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Meeting the Level Measurement Challenges at Lime Processing Plants

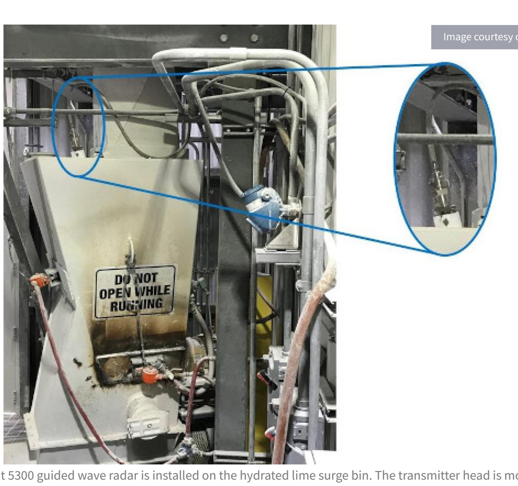

Figure 1: Emerson's Rosemount 5300 guided wave radar is installed on the hydrated lime surge bin. The transmitter head is mounted remotely to minimize the impact of vibrations.

For producers of lime, limestone, and clay products, automation is key to continuous production.

Kurt Gieselman, senior field sales specialist, Rosemount measurement products at Emerson | May 20, 2021

For producers of lime, limestone, and clay products, automation is key to continuous production. A range of instruments are used to help safely produce different products and provide accurate inventory measurements at each stage of the process, from when materials enter the facility, through to dispatch of final products. At most plants, various production techniques are used, with products crushed, ground into powders and heated in a kiln to create hydrated lime. Due to the processes involved and nature of the products, conditions in the plant are harsh. This creates a challenging environment for automation technology.

In general, the biggest instrument challenge producers face is obtaining reliable and accurate level measurements of solid materials. That includes measurement of the crushed and powdered limestone, coal in silos that feed kilns, and hydrated lime as it is produced. All these applications have challenging operating conditions due to the weight of the material, dust, and low reflectivity of the surface.

At a large lime processing plant in the US, the production team had tried several level measurement technologies to measure solids with varying degrees of success. If a device was able to make a measurement, then the next issue would be how maintain the device in operating conditions where dust, heavy materials, and vibrations are common. Correct installation was a key part of a successful measurement solution.

The first application at the plant involved a hydrated lime surge bin, where finished product passes through the bin before being conveyed to large storage silos. They wanted to run a screw conveyor to carry the material out of the surge bin at a steady rate. To do this, an optimal level height was needed but getting a stable reading was challenging. Within the small surge bin, the material tended to compress in some areas and to create gaps and bridges in other areas. To prevent this, pneumatic vibrators are used to shake and re-distribute the material. Previously, a capacitance probe had been used to perform the level measurement, but its measurements were erratic and slow to respond to level changes. In addition, the high vibration shortened the lifespan of the capacitance unit to only a few months. As the surge bin is only four feet tall, this made guided wave radar the ideal choice (see Figure 1).

A Rosemount 5303 guided wave radar (GWR) from Emerson was selected to replace the capacitance probes. Suitable for measuring liquids or solids, it was easy to configure the device for solids application using its software. For example, since the probe was installed parallel to the slope of the bin, the horizontal level measurement needed to be corrected for the slant by typing in the angle of the probe into the software. In addition, the device is available with a remote housing extension for mounting the transmitter head away from the probe. This protected the electronics from the vibration, helping extend the life of the device. A critical advantage of the GWR is its ability to provide accurate measurements in small tanks with rapidly changing levels, which is essential for this application and enables a steady level to be maintained. The device is proving to be reliable and maintenance free. The improvement in measurement accuracy has allowed the process to become more stable.

Coal used to heat the kilns is stored in 112-ft silos requiring a level measurement to monitor the inventory to ensure the kilns are always supplied with fuel (see Figure 2). Coal is pulled out of the two silos simultaneously and the measurements are used to determine when to order more coal. With no place to store surplus fuel, good inventory management is essential. The silo must be ready to receive the full amount of coal from the barge when it arrives. Receiving only a partial load is costly and inefficient.

Figure 2: New coal can only be ordered and delivered when there is available space in the large silos. This requires accurate level monitoring to support inventory management.

Previously, an ultrasonic level sensor had been used to perform the measurements in the silos. However, while the device functioned correctly most of the time, occasionally it would "lock up" and despite several work orders to investigate and eradicate the error, the cause was never determined. Because of the unreliability, there was a reluctance to empty the silo to less than 40%.

The production team decided to replace the device and Emerson engineers recommended the Rosemount 5408 non-contacting radar. Due to the height of the silo, a parabolic antenna was installed to direct the radar signals. An air-purging system would normally be applied to prevent dust from blocking the antenna, but since the coal was often wet, dust was not considered to be a problem. When installed, some initial adjustments were required to the threshold settings, after which the device worked well. However, as the weather warmed, the radar started to act in a similar way to the ultrasonic device, with short periods where it would lock up. One of the key features of the Rosemount 5408 is its standard built in data historian, which automatically collects and stores data for up to seven days, making troubleshooting much easier (see Figure 3). Using the data historian and its accompanying tank radar echo spectrum, large signal peaks were found close to the antenna area that corresponded to the times it locked on high readings. This insight to the change in process conditions was not available with the previous ultrasonic unit.

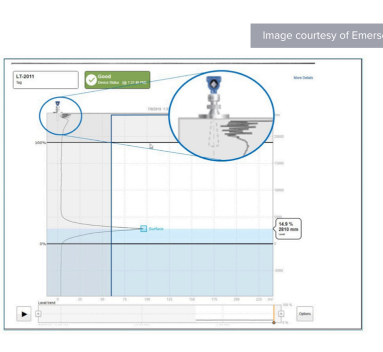

Figure 3: The Rosemount 5408 data historian provides a visual record of the measurements over time and shows where extra echo signal peaks appeared near the top of the coal silo due to the presence of moisture.

Inspection of the device during one of these peaks revealed that moisture was condensing on the antenna and causing the high-level readings. During the summer, the damp coal and high heat created a very humid environment in the vessel, with condensation occurring on surfaces. Air lines were installed to blow off the moisture and this eliminated the condensation issue. The radar has subsequently worked well, providing accurate and reliable measurements. Ultimately, a second radar was installed on the second silo with both a parabolic antenna and air purge system.

The third application challenge involved hydrated storage lime silos. Since the hydrated lime is a finished product, accurate inventory measurements are important as the product accumulates in the silos and is removed for sale. Hydrated lime is a fine dry powder that flows similar to a liquid. Whenever the silo is filled, the powder creates an internal dust cloud similar to a blinding snowstorm. The material is warm, with a slight static charge that makes it cling to surfaces. If the lime comes into contact with any moisture, it tends to form a hard, crusty layer that can be difficult to remove. To perform level measurements, the company had been using a competitive non-contacting radar, but with marginal results. Initially measurements seemed to be correct, but the readings would eventually start to drift. The existing radar used a Teflon cap attached to the antenna to help reduce buildup. However, buildup still occurred and the resulting readings became unstable, requiring the units to be cleaned. This required a maintenance engineer with the appropriate tools to climb over 200 steps to the top of the silo, remove the unit to clean the antenna. This occurred every two or three days and was not only time-consuming, but also hazardous, especially during inclement weather. Each occurrence cost about $50 per trip. While this cost seems small, over time it added up. Plus, each trip was a safety concern and took personnel away from other maintenance tasks.

The production team decided to replace the existing radar with a Rosemount 5408 and worked with Emerson to get the right solution. The access point for the radar was a 6-in. nozzle, which was too narrow for a parabolic antenna. The combination of silo height and low dielectric properties of the hydrated lime exceeded the range limits of a process seal antenna. Thus, a standard cone antenna with a flushing connection for an air purge was recommended (see Figure 4).

Figure 4: The Rosemount 5408 non-contacting radar provides robust measurements without the need for regular cleaning.

As this kind of application typically is very dusty and contaminating, recommendation was made to use a parabolic antenna with an integrated air purging system to keep the antenna clean. Other solutions may be to use either a 4-in. process seal antenna or a 4-in. cone antenna with air-purging option. The new radar has provided robust measurements without the need for cleaning for more than a year now. The radar has replaced daily hand dips of the inventory. By implementing this more reliable measurement device, the automation system measurements are verified with the manual measurements required in the monthly audits and plant operators are able to reconcile inventory mass balances.

After the first three applications were installed, configured, and monitored, the local instrumentation operators were becoming quite familiar with the radars, how they functioned, and were configured. With the support of Emerson and their own on-site experience with the radars, the local operators were able to set up the next application themselves. This application was a large 98-ft-high lime fines silo (see Figure 5). This silo was fed directly from the crusher and supplied lime to the kilns for production of the hydrated lime. The company had been using an ultrasonic device, but it was unstable, unreliable, and inaccurate. The application is challenging due to the amount of dust created, but with using a parabolic antenna and air purge option, the new solution has resulted in a very reliable and accurate measurement.

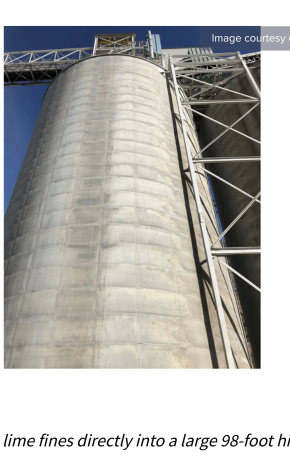

Figure 5: The crusher feeds lime fines directly into a large 98-foot high silo.

The final application involved the measurement of a specialty hydrated lime product on a rail car load out system surge bin. Previously, the product was loaded into trucks and transferred to rail cars. In their new system, the hoppers feed directly into the rail cars, but the product must be measured accurately for billing purposes. Measurement is difficult because it is taken while moving through a 14-ft narrow hopper. Not only is the environment very dusty and the product light and aerated, but the hopper also fills very quickly. Emerson's Rosemount 5408 level transmitter was chosen due to the success on the same product in larger storage silos (see Figure 6). The device accurately tracks the measurements ensuring that railcars can be loaded directly for shipment to customers. The new system has eliminated the step with the truck trailers, making it more streamlined and responsive to order fulfillment.

Figure 6: The Rosemount 5408 transmitter used for the hopper.

Critical to the success of these challenging applications, was the deployment of advanced radar technology combined with supporting advice as to the right installation options needed to maximize performance and reduce long-term maintenance. Also important was how the software for each device was able to simplify the setup for each application and provide clear indication of performance and any adjustments needed.

By having more reliable level measurements, the plant is not only able to efficiently schedule the delivery of raw materials such as the coal, but can also track movement of lime products throughout the plant. By reducing maintenance requirements and manual measurements, and eliminating downtime due to problematic devices this has also increased personnel safety. With more accurate measurements, there is greater assurance of the amount of final product being delivered to the rail cars, ensuring accurate billing and satisfied customers.

Capacitance vs Guided Wave Radar

Capacitance probes have been used within solids level measurement applications for many years and are often chosen based on user familiarity and cost. GWR and capacitance probes look similar, with both having a probe inserted into the vessel and an electronics head providing power and output. The level measurements are obtained quite differently. With capacitance probes, the measured material creates a capacitance as the level changes, with the capacitance reading proportional to the level. If the dielectric properties of the material change, then the proportional level measurement will also change. The measurement can be affected by coating on the probe, air gaps and material compaction.

With GWR, a pulse sent down the probe is reflected off the surface of the material back to the electronics. The time taken for the pulse to reach the surface and back is used to calculate the material level. Changes to the material properties have no effect on the measurement (see Figure 7).

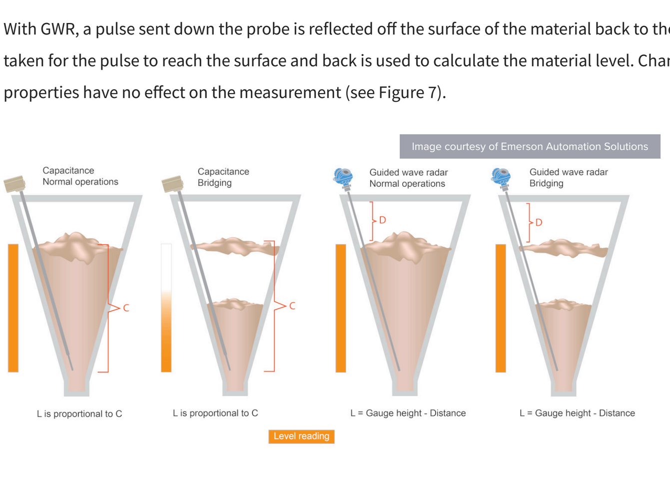

Figure 7: This diagram illustrates the effect of bridging on the level measurement. Using a capacitance probe, the level measurement is impacted by the large air space below the surface. This causes the level reading to appear lower, which in turn can lead to an overfill. GWR is not impacted by changes below the surface.

Ultrasonic vs Non-contacting Radar

Ultrasonic and non-contacting radar also appear visually similar, incorporating an electronics head and through the air sensor. Both technologies transmit a signal to the surface and time it takes for the reflected signal to reach the antenna enables the distance to the surface and level to be measured. The key difference is the speed of the signal, whereby ultrasonic signals travel at the speed of sound and radar at the speed of light. Thus, anything in the vapor space that impacts the travel time will impact the accuracy of the measurement. This includes temperature, dust, and vapors and air purges. This can be significant at the low speed of the ultrasonic signal, but negligible for radar. Another key difference is that radar operates at much higher frequency than ultrasonic, which allows the radar to penetrate through the dust and vapors.

Emerson's Rosemount 5408 is a mid-frequency non-contacting radar based on frequency modulated continuous wave technology that sends a focused signal to the surface that can penetrate through the vapor space and measure the surface accurately. The mid-range 26 GHz frequency is optimal for typical process level application challenges, including condensation, turbulence, nozzles, product build-up, foaming, agitators, and solids. In addition, it has a built-in algorithm for measuring the inclined solids surface. In solids applications with an inclined surface, there can be clusters of multiple small peaks. Using the algorithm, these smaller peaks are combined to create a more robust surface peak.

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