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Technical Conference Paper

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Abstract

Emergency shutdown valves (ESVs) for underground gas storage (UGS) caverns are pivotal final elements to the public safety and prevention of gas leakage and catastrophic failure, while ensuring uninterrupted transportation of energy. Specifically, surface controlled surface safety valves (SCSVs) on wellheads are considered the last line of defense after subsurface safety valves. If the SCSV fails to shut off the well, it can cause damage to humans, the environment, and property. Following the catastrophic Aliso Canyon incident in 2015, the Pipeline and Hazardous Materials Safety Administration (PHMSA) released an advisory bulletin for the operation and maintenance of UGS facilities. Among a list of actions, PHMSA advised operators to conduct periodic functional tests of all surface and subsurface safety valve systems and wellhead pipeline isolation valve(s) to ensure their proper functionality and ability to shut-off in case of emergency.

At Stream-Flo Industries Ltd., an SCSV with advanced control and diagnostics has been developed. The hydraulically actuated valve integrates sensors, control elements, edge computing, and telemetry into a single system with local and remote control. This transforms manual-reset/auto-close valves into smart low power assisted operation with self-health monitoring that can predict potential failure to shut-off and recommend corrective action. The edge computer, or intelligent valve controller (IVC), processes real-time sensor measurements and input into physics-based models to evaluate the valve, hydraulic circuit, and actuation system health.

The system has been laboratory tested with a majority of the mechanical and electrical components field validated. Test results from the hydraulic pressure and valve position data were compared between a healthy and unhealthy valve, thus providing a basis for predicting potential failure. Evaluation of the time-based sensor measurements was crucial in predicting the malfunction of the individual hydraulic circuit and actuation components. Key performance indicators (KPIs) including a new pressure intensity factor were defined to determine the existing valve capacity to fully open and close. In addition, time-based pressure signatures were used to predict and discern hydraulic pressure variances and leakage, which is critical to ensure an uninterrupted valve operation. The IVC can transmit these diagnostic results to a customer PLC/DCS or to the cloud to alert operators of a possible or pending malfunction.

The integrated system dispels many of the government and regulatory agencies' concerns towards the operation and reliability of SCSVs. The real-time health monitoring and analytics approach can be extended to other components of the cavern wellhead and sub-surface valves to develop a holistic improvement to monitoring and inspection.

Key words: Automation, Surface Safety Systems, Valve Actuation, Cavern Safety, Condition-Based Maintenance