# THE POWER OF PROACTIVITY

Figure 1. Population centres worldwide have been built on top of existing gas pipeline networks, creating a series of high consequence areas (HCAs) that require continuous monitoring.


**Phanindra Kanakamedala and Greg Morrow, Emerson, USA, consider leak detection, risk mitigation and tightening regulatory environments.**

With the industry's ever-tightening leak detection and rupture mitigation requirements, regulators are recommending the use of advanced technologies for oil and gas companies to manage their operations safely and profitably. The risks of not having critical data when needed are becoming too great for operators of gas and liquid pipelines and storage facilities.

The latest round of PHMSA's 'Mega' rulings is only one part of a new regulatory landscape unfolding in the US and globally. The emphasis now is on the continuous monitoring of pipeline integrity, and facilitating early detection of anomalies that could indicate a leak or the potential for rupture.

## Leak detection and pipe

Occurrences of leaks and major ruptures are rare, as pipeline systems and networks remain the safest, most economically sound method of transporting energy resources. Historically, leak detection and containment were not as high of a priority for some gas distribution, transmission and gathering pipelines, and hazardous liquid pipelines, as they were being developed.

Earlier pipeline systems were built according to the standards of their time, with more or less robust safety measures. Most of those systems have made marked improvement in safety measures – particularly liquid pipelines – undergoing retrofitting and upgrades to improve safety and comply with regulations. As high-consequence areas (HCAs) have been redefined and expanded, more and more pipelines need to meet higher standards to achieve safety, match industry best practices, and meet regulatory requirements.

## 'Mega' prism: gaps in leak detection

PHMSA stipulations impact many US onshore gas transmission and hazardous liquid pipelines, regardless of size or location. Safety and reporting requirements now extend to more than 400 000 miles of

gas gathering lines. Of note are the tens of thousands of miles of previously unregulated pipe under federal governance.

The federal agency's management of change (MOC) definitions have been broadened concerning "significant changes that pose a risk to safety or the environment." This type of regulatory vocabulary can be viewed as a prism for contemporary alignment, reflecting growing concerns around pipeline integrity management and safeguarding population centres, as well as ties to public perception, reputation management, and the clean energy future paradigm.

Industrial manufacturers such as Emerson have been developing technologies to satisfy legal requirements and corporate responsibilities, exceeding mandates for current leak and rupture detection, and addressing pipeline operators' needs through these evolving lenses. A highly collaborative effort between manufacturers and end users is paramount to ensure technologies remain aligned to the latest industry requirements.

The international governing bodies tend to take cues from American-recommended practices with NTSB, API and GPSA standards often being a measure applied for many companies. Gas pipeline operators are anticipating accelerated growth in regulatory activities and strict non-compliance penalties on both state and federal levels. This is occurring in tandem with a global emphasis on emission reductions and emerging opportunities in the hydrogen and carbon dioxide pipeline market sectors.

All the new rules and their ramifications are providing a global forum for proactive dialogue that centres on addressing the leak detection and mitigation valve installation needs and challenges. It is becoming clear that leak and rupture detection technology guidelines on state and regional platforms could exceed federal requirements, and there is room for greater collaboration to identify the potential for any gaps head-on.

## A new degree of urgency

Any high-pressure or volatile fluid could, and should, be contained and regulated to the right degree. The Mega Rule and the probability of future pipeline legislation add a new sense of sense of urgency and 'meat to the bone'.

For some pipeline companies, this involves implementing leak detection systems where they might not have existed before, conducting integrity assessments for the whole pipeline, and enhancing emergency response plans for entire or continuous systems. This is particularly true for the clean energy future.

The US federal government is aligning the ongoing leak detection and mitigation conversation squarely with efforts to uphold the public's trust, at the same time weighing the cost and benefits around the proposed new development of critical oil and gas pipelines and blended energy infrastructures.

As repair mandates are determined by leak severity with requirements for operators to act quickly to protect people and mitigate the release of emissions, the rules additionally provide latitude and options for pipeline companies to implement innovative and readily available technologies.

A 1Q24 written testimony of a PHMSA deputy administrator before the US House of Representatives Committee on Energy and Commerce reflects how the government is doubling down on the regulatory and environmental perspectives. Accessing leak detection and rupture mitigation capabilities amid new energy transportation and product storage infrastructure solutions on the horizon are being unambiguously identified as a critical link:

"The Notice of Proposed Rulemaking (NPRM) updates decades-old, federal leak detection and repair standards are in favour of new requirements that add an additional layer of safety by deploying commercially available, advanced technologies to find and fix gas leaks that previously may have gone unrepaired in perpetuity."

## New leak detection enforcement mode

In 1Q24, PHMSA was tracking a dozen active hydrogen pipeline research projects, reflecting approximately US$11 million in research investments. The concern is how to safely transport and store hydrogen and hydrogen blends by repurposing existing infrastructure used for natural gas transport and underground storage and improving hydrogen leak detection.

At least four projects were actively being used for the determination of impact areas related to the safe operation of $CO_2$ pipelines, including the probable impact radius for carbon dioxide, innovative leak detection methods, material testing and qualification for repurposing pipelines and underground storage facilities for $CO_2$ transport and storage.

PHMSA, citing its investigation and enforcement activities involving the 2020 pipeline rupture in Satartia, MS, has made $CO_2$ pipeline regulation a top priority, noting an intention to issue a Carbon Dioxide and Hazardous Liquid Pipeline Safety NPRM this year. This incident in Mississippi has opened another door for government intervention to ensure compliance with industry best practices, similar to the 2010 San Bruno, CA natural gas and Marshall, MI crude oil pipeline events, which ultimately became trigger points for some NTSB recommendations now being implemented.

In 2021, 2022 and 2023, PHMSA announced that it set records and last year alone issued over US$12.5 million in proposed civil penalties against operators who did not comply with safety regulations.

Moreover, on the state level, with Colorado as just one example, they appear to be following suit on stern regulations and strict penalties for gas pipeline operators on leak disclosures and line locations. It was reported that new rules in the state were set to double the maximum civil penalty per violation to US$200 000 for non-compliance.

## Faster response, complete isolation

Among notable Mega Rule provisions are requirements for identifying pressure loss and the need for rapid response to gas pipeline ruptures and leaks. The rules specify criteria for the installation of remote-control or automatic shutoff valves, or equivalent technology, at strategic locations and other requirements to ensure affected gas pipeline sections can be completely isolated.

Operators are required to identify ruptures – and close valves to isolate the ruptured segment as soon as practicable – not exceeding 30 minutes from rupture identification. Criteria and levels of complexity differ and may include situations where there are unexplained liquid or gas flowrate changes due to an equipment function, any large release of gas, a fire or explosion in the near vicinity of the pipeline, amid other variables.

**Figure 2. Advanced software with GIS capabilities provides control room operators with a clear view of a potential leak point.**

Is it limited to one location? Are multiple locations impacted? Is it an outage situation? How can leaks be detected and locations pinpointed more strategically and effectively, expediting a response to mitigate the impact of pipeline ruptures?

Among the primary concerns is what's next on the horizon for monitoring and detecting leaks and mitigating ruptures. How many rupture-mitigation valves (RMVs) are necessary? What factors must be considered when determining where and how far apart they should be located?

## Leak surveillance, penalties for oversight

Strides have been made in technologies linked to strategies for recurrent leak surveillance, including how government access to satellite imagery could be readily available and used by regulatory bodies to monitor occurrences such as venting, unlit flares, and emergency release scenarios.

If a leak goes undetected between a company's internal inspection milestones but picked up sooner by regulatory monitors, this can translate into heftier fines, and more cumulative penalisation. If an opportunity to proactively discover and more cost-effectively remediate a leak event is missed, they could be fined for the entire assumed duration of the leak. This is just one example of a regulatory occurrence that the use of the right leak monitoring technology could prevent or fix.

On the other end of the spectrum, pipeline ruptures require rapid response to protect lives, assets, and the environment, and limit impacts, while doing everything possible to maintain the public's trust. If a breach occurs, the technology must accurately and reliably recognise it to ensure pipeline controllers can take confident action to rapidly remediate the situation.

## The right detection, actual localisation

Technology manufacturers are responsible for consistently emphasising the ability to detect and locate, leveraging sophisticated methodologies for identifying and analysing leaks and ruptures. The components and applications vary by oil and gas company, individual specifications, and requirements. One pivot point hinges on the ability of actual leaks or ruptures, not false alarms, to be discovered.

This must allow for operators to be alerted quickly so that a proper response can be facilitated before leaks result in stiffer penalties or situational unmanageability grows. Emerson's PipelineManager software enables rapid detection and high sensitivity to both large and pinhole-sized leaks through statistical analysis and filtering techniques. These advanced capabilities enable companies to achieve more immediate and cost-effective remediation as any leaks can be identified and localised, faster.

## Methods of leak, rupture detection effectiveness

Different methodologies for leak detection include those based on volume or mass balance versus direct instrument monitoring. PipelineManager software utilises both model-based and non-model-based methods. This allows for the selection of the most appropriate technique based on engineering assessments.

The software offers advanced data reception and processing capabilities. Data are integrated from various sources such as flowmeters, pressure sensors, and temperature gauges, to construct a comprehensive real-time picture of pipeline operations. This integration allows for the continuous monitoring of pipeline integrity, facilitating early detection of anomalies that could indicate a leak.

PipelineManager software enhances rupture detection by analysing deviations in flow and pressure measurements, ensuring accurate identification under various operational modes such as pressure control, flow-control, shut-in, or slack conditions. Model-based methods are highlighted for enabling fast and accurate leak detection even in transient conditions. These methods are robust across various operational scenarios – used for low flowrate and product theft scenarios to enhancing rupture mitigation efforts.

PipelineManager software is based on modelling technology that provides pipeline leak detection and localisation, batch composition tracking, automated forecasting, facility planning and operator training, as well as multiple leak detection technologies to detect ruptures.

Deviation analysis and sophisticated statistical evaluation is employed by PipelineManager to differentiate rupture signatures from normal operational changes. Moreover, the software's MAOP monitoring ensures operations do not exceed the safety limits for pressure, critical for preventing incidents. Built-in features enhance safety and operational efficiency via real-time data and alerts for critical parameters.

Operators can generate reports that are shared with authorities, satisfying auditing needs and demonstrating compliance with regulatory requirements. Real-time progression of corrosion and erosion monitoring from anywhere, and long-distance pipeline monitoring can also be set up.

## A meaningful response

An integral piece of PipelineManager software is tied to improving alarm reliability and increasing operator confidence in an appropriate and meaningful response. The quality of input data here is central. Inconsistencies can result in more frequent false positive alarms, with operator fatigue and the potential for control room complacency both at stake.

**Figure 3. Emerson's PipelineManager software uses statistical analysis and filtering techniques to ensure leaks can be quickly identified and localised.**

PipelineManager software enables pipeline companies to sustain high-performance levels with its demonstrated ability to be highly effective in detecting leaks incisively and with minimal false alarms. It can alert on ruptures during events that typically hinder other systems, like pump trips and flow starts. It also reduces sensitivity to transient effects and adapts to various conditions.

It additionally accounts for data from a SCADA system and performs real-time transient modelling using a fully thermodynamic, first principles physical model (a digital twin of the pipeline) to determine if a leak has occurred.

## Leak detection, risk mitigation

Pipeline companies stand at a critical juncture, balancing calls for more robust gas pipeline safety and security prerogatives that are in step with emission reduction goals and the ability to meet rising global energy demands. The development of many mainline gas pipelines in the US occurred more than 60, or even 80, years ago. A few Civil War-era gas distribution segments still exist – that's over 150 years in the ground.

The selection of the appropriate methodology is more of an engineering assessment, considering performance criteria, cost and instrument availability rather than a proving exercise for a particular leak detection technology.

The aim is always to ensure that leaks are discovered and repaired before they can degrade into more serious ruptures.

## Overcoming future leak detection complexity

Proposed rulemaking around advanced leak detection programme (ALDP) performance standards and requirements underscore realities, bringing those associated with establishing minimum standards for evaluating criteria for leak grades and repair schedules that much nearer. There will be vital impacts as they decide how to approach regulations with natural gas, hydrogen and $CO_2$ pipes each at the forefront of a safe and clean energy transition narrative.

When it comes to peeling back layers to identify any potential gaps in strategic leak detection and rupture mitigation strategy and the implementation of an optimal technology, proactive action is the greatest shield against ambiguity or uncertainty.