Eliminating False Alarms and Improving Safety Performance –

Laser-Based Gas Detection Technology on *Terra Nova FPSO*

The original *Terra Nova* gas detection system was designed to utilise a combination of point detectors and line-of-sight (LOS) detectors based on infrared (IR) technology, with the bulk of coverage being provided by the LOS type. Since the facility first started production in 2002 there have been on-going issues with the reliability of the LOS detectors. By 2010 parts of the Terra Nova field were beginning to produce hydrogen sulphide (H_2S) in the well fluids. As toxic gases were not expected in the original *Terra Nova* design, the fixed gas detection system did not incorporate dedicated H_2S detection.
A multi-disciplinary team was assembled to assess and upgrade the overall gas detection system on the Floating, Production Storage and Offloading (FPSO).

BY RAJAT BURUA AND ED SHARPE

After the field began producing hydrogen sulphide in 2010, the Terra Nova FPSO underwent a complete decommissioning and upgrading of its gas detection system *(photos: Senscient)*

Prior to H_2S production, the most significant issue had been performance during adverse weather conditions. During periods of fog or snow many detectors would report a blocked beam fault condition and, depending on the situation, some would falsely detect gas. As a result, Suncor would frequently be forced to assign technicians to clean the lenses and return the units to service.

The assessment team involved personnel from safety, risk analysis, operations, instrumentation and controls engineering. Based on the need to upgrade the gas detection system to detect H_2S and the LOS detector performance issues, several projects were initiated.

The first initiative was to build a gas dispersion model for the *Terra Nova FPSO* and use this analysis to complete a comprehensive gas detection evaluation and optimisation study. In parallel, Suncor began to investigate and trial various gas detection technologies that could address the problems with the existing system and detect both flammable and toxic gas releases.

Evaluation of the Gas Detection System

Detailed analysis based on computational fluid dynamics (CFD) modelling was performed for the *Terra Nova FPSO* by GexCon. The overall objective of the analysis was to test and optimise system performance and suggest improvements for the existing system and detector layout.

The CFD model FLACS was chosen in the present study because it allows the simulation of the relevant toxic and flammable gaseous releases, the modelling of the detailed geometry within the facility, the simulation of both natural and forced ventilation within the facility, the evaluation of gas concentration measured by line and point detectors, the evaluation of danger potential for the dispersion cloud, and the ability to perform parametric sensitivity and optimisation studies. The geometry of the *Terra Nova FPSO* was based on a computer-aided design (CAD) model.

The quantitative evaluation of the GDS in the process modules was based on testing the performance for a large set of realistic gas leak scenarios. The ventilation conditions were determined by the wind speed and direction, the heading of the FPSO, large-scale effects from modules and buildings upwind and downwind of the area of interest, as well as smaller-scale effects from buildings, walls, equipment and piping inside the area of interest itself. In aggregate, over 1,400 gas leak scenarios were simulated and used in the evaluation, detector selection process, optimisation and overall design of the upgrade to the gas detection system.

Selecting the Right Gas Detector Technology

Since it commenced operation in 2002, the *Terra Nova FPSO* has relied primarily on LOS detection. Therefore, Suncor's preferred option was to determine if LOS technology existed that could replace its existing detectors and provide coverage for both flammable and toxic gas leaks. This would minimise structural modifications required to mount new units, avoid having to run new cables and trays, thereby minimising construction time and cost. An extensive search eventually led the Suncor team to lab test, field trial and ultimately select the Enhanced Laser Diode Spectroscopy (ELDS™) technology. This technology, developed by Senscient, had the capability of combining toxic and flammable gas detection in a single LOS detector whilst significantly improving the performance and reliability of the FPSO's overall gas detection system.

In February 2011, a trial ELDS™ unit was acquired and subjected to qualification testing at the *Terra Nova* onshore distributed control system (DCS) simulator. Over a period of two weeks, stringent performance tests were conducted on the device, under four conditions that were known to generate problems for the existing IR detectors: simulated fog using water mist, direct water spray on the device lenses, plastic of various types placed in the beam path, and snow placed over the lens (approximately 2.5 cm thick). The test results showed no issue with performance for all four conditions.

Using a transmitter-receiver configuration, ELDS™ systems detect and measure gas concentrations at specific target gas absorption wavelengths over distances of up to 200 metres. One of the key techniques that enables ELDS™ to detect small fractional absorbances and eliminate false alarms is Harmonic Finger- printing. A Harmonic Fingerprint is a specific set of harmonic components introduced by target gas absorption where the relative amplitudes and phases of the components are known and specific to the target gas absorption line that is being scanned.

Implementation of the Retrofit and Upgrade

Once onshore testing was completed, a dual Methane-H_2S ELDS™ detector was installed on the *Terra Nova FPSO*, in May 2011, in place of an existing IR LOS device that was known to cause issues in the past. The distance between the transmitter (Tx) and receiver (Rx) for this installation was approximately 34 metres. During a trial period that lasted approximately 24 months, the ELDS™ detector performed very well, with zero spurious trips. The only issue identified was a loose mounting bracket that resulted in misalignment, a problem that was easy to identify and resolve. Following the successful offshore trial, a decision was made by Suncor to replace all existing IR LOS gas detectors on the *Terra Nova FPSO* with the ELDS™ technology. In aggregate, 141 IR LOS detectors were slated for replacement. A recommendation from the study by GexCon added another 17 ELDS™ detectors to provide for additional coverage. Therefore, the overall retrofit and upgrade plan called for the decommissioning or 141 IR LOS and the installation of 158 ELDS™ detectors.

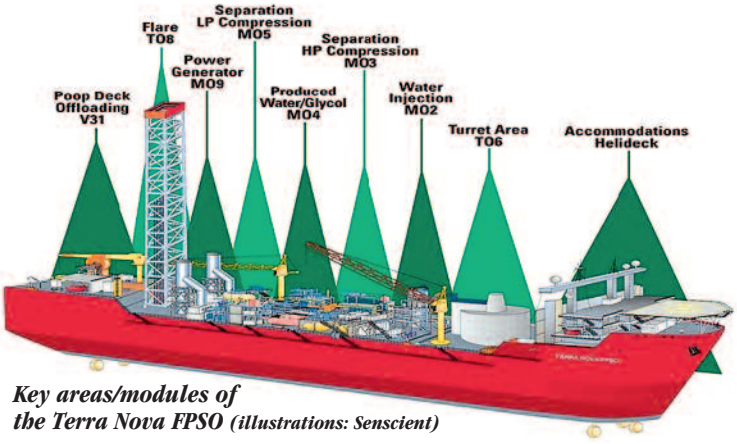
Retrofitting the FPSO while it was on location, in full operation, required significant planning. A thorough work package was developed which provided a plan for the decommissioning of the existing IR detectors, installation of the new ELDS™ detectors and training of personnel. Change out of the LOS detectors commenced in 2013, and is scheduled to be completed int 2015.

Impact on Safety Performance

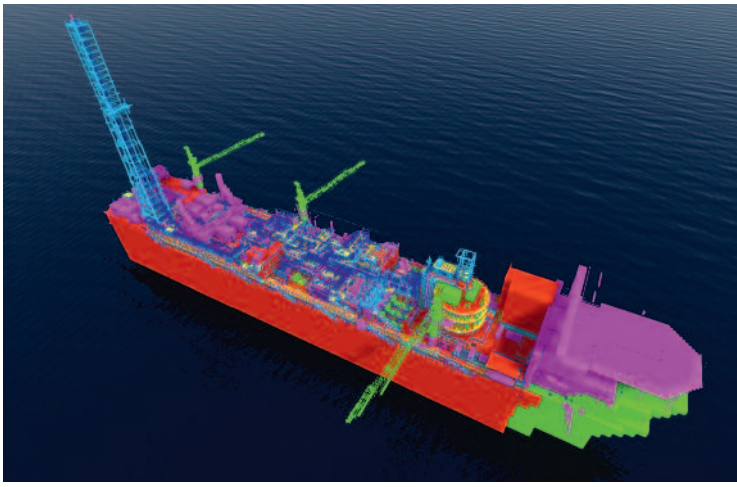
The performance of the upgraded system has been exceptional. Prior to the upgrade, the *Terra Nova FPSO* experienced 3-5 plant trips, more than 200,000 fault indications and 20-25 unrevealed failures per year. Data from the *Terra Nova* data historian, maintenance management system and lost production tracking register was analysed to quantify this performance.

A review of the maintenance management system showed that there was an average of 21 unrevealed gas detector failures per year from 2009 to 2013. The signal these IR devices were sending to the control system indicated full health, however, they failed to respond to a function check. The ELDS™ detectors address this problem by completing a daily diagnostic check and signalling a fault if there is an issue. As of December 31, 2014, *Terra Nova* had not recorded a single unrevealed failure with the laser-based gas detectors. Startup and shutdown of a facility introduce risks that are not present when a plant is in steady state operations. By reducing the number of spurious trips, the time spent in startup or shutdown modes is reduced, thereby decreasing the risk to the facility.

The laser-based sensors installed on the *Terra Nova FPSO* have a minimum detection threshold that is much lower than the older IR-based detectors. Instead of a hydrocarbon detection threshold of 1 LELm/2.5 LELm (low/high alarm), the laser-based detectors can be set to a threshold of 0.2 LELm/1 LELm (low/high alarm), without experiencing any drifting and related spurious alarms. The effect of this five-fold increase in sensitivity is that the detectable volume of any gas cloud is larger. Increasing the sensitivity of detectors increases the detectable volume and makes it more likely that any given detector will be exposed to detectable gas before the flammable volume reaches a dangerous size. Furthermore, the H_2S content on *Terra Nova* means



***Key areas/modules of the Terra Nova FPSO** (illustrations: Senscient)*

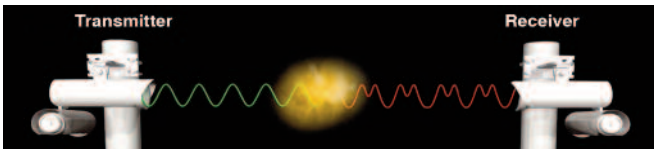


Terra Nova FPSO FLACS geometry model

Terra Nova

The Terra Nova oil field is situated in the Grand Banks, approximately 350 kilometres east-southeast of the city of St. John's in the Canadian province of Newfoundland and Labrador and is the second largest offshore oil field in Canada. The total recoverable oil reserves in the field are estimated by the Canada-Newfoundland Labrador Offshore Petroleum Board (C-NLOPB) to be 419 million barrels. The owners of the Terra Nova field are: Suncor Energy (37.675%), ExxonMobil (19%), Statoil (15%), Husky Energy (13%), Murphy Oil (10.475%), Mosbacher Operating Ltd. (3.85%), and Chevron Canada (1%). Suncor Energy is the operator of the Terra Nova field.

Production from the field began in 2002, through the use of a FPSO vessel. This was the first development in North America to use FPSO technology. One of the largest FPSO vessels ever built, the Terra Nova FPSO is 292 metres long and 46 metres wide. The Terra Nova FPSO can store 960,000 barrels of oil and accommodate up to 120 personnel while producing.



ELDS™ systems use a transmitter-receiver configuration to detect and measure gas concentrations at specific target gas absorption wavelengths over distances of up to 200 metres

even small leaks can be hazardous, thus increased sensitivity is an important tool to ensure worker safety.

A comprehensive dispersion analysis based on worst case H_2S concentrations in the production stream was performed for the entire FPSO. This study revealed that hazardous levels of H_2S could occur in the port half of module M04, the area of the process facility where regeneration of glycol and treatment of gas and produced water takes place. Consequently, a dedicated H_2S detection system was developed and installed in the M04 module utilising laser-based LOS devices.

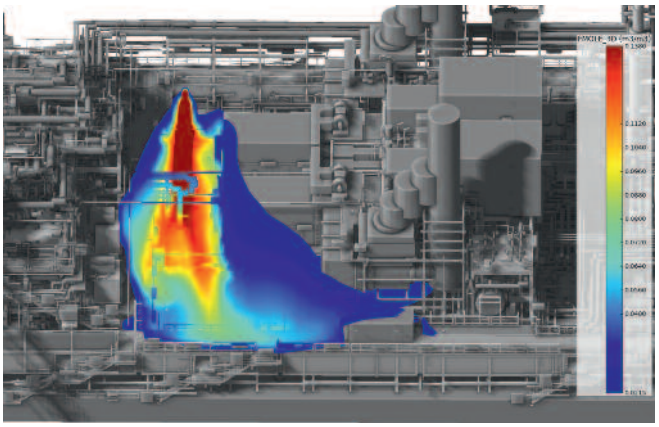
Impact on Maintenance and Offshore Operations

A review of performance data from the *Terra Nova* data historian shows dramatic improvement over the IR devices in spurious trip avoidance. The key metric reviewed was the number of faults/blocked beam indications.

ELDS™ systems installed in field operations

Performance data was reviewed from January to December of 2011 for the IR-based detectors as the FPSO was off station for maintenance for portions of 2012 and 2013. Data from June 2013 to June 2014 was used to capture the performance of detectors that had been changed to laser-based systems.

With such a significant decrease in the number of faults, the requirement for technician response and troubleshooting has been drastically reduced. From 2009 to 2013, an average of 234 maintenance work orders per year was generated, relating to IR LOS detectors being in fault. Note that this number does not include the significant number of maintenance call outs during conditions of limited visibility (rain, fog, mist and snow) to clean detectors as these calls are not tracked. From June 2013 to July 2014, there were only 13 maintenance work orders created relating to issues with laser-based devices.



Gas release simulation resulting in a hazardous flammable cloud scenario (1,250 m³) in the power generation module (M09) – concentration contours from 50% LEL (lower explosive limit) depicted in deep blue, to UEL (upper explosive limit) depicted in dark red

Impact on Production

Historically, the *Terra Nova FPSO* has experienced three to four production trips per year due to false gas detection. These trips have resulted in production deferments of approximately 50,000 to 100,000 barrels per year. During a trip initiated by gas detection, emergency shutdown valves are closed quickly, equipment is tripped and gas inventory is sent to the flare system.

Shutting down the plant in this manner has potential damaging effects on plant equipment such as generators and gas compressors. The FPSO experienced damage to process equipment during emergency shutdowns several times prior to the installation of the laser-based gas detectors, resulting in prolonged outages and significant repair costs. Conversely, there has not been a single instance of false gas detection with the laser-based gas detection technology.

The experience from *Terra Nova* demonstrates that implementation of advanced laser-based gas detection technology can result in a significant improvement in safety, reliability and process uptime in industrial facilities where the threat of a toxic or flammable gas leak exists. ■

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