How Pipeline Management Becomes Part of a Plant Safety Strategy

Written by Chris Liston, Regional Sales Manager, HIMA Americas Inc.

A typical refinery or chemical plant contains miles of pipelines. Identifying and correcting leaks in these pipelines recently has been problematic. The potential cost of remediation and possible financial penalties due to pipeline leaks in plants has increased, as has the threat of damage to the operator's reputation from the possible negative environmental impact. →

Operators have low confidence in commercially available leak detection systems. Operators often delay action when an alarm is received from a leak detection system, risking both financial resources and corporate reputation. Fortunately, the reliability of detection systems has improved. Now, these systems have been adopted into an innovative new approach – the world's first hybrid leak detection solution based on a SIL 3 safety controller. By tightly integrating safety-related hardware and monitoring software, the solution ensures the long-term availability of your pipelines along with the maximum level of safety.

This solution is invaluable to plant managers, as it contributes to reducing the adverse consequences of incidents, improves safety by minimizing the size of leaks, and protects the reputation of the plant and its operator. Plant managers also have the added benefit of utilizing a platform that they already know and trust to carry out all their safety-related functions.

Standards and the Need for Them

Continued improvement of leak detection is necessary because many hundreds of pipeline incidents are reported across the US every year, and these numbers have not seen improvement over the last fifteen years. Material defects are the leading cause here, followed by corrosion, excavation damage and incorrect operation – although excavation has figured more significantly in past years.

In recognition of this, the American Petroleum Institute (API) has released a set of standards to be used as guidelines for the operators to help mitigate the risks and consequences of leaks.

These standards can be summarized as below:

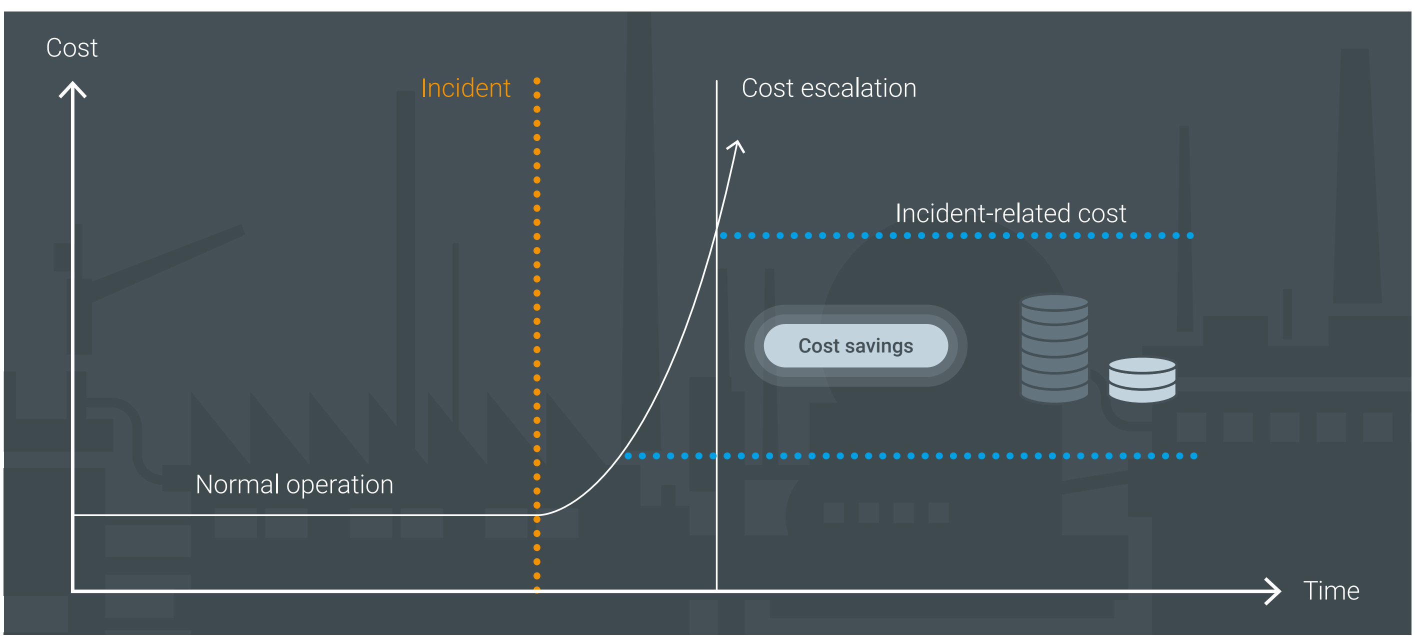
- API 1160 – Overall standard to cover all pipeline integrity management
- API 1130 – Design and implementation of leak detection systems
- API 1149 – Theoretical calculations of possible leak detection system performance
- API 1175 – Standard for the selection, operation, maintenance, and continuous improvement of leak detection systems

What to Look For

Many operators don't know what to look for when shopping around for a reliable leak detection system. There is a combination of factors to look at when evaluating the best solution. The primary four factors are summarized below:

- Sensitivity – A combination of the size of a detectable leak and the time required to detect it.
- Reliability – A measure of the system's ability to accurately assess whether a leak exists or not.
- Accuracy – The ability of a system to estimate leak parameters such as: leak flow rate, total volume lost, and leak location.
- Robustness – The ability of a system to continue to function during unusual hydraulic conditions or when data is compromised.

Every minute matters: Early leak detection saves money



The Evolution of Leak Detection

The industry's response to these standards, and to leak detection overall, has been evolutionary. This evolution can be represented as a set of four steps, of which the first – which we can call Leak Detection 1.0 – uses a single method chosen from the many available. It is worth reviewing these alternatives at this point, as they are not only used for 1.0 but also provide the building blocks for the more recent evolutionary stages. The detection methods must first be classified by whether they are externally or internally based. The external methods discussed are: Acoustic Sensor, Fiber Optic Cable, and Vapor Sensor.

Acoustic sensors are distributed along the pipeline to detect internal noise levels. Any leak produces a low-frequency acoustic noise at its location, which the sensors can detect. This method's advantage is its sensitivity to small leaks, while its disadvantages include a high number of false alarms, which can be caused by vehicles, valves or pumps, and the fact that the method's efficiency and accuracy is dependent on the operator's skill level. Fiber-optic leak sensing depends on installing a fiber optic cable along the entire pipeline length. This cable monitors continuously for temperature changes caused by pipeline leaks.The method's advantages are high leak location accuracy and theft identification. But it has a high installation cost, leak identification times can be slow, stability over time is unproven, and the entire pipeline must be excavated to install the cable. Additionally, the method does not yield any leak size data.

The last external method uses a vapor sensor. A vapor-sensing tube, installed along the entire length of the pipeline, contains air moving at a constant speed towards a sensor at the end of the pipeline. During a scan, an electrolysis cell emits a test peak of hydrogen. If vapor from a leak is detected, the system will calculate where the leak is, based on timing differences between the vapor peak and hydrogen peak arrivals at the sensor. Leak location and size accuracy is high, but the installation price is also steep. Scanning is only performed once or twice a day rather than continuously, so a leak could become extremely large by the time it is detected.

Internal Methods

Five internal or computational pipeline monitoring (CPM) methods are available.

The first is a statistical analysis method that relies on the pipeline pressure and flow profiles reacting to a leak in a typical manner. These profile reactions can be calculated by using the correlation between inlet and outlet flow as well as inlet and outlet pressure. Unfortunately, without a steady state condition, this correlation does not exist. This means that the method does not work in transient conditions, and leak location tends to be of low accuracy, only improving as the leak continues. The method does have the advantage of utilizing existing instrumentation.

Real time transient modeling, or RTTM, uses basic physical laws such as conservation of mass, conservation of momentum, and conservation of energy to create mathematical models of the flow within the pipeline. The pressure and flow profiles are calculated in time steps. When the measured flow deviates from the model, a leak is identified. To design a reliable system with minimal false alarms, the noise level should be continuously inspected to modify the models.

RTTM is very good in transient conditions, and can potentially use existing flow, pressure, temperature, and density instrumentation. However, it is very expensive to program, and continuous tuning is required. Training costs for operators to tune the system must be allowed for, and it is not always possible to obtain all the parameters necessary for programming.

The Volume Balance Method is based on the principle of the conservation of mass; what goes in must come out, unless there is a leak. This method is also used in some SCADA systems. The Compensated Volume Balance variant is the best to use in a leak detection system, as this optimizes its functionality. This version of the method accounts for changes in both pressure and temperature. Rising temperatures result in expansion and building pressures cause compression.

This method uses proven technology and algorithms, utilizes existing instrumentation with minimal programming, and remains effective in transient conditions. However, it can only estimate the leak location. The Pressure Drop Method is a simple approach that uses existing instrumentation; during shutdown conditions, a pressure drop indicates a leak. This method can detect the smallest of leaks, also known as seepages. However, it can only estimate the leak location.

Comprehensive Leak Detection Coverage

		Leak Type		
		Burst	Leak	Seepage
Pipeline Status	Shut-down	EPW PDM	PDM EPW	PDM
	Steady State	EPW VBL(A,R)	VBL(A,R) EPW	
	Transient	VBL(A) EPW	VBL(A)	

EPW: Enhanced Pressure Wave

PDM: Pressure Drop Method

VBL: Volume Balance (Absolute, Relative)

The Negative Pressure Wave method works on the principle that as a leak occurs, it generates a negative pressure wave of a known velocity both upstream and downstream of the leak. The leak location can be calculated by comparing the arrival times of the negative wave at each transmitter. The method utilizes existing instrumentation to provide extreme leak sensitivity and excellent leak location accuracy, with a reduction in false alarms.

Leak Detection 2.0 and 3.0

With the above 'building block' detection methods in mind, we can consider Leak Detection 2.0; this uses multiple leak detection methods simultaneously to provide comprehensive coverage. The approach is a combination of the best three internal leak detection methods: Enhanced Pressure Wave, Compensated Volume Balance, and Pressure Drop Method. By applying these methodologies simultaneously, system availability can be assured for all phases of the pipeline, while also significantly reducing false alarms.

This approach reduces programming costs for the plant operator. Additionally, the system requires little, if any, tuning to compensate for changes in the physical properties of the pipeline, such as corrosion or debris buildup.

The next evolutionary phase, Leak Detection 3.0, introduces the concept of Emergency Shutdown (ESD) action as well as monitoring. It concerns detection of ruptures, which, by definition, are more serious than leaks and must be handled accordingly.

Typically, a leak is classified as a rupture if it reaches or exceeds around 30% of the pipeline flow rate, although the precise value is defined by each plant operator's individual risk analysis.

Rupture detection systems were created as standalone systems operating independently of the leak detection implementation, and designed to shut down a pipeline in the event of a rupture. The leak percentage threshold at which the system reacts can be raised or lowered as necessary.

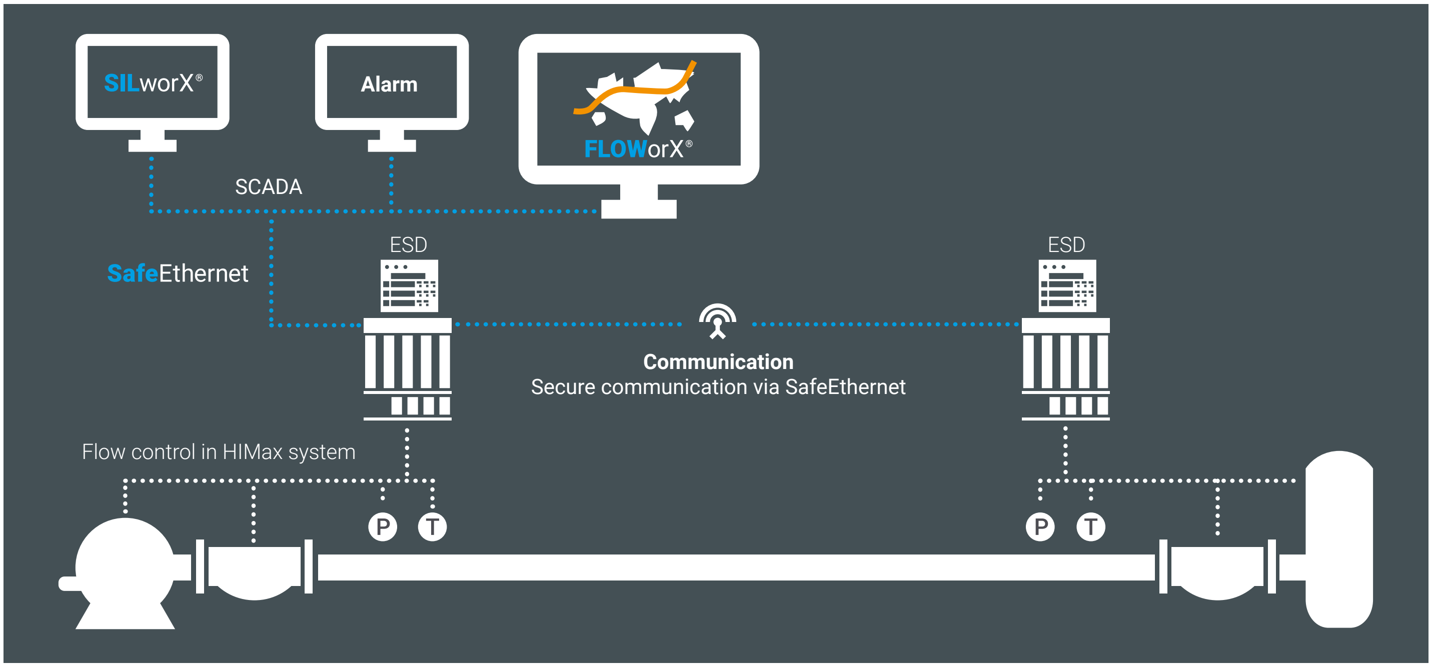
These systems are used particularly in environmentally sensitive areas where a delayed response can be damaging to the environment and the operator's reputation.

Leak Detection 4.0, SIL 3 Safety, and ESD in a Single Hybrid Package

Today, the evolutionary process has reached Leak Detection 4.0. This is an innovative approach in which a leak detection system using the multiple detection methodologies of 2.0, and a SIL 3 safety system with ESD capability, are integrated into the world's first hybrid solution.

The package is available as a complete pipeline management automation solution to help operators of pipelines in refineries and chemical plants to improve their safety. The solution controls and regulates safety-related processes for uninterrupted operation over the plant's entire lifecycle. It can continuously monitor pipelines, shut them down automatically in hazard .

The New Hybrid Solution, Leak Detection and Safety in One System



situations, and prevent or significantly reduce damage. HIMA has implemented this hybrid solution using its XMR technology that combines SIL 3 safety technology with a scalable, fault-tolerant architecture. This helps prevent false alarms, and allows unlimited alterations, modifications, extensions, improvements, and even mandatory proof tests while the plant is in operation.

The SIL 3 controller's performance and multitasking capabilities allow the operator to carry out other safety-related functions in addition to leak detection and shutdown. Successful installation and maintenance of the hybrid safety control system itself are also assured. Along with the automation components necessary for control, regulation, and monitoring of gas and liquid pipelines, the new integrated hybrid solution includes customer support and service.

Conclusion

This 'total solution' approach for pipeline management offers plant operators considerable benefits. Uninterrupted operation and maximum availability are assured, while the system complies with current and upcoming global safety standards according to SIL 3. The system also ensures maximum functional safety and extremely high reliability by automatically shutting down any affected areas during critical situations. As a result, it cuts pipeline operating costs, significantly reduces false alarms, and increases the profitability of installations.

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About HIMA

The HIMA Group is the world's leading independent provider of smart safety solutions for industrial applications. With more than 35,000 installed TÜV-certified safety systems worldwide, HIMA qualifies as the technology leader in this sector. Its expert engineers develop customized solutions that help increase safety, cyber security, and profitability of plants and factories in the digital age.

For over 45 years, HIMA has been a trusted partner to the world's largest oil, gas, chemical, and energy-producing companies. These rely on HIMA solutions, services and consultancy for uninterrupted plant operation and protection of assets, people, and the environment. HIMA's offering includes smart safety solutions that help increase safety and uptime by turning data into business-relevant information. HIMA also provides comprehensive solutions for the efficient control and monitoring of turbomachinery (TMC), burners and boilers (BMC), and pipelines (PMC). In the global rail industry, HIMA's CENELEC-certified SIL 4 COTS safety controllers are leading the way to increased safety, security, and profitability.

Founded in 1908, the family-owned company operates from over 50 locations worldwide with its headquarters in Brühl, Germany. With a workforce of approximately 800 employees, HIMA generated a turnover of approximately €126 million in 2016. For more information, please visit: **www.hima.com**

HIMA has operated in the Americas since the early 1980s. Its headquarters for the Americas is located in Houston, Texas.

Discover more at **www.hima-americas.com**

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