FIBRE OPTIC TECHNOLOGY: BEYOND TRADITIONAL LINEAR HEAT DETECTION

AP Sensing's novel solution addresses the need for monitoring storage tanks and pipelines

> **THE** susceptibility of modern-day assets in the oil and gas industry can pose significant challenges. For example, storage tanks are filled with chemicals that are flammable and often explosive, but these tanks can be ten or more years old and geographically located in regions with substantial lightning activities. Similarly, pipelines are susceptible to leaks and third-party interference (TPI), which can have hefty consequences.

Distributed fibre optic sensing (DFOS) technology is becoming an increasingly popular method for monitoring critical infrastructure such as pipelines, floating and fixed roof tanks, loading docks, warehouses and traffic tunnels. The technology is simple to install and offers significant advantages compared to other monitoring technologies or point sensors. Only one fibre optic cable is needed to monitor an entire pipeline or tank farm, and the cable is capable of continuously monitoring the entire asset 24/7.

DISTRIBUTED FIBRE OPTIC SENSING TECHNOLOGY

DFOS typically uses a pre-existing standard fibre optic telecommunications cable, which is transformed into a linear sensor. The sensor cable detects vibrations, temperature changes and acoustic events. It can also be split into zones, localising events such as fires or pipeline leaks and providing constant, real time updates along the entire sensor cable.

Distributed acoustic sensing (DAS) and distributed temperature sensing (DTS) are two types of DFOS. These methods utilise the Raman or Brillouin effect for DTS, and the Rayleigh effect for DAS. DAS and DTS use a laser source which is installed at one end of the fibre optic cable to inject laser pulses. As the pulse of light travels inside the fibre, backscattered light returns to the sensor carrying information from distances up to 70 km. The monitored distance without any intermediary interrogator can be up to 140 km when two interrogators are used, one on each side of the cable.

FIRES IN TANK FARMS

Two types of atmospheric storage vessels are common in tank farms: floating roof tanks (FRT) and fixed roof tanks (FT). According to statistics from past fires in tank farms, efficient monitoring coverage of the weakest point of these storage tanks provides time for effective and timely fire suppression.

The simple fire triangle provides a general view of how a fire is sustained. At any tank farm, a fire begins when an elevated temperature exceeds the flashpoint of the hydrocarbon cargo within. The hydrocarbon ignites and acts as the fuel for the fire, while the oxygen in the air maintains it. These conditions are perfect for a fire that is difficult to extinguish. A tiny spark in the storage tank from electrical discharge, an exothermic chemical reaction, gas escaping from the roof seal, static electricity or hot working has the capacity to develop into a major fire.

Storage tanks are often built at locations with increased lightning activities. These tanks could have been in operation for the past ten years and have yet another ten years of usage ahead, meaning they need to be maintained and monitored because of gradual breakdown and corrosion processes.

FLOATING ROOF TANK FIRE DETECTION

With FRTs, the combination of the moving deck (or roof) and the degradation over time of the seal allows traces of crude oil onto the internal shell of the corroded tank wall. This situation with iron oxide, air and hydrogen sulphide forms the perfect 'cocktail' for powdered iron sulphide to develop; this cocktail is pyrophoric and instantly ignites.

In order to detect and control this highly exothermic reaction with DFOS, the fibre optic sensor cable is fitted to the rim seal area of the FRT. There, the cable monitors rapidly increasing temperatures and activates foam suppression if needed.

FIXED ROOF TANK FIRE DETECTION

In the case of hydrocarbon cargo with a lower viscosity such as industrial alcohol or diesel, FTs are used for storage. Fire detection for FTs follows the same logic, only the fibre optic sensor cable installation differs. According to statistics, the weakest points of FTs are the vapour vent and the welded roof interface to the vertical shell, which is where the fibre optic cable is installed.

Similar to FRTs, FTs are also aging and faced with the same causes of ignition such as lightning activities and hot work. The evaporative nature of the cargo within FTs results in the accumulation of flammable vapour.

FIBRE OPTIC SENSING FOR TANK FIRE DETECTION

'DTS provides the range, capacity and information needed for industrial fire

protection in tanks and tank farms,' says David Shiu, head of the linear heat detection business unit at AP Sensing.

DTS is also known as fibre optic linear heat detection (FO LHD), where the passive fibre optic sensor cable measures thousands of temperatures in real time, completing a temperature profile across an entire tank farm within seconds. FO LHD is particularly advantageous technology for monitoring tank farms as one fibre optic cable with one or two control units can be used to monitor the entire tank farm, even with complex zoning.

LHD is light and easy to install. Despite its simplicity, multiple project-specific fire zones can be mapped to the control panel. One zone can be assigned per tank and in the case of a fire, FO LHD distinguishes in which tank the fire originates and displays this information via SCADA/BMS. Furthermore, the same fibre optic sensor cable can be defined with multiple alarm thresholds to act as a pre-alarm or multi-knock alarm signal. A variety of alarm parameters (rate-of-rise, maximum, adaptive) can be programmed to each fire zone.

These alarms can be programmed to initiate automatic countermeasures. In the event of a fire, AP Sensing's FO LHD system allows temperature measurement up to 750°C for two hours, tested as per IEC 60331-25. This means that the system not only precisely pinpoints hotspots and locates fires with high accuracy, but can also monitor fire development by continuing to provide vital information about fire development, size and spread over time.

Lastly, the system is easily repairable in the case of a fibre break. Regulation stipulates testing of the fire protection system in certain intervals; testing of AP Sensing's LHD system is simple, timesaving and does not require down-time.

TANK FIRE DETECTION IN ACTION

AP Sensing's FO LHD system has been deployed to different tank farms worldwide including across Europe, the UAE, South America, Oman, Kuwait, the Kingdom of Saudi Arabia, China and South Korea.

In the case of a recent installation in South America, AP Sensing is monitoring industrial alcohol tanks at a chemical plant. The project specified one regular LHD system for each tank, but due to poor experiences with other projects/sites regarding false alarms and continuous maintenance, the tank operator selected AP Sensing's FO LHD solution. This solution with one cable and one interrogator unit monitors all the tanks and provides more information than just single fire alarms.

Due to the precision of the system, the foam extinguishing system was integrated per defined zone and the project is integrated with a central fire alarm and activation system.

Based off the tank contents and site conditions, FO LHD was an excellent choice. Different zones were created for each tank and different levels of alarms were set to reduce all false alarms that could activate the extinguishing system and generate unnecessary costs.

QUALITY AND CERTIFICATIONS

AP Sensing's FO LHD has the industry's lowest false alarm rate and the market's most complete set of product certifications for quality and performance including VdS EN 54-22, UL 521, ULC-S530, FM 3210 and 3010 and SIL-2, and explosion certifications ATEX and IEC-Ex. The system is robust, thoroughly tested and the single DTS unit and fibre optic cable have a reliability beyond the designed mean time between failures (MTBF) of 33 years. All information from the system is available through dry contacts such as Modbus protocol. It is also fully integrable with other tools and fire suppression systems such as foam extinguishing systems or a FACP.

PIPELINE MONITORING

For fibre optic pipeline monitoring, DTS is used to measure the temperature in heated pipelines, while both DAS and DTS sensing are used to detect and localise leaks. DAS is also used to protect pipelines from accidents caused by TPI such as from mechanical diggers and other construction operations. DAS and DTS can be stand-alone or used in conjunction with other technologies.

Pipeline leak detection using either DTS or DAS has many benefits for pipeline operators as compared to traditional pipeline leak detection methods:

- Leak location within meters
- Insensitivity to hydraulic transients
- No loss of performance and suitable to multiphase pipelines
- No dependency on field instrument availability or calibration drift
- Higher sensitivity

Additional functionalities include:

- Real-time scraper tracking
- TPI monitoring of both onshore and offshore pipelines
- Flow assurance monitoring (hydrate formation, waxing formation, liquid accumulation)
- Ground and/or fluid temperature monitoring

For more information:

The information in this article was provided by David Shiu, CEng MIET, AP Sensing's head of linear heat detection. AP Sensing is the market leader in distributed fibre optic technologies, currently monitoring several hundred critical infrastructure projects around the world and endorsed by major companies such as Kuwait Oil Company (KOC), Energinet, Saudi Aramco, Saudi Electricity Company (SEC) and the Eurotunnel. Additional information on DFOS for monitoring pipelines, tank farms or another application area can be found at www.apsensing.com or by email at info@apsensing.com.

01 Cryogenic tanks

02 Sensor cable at FRT rim seal

03 Monitoring storage tanks with redundant setup