

Radar Level Measurement in Circular Silos

Dust formation, abrasion and high temperatures present challenges to reliable level measurement in circular clinker silos. Smart radar instruments provide more accurate results.

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FIGURE 1. Circular clinker silos used to store cement, concrete and similar materials pose problems for traditional level measurement instruments.

Cement companies typically use radar measurement instruments to monitor the level of materials used for the manufacturing of cement, concrete and other building materials. Radar level instruments have proved themselves over the years as an excellent way to overcome measurement problems in circular clinker silos (Figure 1), bunkers, slim silos, stockpiles, mechanical conveyor systems and crushers.

New radar level instruments are better able to deal with problems such as dust, abrasion and high temperatures by utilizing new developments in signal processing and other areas.

Level Measurement Issues

Silos holding solid materials have several measurement issues other than dust and high temperatures. The silos may have obstructions such as feeders, agitators and heating elements that can interfere with a

level measurement. Flow out of the silo can be impeded by the formation of stagnant arches and zones caused by “hammering” at a hopper wall and “funnel flow.”

Ultrasonic level instruments can lose the measurement during filling when large amounts of dust are produced, while electromechanical systems—which lower a weight to the top of the pile—risk the weight being buried. Electromechanical systems also suffer wear from the abrasive media.

Problems may also arise with level measurement in narrow compartments with different grain sizes. High noise levels during filling can affect the measurement, especially with ultrasonic instruments. With electromagnetic instruments, the high noise generates vibrations that can make the measured signal be erratic and not reliable.

With mechanical conveyor systems, monitoring the belt load or feed points into or out of the silo is difficult for electromechanical level instruments because the material is moving and the level can change rapidly. Fast response times are often required, and electromechanical instruments are slow to respond.

In indoor or outdoor stockpiles used to hold incoming or outgoing materials, a varying angled surface of the media can create challenges for radar and traditional level instruments. The level instrument may have to be mounted on a pole above the storage pile, making installation and maintenance difficult. An alignment mount on the device is often needed to keep the angle of repose as close to perpendicular as possible. Maintaining the proper angle of repose with a radar transmitter will improve reliability and accuracy.

Radar level instruments overcome all these problems.

Radar to the Rescue

Radar level instruments (Figure 2) are typically used in clinker silos, and new developments in radar signal processing are making radar more effective than ever.



FIGURE 2. A radar level instrument installed on top of a silo.

Two main areas of improvement over the recent years with radar technology bring about improved reliability and accuracy. One is the new “intelligence” in the electronics that aids in overcoming uneven levels in silos and conveyors. The second is higher frequency from 6 GHz to 26 GHz, allowing for tighter beam angles



FIGURE 3. The Endress+Hauser FMR57 26GHz level instrument has an air purge connection, multi-echo tracking and a small 4-inch antenna to accurately measure level in a silo up to 230 feet tall.

that improve reliability with stagnant zones, arches, pyramids and other uneven levels. The beam is the signal sent to and reflected from the material in the silo. This allows level measurements in narrow compartments and improves reliability even with different grain sizes.

A 4-inch antenna results in improved focusing of radar waves with a beam angle of only 8°, and very high signal dynamics. With these properties, a modern radar instrument (Figure 3) is able to accurately measure level in circular compartment silos during filling.

Beam angle is important because it determines how close the radar instrument’s sensor can be installed to the wall of a narrow compartment. The beam should never reach the wall because it will interfere with the radar signal. For example, when a radar instrument sensor with a wide beam angle is installed too close to the side wall, this causes non-linear inaccuracies throughout the measurement range.

A wide beam angle has its advantages. For example, a 6 GHz radar instrument has a lower, broader frequency than a 26 GHz instrument, so it’s better at penetrating dust. Wide beam angles also provide more of an average representation of the surface. To maximize reliability of a measurement, the installation of the transmitter should be from 1/2 to 1/3 the radius of the vessel.

Advanced Algorithms

With traditional time-of-flight measurements used by radar and some other level instruments, a pulse is emitted, reflected by the surface of the medium, and received by the radar instrument’s antenna. The level in the silo is calculated based on the time it takes for the signal to return. The calculation also makes use of the echo signal curve built into most modern radar level instruments.

Obstacles in the radar beam path—for example, other instruments—may generate an interfering echo signal. These obstacles are traditionally

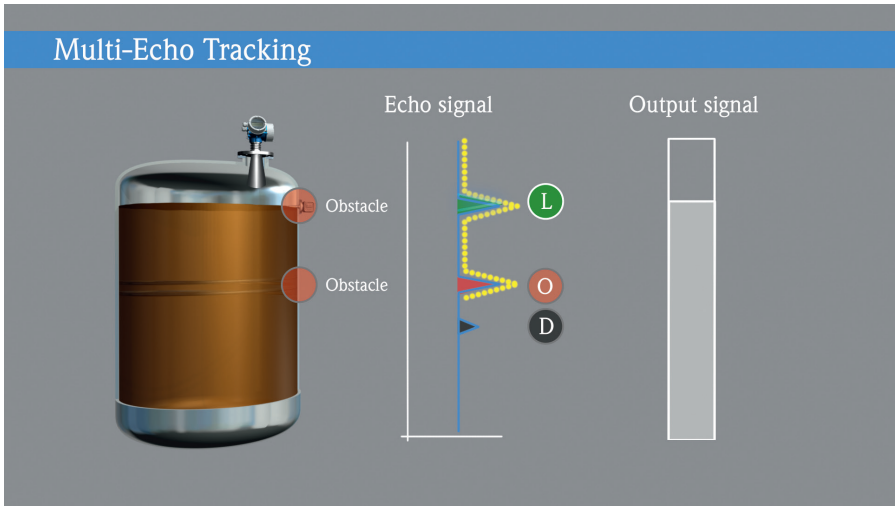


FIGURE 4. Multi echo tracking automatically detects obstacles and compensates for echoes.

excluded from the echo signal analysis based on a mapping function; that is, only signals over the mapping curve are accepted as level signals. If the level signal goes below the mapping curve when filling or discharging a tank, incorrect analyses may occur. The signal jumps erroneously, for example, to a so-called double echo which follows the echo at twice its distance. After the level passes the obstacle, the echo jumps back to the correct level signal.

Advanced signal analysis algorithms, such as multi-echo tracking (Figure 4), provide a more intelligent and reliable echo signal analysis. When the level instrument is first commissioned, a static map is run by the operator. This can be done with an empty vessel or with product in the vessel. The static map then runs in the background while multi-echo tracking processes the resulting signal.

With multi-echo tracking, all echo signals—new and old—are mapped. If obstacles protrude into the signal path, they generate a corresponding signal. The analysis detects the level signal if it ranges below the static map. The level transmitter performs this function during every scan, guaranteeing safe and precise measurement even in the presence of new obstacles in the tank. The ability of the transmitter to learn and

evaluate each critical change brings an increased level of confidence to the process measurement.

The self-learning software algorithms are capable of monitoring and characterizing up to 20 microwave reflections simultaneously, including:

- Level signals
- Interfering signals
- Doppler signals
- Ground signals

The signal type is defined by evaluation of the various reflection properties such as height, position, speed and direction of travel. These evaluation algorithms make it possible to reliably evaluate a signal reflection generated from the level even when it is beneath the mapped interference.

Dealing with Dust

In dusty environments it is common for buildup to appear on the level instrument horn and weaken the propagation of the signal transmission. The horn transmits the radar signal and can accumulate material buildup over time, interfering with the strength of the signal. A risk of strong buildup formation is possible in silos and bunkers, and the use of purge air attached to the horn (Figure 5) may be necessary.

A loss of echo or false high signal can occur at the “area of incoupling” of the

instrument; that is, the area in and at the edge of the horn. Advanced diagnostics in a modern radar level instrument solve this problem. An evaluation of the quality of the signal, measured in decibels at the time of installation, provides the baseline for a clean level measurement around the face of the horn (the “area of incoupling”). The operator uses a diagnostic block to set the established baseline and an allowable degradation in decibels. The operator can also set a range of allowable attenuation before the unit will fail or lock to a false high signal.



FIGURE 5. To combat dust buildup, an air purge can be attached to the horn of a radar level instrument.

The calculated value measured in decibels can be monitored in the control system and used to drive an output. The output of the device can either be an open collector or a 4-20mA signal that starts an air purge system. The air purge can be run as a predictive measurement, while a call for preventive maintenance eliminates excessive build-up around the horn area that can cause failure of the device.

The radar instrument itself can monitor the signal, check against the allowable attenuation values, and provide an alarm before the instrument fails or loses its signal.

Advanced diagnostics can also monitor various inputs:

- Linearized level (for irregular shaped vessels and strapping tables)
- Unfiltered distance (for fast changing processes to react without any algorithm dampening)
- Relative echo amplitude (to monitor the signal strength in relation to the measured level)
- Electronic temperature (to monitor the temperature influence)
- Terminal voltage (to check the quality of the wiring online for water ingress or corrosion)

Easier Replacement

Digital technology employed in most modern radar instruments makes replacement of an instrument easier. For example, the Endress+Hauser FMR57's display (Figure 6) stores instrument data so the display can serve as a data carrier, similar to a USB stick. In this way, the complete configuration settings can be easily transferred from one instrument to the next.



FIGURE 6. The display of an Endress+Hauser radar instrument stores all the instrument's parameters and transfers them to a replacement unit, simplifying maintenance and commissioning.

When a level instrument needs to be removed for maintenance, the display is simply connected to the next instrument. Activating the “duplicate” function transfers the parameter settings directly to the next instrument. This feature reduces the time required for commissioning new instruments.

Summary

Measuring level of cement, concrete and similar materials in silos has always been a problem for traditional level instruments such as ultrasonic and electromechanical devices. Radar level instruments have been widely used in the cement and bulk solids industries for many years, with great success. Recent developments in signal processing algorithms are making radar level instruments more accurate and reliable.

About the Author

Dean Mallon is national marketing manager for the level division at Endress+Hauser. Previously, he was the level product business manager and a rep owner/partner. He remains involved in various committees and is currently serves on the API 2350 5th edition working group.

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