Case Study

Fibre optic sensors detect pipeline leaks

Distributed strain and temperature sensing proves its powers of prediction

Pipeline integrity is of critical importance wherever hazardous products such as gas, oil or LNG are involved – and particularly where those pipelines are located offshore, in remote locations or in environmentally-sensitive areas.

In any of these situations, a leaking pipeline carries a burden far greater than the loss of the product itself. As well as the obvious risks that fire and explosion pose to life and property and the potential for environmental damage, a pipeline failure results in significant direct costs in terms of repair, recovery and remediation – along with the potential for a severely damaging impact on an organisation's public reputation and, ultimately, its share value.

It was with all these issues in mind that Sensornet, the UK-based organisation that is pioneering the use of fibre optic technology in strain and pressure measurement, carried out trials using two of its innovative systems on a product pipeline at a European refinery and petrochemical complex.

The results proved the ability of the two systems – the Sensornet distributed temperature and strain sensor (DTSS) and Sentinel distributed temperature sensor (DTS) – to monitor strain and temperature variances with a high degree of resolution, and to not only detect simulated leaks but also to predict where such a pipeline failure might occur.

The trials proved the ability of real-time fibre optic sensing systems to detect and measure different types of flow on the basis of changes in temperature and strain taking place within a pipeline under varying operating conditions. Using the extensive data gathered from this project, Sensornet is now developing real-time pipeline monitoring systems to detect hydrate formation, which can lead to blockages, and process problems which can lead to a leak – an even bigger problem.

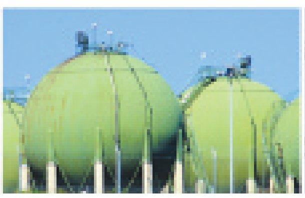
THE DISTRIBUTED DIFFERENCE

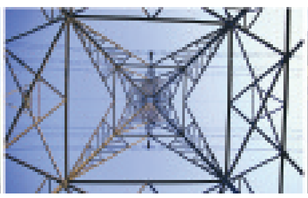
Instead of measuring temperature and strain at a number of predetermined locations along a pipeline (known as discrete sensing), Sensornet's distributed optical fibre systems provide a continuum of data with a spatial resolution that can be as fine as 30cm over lengths.

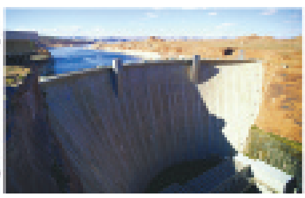
Sensornet systems can both detect a pipeline leak and determine where pipeline failure might occur.

This was the technology put to the test on the refinery pipeline where, for two days in chilly November weather, the two separate systems proved their ability to detect small variations in strain and temperature under a variety of operating conditions.

Both systems share the same outward form, which consists of a transportable 19" rack-mountable case with an inbuilt PC, flip-up monitor, keyboard, uninterruptible power supply and network connection. While the Sentinel DTS provides long range distributed temperature sensing with a resolution down to 0.01°C, the DTSS is







unique in its ability to measure both distributed strain and temperature concurrently and – crucially – completely independently.

The pipeline on which the tests took place was carrying gasoline between two storage tanks, and a leak was simulated by partly opening the valve leading to a third tank.

To prove its ability to detect a potential leak, the sensitivity of the DTSS system was set to a spatial resolution of 5m, where it was able to achieve a strain resolution of around 2με along the 2km length of fibre.

This enabled the simulated leak to be identified clearly, and provided Sensornet with data sets that will be used to further enhance the understanding of changes in pressure, strain and temperature within the pipeline during a leak and thus improve the accuracy of future systems in predicting – and thus preventing – potential leaks.

The Sentinel DTS system also proved its ability to provide an excellent qualitative picture of the fluid flow in the pipeline through the test, demonstrating the ability to provide process control data both before and after the simulated leak.

THE MEASUREMENTS

A total of three fibre runs were attached to the pipeline, two in single-mode to be monitored by the Sensornet DTSS system and the third a multimode fibre for use with the Sentinel DTS.

Throughout the two days of testing, both the DTS and DTSS proved their ability to acquire very fine resolution measurements accurately and rapidly. The DTS showed a temperature resolution of better than 0.1°C with rapid, one-minute measurements and was even able to capture the thermal signature of the fluid as it moved down the pipe.

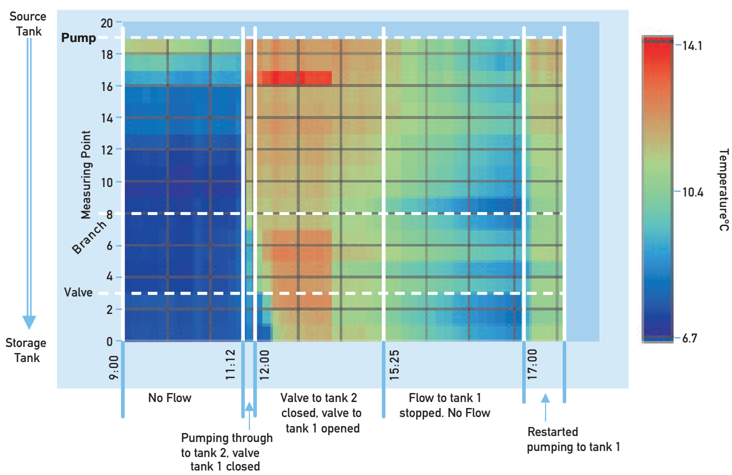
The DTSS system also provided accurate measurements throughout the tests and regularly achieved strain resolutions better than 2με.

FOR THE FUTURE

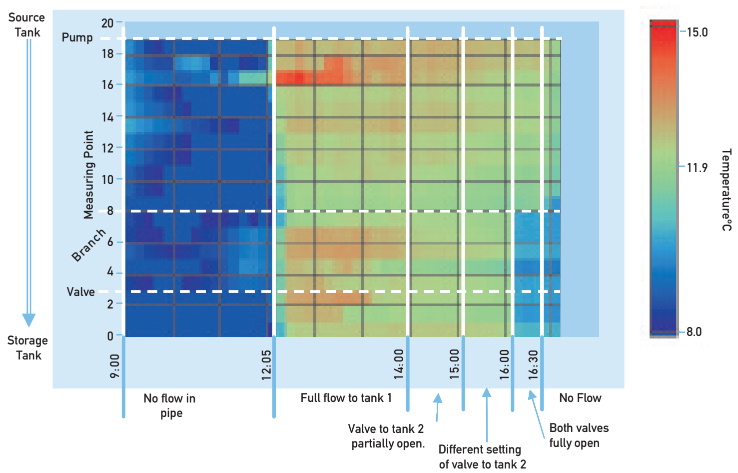
This practical test of Sensornet's distributed sensing technology has demonstrated the ability of distributed sensing to provide process plant and pipeline operators with reliable information about their entire system – detecting blockages and leaks in real time – allowing low-cost remedial action to be taken, instead of high cost repair work after the leak has happened. Potential operational applications include process monitoring in catalyst reaction vessels, high temperature processes and in mixing vessels.

Elsewhere, Sensornet technology is being actively applied in many other areas of the oil and gas industry – both on and offshore – as well as in the civil engineering, power utility, tunnelling and aerospace sectors.

Temperature profiles in flowline



Temperature profile for day 1



Temperature profile for day 2

E&O E