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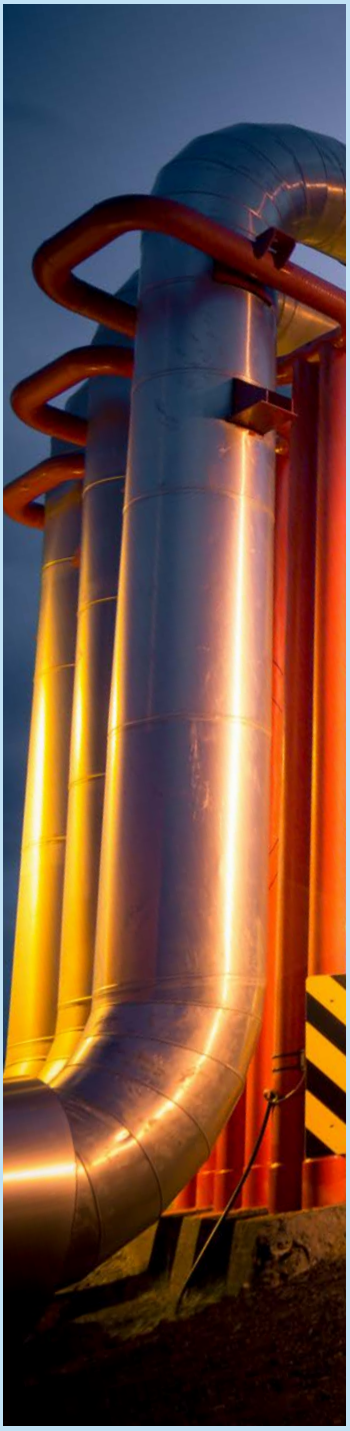

LEAKAGE DETECTION AND FLOW MANAGEMENT IN PIPELINE OPERATIONS IN OIL AND GAS

Abstract

Pipelines transport hydrocarbon fluids millions of miles across the world. Although pipelines are designed, fabricated, and installed to withstand all kinds of environmental conditions, leaks do occur. This happens because of inadequate protection of the pipeline, mechanical reasons such as weld failures, or even ageing. In some cases, vandalism cannot be ruled out. Pipeline leaks not only cause huge financial losses, but also lead to massive ecological disasters and human casualties. The importance of leak detection and management is widely understood and there is continuous research to develop faster and better leak detection systems so that the impact of leaks can be minimised.

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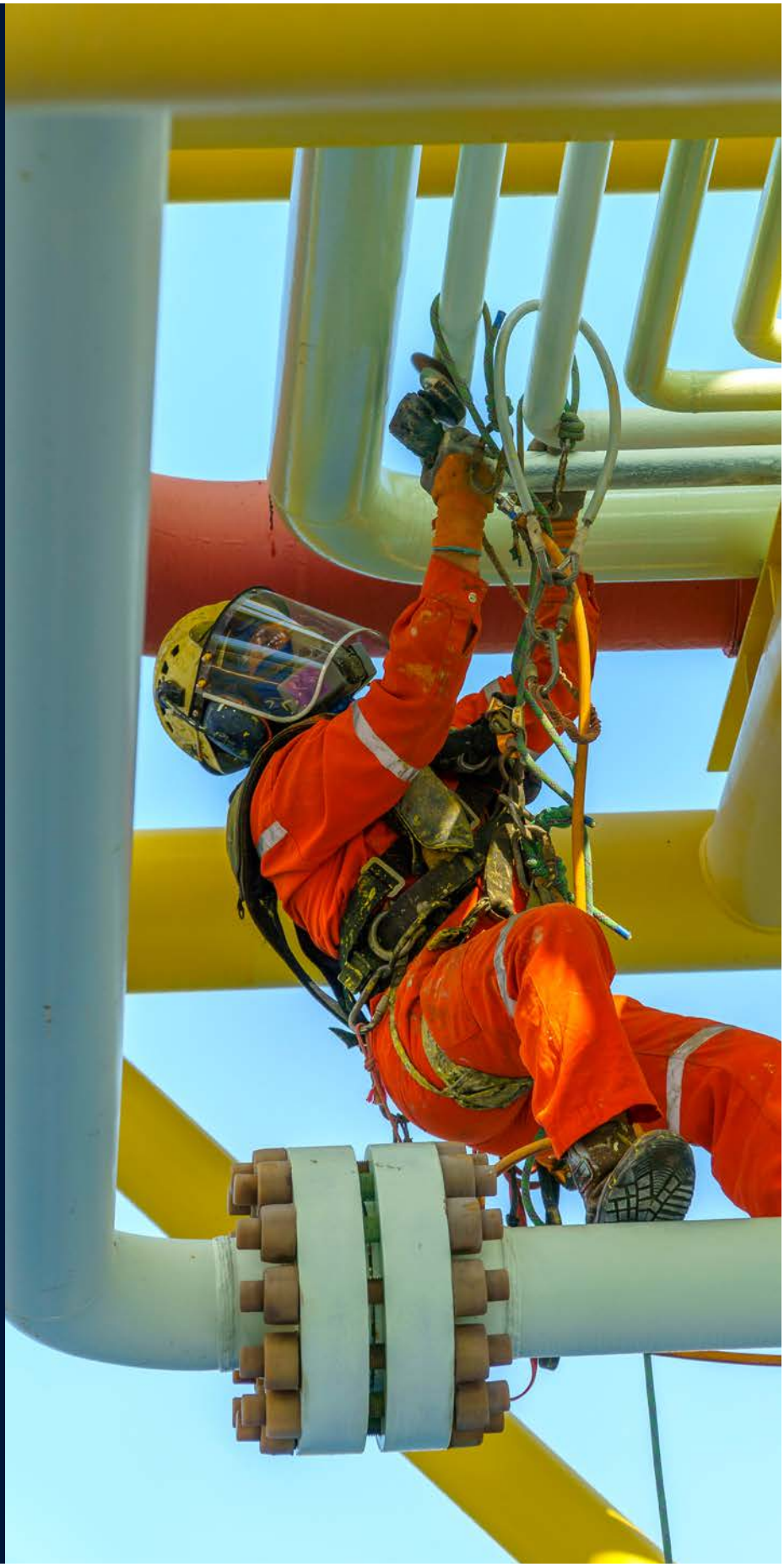
As per a GlobalData report of 2019, natural gas flows through 1.3 million km of the total global transmission pipeline network of over 2 million km. Natural gas, crude oil, petroleum products and natural gas liquids flow through nearly a million km of the global transmission pipeline network. Unlike highways and bridges, pipeline systems, when buried underground, tend to get less attention. Regulatory oversight and irregular maintenance are not unheard of. However, pipeline leaks cannot be ignored; the risks involved are enormous, as demonstrated by numerous small and large accidents. Consequently, leak detection and management is a critical function of oil and gas companies across the world.

In fact, considering the disastrous impact of leaks and spills, several countries have regulations and guidelines in place to manage pipeline operations. The goal of these regulations is to protect both the pipelines and the environment of the locations that the pipelines traverse. Germany, Canada, and the USA are some of the nations that have elaborate regulatory guidelines in place.



Leak detection techniques

The traditional approach to leak detection has been pipeline pressure monitoring. A leak on a pipeline causes a drop in pressure followed by partial recovery. This pressure pulse moves through the pipeline like a wave and operators are alerted to the leak by the changes in pressure. However, this method often involves delays in detection and false alarms too, forcing companies to look for other innovative ways.

Several sensor-based leak detection technologies are now being widely used. There are two broad types of leak detection systems – the **continuous** and the **non-continuous systems**.

The continuous systems of detecting leaks include external devices such as optical fibre cables, acoustic sensors, video monitors and semi-permeable sensor hoses for acquiring pipeline data. Internal devices detect and localise leaks by using data obtained through sensors and they depend on mathematical models for accurate results.

1. **Optical fibre cables,** when installed alongside a pipeline, use their temperature and acoustic sensing abilities to continuously monitor the pipeline for leaks. Light pulses are sent along the optic fibre by a sensor system. A change in vibration due to leaks, or any other abnormal activities, disturbs the light pulses, which, in turn, alert operators. While oil leaks are detected from acoustic changes, gas leaks are detected from temperature changes at the leak site.
2. **Acoustic sensors** installed outside a pipeline can detect leaks by changes in noise levels at various spots along the pipeline. Oil and gas leaks are accompanied by acoustic signals that vary from the baseline noise profile of the pipeline. These variations alert the parties concerned. The challenges associated with this system include the inability of the sensors to sometimes pick up minor variations in sound, leading to occasional misses and false alarms. Vandalism is also a real problem in this system.
3. **Video monitoring** is often used to monitor pipelines over short distances. Infrared sensitive filters in the video system detect leaks and show them as smoke images on the screen. Oil leaks can also be detected by the difference in thermal conductivity of dry and wet ground as detected by infrared cameras. Video monitoring is best used on company premises or other critical areas.
4. **Semi-permeable sensor hoses** installed along a pipeline can detect leaks. The hydrocarbon discharge enters the hose and reacts with a test gas. An analysing unit in the system checks for the presence of hydrocarbons. This is quite a sensitive system and even small leaks can be accurately detected. However, because of various logistical reasons, this system can be used for short pipelines only.

The non-continuous system of leak detection includes inspection by helicopter or UAV (unmanned aerial vehicle), using tracking dogs, right of way (ROW) monitoring, and pipeline inspection gauges. These processes are usually part of routine surveillance but can be implemented when a pressure drop is observed too.

1. **Helicopters** are fitted with infrared cameras or 'leak sniffers' or lasers to detect leaks as they fly over pipelines. The high costs and other practical difficulties of using helicopters have made some companies move from helicopters to UAVs. They are smaller, less expensive, and can be customised to carry different kinds of equipment to inspect pipelines.
2. **PIGs** (pipeline inspection gauges) are tools that carry specialised equipment and are launched into the pipeline. They help operators identify cracks, corrosion zones, leaks and determine wall thickness. Thinning wall thickness could help identify future leak points. Such equipment is used to clean pipelines too.
3. **Tracking dogs** are trained to detect and identify any specific leaked gases or hydrocarbons. The obvious limitation of using dogs is that they can be used over short pipelines only.
4. **ROW monitoring and patrol** involves local contractors or pipeline host communities to look after the pipeline sections passing through their communities. Pipelines in locations prone to vandalism benefit from this technique. If monitored correctly, leaks can be identified early and in an agile manner, and can be managed before any serious damage occurs.*

The need to develop more accurate and robust leak detection systems is a driving force for oil and gas pipeline operators. Data analytics, mathematical models and simulation software are all used to understand and analyse data collected by sensors. Early warning systems for pipeline leaks are being continuously developed, and today there are many models that can predict leaks with high accuracy. And the market is lucrative as well. The global oil and gas pipeline leak detection market is expected to grow tremendously in the coming years.

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