A Higher Level of Performance

Praetorian Fiber Optic Sensing

Pipeline Monitoring, Leak Detection System

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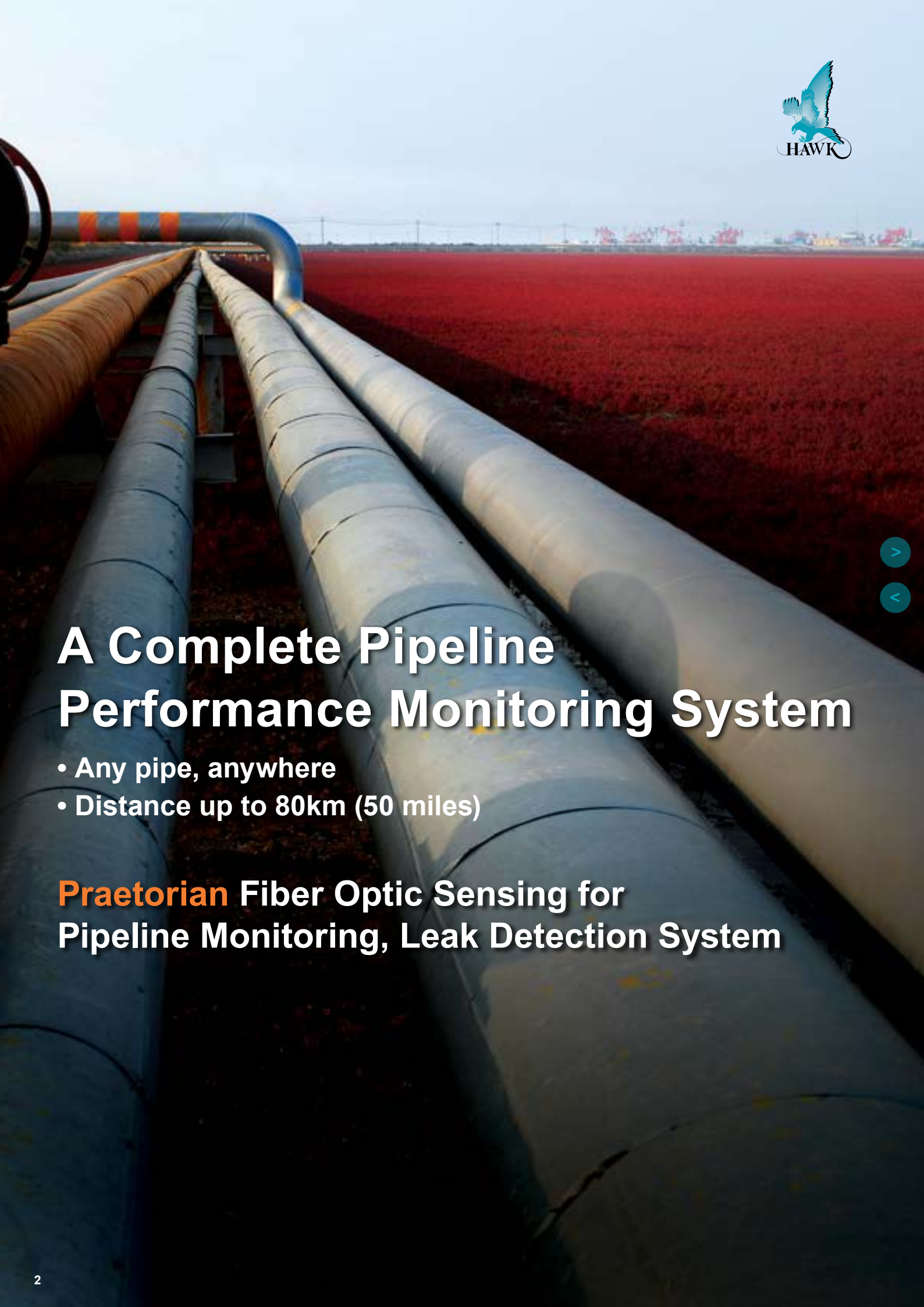


A Complete Pipeline Performance Monitoring System

- Any pipe, anywhere
- Distance up to 80km (50 miles)

Praetorian Fiber Optic Sensing for Pipeline Monitoring, Leak Detection System

Principle of Operation

Praetorian emits a laser pulse down a fiber optic cable to measure vibration and temperature as well as the position of that vibration and temperature.

Using a combination of Rayleigh backscatter, Brillouin Backscatter* and time of flight, Praetorian determines the presence, location, intensity and frequency of vibrations and temperature changes along an optical fiber in real time.

Rayleigh Backscatter responds to physical vibration imparted on the fiber by disturbances to the application. HAWK's signal analysis software allows Praetorian to quickly determine the most likely origin of the vibration and report any erroneous signals to maintenance personnel of potential issues with the pipeline.

Brillouin Backscatter* responds to shifts in environmental temperatures and is used to detect the temperature drop associated with the reduction in fluid pressure caused by the leak 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 alarm and reports them both visually and digitally so that existing site Distributed Control Systems (DCS) can be used to raise an alarm with a maintenance or operations team.

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

Praetorian's fast processing speed and pulse rate allow 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

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

Primary Areas of Application

Installation locations:

- Oil (crude of 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

- Praetorian can function on applications where either the product is invisible (gas) or the pipeline cannot be visually inspected (buried).
- Fiber optic sensing detects not only the presence of the leak but its specific location.
- Praetorian is extremely sensitive, competing (Mass Balance) technologies require large leaks (>1% of flow rate) in order to respond. Praetorian is able to detect “pinhole” leaks.
- Due to the use of “long haul” single mode fiber, 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 meter.

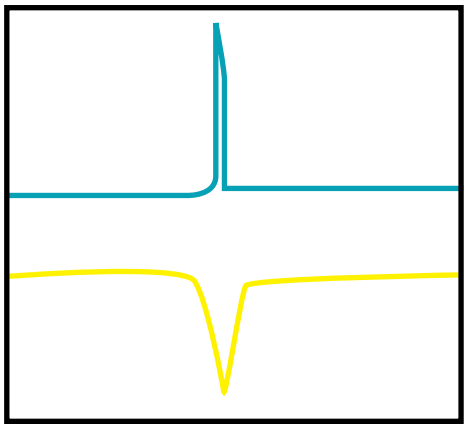
How It Works

Multiple Parameters FOS

Praetorian is unique in the market as it monitors both temperature* and vibration in a single package. The combined parameter sensing allows Praetorian to self confirm that a leak has in fact occurred prior to reporting it. Typically the vibrational response from a leak is immediate and the unit detects this first and begins monitoring that area for an associated temperature drops whilst flagging the area with a pre-alarm.

Once it is detected that a localized temperature drop has occurred at the same area of the vibrational signal the leak is confirmed and an alarm is raised. This is communicated to a Supervisory Control and Data Acquisition (SCADA) System or Distributed Control Systems (DCS).

In the event that the temperature drop does not occur Praetorian will go into a pattern recognition mode and 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 localized weather events can easily trigger an alarm when no leak is present. The advantage of dual sensing method is effectively a complete elimination. Praetorian requires that the presence of both a noise with a leak sound profile and a localized drop in temperature to alarm and both of these conditions occurring at the same place is not a phenomenon that occurs in nature and therefore something the applications environment can produce leading to a false positive.

Time of Flight

Accurately identifying the exact location of a specific signal is accomplished by a method called time of flight. Simply put the amount of time from sending the laser pulse to receiving a return signal is able to be recorded. Due to the internal properties of a fiber optic core the speed of light through a fiber is consistent at approximately two thirds of the speed of light through a vacuum. As this is consistent the return time can be used to calculate a distance on the fiber.

Vibration Detection

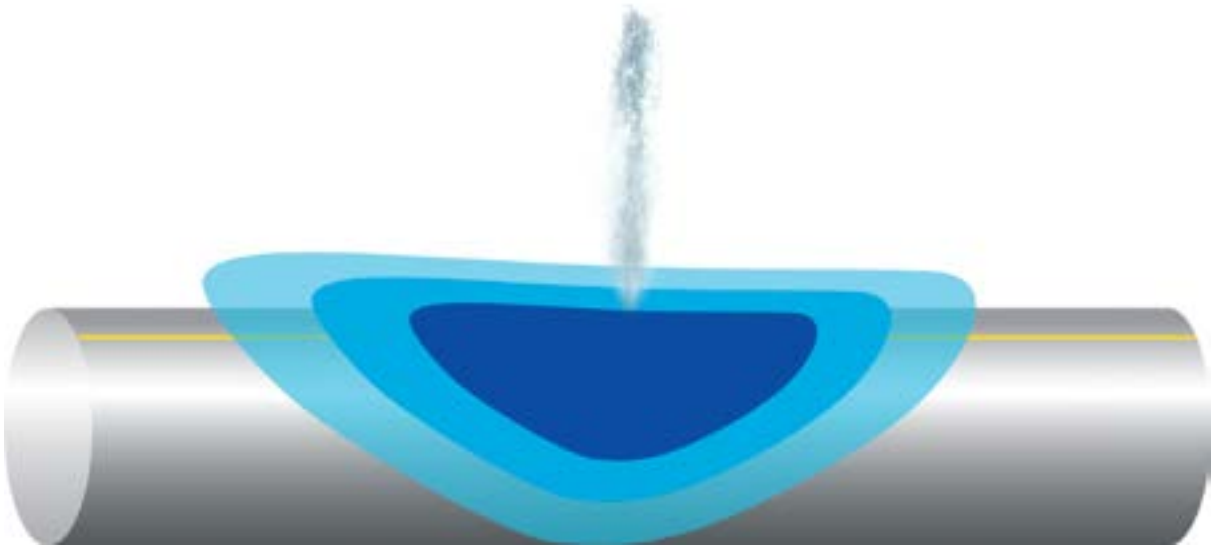
Detection of Vibration is Praetorian's Primary sensing variable and relies on the amount of sound energy created by pressurized fluid escaping the pipeline at the leak location. This is a reliable method of detection as leaks (once started) are consistent and only get worse over time.

In Praetorian an optical effect called Rayleigh Backscatter is used to observe vibrational effects on a fiber. A fiber optic core backscatter is the light that reflects off natural imperfections and polarizations within the fiber and returns back to the light source. The return light gets diffracted into different frequencies similar to light moving through a prism and Rayleigh backscatter is one of these diffracted frequencies. The amount of compression that vibration causes on the core determines the strength of the Rayleigh component of the back scatter. In this way the intensity and frequency of the vibration is measurable by recording the behaviors or the Rayleigh backscatter component.

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 and 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 Praetorian will hunt for a temperature drop at regular intervals. It does this by scanning a separate fiber within the cable and looking for changes to another component of the back scatter caller Brillouin scattering. The system can be calibrated to run very quick (a few seconds) lower accuracy (±1°C) scans of the fiber for temperature changes or to take a slower (half a minute) more detailed scan for maximum accuracy (±0.25°C) of temperature to sense even the smallest changes.



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 result in significant temperature variations. This effect can be seen in the cooling of an aerosol can with extended use.

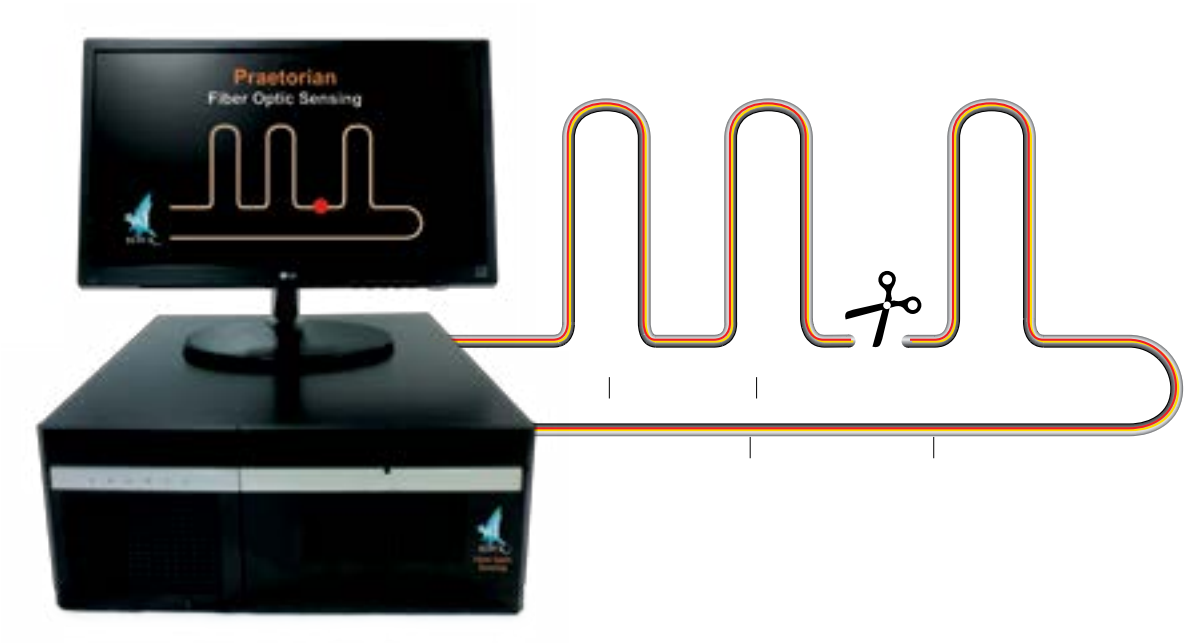
As the pipelines outer surface is rapidly cooled by this effect, a temperature gradient develops in the soil around the pipeline surface. The speed of the temperature gradient development depends on the type of soil and may vary from a few seconds to a few minutes.

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

Praetorian has a number of unique features which make it a market leading technology. The field programmable Gate array allows for ultra fast parallel processing of the returned signals meaning that 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 unit can be attached as a loop to both channels on independent fibers and in the event of a cut 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 Praetorian will monitor the position of the fiber end and check for any change to this. It can instantly identify a cut to the fiber.



In all distributed acoustic fiber sensors, the detected signal level has certain variations depending on polarization state of the received signal which produces scattering of the signal. This scattering can be constructive interference or deconstructive interference, and to date there has been no ability 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 Praetorian uses a highly stable laser controlled to within ±0.04pm allowing the system to handle two independent sensing channels of up to 40km 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	0-50°C
	Unit operating humidity (max)	85% non-condensing
	Dimensions	4RU 19” rack enclosure (190x600x490mm)
	Weight	25kg
	Power supply	110-240VAC (50-60Hz), 24VDC
	Power consumption	<200W
DAS Performance	Sensing range	Up to 40km per channel
	Spatial resolution	250 or 500mm
	Frequency response	1Hz-120kHz (range dependant)
	Dynamic range	50dB
	Temperature sensing range (cable)	-30°C to 200°C (special options for temps up to 800°C and down to -200°C available)
DTS* Performance	Accuracy	±0.25°C
	Resolution	0.01°C
	Scan time	1-2 minutes (depending on temperature parameters)
	Temperature sensing range	-250°C to 700°C
Technical	Light source	Laser (infra red) Class 1M
	Laser wave length	1550.12nm (nanometers)
	Laser stability	±5pm (picometers)
	Acquisition rate	400MHz
	Processor acquisition rate	64Bit (ultra high speed)
	Operating system	Linux
	Output	Modbus over ethernet (standard), relay and USB
	Remote interfacing	Ethernet and 3G/4G enabled
	Processer architecture	Field Programmable Gate Array (FPGA)
	Data storage (removable)	2x 2TB HDD (removable)
	Data storage (internal)	128GB solid state drive

Other Uses

This document covers the use of the Praetorian Fiber optic Sensing system utilizing 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
- Conveyer 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 External Multiplexer
2M Dual Channel with External Multiplexer
04 Four Channel with Internal Multiplexer

Mounting

4R 4RU Rack Mount

Communications

M Modbus TCP/IP

Software Options

PID1 Pipeline Intrusion Detection
LDS1 Leak Detection System
XXXX Special

OEM

X HAWK

FOS	U	ATX	04	4R	M	LDS	X

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