

Half full or half empty?

Hans Westerlind, Emerson Process Management, Sweden, discusses how tank gauging innovations can improve LNG terminal efficiency and safety.

Newly developed technology for tank gauging can help LNG plants and terminals handle the ever-increasing demands on efficiency, safety and accuracy. An open system architecture makes it easy to install the devices needed today and add or replace units in the future. This flexibility protects users' investments so that storage facilities can maintain their efficiency. Additional benefits include lower installation costs, high accuracy and built-in safety functions. One feature with substantial potential for cost savings is wireless transmission of measurement values. This enables high precision tank gauging data to be made available anywhere on the plant at a much smaller cost than before.

Functions and operational requirements

A modern automatic tank gauging (ATG) system for LNG tanks is an integrated high performance measuring and calculation system. The data is used for a number of operations handled via a human-machine interface (HMI) adapted for LNG storage including:

- Monitoring of tank filling/emptying, including overflow prevention.
- Input for inventory management to calculate a storage tank's net content.
- Check of transfer operations, including comparison with ship measured values serving as a basis for custody transfer.
- Skin temperature monitoring.
- Monitoring of density profile to prevent rollovers.

In addition, historical data trends and printed reports should be provided for follow up and documentation.

Although data from the tank gauging systems on LNG onshore tanks is not normally used for custody transfers, it is still important reference data. It can be used for checking the accuracy of the custody transfer calculations, based on data from an LNG tanker ship. A precise calculation of net volumes is also the key for

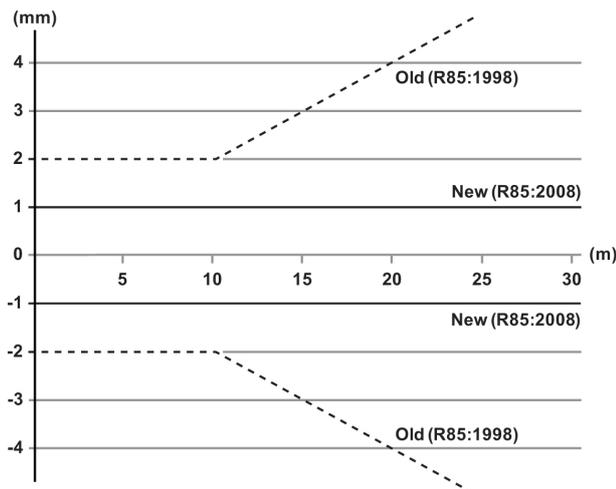


Figure 1. Latest OIML level accuracy requirement under reference conditions.

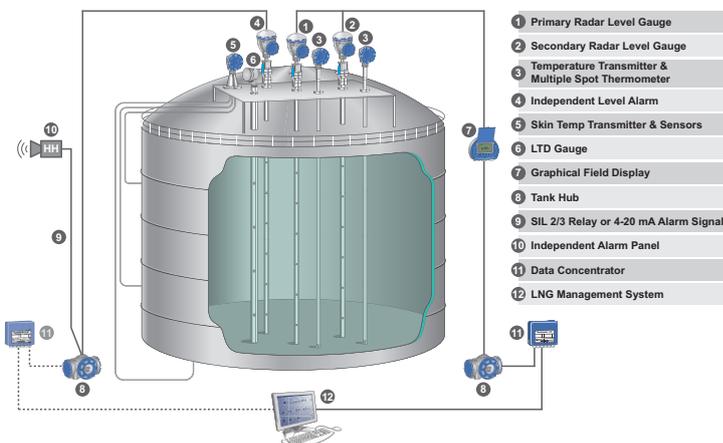


Figure 2. Example of a high performance LNG tank gauging system.

useful inventory data required for both internal accounting purposes and external taxation.

For inventory and transfer measurement purposes, errors and uncertainty in net volume measurement can obviously have large economic implications when the volume is transferred to derived quantities, such as economic value. Depending on the number of transfers, this can add up to a value of several tens of thousands of US Dollars for one tank during one year of operation.

In order to be certain of the performance of the level gauges, a vendor can use a system certified according to a recognised legal metrology standard, such as the OIML standard (Organisation International Metrologie Legal). The performance stipulated in the OIML standard is approximately 1 mm level accuracy under reference conditions, and 2 mm installed accuracy, which is well within the accepted industry requirements for LNG tanks.

System configuration

A typical radar based LNG tank gauging system with a configuration focusing on ultra high reliability combined with high measuring performance can have the following main components:

- A primary high precision radar gauge for level measurement.
- A secondary high precision radar gauge for level measurement.
- Two temperature transmitters, each with up to 16 spot temperature sensors for average liquid temperature measurement.
- A third radar gauge allocated for independent high level alarm. The gauge gives output to an alarm panel via SIL 2/3 rated relay signals.
- Transmitters and temperature elements for skin temperature measurement.
- Separate gauge for temperature and density profiling.
- Graphical field display.
- 'Tank hubs' for data collection from field instruments and transmitting data to the control room area.
- Data concentrators in the control room area for providing data to DCS systems, other HMI systems and communication with general IT systems.
- LNG management software for operator interface and reports. The workstations are configured in network for data distribution and increased redundancy.

The radar level gauge antenna for LNG is designed for measurements on cryogenic liquefied gas. Radar signals are transmitted inside a 4 in. still-pipe, which enables the gauge to have a sufficiently strong echo even under surface boiling conditions. The tank seal is equipped with a double block function, consisting of a quartz/ceramic window and a fire-proof ball valve. A reference device function enables measurement verification with the tank in service.

Open and scalable architecture

One way to implement a flexible tank gauging system architecture is to build the system around a digital 2-wire Tankbus, connecting all measuring devices to a 'tank hub', normally located at the tank foot. From the tank hub, a fieldbus, often Modbus

based, is used to transmit data to the control room. Building the Tankbus based on an open industry standard, like Foundation fieldbus, will allow integration of any device supporting this communication protocol. The fact that the devices are self configuring will make startup easy, as no special knowledge of Foundation fieldbus devices is required. One system can include a wide range of components to build a small or large customised tank gauging system. The modular design allows the system to be expanded/upgraded and suited to future changes in requirements on performance and system scope.

Designing the instrumentation for low power consumption enables the 2-wire Tankbus to be made intrinsically safe. It can also be used to power the connected devices from the tank hub. This solution has several advantages, including the following:

- It is safer, both at system start-up, and in operation.
- Installation is quicker and easier due to less cabling.
- No expensive cable conduits are required.

Driving safety technology forward

Throughout the storage industry, overfill prevention is a key aspect of safe and reliable tank operations. At the same time, level measurement has often been considered as one of the most difficult and unreliable measurements. Obsolete practices and equipment have contributed to the problem. For example, outdated mechanical gauges and indirect measurement methods are often used as the primary level measurement, and a mechanical switch is sometimes used as a high-level alarm. These older gauging methods generally have a high failure rate.

Modern technologies, such as radar, have the capacity to eliminate most of the problems associated with these older systems. Besides offering better accuracy, they can also provide internal diagnostics that can be used for predictive maintenance. The ultimate goal is to increase reliability and availability, thereby reducing the risk for overfills and improving reliability. The tank gauging community has been at the forefront of introducing these new overfill prevention technologies for most types of bulk storage plants, including LNG terminals.

There has been increased focus on overfill prevention in the general bulk liquid storage industry because of some recent accidents, such as the Buncefield incident in South East England in 2005. As a consequence, terminal owners are implementing the most modern and safest practices available. A high-quality level gauge plus an independent overfill prevention system is now becoming an essential purchase for progressive tank owners. The tank gauging industry has plenty of experience and has established best practices for selection of the primary level gauge. But due to experiences from recent accidents, new technologies and equipment cost reductions, previous best practices for the high-level alarm are being questioned. The trend is rapidly

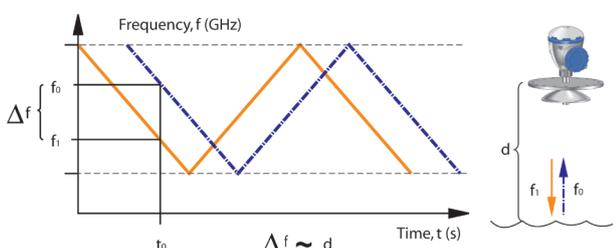


Figure 3. The FMCW method.

changing from using a simple switch into following more refined requirements for high-level alarm functionality, including:

- Independent measurement, separate wiring and preferably UPS-backed.
- Continuous measurement simplifying gauge verification for the high level alarm sensor. Failure to track the level can immediately disclose device malfunction.
- Non-contacting device with as few movable parts as possible (ideally none) that can stick, wear out or require maintenance.
- Safety Integrity Level (SIL) certification per IEC61508, or capability to be upgraded to SIL status, makes the device future-proof (although not necessarily already integrated into a safety instrumented system). The certification also provides failure data, ensures the device is designed to be fail safe and acts as a quality stamp. New devices fulfilling these requirements have emerged.

The American Petroleum Institute (API) has recently updated its API 2350 overfill prevention standard. It has taken a more holistic approach that encourages the use of modern IEC 61508 certified safety equipment. Although the scope of this standard does not cover liquefied gas such as LNG, it is likely to influence the entire storage industry because of the lack of alternative formal guidelines. The new API 2350 is the most current and relevant standard for overfill preventions and it is relevant in a global perspective. Compared to the previous edition, the new API 2350 standard puts emphasis on management systems (Overfill Prevention Process or OPP) and risk assessment systems. Both of these concepts can be applied at LNG plants with similar methodology as used in other petroleum industry tank storage facilities.

A recent innovation with the potential of improving system redundancy and tank gauging reliability is the inclusion of two independent electronics packages integrated into one radar transmitter head – a two-in-one solution. This makes it possible to install one device, and get one primary plus one backup unit, or one primary level gauge plus an independent radar based high-level alarm unit connected to an emergency shutdown system, which can be certified according to SIL 3 requirements. Compared to having two separate gauges with the same functionality, the two-in-one solution makes mechanical and electrical installation easier and less costly.

Radar level gauging for reduced downtime

Since radar level gauges provide high reliability with no moving parts, and only the antenna/probe is inside the tank, they have become widely used both for high accuracy tank gauging in storage tanks and process level measurement.

The radar level gauge/transmitter measures the distance to the surface of the product. Using tank distances stored locally in the memory of the gauge, it calculates the level of the liquid's surface. The radar gauge/transmitter consists of a transmitter head and an antenna. The transmitter head can be combined with any antenna type in the same gauge series, minimising spare parts requirements. No matching of transmitter head and antenna is required, which means the transmitter head can easily be replaced without opening the tank. For radar level measurement, there are two main modulation techniques used today:

- Pulse method.
- Frequency Modulated Continuous Wave (FMCW).

Using the pulse method means that the radar transmitter measures the time it takes for a pulse to travel to the surface and back. The time difference is converted to a distance, from which the level is calculated. The Time Domain Reflectometry (TDR) technology is a special case, when a low power nano-second pulse is guided down a probe towards the process media surface, where it is reflected back. The FMCW method is used by high performance radar level gauges to enable real custody transfer accuracy. Applications range from light products to asphalt. The method has gained a wide acceptance both for shore based LNG tanks and LNG carrying ships. The radar gauge transmits microwaves towards the surface of the liquid. The microwave signal has a linear frequency variation. When the signal has travelled down to the liquid surface and back to the antenna, it is mixed with the signal that is being transmitted at that moment. The reflection from the liquid surface has a slightly different frequency compared with the signal transmitted from the antenna when the reflection is received. The difference in frequency is measured, and it is directly proportional to the distance to the liquid surface. This technology can provide a measured value with high accuracy. The gauges in a high end tank gauging



Figure 4. Two independent radar units in one housing.

system must also be suitable for all climate zones with a wide ambient temperature range.

Smart wireless tank gauging

Many tank storage facilities that would benefit from modern, non-contacting gauging have obsolete or non-existing signal wiring from the tank storage area. Retrofitting the gauging system in such plants is normally expensive and time consuming as the distance between storage tanks and the control room can be more than 1 km, requiring extensive trenching and cabling. As a result of budget restrictions, some plants therefore continue to experience maintenance problems by keeping low performing mechanical tank gauges. Now, with innovative wireless technology, installation of a new radar based tank gauging system can be done without any new long distance signal wiring. This will reduce material and labour cost, as well as engineering and project execution time. By connecting a wireless adapter to the tank gauging system, complete tank inventory data can be sent to the control room via WirelessHART communication. **LNG**