

A Higher Level of Performance



Praetorian Fiber Optic Sensing Conveyor Idler Monitoring and Fire Detection



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**Eliminate Unscheduled
Conveyor Down Time
Real-Time Preventative
Roller Failure Detection**





Introduction

The mechanical nature of conveyors make them highly prone to wear and tear. This can lead to the failure of components and cause failures that can shut down the entire conveyor. Since conveyors are often the main form of movement for raw and saleable material within a plant; it follows that when a conveyor goes down so does the profitability of an operation.

The Praetorian Conveyor Health Monitoring System (CHMS) provides a simple and reliable way to monitor each moving part of the conveyor without the need for additional power or communications to be installed in the field. The Praetorian's sensing capability is so great that even the slight variations in signal caused by wear can be detected and a likely fault can be predicted prior to failure, thereby reducing downtime and damage.

Due to its simple installation requirements, the Praetorian can be installed on new conveyors or retrofitted to existing conveyors. With multi-channel capability, the Praetorian has the capability to monitor multiple conveyors simultaneously so that a single system can be programmed to monitor an entire site.

Function

The Praetorian converts a fiber optic cable into a nearly infinite series of microphones and thermometers recording events 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, the Praetorian reduces the incidences of false positives normally associated with other Fiber Optic Sensors (FOS).

Using a series of pattern recognizing algorithms the Praetorian identifies failing and degrading bearings prior to catastrophic failures that may result in costly unscheduled downtime or safety risks.

Consisting of an Interrogator unit mounted in an indoor area (such as a server or control room) at one end of the conveyor, the Praetorian can be configured to look after a single large conveyor or multiple conveyors. With a total fiber length of 50 miles per Interrogator, it is possible for an entire plant's conveyor systems to be monitored by a single Praetorian system.

As part of the commissioning, comparisons between "brand new" and "fully failed" idlers are made to allow the Praetorian to monitor the wear pattern on idlers and give a 0-100% "wear percentage" to operators. This allows preventative maintenance decisions about roller swap-outs to be made and allows reliability managers to optimize roller lifespan, preventing premature change out of rollers that still have usable lifespan remaining.

From a systems integration approach, the Praetorian reports each conveyor leg, covered by the system with a numerical value for wear percentage. Operators are then able to adjust alarm thresholds to suit their individual conveyor's behavior utilizing trend history gathered over the commissioning period. Each of the alarms and wear percentages are available via a number of digital communication protocols (by default Modbus TCP/IP is supplied). In the event that no SCADA or DCS is being used the Praetorian can be directly operated through its built in Graphical Human Machine Interface (HMI).

The Praetorian's main advantage over traditional measurement methods is that signals are objectively observed, compared and referenced against known good conditions, in real time, instead of relying on a manual audio/visual inspections. Problems with inspection inaccuracies associated with operator fatigue and operator error are avoided through the use of the Praetorian Fiber Optic Sensing system.

Another distinct advantage of using the Praetorian system over traditional periodic inspections is that detected failures can be tracked. This allows trends to be established giving operations the ability to make reasonable estimates of operation hours from detection of wear to complete failure of a roller. This allows for targeted maintenance operations to be conducted during convenient production down times rather than stopping production when a roller is suspected of failing. The subjective nature of audio/visual inspection by different personnel is eliminated.

The Praetorian also Geo-tags alarms allowing maintenance teams to respond immediately or plan maintenance activities to fit with existing schedules.



Principle of Operation

The Praetorian system Interrogator unit is connected to one end of a fiber optic cable which is attached to the conveyor belt's static structure. The Interrogator produces rapidly pulsed laser light set at a precise frequency that excites the fiber and causes it to be responsive to physical changes around it. Some of this light is reflected back (backscattered) to the light source where the Interrogator records and analyses looking for changes to its color relating to physical effects in the application.

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

Time of Flight

Locations of events are able to be accurately determined by a method called time of flight. Similar to radar, sonar and ultrasonic instruments, the amount of time from sending the laser pulse to receiving a return signal is recorded.

Due to the internal properties of a fiber optic cable, the speed of light through a fiber is consistent. As the speed is consistent, the return time can be used to calculate a distance on the fiber down to 10 inches.

Vibration Detection

In the Praetorian Interrogator, an optical effect called Rayleigh backscatter is used to observe vibrational effects on a fiber. In a fiber optic cable, 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 from vibration due to an environmental signal (or noise) on the cable determines the strength of the Rayleigh component in the backscattered light. The intensity and frequency of the vibration is measurable by recording the behaviors of the Rayleigh backscatter component. The change in intensity and frequency is used to determine the position of a disturbance.

Rayleigh backscatter responds to physical vibrations imparted on the fiber by disturbances in the conveyor belt's normal vibrations. Traditionally the challenge of determining conveyor fault though sound has been to be able to remove the huge amounts of noise and vibration that are part of the normal running condition of the fiber.

HAWK'S signal analysis software allows the Praetorian to quickly determine which signals are not consistent with the normal running sounds of the conveyor. While monitoring over longer periods of time, it is possible for the Praetorian to notice signals occurring at a particular location have changed in a manner that indicates increased bearing wear. The system then reports the location of the worn idler or pulley to operators, giving an advanced indication of impending roller failure.

To be classified as an alarm the duration, dominant frequencies and relative intensity of a signal all need to be present within pre-determined thresholds. This reduces the amount of false signals that are reported as alarms.





Temperature Detection

At the same time the Interrogator is monitoring for vibration the Praetorian will continuously hunt for temperature spikes along the belt's length. The main use of temperature in conveyor applications is for fire detection where an ignition has occurred.

The Praetorian accomplishes this by scanning a separate fiber within the cable and looking for changes to another component of backscattered light called Brillouin refraction. The system can be calibrated to run very fast (using lower accuracy ($\pm 1^{\circ}\text{C}$) scans of the fiber for temperature, or take a slower (30-60 seconds) more detailed scan for maximum accuracy ($\pm 0.25^{\circ}\text{C}$) of temperature to sense even the smallest changes.

Temperature as a primary sensing variable is not recommended, as heat transfer from the bearing to the support and from the support to the fiber is minimal. Typically a temperature sensing fiber is connected to an overhead wire that sits under the weather shield and monitors conveyor air temperature. In this way, Distributed Temperature Sensing (DTS) can be used for general fire protection duties of any linear infrastructure.

In normal conveyor belt configurations vibration acts as a primary sensing and detection variable used to schedule maintenance activities, where temperature monitoring is used as an emergency condition detection method.

Primary Areas of Applications

Installation locations:

- Coal Mines, Hazardous Area Suitable (No Infield Electronics)
- Hard Rock Mines
- Quarries
- Buildings
- Unmanned Material Handling Facilities
- Processing Plant Conveyors

Possible applications:

- Overland Conveyors
- Building Fire Detection
- Conveyor Fire Detection
- Remote or Rural Conveyors

Features

Due to its utilization of a Field Programmable Gate Array (FPGA), the Praetorian is able to monitor every point along the fiber. It will constantly monitor for frequency changes in the individual conveyor idler leg stands and monitor changing conditions within the idler bearing.

Another distinct advantage with the Praetorian system is 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. It will 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 change. It can instantly identify a cut to the fiber.

In all distributed acoustic fiber sensors, the detected signal level has certain variations depending on the 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 $\pm 0.04\text{pm}$ allowing the system to handle two independent sensing channels of up to 25 miles 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)	-22°F to 392°F (-30°C to 200°C)
DTS Performance	Accuracy	±0.25°C
	Resolution	0.01°C
	Scan Time	1-2 Minutes (Depending on Temperature Parameters)
	Temperature Sensing Range	-418°F to 1,292°F (-250°C to 700°C)
Technical	Light Source	Laser (Infra-red) Class 1M
	Laser Wave Length	1550.12nm (nanometres)
	Laser Stability	±5pm (picometers)
	Acquisition rate	400MHz
	Processor Acquisition Rate	64Bit (Ultra high speed)
	Operating System	Linux
	Output	Modbus Ethernet TCP/IP (Standard), Relay, USB, SCADA or User Specified
	Remote Interfacing	Ethernet and 3G/4G enabled
	Processor 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 conveyor monitoring 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 Intrusion Detection System (PIDS) Security
- Pipeline Leak Detection System (LDS)
- High voltage power transmission or data Cable Monitoring Systems (CMS)
- Fire Detection
- Infrastructure Strain and Stress Monitoring
- Borehole Condition Monitoring

Praetorian can be installed with temperature, vibration and strain modules.

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

Mounting

4R 4RU Rack Mount

Communications

M Modbus

Software Options

CON1 Conveyor Health Monitoring System

Special

X Not required

FOS U ATX 02 4R M CON1 X



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Additional product warranty and application guarantees upon request.

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