# Architectural and Engineering Specification for a Fiber Optic Pipeline Integrity Monitoring System

## FiberPatrol™ FP7000

**SECTIONS**

This document is intended to provide performance specifications and operational requirements for the FiberPatrol FP7000 Fiber Optic Pipeline Integrity Monitoring System. It is written in a generic format. These specifications may be copied verbatim to form a generic procurement specification.

# SECTION 1: PIPELINE MONITORING SYSTEM TO DETECT LEAKS AND THIRD-PARTY INTERFERENCE

# PART 1 GENERAL

## 1.1 System Summary

The contractor shall install a monitoring system that detects leaks and third-party interference (TPI) in buried pipelines and above-ground infrastructure. The system's sensor cable shall detect and locate gas and liquid leaks from a pipeline, digging within the immediate vicinity, and attempts to tap or otherwise damage the pipeline. The same sensor cable shall also function as a perimeter intrusion detection sensor when attached to a fence.

The detection sensor shall consist of a fiber optic cable buried alongside the pipeline. The cable shall connect to a signal processing module that detects and locates pipeline leaks and third-party interference by analyzing the changes in reflected energy that occur as a result of minute temperature changes (Distributed Differential Temperature Sensing, or DDTS) as well as vibrations in the sensor cables (Distributed Acoustic Sensing, or DAS).

The system shall be capable of being integrated into the facility's Security Management System and/or Supervisory Control and Data Acquisition (SCADA) systems.

## 1.2 Submittals

A. Contractor submittals to the facility owner shall include the following as a minimum:

1. Site conditions report as per article Error! Reference source not found.
2. Configuration and calibration settings for the system after installation and calibration are complete as per article 3.3
3. All manufacturer-supplied software required for the calibration and operation of the system
4. Documentation providing system operation and maintenance procedures.

## 1.3 Qualifications

A. The manufacturer of the system shall have a minimum of five (5) years of experience in the last 10 years of the manufacture and successful implementation of similar systems.

## 1.4 Spares

A. The contractor shall deliver to the facility owner spare system components.

B. For each system component, spares consisting of at least one unit or 10% of the number that comprise the system, whichever is greater, shall be provided.

## 1.5 Warranty

A. The product shall be under warranty for a minimum of three years from the date of purchase.

B. The supplier shall make available replacement components, parts or assemblies for a minimum of 10 years from the date of purchase.

## 1.6 References

A. Abbreviations and acronyms: The following acronyms and abbreviations are used in this document:

1. DAS: Distributed Acoustic Sensing
2. DDTS: Distributed Differential Temperature Sensing
3. MTBF: Mean Time Between Failures
4. MTTR: Mean Time To Replace
5. Pd: Probability of Detection
6. PIDS: Perimeter Intrusion Detection System
7. TPI: Third-Party Interference
8. NAR: Nuisance Alarm Rate.

B. Reference Standards: The following regulatory and industry standards are referenced in this document:

1. Federal Communications Commission: FCC CFR Part 15, Subpart B requirements for Class A devices.
2. Conformité Européenne (CE).

# PART 2 PRODUCTS

## 2.1 Leak and Third-Party Interference Detection System

A. The contractor shall supply a ranging fiber-optic system that performs all of the following functions:

1. Leak detection
2. Physical interference detection
3. Perimeter intrusion detection.

B. The system shall incorporate a sensor that:

1. Detects and locates liquid and gas leaking from the pipeline.
2. Detects and locates manual and machine digging in the immediate vicinity of the pipeline as well as attempts to tap or damage the pipeline.
3. When fence-mounted, the system shall detect and locate perimeter intrusion events by analyzing the vibrations generated when an intruder attempts to cut, climb, or lift the fence fabric.

## 2.2 Manufacturers

A. The FiberPatrol™ FP7000 system from Senstar Corporation (www.senstar.com) meets the requirements stated in this document.

## 2.3 Regulatory Requirements

A. The system shall comply with the following regulations:

1. FCC 47 CFR Part 15, Subpart B requirements for Class A devices
2. CE.

## 2.4 Mechanical Requirements

A. Sensor cable:

1. The sensor cable shall incorporate single-mode optical fibers.
2. The system shall require a maximum of two fibers to perform the sensing functions.
3. The sensor cable shall have the option to be encased in an armor jacket, for use in areas that have a high potential of physical damage to the cable.
4. The sensor cable shall have a minimum bend radius no greater than 15 cm (6.0 inches).
5. The sensor cable shall be installed adjacent to the pipeline.
6. The sensor cable shall not require a cable conduit to be installed along the pipeline area to protect the sensor cable.

7. The sensor cable shall be able to include additional, unused fibers for use by other equipment (such as for data or video communications).
8. The system shall be capable of being used with pre-existing cable providing the optical fibers of the pre-existing cable meet attenuation and reflective event guidelines as set down by the system manufacturer.

B. Sensor unit equipment:

1. The system shall not require any electronic devices, communications cabling, or grounding points to be installed outdoors.
2. All electronics components shall be rack-mountable in an indoor, equipment room environment.
3. The indoor system components shall be designed for standard 19-inch wide rack.
4. The system shall provide the option for a slide-out monitor and keyboard that enables local console access to the system.
5. The system shall include a fiber optic patch panel for interfacing the sensor cable to the processor and controller modules.

## 2.5 Environmental Requirements

A. The sensor cables shall withstand operation in temperatures from –40°C to 70°C (–40°F to 158°F) and a relative humidity of 0 to 100% (condensing) without performance degradation.

B. The sensor unit components shall be designed for indoor use and meet the following requirements:

1. Temperature:
   a. Operating: 10°C to 35°C (50°F to 95°F)
   b. Storage: –20°C to 70°C (–4°F to 158°F)
2. Humidity:
   a. Operating: 20% to 80% (relative, non-condensing)
   b. Shipping and storage: 5% to 85% (relative, non-condensing).

## 2.6 Reliability and Maintenance Requirements

A. Sensor cables: The sensor cables shall have a nominal service life of 20 years, excluding damage caused by non-environmental forces.

B. Sensor unit:

1. The sensor unit modules shall have a predicted mean time between failures (MTBF) of greater than 87,000 hours.
2. The sensor unit shall be capable of performing internal self-diagnostic tests of the internal circuitry, cable continuity, and detection processing.

3. The sensor unit software shall be field-upgradeable.

## 2.7 Electrical Requirements

A. Each sensor unit shall meet the following electrical requirements:
   1. Input power: 100 to 240 VAC, 50/60 Hz
   2. Power consumption: Less than 250W.

B. Backup power: The sensor unit shall be capable of being powered from a third-party uninterruptable power supply (UPS) or standby generator.

C. The sensor cable shall include no conductive elements.

D. The sensor cable shall be intrinsically safe within explosive atmospheres.

E. The sensor cable shall be completely immune to all forms of electromagnetic energy from radio communications, radar, electrical power transmission equipment and lightning.

F. The system shall not require any outdoor power or grounding connections.

## 2.8 Detection Capabilities

A. The sensor shall consist of fiber optic cable that is installed adjacent to the pipeline along the full length to be protected.

B. The sensor shall function in all common soil types.

C. The sensor shall detect leaks during all pipeline phases (steady-state, filling, draining, slugging, and different liquid/gas ratios).

D. Leak detection capabilities:
   1. Detect pipeline leaks over a cable distance of up to 40 km (24.9 mi)
   2. Temperature rate-of-change sensitivity:
      a. Measure change in temperature of the sensor cable relative to a reference point in time
      b. Temperature resolution of 0.0005°C
      c. Detect temperature rates of change with an accuracy of 0.001°C per minute, as measured at the cable location
      d. Detect direction of change (increasing or decreasing)
      e. System refresh update of 1 Hz or better.
   3. Include Distributed Acoustic Sensing (DAS) capabilities with a bandwidth of up to 2 KHz and a strain sensitivity of greater than 5 nano-strains (nε)
   4. Locate leaks with a down-cable accuracy of ±10 m (32.8 ft) or better.
   5. The system shall include configurable background rejection algorithms to minimize nuisance alarms generated by environmental conditions. The background reject algorithms shall be able to:

a. Reject temperature changes generated by weather and diurnal variation

b. Account for temperature changes that occur in common across adjacent regions of the cable

c. Use each measured point along the cable as a reference for background rejection.

6. The criteria used to determine the declaration of a leak detection event shall be configurable. The system shall support the following declaration modes:

a. Leak detection event based on results only from DDTS

b. Leak detection event based on results only from DAS

c. Leak detection event based on results from DDTS and DAS

d. Leak detection event based on results by DDTS or DAS

e. Leak detection event based on a weighted combination of DDTS and DAS.

7. Typical leak detection performance:

a. Gas leak: 500 Standard Liters Per Minute (SLPM) at 40 bar, at 0.5 meter cable offset, detection time 5 minutes

b. Oil leak: 50 Liters Per Minute (LPM) at 40 bar, at 0.5 meter cable offset, detection time 5 minutes

c. High-pressure gas leak (via DAS): 500 PSI, 1/8” orifice, at 0.5 meter cable offset, detection time 30 seconds.

8. Detect multiple simultaneous leaks, when each leak is separated by a sensor cable distance greater than 30 m (100 feet).

E. Third-party interference detection capabilities:

1. Process the signal from the buried sensor cable to detect intruders attempting to cut, tap, drill, or otherwise interfere with a pipeline

2. Process the signal from a buried sensor cable to detect intruders digging within the vicinity of a buried pipeline

3. Process the signal from a fence-mounted sensor cable to detect intruders attempting to breach a fence protecting above-ground infrastructure by cutting, climbing, lifting, or dismantling the fence

4. Locate the position of a detected intrusion within 5 m (16 feet) or less at least 95% of the time for typical intrusions

5. Detect multiple simultaneous intrusions, when each intrusion attempt is separated by a sensor cable distance greater than 30 m (100 feet)

6. Support up to 1140 virtual detection zones

7. Be capable of detecting and locating a sensor cable cut to within 30 m (100 feet)

8. Utilize adaptive algorithms in the detection process to optimally discriminate between actual intrusions and environmental activity

9. Time to detection:
    a. Once an interference event is detected, the system shall be capable of reporting the alarm to the Security Management System within one second.
10. Typical third-party interference detection performance:
    a. Manual digging: 5 to 20 m (16 to 65 ft)
    b. Light vehicle: 3 to 10 m (10 to 33 ft)
    c. Heavy excavating machines: 10 to 60 m (33 to 200 ft)

F. Perimeter intrusion detection performance:
1. The probability of detection (Pd) for a typical intrusion attempt shall be 95% with a 95% confidence factor, when the system is installed in accordance with the manufacturer's directions.
2. False alarm rate: The maximum rate for alarms generated by the internal electronic processes of the processors (cables excluded) shall be less than one per km per month typical, averaged over the total length of the system.
3. Nuisance (environmental) alarms:
    a. The system when calibrated according to manufacturer's guidelines shall not suffer nuisance alarms from any of the following sources:
        .1 Temperature changes
        .2 Sunrise/sunset
        .3 Acoustic or magnetic effects
        .4 Snow
        .5 Fog
        .6 Wind
        .7 Rain and hail
        .8 Sandstorms
    b. The system shall utilize advanced processing and ambient compensation to minimize the probability of nuisance alarms from the following sources:
        .1 Motion of nearby objects or vegetation
        .2 Motion of surface or ground water
        .3 Seismic vibration caused by nearby vehicular traffic
        .4 Seismic vibration caused by nearby rail traffic
4. Time to detection:
    a. Once an intrusion is detected, the system shall be capable of reporting the alarm to the Security Management System within one second.

## 2.9 Cable Cut Response

A. The system shall be capable of detecting and locating a sensor cable cut.

B. The cut location shall be determined and reported with an absolute accuracy of equal to or less than 30 meters (100 feet).

C. In the event of a sensor cable cut, the system shall retain detection and location ability in the portion(s) of the sensor cable that remain connected to the system sensor unit.

## 2.10 Installation and Configuration Capabilities

A. The system shall have the following characteristics, as a minimum:

1. The sensor cable shall be capable of being buried directly adjacent to the pipeline without needing to be put in a conduit.

2. It shall be possible to disable detection along certain sections of the cable where leak detection, TPI or intrusion detection is not required (i.e., lead-in sections).

B. The system shall support a cut-immune deployment configuration in which both sides of the sensor cable continue to detect interference events after a cut occurs.

C. The system shall support the following configuration and calibration features:

1. A Windows-based graphical user interface (GUI), accessible locally or via Windows Remote Desktop.

2. Configuration and calibration settings shall be capable of being stored in a computer file for record keeping purposes and available for reuse when configuring additional or replacement processors.

## 2.11 Networking Capabilities

A. Network manager tools: The system's network management software shall provide the following tools to facilitate system commissioning and trouble-shooting:

1. System status tool that provides a visual display of the status of all processors in the system

2. System event log tool that provides a searchable log of system events.

B. The processors shall support dual Gigabit Ethernet ports on RJ-45 connectors.

C. Network management:

1. The system shall include network management software to manage the communications over the sensor network. The network management software shall be capable of running on a standard Windows PC as well as on the sensor unit itself and be accessible via Windows Remote Desktop.

2. The system's network management software shall provide a TCP/IP-based interface for communicating alarm, status, and configuration data to and from security management systems. The system supplier shall furnish complete

documentation of this interface to facilitate integration with security management systems.

## 2.12 Leak Event Display and Analysis Software

A. The system shall provide system operators with multiple means to visualize the system's response and analyze potential leak events.

B. The leak event display software shall run directly on the leak detection system.

C. The leak event display software shall include the following information:

1. A histogram that shows as a percentage how close the temperate rate of change signal is to meeting the alarm condition
2. A histogram that shows as a percentage how close the acoustic noise signal is to meeting the alarm condition
3. A chart showing the instantaneous temperature rate of change and/or accumulated temperature difference over any selected section of the sensor cable
4. A waterfall display showing the temperature rate of change as a color-coded value for any selected section of the sensor cable and selected time period within the last 24 hours
5. A chart showing the temperature rate of change for multiple selected points along the sensor cable for any selected time period within the last 24 hours
6. A chart showing the instantaneous acoustic amplitude over any selected section of the sensor cable
7. A waterfall display showing the acoustic amplitude as a color-coded value for any selected section of the sensor cable
8. A chart showing the acoustic amplitude for multiple selected points along the sensor cable.

D. The leak analysis software shall enable system administrators to process archived data in order to develop statistics regarding long-term system performance. It shall provide the following features, as a minimum:

1. Display graphs and statistics for the following parameters:
   a. Temperature rate of change (raw, before background subtraction)
   b. Temperature rate of change with background subtraction
   c. Accumulated temperature difference
2. Generate graphs based on a specific location along the sensor cable
3. Display the following statistics:
   a. For a selected parameter, the maximum and minimum values, based on the time and location, along the entire sensor cable

b. For a selected parameter, the maximum and minimum values, based on time and location, for each detection zone

4. The leak analysis software shall run on Windows desktop operating systems.

## 2.13 Event Management

A. The system shall provide a local PC-based operator interface with graphical alarm annunciation at the sensor unit.

B. The system shall provide access to the following information and functionality when in a local or networked configuration:

   a. A user-configurable image depicting the protected site with a schematic perimeter overlay

   b. Hardware monitoring and control

   c. Event detection and alarm generation (including flashing notification message, location marker, and audible alert)

   d. Basic alarm management

   e. Event and alarm logging

   f. Detection zone definition and configuration

   g. Adjustment of detection parameters

C. The system shall support the following alarm management functions:

   1. Maintain complete information on all alarms for 24 hours or until the alarm is cleared.

   2. Alarms shall be cleared by local or remote operator or automatically in 24 hours after alarm generation.

   3. Until cleared, the alarm information shall be compiled in a scrollable multi-column table.

   4. The maintained information shall include:

      a. Unique alarm ID number

      b. Time label

      c. Event duration

      d. Event status

      e. Event strength

      f. Event location.

   5. The system operator shall be able to:

      a. Select any of the alarms from the list.

      b. Enter text notes regarding the cause of the alarm and the mitigation measures.

c. Clear the alarm.

6. Operator notes as well as the alarm clearing event shall be recorded in the event log.
7. Alarm location Format:
   a. The primary format of the alarm location shall be the linear position along the sensor cable.
   b. It shall be possible to express the alarm location in either meters or feet.
   c. Secondary location formats shall be derived from the primary measure using appropriate calibration tables.
   d. Secondary location formats shall require corresponding mapping of the perimeter fence line.
   e. It shall be possible to provide secondary alarm location formats including:
      .1 Software-defined zones
      .2 Latitude and longitude (GPS) coordinates.
8. Event logging:
   a. The system shall maintain and display an event log, including alarms, system notifications, and user actions.
   b. The logs shall be periodically saved to the hard drive.
   c. A new set of log files shall be generated every 24 hours at midnight.

## 2.14 Access Control

A. The system shall require the entry of a valid password at start-up and shutdown.
B. The system shall divide user access into to three security levels:
   1. Operator level for routine operation
   2. Supervisor level for advanced system monitoring, configuration, and troubleshooting
   3. Installer level for advanced configuration and troubleshooting.

# PART 3 EXECUTION

## 3.1 Site Assessment

A. Before installation begins, the installation contractor shall provide a report to the facility's owner documenting any site conditions that may prevent the system from operating satisfactorily.

## 3.2 System Installation

A. The system shall be installed in accordance with the manufacturer's recommended procedures as defined in the manufacturer's documentation for the system.

## 3.3 System Calibration

A. The installation contractor shall calibrate the system in accordance with the manufacturer's recommended procedures as defined in the manufacturer's Product Guide.

B. The installation contractor shall submit to the owner the calibration and configuration settings for the system.

## 3.4 Training

A. The installation contractor or vendor shall train the owner's maintenance personnel in the calibration and system maintenance procedures as given in the manufacturer's product documentation.

# SECTION 2: PIPELINE MONITORING SYSTEM TO DETECT LEAKS

# PART 1 GENERAL

## 1.1 System Summary

The contractor shall install a monitoring system that detects leaks in buried pipelines and above-ground infrastructure. The system's sensor cable shall detect and locate both gas and liquid leaks from a pipeline.

The detection sensors shall consist of fiber optic cables buried alongside the pipeline. The cables shall connect to a signal processing module that detects and locates pipeline leaks by analyzing the changes in reflected energy that occur as a result of minute temperature changes (Distributed differential temperature sensing, or DDTS) as well as vibrations in the sensor cables (Distributed Acoustic Sensing, or DAS).

The system shall be capable of being integrated into the facility's Security Management System and/or Supervisory Control and Data Acquisition (SCADA) systems.

## 1.2 Submittals

A. Contractor submittals to the facility owner shall include the following as a minimum:

1. Site conditions report as per article Error! Reference source not found.
2. Configuration and calibration settings for the system after installation and calibration are complete as per article 3.3
3. All manufacturer-supplied software required for the calibration and operation of the system
4. Documentation providing system operation and maintenance procedures

## 1.3 Qualifications

A. The manufacturer of the system shall have a minimum of five (5) years of experience in the last 10 years of the manufacture and successful implementation of similar systems.

## 1.4 Spares

A. The contractor shall deliver to the facility owner spare system components.

B. For each system component, spares consisting of at least one unit or 10% of the number that comprise the system, whichever is greater, shall be provided.

## 1.5 Warranty

A. The product shall be under warranty for a minimum of three years from the date of purchase.

B. The supplier shall make available replacement components, parts or assemblies for a minimum of 10 years from the date of purchase.

## 1.6 References

A. Abbreviations and acronyms: The following acronyms and abbreviations are used in this document:

1. DAS: Distributed Acoustic Sensing
2. DDTS: Distributed Differential Temperature Sensing
3. MTBF: Mean Time Between Failures
4. MTTR: Mean Time To Replace
5. Pd: Probability of Detection
6. PIDS: Perimeter Intrusion Detection System
7. NAR: Nuisance Alarm Rate

B. Reference Standards: The following regulatory and industry standards are referenced in this document:

1. Federal Communications Commission: FCC CFR Part 15, Subpart B requirements for Class A devices.
2. Conformité Européenne (CE)

# PART 2 PRODUCTS

## 2.1 Leak Detection System

A. The contractor shall supply a ranging fiber-optic system that performs leak detection for buried pipelines.

B. The system shall incorporate a sensor that detects and locates liquid and gas leaking from the pipeline.

## 2.2 Manufacturers

A. The FiberPatrol™ FP7000 system from Senstar Corporation (www.senstar.com) meets the requirements stated in this document.

## 2.3 Regulatory Requirements

A. The system shall comply with the following regulations:

1. FCC 47 CFR Part 15, Subpart B requirements for Class A devices
2. CE.

## 2.4 Mechanical Requirements

A. Sensor cable:

1. The sensor cable shall incorporate single-mode optical fibers.
2. The system shall require a maximum of two fibers to perform the sensing functions.
3. The sensor cable shall have the option to be encased in an armor jacket, for use in areas that have a high potential of physical damage to the cable.
4. The sensor cable shall have a minimum bend radius no greater than 15 cm (6.0 inches).
5. The sensor cable shall be installed adjacent to the pipeline.
6. The sensor cable shall not require a cable conduit to be installed along the pipeline area to protect the sensor cable.
7. The sensor cable shall be able to include additional, unused fibers for use by other equipment (such as for data or video communications).
8. The system shall be capable of being used with pre-existing cable providing the optical fibers of the pre-existing cable meet attenuation and reflective event guidelines as set down by the system manufacturer.

B. Sensor unit equipment:

1. The system shall not require any electronic devices, communications cabling, or grounding points to be installed outdoors.
2. All electronics components shall be rack-mountable in an indoor, equipment room environment.

3. The indoor system components shall be designed for standard 19-inch wide rack.
4. The system shall provide the option for a slide-out monitor and keyboard that enables local console access to the system.
5. The system shall include a fiber optic patch panel for interfacing the sensor cable to the processor and controller modules.

## 2.5 Environmental Requirements

A. The sensor cables shall withstand operation in temperatures from –40°C to 70°C (–40°F to 158°F) and a relative humidity of 0 to 100% (condensing) without performance degradation.

B. The sensor unit components shall be designed for indoor use and meet the following requirements:

1. Temperature:
   a. Operating: 10°C to 35°C (50°F to 95°F)
   b. Storage: –20°C to 70°C (–4°F to 158°F)
2. Humidity:
   a. Operating: 20% to 80% (relative, non-condensing)
   b. Shipping and storage: 5% to 85% (relative, non-condensing)

## 2.6 Reliability and Maintenance Requirements

A. Sensor cables: The sensor cables shall provide a nominal service life of 20 years, excluding damage caused by non-environmental forces.

B. Sensor unit:

1. The sensor unit modules shall have a predicted mean time between failures (MTBF) of greater than 87,000 hours.
2. The sensor unit shall be capable of performing internal self-diagnostic tests of the internal circuitry, cable continuity, and detection processing.
3. The sensor unit software shall be field-upgradeable.

## 2.7 Electrical Requirements

A. Each sensor unit shall meet the following electrical requirements:

1. Input power: 100 to 240 VAC, 50/60 Hz
2. Power consumption: Less than 250W.

B. Backup power: The sensor unit shall be capable of being powered from a third-party uninterruptable power supply (UPS) or standby generator.

C. The sensor cable shall include no conductive elements.

D. The sensor cable shall be intrinsically safe within explosive atmospheres.

E. The sensor cable shall be completely immune to all forms of electromagnetic energy from radio communications, radar, electrical power transmission equipment and lightning.

F. The system shall not require any outdoor power or grounding connections.

## 2.8 Detection Capabilities

A. The sensor shall consist of fiber optic cable that is installed adjacent to the pipeline along the full length to be protected.

B. The sensor shall function in all common soil types.

C. The sensor shall detect leaks during all pipeline phases (steady-state, filling, draining, slugging, and different liquid/gas ratios).

D. Leak detection capabilities:

1. Detect pipeline leaks over a cable distance of up to 40 km (24.9 mi).
2. Temperature rate-of-change sensitivity:
    a. Measure change in temperature of the sensor cable relative to a reference point in time
    b. Temperature resolution of 0.0005°C
    c. Detect temperature rates of change with an accuracy of 0.001°C per minute or better as measured at the cable location
    d. Detect direction of change (increasing or decreasing)
    e. System refresh update of 1 Hz or better
3. Include Distributed Acoustic Sensing capabilities with a bandwidth of up to 2 KHz and a strain sensitivity of greater than 5 nano-strains (nε)
4. Locate leaks with a down-cable accuracy of ±10 m (32.8 ft) or better
5. The system shall include configurable background rejection algorithms to minimize nuisance alarms generated by the following environmental conditions. The background reject algorithms shall be able to:
    a. Reject temperature changes generated by weather and diurnal variation
    b. Account for temperature changes that occur in common across adjacent regions of the cable
    c. Use each measured point along the cable as a reference for background rejection.
6. The criteria used to determine the declaration of a leak detection event shall be configurable. The system shall support the following declaration modes:
    a. Leak detection event based on results only from DDTS
    b. Leak detection event based on results only from DAS

c. Leak detection event based on results from DDTS and DAS

d. Leak detection event based on results by DDTS or DAS

e. Leak detection event based on a weighted combination of DDTS and DAS

7. Typical leak detection performance:

   a. Gas leak: 500 Standard Liters Per Minute (SLPM) at 40 bar, at 0.5 meter cable offset, detection time 5 minutes

   b. Oil leak: 50 Liters Per Minute (LPM) at 40 bar, at 0.5 meter cable offset, detection time 5 minutes

   c. High-pressure gas leak (via DAS) – 500 PSI, 1/8" orifice, at 0.5 meter cable offset, detection time 30 seconds

8. Detect multiple simultaneous leaks, when each leak is separated by a sensor cable distance greater than 30 m (100 feet).

## 2.9 Cable Cut Response

A. The system shall be capable of detecting and locating a sensor cable cut.

B. The cut location shall be determined and reported with an absolute accuracy of equal to or less than 30 meters (100 feet).

C. In the event of a sensor cable cut, the system shall retain detection and location ability in the portion(s) of the sensor cable that remain connected to the system sensor unit.

## 2.10 Installation and Configuration Capabilities

A. The system shall have the following characteristics, as a minimum:

   1. The sensor cable shall be capable of being buried directly adjacent to the pipeline without needing to be put in a conduit.

   2. It shall be possible to disable detection along certain sections of the cable where leak detection is not required (i.e., lead-in sections).

B. The system shall support a cut-immune deployment configuration in which both sides of the sensor cable continue to detect interference events after a cut occurs.

C. The system shall support the following configuration and calibration features:

   1. A Windows-based graphical user interface (GUI), accessible locally or via Windows Remote Desktop.

   2. Configuration and calibration settings shall be capable of being stored in a computer file for record keeping purposes and available for reuse when configuring additional or replacement processors.

## 2.11 Networking Capabilities

A. Network manager tools: The system's network management software shall provide the following tools to facilitate system commissioning and trouble-shooting:

1. System status tool that provides a visual display of the status of all processors in the system
2. System event log tool that provides a searchable log of system events.

B. The processors shall support dual Gigabit Ethernet ports on RJ-45 connectors.

C. Network management:

1. The system shall include network management software to manage the communications over the sensor network. The network management software shall be capable of running on a standard Windows PC as well as on the sensor unit itself and be accessible via Windows Remote Desktop.
2. The system's network management software shall provide a TCP/IP-based interface for communicating alarm, status, and configuration data to and from security management systems. The system supplier shall furnish complete documentation of this interface to facilitate integration with security management systems.

## 2.12 Leak Event Display and Analysis Software

A. The system shall provide operators of the system with multiple means to visualize the system's response and analyze potential leak events.

B. The leak event display software shall run directly on the leak detection system.

C. The leak event display software shall include the following information:

1. A histogram that shows as a percentage how close the temperate rate of change signal is to meeting the alarm condition
2. A histogram that shows as a percentage how close the acoustic noise signal is to meeting the alarm condition
3. A chart showing the instantaneous temperature rate of change or accumulated temperature difference over any selected section of the sensor cable
4. A waterfall display showing the temperature rate of change as a color-coded value for any selected section of the sensor cable and selected time period within the last 24 hours
5. A chart showing the temperature rate of change for multiple selected points along the sensor cable for any selected time period within the last 24 hours
6. A chart showing the instantaneous acoustic amplitude over any selected section of the sensor cable
7. A waterfall display showing the acoustic amplitude as a color-coded value for any selected section of the sensor cable
8. A chart showing the acoustic amplitude for multiple selected points along the sensor cable.

D. The leak analysis software shall enable the system administrators to process archived data in order to develop statistics regarding long-term system performance. It shall provide the following features, as a minimum:

1. Display graphs and statistics for the following parameters:
2. Temperature rate of change – raw, before background subtraction
3. Temperature rate of change with background subtraction
4. Accumulated temperature difference
5. Generate graphs based on a specific location along the sensor cable
6. Display the following statistics:
    a. For a selected parameter, the maximum and minimum values, based on the time and location, along the entire sensor cable
    b. For a selected parameter, the maximum and minimum values, based on time and location, for each detection zone
7. The leak analysis software shall run on Windows desktop operating systems.

## 2.13 Event Management

A. The system shall provide a local PC-based operator interface with graphical alarm annunciation at the sensor unit.

B. The system shall provide access to the following information and functionality when in a local or networked configuration:

    a. A user-configurable image depicting the protected site with a schematic perimeter overlay
    b. Hardware monitoring and control
    c. Event detection and alarm generation (including flashing notification message, location marker, and audible alert)
    d. Basic alarm management
    e. Event and alarm logging
    f. Detection zone definition and configuration
    g. Adjustment of detection parameters

C. The system shall support the following alarm management functions:

1. Maintain complete information on all alarms for 24 hours or until the alarm is cleared.
2. Alarms shall be cleared by local or remote operator or automatically in 24 hours after alarm generation.
3. Until cleared, the alarm information shall be compiled in a scrollable multi-column table.

4. The maintained information shall include:
    a. Unique alarm ID number
    b. Time label
    c. Event duration
    d. Event status
    e. Event strength
    f. Event location
5. The Operator shall be able to:
    a. Select any of the alarms from the list
    b. Enter text notes regarding the cause of the alarm and the mitigation measures
    c. Clear the alarm
6. Operator notes as well as the alarm clearing event shall be recorded in the event log.
7. Alarm location Format:
    a. The primary format of the alarm location shall be the linear position along the sensor cable.
    b. It shall be possible to express the alarm location in either meters or feet
    c. Secondary location formats shall be derived from the primary measure using appropriate calibration tables.
    d. Secondary location formats shall require corresponding mapping of the perimeter fence line.
    e. It shall be possible to provide secondary alarm location formats including:
        .1 Software-defined zones
        .2 Latitude and longitude (GPS) coordinates.
8. Event logging:
    a. The system shall maintain and display an event log, including alarms, system notifications, and user actions.
    b. The logs shall be periodically saved to the hard drive.
    c. A new set of log files shall be generated every 24 hours at midnight.

## 2.14 Access Control

A. The system shall require the entry of a valid password at start-up and shutdown.

B. The system shall divide user access into to three security levels:
    1. Operator level for routine operation

2. Supervisor level for advanced system monitoring, configuration, and troubleshooting
3. Installer level for advanced configuration and troubleshooting

# PART 3 EXECUTION

## 3.1 Site Assessment

A. Before installation begins, the installation contractor shall provide a report to the facility's owner documenting any site conditions that may prevent the system from operating satisfactorily.

## 3.2 System Installation

A. The system shall be installed in accordance with the manufacturer's recommended procedures as defined in the manufacturer's documentation for the system.

## 3.3 System Calibration

A. The installation contractor shall calibrate the system in accordance with the manufacturer's recommended procedures as defined in the manufacturer's Product Guide.

B. The installation contractor shall submit to the owner the calibration and configuration settings for the system.

## 3.4 Training

A. The installation contractor or vendor shall train the owner's maintenance personnel in the calibration and system maintenance procedures as given in the manufacturer's product documentation.