# A NEW APPROACH FOR ACCURATE & RELIABLE STORAGE TANK LEAK MONITORING

Despite the fact that several different leak detection technologies are available, operational experience has shown how difficult it is getting reliable leak detection from a sensing system.

Several pipeline studies [1] [3] based on real life pipeline incidents, have highlighted that conventional leak detection systems in place today on existing pipelines may fail to provide satisfactory pipeline monitoring.

In particular, an examination of ten years' worth of US federal data from the 'Pipeline and Hazardous Materials Safety Administration' (PHMSA), provided in a news report [3], has highlighted that when analysing 960 pipeline spills on the US network that took place over a ten-year period, only 5% of them were spotted by leak detection systems in place. Moreover, only 20% of the 'very significant' leaks (i.e. larger than 1,000 barrels) were detected by monitoring systems.

Similarly, major leak incidents on storage tanks have been reported even more recently.

## CHALLENGES OF LEAK MONITORING ON STORAGE TANK TERMINALS

Based on feedback from operators, false alarms from leak sensors appear to be one of the main issues, if not THE primary concern on many sites.

Possible soil contamination from pre-existing leaks might result in false alarms following pollution carry-over by rain water. Typical cases of this type of false alarm relates to punctual sensors installed upstream the drain valve within the storage tank bunds, monitoring possible presence of leaks in rain water.

Besides pre-existing soil contamination, the following criteria should be considered when selecting a spill detection technology:

- System accuracy in terms of:
  - Minimum detectable quantity
  - Ability to localize the leak
- Responsiveness – detection time
- Reliability over time
- Operating costs:
  - Non-reusable systems
  - Need for recalibration
  - Maintenance
  - Discontinuous monitoring: recurrent expenses in certain cases – e.g. use of tracers
- For discontinuous monitoring: risk of non-detected leaks
- Retrofitting: possibility of system implementation

## LEAK DETECTION TECHNOLOGIES AVAILABLE

Leak detection technologies for pipelines and storage tanks can be either internally or externally based:

1. Internal-based technologies:
   a. Volume or mass balance
   b. Statistical analysis
   c. Rate of change in pressure (and flow for pipelines)
   d. Real Time Transient Model (RTTM) - pipelines
   e. Negative pressure wave - pipelines

2. External-based technologies:
   a. Liquid sensing cable
   b. Fiber optic cable
   c. Vapour sensing tube
   d. Acoustic sensor
   e. Vapour sensor
   f. Infrared camera
   g. Tracer systems
   h. Other technologies of punctual sensors – storage tanks

Despite recent technological improvements, internal leak detection technologies may not be able to fulfill increasingly stringent requirements in terms of accuracy and/or reliability imposed by some regulatory standards or agencies.

## ADDRESSABLE, REUSABLE SENSING CABLE TECHNOLOGY

French-based TTK has developed a patented addressable system based on sensing cables and probes, allowing early stage, accurate and reliable leak detection.

The structure of the sensing cable section is shown in Figure 1.

The functioning principle of TTK sensing cable is the following:

- sensing string divided in multiple cables (or 'sections') of nominal length
- each section provided with an embedded microprocessor-based electronic module, housed in liquid-proof shell (IP68 rated), so that each

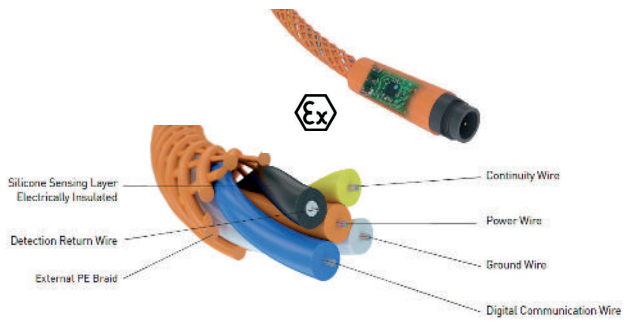


Figure 1: Addressable sensing cable structure

| | Capabilities | Limitations |
|---|---|---|
| Liquid sensing cable | Method can determine leak location | Cannot estimate the size of the leak |
| | A reasonably fast response time | May not be able to trig emergency shutdown actions in a very quick time |
| | Minimally affected by multi-component flow conditions | Multiphase flow leak may not be detected if only gas escaped |
| | More sensitive than computational methods | Installed cost is generally high. Retrofitting to existing pipelines could also be costly |
| | Limited risk of false alarms thanks to direct product sensing | Some of the available liquid sensing cables are not reusable |
| | More sensitive than computational methods and responds | Acoustic/vibration, strain and temperatures sensing are in seconds to minutes prone to false alarms due to other sources than the leaks |
| Fiber optic cable | Method can determine leak location | Usually cannot estimate the size of the leak |
| | Method can estimate the concentration of the hydrocarbon and maybe the size of the leak (only for chemical sensing fibers) | Stability of the chemical coating is an issue which could lead to missed leaks (only for chemical sensing fibers) |
| | A reasonably fast response time | Re-calibration may be required |
| | Minimally affected by multi-component flow conditions | Multiphase flow is problematic for this technique |
| | Fiber Optic is immune to electromagnetic interference (noise) | Installed cost is generally high. Retrofitting to existing pipelines could also be costly |
| | | Significant constraints for unit installation along the pipeline |
| Vapour tube | Location of the leak can be estimated | Response time is slower than most other continuous external measurement types |
| | The size of the leak can be estimated by concentration measurements | Retrofitting to existing pipelines could be costly |
| | Minimally affected by multi-component or multiphase flow conditions | This method is not effective for above ground pipelines |
| | More sensitive than computational methods and responds in seconds to minutes | Installed cost is generally high |
| Acoustic emissions | Method can determine the location of the leak | High flow noise conditions may mask the leak signal (valve or pump noise, multiphase flow) |
| | Size of leak can be estimated | Numerous sensors may be needed to monitor long pipelines |
| | Minimally affected by multi-component flow | Installed cost is generally high |
| | More sensitive than computational methods and responds in essentially real-time | Potential false alarms due to other sources than the leaks, depending on the performance of the computational method |
| | The acoustic emission method can be used on new or retrofitted to existing pipelines | Leak resolution is generally well above 20m |
| Thermal imaging | Method can determine the location of the leak | Affected by environmental conditions |
| | Size of leak can be estimated | Numerous cameras are needed to monitor long pipelines |
| | Minimally affected by multi-component flow | Installed cost is generally high |
| | The method can be used on new or retrofitted to existing pipelines | Need frequent maintenance to ensure clear vision field |
| | | Easily accessible to vandalism or thefts |
| | | Low rate leaks cannot be detected reliably |

Table 1: Advantages and limitations of main external leak detection technologies

section becomes autonomous from the rest the string
- electronic modules communicating with a remote electronic panel through a low-power digital communication bus fit for hazardous areas (Ex zone 0)
- sensor element composed of coextruded, conductive silicone absorbing hydrocarbon liquids or their vapors in case of physical contact with them
- electrical resistance increasing as consequence of the induced swelling

When the electrical resistance reaches a factory pre-set value, the alarm panel receives a leak alarm by the electronic module with the localisation of the leak on the concerned element – thanks to its unique address.

Since the hydrocarbon absorption process is reversible, the sense cable can be reused. This allows easy site leak testing after installation, under real conditions.

The outer surface of the sensor element is electrically insulated and highly hydrophobic and is not affected by the environmental conditions such as water, dust/dirt, etc.

TTK sensing cables are available in standard lengths (3m, 7m, 12m and 20m), interconnected to form a continuous sensing string up to 800m per circuit.

Three references by TTK are available, with different sensitivity:
- **FG-OD:** standard response
- **FG-ODR:** less sensitive, where hydrocarbons can be present in normal operation
- **FG-ODC:** enhanced sensitivity (for heavy crude oil, HFO, vapors…) – about three times faster than FG-OD

In particular, FG-ODR cable is designed to absorb some contaminants, while still providing detection of fresh leaks.

TTK addressable sensing cables are maintenance-free:
- No calibration required – regular circuit spot test easy to perform
- Cable cleaning required only in case of heavy contaminants
- Dynamic and truly multi leak detection
- 10-year supplier warranty provided

## IMPLEMENTED RELIABLE EARLY LEAK DETECTION ON STORAGE TANK TERMINALS

For storage tank retrofitting, either of two following techniques based on sense cables have been recommended/implemented:

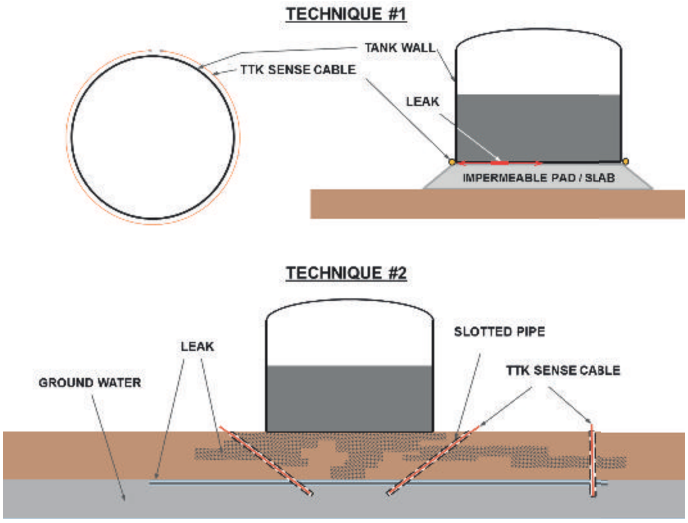


Figure 2 – Recommended Techniques for Storage Tank Retrofitting

1. Above ground installation, storage tank built on an elevated impermeable pad or slab: sense cable placed at the foot of the tank wall, thus avoiding contamination from pre-existing soil pollution. This arrangement allows sensing leaks both from the bottom plate and tank wall
2. Underground installation, soil and groundwater quality monitoring: sense cable placed inside a slotted pipe within a small diameter, low depth well – low-cost, widely available microdrilling tools are employed to perform the bores. False alarms due to some pre-existing contaminants are avoided using low sensitivity sense cable and/or hydrocarbon absorbing mesh placed around the sense cable.

Figure 3: Example of installation with monitoring wells (main oil & gas operator in Asia)

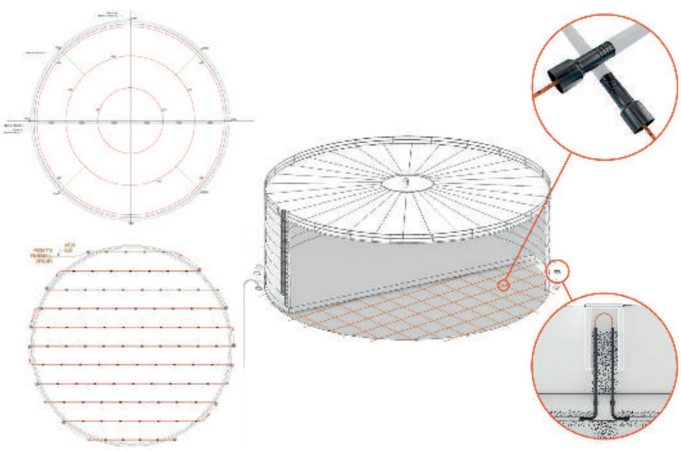

Figure 4: Recommended technique for new storage tank

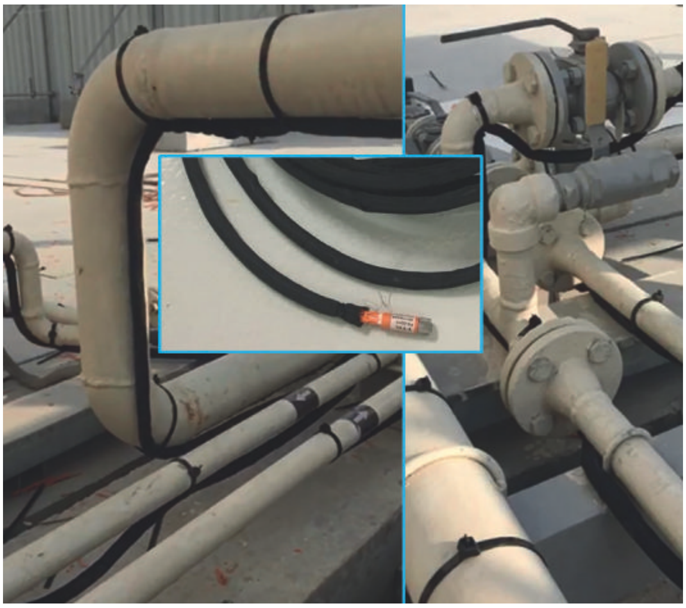

Figure 5: Example of installation on above ground lines

Punctual sensor (probe) system including a specially-designed floater avoiding contact with small quantities of contaminants is also available for installation at tank bund low points/sump pits.

On new builds, it is recommended to install the sense cables underneath the bottom plate, inside slotted pipes provided with a filtering sleeve. The sense cables, which can be deployed with different arrangements, are accessible via external pits as shown in Figure 4.

Similarly, monitoring of underground lines is also performed using sense cables placed inside slotted pipes.

On above ground lines it is recommended to strap the sense cable at pipe bottom after placing it inside a UV-protective braid.

The arrangements described above, based on reusable, addressable sense cable, constitute a new approach to achieve accurate and reliable leak monitoring of storage tank terminals.

## REFERENCES

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## FOR MORE INFORMATION

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