

DTGS Leak Detection Test Procedure

1. Test Environment

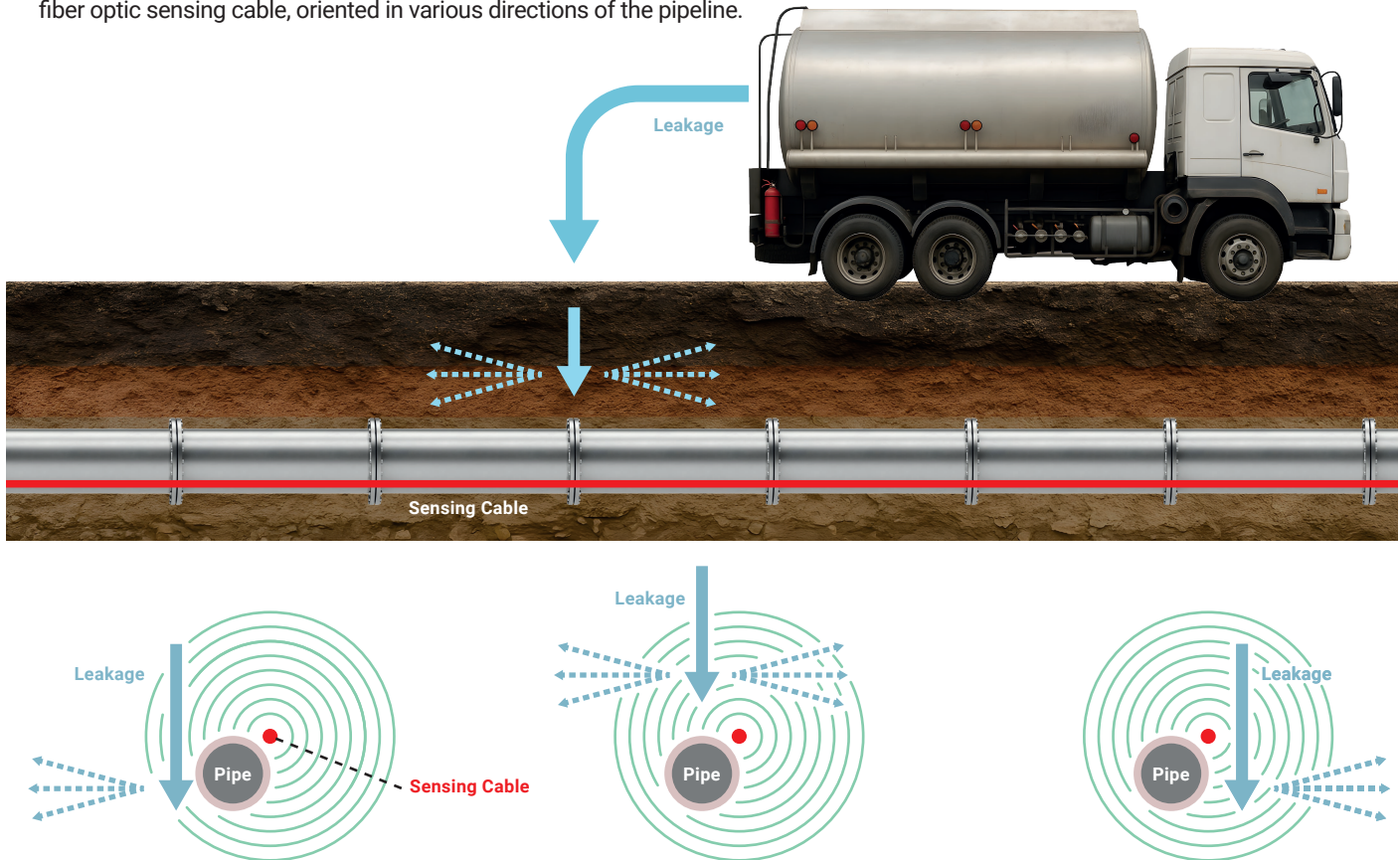
Since creating direct holes in the newly installed pipeline for testing would damage the pipeline, leak detection simulation setups will be used for testing and inspection based on the following principles. This test procedure has been prepared to verify both acoustic DAS and Distributed Temperature Gradient Sensing (DTGS)-based fiber optic leak detection systems.

2. Test Application

Test and inspection preparations will be carried out at 3 or more test points selected by the administration from 8 (eight) different leak simulation setups completed during the construction phase.

2.1 Simulation Setup

- Steel pipes approximately 2 meters long and the thickness of a finger will be prepared.
- One end of each pipe will be sealed, and two holes with diameters of 2 mm and 3 mm will be drilled about 10 cm above the sealed point.
- Nipples will be mounted on the other end of the pipes to connect them to the pressurized water system.
- The pipes will be placed and fixed at different locations along the pipeline at approximately ± 10 cm (or the pipe diameter) close to the fiber optic sensing cable, oriented in various directions of the pipeline.



2.2 Fluid and Application Method

- During the test, water at a pressure close to the nominal operating pressure of the pipeline will be applied to the simulation pipes.
- The controlled leakage of water into the external environment will generate both acoustic DAS signals (Orifice Noise and Negative Pressure Pulse) and thermal DTGS signals through environmental interaction.
- Acoustic signals are expected to be detected immediately at the start of the leak; temperature changes will be detected once the fluid reaches the fiber.
- DTGS signals, representing temperature gradients, are typically detected 1–2 minutes after the leak occurs, depending on soil conductivity, cable placement, and underground saturation conditions.

2.3 Fiber Optic Detection and Monitoring

- The fiber optic detection system will operate in both DAS and DTGS modes.
- Leak events will be classified as: NPP (Negative Pressure Pulse), OFN (Orifice Flow Noise) and DTGS (Temperature Gradient Change). Events will be displayed on the monitoring screen with location data, time-based temperature curves, frequency analysis (e.g., waterfall plots), and alert types.
Test results will be evaluated based on the following performance criteria:
 - - Typical Sensitivity: <5 LPM liquid leak
 - - Response Time: 30 seconds to 5 minutes
 - - Location Accuracy: ±10 meters

3. Alarm and Reporting

- Whether an alarm is generated for each simulated leak point will be observed, and the system's Alarm-Fusion configuration will be verified.
- The detection system will send alarm notifications to authorized mobile phones via email and SMS.
- The following outputs will be archived for each test:
 - Event screen capture
 - Time and channel number data
 - Temperature change curve based on fiber distance
 - Test location coordinates
 - Detection mode(Acoustic and DTGS)

4. Additional Evaluation Criteria

- The system's ability to generate alerts from multiple modes (multi-modal detection) will be evaluated.
- Time synchronization (GPS/NTP compliance) will be verified.
- The correlation between DTGS signal delay and cable offset will be noted.
- Any delayed detection events will be analyzed to assess the relationship between leak propagation and fiber contact.