The Relationship Between Safety and Natural Gas Distribution Pressure

by Ben Inkrott

The 2018 gas explosions in the Merrimack Valley region of Massachusetts and the Pipes Act of 2020 put a spotlight on natural gas distribution pressure. Industry professionals understand that managing pressure is a critical and necessary part of delivering natural gas safely and efficiently from point A to point B. But, when pressure is not appropriately managed, it can lead to catastrophic consequences.

Utilities have many tools at their disposal to manage gas pressure safely, such as regulators and SCADA systems. In addition, emerging technologies are now available, such as residential smart meters with pressure sensors and valves and battery-powered devices/gateways, that can monitor pressure in even the most remote locations. By combining new and old technologies, utilities can monitor real-time pressure throughout their entire gas distribution system while providing safe and reliable gas.

Science Rules

Pressure is essential to natural gas distribution systems and is a fundamental element of several physics equations, including many gas laws: Ideal Gas, Gay-Lussac, and Boyle's. We may not be physicists, but we know that temperature, pressure, and volume are all related.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Pressure is directly proportional to temperature. As temperature increases, pressure increases (Gay-Lussac's Law). However, pressure is inversely proportional to volume. So as volume increases, pressure decreases (Boyle's Law). Additionally, thermodynamics tells us that energy flows from high concentrations to low concentrations. Or, in simpler terms, energy follows the path of least resistance. This means that high pressure flows to areas of low pressure. Pressure is also significant because the higher the pressure, the more gas that can be contained in a cubic foot.

These fundamental physical properties explain how pressure is a critical component of natural gas distribution.

Pressure plays a vital role in the distribution of natural gas. It's precisely what gets natural gas from point A to point B in the system. Compressor stations are strategically placed along the pipeline to increase pressure and keep the gas moving. Regulator stations are also placed along the pipeline to knock pressure down to safe limits for distribution. When natural gas reaches the residence, pressure is what allows it to flow to the right appliances.

While pressure is the lifeblood of natural gas distribution, it can also be its Achilles' heel. In 2018, three communities in the Merrimack Valley were rocked by gas explosions. This disaster was caused by failed pressure regulation upstream that resulted in residences seeing dangerously high pressure. The explosions caused death, injuries, and hundreds of millions in damages and lawsuits.

Pressure Regulation

The Merrimack Valley incident is a reminder of just how critical it is to manage natural gas pressure in a distribution system. In the past, utilities have deployed several solutions to actively manage the pressure. A common approach is to use residential pressure regulators. These devices, located at the residential meter, help reduce pressure in high-pressure distribution systems so that common household appliances can safely use natural gas. Often, these regulators remain in the field for over 20 years and can be a "set it and forget it" technology if there isn't a change-out program. However, if regulators are left in the field too long, they can rust or have a build-up of dirt and debris, causing them to be unreliable at regulating pressure. Therefore, utilities will often have change-out programs to prevent regulators from being in the field too long.

However, not all-natural gas systems have these in place. For example, in the Northeastern United States, low-pressure distribution systems are common. Pressure is reduced to the residential pressure at an upstream regulator station, and the gas flows continuously at low pressure until finally reaching the residence—where there is no pressure regulator at the meter. In low-pressure distribution systems, an over-pressure event upstream is passed down to all customers on that system. This is precisely what happened at Merrimack Valley, which led to the enactment of the Pipes Act of 2020.

The Pipes Act of 2020 requires upstream regulator stations to have a secondary or backup pressure-relieving or overpressure-protection safety technology. It also calls for the gas pressure of low-pressure distribution systems to be monitored at locations of critical pressure-control equipment like regulator stations.

Before this legislation, it was enough to "report" as opposed to "monitor." While this change seems subtle, it carries significant weight for utilities. Reporting is typically done passively with a chart recorder or even manual reads recorded and viewed after the fact. Monitoring requires that a device be able to measure, record, and actively communicate. This way, changes in pressure are managed proactively.

Many gas utilities monitor their pressure using line-powered SCADA systems. These systems provide timely and accurate insight at critical pressure locations, plus they offer real-time alarms and shutoff valve actions if there is a pressure emergency. The challenge is that it can be expensive—especially if it's located in a remote area.

Monitoring Pressure at Regulation Stations

Merrimack Valley and the Pipes Act of 2020 are fostering product innovation. For instance, utilities are now using Advanced Metering Infrastructure (AMI) to monitor pressure in remote locations where line power isn't available, or setting up a SCADA system is cost-prohibitive.

Utilities are using battery-operated devices/gateways with pressure sensors to replace chart recorders. This allows real-time pressure monitoring at out-of-the-way pressure regulation stations. In addition, utilities can aggregate the pressure data from these devices with SCADA data to provide a system-wide view of pressure for even the most isolated locations.

These battery-powered devices/gateways also enable real-time pressure alarms based on configurable thresholds. Not only can they be fixed at a regulator station, but they can also be an integral tool in the technician's tool bag. Battery-powered devices/gateways can be tapped anywhere along the distribution line to get a snapshot reading of pressure. That pressure data can then be transmitted over the network and aggregated with all other pressure data sources.

Residential Pressure Monitoring

Not only can AMI help utilities monitor pressure at regulator stations, but it can also help at the home. Some residential smart meters have integrated pressure sensors to transmit data and alarms. Utilities have never had this granular pressure data at their fingertips before, and it's helping to enable an advanced level of safety.

The Sensus Sonix IQ™ is one of the first smart meters that has an integrated pressure sensor. The pressure sensor enables edge intelligence that allows the meter to close an integrated shutoff valve in a high-pressure scenario. Had a smart meter with a pressure sensor and valve been on those homes in Merrimack Valley, the damages to property and loss of life might have been prevented. The meters would have

sensed a high-pressure event and closed the valves automatically. The utility would have been notified in real-time and been able to contact customers for a speedy evacuation.

High-pressure events at the home tend to get the most coverage, but low-pressure events can be just as dangerous. A smart meter with valve and pressure capabilities can help there as well. Take, for instance, an outage. If a customer loses pressure and the pilot light goes out, a smart meter can detect the low-pressure event and shut the gas off. This safety measure prevents a potentially dangerous situation

By having clear visibility into their system, utilities can make decisions based on edge intelligence. For example, utilities can take a proactive approach to regulator change-outs and repairs. There are regulators that have been in the field for over 20 years. Smart meters can inform the utility when the regulator is failing, if dirt or debris is present, is not set correctly, or when a service line valve is not fully open. It's not uncommon for utilities to find that a regulator was rusted out in the inside, and it was time for a replacement. After never seeing this level of pressure data, a utility may be surprised at just how much pressure variation there is at the home. This data is helping utilities rethink their change-out programs and make repairs before safety issues arise.

There's also a fiscal component to pressure monitoring. Pressure can impact the amount of gas contained in a cubic foot. If a smart meter shows that delivery pressure at the residence exceeds the intended delivery pressure, then the utility is "giving away" gas. The higher pressure allows for more gas to be packed into the delivery. The opposite is true at lower than anticipated delivery pressure, with the customer not getting the value for what they paid. Either way is a problem.

The Path Forward

Pressure is a critical component of natural gas distribution. When it is not managed correctly, pressure can lead to catastrophes. The Pipes Act of 2020 takes a step forward by providing pressure monitoring and management requirements for utilities, but it doesn't dictate the technologies to implement. There are many technologies that utilities could implement to harness the power of pressure in their distribution systems. It's not a one-size-fits-all approach but a collection of technologies that provide insight into their overall current and historical system performance. Combining next-gen technologies with existing solutions provide utilities with a clear path forward and will help prevent another Merrimack Valley disaster.