

Distributed Temperature and Acoustic Sensing (DTS & DAS) for Oil and Gas Pipeline Monitoring

Oil and gas pipelines are critical infrastructure assets transporting hydrocarbons over long distances through remote, environmentally sensitive, and often high-risk regions. Ensuring pipeline integrity, leak prevention, and security is essential for safe operations, environmental protection, and regulatory compliance.

Pipeline operators face two major risk categories:

- Operational integrity risks, including leaks, product release, and thermal anomalies
- Security risks, including third-party interference (TPI), unauthorised or accidental excavation, tapping, vandalism, terrorism and intentional intrusion

Fiber optic sensing technologies offer a powerful, integrated approach to addressing both risks.



Distributed Temperature Sensing (DTS) enables continuous thermal monitoring for leak detection and pipeline integrity management

Additionally, Distributed Acoustic Sensing (DAS) provides real-time detection of vibration and acoustic signatures associated with third-party intrusion and external threats.

Together, DTS and DAS provide continuous, real-time monitoring along the entire pipeline corridor.

Key Challenges

- Long, remote pipeline routes with limited access
- Risk of small leaks going undetected
- Third-party excavation and encroachment damage
- Environmental and regulatory exposure
- Difficult terrain and harsh operating conditions
- High consequences of failure, including safety, environmental, reputational, and financial impacts

Technology Overview

Distributed Temperature Sensing (DTS)

DTS uses optical fibers as continuous linear temperature sensors. Laser pulses are transmitted through the fiber and backscattered light (typically Raman scattering) is analysed to measure temperature along the full pipeline route.

DTS enables:

- Continuous temperature monitoring
- Leak detection through thermal anomalies
- Asset and process monitoring

Distributed Acoustic Sensing (DAS)

DAS uses the optical fiber as a distributed acoustic/vibration sensor by analysing coherent backscatter (typically Rayleigh-based) to detect and classify events along the pipeline.

DAS enables:

- Third-party intrusion detection
- Excavation and digging detection
- Vehicle and foot traffic monitoring
- Pipeline Inspection Gauge (PIG) Tracking
- Security event classification and localisation

Key Benefits of Fiber Optics

- Provides real time temperature measurements along the pipeline with early indication of a potential leak (DTS)
- Provides early indication of third party activity before the pipeline is breached or damaged
- Immunity to electromagnetic interference (EMI/FRI)
- Passive sensing element (no power required in the field)
- Sensing cable with a design life of 25+ years
- Minimal maintenance requirements

System Architecture

A typical integrated DTS/DAS pipeline monitoring system includes:

Control and analytics platform for alarm management and event classification

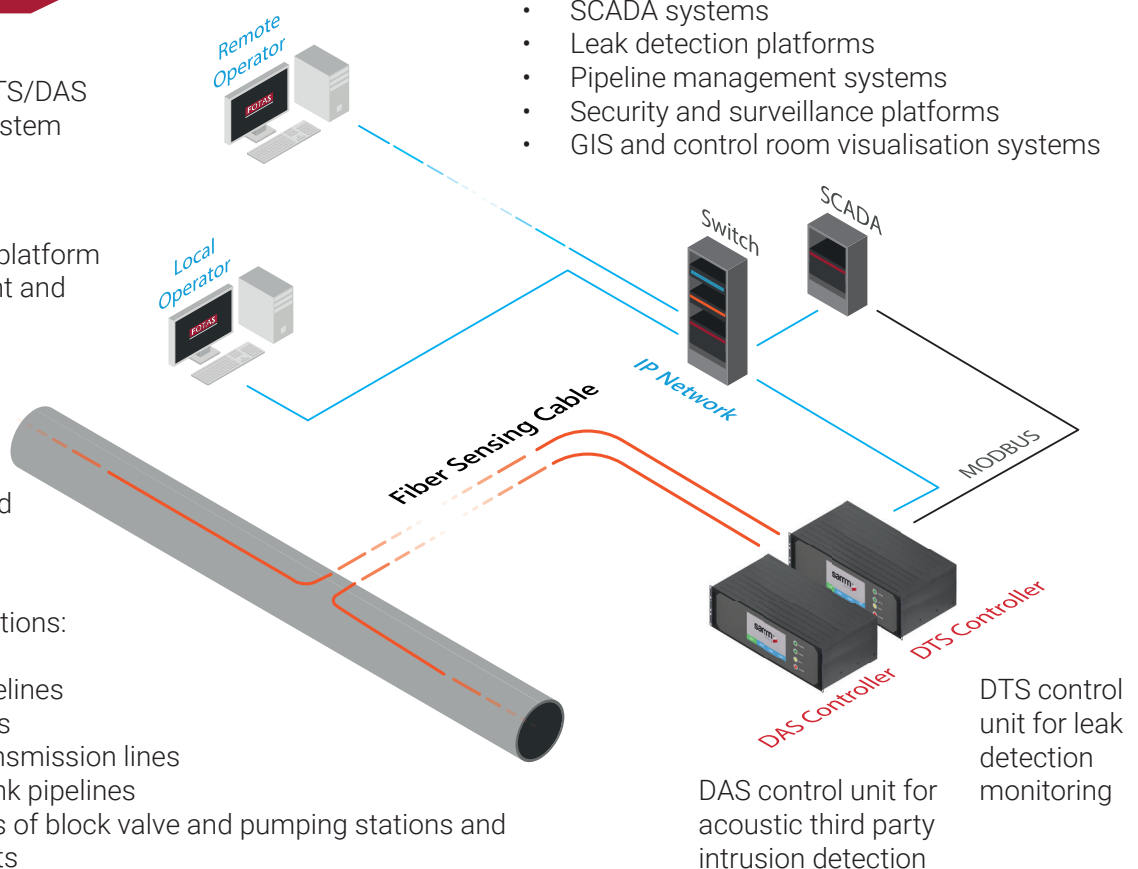
Fiber optic sensing cable installed alongside or integrated with the pipeline

Deployment configurations:

- Buried pipelines
- Above ground pipelines
- Undersea pipelines
- Cross-country transmission lines
- Gathering and trunk pipelines
- Protect perimeters of block valve and pumping stations and other critical assets

Integrated DTS/DAS systems can interface with:

- SCADA systems
- Leak detection platforms
- Pipeline management systems
- Security and surveillance platforms
- GIS and control room visualisation systems



Key Factors for Successful Deployment



Fiber Deployment

- Buried directly alongside pipeline
- Integrated with pipeline infrastructure where appropriate
- Routing optimised for thermal and acoustic coupling



Cable Selection

- Ruggedised cable suitable for buried environments
- Mechanical protection for long-term durability
- Compatible design for both DTS and DAS performance with mixture of Multi-Mode and Single-Mode fiber cores



System Design

- Alarm zoning and event classification strategy
- Redundant architectures for critical pipelines
- Integration with existing monitoring systems

DTS FOR LEAK DETECTION

Product leaks often generate localised temperature anomalies that can be detected by DTS with an accuracy of just a few meters.

Examples include:

- **Gas leaks** - Joule-Thomson cooling may create localised temperature drops during depressurisation
- **Liquid hydrocarbon leaks** - can produce temperature changes due to product-soil interaction and may alter surrounding thermal profiles
- **Operational upsets** - abnormal heating or cooling associated with flow disturbances may indicate developing issues



Key DTS Applications

Pipeline Leak Detection

- Early detection of small leaks
- Continuous monitoring along entire route
- Rapid localisation for response and repair

Pump Station and Facility Monitoring

DTS can monitor:

- Valves and manifolds
- Pumps and rotating equipment
- Critical pipeline connections

Key Benefits

- Continuous distributed monitoring
- Early leak detection and localisation
- Reduced environmental exposure
- Faster incident response
- Enhanced integrity management
- Support for regulatory compliance

DAS FOR THIRD-PARTY INTRUSION

Third-party interference is a leading cause of pipeline damage.

DAS detects and classifies activity such as:

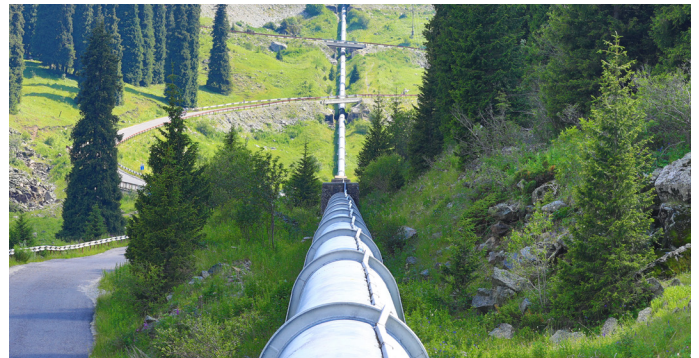
- Mechanical excavation
- Hand digging
- Vehicle activity near right-of-way
- Foot traffic and unauthorised access
- Construction encroachment
- Deliberate tampering attempts

Event Classification

Advanced DAS analytics can distinguish between:

- Background environmental noise
- Benign activity
- Potential threats
- Critical intrusion events requiring immediate response

This reduces nuisance alarms while improving actionable detection.



Key DTS Applications

Excavation Detection

Early warning of:

- Backhoe activity
- Trenching
- Drilling near the pipeline

Right-of-Way (ROW) Security Monitoring

Continuous monitoring of pipeline corridors for:

- Unauthorised activity
- Encroachments
- Security threats

Tamper and Impact Detection

Detection of:

- Mechanical impacts
- Cutting attempts
- Physical interference with the line

Key Benefits

- Continuous corridor-wide intrusion detection
- Real-time event localisation
- Reduced risk of third-party damage
- Improved response times
- Lower patrol and surveillance burden
- Enhanced security and situational awareness

INTEGRATED DTS + DAS SOLUTION

Combining DTS and DAS creates a unified monitoring solution covering both operational and security threats.

Integrated detection capabilities include:

- Leak detection
- Excavation detection
- Intrusion monitoring
- Asset and right-of-way protection

Combined Benefits

- Single fiber supporting multiple sensing functions
- Comprehensive risk coverage
- Reduced infrastructure requirements
- Unified alarm and event management
- Improved operational visibility