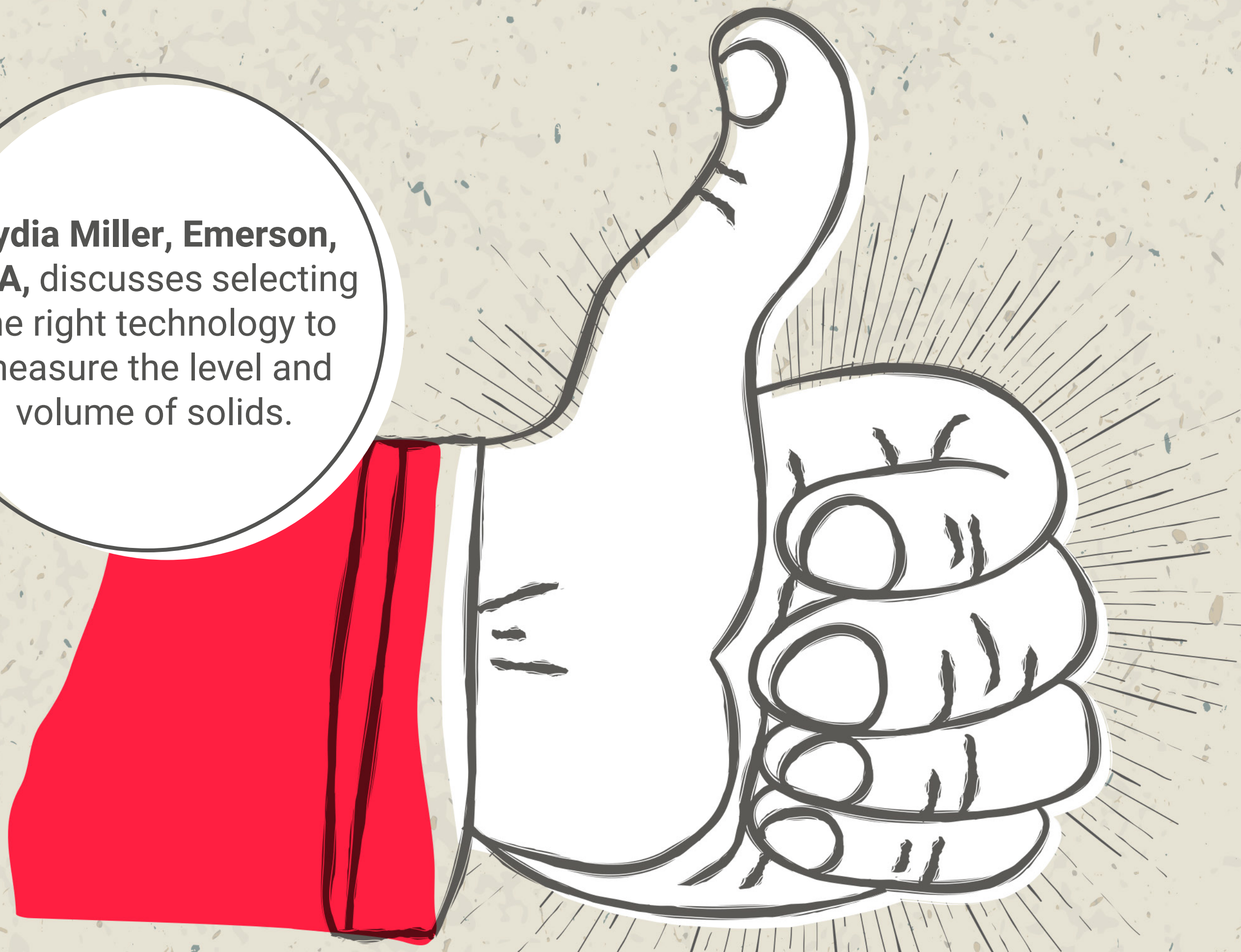
THE RIGHT STUFF

Lydia Miller, Emerson, USA, discusses selecting the right technology to measure the level and volume of solids.



Measuring the level and, subsequently, the volume of solids, is more complex than simply measuring liquid level. When determining liquid level, there is only the need to measure a single point on the surface, because the level will be identical at any point within the vessel. With solids, however, the material surface consists of a multitude of peaks and troughs that constantly shift as the vessel is filled and emptied. Depending on how much material piles up before sliding, along with the vessel's width, the difference between the level of a peak and a trough can be up to 100%.

For many years, mechanical devices such as yo-yos – in which a length of wire lowers a weight onto the surface of the material – have been used to perform solids level measurement. However, these systems require regular maintenance, which can expose personnel to hazardous conditions on tall silos, and their accuracy, reliability and repeatability of measurement is limited. Also, if the weight breaks free, it can damage machinery downstream. Such mechanical measurements can be performed by automated means or manually. Often, manual measurement methods continue to be used because that is the way it has always been done or because there are concerns with using or implementing an automated system. However, significant progress has been made with automated systems for solids measurement, and many operators of modern production plants have upgraded to continuous automated measurement technology. Today, integrating automation into solids measurement can improve safety, reliability and repeatability, and enable accurate continuous measurements to be accessed from remote locations such as a control room.

Figure 1. Significant progress has been made with automated systems for solids measurement, with operators upgrading to continuous automated measurement technology.

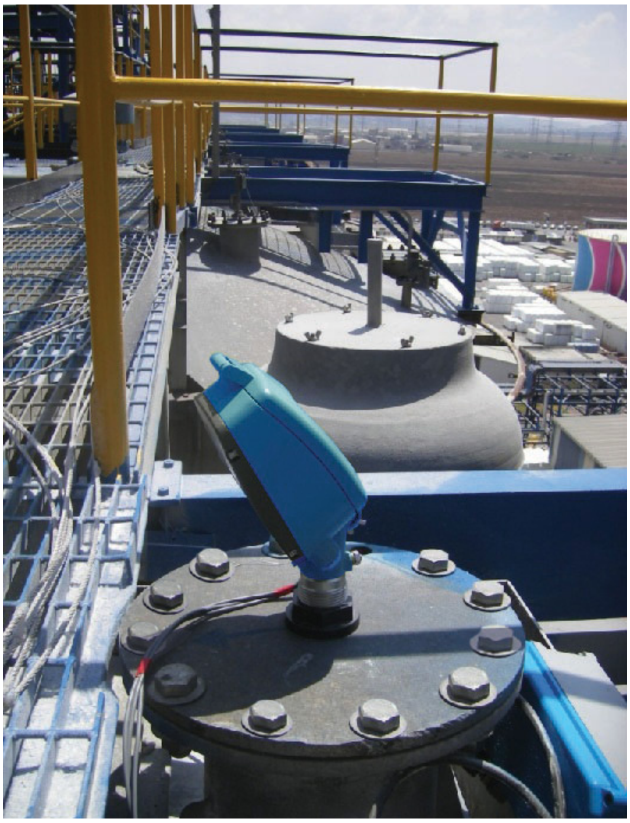


Figure 2. Safety, reliability and repeatability can be improved by integrating automation into solids measurement.

Automated measurement technologies

The appropriateness of the various automated technologies for solids measurement is application-dependent, and these can be split into two main types. The first is continuous level measurement in smaller vessels used to control a production process or ensure that there is material available. In such applications, rapid changes in surface level can occur due to the speed at which material enters and exits the vessel. This requires technology that can perform rapid level measurements and respond to these changes quickly.

The second application type is volume measurement of solids in larger vessels or warehouses used for bulk storage, which is often related to inventory control. Here, there is a much greater surface area to monitor, and inaccurate measurement can lead to a huge discrepancy in product volume. As the surface level changes much more slowly, device speed is less relevant, but greater accuracy is required to support better inventory management.

There are several automated technologies used for measurement applications, but the most widely applied for solids measurement are guided wave radar, non-contacting radar and acoustic phased array antennas.

Guided wave radar

Guided wave radar (GWR) transmitters provide continuous level measurements. Based on microwave technology, they are especially well-suited for applications involving smaller vessels with a diameter of less than 33 ft (10 m) containing powders and small granular materials, and where the installation area is restricted. Probe end projection functionality can be used to allow for measurements when the surface pulse is too weak to be detected. This commonly occurs when the material dielectric constant is very low, especially in combination with a long distance to the surface or electromagnetic interference. Dielectric constant refers to the electrochemical property of a fluid related to the fluid's ability to transmit electrical charges from one body to another. When the material's dielectric constant is low, only a portion of the electrical signal is reflected off the top of the material. The rest of the signal continues down the probe.

When the signal reaches the end of the probe, there is a strong reflection. Since the microwave signal propagates slower in the material than it does in air, this echo is seen at a distance further than the actual probe end. The actual probe length, the probe end reflection echo location, and the dielectric of the material can be used to calculate the level of the material when the initial reflection from the top of the material is not strong enough to make a direct reading. This function is recommended for solids with a dielectric constant less than or equal to two, such as perlite or plastic pellets.

In solids applications, the material can cause down-pull forces on vessel roofs, so the roof must be able to withstand the maximum probe tensile load, which depends on silo size, material density and the friction coefficient. Forces increase with the buried length, the vessel width and the probe diameter. A flexible single lead probe is the most suitable choice for GWR in solids applications, as long as the tensile load is properly calculated and the most appropriate cable thickness is used.

Non-contacting radar

Non-contacting radar transmitters also provide continuous level measurements, but there is no contact with the material surface. Pulse radar or frequency modulated continuous wave (FMCW) techniques are used to perform the measurement. FMCW devices can improve the measurement of solids compared to pulse transmitters because they continuously send out microwave energy, meaning the total amount of energy spent at the surface will be much higher. In practice, this means FMCW transmitters are much better than pulse devices at determining weak echoes within a noisy environment. FMCW devices also have much higher resolution than pulse radars. In solids applications, sloping surfaces deflect energy away from the radar and can generate several small reflections. By using a measurement algorithm that merges the peaks of an uneven surface, the latest FMCW transmitters can provide high reliability even with rapid changes in level.

Non-contacting radar devices still see only the portion of the surface within their beam angle. Like GWR transmitters, this makes them a suitable choice for applications using smaller vessels or silos, where fast movements are possible, but accurate volume measurements are seldom needed. Unlike GWR, however, there are no restrictions with respect to the weight of the material and pull forces.

Acoustic phased array antennas

Acoustic phased array antennas, often used in 3D solids scanners, generate a mixture of three audible or acoustic signals, including one dust-penetrating, low frequency acoustic signal, and receive multiple echo signals from the contents of a storage vessel. Digital analysis of these echoed signals produces accurate level and volume measurements by mapping all the signals across the entire surface within the beam angle of the device. The wide beam angle produced by acoustic phased array devices is particularly suited to very large vessels in bulk storage inventory applications.

Matching the received data with known vessel dimensions allows 3D solids scanners to calculate product volume, enabling the immediate and accurate listing of inventory value for accounting and financial reports. It also allows for annual or rolling inventory measurement, to help prevent the over-purchasing or under-purchasing of products. Efficient inventory management optimises stock control and ensures that capital is not tied up unnecessarily.

Emerson's Rosemount™ 5708 3D Solids Scanner is an acoustic phased array device that not only provides continuous online volume measurement, but also offers visualisation of the peaks and troughs within vessels. This is important because uneven sidewall loading can cause a bin or silo to collapse with potentially catastrophic consequences. By showing how the material is distributed within the vessel, 3D mapping helps to prevent the threat of structural damage, as well as optimise storage capacity and improve production efficiency. As 3D mapping is displayed on remote computer screens, personnel do not

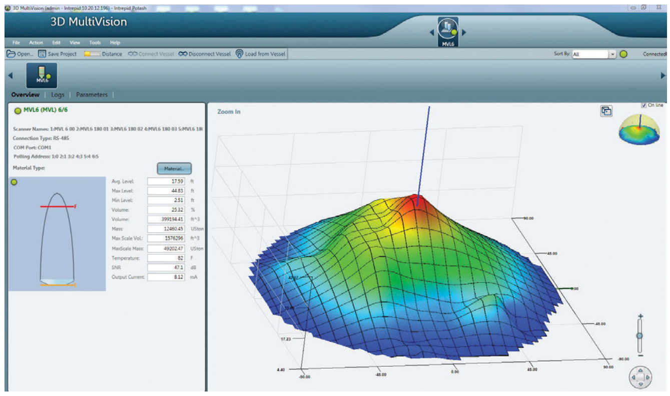


Figure 3. Emerson's Rosemount 5708 3D Solids Scanner offers visualisation of the peaks and troughs within vessels.

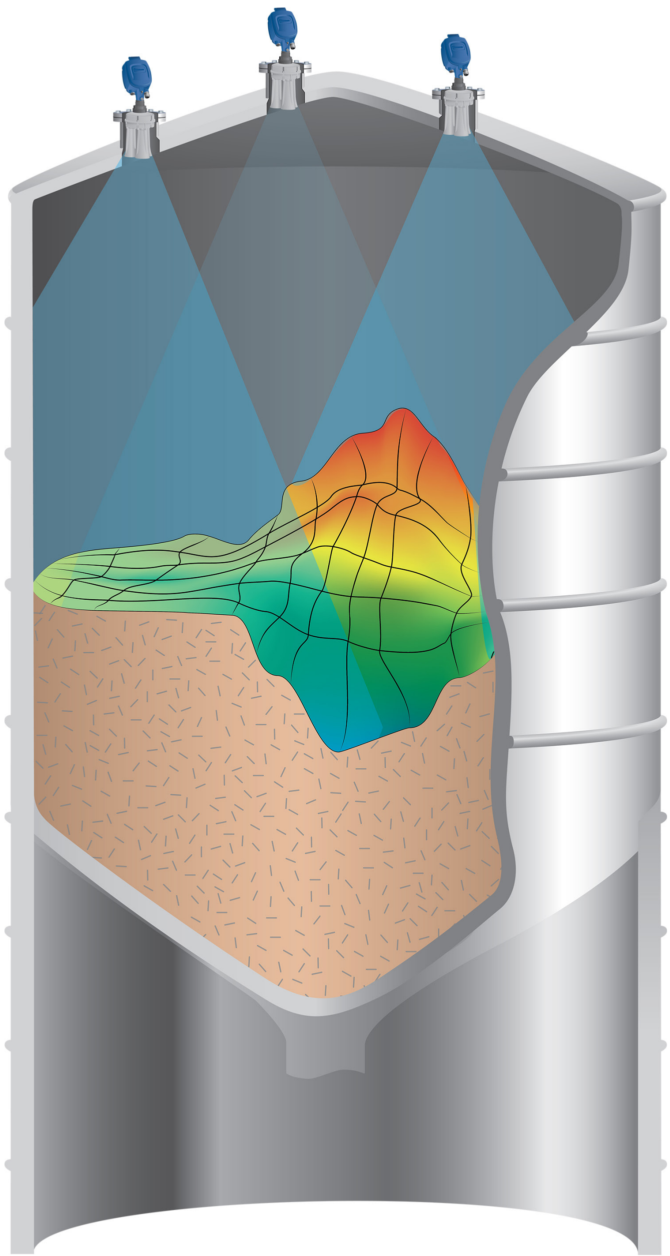


Figure 4. In very large storage warehouses or irregularly shaped silos, multiple 3D scanners can be used to provide the necessary level of control.

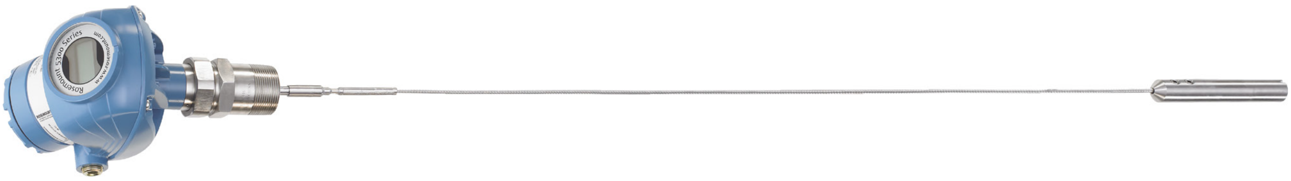


Figure 5. Guided wave radar transmitters are especially well-suited for applications involving smaller vessels containing powders and small granular materials, as well as where the installation area is restricted.

need to climb on vessels, thereby reducing the risk of accidents and exposure to harsh conditions.

Measurement variables

There are certain variables that can affect accuracy and reliability in solids measurement, so it is important to select the right technology in each case. These variables include the following:

Uneven surface

Non-contacting radar transmitters are most affected by uneven surfaces, since much of their signal is not reflected directly back and, instead, may be redirected away from the device. To compensate for this, the device gathers several smaller echoes within the radar footprint and merges them into a single echo, creating an effective way to decipher between the surface echoes and noise. With GWR transmitters, the microwave signal is less affected by uneven surfaces since it is guided by the probe. Acoustic phased array technology is not affected, and it triangulates all the measurements over a wide surface area, resulting in greater accuracy.

Dielectrics and bulk density

For radar technology, the dielectric constant of solids is a key indicator of the amount of signal that will be reflected and, therefore, the possible measuring range. However, devices based on radar technology are not affected by bulk density (weight of solids divided by total volume). Acoustic technology, on the other hand, is not affected by dielectric properties, but can be affected by bulk density, although most solids materials do not absorb enough of the acoustic signal for it to be an issue.

Dust

A considerable amount of dust can be created during the fill cycle in solids applications. Radar and acoustic phased array technologies can both handle dust in the vapour space well, but a heavy layer of dust on the antenna can block the signal. With non-contacting radar, an air purge system may be required. However, some users may be reluctant to use air purging due to the cost of maintaining the air flow, or the fact that air purging may disturb the process. An alternative solution is provided by devices with a process seal antenna. With GWR, the natural flexing of the probe can knock off excessive dust build-up. The fact that acoustic devices operate at lower frequencies is an advantage in dusty applications, because low frequency sound waves are absorbed less than high frequency sound waves as they travel through dust.

Condensation

Condensation is present in many solids applications, so consideration needs to be given to its effects on the technology. Condensation can also tie up dust and create a layer on wetted parts. GWR is not affected by condensation, although build-up on the probe could affect readings. Signal quality diagnostics provided by the devices can monitor this. Non-contacting radar may need air purging or a process seal antenna to cope with condensation-related issues. Acoustic phased array technology includes self-cleaning functionality, which reduces the need for maintenance. Using a PTFE (teflon) antenna further reduces maintenance requirements.

Noise

Many solids applications are noisy environments, but sound has no effect on radar-based devices. Acoustic devices are impacted by noise around the 2.3 kHz, 4.5 kHz and 7 kHz frequencies. However, it is rare that all three frequencies are disturbed at the same time, and an acoustic phased array device can work even if two frequencies are compromised.

Electrostatic discharges

In some applications, such as plastic pellets, electrostatic charges can build up and eventually discharge. GWR is the most suitable technology for these applications. While their electronics can tolerate some static charge, providing a good earth ground for the electronics by anchoring the end of the probe to the vessel will create ground paths for discharge away from the electronics.

Open air applications

In these applications, there are no walls or roof on which to install instruments, so the biggest challenge is finding an installation point. Protection from external factors such as wind and rain can also be a challenge. Non-contacting radar devices are often recommended in these applications, as they are not affected by outdoor conditions. Acoustic devices are also a viable option for open air applications, as long as the wind speed is below 18.5 mph (30 km/hr).

Support and guidance

With so many factors to consider when selecting an automated solution for a specific solids measurement application, it is useful for plant operators to be able to call on expert support. Automation technology suppliers who can offer a broad range of instrumentation are perfectly placed to guide users on selecting, installing and implementing the most appropriate technology. DB