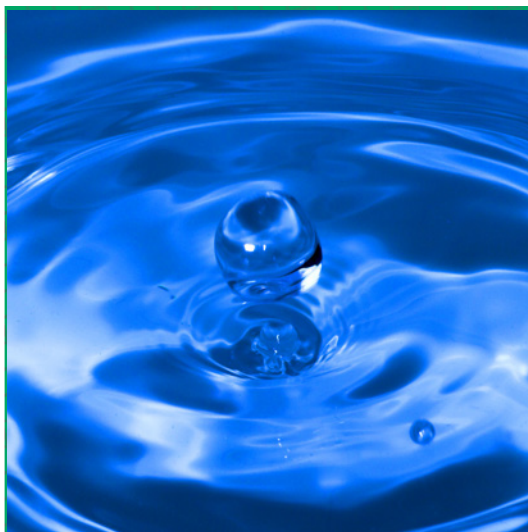

Optimising Level Measurement Performance in Underground Tank Installations

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Storage tanks are often buried underground to insulate their contents from very low ambient temperatures, however the problems of condensation, ice formation and low viscosity media often compromise the accuracy of level measurements. Ingemar Serneby, Senior Application Specialist at Emerson Process Management explains how the correct selection and installation of radar devices will minimise these problems to give the best measurement accuracy.

Underground storage tanks are used in many different industries and are very common in the upstream oil and gas facilities, particularly those operating in colder regions. They are installed below ground to insulate their contents from very low ambient temperatures and are often buried up to 1.5m deep. The purpose of these tanks is the same as for their above ground counterparts, functioning as flare knockout tanks, drainage tanks and separators. The tanks are used to store oil, water, natural gas liquids, and mixtures of hydrocarbons and water.

Typically these applications are based around a horizontal bullet tank of 2-3 metres diameter with two nozzles 75-100 mm diameter and approximately 2-3 metres tall. Access to the tanks to measure temperature and/or level is provided by the nozzles or a stilling well with an entrance that sits above ground. One nozzle is typically used for temperature monitoring and another for level measurements, which can be performed by either a continuous or single point measurement, or using a hand-dipping method.

Challenges

Condensation is often a problem with underground tanks. Although the storage conditions are usually stable, the contents may enter the tank at a higher temperature and will cool over time to match the storage conditions. As the contents cool, condensation forms on the coldest parts of the tank, which are usually the stilling well or nozzles where the instruments are installed. If the ambient temperatures are low enough, ice will form, which could affect the accuracy and reliability of the level measurements. Low temperatures also increase the viscosity of the contents causing coating and build-up on wetted surfaces as the level rises and falls.

Because access to underground tanks is from the surface using a nozzle or stilling well, only top-down level technologies such as mechanical level gauges or radar based instruments (guided wave or non-contacting) can be used.

Choosing the Right Technology

The traditional approach to measuring level is hand dipping. However, obtaining accurate results can be particularly difficult when the operators are exposed to cold weather, wet or snowy conditions, lightning and high winds. Access may be restricted during these times and also during the hours of darkness. In addition, the need to wear gloves and other protective equipment makes it more difficult for dipping equipment to be used. There is also the possibility of measurements being incorrectly taken or erroneously recorded due to human error.

To provide continuous measurements, some underground tanks have been fitted with a mechanical level gauge. However, these are prone to problems due to sticking caused by coating and the build-up of condensation and ice. The presence of moving parts also means there is a need for regular maintenance or renewal.

Radar technology provides an accurate, versatile and reliable alternative to hand-dipping and mechanical devices for level measurement applications. There are no moving parts to wear or stick and radar devices (particularly guided wave radar) are less sensitive to condensation and the formation of ice. Measurement accuracy is independent of product properties and their integrated probe and transmitter construction means they are virtually maintenance free. However, choosing and installing the correct type of radar is crucial to achieve the desired measurement accuracy for individual applications.

Guided wave radar (GWR) and non-contacting radar (NCR) are both top down, direct measurement technologies that measure the distance to the surface. Whereas GWR radar uses a probe to 'guide' the radar to the surface, non-contacting radar uses an antenna to transmit the signal through the vapour space.

With radar-based technologies, the dielectric constant of the media is a key indicator of the strength of signal that will be reflected back to the gauge. Underground tanks often contain products that have a low dielectric constant, such as hydrocarbons. To improve the maximum measuring range in these materials, technologies are available that provide accurate level measurements even when the returning signal strength is weak.

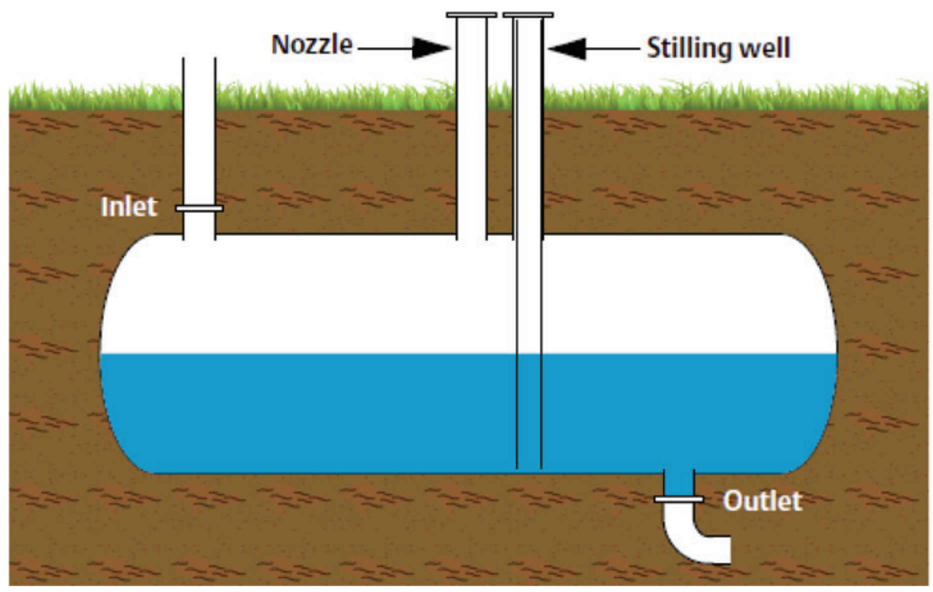

Figure 1. Underground tank with a tall nozzle and a stilling well

Both GWR and NCR can be applied to underground applications. As a general guide, GWR is preferred when an oil/water interface measurement is required. GWR is also a better option where condensation is present or the product to be measured has a very low dielectric constant (< 1.9) or a turbulent surface. For many applications, GWR will typically provide greater accuracy than NCR.

NCR is a better option for tanks with a long nozzle where a viscous product can cause heavy coating/build-up on wetted parts such as the probe of a GWR. However, it is important to note that NCR may need air purging to cope with condensation related issues. Cone antennas must be used and the antenna size should closely match the nozzle or stilling well pipe diameter.

When installing either type of radar device in an underground tank with a cathodic protection system (used to reduce corrosion within the tank) the radar needs to be grounded. For locations where surges from lightning may be a problem, the use of a transient terminal block will provide electronic components with a higher degree of protection against transients.

Radar for use in Stilling Wells

Single rigid or flexible GWR probes may be used in stilling wells. For longer nozzles, a stilling well is sometimes required to screen out possible noise induced by the nozzle walls. Care should be taken to ensure that the probe does not touch the side walls of the stilling well. If the probe touches the wall, false reflections will create false level measurements. When used in metal stilling wells, single rigid probes offer a stronger return signal than when used in open applications. This makes them suitable for low dielectric and interface applications.

When using NCR in stilling wells the antenna should match the stilling well pipe size with the gap between the antenna and the pipe wall made as small as possible. Larger gaps may impact performance.

Summary

Radar technology provides an accurate, versatile and reliable means to measure level in underground tanks. Unlike mechanical level gauges, there are no moving parts to wear or stick. Measurement accuracy is independent of product properties and the integral probe-transmitter solution is virtually maintenance free. Radar devices, particularly guided wave radar, are less sensitive to the problems of condensation and ice formation. Non-contacting radar is a good option when viscous product can cause heavy coating/build-up on wetted parts.

Case History

A major oil refiner in Canada needed to automate the level management in its flare knockout tank to prevent overspill situations that could compromise plant safety. The company was using a mechanical float-based system, but this was proving unreliable because of the tendency of the oily water mix to coat the wetted parts. The unreliable instrumentation meant that to prevent an overfill situation and maintain plant safety, trucks were sent to empty the tanks sooner than was necessary - incurring additional operating costs.

The customer decided to install Emerson's Rosemount 5402 non-contacting radar on the existing stilling well and the antenna was trimmed to fit. One of the elements of setting up a radar unit for use in stilling wells is the need to compensate for the change in propagation speed of the signal which naturally occurs in pipes. The PC configuration tool - Radar Master automatically initiates this calculation when the user inputs the pipe's inside diameter, helping to optimise performance. The trending tools built into the software provide redundancy to the DCS trends and allowed the operators to focus more closely on the level readings corresponding to process events.

The accurate and reliable level measurements provided by the Rosemount non-contacting radar increased operator confidence in the level measurement, enabling the tanks to be utilised to their full capacity. This means that fewer trips (by operators) are required to empty the tanks. Overall operation and maintenance costs have been reduced by $10,000 per year.

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Liquid Level Switches Based on Tuning Fork Technologies Introduced

Endress+Hauser (Switzerland) releases Liquiphant FTL31 and FTL33 liquid level switches based on vibrating tuning fork technology. The sensors are excellent replacements for float switches or conductive, capacitance and optical sensors. The FTL31 is designed for the chemical, oil and gas and other Industries, while the FTL33 is more suited for use in the food and beverage, and pharmaceutical industries. Both sensors also work in areas where those measuring principles are not suitable due to conductivity, build-up, foam, turbulence, flow conditions or air bubbles.

A piezoelectric drive causes the tuning fork of the Liquiphant sensor to vibrate at its resonance frequency. When the tuning fork is immersed in a liquid; its frequency changes due to the change in density of the surrounding medium. The electronics system in the switch monitors the resonance frequency, and indicates whether the tuning fork is vibrating in air or is covered by liquid.

The level switches can be installed in any vertical or horizontal position in a vessel, pipe or tank. Foam formation, changing conductivity or density does not affect their function. Both level switches have an external function test feature and an LED indicator for on-site testing.

The Liquiphant FTL31 is suitable for use in tanks, vessels and pipes. It has a 316L stainless steel housing, works in process temperatures up to 302 ºF and pressures to 580 psi, and is unaffected by changes in ambient temperature. Leading applications include overfill prevention or pump dry-run protection in cleaning and filter systems, as well as in cooling and lubrication vessels.

The Liquiphant FTL33 meets food industry requirements with 3-A and EHEDG certificates. It designed to work in applications where CIP and SIP cleaning takes place, and has a stainless steel enclosure with optional IP69K protection. It can be used in storage tanks, mixing vessels and pipes where internal and external hygiene requirements are particularly stringent.CRN, EN10204-3.1 material certificate, and marine certifications are available.

Both sensors can have either a three-wire DC-PNP output or 2 wire ac/dc output when the liquid level reaches the switching point. Each device has two operating modes:

In maximum safety (MAX) mode, the device keeps the electronic switch closed as long as the liquid level is not touching the fork, as in overfill prevention applications.

In minimum safety (MIN) mode, the device keeps the electronic switch closed as long as the fork is immersed in liquid. This is useful in applications such as dry-run protection for pumps.

By choosing the correct operating mode, a user ensures the device switches in a safety manner even if the power supply is interrupted.

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The Next Quantum Leap for Gas Flow Measurement and Control

Bronkhorst (UK) has successfully supplied gas, liquid and vapour flow/pressure measurement and control instrumentation to numerous industries for over 34 years. This success, entirely based upon close collaboration with their customers, has resulted in countless industry-changing advances in both measurement technology and its implementation within continuous process improvement. The latest generation El-Flow Prestige thermal mass flow meters and controllers represents a truly ground-breaking shift in versatility and user-friendliness.

Whilst further technical details can be seen below, the principal customer benefits are based upon: further advances in flow-signal processing, highly stable flow control regime virtually impervious to process fluctuations, advanced control valve design, an on-board gas conversion model, significantly reduced power consumption, and a user configurable device with a multitude of additional features and benefits.

These benefits were developed in answer to the specific needs of industry to constantly improve both the technological and commercial basis upon which economic success is based. The close collaboration mentioned above highlighted very clear requirements to increase – yield, profitability, process stability, quality, flexibility, lifetime and MTBF. At the same time, these benefits would be required to decrease – waste, energy, re-work, inventory, cost, down-time and complexity. The Bronkhorst El-Flow Prestige has answered each and every one of these needs and a few more besides !

A fundamental corner-stone of the Bronkhorst ethos is constant improvement in all that we do and this dedication to excellence has, over many years, realised a number of world class innovations. Within the field of thermal mass flow measurement, Bronkhorst has applied its vast R&D capability to further technological advances based upon the following five core developments :

The sensor now benefits from the enhancement of the Differential Temperature Balancing technique whereby the two sensor windings are power regulated to the same temperature above the gas stream ambient. Upon flow, the difference in power between these two windings to maintain the same measured temperature is directly proportional to the mass flow. This technique, and the sensor design, provides significantly increased reproducibility, linearity within the calorimetric flow regime, insensitivity to humidity fluctuation and the eradication of signal fold-over upon flow saturation.

The PC-Board, whilst being completely re-designed for increased speed and processing power, also includes an on-board EEPROM for data storage and enhanced temperature measurement for sensor signal steering and optimisation, together with the support of multiple fieldbus communications and user selectable in/out options accessible via a dedicated pin on the electrical connector. These improvements have been achieved whilst also significantly decreasing the power consumption of the device.

At the very heart of the Bronkhorst El-Flow Prestige is the the Laminar Flow Element (LFE) or "shunt" that determines the proportion of flow between the bypass sensor and the main flow channel. Engineering improvements have been applied to enhance the empirical instrument accuracy as well as further improving flow-pressure drop linearity.

Advanced re-engineering of the Control Valve has resulted in smooth and frictionless control characteristics that have a direct positive impact on stability, longevity of response and MTBF.

The solid metal Electrical Housing is now more user friendly than previously, has yet further increased EMF stability, is now UL approved and is common across all fieldbus options

Further technical advancements include an extremely fast dynamic response, an on-board gas conversion model, 25 selectable gases together with the on-board calculation of mixtures with up to five components, user selectable full-scale flow range-ability within 40% and 120% of the nominal capacity, downturn of 150:1 in digital mode, user configurable control characteristics, various on-board alarm and counter functions and an optional integrated shut-off valve.

The Bronkhorst El-Flow Prestige Series has been developed to meet the ever more stringent needs of industry for greater process precision, stability and cost control whilst eliminating down-time, waste and re-work. Close working relationships and collaborations have been seen within applications for the Compound Semiconductor, Nanotechnology, Glass Coating, Optical Fibre Manufacturing, Specialty Gas, Pharmaceutical, Chemical, Analytical, R&D and University Research industries to name but a few.

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