How to select a continuous level sensor

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Using a continuous level sensor to monitor the material level in your storage vessel can help you keep material flowing smoothly and prevent costly process interruptions. To help you choose a continuous level sensor without having to wade through volumes of technical data, this article briefly describes the types available and the pros and cons of each and explains what information you need to gather before working with a sensor supplier.

A continuous level sensor measures the amount of material in a storage vessel on a continual basis, rather than just indicating whether the material is above or below a certain point, as point level sensors do. This makes a continuous level sensor ideal for monitoring material inventory in your vessel to prevent downtime. Depending on the sensor type and supplier, the continuous level sensor can output data to a console or panel, send the information to a PLC or PC, or send the information to the Internet for anywhere, anytime access. An advanced system using multiple sensors can report data from multiple vessels at your site or from vessels at multiple sites, making it easy to monitor your entire operation's inventory status.

Choosing the right continuous level sensor for your application, however, can seem like ordering off of a menu when you don't speak the language. An overwhelming amount of information is available about the different types of sensors and the technologies they use. And a level sensor is just one of the many pieces of equipment you need to worry about. Knowing some basics about how different sensor types work and their pros and cons can help you determine which sensor you need.

Before getting into these basics, however, it's important to understand that a continuous level sensor, which is typically mounted on the top of a vessel, has a default *dead zone* (or *blanking distance*) that it can't measure. The dead zone is the area between the highest point the sensor can measure and the vessel's top. When the material reaches the bottom of the dead zone, the sensor will indicate that the vessel is full. Dead-zone height varies by sensor type but can range from about 4 inches to about 36 inches. Most suppliers preset the dead-zone height in the sensor controller based on the sensor type, but a dead zone's height can be increased if the application requires a lower full point.

Sensor types

Types of continuous level sensors include weight-and-cable, 3D-scanning, guided-wave radar, open-air radar, and ultrasonic. Each type operates differently and has its pros and cons.

Weight-and-cable. A weight-and-cable (or *plumb bob*) sensor works like an automatic measuring tape: The sensor lowers a cable with a weight (also called a *bob* or *probe*) attached to its end into the vessel, as shown in Figure 1a. The sensor determines the material's level by measuring how much cable has been let out when the weight reaches the material's surface; then the sensor retracts the cable and returns the weight to the vessel's top. Not strictly a continuous sensor, the weight-and-cable sensor is programmed to take measurements at predetermined intervals, such as every 30 minutes, once an hour, every 6 or 8 hours, or once a day.

The weight-and-cable sensor measures a single vessel location directly below its mounting location and is highly accurate and reliable. The weight-and-cable sensor's measuring range can be up to about 180 feet, and the dead zone is minimal, just 4 to 8 inches measured from the sensor's mounting location to the weight's tip when the cable is fully retracted.

Pros. The weight-and-cable sensor:

- Isn't affected by dust or other adverse process conditions
- Has minimal contact with the stored material
- Can be used in vessels up to about 180 feet tall
- Is available in models that can handle temperatures up to 1,000°F
- Isn't affected by material buildup
- Isn't affected by material characteristics, such as angle of repose or low dielectric constant
- Can measure extremely light, signal-absorbing materials
- Is approved for use in hazardous, high-dust locations
- Is simple to install and set up
- Requires no calibration
- Provides consistent, repeatable, and accurate measurements
- Has a low purchase cost compared to the other sensors

Cons. The sensor:

- Doesn't instantaneously respond to material-level changes
- Measures a single vessel location
- Isn't recommended for use in high-pressure vessels

3D-scanning. Unlike any other continuous level sensor, the acoustics-based 3D-scanning sensor takes measurements at multiple points within the vessel, as shown in Figure 1b. The sensor uses three independent *transducers,* that transmit low-frequency sound pulses to the material surface. The sound pulses bounce off the material in several locations, and the sensor measures the time it takes for the pulses to return (or *echo*) back to the transducer.

The 3D-scanning sensor has a measuring range of up to about 200 feet and a 19-inch dead zone. The sensor uses an advanced algorithm that takes into account the material's irregular surface topography and assigns each measuring point a weight to precisely determine the material volume and produce a 3D image of the material level.

Pros. The 3D-scanning sensor:

- Provides continuous level measurement
- Is nonintrusive and doesn't contact the material
- Measures multiple vessel points to create a 3D map of the material's surface and accurately calculate the material volume
- Can measure uneven material surfaces, including sidewall buildup and cone-up or cone-down formation
- Can report minimum, maximum, and average material levels
- Can be used in vessels up to about 200 feet tall
- Is available in high-temperature models up to about 350°F
- Isn't affected by material characteristics
- Works in very dusty conditions
- Is approved for use in hazardous locations
- Self cleans and requires minimal maintenance

Cons. The sensor:

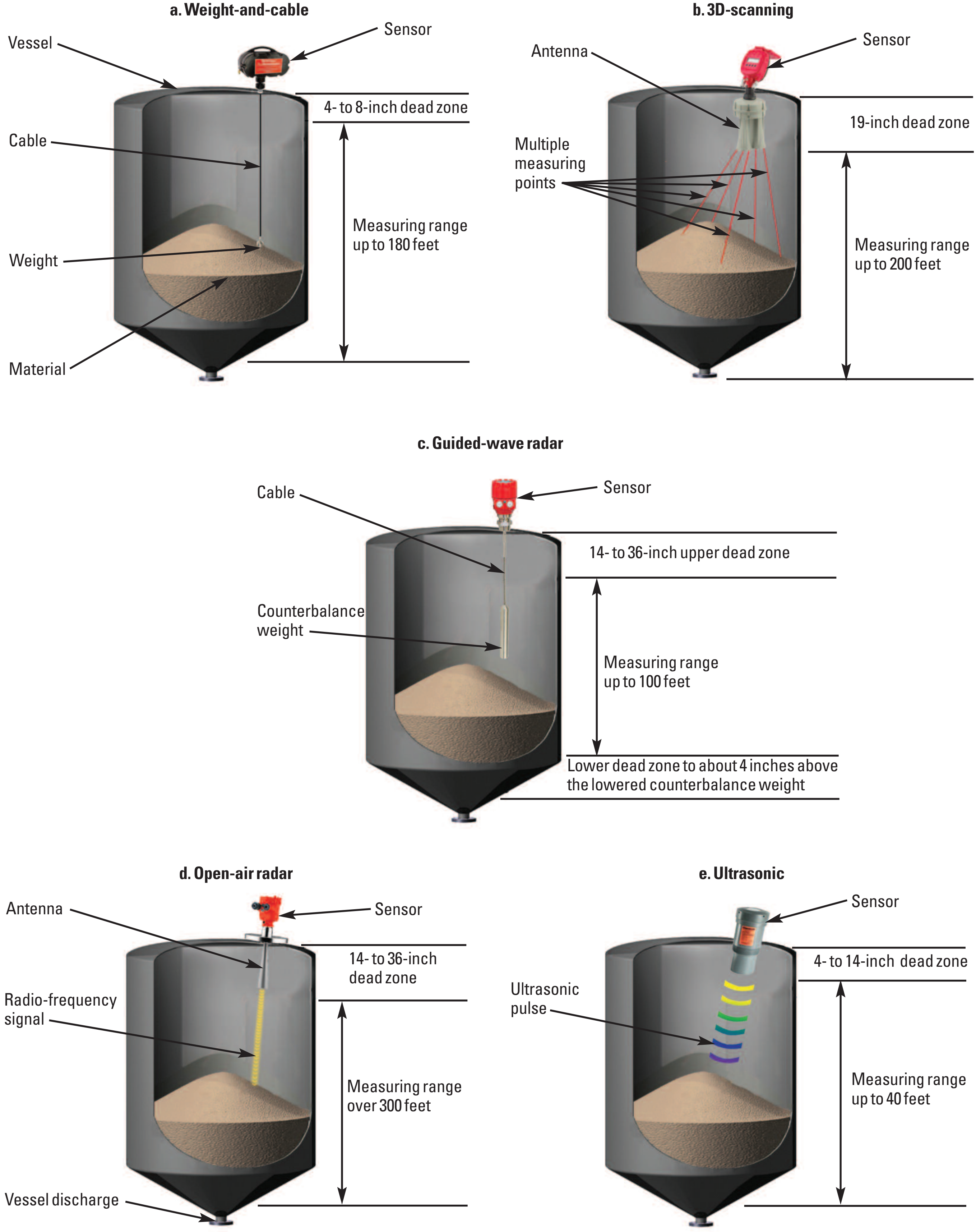
- Requires time to process multiple sound pulse echoes, limiting its sample rate
- May not perform well in an environment with a lot of background noise
- Isn't recommended for measuring a material with a bulk density less than 11 lb/ft^3 because such a material will absorb the sound pulse
- Must be carefully located and mounted to accurately map the vessel dimensions
- May not perform well in small vessels with corrugated walls, which can create false echoes
- Has a high purchase cost compared to the other sensors

Guided-wave radar. A guided-wave radar sensor uses *time-domain reflectometry* to measure the distance from the sensor to the material. For this sensing method, a low-power microwave signal is sent along a sensing probe (a cable with a counterbalance weight at its end) that acts as a wave guide, concentrating the radar signal within a small diameter around the probe. The sensor calculates the material level based on the signal's flight time. The sensor's cable diameter and length vary depending on the material's characteristics and the vessel size.

The guided-wave radar sensor's dead zone is typically 14 to 36 inches, although the zone is smaller with some newer models. This sensor also has a second, lower dead zone, as shown in Figure 1c, generally from the bottom of the vessel to about 4 inches above the top of the counterbalance weight at the extended cable's end. The sensor measures the material level at a single point in the vessel (the cable's location) between the bottom of the upper dead zone and the top of the lower dead zone.

Figure 1

Continuous level sensor types



Pros. The guided-wave radar sensor:

- Provides continuous level measurement
- Provides highly accurate measurements
- Is suitable for almost any vessel shape or diameter
- Is available in high-temperature models up to about 800°F
- Performs well in vessels prone to changes in dust level, humidity, temperature, pressure, and material bulk density
- Can be used in high-pressure vessels
- Is relatively easy to install and set up

Cons. The sensor:

- Has a sensing probe that's in constant contact with the material
- Measures a single vessel location
- Typically has a maximum cable length of less than 100 feet, limiting the measuring range
- Doesn't perform well with materials with a very low dielectric constant
- May not be suitable for use with heavy or abrasive materials, such as large rocks, which are difficult to measure and can impose a high tensile load on the cable and damage it
- Has a relatively high purchase cost (but typically lower than open-air radar or 3D-scanning sensors)

Open-air radar. An open-air radar sensor transmits a radio-frequency signal to the material surface, which reflects a small portion of the signal back to the sensor's antenna. The sensor processes this returned signal to determine the material's level. The sensor's antenna is typically aimed at the vessel's discharge, as shown in Figure 1d, to prevent the signal from reflecting off the angled bottom when the vessel is nearly empty, which could cause false measurements.

Sensor models are available with different antenna types and operating frequencies (typically ranging from 6 to 76 gigahertz). Which model will perform successfully in an application depends on the vessel height, the material being measured, the presence or absence of dust, and the sensor's operating frequency.

The sensor's measuring range varies depending on the operating frequency. Sensors with frequencies of 26 gigahertz or less can measure up to about 100 feet, while a 76-gigahertz sensor can measure over 300 feet. The open-air radar sensor's dead zone generally ranges from 14 to 36 inches, depending on the antenna. The sensor measures the material level at a single point where the antenna is aimed.

Pros. The open-air radar sensor:

- Provides continuous level measurement
- Is nonintrusive and doesn't contact the material
- Can be used in vessels over 300 feet tall
- Is available in high-temperature models up to about 350°F
- Is virtually unaffected by changes in process temperature, pressure, or material bulk density

Cons. The sensor:

- Measures a single vessel location
- Doesn't work well with materials that have a low dielectric constant, which don't reflect much radar signal back to the sensor
- Must be carefully located to ensure that the signal is properly directed
- Requires frequent air purging, so a supply of compressed air must be run to the sensor
- May not perform reliably in very dusty environments
- Is susceptible to condensation and material buildup on the antenna, which may cause signal attenuation and adversely affect performance, particularly with a smaller antenna on a higher-frequency sensor
- Can have a limited measuring range when the sensor is using a wide beam angle
- Is susceptible to false measurements in nearly empty cone-bottomed vessels
- Tends to have a high purchase cost compared to the other sensors

Ultrasonic. An ultrasonic sensor transmits an ultrasonic pulse of pressurized air to the material's surface. The pulse reflects off the material as an echo and is received by a microphone in the sensor. The sensor is generally aimed at the vessel discharge, as shown in Figure 1e, to prevent the signal from bouncing off a nearly empty vessel's angled hopper bottom and causing false measurements.

The ultrasonic sensor's dead zone is typically 4 to 14 inches, and its measuring range is typically limited to about 40 feet but can be higher in some low-frequency models. The sensor measures the material level at a single point on the material's surface.

Pros. The ultrasonic sensor:

- Provides continuous level measurement
- Is nonintrusive and doesn't contact the material
- Is available in high-temperature models up to about 300°F
- Requires minimal maintenance
- Is easy to install and calibrate
- Has a relatively low purchase cost compared to the other sensors

Cons. The sensor:

- Measures a single vessel location
- Typically measures only up to about 40 feet
- Doesn't perform well in dusty conditions or with pressure fluctuations, vessel turbulence, or large particle sizes
- Isn't recommended for vessels containing steam
- May not perform well in high-pressure vessels

Evaluating your level measurement needs

Before you contact a supplier to determine which level sensor is best for your application, you should know some basic information about your material, your vessel, and your operation. This preliminary information will help you quickly rule out sensor types that won't work for your application or budget.

Your material:

- What is the material?
- What is its bulk density in pounds per cubic foot?
- Is it sticky?
- Does it tend to create buildup?
- Is it corrosive?
- What's the material's moisture content?
- Does the material create dust, steam, or vapor?

Your vessel:

- What are the vessel's dimensions?
- Are there limitations to where the sensor can be mounted?
- What's the temperature in the vessel?
- What's the pressure in the vessel?
- Is there excessive noise or vibration in the vessel?

Your operation:

- How often do you need to measure the material level or access the data?
- How many people need access to the data, and how will it be shared?
- Is monitoring the material level in one vessel at a time okay, or do you need to monitor levels in multiple vessels simultaneously?
- Do you need a notification or alert if the level reaches a certain high or low point?
- How accurate do you need the measurements to be?
- What is your budget?

Most sensor suppliers offer an online application worksheet addressing many of these questions that can help you evaluate your application. Completing the worksheet is great preparation for working with a supplier to select the right continuous level sensor for your needs. **PBE**

For further reading

Find more information on continuous level sensors in articles listed under "Level detection" and "Storage" in *Powder and Bulk Engineering*'s article index in the December 2013 issue or the Article Archive on *PBE*'s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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