

NovaPT™-D Sapphire Fiber Optic Pressure and Temperature Sensing System



Continuous and permanent monitoring of pressure and temperature in wells for oil, natural gas, and geothermal power production is important to maximize productivity and to prolong well production life. However, these wells usually involve high pressure, elevated temperature, or other highly diffusive or corrosive species including hydrogen and H₂S. The combination of these harsh conditions often challenges the reliability and performance of downhole measurement devices. Electrical based pressure sensors not only are restricted for temperatures below 200°C but also have a significant limit on the maximum well depths due to the electrical cable impedance. Optical sensors interrogated by fiber optics can often be operated at higher temperatures. These sensors are usually fiber Bragg grating (FBG) or Fabry-Perot interferometry designs and are usually based on the employment of amorphous materials such as silica or a multi-material-based core structure for the key transduction. Given the susceptibility of these materials or structures to hydrogen diffusion and their relatively significant mechanical creep rates under high pressure or high temperature, the drift rates of these sensors are often significant, which could in turn lead to significant and cumulative pressure and/or temperature errors.

NovaPT™-D is a patented and field-proven fiber optic pressure and temperature sensor system for permanent downhole installation. The sensor is built with a monolithic single-crystal sapphire structure, which renders NovaPT™-D with two unique features. One is its highest temperature rating in the market today. The second

feature is that the core sensor structure itself possesses exceptional physical and chemical robustness, which ensures not only the highest level of reliability but also superior long-term stability. This nature sets the NovaPT™-D apart from the other downhole pressure sensors which heavily rely on the sensor metal housing protection and can quickly be degraded once the housing integrity is compromised. These unique features along with other major characteristics are summarized below:

- High operating temperature up to 600°C
- Exceptional reliability ensured not by the protective metal housing but more importantly by the sapphire intrinsic physical and chemical robustness
- High resolution and high accuracy
- Long sensing distance
- Low profile sensor housing and compact surface interrogator that can support as many as 16 sensors

These characteristics make the NovaPT™-D sensor an unparalleled choice for all downhole pressure and temperature measurement needs, including but not limited to oil, natural gas and geothermal wells.

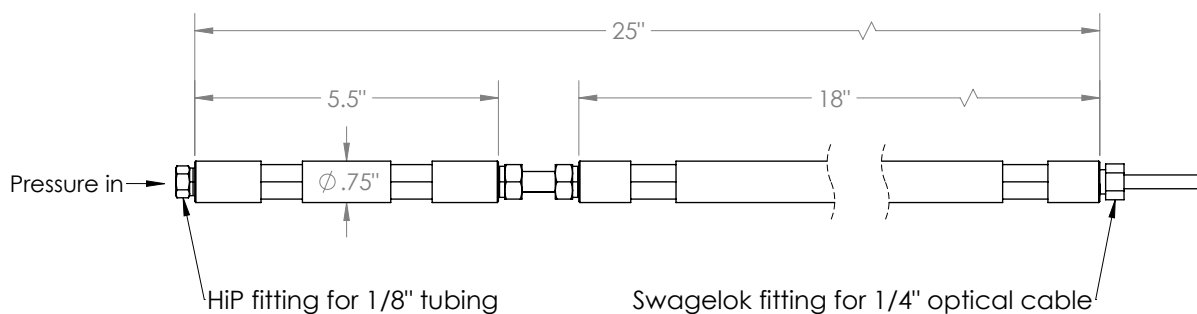
TECHNICAL SPECIFICATIONS

SENSORS	
Model	NovaPT™-D
Maximum Pressure	14MPa (2kpsi) 55MPa (8kpsi) 131MPa (19kpsi)
Pressure Precision	0.002% F.S.
Pressure Accuracy	0.05% F.S.
Pressure Drifts	0.05% F.S. at 200°C per year
Temperature Precision	0.0005°C
Temperature Accuracy	0.5°C
Temperature Drifts	<0.2°C at 300°C per year
Maximum Temperature	200°C, 250°C, 300°C or custom up to 500°C (metal coated optical fiber required)
Sampling Rate	1Hz
Optical Fiber	9µm-core singlemode
Sensor Dimensions	0.75" (diameter) x 25" (length) 0.375" (diameter) x 3" (length) Option
Sensor Packaging Material	SS 316L or Alloy 718

SURFACE INTERROGATORS	
Model	Coswave
Sensor Channels	Up to 16
Optical Fiber	9µm-core Singlemode
Maximum Sensing Distance	15km
Fiber Connector	LC/APC
Power Supply and Consumption	240/110V, 50/60Hz, 5W
Dimensions and Weight	215 x 205 x 55mm; 1.45kg
Computer Interface	Ethernet
Operating Environment Conditions	0 to 60°C; 10-95% humidity with no condensation

SENSOR HOUSING AND CABLE CONSIDERATION

The sensor probe is packaged in a 0.75" diameter housing, which may be made of SS 316L or Alloy 718. Key dimensions of the sensor housing and its connection to a ¼" fiber cable are shown in the drawing below. Using Alloy 718 for the housing main body is recommended for service temperatures greater than 300°C even without the presence of aggressive chemical species such as H₂S given its superior resistance against oxidation. Due to the limited pressure rating of the Swagelok fitting, the fiber cable will be connected directly to a ¼" diameter tail of the front 5.5" portion of the sensor housing via direct welding or a customer preferred method for pressure ratings greater than 10,000psi.



A small form factor sensor housing with 0.375" diameter and 3" length is available for special applications where a low physical profile is critical. This housing design permits versatile connections to an optical cable. Typical sensor-to-cable connections include metal compression fittings, laser welding or other special means by customers.

The compact surface interrogator delivers Class I eye-safe light via 9µm-core singlemode optical fiber to the sensor. Pressure and temperature are simultaneously output by the accurate demodulation of the optical signal

returned from the sensor. The system is operated at the C-band where silica optical fiber exhibits the minimum transmission loss, permitting the sensing distance to be at least 15km.

Single-crystal sapphire is an extremely stable and robust material both physically and chemically and can operate reliably as a sensor material for temperatures well above 1000°C [1-2]. The maximum service temperature of the NovaPT™-D sensor is mainly dictated by the fiber coating material. The table below shows commercial fibers with typical coating options for different long-term service temperatures.

Fiber Coating Material	Maximum Service Temperature (°C)
Standard Acrylate	80
High-Temp Acrylate	150
Polyimide	300
Aluminum or Copper	400
Gold	600

REFERENCES

1. Y. Zhu, Z. Huang, F. Shen, A. Wang, "Sapphire-fiber-based white-light interferometric sensor for high-temperature measurements," *Opt. Lett.*, 30, 711(2005).
2. Sentek NovaPT™-E datasheet - <http://sentekinstrument.com/ept/>

ORDERING INFORMATION

Please send your quote request to sales@sentekinstrument.com and specify sensor maximum operating temperature, maximum pressure, housing material (SS316L versus Alloy 718) and interrogator channel count.