest component of the spectrum data was at the first order (1x) of pump speed. In other words, the highest vibration event was happening once per pump crankshaft rotation.

Normally, in a quadruplex pump, the highest expected order is 4x, because there are four plungers (four events per crank rotation). Further investigation was necessary as to why this irregular behavior was happening.

Pulsation dampeners were checked and found to have adequate charge. They had been well maintained. The data suggested one or more of the fluid ends were not pumping properly.

The operator said the pumps had been recently overhauled with new valves and was reluctant to open them up due to strict production targets.

Pulsation and vibration were measured and found to exceed the guidelines on the piping near and far away from the pumps, so the customer requested a computer pulsation study to address concerns with shaking pipes and broken pipe clamps. It was suggested that a flow study should be included in the analysis.

A pulsation model was created for

Shown here is the Quadruplex double-diaphragm pump.

the suction and discharge systems, which predicted high shaking forces in the piping at a number of locations. This model assumed a fully functioning set of four fluid ends.

A flow comparison of measured and predicted flows revealed a 25% shortfall and that one plunger was not flowing product at the time of field testing. A simulation was then completed using the pulsation model of a pump with only three plungers active. To help validate the model, the three-plunger model results were compared to the field pulsation data collected near the slamming check valve.

As can be seen in the pulsation plot illustration, the shape and characteristics of the four-plunger prediction did not match the field data at all, while there was a much more qualitative and quantitative similarity between the three plunger model and the measured field data.

It was suspected one of the fluid ends was vapor locked, as it appeared the operator would start the pump under load, as opposed to using a bypass loop to unload during startup.

Starting a reciprocating pump under load has many drawbacks, one being that if the fluid ends are not primed, discharge line pressure will not allow the enclosed vapor to escape through the discharge valves. This is because of clearance volume pressures of the vapor not rising sufficiently to exceed discharge line pressure and pass through the valve.

As the model predicted high shaking forces because of pulsation at many points in the system, even with a properly functioning pump, it was determined that the original pulsation control was not adequate.

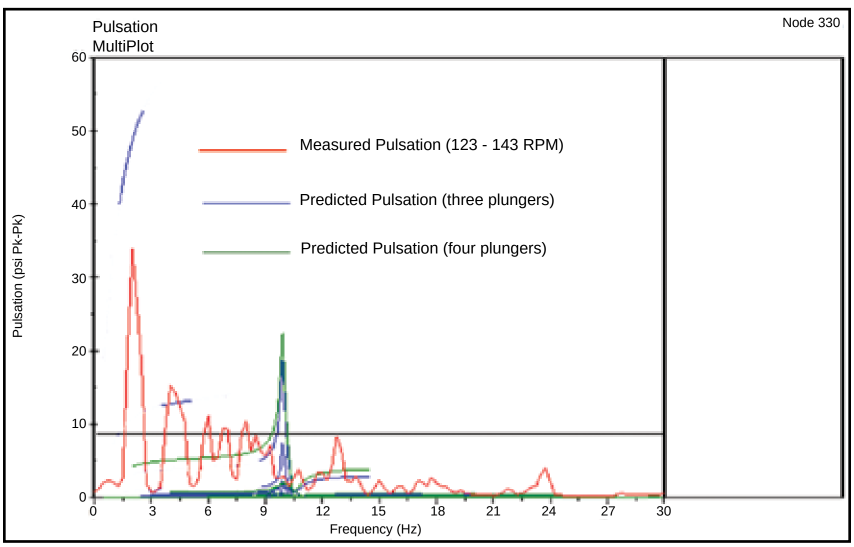
The operator was very concerned about the risk of vibration causing a failure that could lead to equipment downtime and impact safety in the facility. The existing pulsation control included a gas-charged pulsation dampener on each manifold of the suction and discharge.

Single dampeners are often ineffective at many speeds of a variable speed pump (see April 2012 *CompressorTech[Two]*, p. 58). In order to provide control of pulsation across the entire speed range of the system, a second dampener was required for both systems.

The customer chose to implement a maintenance-free, liquid-filled dampener option so the pump system would maintain some pulsation control, even if the existing gas charged dampener lost its charge or failed.

Vapor locked or malfunctioning fluid ends can cause unexpectedly high pulsations that can travel long distances, creating vibration problems along the way on piping and equipment such as check valves. These problems have a direct effect on flow, providing an easy monitoring indicator to evaluate these problems.

Addressing pulsation control at the design stage with an API 674 pulsation study can do much to prevent high-risk vibrations on plant liquid piping, prevent costly trial and error troubleshooting, and prevent expensive field modification solutions.



This graph shows predicted pulsation compared with measured field pulsation at the check valve.