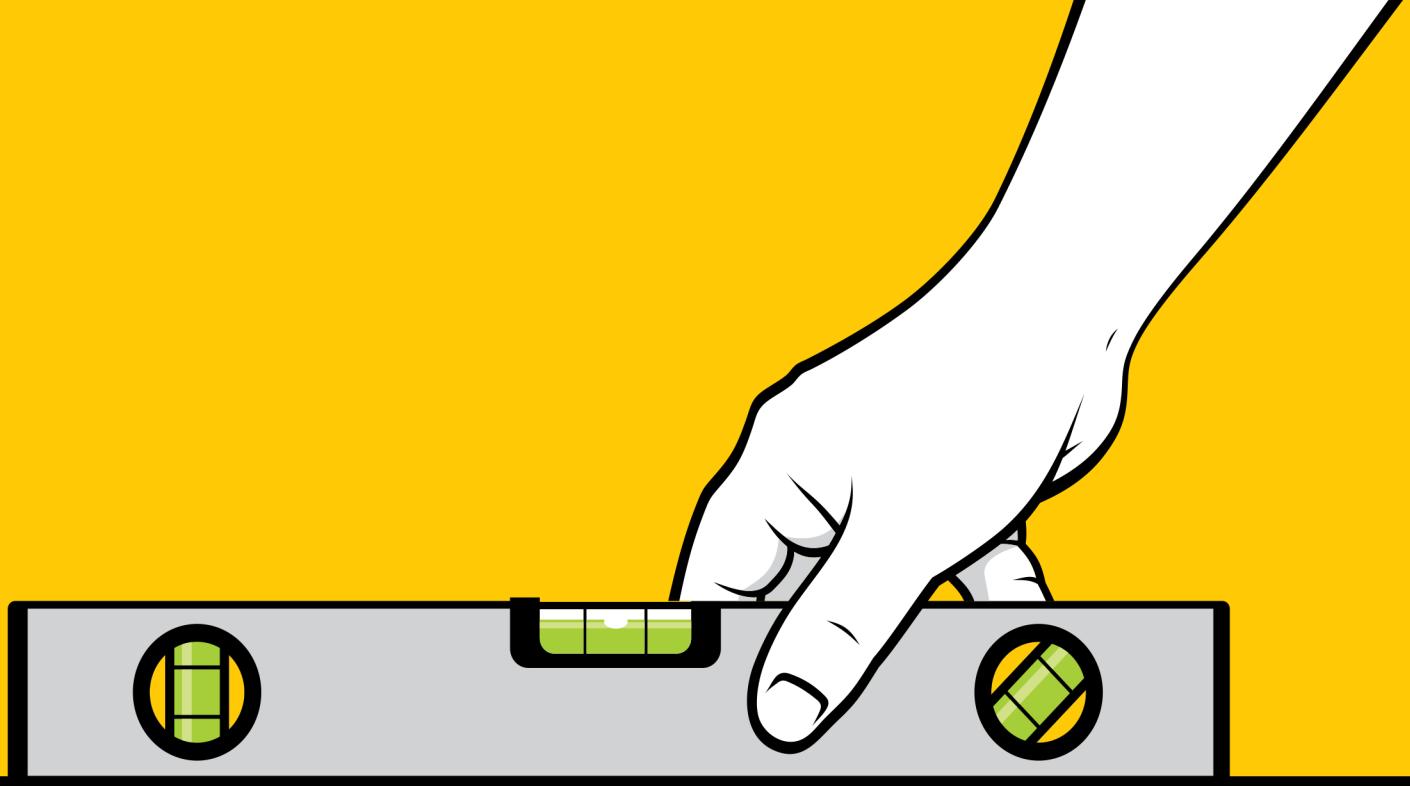

LEVEL MEASUREMENT: THE BASICS

Adam Wishall, Varec Inc., USA, outlines key points to consider when selecting the most suitable gauge for tank level measurement.

Level measurement, as it relates to oil and gas, petrochemicals and hydrocarbons, includes point and continuous level methods. With point level, instruments are used to detect whether a fluid is below or above a specific point. Typically, this method is used to prevent overfilling of the tank or dropping the level below a minimum threshold. Continuous level is designed to understand the amount of liquid within the tank to support general inventory or process control.

Tank gauging is often synonymous with the term 'level measurement' as these devices enable the level measurement process to take place. There are many tank gauging systems available, but no particular instrument or system should be chosen based on data specifications alone. Nor should the accuracy of a level-based system be the only specification when making business decisions. The investment of the system itself, and the associated costs of materials, labour and maintenance should be considered. The type of liquid in the tank, the measurement conditions and the tank itself are other factors to consider.

Tank gauges fall into the following categories: manual, float and tape, servo, and radar. Each of these will be discussed within this article.

Manual

Manual tank gauging is still commonplace today as a way of measuring level and to verify performance calibration. This technique uses graduated dip sticks or dip tapes.

Figure 1. A gauge board on a tank.

Benefits of this level measurement method include: extremely low instrumentation costs, no need for power, and ease of use.

However, skilled personnel are required to perform checks, and accuracy is not as high due to the potential for human errors. The gauge must also be on the top of the tank to take measurements, which results in potential exposure to product or fumes.

Float and tape

Also known as 'automatic tank gauges', float and tape gauges have been in the marketplace for nearly 90 years. This method works by using a large float inside the tank, attached to a negator spring via a perforated tape. The negator spring provides constant tension, which balances the float on the liquid. The perforated tape engages pins on a sprocket wheel that, in turn, drives the counter assembly. Alternatively, when a gauge board is used to display the level, the negator spring is replaced by a counterweight system. The liquid level in the tank is displayed on the gauge counter or indicated on the gauge board.

The cost of the device is moderate and its accuracy levels are high enough for most operations that do not need custody transfer accuracy. It is also extremely reliable and simple to use, and no power is required. The main drawback of this method is that occasional maintenance is necessary.

Float and tape transmitters vary in their capabilities and application, from simple indication of alarms, to level encoding and temperature measurement integration. Transmitters convert the measurement parameter to an electrical signal for transmission over an instrumentation field bus or communications loop. Most transmitters use an incremental or absolute encoder with brush, optical, magnetic, or capacitive sensors.

When connected to standalone float and tape gauges, transmitters do the following:

- Help visualise gauge data via the control room system.
- Integrate temperature to have multivariable measurement.
- Use standard net volume or mass calculations for accounting.
- Integrate gauge data into a programmable logic controller (PLC) or distributed control system (DCS).
- Integrate with multiple protocols, i.e. MODBUS, Biphase Mark, Mark/Space.

When used in combination with advanced gauging technologies, transmitters can:

- Provide redundancy and back-up level measurement, with a local mechanical level indication that does not require power.
- Add temperature in addition to the level measurement from both float and tape and radar gauges.
- Integrate with multiple protocols, i.e. MODBUS, Biphase Mark, Mark/Space.

Servo

Servo gauges are electromechanical gauges that use a small displacer instead of a float. The displacer has buoyancy, but it does not float on the liquid. It must be suspended by a thin wire that is connected to the servo gauge on top of the tank. The weight of the displacer is balanced against a magnetic coupling and the wire drum of the servo unit. The signal, an indication of the position of the displacer, is sent to the motor's control circuit. As the liquid level rises and falls, the position of the displacer is automatically adjusted by the drive motor. An electronic transmitter sends the level information over a field bus to the control room.

Benefits of this level measurement method include: a high level of accuracy; it can provide other variables in addition to level (i.e. spot density or multi-spot density profile, up to three liquid interfaces, water level and the tank bottom); and only occasional maintenance should be necessary. This method is a preferred solution for clean, refined liquids, such as gasoline, jet fuel, kerosene, chemicals, LNG, etc.

Drawbacks of this level measurement method include: it is the most expensive type of gauge on the market; it requires power; communications must be at the top of the tank; and it typically requires a stilling well. Also, maintenance and calibration activities must be on the top of the tank where there is potential exposure to the product or fumes.

Radar

Radar tank gauges have become very popular in the marketplace. They are a 'downward-looking' measuring system that must be installed on the roof of a tank. The gauges measure the distance from the reference point to the liquid surface. Radar impulses are emitted by an antenna, reflected off the product's surface and received

again by the radar system. The distance to the liquid surface is proportional to the travel time of the impulse or frequency shift of the transmitted signal. Due to the nature of the microwave, radar tank gauges need to be equipped with functions to suppress interference echoes (such as from edges and weld seams) in the tank so they are not interpreted as level measurement.

Benefits of this level measurement method include: it provides a high level of accuracy; no maintenance is needed aside from occasional cleaning; there is no direct contact with the liquid; and it is complementary for a wide variety of liquids, including heavy asphalt and crude oil.

Drawbacks include: high costs in high accuracy applications; the method only provides level measurement; power is required; communication must be at the top of the tank; performance is impacted by placement (i.e. it must be installed perfectly level and not be too close to the tank wall); maintenance and calibration activities must be on the top of the tank; and there is potential exposure to product or fumes when on top of the tank. This method is not recommended for all products, such as those with a low dielectric constant.

The importance of tank type

There are several common storage tanks for bulk liquids and, depending on the tank type or mounting options, a particular tank gauge or measurement solution may be more suitable. Tanks are chosen according to the flash point of liquid stored. Generally speaking, in refineries, tank farms and terminals, aboveground fixed roof tanks or floating roof tanks are predominant.

Fixed roof tanks

Fixed (cone, dome or umbrella) roof tanks are the most common and identifiable bulk storage tanks. They range in sizes up to 98 ft (30 m) tall x 328 ft (100 m) wide and are used to store liquids with very high flash points, such as fuel oil, heavy oil, kerosene, diesel oil, water, bitumen, etc. The addition of a fixed roof reduces environmental emissions and provides additional strength to allow slightly higher storage pressures than that of atmosphere.

Float and tape gauges can be installed on the tank side or on the roof of this kind of tank. Servo and radar gauges must be installed on the tank roof.

Floating roof tanks

Some storage tanks need a floating roof in addition to, or in lieu of, the fixed roof. A sealing device is installed on the peripheral space between the roof and shell plate, which acts as a safety and pollution prevention device by trapping the vapour from low flashpoint products. Floating roof tanks are broadly divided into internal floating roof (IFR) and external floating roof (EFR) tanks. IFR tanks are used for liquids with low flashpoints (such as gasoline, ethanol, etc.), while EFR tanks are suitable for medium flash point liquids (such as naphtha, kerosene, diesel, crude oil, etc.).

Float and tape gauges commonly use a pan/well inside the floating roof. Servo and radar gauges require a gauging platform to mount the gauge over the product. Many platforms provide a stilling well as a stable and calm surface to enable accurate measurements.

Sphere and bullet tanks

Flat-bottomed, cylindrical or spherical storage tanks are used to store liquefied gases with very low flash points (LNG, LPG, ethylene, butane and ammonia) under pressure or at temperatures under -148°F (-100°C). Bullet tanks are long, cylindrical tanks with round or flat ends that are prefabricated and installed horizontally or vertically. Most often, they store products that support facility operations, such as additives for injection, fuels to run refinery processes or byproducts, such as transmix from terminal product receipts. Bullet tanks can also store liquefied gases under pressure.

Radar, servo or magnetostrictive technologies are ideal for these tanks due to their size and the products stored.

Underground storage tanks

Underground storage tanks are commonly used to store petroleum-based products. They are regulated to prevent the release of petroleum and contamination of groundwater. In the US, they are primarily used at automobile filling stations, but can also be found at military bases, airports and tank farms.

Gauge sticks, tank level sensors or magnetostrictive probes are commonly used with these tanks.

Going beyond level measurement

Requirements for the management of bulk liquids are unique for each organisation that operates a storage facility. Level measurement is likely only one factor in the equation. There are four key areas that should be considered to understand operational needs.

Inventory or custody transfer

Inventory control describes the management of liquid inventories that generally do not change ownership when moved or used. Custody transfer implies that two or more parties have an agreed system for accurately measuring the amount of product transferred. Tank gauging systems may be selected based on accuracy, repeatability or the ability to perform multiple measurements, and can vary significantly in cost. It is important to understand what type of level measurement is actually required.

Product movements and operations

Facility operators use logistics processes to plan daily activities. As such, instrument viability and repeatability is often more important than absolute accuracy. It may be necessary to have complete integration and functionality to view and track all product movement totals and discrepancies, as well as the ability to have supervisory control of pumps and valves. Ideally, the data collected through the tank gauges should feed into a centralised inventory management system. These systems tend to be out-of-the-box and are, therefore, more cost-effective. However, with custom programming, a PLC or DCS can also be used.

With an inventory management system, facilities can also establish alarm limits based on their reaction time to

Figure 2. A petrochemical tank farm.

track data – in real time, while notifications happen at the control panel. This process enables operations to increase the maximum flow rate and increase the amount of inventory to sell by effectively gaining more storage space in the tank while still ensuring safety.

Accounting and reconciliation

It is critical for facilities to have timely and accurate level measurement, and accounting of the products stored in tanks. This means that facility operators must correctly report the volume stored, received, issued, transferred and moved. Some tank farms require management of commingled inventory and reporting by the product owner. Managing gains or losses within industry standard percentages on a daily, weekly and monthly basis is also extremely important. Accounting and reconciliation solutions, including inventory ledgers by product and owner, meter reconciliation, physical inventory reconciliation, and reporting tools, are highly recommended. The ideal solution should also allow users to review trends and take appropriate actions.

Environmental compliance

Programmes and regulations relating to overfills, leaks and emissions of environmentally damaging products are now in place and must be adhered to by facilities. Bulk storage facilities typically desire a solution that can integrate with instruments that are already installed to provide and manage alarms that help detect leaks. This can be accomplished using an inventory management system or custom PLC programming.

Conclusion

Whether a company is looking for a better way to track and measure bulk liquid assets, enhance automated processes, increase process control, streamline inventory accounting and reconciliation, or improve safety regulations within a tank farm, level measurement is the place to start. An accurate level measurement system is at the core for building more efficient operational processes in tank farms and terminals.

This article is not intended to answer every question, but rather provide an overview on level measurement and the impact on managing bulk liquids. Organisations are encouraged to complete their own due diligence.