

A Higher Level of Performance



Praetorian Fiber Optic Sensing Pipeline Monitoring, Leak Detection System



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www.hawkmeasure.com



A Complete Pipeline Performance Monitoring System.

- Any pipe, anywhere
- Distance up to 25 miles (40km)

Praetorian Fiber Optic Sensing



Principle of Operation

The Praetorian emits a laser pulse down a fiber optic cable to measure vibration and temperature. It will also locate the position of the vibration and temperature being measured.

Using a combination of Rayleigh backscatter, Brillouin Backscatter* and time of flight the Praetorian will determine physical disturbances to the fiber. It will identify the location, intensity and frequency of the disturbances (vibrations/temperature) along the optical fiber in real time.

Rayleigh Backscatter responds to vibrations applied to the fiber. HAWK's signal analysis software allows the Praetorian to quickly determine the most likely origin of the vibration and report any error signals to maintenance personnel. The error signals represent potential issues with the pipeline.

Brillouin Backscatter* responds to changes in ambient temperatures and is used to detect temperature changes caused by leaks (taking advantage of the Joule-Thomson effect).

Function

HAWK's Praetorian System continually monitors large spans of pipeline, looking for vibration and temperature changes. Once found, the system confirms the alarms and reports them to an existing site Distributed Control Systems (DCS) to alert maintenance or operations teams.

The Praetorian can be thought of as a series of microphones and thermometers along the fiber, recording in real time. The system analyses an enormous amount of data using Field Programmable Gate Array (FPGA) architecture to provide real time feedback on the likely origin and type of the disturbance. Utilizing proprietary pattern recognition software and multi variable sensing, the Praetorian reduces the incidences of false positives normally associated with Fiber Optic Sensors.

The Praetorian's fast processing speed and pulse rate allows it to detect minute interferences that may otherwise go unnoticed. Some examples of detectable activities include:

- Pipeline leakage
- Ground disturbance
- Manual excavation
- Machine excavation
- Vehicle movement near pipeline
- Hot tapping and/or theft
- Seismic activity

The Praetorian also Geo-tags alarms allowing security or surveillance teams are able to response immediately.

Primary Areas of Application

Installation locations:

- Oil (Crude or refined)
- Gas (any type)
- Chemical
- Mining tailings
- Water/waste water
- Brine
- Slurries
- Steam

Applications:

- Buried pipelines (any depth of cover)
- Unburied pipelines (on supports or laid on ground)
- Any fluid (gas, oil water or chemical)
- High or low pressure
- High or low temperature
- Hazardous applications
- Corrosive applications
- Steam lines
- Service gasses





Advantages

- The Praetorian can function on applications where the product is invisible (gas) or the pipeline cannot be visually inspected (buried).
- Fiber optic sensing detects not only the presence of a leak but its specific location.
- The Praetorian is extremely sensitive, competing (Mass Balance) technologies require large leaks (>1% of flow rate) in order to respond. The Praetorian is able to detect "pinhole" leaks.
- Due to the use of "long haul" single mode fiber the Praetorian is able to detect leaks at long distances.
- Existing Fiber optic data infrastructure may be utilized.
- System is passive, no electricity is required in the field.
- No maintenance or calibration require after commissioning.
- Self-diagnostics monitor the unit's condition and maintain optimum performance.
- Not effected by electromagnetic fields (EMF), lightning or weather events.
- Easy, low cost installation with pipeline.
- Low cost per foot.

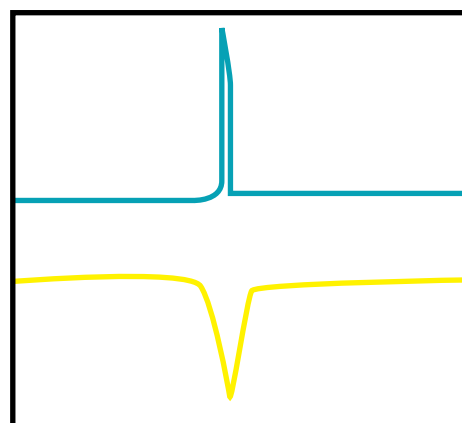
How it works

Multiple Parameters FOS

The Praetorian is unique in the market, as it monitors both temperature* and vibration in a single package. The combined parameter sensing allows the Praetorian to confirm that a leak has occurred prior to reporting it. The vibrational response from a leak is immediate. The unit detects the vibration and begins monitoring for temperature drops, while flagging the area of concern with a pre-alarm.

Once it is determined that a temperature drop has occurred in the same area of the vibration signal, the leak is confirmed and an alarm is raised. The alarm is the sent to a Supervisory Control and Data Acquisition (SCADA) System or Distributed Control Systems (DCS).

In the event that the temperature drop does not occur the Praetorian will go into a pattern recognition mode. It will conduct frequency and intensity analysis, in an attempt to classify the vibration against an onboard library. If a vibration cannot be classified, the system will record the signal and flag it as an alarm with an unknown origin prompting the operator to respond.



Distributed Acoustic Sensing - Sound

Distributed Temperature Sensing - Temperature*

False positives are a major concern for single variable systems. Environmental noises or local weather events can easily trigger alarms when no leaks are present. The Praetorian requires the presence of a noise with a leak sound profile and a localized drop in temperature to cause an alarm. Both of these conditions occurring at the same place is not a phenomenon that occurs in nature.



Time of flight

Accurately identifying the exact location of a specific signal is accomplished by a method called time of flight. The amount of time from sending the laser pulse, to receiving a return signal is recorded. The return time can then be used to calculate the distance of disturbance along the fiber.

Vibration Detection

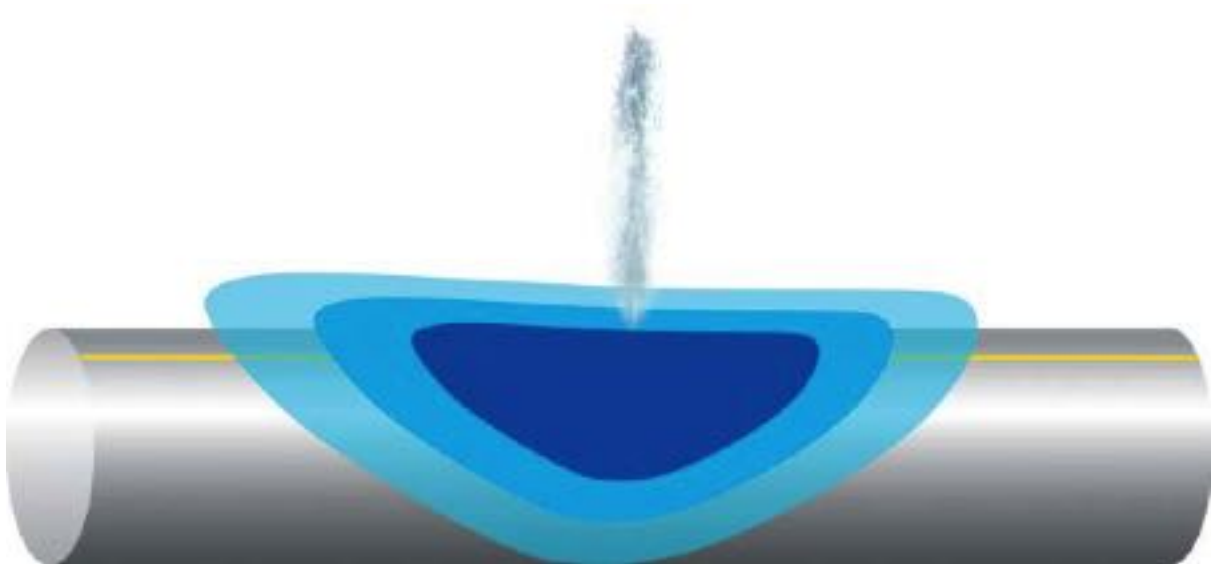
Detection of Vibration is the Praetorian's Primary sensing variable. It relies on the amount of sound energy created by pressurized fluid escaping the pipeline at the leak location. This is a reliable method of detection as leaks (once started) are consistent and only get worse over time.

In the Praetorian an optical effect called Rayleigh Backscatter is used to observe vibrational effects on a fiber. Fiber optic core backscatter is the light that reflects off natural imperfections within the fiber and returns to the light source. The returned light gets diffracted into different frequencies and Rayleigh backscatter is one of these diffracted frequencies. The amount of compression that vibration causes on the fiber determines the strength of the Rayleigh component of the back scatter.

For a signal to be classified as a pre-alarm (not yet confirmed by temperature drop) the noise profile must match a series of conditions. These include: consistency, time, intensity and frequency. All of these parameters need to be within thresholds determined during the commissioning and testing period. This reduces the amount of false signals making it to pre-alarm condition.

Temperature detection*

Once a signal is flagged as a pre-alarm, the Praetorian will hunt for a temperature drop at regular intervals. It does this by scanning a separate fiber within the cable bundle. It looks for changes to another component of the back scatter called Brillouin scattering. The system can be calibrated to run very fast (a few seconds) with lower accuracy of $\pm 1^{\circ}\text{C}$. It can also use a slower scan rate (half a minute) for a maximum accuracy of $\pm 0.25^{\circ}\text{C}$.



Leakage from a compressed pipeline is identified by the development of a cold spot due to the pressure release known as the Joule- Thomson effect. A small pressure change results in significant temperature variations. This effect can be seen in the cooling of an aerosol can with extended use.

As the pipeline's outer surface is rapidly cooled by this effect, a temperature gradient develops in the soil around the pipeline surface. The speed of the temperature gradient development depends on the type of soil and may vary from a few seconds to a few minutes.

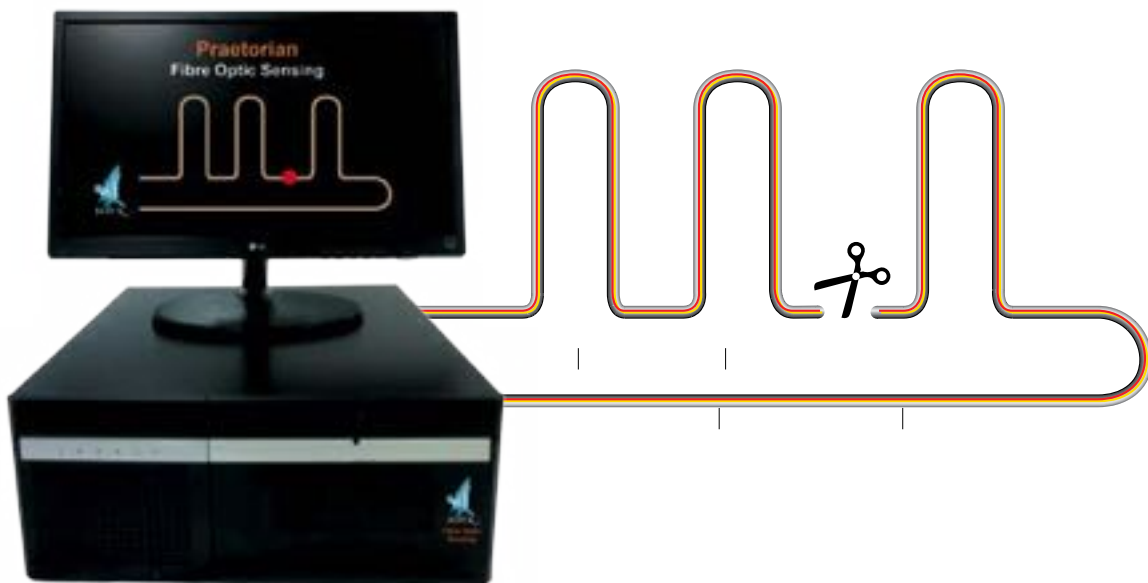
The cooling effect is independent of the soil temperature and the magnitude of the cooling effect remains the same regardless of soil temperature.



Unique Features

The Praetorian has a number of unique features which make it a market leading technology. The field programmable Gate array allows for fast parallel processing of the returned signals. The Praetorian does not have to time splice or “skip” sections of time to keep up with incoming signals.

One distinct advantage with the Praetorian system is that it is able to work such that it is immune to the effects of a broken or cut fiber. The fiber can be attached as a loop to both channels of the Praetorian. In the event of a cut, the Praetorian will report the damage, but continue to monitor the fiber (on both sides up to the cut). Alternatively if installed in a non-looped fashion. The Praetorian will monitor the position of the fiber end and check for any changes. It can instantly identify a cut to the fiber.



In all distributed acoustic fiber sensors, the detected signal has certain variations that depend on the polarization state of the received signal. These variations can be constructive interference or deconstructive interference, and to date there has been no way to compensate for this scattering which is referred to as Signal Fading.

HAWK has patented an effective solution to overcome signal fading, where small signals can be detected without fading.

Unlike systems restricted by Multimode LED light sources, the Praetorian uses a highly stable laser controlled to within $\pm 0.04\text{pm}$ allowing the system to handle two independent sensing channels of up to 25 miles (40 Km) each, without any loss of measurement in switching or time splicing.



Technical Specifications

Category	Parameter	Description
General	Sensing Element	Fiber Optic Sensing Cable
	Number of channels	1 or 2
	Interrogator operating Temperature	32°F-122°F (0-50°C)
	Unit operating Humidity (max)	85% non-condensing
	Dimensions	4RU 19" Rack Enclosure 7in x 24in x 19in (190x600x490mm)
	Weight	55lbs (25kg)
	Power Supply	110-240VAC (50-60Hz), 24VDC
	Power consumption	<200W
DAS Performance	Sensing Range	Up to 25 miles (40km) per channel
	Spatial Resolution	10in or 20in (250 or 500mm)
	Frequency Response	1Hz-120kHz (Range Dependent)
	Dynamic Range	50dB
	Temperature sensing range (cable)	+/- 0.25°C
DTS* Performance	Accuracy	0.01°C
	Resolution	1-2 Minutes (Depending on Temperature Parameters)
	Scan Time	-418°F to 1,292°F (-250°C to 700°C)
	Temperature Sensing Range	Laser (Infra-red) Class 1M
Technical	Light Source	1550.12nm (nanometres)
	Laser Wave Length	±5pm (picometers)
	Laser Stability	400MHz
	Acquisition rate	64Bit (Ultra high speed)
	Processor Acquisition Rate	Linux
	Operating System	Modbus over Ethernet (Standard) , Relay and USB
	Output	Ethernet and 3G/4G enabled
	Remote Interfacing	Field programmable gate array (FPGA)
	Processor architecture	2x 2TB HDD (removable)
	Data Storage (Removable)	128GB Solid State Drive
	Data Storage (Internal)	128GB Solid State Drive



Other Uses

This document covers the use of the Praetorian Fiber optic Sensing system using the Leak Detection System (LDS) software suite and hardware. However there are a large number of other applications Praetorian is well suited to monitor. These include but are not limited to:

- Perimeter Security
- Conveyor Malfunction and Fire Detection
- Fire Detection
- Infrastructure Strain and Stress Monitoring
- Borehole Condition Monitoring

Praetorian can be installed with Temperature*, Vibration and Strain* Modules and expanded to suit a wide range of sensing application.

**Distributed Temperature Sensing (DTS) is a highly recommended option for leakage detection systems.*

Part Numbering

Model

FOS Praetorian Fiber Optic Sensing Interrogator

Power Supply

B 24VDC

U 110-240VAC

Sensing Method

AXX Distributed Acoustic Sensing

TXX Distributed Temperature Sensing

ATX Distributed Acoustic and Temperature Sensing

Channel

01 Single Channel

02 Dual Channel

1M Single Channel with Multiplexer

2M Dual Channel with Multiplexer

04 Four Channel

Mounting

4R 4RU Rack Mount

Communications

M Modbus TCP/IP

Software Options

LDS Leak Detection System

Version

X HAWK

FOS U ATX 04 4R M LDS X

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