Three Stage Surge Mitigation for Pumping Applications

Water utility resolves frequent water hammer events through surge control

When thinking of transients, several meanings could pop into your mind: something temporary; a person who stays in one place for a short time; or a momentary variation in current, voltage or frequency. In water pipelines and pumping systems, hydraulic transients are created when sudden changes in flow rates occur. While the actual events may be temporary, extreme changes in pressure can cause permanent, catastrophic failure of a pipeline. The cause of transients, also known as water hammer or pipeline surges, can be as simple as the starting and stopping of a pump or as dramatic as a sudden loss of power, pump failure or a malfunctioning valve.

New pump control valve with control panel. Courtesy of Cla-Val.

Being in the Know

Dealing with pipeline surges can be done proactively or reactively. In new systems or those that require upgrades, an effective and proactive approach is to analyze the potential for surges during the design phase of the project. Options range from software developed by pump or valve manufacturers to businesses that provide hydraulic modeling and perform simulations to identify strategies for surge mitigation and other undesirable pipeline conditions. The analysis should identify and take into consideration conditions that could contribute to the creation of surges such as long pipe runs, the location of elevated storage tanks, and the type of equipment in pump and booster pump stations.

In existing systems, the collection and examination of performance data enables operators to identify conditions before, during and after surge events and pursue ways to anticipate and minimize such occurrences (i.e., let it happen and figure out how to prevent it from happening again). Many times, the most effective preventative strategy is to look at the type of pump control valves that are being used in pumping applications.

A recent example of a water utility navigating its way through surge prevention and water hammer control is Greenville Utilities Commission (GUC). GUC provides electric, water, sewer, and natural gas services to the City of Greenville, North Carolina, and 75% of Pitt County. Located just inland off the coast, Greenville lives up to its name, featuring more than 20 city parks, plentiful magnolia trees and centuries-old oaks, surrounded by nearly 700 square miles of prime agricultural land.

Dropping the Hammer

Before

The pumping system in GUC's main water treatment plant was beginning to experience frequent water hammer events causing line breaks in its system. Pump starts and stops were the common denominator and all signs pointed to an aging actuated butterfly installed adjacent to one of four high-service pumps as the probable cause due the relative lack of fine control during the closure cycle. Initially, GUC had decided to replace the suspect valve with a pneumatically actuated butterfly valve because of its simplicity and relatively low cost. However, still concerned about the negative impact of repeated water hammer events, GUC staff engaged the services of water network monitoring consultant Syrinix to determine the root of the problem. When presented with the data collected by Syrinix, GUC decided to consider other options to address the water hammer issues, ultimately contacting local pump expert Charles R. Underwood Pumps (CRU) to explore what the best long-term solution should be. GUC consulted with CRU's in-house application engineer, Zach Hinnant, P.E., who suggested an altogether different approach than originally considered.

A variable frequency drive (VFD) was not appropriate in this application due to a few reasons: operations having the ability to run a pump at speeds that may be problematic as their water model was incomplete at the time; the cost of rebuilding the motor to make it inverter duty rated; existing controls and wiring were in place for pump control and all the additional costs involved made it a poorer choice.

Having had several successful installations under his belt in pumping systems with similar issues, Hinnant recommended an electronic pump control valve with a valve controller programmed with a customized pump control algorithm to mitigate potentially damaging water hammer events.

The electronic valve he had in mind utilizes two solenoids for position control with the valve stroke determined by an adjacent panel-mounted electronic valve controller programmed with a control application to produce a linear flow curve through the critical range of valve position (50% to fully closed), which, in turn, would minimize pressure transients. Because the valve is electronically controlled, it would not experience the problems associated with hydraulic opening and closing where the stroke accelerates at critical points due to high-pressure differentials across the valve. While electric motor actuated butterfly valves are fully capable of providing linear valve opening/closure, they do not result in a linear flow curve because the opening/closing is not staged at the various points of critical valve position.

After

The Multistage Solution

The valve that was ultimately installed at GUC's main water treatment plant provides a three-stage closure operation based on system conditions. Staging closure at critical points of valve position allows the system adequate time to equalize to the change in flow conditions during the entire cycle. The electronic pump control valve gives GUC the ability to control the valve's closure time electronically as well as the ability to identify and adjust the opening and closure times they desire via the valve controller's control application. The programmed controller application monitors the valve's position throughout the three stages to stay within the preset requirements, thus achieving specific percentages of closure at specific times. Having three distinct stages is important.

Stage One: Takes the valve partially through its closure cycle quickly to a pre-identified point (see Fig. 1).

Stage Two: This is the most critical of the three stages because the system will begin to react to the pending closure. This stage requires the most control to smooth out the flow (i.e., spreading the position/ percent of the valve's closure over time to achieve controlled, gradual closure).

Stage Three: In the final 10% of the valve closure, the disc retainer is now already within the seat so there is very little flow, which in turn, prevents water hammer from occurring.

In the Greenville installation, the appropriate timed stages were identified using Cla-Val's Pump ComparFlow software, a program developed to consider pipeline system hydraulics by looking at several parameters such as flow, pipe diameter and length, static head, valve sizes and types, energy costs, etc.

The stroke of the valve influences the timing to achieve desired position. Once the timing was entered into the valve controller application, it monitored and adjusted the position of the valve accordingly throughout the programmed timeframe. The controller is field adjustable and can be fine-tuned during commissioning.

When the electronic pump control valve was installed at the high-service pump, the results were immediate. The S3 severity score instantly lowered. S3 is a calculated measure of pressure changes over a specific time developed by Syrinix; a high score indicates a big change, while a stable pressure would give a result of 0. Prior to installing the new valve, the S3 number was 235 but dropped to 80 after installation, eliminating the dangerous transients and line breaks. (see Fig. 2).

GUC have been completely satisfied with the results and have already replaced another 18" valve. Plans are in place to replace several more valves in the future.

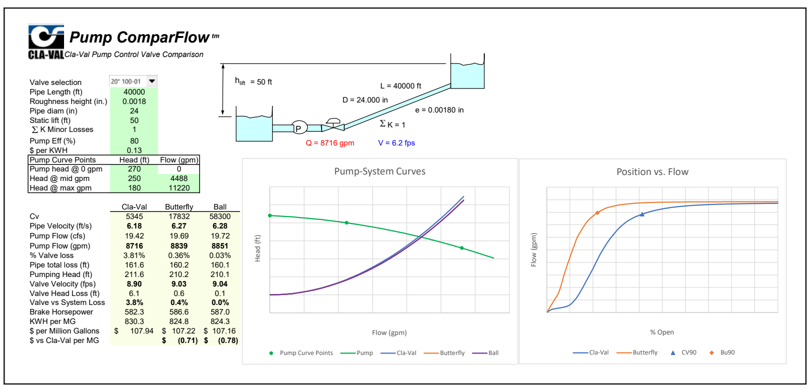

Figure 1. *This is a Cla-Val developed software program for analyzing controllability of control valves in pumped systems, looking at installed valve characteristics,published valve curves, pump and system curves. Courtesy of Cla-Val.*

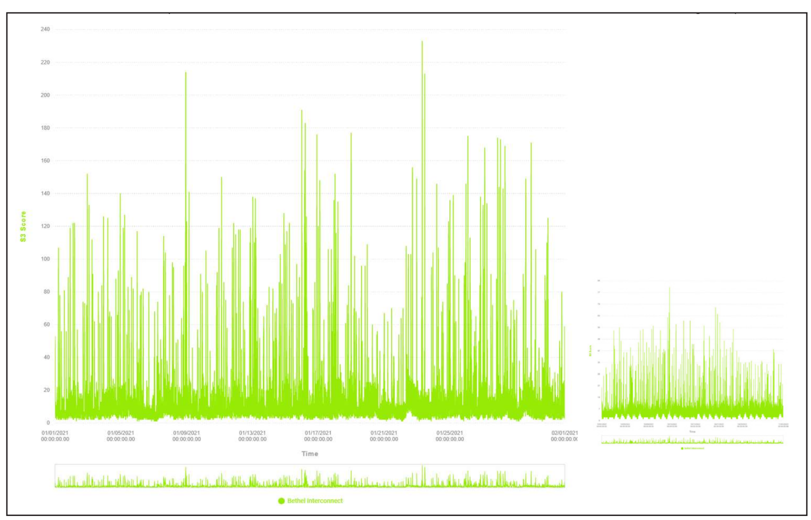

Figure 2. *Graph showing S3 readings. Courtesy of Syrinix.*

63 Series

(100-01 Main Valve)

PUMP CONTROL VALVE

Product Features

- Valve can be sized for minimal head loss
- Eliminates surges due to starting and stopping of pumping system
- Electronically control opening and closing speed, time and position
- Programmable control curves for optimum opening and closing rates
- Multi-function capability; hydraulic check feature
- Real time data transmission of pressure, flow and position
- Uses line pressure for operation (no hydraulic cylinders or motor actuators required)
- Manual bypass capability
- Service without removing from line

Main function

- The CLA-VAL 63 SERIES is an electronic pump control valve designed for installation on the discharge of booster pumps to eliminate pipeline surges caused by the starting and stopping of the pump. The valve is controlled using the CLA-VAL PC-22D Pump Control Panel and has the option to interface with SCADA systems for retransmission of pressure, flow rate, valve position, and valve alarms.
- When the pump is started, the PC-22D Pump Control Panel signals the control valve to slowly open. A programmable control curve can be set to optimize the opening time. The completely self-contained control system accurately meters and controls flow rate. Should a power failure occur, a check feature will close the valve preventing reverse flow regardless of valve position. When the pump is shut-off, the PC-22D Pump Control Panel signals the control valve to slowly close. A programmable control curve, independent of the opening curve, optimizes the closing time.

System Solutions

- CLA-VAL offers system solutions to prevent cavitation, noise, corrosion, mineral build-up, flow metering, and electronic valve control, to name a few solutions.
- Optional features including but not limited to; solenoid shut-off, check feature, return flow, and remote sensing.
- Contact CLA-VAL for full line of options!

Typical Applications