



# RADAR PROVIDES PRECISE LEVEL MEASUREMENT IN LNG TANK GAUGING SYSTEMS

*Håkan Jubel explains how the latest non-contacting radar level gauges meet the various challenges associated with accurately and reliably determining the level of LNG in full containment tanks*



**F**ull containment tanks for storing LNG are large and complex structures with a typical capacity of up to 200,000 m<sup>3</sup>. They include an inner liquid containment steel tank, an outer concrete (or steel) tank for secondary containment control, and thermal insulation between the two to minimise liquid boil-off.

The planning, design and construction of such technically advanced tanks requires significant investment, and payback times can be lengthy. For this reason, tank farm operators need to implement accurate and reliable tank gauging systems that will help to minimise operating and maintenance costs, thereby enabling a quicker return on investment.

Level and temperature measurement technology forms a key part of tank gauging systems for LNG vessels. Obtaining reliable and precise measurements of the liquid level inside each tank is essential for inventory management and custody transfer purposes. Level and temperature are also measured for safety purposes, to prevent overfills. By monitoring level and insulation space temperature, it is also possible to identify leaks, helping to prevent product loss and potential safety incidents. Early detection of overfills and detecting leaks is also important in avoiding environmental incidents.

## MEASUREMENT CHALLENGES

Determining the level and temperature of LNG in full containment tanks presents various challenges for measurement technology. Because these tanks are so large, with the required measurement range often over 40 metres (131 feet), this makes accuracy difficult to achieve. Also, these closed tanks are not opened during operation, and instruments are normally not accessed for maintenance purposes during their entire lifecycle. This makes it crucial for measurement technology to be reliable, and redundant level measurements are often vital within these applications.

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

## TRADITIONAL METHODS OF MEASUREMENT

Level measurement in LNG applications has traditionally been performed using either a float and tape or via servo technology. In the former method, a large float inside the tank is connected to a spring motor and a 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.

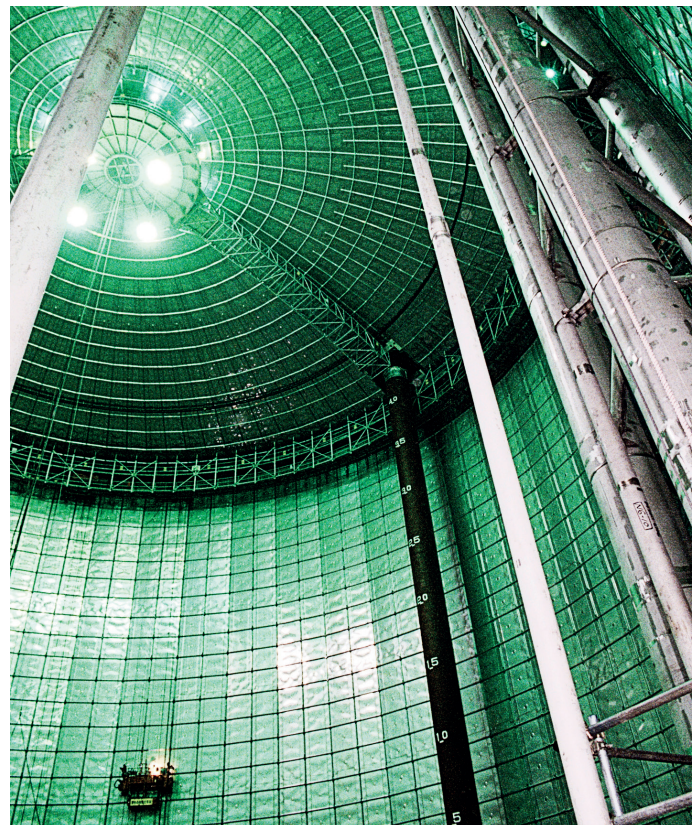


Figure 1. Inside a full containment tank.

In 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. 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. An electronic transmitter sends the level information to the control room using fieldbus communications.

Although these methods are still widely used, they have major shortcomings. The accuracy of a float gauge is often poor. There are plenty of error sources, such as buoyancy differences, dead-band, backlash and hysteresis in the mechanisms. If anything goes wrong with the float, the

tape or the guide wires, service work must be carried out inside the tank. The float gauge is a relatively simple device, but it has many moving parts that will require maintenance and repair over its lifetime. Servo gauges generally perform better than float gauges, but they also have many moving parts. Because the displacer and the wire are in contact with the tank liquid, servo gauges may require more attention for calibration, routine maintenance and repair. The modern approach involves using top-down non-contacting radar level gauges to provide precise measurement, and this has become the world's fastest growing tank gauging technology in LNG applications.

**NON-CONTACTING RADAR**

Non-contacting radar gauges are used to provide accurate and reliable level measurements in a broad range of challenging applications. Temperature variations, dust and pressure changes do not affect the accuracy of this technology, and because these devices are non-contacting, they are suitable for use in vessels with agitators as well as tanks containing viscous, sticky or abrasive fluids.

To reliably measure the level in an LNG tank, a radar gauge needs a sufficiently strong echo from the LNG surface. The latest devices use two-wire Frequency Modulated Continuous Wave (FMCW) technology that optimises their radar signal strength and produces a more robust and reliable measurement. With LNG applications, a 4-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 0.5 millimetres (0.020 inches) instrument accuracy. Using a precise radar level gauge can deliver a 180% reduction in volume uncertainty over traditional methods.

The long measuring distance required in full containment LNG 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.

Non-contacting radar level gauges are ideal for use in LNG tanks because their electronics are housed within the transmitter head, located outside the vessel. In addition, a specific antenna option can be employed to enable it to function in such an extreme environment. These gauges can boast impressive reliability, with mean time between failures for critical parts measured in decades. In addition, their design minimises maintenance requirements because they have no moving parts and do not touch the liquid.

**TEMPERATURE MONITORING**

Non-contacting radar level gauges are integrated into high-performance LNG tank gauging systems that also include devices to monitor tank

Figure 2. A typical radar-based LNG tank gauging system

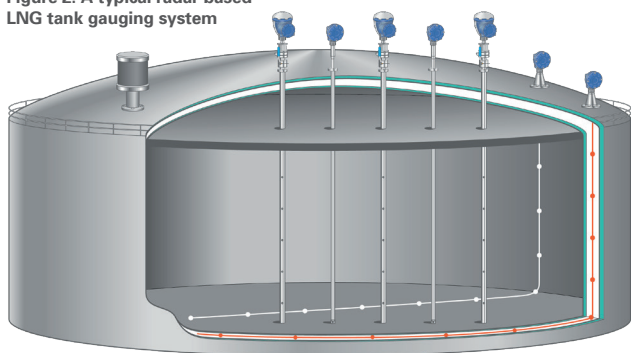


Figure 3. Rosemount 5900S Radar Level Gauge with LNG antenna

temperature and density profiles to detect stratification. This occurs when two separate layers of LNG are formed within a tank and can potentially lead to a dangerous condition called 'roll-over', which can result in an instantaneous release of boil-off vapour.

Additional temperature measurements monitor the cool-down process and support leak detection. Both functions are achieved by using multiple temperature sensor elements. 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).

**DIVERSE AND IDENTICAL SEPARATION**

The safety functions provided by tank gauging technology are critical in LNG applications. It is common practice for applications involving full containment tanks to install three level gauges – primary and secondary gauges supporting the basic process control system (BPCS), and a third providing information for the overfill prevention system (OPS). The safety instrumented system (SIS) may integrate input from all three gauges in a setup where SIS alarms are triggered on a two-out-of-three voting scheme.

There is a misconception that standards require the technology used for the OPS to be different from the technology used for the BPCS, e.g. radar and servo technology. This is typically referred to as diverse separation. However, it is confirmed within the IEC 61511-2 standard, which provides best safety practices for the implementation of a modern safety instrumented system, that it is legitimate to use the same technology for both. This is known as identical separation, and IEC 61511-2 states that this method 'may have some advantages in design and maintenance because it reduces the likelihood of maintenance errors.'

Diverse and identical separation are both valid options. However, diverse separation introduces extra complexity and increases the likelihood of human error, as personnel need to learn about installing, configuring and proof-testing two different technologies rather than just one. There is a growing insight that reducing maintenance and similar 'handling errors' is critical – by some estimates, 75% of industrial accidents are traceable to organisational and human factors. In this context, the Buncefield oil storage terminal fire in 2005 provides a case in point. Buncefield had redundant and diverse technology for overfill protection, but the high-level alarm was inoperable due to human error. It had been taken offline for testing and had not been reinstalled correctly, so it was not functioning.

**PROOF-TESTING**

Certain vendors claim that proof-tests are not required and that the use of 'self-tests and diagnostics' is sufficient. However, such claims are incorrect. Level gauges used in a SIS must be periodically proof-tested to ensure that they will function properly when a 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 method can involve workers having to climb tanks to access the instruments, putting their safety at risk. However, the latest devices enable proof-tests to be performed remotely from the control room, thereby making the procedure safer, faster and more efficient.

**SUMMARY**

With LNG being stored in large, full containment tanks that remain closed during operation and are not normally accessed for maintenance purposes, tank gauging systems must be able to deliver reliable and accurate level measurement throughout the entire service life of the tank. Solutions based on the latest non-contacting radar technology offer a range of benefits compared to float and tape or servo technology methods. Radar technology provides highly accurate, reliable and robust measurements at long range, helping to ensure safety and to deliver a faster return on investment by minimising operating and maintenance costs.

**FOR MORE INFORMATION**

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