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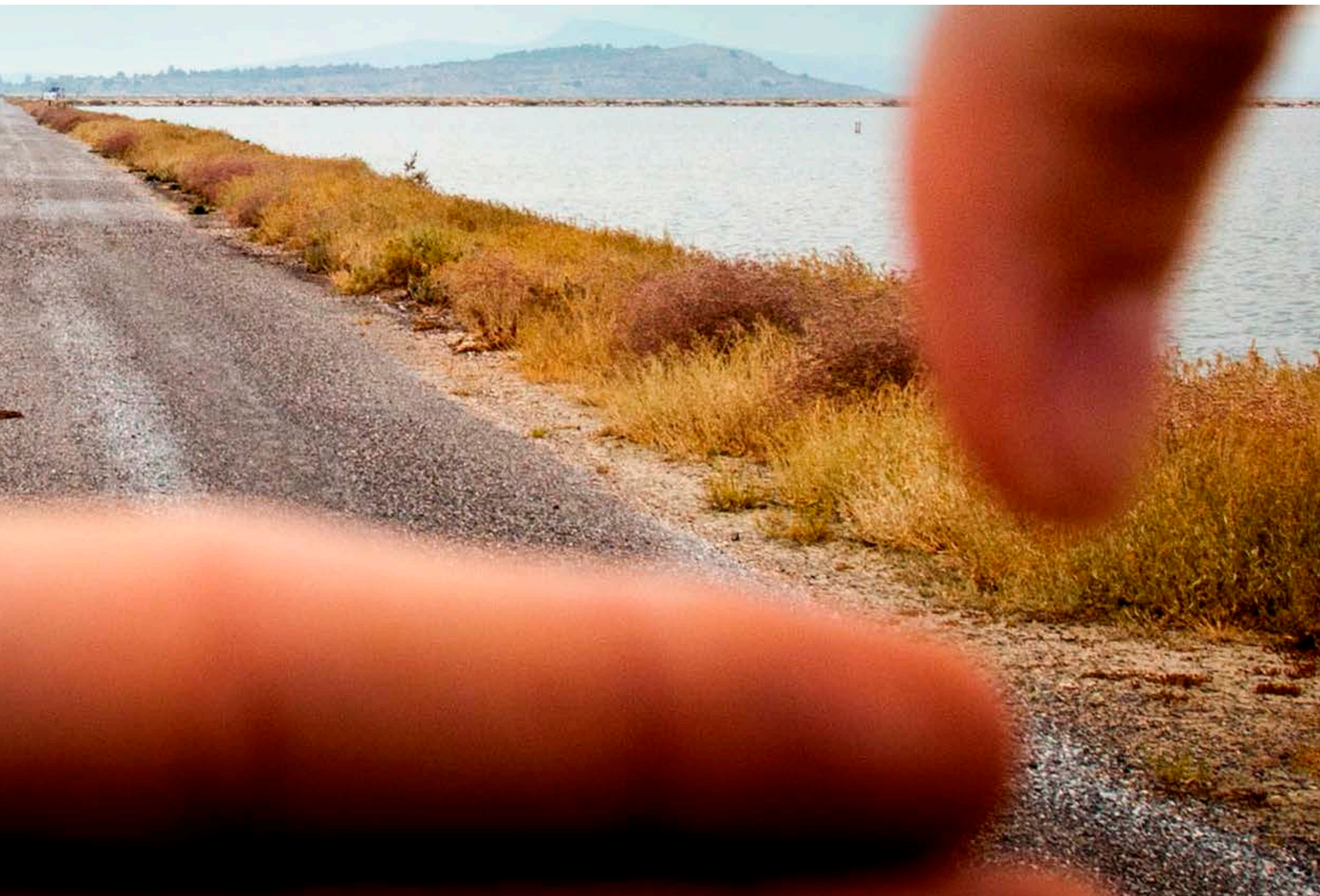
THE
EXPECTED

Dr. Jun Zhang, CEO of Atmos International, UK, highlights the importance of a combined approach to integrity management.

Pipelines exist in some of the harshest conditions possible. From the frozen climates of Canada and Russia, to the arid deserts of Africa and the steep mountains of Latin America, pipeline operators not only have to operate in challenging conditions but also maintain legacy pipelines dating back decades or more. While technology today is more advanced than ever, the cradle-to-cradle approach of understanding the lifecycle of a pipeline is increasingly important. Despite this mindset, pipelines are still vulnerable and require careful management, particularly in sensitive environments such as high consequence areas near waterways.

One of the largest pipeline regions, the US, has clear regulations in place to guide operators and the supply chain. As well as undertaking regular inspections, evaluations and maintenance,



areas at considerable risk of failure must be prioritised. API recently issued Recommended Practice 1160 (RP 1160) 'Managing System Integrity for Hazardous Liquid Pipelines' (February 2019). This underlined the need for robust processes for the assessment of potential risks, and the establishment of safety systems across a network. In addition, RP 1160 outlines how operators and owners need to ensure these assessments are sustained and managed regularly.

As engineering standards advance alongside a greater environmental concern, integrity is essential. Within the mining industries, pipelines operate under immense conditions, reaching elevations of thousands of feet in hard to reach remote areas. In Russia, the operator of the Eastern Messoyakha field is now using drone flights along the 485 km pipeline leading to its terminals. Drones can provide expert visual assessments, including 3D visualisation and heat mapping, enabling engineers to assess physical repairs from long distances. However, limitations such as weather conditions do apply.

For essential supply pipelines such as gas and water, failure to deliver can have serious impacts on customer service and operational licences. Additionally, within the gas sector, a drive to meet 2050 carbon emissions means that old pipelines will need to be replaced by 2030.

Multi-disciplinary approach

A combined approach and way of thinking are necessary, collectively known as pipeline integrity management (PIM). Working as part of a multi-disciplinary team, partners such as geologists, engineers, software specialists and pipeline manufacturers can apply their knowledge, experience and combined expertise to assess pipeline integrity. In short, there is no single solution to pipeline integrity, and each aspect needs to be considered in the context of its implications to another. For example, seismic movements, metal strength and fatigue, and the internal conditions of the pipeline can all affect the pipeline integrity. Operators who apply this mode of thinking – a form of continuous improvement and total production maintenance – will undoubtedly have better reliability, safety and performance across their networks.

While in the past, some leaks were tolerated as 'part of the process', catastrophic failures and incidents have enforced a major shift in attitudes. API standards have played a role in this, alongside government legislation and regulations, but equally, PIM now has professional status – creating higher visibility within organisations. The three pillars of responsibility are applicable to pipeline integrity:

- Environmental – no damage to the environment, or mitigated at worst case scenario. Geography should be considered when designing pipelines.
- Social – protecting people and communities, especially in high consequence areas and large population density areas.
- Economic – de-risking, cost and liability management.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) regularly records details of pipeline breakdowns in the US. Common causes include:

- Corrosion.
- Excavation damage.
- Incorrect operation.
- Weld failures.
- Equipment failures such as pumps and valves.
- Natural forces such as weather.
- Other outside forces such as vandalism.
- Theft.

Putting additional tools to the test

When considering pipeline integrity management, all the above causes of pipeline failures need to be considered. But how can the internal condition and operation of a pipeline be monitored? Operators have several solutions available to them, including the expense of pigging. With the costs likely to be in the tens of thousands of dollars, pigging does come with financial and operational impacts. Although intelligent or smart pigs have been developed, there are limits to the amount of data and insights it can provide. Also, in several cases, pigs get stuck in pipelines, causing further damage and loss of operations. Inline inspection tools can also assist in identifying any changes and areas of concern, including metal fatigue, corrosion, cracking, and pipeline deformities.

Hydrostatic testing can also provide integrity assessment, though the equipment may become vulnerable if pressures are exceeded or hairline cracks open within the pipeline wall. However, these only provide a short window snapshot and do not provide insights for future pipeline problems. Hydrostatic testing should be part of an overall methodology, especially where potential problems may occur.

Leak detection: the last piece of the jigsaw?

Modern pipelines now have leak detection systems (LDS) installed as part of the pipeline commissioning. Legacy pipelines often require additional LDS, especially the use of non-intrusive technologies. Even if PIM is in place, there are still risks of pipeline failure.

Leak detection systems offer the final piece in mitigating the impact of leaks, especially in hard to predict situations such as theft, vandalism and natural causes such as landslides and sustained periods of harsh weather.

The concept of computational pipeline monitoring (CPM) is well documented and there are several suppliers that will provide LDS.

CPM technologies include:

- Acoustic or negative wave pressure.

- Pressure and flow monitoring.
- Statistical analysis.
- Real-time transient model.
- Line balance.

Operators select the most appropriate methods depending on the fluid type, pipeline length, operating conditions, performance requirements and instrumentation. However, there are some benefits to using one CPM method over another. One size does not fit all, and it can often be a challenging task for operators to choose the right method. Expert suppliers can combine different methodologies for an integrated system using a 'best available technology' approach.

Beyond traditional integrity challenges

Theft is also an increasing problem when it comes to maintaining pipeline integrity. As seen in Mexico earlier this year, theft can have catastrophic outcomes: hundreds of casualties, with pipelines made extremely vulnerable to additional ruptures. Theft detection and location are therefore vital to mitigating the impacts of theft and vandalism. While some thefts are extremely sophisticated – with some industry experts claiming they had hired the people who welded the tapping points – many thefts are rudimentary and use crude smash and grab techniques, including using t-shirts as bungs to attempt to reduce the flow of product escaping.

Leading LDS providers also offer increased accuracy in terms of leak location, combining GPS technology, offline analysis and network mapping – enabling faster response times to mitigate leak impacts.

Conventional leak detection methods search for small leaks as well as ruptures. Rupture detection is a back-up to the existing SCADA system that is designed to stop pumping should a pipeline rupture occur. Otherwise, the operator could try to restart the pipeline, believing that the pump has just tripped, spilling more product through the ruptured pipeline.

Events such as instrument failure or a hydraulic anomaly can cause a false alarm. The operator has little time to confirm a leak before acting to shut down the pipeline. A pipeline shutdown is expensive and results in a loss of revenue. The emergency response costs are extremely high. To maintain operator confidence, the rupture module should not issue a false alarm or fail to alarm when a rupture occurs. A rupture detection module should:

- Not issue a false alarm during any pipeline operations.
- Detect ruptures quickly.
- Detect every rupture, irrespective of its location on the pipeline.
- Alarm even when the rupture trips a pump.

API 1175 states that potential leaks requiring immediate shutdown are 'rupture alarms or rupture indications (for example if a unit trips at stations due to low pressure).' An LDS is designed to detect the smallest leak in the shortest amount of time. Rupture detection is designed to detect the unique signature that occurs with a high volume or high rate of product release.

Rupture detection should be highly reliable, allowing the operator to confidently shut down the pipeline immediately, minimising damage.

Flexibility

In hard-to-reach areas where there is a lack of infrastructure, power, communication and instrumentation available, leak detection systems should offer a flexible approach. Advances in technology mean it is possible to install systems anywhere. Non-intrusive sensors now provide much higher levels of repeatability and data. Cost-effective applications of flow and pressure sensors along pipelines are now possible without drilling or cutting a pipeline – further preserving integrity. Combining these with high-speed data collection and transmission devices makes effective leak detection feasible in remote areas.

Legacy pipelines were not designed to operate under the pressures currently used within modern networks. This means additional monitoring and evaluation are necessary. Some technology suppliers are now able to deliver high-speed data collection and communications in a single device. This unit can provide network-enabled technology such as multi-channel data loggers, adaptable sensor inputs and onboard communications such as cellular and radio links. They can work independently or as part of a networked system. Units conform to ATEX/IECEx directives, are IP68 rated and can be used in subterranean environments. The lack of power previously provided challenges, especially in remote areas. However, rugged solar panel, wind turbine and fuel cell technology is providing pipeline leak detection and management for even the most hostile of regions.

Preparation is key

Despite the depth, knowledge and level of expertise available, not all regions have regulations in place. Equally, different geographies have their own complexities. While preventing leaks should be a priority, preparing for mitigating the impact of a release through a variety of means is essential. Therefore, PIM should extend to leak detection, theft detection and location. The combined use of all technologies including intelligent (smart) pigging, hydrostatic testing and CPM will provide increased accuracy, faster analysis and detail on pipeline breaches, small or large.

Underpinning all of this is detailed training and effective control room procedures for operators on managing leak detection systems, identifying pipeline integrity issues and establishing a risk/threat-based approach for all pipelines.