Emergent level technologies seek right applications

»Growing interest in vibrating fork for point level, radar for continuous level measurement

By Joe Lewis

The water and wastewater industries often call for level measurement of materials in containment or in open vessels. In some cases we simply need to control the process of filling or emptying a tank using point level sensors. Other times we need to monitor or control the changing level of a fluid in a tank with a continuous output signal, either analog or serial.

In either case we need to make sure that we fit the correct level measurement technology to the application and balance issues of cost-versus-performance and long-term reliability. Two technologies receiving much deserved interest in recent years are vibrating fork (tuning fork) units for point level measurement and radar (contact and non-contact) for continuous level measurement.

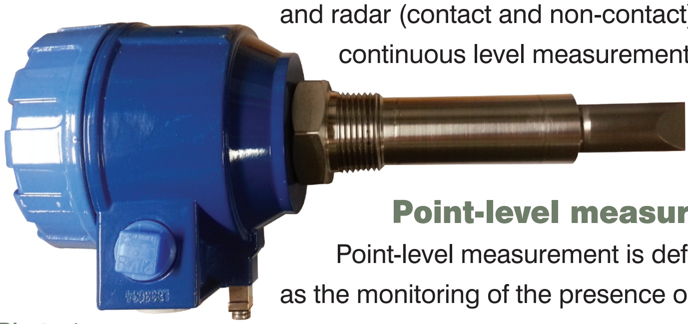

Photo 1

Point-level measuring

Point-level measurement is defined as the monitoring of the presence or absence of the fluid at a predetermined point in the tank or bin. Most often we are interested in controlling a filling or emptying process and use the contact closure output of the level sensor as either input to a PLC or other control system, or we use the contact closure to directly operate a piece of process equipment like a pump or valve.

Many different types of point-level sensor technologies have been employed in the water and wastewater industries — including float switches, bubbler pressure-switch-based systems, hydrostatic sensors, ultrasonic gap switches, conductance and capacitance sensors and RF admittance level sensors. Recent years have seen the growing use and interest in "vibrating" fork level sensors or switches. These are also known as "tuning fork" level sensors (See Photo 1).

The vibrating element level sensor operates by establishing a vibration in the sensor probe at its mechanical resonant frequency. Typically this is accomplished using piezoelectric technology and exciting the piezoelectric crystals via the sensor's electronics. The presence of the medium within the fork changes the frequency or stops the vibration completely, leading to a change in the state of the level sensor output and indicating material presence. Vibrating fork level sensors offer many advantages over the other technologies and this is the reason behind its growing popularity. The advantages and disadvantages of the vibrating element point level sensor are summarized in Table 1.

The vibrating element is available in both a fork and rod design. Both are used for liquids and bulk solids but different embodiments are required, i.e., you cannot buy one unit that handles both a wide range of liquids and slurries, as well as bulk solids. The rod probe design is only used for solids and is preferred because the bulk solid material will not bridge between the tines, which is possible with fork designs. The vibrating fork for liquids is virtually universal handling liquid and slurry materials with density as low as 0.7 g/cm3 and viscosity up to a maximum of 10,000 cSt (mm2/s). The virtually universal application nature, low-moderate cost structure and solid-state (no moving parts) design makes the vibrating fork for liquids and slurries very attractive. Vibrating rods have been increasing in popularity for bulk solid applications as well.

Continuous level

Measuring the continuously changing level of the fluid in a container is known as continuous level measurement and is typically used for inventory measurement and process level-control applications. Measuring inventory levels answers the question of how much material is in the vessel. Process level measurement can be referred to as a control application where the continuously changing level in a vessel is a variable input to a control function or where control is required in a continuously filled and emptied vessel.

Traditionally hydrostatic (or ΔP) and acoustic (ultrasonic) technologies have been used for continuous level measurement of liquids and slurries in water and wastewater industries. However, recent years have seen the emergence and use of radar technology, especially non-contact or through-air radar.

Radar units actually measure the distance of the empty space between the level-sensor antennae and the fluid surface. This distance measurement is made, generally speaking, at a single point on the surface of the material, leading to issues in powder and bulk solid applications, but is generally accurate for liquids. The radar-based level sensor emits energy of high frequency, but generally low power, towards the surface of the material. While most of the energy is absorbed by the material, a portion is reflected back to the level sensor. The time-of-flight of the radar energy is measured and related to the distance.

Both contact and non-contact embodiments of radar technology exist and are used in water and wastewater applications. The contact variety is known as guided-wave radar or TDR (time domain reflectometry) where a continuously suspended probe guides the radar energy to the material surface. In the non-contact version the energy is emitted into the atmosphere toward the material surface. The later variety (non-contact units) has increased in popularity due to a natural preference for non-contact technology, similar to ultrasonic devices.

The use of radar technology is increasing in popularity as more vendors become available and are improving their non-contact offerings to compete with ultrasonic technology in price and performance. Advantages and disadvantages of radar units are shown in Table 2.

Licensing issues

One disadvantage listed for radar units that needs a little more discussion is the FCC licensing requirement. This is bad news for those manufacturers without a proper license and for the users of those units. However, it is arguable as to whether FCC licensing of radar based continuous level measurement sensors should be required or not. So arguable is it that new rules may be forthcoming.

Radar units emit electromagnetic energy in a variety of frequency ranges including 5.925-7.250 GHz, 24.05-29.0 GHz and most

Advantages	Disadvantages
Detects liquids, slurries and solids	Different sensor for solids though
Not dependent on dielectric, conductivity, density, foam etc.	Minimum density is 0.7 S.G. (0.7gcm3)
Solid-state electronics (no moving parts)	Some may be slightly more expensive than some mechanical alternatives
Solid-state electronics (no moving parts)	
Solid-state or Relay output available	
Handles relatively high process temperature (266 F/130 C)	
Readily available from multiple vendors	
Compact housing and miniature units available	
Good materials, coating and hygienic probe finishes available	

Table 1: Advantages and Disadvantages of Vibrating Element Point Level Sensors

recently 75-85 GHz. In March, the FCC proposed to amend the rule regarding unlicensed level measurement sensors in outdoor applications. This is known as FCC 12-34 and is a notice of proposed rule-making. FCC 12-34 specifically calls out "LPR devices" as "level probing radar" and defines these devices as "low-power radars that measure the level (relative height) of various substances." This FNPRM (Further Notice of Proposed Rule Making) concludes with the recommendation that "with appropriate rules" (whatever that means) LPR's can operate without a license.

FCC 12-34 states its rational for this recommendation of unlicensed operation of radar level sensors as follows:

"To address the apparent need for a comprehensive and consistent approach to LPR devices, we are proposing in this FNPRM rules that would apply to the operation of LPR devices installed in both open-air environments and inside storage tanks in the following frequency bands: 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz." Further it states "LPR devices can provide accurate and reliable target resolution to identify water levels in rivers and dams or critical levels of materials such as fuel, sewer-treated waste, and high risk substances, reducing overflow and spillage and minimizing exposure of maintenance personnel in the case of high risk materials."

Also, "We are proposing a set of rules that would be applicable to LPR devices (including TLPR devices) that would allow the expanded development of a variety of radar level-measuring products that will benefit the public and industry and improve the accuracy and reliability of these measuring tools beyond that which is permitted under our current Part 15 rules. To the extent practicable, these proposals would also harmonize our technical rules for LPR devices with similar European standards in an effort to improve the competitiveness of U.S. manufacturers in the global economy. We believe that, with appropriate rules, LPR devices can operate on an unlicensed basis in the proposed frequency bands without causing harmful interference to authorized services."

It couldn't have been written better by a manufacturer of unlicensed radar devices, but it is potentially good news for manufacturers and the industry in general.

Conclusion

Water and waste treatment have changed over the years and so has much of the process measurement instrumentation used within the treatment facilities. Level measurement technology is no exception. Vibrating fork and non-contact radar are the latest in a wave of technology solutions that have been developed in recent years to benefit the water/waste processing industries. Changes continue and should be watched closely. Vibrating fork technology has matured and there are few changes coming up, but potential changes to the licensing requirement for non-contact radar unit will likely keep evolution of these devices moving forward. Without a licensing requirement, more manufacturers and product may be available and costs may go down. We will have to wait and see.

For more information about level measurement technology, go to www.blueleveltechnologies.com. Follow BlueLevel on Twitter @BlueLevelTech and check out their Facebook page at http://www.facebook.com/pages/BlueLevel-Technologies/97182916337. Their Expert's Blog is at www.blueleveltechnologies.com/blog.

Advantages	Disadvantages
Superior measurement accuracy	More expensive
Not impacted by internal vessel atmosphere or changes in temperature	Limited vendor availability
Wider range of application including powder and bulk solids	FCC licensing may be required
High temperature applications up to 392 F (200 C) are standard	
Very fast response to changing levels	

Table 2: Advantages and Disadvantages of Radar Level Measurement Sensors