Fr SR 04

Multi-sensing Cable Specification- Aligning User Requirements with Sensor Design

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SUMMARY

Fiber optic sensing offers a flexible, reliable, cost-effective approach to gather information in geophysics about spatial-temporal distributions of physical quantities such as temperature, strain, pressure, humidity, vibration, and acoustic signals over distances of up to several tens of kilometers over a single sensing cable. The implementation of fiber optic sensing enables early detection and localization of defects and incidents related to seismic events, land slides, settlements, leakages, seepages, erosion and moreover provides essential information to optimize the functionality of infrastructures in the fields of energy production, transportation, construction, as well as to improve industry yields and safety.

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Today, specialized cabling companies develop and manufacture fiber optic sensors, which are selectively compatible with the monitoring technology in use (Brillouin, Raman, Rayleigh, Fiber Bragg Gratings). Such sensors must cope with the severe mechanical and environmental requirements imposed during installation and asset operation. Often they must survive in rough physical and chemical environments, where high tensional stress and lateral loads, extended temperature range, hostile embedding milieu and soil type, humidity, corrosive agents, high hydrostatic pressure may be present.

In order to enable high measurement accuracy, reproducibility and speed, while still assuring highest reliability and durability, the cable manufacturers, in accordance with system integrators and operators, must

- meticulously chose the suitable materials
  - sheathing polymers
  - metals for armoring and tubing
  - filling gels
- make/buy specific subassemblies
  - specialty optical fibers
  - FIMT - Fiber In Metal Tube
  - composite strengthening members
  - electrical conductors
- assure thoroughly qualified manufacturing processes
  - control of EFL - Excess Fiber Length – for temperature sensing cables
  - inter-layer adhesion for strain sensing cables
- perform extensive product validation
  - optical performance assurance
  - mechanical and environmental testing
  - assessment of chemical and electrical parameters for hybrid sensors
  - analysis of the acoustic impedance between cable layers and the surrounding milieu for acoustic sensing cables
- apply in the design process all relevant available information about installation and operation practices.

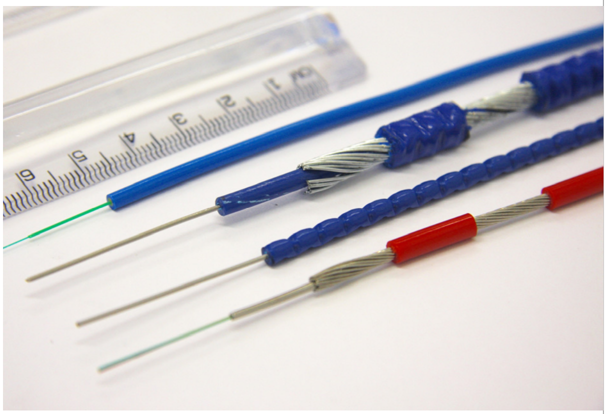
The identification of the most suitable sensor typology and the qualification of its performances are performed in accordance to new fiber optic sensing international standards. These regulations impose technical and practical requirements to the sensing system. For example they may demand to employ:

- hydrogen-resistant optical fibers
- cables complying with extreme temperatures, elevated strain, extreme hydrostatic pressure
- accessories (optical joints, feed-throughs, loops, terminations) compatible with rough environment (e.g. for deep-sea application)
- read-out instrumentation achieving long spatial range, high measurement resolution, short acquisition time
- specific installation that guarantee the integrity of the sensing system, without harming the integrity and functionality of the monitored infrastructure
- well-defined operation practices, which enable reliable, uninterrupted service for extended time, avoiding false alarms.

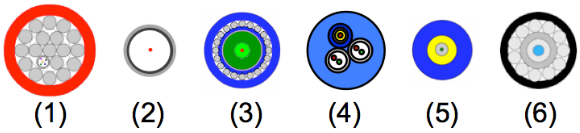
Standard telecom commodities, easily available on the market, often cannot intrinsically fulfill such demanding requirements.

Different scenarios of application of fiber optic sensing span over the monitoring of oil and gas boreholes and geothermal wells (temperature and pressure profiling, case compaction monitoring, hydrocarbon flow management), geophysical analysis of oil reservoirs, structural-health monitoring of pipelines, tunnels, bridges, dams and other large civil structures in seismic or, in general, unstable regions, geotechnical investigation of construction sites, environmental surveys and civil security actions.

The successful application of fiber optic sensing does not depend exclusively on the performance of sensors and measurement devices, but on the whole chain of implementation in the field, including the definition of the procedures for integrating the sensing system in the utility to be monitored, the correct interpretation of the measured signals, the decision-making process in case of detection of a specific event, and the appropriate choice and execution of corrective actions.



Fiber optic sensing cables BRUsens Strain and BRUsens Temperature.



Schematic cross sections of different optical fiber sensing cables:

(1) armored temperature sensor
(2) metal tube-in-tube extreme temperature sensor
(3) armored strain sensor
(4) combined strain and temperature sensor
(5) light metal-free strain sensor
(6) acoustic sensor