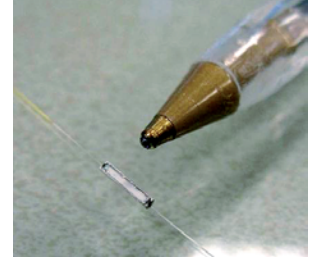
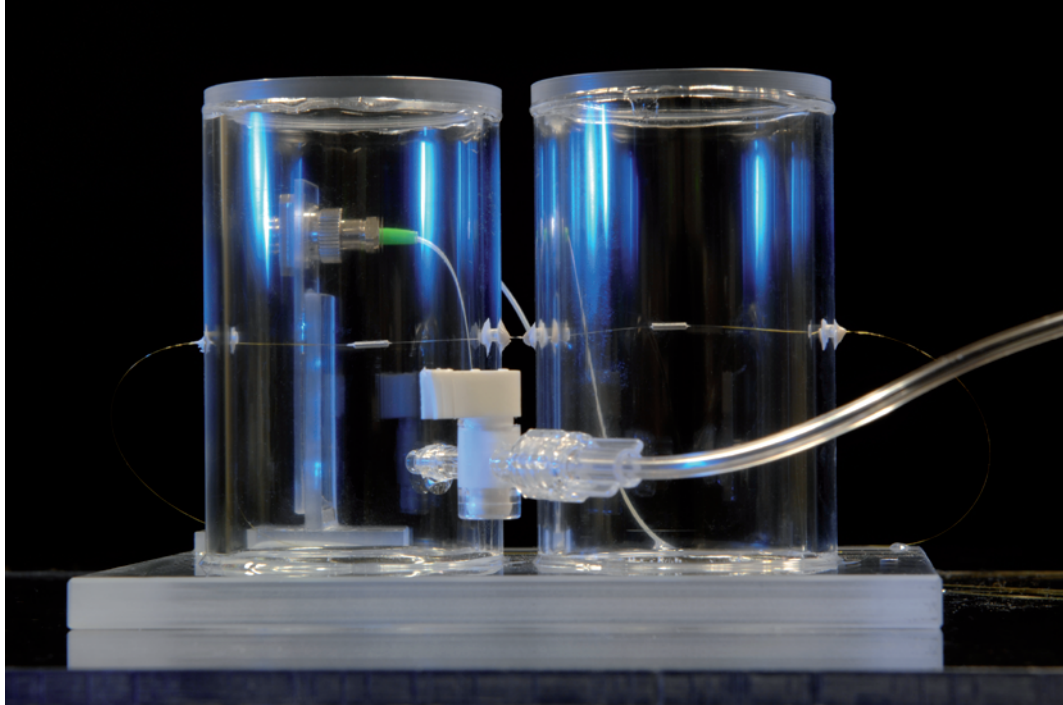


# OPTICAL FIBER SENSOR SYSTEM



Two miniaturised fiber optic pressure sensors. The small size is ideal for in-vivo pressure sensing, while TNO's sensor system design, i.e. sensor, read-out and data processing algorithms, allows a very high pressure sensitivity.

**TNO** innovation  
for life

TNO develops dedicated fiber optic sensor systems, which provide sensing solutions where other techniques fail. Intrinsic properties of fiber optic sensing, like immunity for electromagnetic interference, lightweight, small sized and corrosion resistance are some of the unique features that are fully exploited in many different applications by TNO's fiber optic sensing experts.

For example, the photograph (right) shows two miniaturised fiber optic pressure sensors. The small size is optimised for in-vivo pressure sensing, while TNO's sensor system design, i.e. sensor, read-out and data processing algorithms, allows a very high pressure sensitivity. Feel free to consult one of our experts to discuss what potential fiber optic sensing can bring to your specific application and sensing needs.

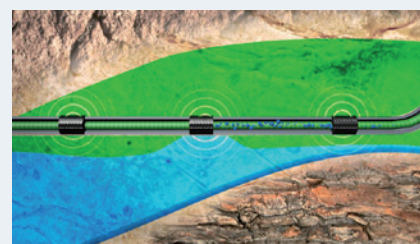
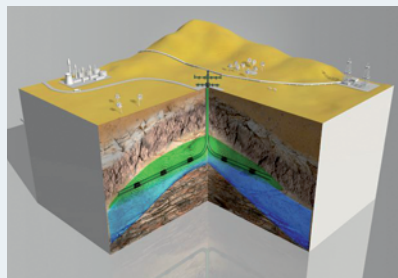
Fiber optic sensing technology provides our customers unique insight in chemical, biological and industrial processes. The sensing principle is based on the interaction of light with its surroundings brought to the measurement location by means of an optical fiber. There are a number of advantages of using light for sensing combined with a small sized and light weighted optical fiber:

- **unique** optical multiplexing potential, i.e. a large number of fiber optic sensors can be addressed and read out by a minimal number of lead fibers;
- intrinsically **safe** in explosive environments;
- **unprecedented** sensitivity and dynamic range;
- high temperature, pressure and corrosion **resistant**;
- **unsusceptible** to Electro-Magnetic Interference (EMI).



Example of one of TNO's hydrophone streamers. TNO develops fiber optic hydrophone systems comprising of many individual hydrophone sensors with unprecedented sensitivity and noise levels well below sea state zero.

With the acceptance of Fiber Optic technologies like Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) in the oil and gas industry, there is a growing demand for monitoring the chemical composition in the well. The value of knowing the chemical composition of the produced fluids over long distances and under harsh conditions has become essential for efficient production optimisation. Together with Shell TNO has matured this technology and acquired a solid patent position. The principle of monitoring named Distributed Chemical Sensing (DCS) is a proven monitoring technology for the reversible detection of  $H_2O$ ,  $CO_2$  and  $H_2S$  molecules in diverse media and under extreme conditions. The applications for DCS are numerous and the technology can be adapted by developing a specific coating and packaging to suit the requirements of the application, also outside the oil and gas industry.

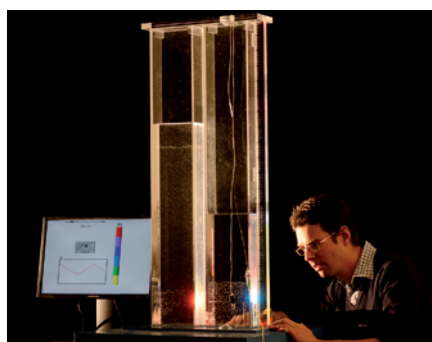


Artist impression of an oil well in which a distributed chemical sensor is positioned providing real time information on the oil production distributed along the well.

These unique properties fill the gap left by conventional (electrical) sensors and open a whole new area of special applications.

TNO has conducted research into fiber optic sensors systems for more than 30 years. We have been providing sensing solutions in various fields and for many different applications, exploiting the full potential of what fiber optic sensing can bring the industry. To give an idea on our track record, we have developed fiber optic hydrophone arrays for the Royal Dutch Navy (a.o.) and tested successfully in sea trials. For the oil and gas industry we developed a fiber optic flow meter capable of measuring flowspeeds up to 25 m/s down to 0.5 m/s operating at temperatures exceeding 300° C and at pressures up to 100 Bar. Fiber optic sensing also finds its way into medical applications for which we developed a haptic feedback clamp for minimal invasive surgery and small-sized pressure sensor arrays for in-vivo distributed sensing.

The years of experience in fiber optic sensing and moreover dedicated sensor system developments have left us with a large network of potential supply chain partners ranging from OEM supplier to full system integrator, an impressive track record and a solid IP position on key elements.

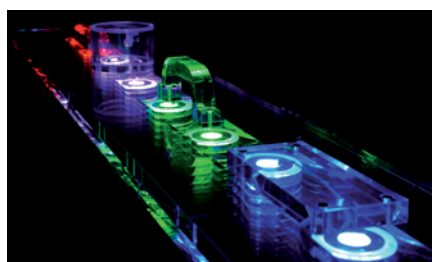


Demonstration setup of a patented fiber optic liquid level sensor system. The intrinsically safe fiber optic sensor system provides millimeter accuracy in determining the interface level between e.g. oil and water.

Can fiber optic sensing solve your sensing challenges? To answer that question let us first take a look at all the different parameters that are accessible using fiber optics:

- Acceleration
- Vibration
- Temperature
- Strain
- Pressure
- Shape
- Flow velocity
- Magnetic field
- Liquid level
- Density
- Viscosity
- Humidity
- Chemicals.

At TNO we develop tailored solutions to your sensing needs. We develop the complete system from sensor to up to the processing algorithms allowing our customers to visualise their process. The sensor system development extends to a prototype level after which we play a consulting role in the first series production of the sensor system.



We are in the business of providing unprecedented sensing solutions to our customers, allowing

- efficient real time optimisation of production processes;
- improved system reliability and availability;
- insight in industrial, chemical or biological processes.



**TNO.NL**

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