ForeSite® Sense Optical

Provides comprehensive multiparameter downhole sensing for well production, injection, storage, and monitoring

Applications

- In-well flow pressure measurement
- Reservoir pressure determination during shut-ins
- Data gathering for pressure-transient analysis (permeability, skin, and reservoir boundary determination)
- Management and control of well ramp-up
- Interference testing and reservoir connectivity determination
- High-pressure stimulation
- Intelligent wells
- Land, platform, and subsea wells
- Multizone wells
- Extreme high-temperature and high-pressure wells
- High-rate wells

Features and Benefits

- The ForeSite Sense optical solution delivers stable measurements with no measurable drift, which reduces uncertainty of absolute pressure and temperature measurements over the life of the field.
- The solution withstands impact, vibration, and significant pressure surges. It has undergone extensive mechanical-shock and vibration survivability and highly accelerated life test (HALT) testing.
- The solution has a minimal number of components and no moving parts, which reduces potential failure modes, increases tool life, and decreases maintenance costs.
- The solution is electronically passive, and has no electronics downhole, which increases system reliability and stability.
- Reservoir pressure data is available on demand, reducing well interventions and production shut-ins.
- Improved cable-to-gauge integration exceeds the full strength of the downhole cable for continued data delivery in the harshest environments.
- The solution enables short-term operation at pressures up to 30,000 psi (206.8 MPa), which facilitates use during critical well-stimulation operations.

The ForeSite Sense Optical solution leverages 30 years of experience and 14,000 sensors installed worldwide.

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ForeSite® Sense Optical

Tool Description

The ForeSite Sense optical solution provides permanent reservoir monitoring in moderate to ultra-extreme well conditions. The gauge can be combined with multiple ForeSite Sense optical gauges or other optical gauges on a single fiber or cable, which provides comprehensive multiparameter downhole sensing for well production, injection, storage, and monitoring.

The ForeSite Sense optical gauge uses a Weatherford optical-glass Bragg-grating sensor and glass-to-metal penetrator technologies for ultra-extreme well conditions. The gauge has minimal parts and no in-well electronics. It is immune to electromagnetic interference, which enables functionality while using other electrical completion components.

ForeSite Sense optical devices are well suited for high-value wells. They deliver stable, reliable, high-resolution measurements with no measurable drift. The design has undergone extensive HALT testing to confirm continuous operation in harsh environments.

Options

- Multiple pressure and temperature measurements per fiber
- Single- or dual-configuration per mandrel
- Tubing or annulus sensing with universal pressure foot
- Multiple gauges on a common optical fiber to enable multizone applications
- Integration with optical flowmeter, distributed temperature sensing (DTS), and distributed acoustic sensing (DAS) technologies enable simultaneous acquisition on a single fiber or cable

ForeSite Sense optical pressure and temperature gauge showing pressure foot region.

ForeSite® Sense Optical

Specifications

Operational Performance

Maximum temperature	392°F (200°C)
Calibrated temperature	77 to 392°F (25 to 200°C)
Calibrated pressure range	Atm to 20,000 psi (Atm to 137.9 MPa)
Over pressure	24,000 psi at 392°F (165.5 MPa at 200°C)
Collapse pressure at room temperature (RT)	> 24,000 psi (> 165.5 MPa)
Burst pressure at RT	> 30,000 psi (> 206.8 MPa)
Minimum storage temperature	-40°F (-40°C)
Update rate	1 sec, no limit

Pressure Metrology

Accuracy	± 3 psi (± 0.02 MPa)
Resolution*	≤ 0.05 psi (≤ 0.0003 MPa)
Long-term stability/yr	< 0.5 psi/yr at 392ºF (< 0.003 MPa at 200ºC)

Temperature Metrology

Accuracy	± 0.18°F (± 0.1°C)
Resolution, RMS	≤ 0.036°F (≤ 0.02°C)
Long-term stability/yr	< 0.18 at 392°F (< 0.1 at 200°C)

Mechanical

Material	Inconel® 718
Outside diameter	0.875 in. (22.2 mm)
Length	13 in. (330 mm)

Shock and Vibration Data

Vibration	15 G_{rms} [20 to 2,000 Hz (NavMat)]
Shock	100 g, 9 ms half sine
Drop	500 g, 1 ms half sine
Thermal shock/min	53.6°F (12°C)

*Depends on update rate

ForeSite® Sense Optical

Optical Pressure/Temperature Gauge

The ForeSite Sense optical pressure and temperature gauge (P/T), provides comprehensive multi-parameter downhole sensing for well production, injection, storage, and monitoring. The gauge system, part of the optical family of P/T, is compatible with other downhole optical monitoring techniques such as distributed temperature sensing and distributed acoustic sensing.

The optical P/T gauge uses the Weatherford optical-glass Cane Bragg-grating sensor and glass-to-metal penetrator technologies for harsh downhole conditions. The gauge has minimal parts and no in- well electronics. The sensor is immune to electromagnetic interference, which enables functionality while using other electrical completion components.

Features and Benefits

- Stable P/T measurements with no detectable drift eliminates concerns about absolute measurements over the life of the well
- On-demand P/T data reduces well interventions and production shut-in
- Simplified design reduces potential failure modes to extend the life of the gauge and decrease maintenance costs
- Surface electronics, with no downhole electronics, enhances the reliability and stability of the system

Specifications

Operational Parameters

Operating Pressure Range	15,000 psi
Operating Temperature Range	Up to 392°F (200°C)

Pressure Metrology

Accuracy	±5 psi
Resolution	≤ 0.05 psi (≤ 0.0003 MPa)

Temperature Metrology

Accuracy	± 0.9°F (± 0.5°C)
Resolution	≤ 0.036°F (≤ 0.02°C)

Mechanical Parameters

Material	Inconel
Outside Diameter	0.25 in

ForeSite® Sense Optical

Temperature Sensor

The ForeSite Sense optical temperature sensor provides ultrahigh-performance temperature measurement with the ability to be multiplexed for quasi-distributed sensing along areas of interest in the wellbore. Using the same glass sensor technology as the successful Weatherford optical pressure and temperature gauge, optical delivers unique long-term stability and reliability with a fast update rate and ultrahigh resolution.

The Weatherford standard Bragg grating interrogator (BGI) interrogates the sensor for dry tree and subsea applications, eliminating the need for special interrogators. The Bragg grating-based sensing element can be easily multiplexed to enable multiple, highly accurate temperature-measurement points along the well. The optical-point temperature sensors are readily integrated into the field-proven Weatherford 1/4-in. optical cable for in-well applications and can be combined with other optical sensors for distributed temperature sensing (DTS), pressure/temperature (PT), flowmeter, and seismic applications. ForeSite Sense can provide up to 100 times the resolution of DTS and 25 times the stability, with near real-time monitoring capability reducing measurement error in dynamic flow conditions such as well starts, stimulations, production, or shut-ins.

This system also interfaces with all ForeSite Sense components including connectors, splitter assemblies, and wellhead pressure barriers. Cable packaging is identical to that of other in-well hydraulic and instrument lines, enabling the use of standard handling and installation techniques.

Features and Benefits

- Optical technology platform provides a sensor design with no electronics, a minimal number of components, and no moving parts, to deliver a high degree of reliability over the life of the well.
- Optical Bragg grating technology provides multipoint arrays (multiplexing of the optical sensors on a single optical fiber) for temperature profiling with an order-of-magnitude improvement in resolution and stability over Raman DTS systems, enhancing reliability.
- ForeSite Sense technology results in extremely low drift, eliminating concerns about absolute temperature measurement over the life of the field.
- Cable splicing and repair can be conducted at the wellsite to minimize interruptions in operations.
- Flexible 1/4-in. cable passes readily through wellheads, packers, safety valves, and other in-well completion equipment, enabling use of the ForeSite Sense in a wide variety of situations.
- Cable packaging is identical to that of other in-well hydraulic and instrument lines, enabling use of standard handling and installation techniques to comply with industrial standards for instrumentation cable.
- Proven design protects fibers from cable stresses.
- Industry-leading fiber protection ensures reliability throughout the life of the well.
- Shock and vibration resistant sensor provides mechanical survivability to endure rigorous qualification and long-term testing, enabling use with perforating or hydraulic fracturing operations.

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* Inconel is a registered trademark of Special Metals Corporation.

ForeSite® Sense Optical

Temperature Sensor (continued)

Specifications (continued)

Operational Performance

Collapse pressure	>25,000 psi (>1,724 bar)
Burst pressure at room temperature	>35,000 psi (>2413 bar)
Operating Temperature	77 to 239°F (25 to 115°C)
Maximum temperature	257°F (125°C)
Minimum storage temperature	-58°F (-50°C)
Update rate	1 sec, no limit

Temperature Metrology

Accuracy	±0.900°F (0.50°C)
Resolution[a]	0.018°F (0.01°C)
Long-term stability/year at 239°F (115°C)	<0.090°F (<0.50°C)
Temperature sensors[b]	Up to 18 per fiber

[a] Typically <0.009°F (0.005°C) at 5 min. averaging
[b] Multifiber cable available

Shock and Vibration Data

Vibration	15 G_{rms} random (10 to 2,000 Hz Navmat)
Shock	100 g, 9ms half sine
Drop	500 g, 1 ms half sine
Thermal shock/min	53.6°F (12°C)

ForeSite® Sense Optical

Optical Gauge Mandrel

The ForeSite Sense optical gauge mandrel provides a means of mounting optical or electronic pressure gauges onto the completion string, and provides the required mechanical protection to ensure reliable operation of the downhole gauges. Different configurations of the gauge mandrel are available to support above-packer or below-packer operations and interzonal monitoring requirements. Single-, dual-, and triple-gauge configurations are available for tubing and annulus pressure and temperature measurements.

The gauge mandrel is manufactured to meet application requirements under API 5CT standards. The gauge mandrel supports control-line bypass for applications requiring chemical injection or for intelligent-well configurations in which control lines are required for flow-control valves.

Features and Benefits

- Machined one-piece metal mandrel is weld free, for added durability.
- Certified connections enhance durability and reliability.
- Metal-to-metal primary and back-up seals between the mandrel and the gauge further improve reliability.
- Streamlined mandrel outside diameter (OD) reduces installation time by eliminating hang-ups while passing through the riser and blowout preventer.
- Full-bore mandrel inside diameter (ID) is equal to that of the completion tubing, which enables smooth access for completion or intervention equipment.
- Protective mandrel body shields the entire length of pressure and temperature (P/T) gauges from the internal wall of casing to ensure reliable readings throughout the course of operations.
- Gauge-to-mandrel connection simplifies installation by enabling pre-mounting of the downhole cable to the gauge.
- Mandrel pressure ratings are equal to or greater than those of the completion tubing to support the integrity of the completion.
- Pressure-test port saves time by enabling testing of the seal integrity before running the mandrel in the hole.

Specifications

The mandrel can be custom made from various materials to suit different well environments. Thread connections, size, and weight can be modified to suit completion tubing. Single-, dual-, or triple-gauge housing configurations are available.

Due to the large number of variations of gauge mandrels, specifications are available upon request for the chosen mandrel design. Specifications will vary depending on mandrel material, gauge configuration, completion design, and type of connection.

ForeSite® Sense Optical

Optical Downhole Cable

The ForeSite Sense optical downhole cable provides a high-performance signal pathway for downhole pressure, temperature, and seismic measurements. This cable accommodates up to four single- or multi-mode fibers in any combination. Its fibers support distributed temperature sensing (DTS) and distributed acoustic sensing (DAS), as well as Bragg grating pressure and temperature gauges, multi-point temperature arrays, flowmeters, and seismic accelerometers. The Bragg grating sensors can be multiplexed on a single fiber, and a downhole cable splitter enables further multi-zone sensing architectures for enhanced production-monitoring capabilities.

The cable is engineered for reliable performance throughout the life of the well. The proprietary design incorporates an ultra-premium fiber-protection system that guards against cable stresses and degradation to eliminate the need for periodic replacement.

This protection system also helps maintain the factory-calibrated temperature-profiling measurement throughout the life of the well. The cable can be supplied with hydrogen-resistant fibers that prevent long-term degradation of the optical system caused by hydrogen intrusion.

The standard 1/4-in. outside diameter (OD) cable is compatible with all Weatherford optical completion components, including connectors, splitter assemblies, sensors, and wellhead-pressure barriers. Weatherford accommodates a range of cross-coupling clamping variations and provides a choice of final encapsulation materials and configurations, such as 0.43 × 0.43 in (11 × 11 mm) square or 0.43 in (11 mm) round, or flatpack packaging.

Features and Benefits

- Multi-fiber design enables multi-parameter measurements in the wellbore, which reduces the number of wellhead penetrations and monitoring system complexity.
- Cable compatibility with all optical sensing products facilitates monitoring system design flexibility and reduces overall system cost.
- Cable packaging is identical to other in-well hydraulic and instrument lines, which enables use of standard handling and installation techniques.
- Flexible cable can pass through wellheads, packers, and other in-well completion equipment to reduce installation time and costs

ForeSite® Sense Optical

Optical Downhole Cable (continued)

Specifications

Construction

Model	Extreme		Thermal
Cable size	1/4 in. (6.35 mm)		
Wall thickness	0.028 in. (7.112 mm)	0.035 in. (0.889 mm)	0.035 in. (0.889 mm)
Optical fibers	Up to 4 fibers[a], single-mode or multi-mode		
Inner metal tube	304 Stainless steel		
Buffer	AA1070 Aluminum		None
Outer armor tube: INCOLOY® 825* OD × wall	0.25-in. OD × 0.028 in. wall (6.35 mm OD × 7.112 mm wall)	0.25-in. OD x 0.035 in. wall (6.35 mm OD × 0.889 mm wall)	

Mechanical Properties

Weight in air	0.1 lb-ft (0.1488 kg-m)	0.11 lb-ft (0.1637 kg-m)	
Working pressure	20,000 psi (1,379 bar)	25,000 psi (1,724 bar)	
Collapse pressure	>30,000 psi (2,068 bar)	>35,000 psi (2,413 bar)	>30,000 psi (2,068 bar)
Burst pressure	20,000 psi (1,379 bar)	25,000 psi (1,724 bar)	15,000 psi (1,034 bar)
Maximum tensile load	1,500 lb (680 kg)	2,000 lb (907 kg)	
Maximum splice-free length	27,000 ft (8,229 m)	10,000 ft (3,048 m)	

Environmental Specifications

Maximum operating temperature[b]	392°F (200°C)		572°F (300°C)
Minimum storage temperature	-40°F (-40°C)		
Pressure range	Atm to 20,000 psi (1,379 bar)	Atm to 25,000 psi (1,724 bar)	Atm to 20,000 psi (1,379 bar)

[a] Thermal may have more fibers on a case-by-case basis. Custom optical fiber configurations can include any combination of single-mode or multi-mode optical fibers.
[b] DTS temperature range will depend on optical fiber selection.

* Incoloy is a registered trademark of Special Metals Corporation.

ForeSite® Sense Optical

Downhole Optical Cable

The ForeSite Sense downhole optical cable provides a high-performance signal pathway for optical sensing solutions. The optical cable uses a streamlined manufacturing process to improve lead times and cost. The cable manufacturing process also provides the capability to integrate engineered optical fibers supplied by other vendors.

Features and Benefits

- Single-fiber design obtains different types of measurements in the wellbore, which reduces the complexity of the monitoring system along with the number of wellhead penetrations.
- Cable compatibility with all ForeSite Sense products enhances the flexibility of the monitoring-system design and reduces the overall cost of the system.
- Cable packaging is identical to other in-well hydraulic and instrument lines, which enables use of standard handling and installation techniques.
- Flexible cable can pass through wellheads, packers, and other in-well completion equipment to reduce installation time and costs.

Specifications

Construction

1/4-in. cable	Single Cable	
	0.028-in. wall	0.035-in. wall
Optical fiber	Single Fiber	
Outer armor tube, Incoloy® 825* or 316SS	0.25-in. OD × 0.028-in. wall (6.35 mm OD × 0.711-mm wall)	0.25-in. OD × 0.035-in. wall (6.35 mm OD × 0.889 mm wall)

Mechanical properties

Working pressure	20,000 psi (1379 bar)	25,000 psi (1724 bar)
Collapse pressure	>30,000 psi (2068 bar)	>35,000 psi (2413 bar)
Maximum tensile load	1,500 lb (680kg)	2,000 lb (907 kg)

Environmental specifications

Operating temperature range	-4 to 392°F (-20 to 200°C)
Minimum storage temperature range	-40°F (-40°C)

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ForeSite® Sense Optical

Optical Turn-Around for In-Well Sensing

The ForeSite Sense optical turn-around for in-well sensing facilitates dual-ended fiber-optic operations. A dual-ended operation enables optical signals to be launched into both ends of the optical fiber for in-well monitoring. This ability enables distributed temperature sensing (DTS) to correct for hydrogen darkening and other attenuation effects. Dual-ended optical-fiber sensing also enables stimulated Brillouin scattering systems to be employed in the well.

Weatherford offers two classes of optical turnarounds. The mini turnaround is optical-fiber-based and operates in environments up to 392°F (200°C), whereas the optical-based turnaround is forged from the durable Weatherford Cane glass platform with stable operation up to 572°F (300°C). Both turn-arounds are enclosed within a rugged housing made from Inconel® 718 material. The turnaround is available for single- or multimode optical fiber.

Features and Benefits

- Compatibility with the Weatherford optical sensing products provides increased reliability and accuracy of distributed temperature measurements.
- Compact packaging provides clearance and ease of deployment, reducing installation time and cost.
- Housing attaches securely to the mandrel for long-term stable operation, even during high-pressure events such as stimulation, to provide continuous dual-ended DTS measurements.

Specifications

Operational Performance

Type	Mini		Standard	
Maximum temperature	392°F 200°C		572°F 300°C	
Maximum pressure	20,000 psi 1,379 bar			
Configurations	Single-mode	Multimode	Single-mode	Multimode
Insertion loss	< 0.7dB @1,550nm	< 1.0dB @1,300nm	< 1.0dB @1,550nm	< 1.4dB @1,300nm
Collapse pressure	TBD		TBD	
Burst pressure	TBD		TBD	
Storage temperature	-58 to 185°F -50 to 85°C			

ForeSite® Sense Optical

Optical Turn-Around for In-Well Sensing

Specifications (continued)

Shock and Vibration

Vibration	15 G_{rms}, random [50 to 2,000 Hz Nav Mat)]	15 G_{rms}, random [20 to 2,000 Hz Nav Mat)]
Shock/drop	500 g, 1 ms half sine	

Mechanical

Housing material	Inconel 718	
Outside diameter	0.375 in. (9.5 mm)	0.625 in. (15.9 mm)
Length*	2.75 in. (70.0 mm)	3.40 in. (86.4 mm)

* Length includes protective housing, but not integrated splice tube (31-in. length typical)

ForeSite® Sense Optical

Optical Dry Mate Connector

The ForeSite Sense optical dry mate connector provides low-loss, reliable optical connections for permanent well-monitoring applications. The pressure-testable design allows for a seal verification test after mating on the rig floor to ensure proper connection and improve the integrity and reliability of the optical monitoring system. The connector has an integral locking mechanism based on a scalloped nut design to prevent loosing and back-off during operation. The scallop nut design reduces the time for connection and eliminates the need for locking wires, which can be wrongly applied on the rig floor.

The optical dry mate connector complies with industry standards for instrumentation connectors. It has been fully qualified through extensive testing including vibration, shock and drop, thermal cycling, and mate/de-mate cycling. The connector has also been qualified through combined stress testing including tensile load tests while pressurized to 22,000 psi (1,517 bar) and combined thermal and pressure cycling to 22,000 psi (1,517 bar) and 302°F (150°C).

The connector integrates with Weatherford downhole optical cables, the connector can be mated on the rig floor, minimizing rig time. The connector can house up to 3 optical fibers (any combination of singlemode and multimode) and integrates with all ForeSite Sense solutions. The low loss optical connector also provides optical continuity for DAS (distributed acoustic sensing) applications.

Features and Benefits

- Nonelectrical design is intrinsically safe and has minimal effect on completion design and installation.
- Metal-to-metal primary seal eliminates leaks, enhancing system integrity and reliability.
- Three pin connector supports three optical fibers to accommodate any combination of single-mode and multimode optical fibers for added versatility.
- Low optical loss and optical back reflection enhance optical system performance and optimize management of optical budget.
- Inconel 718 construction suits most well types.

ForeSite® Sense Optical

Optical Dry Mate Connector

Specifications

Parameter	Value and conditions
Insertion loss, L_I	0.5 dB max
Single-mode return loss, L_R Multimode return loss, L_R	-45 dB max -35 dB max
Number of channels	3
Optical fiber type	Single-mode and multimode
Maximum operating pressure	20,000 PSI (1379 bar)
Maximum over pressure	22,000 PSI (1517 bar)
Minimum storage temperature	-40°F (-40°C)
Minimum operating temperature	32°F (0°C)
Maximum operating temperature	302°F (150°C)
Random vibration	10g RMS, 20 Hz – 2 kHz
Mechanical shock/drop	100 g, 9 ms half sine pulses 500 g, 1 ms half sine pulses
Overall length	4.607 in. (117mm)
Outer diameter	1.062 in. (27mm)

ForeSite® Sense Optical

Cable Protector

The Weatherford cable protector supports single or multiple cables and control lines outside the tubing to prevent damage or stretch where the cable or control line crosses pipe joints, safety valves, crossovers, and other associated downhole hardware.

Weatherford provides a wide range of cable protectors to suit different types of well-monitoring applications. The type of cable protector required depends upon completion configuration, wellbore geometry, and well type. The cable protector is customized for specific tubing sizes, thread types, materials, coupling dimensions, number of cable or control lines, encapsulation size of cable or control lines, and overall dimension requirements inside the casing.

The one-piece assembly has no loose parts, with the bolting inbuilt to the protector. Using a pre-engaged swing bolt enables easy fitting and torqueing during installation, which saves rig time and reduces the risk of cable damage. If needed, cable protector refurbishment is offered where practical.

The protectors, which are ductile yet hard-wearing and reliable, are highly resistant to steady-state shock and shock loads. The standard protectors withstand high axial loads up to 30 tons (67,200 lbf) and high lateral loads up to 20 tons (44,800 lbf).

Protector material is all-cast carbon steel or stainless steel, which conforms to NACE Standard MR0175 for sour wells. For optical or electronic cables, Weatherford provides predominantly cast-cross-coupling protectors as a safe means of deploying cable in the well. Other alloys suited for harsh environments are also available. Advanced polymers are offered for low friction and superior impact resistance.

Features and Benefits

- Bolting system locks the protector in place with close fit over coupling.
- Bolting or tightening torque resists axial and rotational lateral movement.
- Contoured profile mitigates the potential for impact while running or pulling the completion string by deflecting the cable away from damaged casing and production string hang-ups.
- Angled or chambered profile protects the bolting mechanism against running hang-ups.

ForeSite® Sense Optical

Cable Protector

Specifications

General	Wiper Blade	I-Wire	Cast/Strapped X-Coupling	Stamped X-Coupling	Polymer X-Coupling
Well geometry	Vertical, no deviation, no dogleg	Vertical, no deviation, no dogleg	Any well deviation through horizontal	Any well deviation through horizontal	Any well deviation through horizontal
Applications	Single, 1/4-in., bare line only	Up to 2 1/4-in. lines	For any cable and line combination and encapsulation	Up to five bare lines or three encapsulated cables	For any cable and line combination and encapsulation
Outer diameter*	2-7/8 to 3-1/2 in. (50.8 to 76.2 mm)	All tubing sizes	All tubing sizes	All tubing sizes	All tubing sizes
Length	15 in. (381 mm)	18 in. (457.2 mm)	Varies upon design criteria	Varies upon design criteria	Varies upon design criteria
Make-up	Pneumatic or manual, with 3/4-in. banding	Pneumatic or manual, with 3/4-in. banding	30-ft/lb (40.7-N•m) captive bolts	Pneumatic or manual, with hinged tapered pin	30-ft/lb (40.7-N•m) captive bolts
Casing size	5 to 6-5/8 in. (127 to 168.3 mm)	4-1/2 to 6-5/8 in. (114.3 to 168.3 mm)	5-1/2 to 9-5/8 in. (139.7 to 244.5 mm)	5-1/2 to 9-5/8 in. (139.7 to 244.5 mm)	5-1/2 to 9-5/8 in. (139.7 to 244.5 mm)
Casing weight	20.3 to 50.4 lb (9.2 to 22.9 kg)	18.8 to 20 lb (8.5 to 9.1 kg)	User specified	User specified	User specified
Special protector**	N/A	N/A	Available	Available	Available

* Protector clearance with tubing and casing combinations are verified for each completion
** SSSV, SSAV, GLM, injection valve, ICD/ICV, and X-overs
Note: Selection criteria and final cable protector programmed are project specific. Torque and drag, and tubing-stress-analysis tools, will support the final choice.

ForeSite® Sense Optical

Tubing Hanger Termination Kit: Bend Restrictor for Tubing Encapsulating Cable (TEC)

The ForeSite Sense bend restrictor for 1/4-in. downhole instrument cables prevents cable damage at high stress points at the top of the tubing hanger. The tubing bend restrictor is placed at the fitting on top of the hanger to prevent the cable from breaking at the fitting and to prevent the minimum bending radius of the cable from being exceeded.

The 1/4-in. TEC is typically fed through the tubing hanger on dry trees. The TEC is normally sealed off with one or two metal-to-metal seal fittings, with one on top and one on the bottom of the tubing hanger. Further, the cables are normally wrapped once or twice around the neck of the tubing hanger before landing the hanger. During the landing process, pinching or breaking of the Instrument TEC cable can occur. The bend restrictor reduces the probability of cable damage.

Features and Benefits

- Sizes available for 1/8-, 1/4-, 3/8-, and 1/2-in. tubing fittings; adapters for other sizes or configurations are available upon request.

Tubing Hanger Termination Kit: Tubing Hanger Feed-Through Fitting

The ForeSite Sense tubing hanger feed-through fitting provides a pressure barrier at the point of entry between the tubing hanger and the cable. TEC downhole Instrument cables are typically fed through the tubing hanger on dry trees and are sealed off with one or two metal-to-metal seal fittings.

Features and Benefits

- Metal fitting alloys are available in either Inconel or stainless steel.
- Fitting configuration uses common rear and front ferrule metal seals.

ForeSite® Sense Optical

Optical Wellhead Outlet

The ForeSite Sense optical wellhead outlet (OWHO) organizes the feed-through and exit of optical cable from a platform or land wellhead. With over 500 units installed to date, the OWHO provides a robust secondary pressure barrier at the wellhead to the primary in-well pressure containment system and a proven, reliable optical interface between downhole optical cable and surface cabling systems.

Weatherford offers multiple OWHO solutions to suit client requirements. The OWO is rated for standard service and can be customized for sour or corrosive service. The base model OWHO-10 is rated to 10,000 psi (689.5 bar) and 302°F (150°C) continuous operation, and allows up to four optical feed-throughs. The high-pressure OWHO-15 can accommodate up to four optical fiber feed-throughs and operates in environments up to 15,000 psi (1,034.2 bar) and 392°F (200°C). For extreme environments, the OWHO-15X model additionally meets API 6FB fire test requirements. The OWHO-6T operates in thermal environments up to 527°F (275°C) at a reduced pressure of 6,000 psi (414 bar).

The OWHO is typically manufactured to suit client requirements in terms of compatibility with flange size and material specifications. It has an extensive track record for installations worldwide in land and platform settings.

Features and Benefits

- Proven high pressure optical feed-throughs are designed to operate in harsh environments, providing a significant performance margin when the OWHO is operated at wellhead conditions.
- Durable construction of 17-4 alloy steel delivers reliability throughout the duration of production operations.
- Metal-to-metal seals prevent leaks to ensure high pressure system integrity.
- Post-installation testing capacity of all seals allows confirmation of pressure integrity.

ForeSite® Sense Optical

Optical Wellhead Outlet (continued)

Specifications (continued)

Model	OWHO-6T	OWHO-10	OWHO-15	OWHO-15X
Maximum operating pressure	6,000 psi (414 bar)	10,000 psi (689 bar)	15,000 psi (1,034 bar)	
Maximum operating pressure*	9,000 psi (620 bar)	15,000 psi (1,034 bar)	22,500 psi (1,552 bar)	
Operating temperature	527°F (275°C)	302°F (150°C)	392°F (200°C)	347°F (175°C)
Fiber capacity (SM or MM)	4		3	
Material	17-4 Alloy Steel (typically)			
Overall length**	9 in. (229 mm)	6.75 in. (172 mm)	9 in. (229 mm)	
Service	Rated and certified for standard service (sour available)			
Certification	Det Norske Veritas			
Compliance	API 6a PSL 3 and NACE-MR0175			API 6FB
Number of seals	2 barriers in every leak path between valve clock and exterior			
Seal testing	Post installation testing capability, all seals			

*Determined as per API 6A, section 7.3.2
** Length measured without the flange/adapter

ForeSite® Sense Optical

Surface Fiber Optic Cable

The ForeSite Sense surface fiber optic cable consists of a zero-halogen-polyolefin outer jacket containing four polyester elastomer buffered fibers surrounded by an aramid yarn strength member.

Specifications

Optical Fibers

Optical fiber numbers	50 H (1 and 2)	010X (3 and 4)
Applicable specifications	CCITT G.651 & IEC 60793-2-10 Type A1a	CCITT G.652B & IEC 60793-2-50 Type B1.1
Fiber type	Graded index, multi-mode	Single-mode
Core diameter	50 µm ± 2.5 µm	8.3 µm nominal
Cladding diameter	125 µm ± 2 µm	125 um ± 1 um
Coating diameter	245 µm ± 10 µm	
Attenuation	< 3.50dB/Km @ 850nm < 1.50dB/Km @ 1300nm	< 0.70 dB/Km @ 1310nm < 0.70 dB/Km @ 1550nm
Proof test	100 Kpsi	

Mechanical Properties

Outer jacket OD	0.230 in. (5.84 mm)
Maximum installation tension (IEC 60794-1-E1)	225 lb (1000 N)
Maximum operating tension (IEC 60794-1-E1	91 lb (400 N)
Crush (IEC 60794-1-E3)	700 N/cm
Impact (IEC 60794-1-E4)	1.0 N-m
Cable bend (IEC 60794-1-E11)	20 N, 10 cycles
Minimum bend radius installation	4.4 in. (11.2 cm)
Minimum bend radius operating	2.2 in. (5.6 cm)
Cable weight	22 lb/1000 ft (33 kg/km)

Environmental Properties

Storage temperature	-40 to 176°F (-40 to 80°C)
Operating temperature	-4 to 176°F (-20 to 80°C)

ForeSite® Sense Optical

Outdoor Optical Data Acquisition System

The ForeSite Sense outdoor optical data acquisition system provides an economical means for obtaining pressure and temperature (PT) data from downhole optical PT gauges. This outdoor optical data acquisition system can be used in gas lift optimization, sand-face monitoring, and frac-string monitoring applications.

This outdoor optical monitoring system can help operators to maximize recovery. Operators input this real-time data into Weatherford nodal modeling software to design a precise gas-injection program that delivers a higher, more stable production rate.

Additional in-well optical fibers can easily be integrated into the system for increased functionality.

Features and Benefits

- Real-time downhole single-point pressure and temperature monitoring captures flowing bottom-hole pressures and pressure-transient data
- Data-transmission capability enables transfer over existing customer SCADA infrastructure

Specifications

PT Gauge Monitoring

Number of optical channels	1 to 4
Units of measure (selectable)	Metric, imperial, oilfield

Output Options

MODBUS®, serial 232, 422, 485, TCP/IP	ASCII, RTU
External Communications	RJ-45 Ethernet
Internal Storage	30 days at 1 Hz

Electrical Power

Input voltage	24 V DC nominal
Power Consumption	<50 W (30 W typical)

Mechanical

Packaging	IP66/Nema 4X
Classification	IECEx Zone2

Environmental

Operating temperature range (shaded)	-5 to 131°F (-15 to 55°C)
Shipping and storage temperature range	-40 to 176°F (-40 to 80°C)
Relative humidity, non-condensing	95%
Transportation vibration	6.0 Grms

ForeSite® Sense Optical

Optical Data Acquisition System

The ForeSite Sense optical data acquisition system provides an economical means for obtaining pressure and temperature (PT) data from downhole optical PT gauges. This optical data acquisition system can be used in gas lift optimization, sand-face monitoring, and frac-string monitoring applications.

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Input voltage	24 V DC nominal
Power consumption	<50 W (30 W typical)

Mechanical

Packaging	IP66/Nema 4X
Classification	IECEx Zone2

Environmental

Operating temperature range (shaded)	-5 to 131°F (-15 to 55°C)
Shipping and storage temperature range	-40 to 176°F (-40 to 80°C)
Relative humidity, non-condensing	95%
Transportation vibration	6.0 Grms

ForeSite® Sense Optical

Wellhead Optical-Sensing Data Acquisition Unit

The ForeSite Sense data acquisition system provides standalone data acquisition, storage, and transmission of downhole optical sensor data. The unit functions efficiently on satellite platforms or in desert, arctic, and swamp locations where environmental protection, central power, and communications are limited or unavailable. Locations without controlled air will not affect the local storage capacity of the system or its capability to deliver web-enabled, on-demand access to readings.

This unit monitors downhole optical sensors as part of the Weatherford optical monitoring family of products and solutions. The optical-sensing data acquisition unit has the storage capacity to hold an extensive amount of high-frequency data from downhole optical gauges, and can support optical PT gauges from multiple wells.

The configuration and application software is identical to that used in the ForeSite Sense BGI system, which supports communication protocols that conform to industry standards for flexible data handling.

Features and Benefits

- External status display facilitates system operation checks.
- High-rate recording capability ensures that data is recorded at the highest density—even if only a slow update rate is sent to the control room in the production facility.
- Data recording enables detailed analysis of any production anomalies and allows for data retrieval if the data link is lost.
- Passive downhole equipment facilitates upgrading of the surface unit hardware and software as enhancements become available to improve overall sensing system performance.

Options

- Zone 2 certification
- Solar panel system

Specifications

PT Gauge Monitoring

Monitoring capability	52 wells, maximum
Units of measure (selectable)	Metric, imperial, and oilfield

Physical

Zone 2 dimensions (W × H × D)	24 × 30 × 8 in. (610 × 762 × 203 mm)
Zone 2 weight	125 lb (57 kg)

ForeSite® Sense Optical

Wellhead Optical-Sensing Data Acquisition Unit

Specifications (continued)

Output Options

MODBUS® protocol*, serial 232, 422, 485, TCP/IP	ASCII, RTU, master or slave
Simple serial 232, 422, 485	ASCII
OPC 2.0 data access standard	Client and server
Data files by LAN or WAN	Flat file or web browser
Web-enabled data visualization and transfer	LAN and web browser
Direct SQL database access	ODBC driver

* MODBUS is a registered trademark of Schneider Automation Inc.

Electrical Power

24 VDC nominal	18 to 32 VDC
AC nominal	120/230 VAC
Maximum current	1.6 amp @ 24 VDC
Power consumption	38 W (typical, at room temperature)

Environmental

Operating temperature range (shaded)	-40° to 145°F (-40° to 63°C)
Shipping and storage temperature range	-40° to 185°F (-40° to 85°C)
Relative humidity, non-condensing	95%
Transportation vibration	3.0 Grms, random and sine

ForeSite® Sense Optical

BGI Data Acquisition Unit

The ForeSite Sense BGI data acquisition unit interrogates fiber optic Bragg-grating sensors to provide continuous, reliable and actionable information. This data-acquisition unit represents the latest generation of high-performance surface instrumentation for monitoring Weatherford electronic and optical downhole sensors.

As a part of the Weatherford production and reservoir monitoring solution, the BGI data acquisition unit supports hundreds of downhole optical pressure and temperature (P/T) sensors in multiple wells. This state-of-the-art Bragg-grating interrogator (BGI) delivers readings on demand and is Web-enabled for remote access and control. Its local storage capacity enables the system to hold an extensive amount of high-frequency data over broad time intervals.

The BGI surface instrument is completely scalable up to 52 optical ports to permit expansion of the number of Bragg-grating pressure and temperature gauges to meet application requirements.

The system is compatible with all Weatherford Bragg-grating based technology. The interrogation system utilizes a rugged, stable optical source that provides an increased optical power budget, enabling interrogation of sensors even in the presence of high attenuation caused by poor optical connections or hydrogen darkening.

The BGI data acquisition unit enables downhole pressure and temperature gauges and temperature arrays to be integrated with other optical or electronic sensing types, such as distributed-temperature-sensing (DTS), multi-phase flowmeter, seismic sensors and quartz gauges.

Features and Benefits

- Simple scalability to 52 ports provides configuration flexibility and maximum coverage across multiple well installations.
- Modular system hardware and software components enable easy upgrading as enhancements become available to improve sensing system performance.
- On-demand web browser facilitates viewing of real-time and historical data to provide actionable information for production optimization.
- System compatibility with other ForeSite Sense instrumentation supports a range of optical-sensor types by simply adding a suitable interrogation module and optical multiplexer.
- High-frequency interrogation and storage of well data provide for detailed analysis of production anomalies.
- High-rate recording capability ensures that data is recorded at the highest density—even if only a slow update rate is sent to the control room in the production facility.
- On-site and remote configuration, setup, and output options enable simplified operations.

ForeSite® Sense Optical

BGI Data Acquisition Unit (continued)

Specifications

General Specifications

Number of optical ports	4, 8, 16, 32, or 52
Number of sensors per port	3 or 4, depending on maximum pressure
Update rate selectable range	1 sec to no limit
Communications port	Ethernet

Mechanical Specifications

Packaging	3U 19-in. rack
Weight (4 port version)	17 lb, 9 oz
Enclosure	IP20
Electronic PCB	3U Eurocard standard

Electrical Power Specifications

Input voltage	100 to 120 / 200 to 240 V~ 50/60 Hz 2.5A
CE low-voltage directive 73/23/EEC compliant	IEC 60204-1

Environmental Specifications

Operating temperature range	-4 to 145°F (-20 to 63°C)
Storage temperature range	-40 to 185°F (-40 to 85°C)
Thermal shock	<18°F/hr (<10°C/hr)
Relative humidity, non-condensing, operating range	10 to 80%
Relative humidity, non-condensing, storage range	0 to 95%
CE electromagnetic compatibility, 89/336/EEC compliant	IEC 61000-4-2 through 4-6, IEC 61326-1
Operational vibration	10 to 2,000 Hz, 0.1 g (Navmat), 10 mins
Transportation vibration	10 to 2,000 Hz, 6 g (Navmat), 10 mins

ForeSite® Sense Optical

Distributed Temperature Sensing

The ForeSite Sense distributed temperature sensing (DTS) system delivers wellbore thermal profiles along the entire length of optical fiber. The DTS system is part of the Weatherford temperature-monitoring solution. This DTS functionality enables operators of oil and gas fields to monitor the temperature at all points in one or more wells and hence calculate parameters such as inflow/outflow rates and gas/fluid contributions, in addition to observing the performance of control valves, gas lift, and monitoring well integrity and flow assurance.

The DTS monitoring solution is available as a permanent monitoring system as well as an ad hoc logging service when characterization or a health check is required.

Features and Benefits

- Compatible with industry standard optical fibers for ease of system integration.
- Rugged design features the Weatherford downhole optical cable, the industry's most durable and longest-lasting in-well optical cable.
- Double-ended DTS configurations improve long-term accuracy and stability.
- Downhole optical cable compatibility facilitates use of other optical sensors and gauges from the ForeSite Sense reservoir monitoring solutions portfolio.

Options

- Rackmount or outdoor systems
- ATEX Certification
- Optical Switch 2, 4, or 16 channels

ForeSite® Sense Optical

Distributed Temperature Sensing (continued)

Specifications

Specifications for rackmount unit (DTS-y3k) and outdoor unit (wh-DTS-y3k) are the same.

Operating Performance

Unit type	DTS-y3k-10	wh-DTS-y3k-16
Distance range	6.21 miles (10 km)	9.94 miles (16 km)
Spatial resolution	3.28 ft (1m)	
Sampling interval	1.64, 3.28, 6.56 ft (0.5, 1, 2 m) selectable	
Number of channels*	1, 2, 4, 16	
Temperature resolution**	32.054°F (0.03°C)	32.108 °F (0.06°C)

* optional switch required for 2, 4, and 16 channels
** 10 minute measurement, 1σ, without optical switch

Certifications

Unit type	DTS-y3k-10	wh-DTS-y3k-16
ATEX type “n”	II 3G Ex nA ic [op is] II C T4 Gc X	
Laser class	IEC 60825-1/2007, Class1M	

Environmental Parameters

Unit type	DTS-y3k-10	wh-DTS-y3k-16
Operating temperature	-40 to 149°F (-40 to +65°C)	
Storage temperature	-40 to 158°F (-40 to +70°C)	
Humidity (operating)	20% to 80% relative humidity (no condensation)	
Power requirements (AC) (W)	16	
Dimensions (W×H×D)***	7.79 × 5.20 × 6.39 in. (197.8×132.0×162.2 mm) (6 slots width)	

*** Dimensions exclude protective cap of optical connector

ForeSite® Sense Optical

ULTRA Distributed Temperature Sensing

The ForeSite Sense ULTRA distributed temperature sensing systems deliver wellbore thermal profiles and analysis for the entire length of optical fiber. The system is part of the Weatherford temperature-monitoring solution. This DTS functionality enables operators of oil and gas fields to monitor the temperature at all points in one or more wells and hence calculate parameters such as inflow/outflow rates and gas/fluid contributions, in addition to observing the performance of control valves, gas lift, and monitoring well integrity and flow assurance.

The ULTRA DTS monitoring solution is available as a permanent monitoring system as well as an ad hoc logging service when characterization or a health check is required. The system's downhole optical cable can be installed with or without optical sensors and the surface equipment is permanently installed or mobilized when temperature profile is required.

The ULTRA DTS system is an integral part of its surface instrumentation and data system, providing a data source integrated with other installed sensing systems, including in-well reservoir pressure and temperature, flow, and multiphase-flow sensors.

Features and Benefits

- Compatible with industry standard optical fibers for system integration.
- Rugged design features Weatherford downhole optical cable, the industry's most durable and longest-lasting in-well optical cable.
- Sensor system design uses no in-well electronics to withstand harsh environments and function in high-temperature operations.
- Integrated reference coils at the surface ensure temperature accuracy
- Double-ended DTS improve long-term accuracy and stability
- Downhole optical cable is compatible with all ForeSite Sense reservoir monitoring solutions.
- Compatibility with proprietary data visualization software provides seamless data analysis.

Options

- Rackmount or outdoor systems
- ATEX certification
- Single-ended, Double-ended and J-type configurations
- Integration with ForeSite Sense optical pressure and temperature sensors and optical flowmeters
- Monitoring ranges up to 9.9 miles (16 km) optical fiber length

ForeSite® Sense Optical

ULTRA Distributed Temperature Sensing

Specifications

Operating Performance

Distance range	1.2, 2.5, 4.9, 7.5, 9.9 miles (2, 4, 8, 12, and 16 km)
Spatial resolution	2.3 ft (0.7 m)
Sampling interval	0.5 ft up to 2.5 miles (0.15 m up to 4 km) 0.8 ft up to 7.5 miles (0.25 m up to 12 km)
Number of channels	1, 2, 4, 6, 8, 12, or 24
Measurement interval	User selectable: from 30 sec to 24 hours
Measurement modes	Single-ended or dual-ended (including fiber break recovery

Environmental Parameters

Operating temperature*	(-10 to +60°C)
Storage temperature	(-40 to +80°C)
Humidity	0 to 95% relative humidity non-condensing
Power requirements	100 to 240 VAC, 50/60 Hz, 50 VA maximum
Laser class	IEC 60825-1:2007 1M (eye safe)
ATEX certification (optional)	EX II (1) GD; I M2

*Other temperature ranges available

ULTRA Dual-Ended Configuration Temperature Metrology – Measurement time: 30 seconds

Fiber distance	547.9 ft (167 m)	1,637.9 ft (499.25 m)	2,720.6 ft (829.25 m)	17,472.1 ft (5,352.5 m)	18,643.4 ft (5,682.5 m)	19,727.7 ft (6,013 m)
Fiber temperature	32°F (0°C)	302°F (150°C)	167 °F (75°C)	167 °F (75°C)	302°F (150°C)	32°F (0°C)
Calibration error	3.19°C	2.19°C	2.19°C	1.08°C	1.91°C	2.40°C
Temperature repeatability	5.86°C	4.87°C	4.00°C	2.33°C	2.98°C	1.79°C
Spatial temperature resoultion	6.24°C	5.06°C	3.86°C	2.14°C	2.61°C	1.64°C
Spatial resolution	-	-	-	-	7.61 ft (2.32 m)	-

Temperature metrology specifications are dependent on the system configuration; please enquire with your local Weatherford representative.

ForeSite® Sense Optical

ULTRA Distributed Temperature Sensing

Specifications

ULTRA Dual-Ended Configuration Temperature Metrology – Measurement time: 10 minutes

Fiber distance	547.9 ft (167 m)	1,637.9 ft (499.25 m)	2,720.6 ft (829.25 m)	17,472.1 ft (5,352.5 m)	18,643.4 ft (5,682.5 m)	19,727.7 ft (6,013 m)
Fiber temperature	32°F (0°C)	302°F (150°C)	167 °F (75°C)	167 °F (75°C)	302°F (150°C)	32°F (0°C)
Calibration error	0.79°C	2.22°C	0.99°C	1.49°C	1.86°C	1.17°C
Temperature repeatability	0.98°C	1.26°C	0.88°C	0.72°C	0.96°C	0.15°C
Spatial temperature resoultion	1.43°C	1.48°C	0.80°C	2.14°C	0.80°C	0.53°C
Spatial resolution	-	-	-	-	6.4 ft (1.95 m)	-
Worst-case environmental temperature effect	-	-	-	-	4.92°C	-
Low environmental temperature effect	-	-	-	-	2.23°C	-
High environmental temperature effect	-	-	-	-	1.22°C	-
Environmental temperature repeatability	-	-	-	-	1.09°C	-

ULTRA Dual-Ended Configuration Temperature Metrology – Measurement time: 1 hour

Fiber distance	547.9 ft (167 m)	1,637.9 ft (499.25 m)	2,720.6 ft (829.25 m)	17,472.1 ft (5,352.5 m)	18,643.4 ft (5,682.5 m)	19,727.7 ft (6,013 m)
Fiber temperature	32°F (0°C)	302°F (150°C)	167 °F (75°C)	167 °F (75°C)	302°F (150°C)	32°F (0°C)
Calibration error	0.53°C	0.48°C	1.13°C	0.49°C	0.47°C	0.33°C
Temperature repeatability	0.43°C	0.68°C	0.48°C	0.32°C	0.46°C	0.24°C
Spatial temperature resoultion	0.58°C	0.72°C	0.56°C	0.26°C	0.35°C	0.24°C
Spatial resolution	-	-	-	-	6.5 ft (1.98 m)	-

Temperature metrology specifications are dependent on the system configuration; please enquire with your local Weatherford representative.

ForeSite® Sense Optical

DTS Distributed Temperature Sensing Unit

The ForeSite Sense DTS distributed temperature sensing unit delivers a wellbore thermal profile and analysis for the entire length of optical fiber. The system is part of the Weatherford temperature-monitoring solution. This DTS functionality enables operators of oil and gas fields to monitor the temperature at all points in one or more wells and monitoring well integrity and flow assurance. DTS data can be used to calculate parameters such as inflow/outflow rates and gas/fluid contributions, in addition to observing the performance of control valves, gas lift, and.

The DTS monitoring solution is available as a permanent monitoring system as well as an ad hoc logging service when characterization or a health check is required. The system's downhole optical cable can be installed with or without other optical sensors and the surface equipment can be permanently installed or mobilized when a temperature profile is required.

The Weatherford DTS system is an integral part of its surface instrumentation and data system, providing a data source integrated with other installed sensing systems, including in-well reservoir pressure and temperature, flow, and multiphase-flow sensors.

Features and Benefits

- Compatible with standard optical fibers for ease of system integration.
- Rugged design features a ForeSite Sense downhole optical cable, the industry's most durable and longest-lasting in-well optical cable.
- Sensor system design uses no in-well electronics to withstand harsh environments and function in high-temperature operations.
- Integrated reference coils at the surface ensure temperature accuracy.
- Double-ended DTS improve long-term accuracy and stability.
- Downhole optical cable is compatible with all ForeSite Sense reservoir monitoring solutions.
- Compatibility with proprietary data visualization software provides seamless data analysis.

Options

- Single-ended, double-ended and J-type configurations
- Integration with ForeSite Sense optical pressure and temperature sensors and optical flowmeters
- Monitoring ranges up to 12.4 miles (20 km) optical fiber length

ForeSite® Sense Optical

DTS Distributed Temperature Sensing

Specifications

Operating Performance

Distance range	3.1, 6.2, 9.3, 12.4 miles (5, 10, 15, and 20 km)
Spatial resolution	3.9 ft (1.2 m)
Sampling interval	0.82 ft up to 3.1 miles (0.25 m up to 5 km) 1.64 ft up to 6.2 miles (0.5 m up to 10 km) 3.28 ft up to 12.4 miles (1 m up to 20 km)
Number of channels	Up to 32
Measurement interval	Approximately 10 seconds to 14.8 hours (at 1-m sampling)
Measurement modes	Single-ended or dual-ended (including fiber break recovery

Environmental Parameters

Operating temperature*	32 to 104°F (0 to 40°C)
Storage temperature	-4 to 140°F (-20 to 60°C)
Humidity	85% maximum, non-condensing
Power requirements	100 to 240 VAC, 50/60 Hz, 50 VA maximum
Laser class	Class 1 (IEC 60852-1-2001)
Well operating temperature range	Up to 392°F (200°C)

*Other temperature ranges available
Temperature metrology specifications are dependent on the system configuration; please enquire with your local Weatherford representative.

Single-Ended Configuration Temperature Metrology – Measurement time: 40 seconds

Fiber distance	328 ft (100 m)			32,021 ft (9,760 m)		
Fiber temperature	32°F (0°C)	167 °F (75°C)	302°F (150°C)	32°F (0°C)	167 °F (75°C)	302°F (150°C)
Calibration error	0.08°C	0.15°C	0.11°C	0.12°C	0.31°C	0.02°C
Temperature repeatability	0.83°C	0.86°C	1.02°C	2.31°C	2.34°C	2.65°C
Spatial temperature resoultion	0.85°C	0.89°C	1.06°C	2.33°C	2.34°C	2.69°C
Spatial resolution	-	-	-	<6.56 ft (<2 m)	<6.56 ft (<2 m)	<6.56 ft (<2 m)
Warm-up time at 68°F (20°C)	-	-	-	-	320 sec	-
Warm-up time at 32°F (0°C)	-	-	-	-	80 sec	-
Warm-up time at 104°F (40°C)	-	-	-	-	560 sec	

ForeSite® Sense Optical

DTS Distributed Temperature Sensing

Specifications (continued)

Single-Ended Configuration Temperature Metrology – Measurement time: 10 minutes

Fiber distance	328 ft (100 m)			32,021 ft (9,760 m)		
Fiber temperature	32°F (0°C)	167 °F (75°C)	302°F (150°C)	32°F (0°C)	167 °F (75°C)	302°F (150°C)
Calibration error	0.05°C	0.18°C	0.12°C	0.05°C	0.09°C	0.13°C
Temperature repeatability	0.21°C	0.24°C	34°C	0.62°C	0.64°C	0.72°C
Spatial temperature resoultion	0.25°C	0.32°C	0.40°C	0.63°C	0.64°C	0.75°C
Spatial resolution	-	-	-	<6.56 ft (<2 m)	<6.56 ft (<2 m)	<6.56 ft (<2 m)
Worst case env T effect	-	-	-	-	(1.52°C)	-
32°F (0°C) Env temp effect	-	-	-	-	(1.22°C)	-
104°F (40°C) Env temp effect	-	-	-	-	(0.82°C)	-
Env temp repeatability	-	-	-	-	(1.52°C)	-

Single-Ended Configuration Temperature Metrology – Measurement time: 1 hour

Fiber distance	328 ft (100 m)			32,021 ft (9,760 m)		
Fiber temperature	32°F (0°C)	167 °F (75°C)	302°F (150°C)	32°F (0°C)	167 °F (75°C)	302°F (150°C)
Calibration error	0.07°C	0.08°C	0.11°C	0.07°C	0.12°C	0.30°C
Temperature repeatability	0.17°C	0.18°C	0.16°C	0.37°C	0.35°C	0.36°C
Spatial temperature resoultion	0.16°C	0.26°C	0.30°C	0.32°C	0.32°C	0.41°C
Spatial resolution	-	-	-	<6.56 ft (<2 m)	<6.56 ft (<2 m)	<6.56 ft (<2 m)

Temperature metrology specifications are dependent on the system configuration; please enquire with your local Weatherford representative.

ForeSite® Sense Optical

Subsea Optical Interrogator

The ForeSite Sense subsea optical interrogator provides subsea data acquisition and data transfer for in-well optical PT gauges and temperature sensors. The subsea interrogator is based on the highly stable and reliable ForeSite Sense BGI acquisition unit for surface installations. With four optical channels, the system can interrogate up to 16 optical gauges (depending on the operational pressure of the gauges).

The unit can be incorporated into a variety of atmospheric enclosures available either from Weatherford or other vendors throughout the subsea controls industry. Power requirements and heat dissipation have also been addressed during qualification testing.

Features and Benefits

- Optical interrogator design accommodates multiple in-well gauges to simplify the topside configuration.

Specifications

Interface Parameters

Operating temperature	-0.4 to 104°F (-18 to 40°C)
Storage temperature	-4 to 158°F (-20 to 70°C)
Qualification	IWIS Spec ISO 13628-6:2006

Electrical Interface

Power supply voltage	110 or 240 VAC
Power consumption	<20 W (13 W typical)

Optical Interface

Number of optical channels	4

Mechanical Parameters

Canister diameter	10.24 in.(260 mm)
Canister height, including connector	22.18 in. (563.3 mm)
Canister weight	230.9 lb (104.74 kg)