How Powder Says T(h)ank You

Tank Measurement Considerations for Powders and Solids

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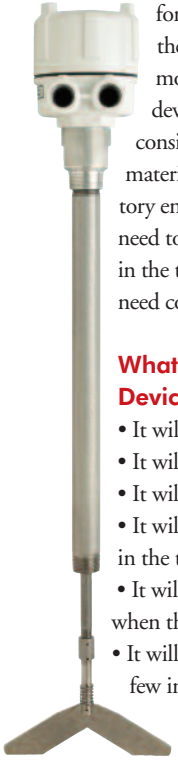
Inventory control. Inventory turns. Inventory accuracy. Inventory management. It's all about inventory and controlling its related costs. Your job is to figure out just how much material you have on hand and when you need more. Simple in theory, not quite so easy when you are running multiple production lines or asked for month-end inventory in about an hour. However, there are devices that can help make your inventory more accurate and your job easier. To select the device that is best for a particular tank, it is helpful to consider the material being measured, whether the material surface tends to be even or irregular; the regulatory environment; the size of the tank; 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.



For high level detection in a tank, a rotary can also be mounted on the top of the tank and an extension can be custom fabricated to reach the paddle to the desired level.

What Can You Expect From a Level Detection Device?

- It will help you manage your inventory.
- It will eliminate the need to climb tanks to check levels.
- It will enhance safety in the workplace.
- It will alert you when material reaches a particular level in the tank.
- It will provide a single measurement that is repeatable when there hasn't been any activity in the tank.
- It will provide an accurate distance to product within a few inches.
- It will measure headroom in the tank or the distance to the material, so you know how much space is left in the tank.

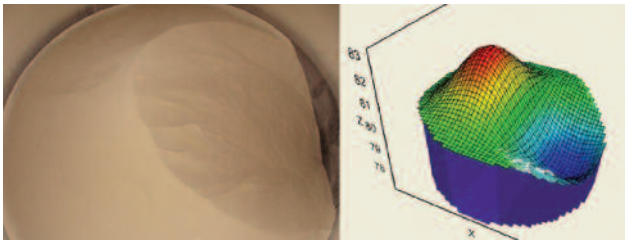
What Can't You Expect?

It's a common fallacy that a tank level will convert to mass or volume and then to pounds accurately. The nature of powders, granular materials or pellets is that they will settle, shift and compact in the tank. It's true that some advanced devices incorporate compaction calculations into their software, which will 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.

Rotary Level Indicators

Rotaries are a familiar and common device used for high or low level point level indication in bins, tanks and silos. A rotary sends an alert via a horn, light or an alarm panel when material reaches (for high level detection) or falls away from (for low level detection) the rotary paddle. The principle of operation for rotaries is quite simple. When the rotary is used to alert that material has reached a high level while the bin is filling, the paddle rotates continually until material reaches the paddle. When the paddle meets resistance due to the presence of material, it stops rotating and sends an alert. Conversely, as a low level indicator, the paddle will begin turning when material drops below the level of the paddle and will send an alert, or it can be wired to start-up a process system.

Rotaries are used in a wide range of powder and bulk solid materials and can be used in materials with a bulk density to 150 lb/cu ft3, so they can be used in light powders, granulars and pellets, as well as very coarse materials such as aggregates. Rotaries are applied in just about every industry including agriculture and food processing, chemical and pharmaceutical manufacturing, plastics and packaging materials, pulp and paper, mining, power generation and renewable fuels industries.



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.

There are different types of rotaries that warrant consideration dependent on how critical the role of the rotary is in the operation. For instance, if a rotary is critical in starting, stopping, or controlling a process, or causing a work stoppage if a bin should become empty. Most standard rotaries are designed to provide protection from system power failure. Some feature a motor that automatically shuts down when material is present, which also serves to extend motor life. When it is crucial to confirm the continuous operation of a rotary, the application calls for a genuine fail-safe rotary that continually self-diagnoses, and in the event of a failure, sends an immediate warning

A 3D Scanner is a non-contact, dust penetrating devices that measures multiple points in the tank to provide greater accuracy.

and instantaneous corrective response. These models often have an LED light or other visual indicator on the unit for visual monitoring of the motor status.

Rotaries are increasingly applied in new and innovative ways. For high level detection at the interior of a bin, a vertical extension on a rotary can allow it to be extended up to 12 feet down into the bin. This configuration is recommended for a center-fill bin when the operation wants to allow a specific amount of headroom in the bin. Mounted on the top of the bin, a vertically-extended rotary can alert when material is higher toward the center of the bin, versus simply detecting the level of material near the sidewall which could be at a lower level when filling the bin (cone up) and at a higher level when emptying the bin (cone down). For thick bins walls, such as those in cement silos often found at power, ethanol, cement and fertilizer plants, a horizontal extension allows for 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 1-1/4- or 1-1/2-inch NPT opening without entering the bin.

Capacitance Probes

Capacitance sensors are designed for a wide array of applications and materials and may be used in powders, granulars, pellets and other solid or slurry materials. The sensors may be used for high-, mid- and low-level detection in bins, silos, tanks, hoppers, chutes and other types of vessels where material is 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 are able to detect very small changes in capacitance, typically one picofarad. When selecting a capacitance probe, understanding the radio frequency range of the device and its impact on other equipment in the plant is an important consideration. 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 utilize RF may be prone to interference from other RF devices, such as two-way

radios. There are capacitance probe designs that utilize electronic circuits incorporating frequency shift oscillators and balanced bridges operating at frequencies between 100 KHz and 2 MHz in the RF range. Alternatively, there are capacitance probe designs that use a discharge time constant detector circuit, which sense capacitance changes of less than one picofarad, and operate 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 food processing or pharmaceutical applications a shielded, Delrin-sleeved sanitary probe is often appropriate, and dependent on the particular application may 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 for the food, beverage, and pharmaceutical industries. A sanitary probe should be designed for quick disconnect from the device for inspection and cleaning. Sanitary versions of capacitance probes used in the pharmaceutical and food industries are also designed so there are no exposed threads where material can buildup 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 shielded portion of the probe emits a non-sensing signal that forces the active signal to examine a large area around the probe, enabling a capacitance probe to be used in vessels that are used to store a wide variety of materials without the risk of false alarms.

A time delay feature can minimize false alarms in case there is a sudden material shift caused by rapid filling or emptying of tanks or process activities. 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.

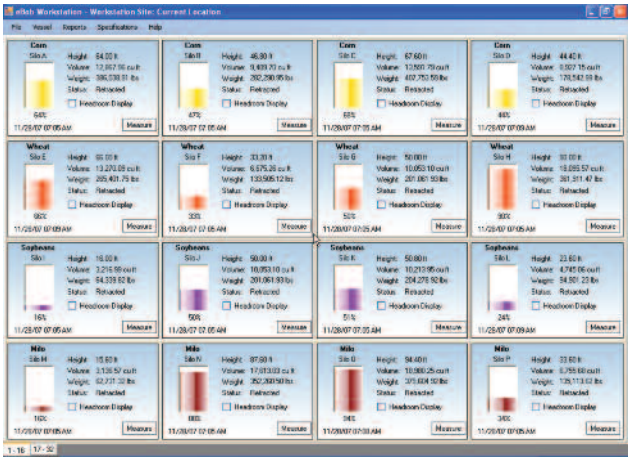
If continuous process operation is critical, look for a capacitance sensor that features fail-safe protection to eliminate process shutdowns, overfills, empty conditions or accidents. To prevent overfills or material shortages, a high/low selectable switch allows the sensor to be

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 dependent 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 where material flow or bridging may damage a standard probe. This type of probe mounts flush on the wall of the tank, on a conveyor housing or in a chute. When mounted in tanks with thick walls or angled hoppers, a bin wall adapter is used to mount the probe flush or slightly protruding the inside of the vessel wall, which will help eliminate false signals due to excessive buildup on the probe surface.

When the tank is small or has internal obstructions, a bendable probe can be used in the tank to avoid obstructions, while still allowing adequate probe surface area to detect the presence or absence of material. A bendable probe can be used in many solid materials;



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

including smaller mixing tanks or storage vessels used in material processing applications.

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 where there is 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 safely mounted in a location away from the sensing probe, which will protect the electronics from the source of heat or vibration.

Vibrating Level Sensors

The vibrating level sensor or vibrating rod is a piezoelectric-driven vibration-type level switch can be used for level detection in bins, silos and hoppers filled with powders or dry bulk solid materials. A vibrating level sensor can detect extremely light, 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 are rugged sensors that are often constructed of durable stainless steel and are virtually wear- and maintenance-free. A vibrating

A bob-style sensor provides high accuracy when mounted near the outer perimeter of the tank.

level sensor can be utilized 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 nearly empty.

Vibrating level sensors are piezoelectric devices with a single rod shaped vibrating element. The rod of the sensor vibrates when there is no material covering the active rod. When the rod is covered with material, the vibration is dampened and an electronic circuit causes a relay to switch and send an alert. When the rod becomes uncovered, the vibration restarts and the relay will switch back.

Unlike a tuning fork that has two probes where material can become lodged and give a false signal, a vibrating rod features a single probe design that prevents material from bridging and giving a false signal. Vibrating level sensors are known for high performance and reliability. Since the sensitivity is located at the tip of the sensor, material built-up on the vessel wall will not influence the function. Plus, the combination of low energy and tip sensitivity will reduce false alarms, due to rat-holing around an active sensor. As the vibrating level sensor is piezoelectric, it can be used to overcome difficulties in some applications that may be associated with changes in dielectric constant, humidity, temperature or material density.

With advancements in product design, most vibrating rods do not require calibration and easily adjust 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 available features may include models for high temperatures or with remote electronics. Dependent on the manufacturer, some vibrating rods can be extended down into the tank if the vibrating sensor is to be used in a top-mounted application for high-level detection.

Bob-Style Sensors

If minimal contact with the material in the tank is acceptable, a weight and cable-based sensor is a very economical and accurate continuous level measurement choice. Weight and cable-based or bob-style sensors can be ideal for diverse applications for most any industry as these sensors are not affected by dust, humidity, temperature, dielectric constant or fumes that may be present in the bin. Plus, as a stainless steel probe at the end of the cable makes minimal contact with the material, there is minimal risk of contamination. This type of sensor works in virtually any material regardless of particle size or bulk density including very light materials like fine powders to heavy, dense materials like aggregates. If there are multiple tanks containing different types of processing, packaging or waste materials that need to be monitored, "bobs" are a proven technology that have been in existence for over 20 years and are trouble-free, long-lasting and require no calibration.

A single-blade vibrating type level switch is superior to a tuning fork that has two probes where material can become lodged and give a false signal.

A bob-style sensor can be used in bins up to 180 feet tall, but are also often used in smaller, active process bins under 40 feet tall. For the best accuracy, the sensor should be mounted on the roof about 1/6 of the way in from the outer perimeter of the bin, which places it ideally to account for the angle of repose on a center-fill bin. Properly mounted on a center-fill, center-discharge bin, bob-style sensors will consistently provide 5- to 7-percent accuracy. 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 utilizing a wide variety of communication options. Most cost-effective and popular is a control console mounted at ground level that can report the data from one up to over 100 bins and provides information such as distance to product (headroom), height of product and percentage full. If the preference is to have bin data sent to a personal computer, several companies offer Windows-based software to report detailed data for multiple bins simultaneously and feature a visual report of bin levels. Other communications include the ability to send automated e-mail alerts when bins reach a predetermined level. Internet-based monitoring solutions are also available that enable 24/7 access to bin data from any device with a Web connection, and also allows for managing multiple sites from any remote location.

Ultrasonic and Radar

These types of measurement devices are popular as they eliminate the risk of contamination or interfering with the internal bin structure, since the device does not come into contact with the bin material. They are also ideal and highly accurate for liquid applications, as liquid levels are even across the tank. Ultrasonic and radar-based technologies are single-point, continuous measurement devices which can be used for ongoing level measuring and monitoring of tanks that are up to 100 feet 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 that is reflected 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 of the ultrasonic and radar devices on the market today offer broad processor capabilities that provide remote display options on a dedicated display panel or have PC software that allows for the monitoring of tanks from the comfort of an office. Many manufacturers offer user-friendly system designs that simplify the implementation and maintenance of an installation, and offer communication solutions that can be integrated with an existing plant infrastructure. Both ultrasonic and radar-based devices can be programmed to simply send a 4-20 mA analog output signal directly to an existing control system, or send data to a PC running a calibration/data logging program using RS-485 communications.

Ultrasonic and radar may not perform consistently in high dust environments, where their signals can become "confused" and provide inaccurate measurements or no data at all. Since they only measure a single point in the tank, they may offer compromised accuracy in materials like powders that are more prone to bridge or have an irregular surface area which makes the tank more difficult to measure accurately. If these sensors are used in hygienic applications, special consideration needs to be made for sanitary fittings such as stainless steel, food-grade Teflon® or Delrin®-insulated components that will not contaminate material.

A pulse radar device with an aluminum housing and Teflon (PTFE) antenna is an ideal solution for level measurement applications with the demanding hygienic requirements of the pharmaceutical industry. When selecting an ultrasonic or radar device, look for one that is self-calibrating, or easy to calibrate due to the variability of materials that may be measured. And, 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 compatibility.

3D Scanners

A 3D scanner is a non-contact, dust-penetrating bin volume measurement system that uses acoustics-based technology to measure bin contents at multiple points within the bin. 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 Scanner takes

measurements from multiple points within the bin and uses these points to help estimate the volume of material in the bin.

A 3D scanner is unique because it is able to map the topography of the bin and create a computerized profile of the bin 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 which 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 bin contents.

A 3D scanner performs in tanks up to 200 feet tall and in materials with bulk densities greater than 12 pounds per cubic foot. Facilities that install 3D technology are seeking improved inventory accuracy, with a 3D scanner proven to deliver .5- to 3-percent volume accuracy when mounted in the proper location and used in a bin that is less than 45-feet in diameter. For bins greater than 45-feet 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 bin 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 very realistic view of inventory levels and helps managers more closely track inventory and reduce production shut downs. 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.

When it comes to managing inventory in any tank in your operation, the first consideration is what type of information you need. Tank size, the number of tanks, and whether they need to be networked will also influence the type of system you select. And remember, level measurement is not a one-size-fits-all solution. It's a puzzle with many pieces that, when put together right, will give you a better picture of your inventory.