INCREASING SAFETY AND OPTIMISING TANK USAGE

Victoria Lund Mattsson explains how modern tank gauging systems not only provide accurate and reliable level measurements, but also prevent overfills and predict roll-overs in cryogenic tanks storing LNG.

Liquefied natural gas (LNG) is stored in full containment, cryogenic tanks that can hold up to 200,000m^3. These vessels include an inner steel tank to contain the liquid, and an outer concrete or steel tank serving as a secondary containment measure. There is thermal insulation between the two tanks to minimise liquid boil-off during storage. Designing and constructing such large and technically complex structures is costly and obtaining a return on investment (ROI) can take a long time. One way to achieve faster payback is to implement a modern tank gauging system that will help to optimise tank usage, increase safety, and minimise operating and maintenance costs.

Level and temperature measurement technology plays a key role in modern LNG tank gauging systems. Operations depend on reliable and precise measurement of the liquid level inside each tank for inventory management purposes. Monitoring level and insulation space temperature is a means of identifying tank leakage, helping prevent costly product loss and potential safety incidents, and ensuring environmental compliance. Level and temperature are also measured for safety reasons, as part of an overfill prevention system (OPS).

Measurement challenges

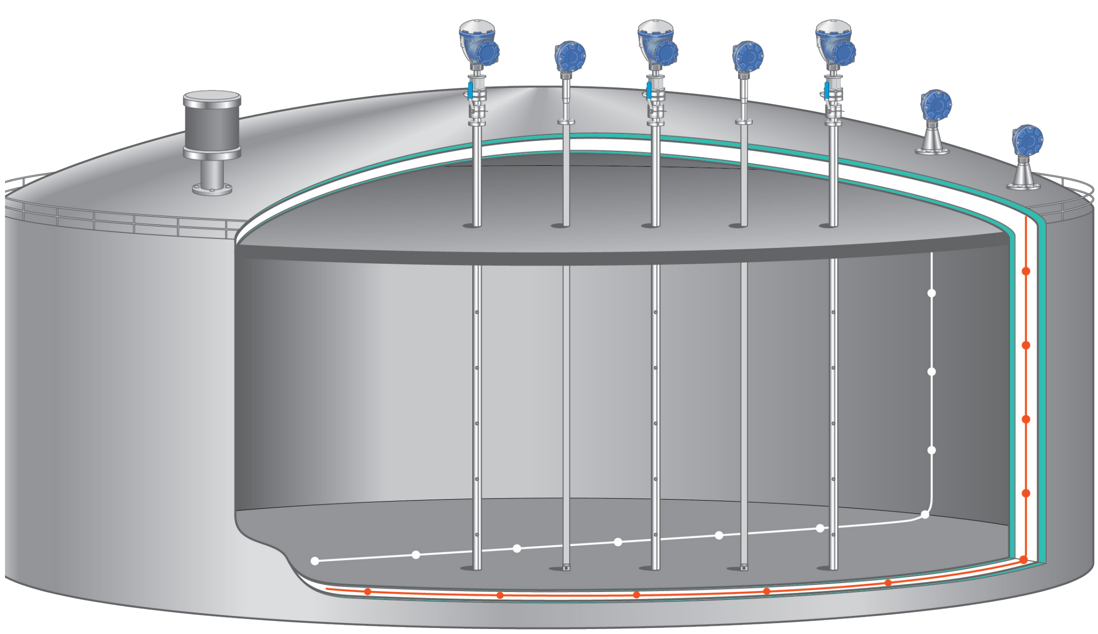
Measuring level and temperature in full containment tanks presents several challenges for accuracy and reliability. The size of the tanks means the required level measurement range can often be over 40m, making high levels of accuracy difficult to achieve. During their lifespan, the tanks are not opened during operation so instruments cannot be easily accessed for maintenance and calibration. Instrument reliability is therefore crucial, and redundant level measurements are often vital.

The inner structure of full containment tanks presents a further measurement challenge. Standard storage tanks have only one vapour space, but full containment tanks have two – one outside the tank's fixed suspended deck and another inside it. These two spaces have different temperatures and for inventory purposes this needs to be considered when calculating the liquid equivalent within the spaces.

Radar technology

The modern approach to providing precise level measurement involves the use of non-contacting radar gauges. Radar gauges boast good reliability, with the mean-time-between-failures for critical parts measured in decades. In addition, they have no moving or wetted parts, which helps to minimise maintenance requirements and the frequency of parts replacement.

These devices use microwave signals that are emitted towards the surface of the liquid and are reflected back to the transmitter, enabling the level to be measured accurately and reliably. To perform continuous level measurements in a full containment, cryogenic tank, a radar gauge needs a sufficiently strong reflected signal, known as an echo, from the liquefied gas surface. The



A typical radar-based LNG tank gauging system.

A look inside a full containment tank.

latest gauges are based on frequency modulated continuous wave (FMCW) technology and have sensitivity more than 30 times greater than in those based on the older pulse modulation technique. This maximises the signal strength and enables FMCW devices to deliver greater measurement accuracy and reliability. To combat the extreme temperatures within cryogenic tanks, a specific antenna option is used to enable a gauge to function correctly. The electronics are housed within the transmitter head, which is located outside the tank, enabling easier access for maintenance, should it be required.

To further improve the signal strength of non-contacting gauges in LNG and liquefied gas applications, the radar signal is guided within a still-pipe, resulting in a strong, undisturbed echo from the surface. As a result, these devices can provide highly accurate measurements at distances of over 55m.

Overfill prevention

Automatic tank gauging and overfill prevention can be provided in the same tank gauging system. The Rosemount Tank Gauging System from Emerson, for example, is certified according to the IEC 61511 standard as a system solution, meeting specifications for both process control and safety applications. It is common practice for systems to include three level gauges – primary and secondary gauges supporting the basic process control system, and a third providing information for the OPS, with alarms triggered on a two-out-of-three voting scheme.

A key consideration when storing LNG is the potential for rollovers – dangerous releases of boil-off vapour and pressure build-up that can occur when stratification (when two separate layers of LNG are formed within a tank) is left unchecked. The consequences of rollovers can be severe – causing tank integrity damage that can release large quantities of natural gas into the atmosphere. As a preventative action to detect stratification, LNG tank gauging systems can include software solutions to calculate when a rollover might occur, and level temperature density devices to monitor tank temperature and density profiles.

Organisations have traditionally kept their rollover prediction and inventory management software installed separately on different PCs. However, the Rosemount TankMaster inventory management software package from Emerson offers both functions in a single solution, which helps to lower costs, improve ease-of-use and accelerate operator training.

Remote proof-testing

Level gauges deployed in any safety instrumented system must be periodically proof-tested to ensure they will work properly when required. Two types of proof-tests – comprehensive and partial – are performed in compliance with both IEC 61511 and the American Petroleum Institute's API 2350 standard.

Comprehensive proof-tests are time consuming and involve technicians having to climb tanks to access devices, putting their safety at risk. This method can also cause downtime, affecting profitability. In contrast, partial proof-tests have a reduced scope and target individual devices to ensure there are no internal problems and to bring the probability of failure on demand (PFD) – the risk of it failing to perform its intended function – back to a percentage of the original level.

As a partial proof-test detects only a percentage of potential failures, a comprehensive test must eventually be carried out to return a device to its original PFD. However, partial testing can provide crucial technical justification to extend the time in-between comprehensive tests. This enables testing to be scheduled around planned shutdowns, thereby reducing costs.

Innovative technologies now enable the partial proof-testing of radar gauges to be performed remotely. The latest devices incorporate proof-testing functionality that just requires the inputting of a straightforward sequence of settings and commands from an interface in the control room, or remotely via a graphical field display. This eliminates the need for workers to climb tanks and be exposed to tank contents, thereby saving time, reducing risk and improving safety.

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