TELEMAC

Leak Detection - Application Note

AMMONIA PIPELINE FIBER OPTIC LEAK DETECTION IN FERTILIZER PLANT

THE SUREST WAY TO DETECT THE PRECISE LOCATION OF ANY LEAK IN HAZARDOUS SUBSTANCES PIPELINES AND PROVIDE TOTAL INTEGRITY THROUGHOUT YOUR PIPELINE NETWORK, ENSURING EFFICIENT, SAFE AND SECURE OPERATION

- Distributed Fiber Optic Sensors
- Provides Leak Detection for the Continuous Length of the Pipeline
- Ethylene, Hydrogen, LPG, CO2, Oxygen Leak Detection
- Establishes a Clear Indication of the Leak and Location
- Suitable for Hazardous Zones
- Intrinsically Explosion Safe
- Long Range Measurement
- High Resolution
- High Reliability and Confidence Level
- Immune to Electromagnetic Interference
- Cryogenic Monitoring

References

- Leakage detection of ammonia rack pipeline in a fertilizer plant (Yara Italia S.p.A.) - Italy
- Leakage detection of ammonia rack pipeline in a fertilizer plant (Yara France) - France
- Ammonia reactor vessel hotspot monitoring
- (Yara) - The Netherlands
- Leakage detection of ammonia rack pipeline in a fertilizer plant (Borealis) - France
- Ammonia leakage test (Yara Le Havre) - France
- Leakage detection of a 2.5 km of ammonia pipeline (GPN) - France
- Leak detection on hydrogen pipeline (Skotan S.A.) - Poland
- Leakage detection of 57 km ethylene Pipeline (Sasol Germany GmbH) - Germany

AMMONIA PIPELINE FIBER OPTIC LEAK DETECTION IN FERTILIZER PLANT

Over the past decades, several major industrial accidents led the chemical industries handling large quantities of dangerous substances. National regulation bodies are to reinforce the safety and prevention measures of their installations.

Leakages of petrochemical products such as **crude or refined oil, gas, LNG, ammonia or chlorine** can be at the origin of toxic releases, which can have severe consequences on the installations as well as on the environment and nearby inhabitants. Industries are prompted to take all possible measures to reduce the occurrence and the consequences of such catastrophic events by implementing additional technical safety barriers in order to prevent or mitigate any potential danger on their key structures such as pipelines, storage facilities, transfer lines and ammonia reactor vessels.

Pipeline leakages may have different origins, such as **corrosion, fatigue, material flaws, shocks, abnormal temperatures, extreme pressures, or excessive deformations** caused by ground movement. In the case of ammonia, leakages can be detected by the rapid drop of temperature due to the evaporation of the released liquid ammonia and its evaporation gases.

These local thermal anomalies can be reliably detected by a fiber-optic distributed temperature sen-sing system able to detect temperature changes of the order of 1°C, with 1m spatial resolution and 10s response time. A fiber optic cable is installed under the ammonia pipeline along its whole length and is connected to a measurement system that can automatically detect temperature anomalies which are telltale of an ammonia leakage and **generate an alert** to initiate appropriate response actions on the affected pipeline section. Such a system has been developed by SMARTEC and permanently deployed at several industrial sites.

EXISTING TECHNOLOGY LIMITATIONS

Often leaks are not detected until the amount of leakage is large. By this time significant environmental damage may already have occurred.

Even when conventional system detect a leak, they are not able to pinpoint the location - leading to further delays and further expenses due to loss of product.

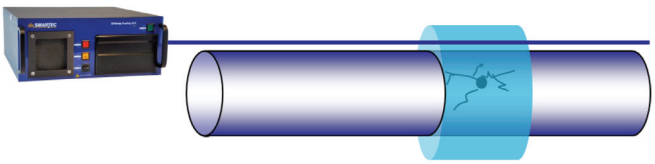
Sniffers and thermal cameras typically have high maintenance costs and require the installation of a large number of units to achieve a good level of coverage and small leakage detection performance.

Certain leak detection and inspection systems are used on a intermittent basis. If a leak occurs in between inspections, this will not be detected and critical safety levels may have been reached.

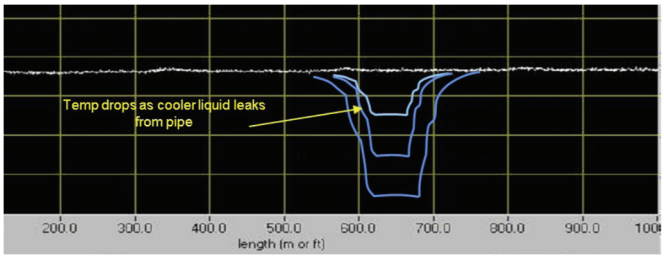
FIBER OPTIC LEAK DETECTION

The basic principle of pipeline leakage detection through the use of distributed fiber optic sensing relies on a simple concept: when a leakage occurs at a specific location along the pipeline, the temperature distribution around the pipeline changes. This change in temperature is localized both in space (a few meters around the leakage location) and in time (the onset of the leak). The origin of the temperature disturbance around the pipeline depends on the type of pipeline and its surroundings.

In a **gas-carrying or liquefied gas-carrying pipeline,** when a leak occurs at a location along the sensing line the Distributed Temperature System (DTS) system will detect a localized temperature drop or “cold spot”. The gaseous substance flowing through the pipeline is cooled down by the pressure release through the leaking pipe section and cools the pipe section and the surrounding area. It is also possible to observe a hot-spot when a leak occurs in a gas-carrying pipeline, for example, in a pipeline carrying water vapor.



In the event of gaseous leak, the temperature drops due to the gas expansion (Joules Thomson effect).



As product leaks from a pipe it can cause temperature differentials due to differences with ambient conditions or Joules Thompson effect.

Leak Detection - Application Note

AMMONIA PIPELINE FIBER OPTIC LEAK DETECTION IN FERTILIZER PLANT

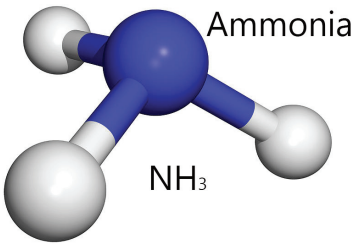
In a **liquid-carrying pipeline**, when a leak occurs at a location along the sensing line the DTS system will detect a localized temperature rise or “hot spot”.

The liquid substance flowing through the pipeline is typically warmer than the structures adjacent the sensing line such that when the liquid escapes from the pipeline it tends to warm such structures.

It is also possible to observe a cold-spot in the case of leaks from a liquid-carrying pipeline, for example, if the transported liquid is colder than the environment.

AMMONIA

In the specific case of ammonia pipeline, the main effects of leakages are the following:



- The liquid component of the ammonia leakage drops to a temperature of – 33°C and wets the sensing cable directly through dripping, splashing and spraying, provoking a fall in the recorded temperature.
- The gaseous component of the ammonia leakage forms a cold plume that also cools down the sensing cable.
- Part of the gaseous component of the ammonia leakage condensates on the pipe and cable surface, producing an addition-al liquid phase.
- The leakage also produces a drop of temperature of the pipeline itself that is transmitted to the sensing cable.

BENEFITS

Benefits to the Health, Safety & Environment Manager:

- Improved safety of infrastructure and to personnel
- Enhanced system reliability through reduced downtime
- Lower risk of environmental damage
- Improved productivity

BENEFITS AT OPERATIONAL LEVEL:

- Leaks will be detected quickly thus minimizing risk to operations personnel, neighbors and the environment.
- The optic signals used for the leak detection are extremely low power and incapable of igniting flammable gases making then suitable for use in hazardous zones.
- The sensing element is a passive fiber optic cable with a design life of over 30 years with minimal maintenance costs.
- Micro leaks can be detected, allowing action to be taken early before leaks grow larger and cause potentially major catastrophes.

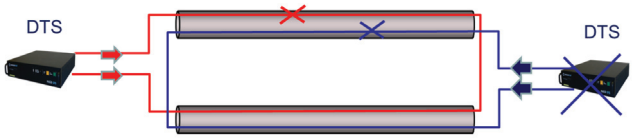
System is fully automated lowering operating costs with less risk of human error. It can interface with existing SCADA and industrial control system using standard proto-cols (electrical relays, OPC, Modbus).

RELIABILITY & AVAILABILITY

For mission-critical applications such as poisonous gas leak detection, several strategies can be used in order to ensure the reliability and high availability of such a system.

Optical fibers are always installed inside a cable to protect them mechanically, while ensuring the minimum possible thermal isolation. Additional strategies for increasing reliability and availability include the following:

- Using a looped cable, where both ends of the sensing cable are connected to separate channels of the interrogator
- Using cables containing multiple optical fibers
- Using multiple cables along the same pipeline
- Using two interrogators connected to different fibers in the same cable or to different cables



Redundant setup with two interrogators and looped fibers.

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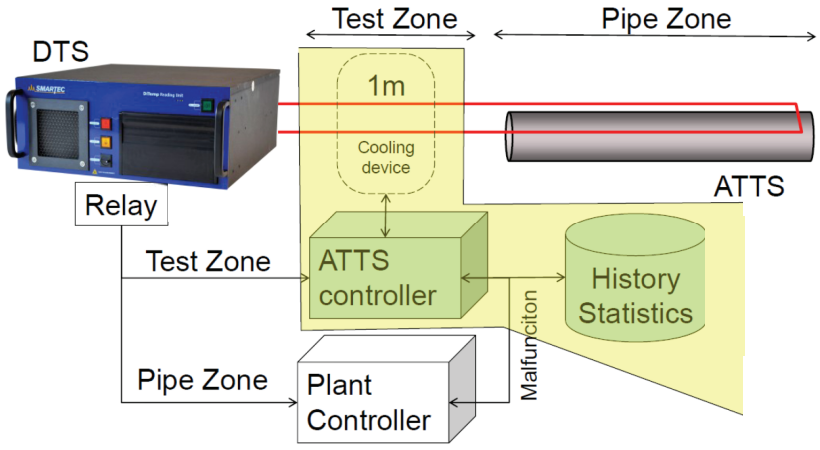


ATTS block diagram (ATTS in the shaded zone).

CONFIDENCE LEVEL

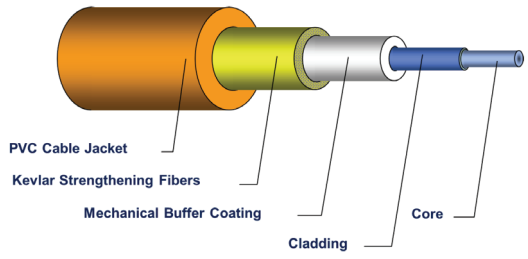
The Automated Trip Testing System (ATTS) is a device, fully independent of the data acquisition system, which can create an artificial leak along the sensing cable. In so doing, the correct response of the system and alarms can be verified.

SIL 2 CERTIFICATION

The Smartec's pipeline monitoring systems is certified as a **Safety Integrity Level 2 (SIL 2)** when used with the Automated Trip Testing System (ATTS).

SYSTEM COMPONENTS

The Smartec's pipeline monitoring systems are based on a combination of sensing cables, measurement instruments and data processing software.



Different cables are available for temperature sensing (normal and high temperatures).

The cables are designed to be installed on the pipeline surface or in its vicinity.

The Distributed Temperature (DiTemp) measurement instru-ments can measure sensors with a length of up to 2 x 45 km (upstream and downstream).

Software packages are available for detecting leakages of gas, fluids and multiphase pipelines, to display and publish the mea-surement results in a user-friendly interface, and to generate warnings when abnormal conditions are detected.

GIS maps can be used to highlight precise locations of events.

Leak Detection - Application Note

DiTemp
Raman Reading Unit
Temperature

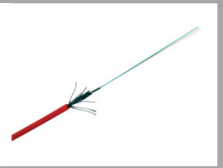
DiTemp Light
Raman Reading Unit
Temperature

DiTemp Harsh+
Raman Reading Unit
Temperature

DiTemp
Automated Trip
Testing System

DiTemp
External Optical
Multiplexer

DiTemp
Relay Alarm
Module Switch



DiTemp
Ordinary Cable
Temperature

DiView
Software

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Roctest

Roctest is the leading developer, manufacturer and supplier of innovative sensing technologies based on vibrating wire and fiber optic sensors for geotechnical and structural instrumentation.

We are featuring a complete line of conventional sensor-based solutions ranging from the ultra-robust traditional vibrating wire technology to state-of-the-art fiber-optic technology used for the measurement and monitoring of geotechnical projects and structural health monitoring (SHM) of critical assets such as: dams, tunnels, mines, buildings, bridges, nuclear power plants and many other structures too numerous to list.

Roctest offers a wide range of pressuremeters, rock dilatometers, laboratory and in-situ testing equipment for soil and rock.

Available Application Notes

- FO Leak Detection for Dams and Dikes
- Dam & Dike Instrumentation and Safety Monitoring
- Tunnel Instrumentation & Structural Health Monitoring
- Bridge Instrumentation & Structural Health Monitoring
- Building Instrumentation & Structural Health Monitoring
- Historical Monument Instrumentation
- Geotechnical and Structural Monitoring
- Nuclear Power Plant Instrumentation
- FO Movement Detection in Tunnels
- FO Leak Detection for Chemical Plants
- FO Leak Detection for Pipelines
- Storage Facility Instrumentation
- Cliff Instrumentation

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