Using radar-based level measurement improves efficiency and safety at LNG import terminals

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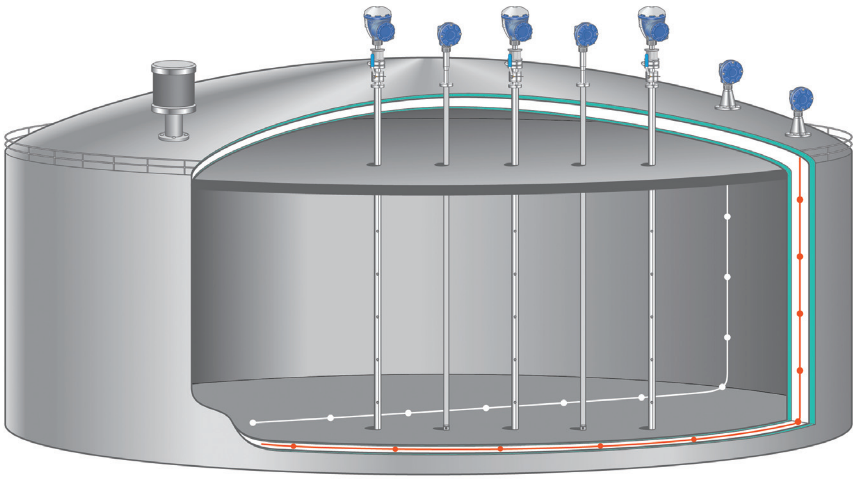

Model of a storage tank with Emerson measuring equipment technology in place

The cryogenic full-containment tanks used for storing LNG are large, complex structures with a typical capacity of between 30,000 and 200,000 cubic metres.

These vessels include an inner liquid containment steel tank, an outer concrete (or steel) tank for secondary containment control, and thermal insulation between the two to avoid liquid boil-off during storage.

Investment

Because these vessels are so technically advanced, their design and construction requires significant investment from tank farm operators, and payback times can be lengthy.

It is therefore important to implement accurate and reliable tank gauging systems that will help in maximising storage capacity and throughput, as well as minimising maintenance costs, thereby ensuring a faster return on investment, according to the US Emerson company, whose headquarters are in St. Louis, Missouri.

Level and temperature measurement technology forms a key part of an LNG tank gauging system.

The Emerson Rosemount 5900S Radar Level Gauge with LNG antenna

The ability to accurately and reliably measure the level of the liquid inside each tank is essential for inventory management and custody transfer purposes, and therefore in helping to maximise profitability.

Level and temperature are also measured as part of an overfill prevention system (OPS).

Filling a tank above its capacity can cause an overspill, which presents a safety hazard.

In addition, monitoring level is an important means of ensuring that tanks are not leaking, thereby helping to prevent product loss and potential safety incidents.

Preventing overspills and having the ability to detect leaks early is also vital in helping to comply with environmental regulations.

Challenges

Measuring level and temperature in full containment storage tanks presents several challenges. The required measurement range in these tall structures can often be 40 metres (131 feet) or more, which makes it difficult to achieve high levels of accuracy.

Also, such tanks are not opened during operation, which adds complexity when it becomes necessary to access instrumentation for maintenance. Equipment reliability is therefore a major consideration when selecting measurement technology for these applications.

A further challenge is presented by the inner structure of these tanks. Standard storage tanks have only one vapour space, but in full containment tanks there are two - one outside the tank's fixed suspended deck and another inside it.

These two large spaces have different temperatures and for inventory purposes this needs to be considered when calculating the liquid equivalent within the spaces.

Methods

Level measurement in these tanks has traditionally been performed using either a float and tape method or servo technology.

In the former, a large float inside the tank is connected to a spring motor and mechanical numeric indicator at the lower end of the outside of the tank through a pulley system.

For remote monitoring, the float gauge may be equipped with a transmitter, which provides tank level values to the control room.

When adopting the servo method, the float is replaced by a small displacer, which has buoyancy, but does not float on the liquid.

The displacer needs to be suspended by a thin wire, which is connected to the servo gauge on top of the tank.

Tension

A weighing system in the servo gauge senses the tension in the wire. Signals from the weighing mechanism control an electric motor in the servo unit and make the displacer follow the liquid level movements.

A transmitter sends the level information to the control room using digital communications.

Although widely used, these methods have major shortcomings.

For example, the accuracy of a float gauge is often poor, with multiple error sources including buoyancy differences, dead-band, backlash and hysteresis in the mechanisms.

The float gauge is a relatively simple device, but has many moving parts that will require regular maintenance over its lifespan.

Servo gauges generally perform better than float gauges, but also have many moving parts.

Because the displacer and the wire are in contact with the liquid, servo gauges may require more attention for calibration and maintenance.

The modern approach involves using top-down non-contacting radar level gauges to provide accurate and reliable level measurement.

This has become the world's fastest growing tank gauging technology in cryogenic applications.

The measurement of liquid level by non-contacting radar gauges is based on microwave signals emitted towards the surface and reflected back to the transmitter.

To reliably measure the level in a full containment tank, a radar gauge needs a sufficiently strong reflected signal, known as an echo, from the LNG surface.

Radar gauges based on two-wire frequency modulated continuous wave (FMCW) technology transmit a radar signal with increasing frequency over time to create a signal sweep.

The signal echo reflected from the surface is picked up by the antenna. Because the frequency of the transmitted signal constantly varies, the echo frequency always differs slightly to the transmitted signal at any given moment.

The difference between these frequencies is directly proportional to the echo delay - i.e., the distance from the transmitter to the surface - which enables accurate measurement of the level.

Sensitivity

The sensitivity of transmitters based on FMCW technology is more than 30 times higher than those based on pulse radar technology.

This maximises their signal strength and enables them to deliver greater measurement accuracy and reliability.

In LNG applications, a four-inch still-pipe guides the radar signal, resulting in a strong, undisturbed echo from the surface of the liquid.

Typically, the radar sweep is controlled by a crystal oscillator to achieve instrument accuracy of 0.5 millimetres (0.020 inches).

Non-contacting radar level gauges are suitable for use in LNG storage tanks because their electronics are housed within the transmitter head, located outside the tank.

These devices can measure the LNG level in the tank without any physical contact with the surface, and without the need for inside-tank components that would require maintenance.

Antenna

A specific antenna option can be employed to enable a device to function in such an extreme environment.

These devices have minimal maintenance requirements, as they have no moving parts and do not touch the liquid, and they can boast impressive reliability, with mean time between failures for critical parts measured in decades.

The long measuring range required in these tall tanks can be challenging for non-contacting radar level gauges.

However, the latest devices can provide highly accurate measurements at distances of over 55 metres (180 feet), and furthermore, the measurements can be verified while the tank is in operation.

This is achieved through comparing measured level values to the known distance of a reference pin mounted in the still-pipe along with a deflection plate at the end of the pipe.

Temperature

The high-performance LNG automatic tank gauging systems into which non-contacting radar level gauges are integrated also include Level Temperature Density (LTD) devices to monitor tank temperature and density profiles, to detect stratification.

Stratification occurs when two separate layers of LNG are formed within a tank and this can potentially lead to a dangerous release of boil-off vapour called a roll-over.

Separation

The accurate multiple spot temperature sensors used for inventory measurements also provide an online temperature profile as a back-up to the LTD instruments.

Additional temperature measurements are made by multiple spot temperature sensors to monitor the cool-down process and to add leak detection. Both functions are achieved by using several single spot temperate sensor elements which are fully integrated in the tank gauging system.

These are distributed along the inner tank wall and at the tank bottom (for cool-down supervision) and within the insulation space between the inner and outer tank walls (for leak detection).

Three level gauges are typically installed on an LNG storage tank – one supporting the basic process control system (BPCS), a secondary and redundant gauge for inventory, and a third providing information for the OPS.

In compliance with the International Electrotechnical Commission's 61511-2 standard, the same technology can be used for all three gauges.

Compared with using different technologies, this 'identical separation' method provides the advantage of reducing complexity and the likelihood of human error during installation and maintenance.

Proof-testing

Level gauges used in a safety instrumented system must be periodically proof-tested to ensure that they will function properly when a safety demand occurs.

These tests have traditionally been carried out by technicians in the field and verified by a worker in the control room. This time-consuming and labour-intensive method can involve workers having to climb tanks to access the instruments, putting their safety at risk.

However, new technology within the latest radar level gauges now enables operators to undertake proof-testing remotely by inputting a straightforward sequence of settings and commands from their interface in the control room.

This eliminates the need for workers to climb tanks and/or be exposed to tank contents, and thereby provides significant benefits in terms of reducing risk, saving time and improving efficiency. ■