Tank gauging innovations improve LNG terminal efficiency and safety

Newly developed technology for tank gauging can help LNG facilities 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 become and stay efficient. Additional benefits include lower installation costs, high accuracy and built-in safety functions. One feature with substantial potential for savings is the 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

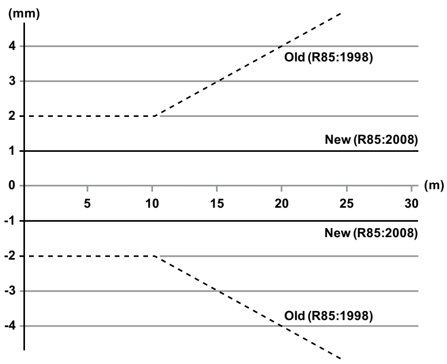
A modern automatic tank gauging (ATG) system for LNG tanks is an integrated high performance measuring and calculation system. The data is used for a number of operations handled via a human-machine interface (HMI) adapted for LNG storage:

- Monitoring of tank filling/emptying including overfill prevention
- Input for inventory management to calculate storage tanks 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.

Also reliable level, temperature and density alarm functionality is essential from a safety and efficiency point of view. In addition, historical data trends and printed reports should be provided for follow-up and documentation.

Although data from the tank gauging system on LNG onshore tanks are not normally used for custody transfer they are still important reference data. They can be used for checking the accuracy of the custody transfer calculations made based on data from an LNG tanker ship. A precise calculation of net volumes is also the key for 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 amount 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 recognized legal metrology standard such as for example the OIML standard (OIML = 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:

- One primary high precision radar gauge for level measurement.
- One secondary high precision radar gauge for level measurement
- Two (2) 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 inch 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

High precision LNG radar tank gauge

tank foot. From the tank hub, a fieldbus, often Modbus based, is used to transmit data to the control room. By making the Tankbus based on an open industry standard, like Foundation fieldbus, it will allow integration of any device supporting this communication protocol. By making the devices self configuring, startup will be easy requiring no special knowledge of Foundation fieldbus devices. One system can include a wide range of components to build a small or large customized tank gauging system. Due to the modular design, a system can later easily be expanded/upgraded and suited to future changes in requirements on performance and system scope.

By designing the instrumentation for low power consumption the 2-wire Tankbus can be made intrinsically safe and be used to power the connected devices from the tank hub. This solution has several advantages:

- 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. But at the same time, level measurement has often been considered as one of the most difficult and unreliable measurements. Obsolete practices and equipment has contributed to the problem. For example, outdated mechanical gauges and indirect measurement methods are often used as the primary level measurement. Maybe a mechanical switch is used as a high-level alarm. These older type of gauging methods generally have a high failure rate.

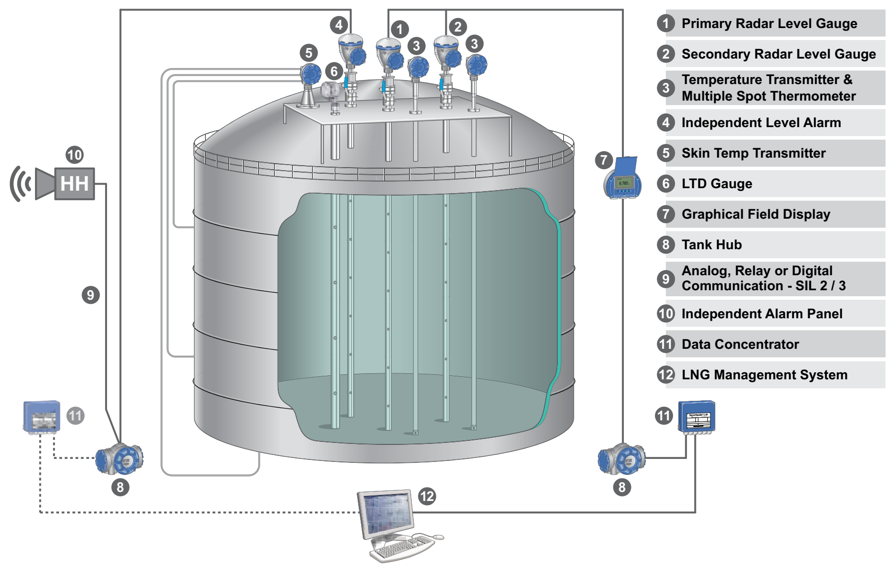
Modern level technologies like radar have the capacity to eliminate most of the problems associated with these older type systems. Besides offering better accuracy, they can also give internal diagnostics that can be used for predictive maintenance. The ultimate goal is of course to increase reliability and availability, thereby reducing the risk for overfills as well as getting reliable operations. 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.

One important driver for the focus on overfill prevention in the general bulk liquid storage industry is some recent accidents like the Buncefield incident in south east England in 2005. As a consequence terminal owners and owners are implementing the use of the most modern and safest practices available. High-quality level gauge plus an independent overfill prevention system is now becoming an essential given for progressive tank owners. The tank gauging industry has plenty of experience and established best practices for selection of the primary level gauge. But partially due to experiences from recent accidents, partially due to new technologies and equipment cost reductions, old best practices for the high-level alarm are being questioned. The trend is rapidly changing from using a simple switch into the following more refined requirements for high-level alarm functionality:

- Independent measurement, separate wiring and preferably UPS-backed.
- Continuous measurement simplifing gauge verification for the 'high 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 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.

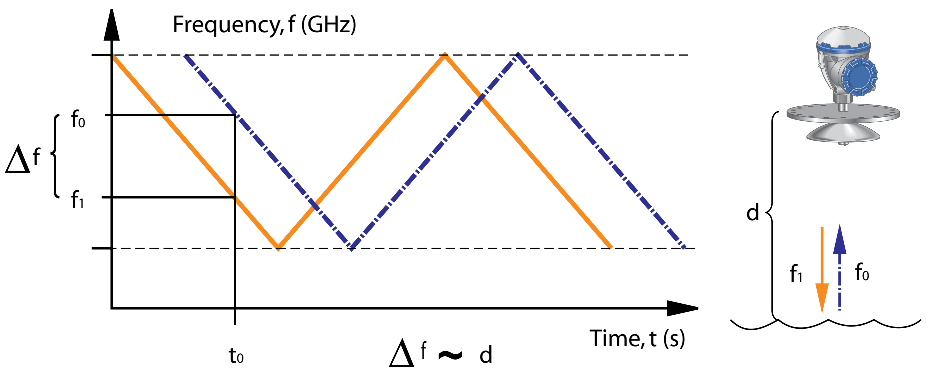
The American Petroleum Institute (API) has recently updated its API2350 overfill prevention standard to a more holistic approach that encourages the use of modern IEC 61508 certified safety equipment. Although the scope of this standard does not cover liquefied gas such as LNG, it is likely to influence the entire storage industry because of the lack of alternative formal guidelines. The new API 23650 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 system. 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



Example of high performance LNG tank gauging system

Tank gauging



The FMCW method

two independent electronics packages integrated into one radar transmitter head. 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-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, minimizing 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 mainly two modulation techniques used today:

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

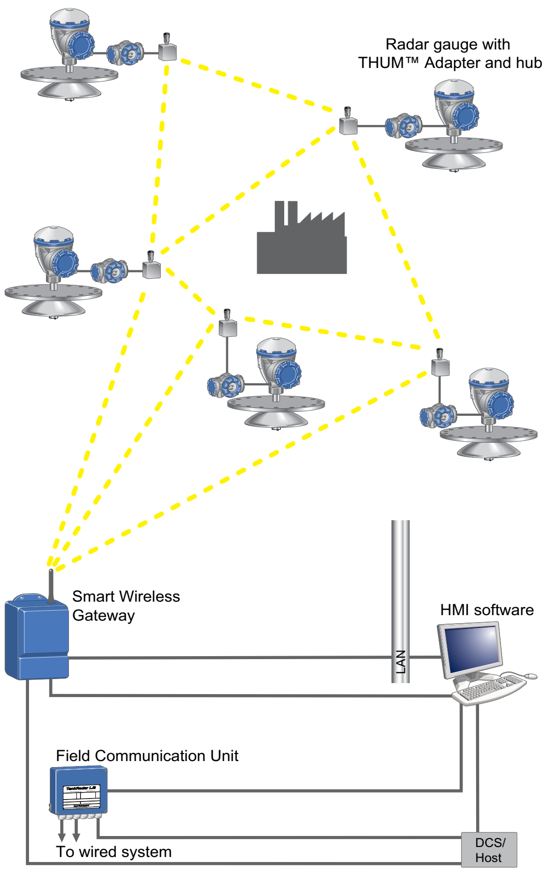
Using the pulse method means that the radar transmitter measures the time it takes for a pulse to travel to the surface and back. The time difference is converted to a distance, from which the level is calculated. The Time Domain Reflectometry (TDR) technology is a special case, when a low power nano-second 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 system must also be suitable for all climate zones with a wide ambient temperature range.

Two independent radar units in one housing

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. Retrofit of 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 one kilometer requiring extensive trenching and cabling. As a result of budget restrictions, some facilities 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 radically 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.

Wireless Tank Gauging



Tank gauges work as independent nodes securing data transfer in spite of mechanical obstacles