

# Pipeline Integrity Monitoring with Fiber Optic Sensors



The surest way to detect the precise location of any leak, in long distance pipelines and provide total integrity throughout your pipeline network, ensuring efficient, safe and secure operation.

- Distributed Fiber Optic Sensors
- Temperature Profiling
- Axial and Bending Strain Measurement
- Leakage Detection
- Third-Party Intrusion Detection
- Long Range Measurement
- High Resolution
- Excellent Long-Term Stability
- Multiple Sensing Cable Designs
- Intrinsically Explosion Safe

The integrity management of on and offshore pipelines presents challenges that are quite unique. Their long length, high value, high risk and often difficult access conditions, require continuous monitoring and an optimization of maintenance interventions. The main concern for pipeline owners comes from possible leakages that can have a severe impact on the environment and put the pipeline out of service for repair. Leakages can have different causes, including excessive deformations caused by earthquakes, landslides or collisions with ship anchors, corrosion, wear, material flaws or even intentional damage.

Leakages can be detected and localized using distributed fiber optic temperature sensors. Fluid pipelines generate a hot spot at the location of the leak, while gas pipelines generate a cold spot due to gas pressure relaxation. These localized thermal anomalies can be detected by a Distributed Temperature measurement system such as DiTemp, which provides good spatial, time and temperature resolution.

Furthermore, it is often possible to detect damage before a critical state is reached. Our solutions are ideally suited for these tasks. Measuring distributed or localized strain detects the increased stresses caused by external actions such as landslides and earthquakes, or internal causes such as cross-section reduction due to corrosion and wear.

Finally, distributed temperature and strain monitoring can detect third party intrusion before any damage is done to the infrastructure.

**3-D** **INTEGRITY MANAGEMENT**

## Monitoring Gap with Existing Technology

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

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

Certain leak detection and inspection systems are used on an 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

3-D's Smartec leak detection and localization system is extremely sensitive and able to detect leaks of less than 1 litre. With the regular updates the system provides you will be notified while the leak is still manageable.

Leaks can be pinpointed to within 1m with this technology. This rapid location minimizes response time, and any potential excavation expenses in order to find and repair the leak.

This technology is a permanent monitoring solution and continuously monitors at all points along the pipe at all times, providing complete pipeline integrity control.

## Benefits

Benefits to Asset Manager:

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

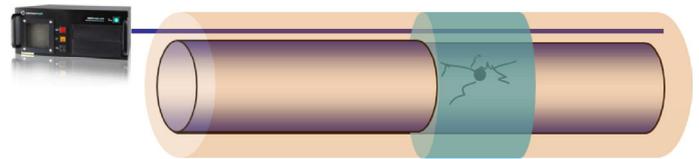
Benefits at Operational Level:

- Any leaks will be detected quickly thus minimizing risk to operations personnel. The optic signals used for the leak detection are extremely low power and incapable of igniting flammable gases making it 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.
- Small and micro leaks can be detected, allowing action to be taken early before leaks grow larger and cause potentially major catastrophes. Additional sensors can be used to monitor the structural integrity of the pipeline, alerting the operator to any movement in the pipeline that could potentially lead to mechanical failure.
- 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 protocols (OPC, Modbus, electrical relays).

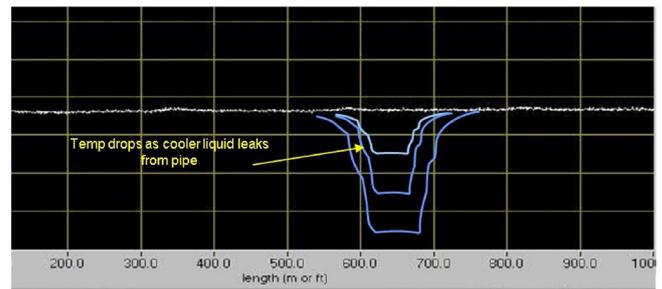
## Fluid or Gas Detection

The system is based on temperature measurements using distributed fibre optic sensing technology and can be used to detect both liquid and gaseous leaks.

In the event of a gaseous leak the temperature drop due to the expansion (Joules Thompson effect) is instantaneous and can be considerable (can be greater than  $-100^{\circ}\text{C}$ ). The system provides measurements as quick as 10 seconds and such rapid detection is essential in the case of potentially explosive gases.

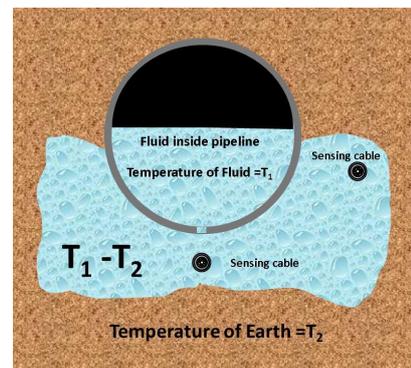


*In the event of gaseous leak, the temperature drops due to the gas expansion (Joules Thomson effect).*



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

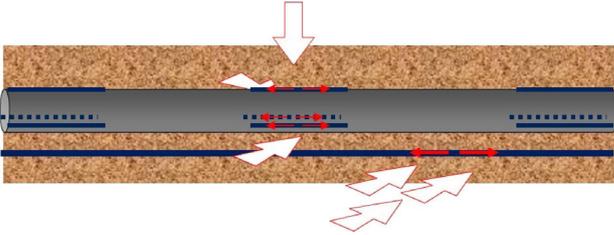
In the effect of liquid leakage (e.g. oil, water) the temperature change is less pronounced. However the key is in the sensitivity of the system which can detect changes as small as  $0.01^{\circ}\text{C}$ .



*Fast detection and location of a liquid leak allowing rapid response.*

## Structural Integrity & Intrusion Detection

In areas where structural movement is anticipated (e.g. subsidence, tectonic movement, landslides) structural integrity sensors can also be integrated into the system. This system is very sensitive and can detect very small strains (less than 10 micro strain), thus detecting any movements in the surrounding environment before this causes potential mechanical damage to the pipeline.



Accurately locate pipe strain caused by buckling, hammer, structural fault, anchor drag or ground shift.

Depending on cable configuration, this system can also be utilized for intruder detection and the precise location of any intrusion can be pinpointed and communicated to the control centre.

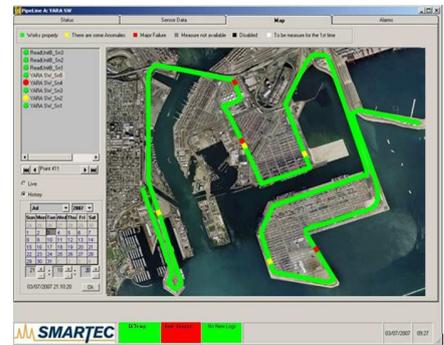


Third party intrusion detection and non-authorized works interferences.

## System components

The 3-D's Smartec 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), strain sensing and combined strain, and temperature sensing. The DiTemp measurement instruments can measure sensors with a length of up to 2 x 45 km (upstream and downstream).

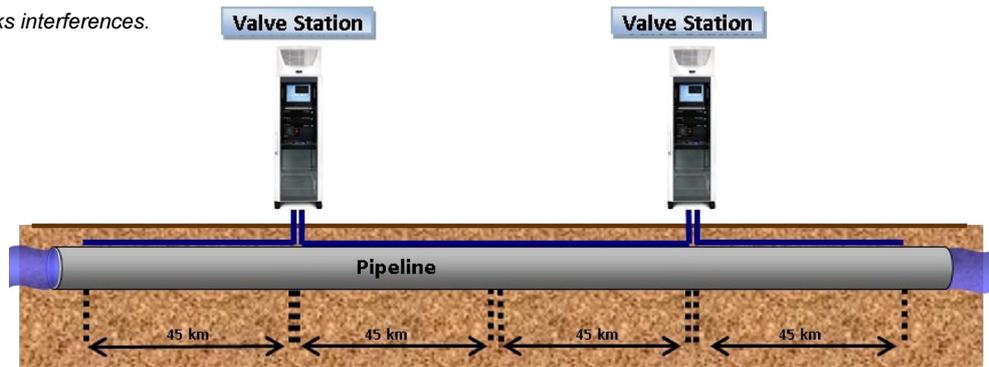
Software packages are available for detecting leakages of gas, fluids and multiphase pipelines, to display and publish the measurement results in a user-friendly interface, and to generate warnings when abnormal conditions are detected.



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

## Full Pipeline Coverage

The leak detection cable is installed along the length of the pipeline and takes measurements every 1m along the cable length. The system can be used on long distance pipelines with stations situated every 90 km along the pipeline.



The system can be used on long distance pipelines with stations situated every 90 km providing full coverage of the pipeline with the ability to pinpoint the leak to within 1m.

## Integrity Management Instruments



Distributed Temperature Sensor



SMARTProfile Distributed



MuST FBG Strain Sensor



MuST FBG Temperature Sensor



SOFO Deformation Sensor



DiTemp Distributed Temperature Sensing System



DiTemp Harsh Distributed Temperature Sensing System



DTSS Distributed Temperature & Strain Sensing System



MuST FBG System Datalogger



SOFO VII Datalogger

## Project References

- Deformation/strain monitoring under water gas pipeline - Switzerland (picture 1)
- Strain and temperature monitoring of reinforced thermoplastic pipeline - USA (picture 2)
- Industrial cooling water pipelines leak detection - Qatar (picture 3)
- Leakage detection of 55 km brine water pipeline - Germany (picture 4 and 5)
- On-field intrusion detection test on gas pipeline - Germany (picture 6 and 7)
- Deformation monitoring of buried gas pipeline - Italy (picture 8)
- Multiphase pipeline leakage detection - Italy (picture 9)
- 1 km water pipeline deformation monitoring - USA (picture 10)
- Assessment of buried pipelines after earthquake-induced ground movement -USA (picture 11)
- 6 km oil pipeline leakage detection - Italy
- 154 km mining production's concentrate pipeline leak detection - Chile
- Leak detection of 9 km crude oil pipeline - Italy
- 23 km gas pipeline third party intrusion detection and leak detection - Switzerland



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