Match the Level Measurement System to the Job

Consider materials and work environment when choosing a device

By Jenny Nielson Christensen, BinMaster

INVENTORY MANAGEMENT is all about inventory and controlling its related costs. Your job is to determine how much material you have on hand and when you need more so that you don't run out. But these dusty powders are stored in large, dark, enclosed tanks. Without x-ray vision, you have no way to see what's actually in them.

Fortunately, devices are available to help make inventory more accurate and your job easier. To select the device that is best for a particular application, consider the material being measured, whether the material surface tends to be even or irregular, the regulatory environment and tank size, and whether you need to know when inventory has reached a certain level in the tank — which calls for a point level device — or you need continuous level measurement.

What can you expect from a level detection device? It will:

- Help you manage your inventory;
- Eliminate the need to climb tanks to check levels;
- Enhance safety in the workplace;
- Alert you when material reaches a particular level in the tank;
- Provide a single, repeatable measurement when there hasn't been any activity in the tank;
- Provide an accurate distance to product within a few inches; and,
- Measure headroom in the tank or the distance to the material to determine the remaining space in the tank.

What can't you expect? It's a common fallacy that a tank level will convert to mass or volume and then to pounds accurately. The nature of powders is that they will settle, shift and compact in the tank, often creating a topography reminiscent of a lunar surface. New, advanced devices can measure multiple points in the tank to account for surface variations. Adding strapping tables to account for compaction will improve inventory accuracy and compensate somewhat for the behavior of the material. However, a level measurement device is not a scale.

Let's explore some of the level sensor options and considerations when selecting a device, starting with simple sensors and building toward more complex, accurate continuous level technologies.

ROTARY DEVICE

Figure 1. For high-level detection in a tank, a rotary is mounted on top of the tank, and a custom-fabricated extension places the paddle at the desired level.

ROTARY LEVEL INDICATORS

Rotaries are familiar and common devices used for high- or low-level point level indication in bins, tanks, and silos. Rotaries can be used in most powders as long as the bulk density is at least 1 lb/ft^3. They are versatile enough to use in other materials such as granules, pellets, and coarse, lump materials with bulk densities up to 150 lb/ft^3.

The principle of operation for rotaries is simple: A rotary sends an alert via a control room, horn, light, or an alarm panel when material reaches or falls away from the rotary paddle. When material has reached a high level during filling, the paddle rotates continually until material reaches the paddle (Figure 1). When the paddle meets resistance from the material, it stops rotating and sends an alert. Conversely, as a low-level indicator, the paddle will begin turning when material drops below paddle level and will send an alert or can be wired to start up a process system.

Different types of rotaries warrant consideration depending on how critical the rotary's role is in the operation. What this means is what is the impact on an operation if a rotary should lose power or fail? This comes into play if a rotary is critical in starting, stopping, or controlling a process or in causing a work stoppage if a tank should become empty. Most standard rotaries are designed to provide protection from system power failure. Some feature a motor that "goes to sleep" or "de-energizes" to shut down automatically when material is present, which also serves to extend motor life. When it is crucial to confirm a rotary's continuous operation, the application calls for a fail-safe rotary that self-diagnoses continually and, in the event of a failure, sends an immediate warning and instantaneous corrective response. These models often have an LED light or other visual indicator on the unit to visually monitor the motor status.

Rotaries increasingly are applied in new and innovative ways. For high-level detection of a tank's interior, a vertical extension on a rotary can allow it to be extended up to 12 ft. down into the tank. This configuration is recommended for a center-fill tank when operation wants to allow a specific amount of headroom in the tank. Mounted on the top of the tank, a vertically extended rotary can alert when material is higher toward the center of the tank as opposed to simply detecting the level of material near the sidewall, which could be at a lower level when filling the tank (cone up) and at a higher level when emptying the tank (cone down). For thick tank walls, such as those in cement silos, a horizontal extension allows a rotary to be used to detect material levels through the sidewall. When a horizontal extension is combined with a collapsible paddle, the rotary can be installed through a 1¼- or 1½-in. NPT opening without entering the tank.

CAPACITANCE PROBES

Capacitance sensors are designed for an array of applications and can be customized with different type of probes, lengths or extensions. These sensors may be used for high-, mid-, and low-level detection in bins, silos, tanks, hoppers, chutes, and other types of vessels in which powders are stored, processed, flowing or discharged.

Capacitance sensors operate by detecting the presence or absence of material in contact with the probe by sensing a change in capacitance caused by the difference between the dielectric constant of the material in the tank and the air. These sensors detect very small changes in capacitance, typically one picofarad (pF). When selecting a capacitance probe, understanding the radio frequency (RF) range of the device and its impact on other equipment in the plant is important. According to the

Federal Communications Commission, signals in excess of 9 KHz are classified as “RF” and are prone to radiate.

Capacitance sensors that emit RF signals may interfere with nearby electronic plant equipment. Conversely, capacitance probe designs that use RF may be prone to interference from other RF devices, such as two-way radios. Some capacitance probe designs use electronic circuits incorporating frequency shift oscillators and balanced bridges and operate at frequencies between 100 KHz and 2 MHz in the RF range. Alternatively, other designs use a discharge time constant detector circuit that senses capacitance changes of less than one pF and operates at only 6 KHz, which is well below the RF level of most plant equipment. Since this type of capacitance sensor operates at such a low frequency, it will not interfere with nearby electronic plant equipment and is not susceptible to interference from other equipment.

For chemical processing applications in which the risk of contamination must be minimized, a shielded, Delrin-sleeved sanitary probe often is appropriate and will meet the regulatory requirements for the material application. A sanitary probe must be tested and proven to meet USDA or 3-A Sanitary Standards for hygienic equipment design to ensure the purity of material being measured is not compromised. A sanitary probe should be designed for quick disconnect from the device, so it may be removed from the tank easily for inspection and cleaning. Sanitary versions of capacitance probes also are designed so no exposed threads allow material to build up and become contaminated.

To guard against false readings from buildup on the probe or bridging between the sidewall and the probe, a portion of the probe should be shielded. The probe’s shielded portion emits a non-sensing signal that forces the active signal to examine a large area around the probe. This enables a capacitance probe to be used in tanks that store a variety of dusty, sticky or clinging powders without the risk of false alarms.

Figure 2. A bendable capacitance probe can be used to detect the level of powders in space-constrained tanks and mixers.

A time-delay feature can minimize false alarms in case of a sudden material shift caused by rapid filling or emptying of tanks or process activities. A time delay operates by “waiting” a set period of time before acknowledging the signal for a change in the presence or absence of material. A time delay can be set separately for “uncovered to covered”

or "covered to uncovered" conditions and may be adjusted for a delay of up to 30 seconds.

If continuous process operation is critical, look for a capacitance sensor that features fail-safe protection to eliminate process shutdowns, overfills, empty conditions or accidents. To prevent overfills or material shortages, a high/low selectable switch allows the sensor to be set for fail-safe high or fail-safe low.

An extended, flexible cable extension can be attached to the capacitance probe in instances when the sensor is mounted on top of the tank and will be used for high-, mid-, or low-level detection. The extension can be customized to the desired length depending on how far into the tank the material must be detected. A flexible extension is immune to the type of damage that may occur with a rigid probe.

A flush-mounted probe can be used in narrow or space-constrained areas or in applications in which material flow or bridging may damage a standard probe. This type of probe mounts flush on the tank wall, on a conveyor housing, or in a chute. When mounted in tanks with thick walls or angled hoppers, a tank wall adapter is used to mount the probe flush or slightly protruding on the inside of the vessel wall, which will help eliminate false signals resulting from excessive buildup on the probe surface.

When the tank is small or has internal obstructions, a bendable probe can be used to avoid such obstructions while still allowing adequate probe surface area to detect the presence or absence of material. A bendable probe can be used in places where other sensors won't fit, including smaller mixing tanks or storage vessels used in material processing applications (Figure 2).

If your facility has an explosion-proof requirement, you will need to specify a capacitance sensor designed and certified for hazardous location applications. This CSA certification ensures the sensor housing is tested and proven to provide explosion-proof protection in volatile process environments.

If the application is in a high-temperature environment or in an area with excessive vibration, it is appropriate to install a capacitance probe that houses the electronics and probe in separate enclosures. This remote configuration allows the sensor's electronics to be mounted safely in a location away from the sensing probe, which will protect the electronics from heat or vibration.

LEVEL SWITCH

Figure 3. A single-blade vibrating-type level switch can detect light, fluffy materials as well as heavy materials.

VIBRATING LEVEL SENSORS

The vibrating level sensor (Figure 3), or vibrating rod, is a piezoelectric-driven vibration-type level switch that can be used for level detection in bins, silos, and hoppers filled with powders and other dry bulk solid materials. A vibrating level sensor can detect fluffy materials as light as 1.25 lb./cu. ft.^{3}, such as powders and flakes, or can be used for heavy materials, such as granulars or pellets. These rugged sensors often are constructed of durable stainless steel and are almost wear- and maintenance-free. A vibrating level sensor can be used as a high-, mid-, or low-level alert and can be mounted on the top of the tank as a high-level detector or in the bottom cone of a tank to sense when the tank is almost empty.

Vibrating rod level sensors have a single rod-shaped vibrating element. The sensor's rod vibrates when no material covers the active rod. When the rod is covered with material, the vibration is dampened, and an electronic circuit causes a relay to switch and sends an alert. When the rod becomes uncovered, the vibration restarts, and the relay will switch back. Unlike a tuning fork that has two probes that can cause material to become lodged and give a false signal, a vibrating rod's single-probe design prevents material from bridging and giving a false signal.

Vibrating level sensors are reliable because the sensitivity is located at the tip of the sensor, and material built up on the vessel wall will not influence the sensor's function. In addition, the combination of low energy and tip sensitivity will reduce false alarms resulting from rat-holing around an active sensor. Because it is piezoelectric, the sensor can be used to overcome difficulties in some applications that may be associated with changes in dielectric constant, humidity, temperature or material density.

Figure 4. A top-mounted tilt switch is used for high-level detection, activating an alert when the material tilts the switch by 15°.

With advancements in product design, most vibrating rods do not require calibration and adjust easily to the desired sensitivity level. For process-critical applications, be sure to look for features such as a fail-safe alert that will provide notification when power is interrupted to the unit to avoid overfills and empty tank situations that could shut down operations. Other models may include features for high temperatures or with remote electronics. Depending on the manufacturer, some vibrating rods can be extended down into the tank

BOB SENSOR

Figure 5. A bob-style sensor works like an automated tape measure without the safety risks and hassle of climbing tanks.

if the vibrating sensor is to be used in a top-mounted application for high-level detection.

TILT SWITCH

A tilt switch is a high-level indicator designed to install easily and require no routine maintenance. A hanging tilt switch is installed by suspending it from a flexible cable within the tank or over a pile of material. As material rises below the switch, it will tilt and activate a microswitch when the tilt reaches 15° (Figure 4). A hanging tilt switch also can be used for plugged chute detection.

Alternatively, a fixed-mount tilt switch mounts from the outside on the top of the tank though a process connection. An angular motion transferred into linear motion activates an electrical microswitch that can be used for a direct input to a control system or to activate an external alarm. The switch is activated when material rises and tilts the switching mechanism 15°. A fixed-mount tilt switch can be custom-made in lengths from 1 to 8 ft. Depending on the distance from the top of the bin, an alert should be activated.

BOB-STYLE SENSORS

If minimal contact with the material in the tank is acceptable, a weight- and cable-based sensor (Figure 5) can be used for continuous level measurement. Weight- and cable-based, or bob-style, sensors are suitable for most powder applications as these sensors are not affected by dust, humidity, temperature, dielectric constant, or fumes that may be present in the tank. Because a stainless steel probe at the end of the cable makes minimal contact with the material, contamination risk is minimized. This type of sensor works in most material regardless of particle size or bulk density, including very light materials such as fine powders to heavy, dense materials. If multiple tanks containing different types of processing, packaging, or waste materials need to be monitored, bobs are a versatile technology that has been used for more than 20 years.

BIN VIEWING SOFTWARE

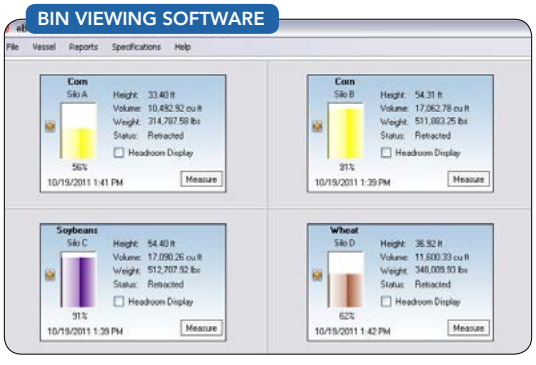

Figure 6. Windows-based software, available with bob-style systems, allows for viewing the levels of multiple tanks simultaneously.

A bob-style sensor can be used in tanks up to 180 ft. tall but are often used in smaller, active process tanks under 40 ft. tall. For the best accuracy, the sensor should be mounted on the roof about ⅙th of the way in from the outer perimeter of the tank, accounting for the angle of repose on a center-fill tank. Properly mounted on a center-fill, center-discharge tank, bob-style sensors will provide 5%–7% accuracy consistently. They work by releasing a cable with a weighted sensor probe that stops and retracts when the probe comes into contact with material. Redundant measurements are taken when the sensor probe is both descending and retracting to guarantee every measurement is precise.

Bob-style sensor networks can be integrated using a variety of communication options, such as a control console mounted at ground level that can report the data from one to more than 100 tanks and provide information such as distance to product (headroom), height of product, and percentage full. If the preference is to have tank data sent to a personal computer, several companies offer Windows-based software (Figure 6) to report detailed data for multiple tanks simultaneously and feature a visual report of tank levels. Other communications include the ability to send automated email alerts when tanks reach a predetermined level. Internet-based monitoring systems also are available that enable 24/7 access to inventory data from any device with a Web connection — including tablets and smartphones — and also allow for managing multiple sites from any remote location.

3D SCANNERS

A 3D scanner (Figure 7) is a noncontact, dust-penetrating tank-volume measurement system that uses acoustics-based technology to measure

Figure 7. A 3D scanner is a non-contact, dust-penetrating device that measures multiple points in the tank to provide better accuracy.

tank contents at multiple points within the tank. What makes a 3D scanner different is that unlike ultrasonic or radar devices that are measuring one point and determining a single distance, the 3D solids scanner takes measurements from multiple points within the tank and uses these points to help estimate the volume of material in the tank. Sampling measurements from multiple points when the material surface of the tank is uneven enables the scanner to calculate tank volume for powders with better precision.

A 3D scanner is unique because it can map the topography of the tank and create a computerized profile of the tank contents. This allows for greater accuracy as it detects cone up, cone down, bridging, and sidewall buildup and then accounts for these variations when it provides the volume estimate. The 3D scanner comes equipped with

software that displays the tank data in an easy-to-read format. The measurements are sent to a main display screen and includes data such as average, minimum, and maximum distances; level; temperature inside the tank; and volume percentage. The 3D mapping software depicts surface irregularities in a visual representation of the tank contents (Figure 8).

A 3D scanner can perform in tanks up to 200 ft tall and in materials with bulk densities greater than 12 lb/ ft^3. Facilities that install 3D technology are seeking improved inventory accuracy; a 3D scanner can deliver 0.5%–3% volume accuracy when mounted in the proper location and used in a tank that is less than 45 ft in diameter. For tanks greater than 45 ft in diameter, a multiple scanner system can record measurement data from multiple devices and then combine the data to report volume to a personal computer and provide a single graphical representation of the tank contents.

A 3D scanner is desirable when highly accurate volume inventories are needed to help in optimizing purchasing, delivery logistics, production planning and financial management. Mapping the contents provides a realistic view of inventory levels, helps managers track inventory more closely, and reduces production shutdowns. By detecting buildup, a 3D scanner allows the maintenance crew to perform timely preventive maintenance and cleaning, which over the long term can protect the tank from potentially damaging structural stress.

ULTRASONIC AND RADAR DEVICES

These types of measurement devices eliminate the risk of contamination or interference with the internal tank structure because the device does not come into contact with the tank material.

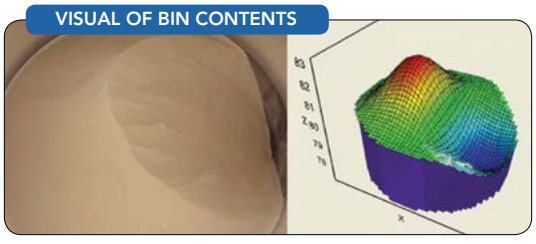

Figure 8. The 3D scanner can provide a visual representation of bin contents depicting high and low levels in the tank. The visual on the left is the tank contents, and the 3D representation is on the right.

Ultrasonic and radar-based technologies are single-point, continuous measurement devices used for ongoing level measuring and monitoring of tanks up to 100-ft tall. An ultrasonic device generates an ultrasonic pulse that is sent to the surface of the material in the tank. The pulse reflects off the product and returns to the sensor in the form of an echo. The amount of time the echo takes to return to the sensor determines the distance to the material. Radar-based devices generate an electromagnetic wave that travels to the material surface being monitored then bounces off the surface back to the sensor. The calculated distance is based on the length of time it takes the wave to return from the surface.

Many ultrasonic and radar devices offer broad processor capabilities that provide remote display options on a dedicated display panel or have PC software that allows tanks to be monitored from an office. Many manufacturers offer system designs intended to simplify system implementation and maintenance and offer communication technology that can be integrated with an existing plant infrastructure. Both ultrasonic and radar-based devices can be programmed to send a 4-20 mA analog output signal to an existing control system or send

data to a PC running a calibration/data logging program using RS-485 communications.

Ultrasonic and radar generally are not the best choices for powders because high-dust environments can cause their signals to become "confused" and provide inaccurate measurements or no data at all. Because these devices measure only a single point in the tank, accuracy may be compromised in materials such as powders that are more prone to bridge or have an irregular surface area. They also need intensive maintenance in powder applications, requiring frequent cleaning or an air purge to keep the sensor working properly. However, they can be suitable and highly accurate for liquid applications, as liquid levels are even across the tank.

If these sensors are used in hygienic applications or applications sensitive to cross-contamination, special consideration should be made for sanitary fittings such as stainless steel, Teflon, or Delrin-insulated components that will not contaminate material.

A pulse radar device with an aluminum housing and Teflon (PTFE) antenna can be used for level measurement applications with the demanding regulatory requirements of the chemical industry. When selecting an ultrasonic or radar device, look for one that is self-calibrating or easy to calibrate because of the variability of materials that may be measured. Be sure to match the device capabilities with the desired communications options, whether they are 4-20 mA, RS-232, or RS-485 or PLC-based.

MAKING THE RIGHT CHOICE

When it comes to managing inventory in any tank in your operation, the first consideration is what type of information you need. Are you seeking level, volume, or weight? If you simply need to know whether a tank is empty or full, choose a point level device. If you need to know the tank's level, such as percentage full, headroom, or distance to product on an ongoing basis, consider a continuous inventory management system such as a bob-style, ultrasonic, radar, or 3D device. A non-contact device may be desired if the regulatory environment demands it. Keep in mind that some non-contact devices perform inconsistently or unreliably in dusty environments. Finally, check to ensure the necessary certifications apply if the device is being used in a volatile environment.

Tank size, the number of tanks, and whether they need to be networked also will influence the type of system you select. If you are seeking convenience, look for a system that offers wireless installation as well as software or consoles that centralize the location of your data and can generate the types of reports you need. The precision of inventory accuracy can vary from one operation or even one tank to the next. Getting an accurate measurement for a single point in the tank can be accomplished easily, but it might not give you the overall volume accuracy you need. For uneven material surfaces, tanks with multiple fill and discharge points, or very large tanks, expect the system to be more complex and more expensive.

And remember, when it comes to level controls, you can find a robust selection of technologies at prices ranging from a few hundred to a few thousand dollars. Level measurement is not a one-size-fits-all product. It is a puzzle with many pieces that when put together right will give you a better picture of your inventory.

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AUTOMATE FOR INVENTORY ACCURACY

You can eliminate the dangerous and time consuming task of climbing to manually measure silos with an automated level measurement system. The 3DLevelScanner measures and maps silo contents across uneven material surfaces, instead of a single measurement point, to provide a very high level of inventory accuracy.

Get to the Point (Level)!

Sometimes you need continuous level measurement and sometimes you just need to know when material in the silo reaches a certain point. Point level indicators are reliable, accurate and very affordable. Whether you need high, low or mid-level detection, there are a variety of devices that can easily meet your needs.

Go with the Flow

If you're looking for affordable, reliable and easy-to-use flow or no flow notification, the new BinMaster FD-2000 flow detector might just be the solution you're looking for. This microwave-based sensor detects flow or no flow conditions in solids and powders at transition points in a variety of applications such as:

- Gravity chutes
- Pipelines
- Ducts
- Feeders
- Gravity spouts
- Gravity feeders
- Mechanical conveyors
- Pneumatic conveyors

Get in the know *LEVEL & FLOW*

Sensor Type	How It Works	Use in	What's Special
Rotary	Paddle stops turning when material reaches it and activates an alert	Dry bulk solids of all types with bulk density of at least 2 lb./cu.ft.	Top and side-mounted models. Extensive selection of paddles, extensions and mounting plates for customization. Fail-safe MAXIMA+ alerts to status of power and motor.
Vibrating Rod	Vibration stops when material reaches its level to alert to silo status	Dry solid materials with bulk density as low as 1.25 lb./cu. ft.	Unique sword-shaped probe resists buildup and prevents false alarms. Rigid and flexible extensions for top mounting. Self-cleaning with no moving parts
Capacitance Probe	Senses presence or absence of material caused by a change in dielectric constant of material versus the air	Wide variety of solid, liquid and slurry materials	Wide variety of probe materials and lengths for custom applications. Simple "quick-set" calibration. PRO-Shield compensates for buildup.
Tilt Switch NEW!	Rising material tilts switch to 15° to activate alert	Solids with bulk density of 15 lb./cu. ft. or greater	Top mount or hanging. Very economical and easy to install. Rugged construction and simple design.

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