Northeast GAS ASSOCIATION
NYSEARCH

Technology Brief

Critical Valve Operability

Description: **A project to develop a field deployable instrument to measure acoustic emissions of critical valve positioning in the gas distribution system to confirm operability.**

Status: **Engineering prototype undergoing optimization and an acoustics expert evaluating analog/digital trends with different valve position, material, size, type, and gas flow.**

BENEFITS

Within the natural gas distribution system, various valves are deemed as critical to system operation. Ensuring reliable operation of these critical valves provides safe and effective delivery of natural gas to customers. Periodic valve inspections are required to confirm operability within a distribution system. These inspections include exercising the valve and ultimately rely on knowing the valve position. At times, during inspections, exact position of the valves requires further investigation. The valve may be open, partially open, or closed. Furthermore, the valve may be broken or inoperable and unknowingly left closed following an inspection leading to a natural gas outage. Thus, a field deployable instrument that could directly identify valve position would provide more confidence and a validation method of critical valve operability for field operations.

BACKGROUND

Gas flows through a utility distribution network by differences in pressure along the pipelines. Valves are systematically placed throughout gas distribution lines to create a reduction in a specific area of the pipeline to increase the pressure difference or completely block flow in emergency situations. Increased pressure differences cause the gas to flow with some speed through the valve generating a sound. Acoustic, ultrasonic, or vibration sensors mounted on the body of the valve or connected to the valve body (via a valve key) can detect this sound. A typical valve, valve box, and valve key are shown in Figure 1.

Figure 1. Valve (left), Valve box (vertical segment above valve), Valve key (right)

Theoretically, the sound of the gas flow will change in frequency and amplitude as the valve position moves from fully open to fully closed. Partially open or partially closed valves are also expected to generate a variance in sound due to turbulence changes in gas flow.

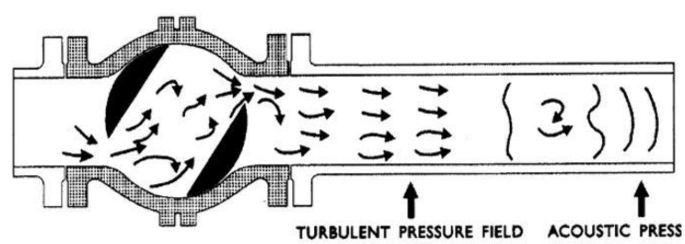

Figure 2. Flow through a partially open valve

TECHNICAL APPROACH

NYSEARCH has contracted with Bruce K. Campbell Consulting to investigate the concept for using acoustics to confirm exact positioning of critical valves.

The tasks of this project focused on the development of a critical valve position indicator that uses changes in the sound generated by the gas flowing through a valve to represent valve positions. This non-invasive technology will confirm the valve can isolate gas flow and block pressurization. Along with an acoustics emission measurement, the instrument will incorporate a digital signal for visual verification by operators.

The approach distinguishes sounds that differ based on valve position changes. The sound of gas flow over the critical valve will be measured by an accelerometer mounted on the valve key housing. It is amplified and converted from analog to digital readings, and evaluated by an operator with noise-cancelling headphones and a visual display of the sound.

One method to visualize the measurement of multiple frequencies is with a frequency amplitude plot. Amplitude is the measure of how loud a certain sound is and frequency is the measure of the pitch of a sound. Incorporating time, frequency, and amplitude in a plot such as the one shown in Figure 2 can be used to acquire acoustic data, perform signal analysis and display and record results.

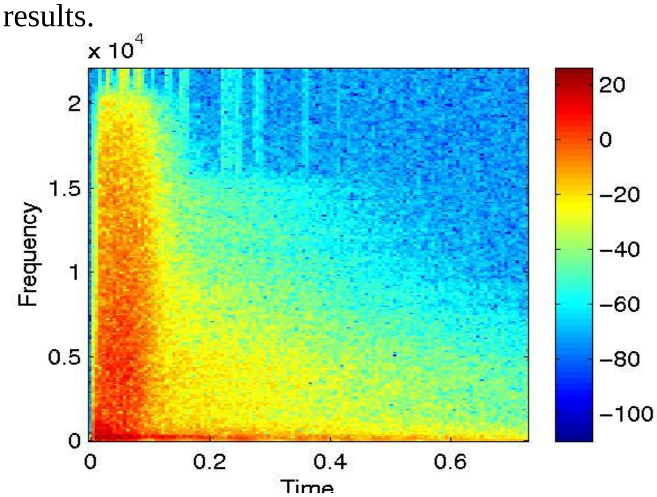

Figure 3. Frequency, time, amplitude plot

Various portable data acquisition systems are being evaluated for ease of field use. An application through smart phones or tablets (iOS or Android) serves as a more modern system for operators. Many utilities use rugged laptops, "Toughbooks" and those serve as another alternative to display and record acoustic measurements in the field.

The initial prototype system was designed based on an extensive survey that collected information on the needs and characteristics of utility valve systems. In general, all valve keys were custom made for each utility's critical valves and all used a T-handle to access valve boxes.

A test flow loop was fabricated with five representative critical valves installed and tested with the acoustics prototype. All valves were tested in low and high flow conditions and in low and high pressures. Changes in valve position were successfully detected by the change in sound of the flow going through the valve both visually and audibly. This initial testing demonstrated the proof of concept for critical valve position indication using acoustics technology.

Figure 4. Field testing of prototype acoustic system

PROGRAM STATUS

The acoustics system prototype is undergoing standardization to include a combination of off-the-shelf parts to execute repeatable and reliable field test runs. Also, various options are being further considered for visual display of acoustics measurements. Once the prototype is refined to be field-deployable, long term field testing at participating company locations are to be completed. Long-term field test results would determine the full application of acoustics technology in evaluating critical valve operability.

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