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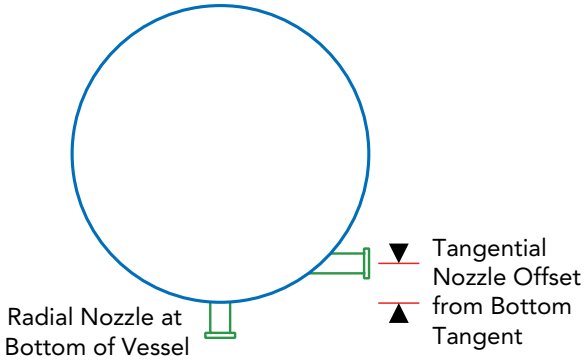
Get to the Bottom of Level Limitations

Positioning the lowest tap for a measurement demands care

By Andrew Sloley

The most-common technologies for liquid level measurement use either a differential pressure reading or a displacer with a buoyant force to infer liquid level. In both cases, the device must see into the vessel via level taps or nozzles. Vessel fabrication requirements can restrict the placement of such taps. A recent case of specifying a horizontal separator highlights one of these limits.



HORIZONTAL VESSEL CROSS-SECTION
Figure 1. Two options for the lowest level tap are a nozzle on the side offset from the tangent or a nozzle right on the bottom.

That vessel could accumulate liquid condensate from a gas system. Nominally, the vapor was liquid free. Nevertheless, due to upstream upsets, heat loss or other operating conditions, small amounts of liquid could collect; the liquid rate was assumed to be very low.

Operators would inspect a local level indicator on a schedule and then drain the vessel to a closed system as needed. Ideally, only a little liquid would accumulate, so a very small capacity drain system would suffice.

Vessel Inner Diameter, ft	Minimum Distance Above Tangent for 1–2-in. Nozzles, in.
3 < 3½	1½
3½ < 5	2
5 < 6½	2½
6½ < 7½	3
7½ < 8½	3½
8½ < 10	4
10 < 11	4½
11 < 12	5
12	5½

Table 1. Appropriate distance increases as vessel diameter goes up.

RECOMMENDED PLACEMENT

The facility wanted to spot even the first small amount of liquid. This would ease troubleshooting and detecting upstream upsets. Dead volumes would hamper identifying the shift in which an upset occurred.

Figure 1 shows a cross section of the horizontal vessel. Ideally, the level instrument would use a tap on the side of the vessel tangent to the bottom and a higher liquid tap. However, as Figure 1 indicates, the lower level tap is offset. Rather than being aligned with the bottom of the vessel, the nozzle instead is a distance above.

A nozzle exactly on the vessel tangent can pose two mechanical issues, one for the vessel and the other for the nozzle.

Installing an exact tangential nozzle demands relatively long welds and special construction. This is particularly true for small vessels. Moving the nozzle up slightly, off the tangent line, makes vessel fabrication easier and cheaper.

Also, a nozzle exactly tangential to the vessel requires a long horizontal distance to add space between the vessel wall and the side of the nozzle flanges. Shifting the nozzle away from the tangent puts the nozzle in a location where the curve of the vessel moves away from the nozzle flange; this makes the nozzle shorter.

Table 1 lists recommended minimum distances off the tangent for different vessel diameters. As the vessel gets larger, the unmeasured space below the lower nozzle can become large.

An alternative configuration (also shown

A nozzle on the vessel tangent can pose mechanical issues.

in Figure 1) puts the lower nozzle on the bottom of the vessel. This eliminates the problem of the dead volume. However, it makes the nozzle susceptible to blockage from sediment, scale or debris that falls to the bottom of the vessel.

While differential pressure cells can work with nearly any nozzle configuration, displacers usually function best with an external level well added. The external level well opens up the possibility of using other technologies, such as mechanical and magnetic float ones, as well.

In all cases, sensible equipment specification requires taking things such as nozzle minimum clearances into account. Equipment specification must consider not just process needs but also mechanical and cost constraints. The wise engineer understands both the process and the mechanical requirements. In this particular case, the need to measure levels close to the vessel bottom may conflict with mechanical requirements of keeping a minimum offset for the nozzles.

Eventually, we opted to use a nozzle attached to the bottom of the vessel because this would provide the most reliable reading of low liquid levels. ●

ANDREW SLOLEY is a contributing editor for *Chemical Processing*. Email him at asloley@putman.net.

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Consider FMCW Radar for Level Measurement

Technology helps plant continuously monitor inventory in dust-prone environment

By Joe Incontri, Krohne, Inc.

A company that manufactures and processes polyvinyl chloride (PVC) stores a variety of PVC shapes in several slim silos reaching heights of more than 65 ft (20 m). It supplies product for production as well as for third parties. In addition to PVC powder and PVC granulate, the silos also store regenerated PVC extracted from old shredded products.

MEASUREMENT REQUIREMENTS

The level in the silos (Figure 1) must be measured continuously to ensure a reliable production supply. The atmosphere is extremely dusty, and the PVC dust is very sticky. Level measurement previously was done using ultrasonic devices, but this method often failed because of the great amount of dust buildup and signal interference in the ullage space.

TALL SILO ISSUES
Figure 1. Tall, narrow silos prove challenging for level measurement as the PVC dust builds up and is sticky.

The atmosphere is extremely dusty, and the PVC dust is very sticky.

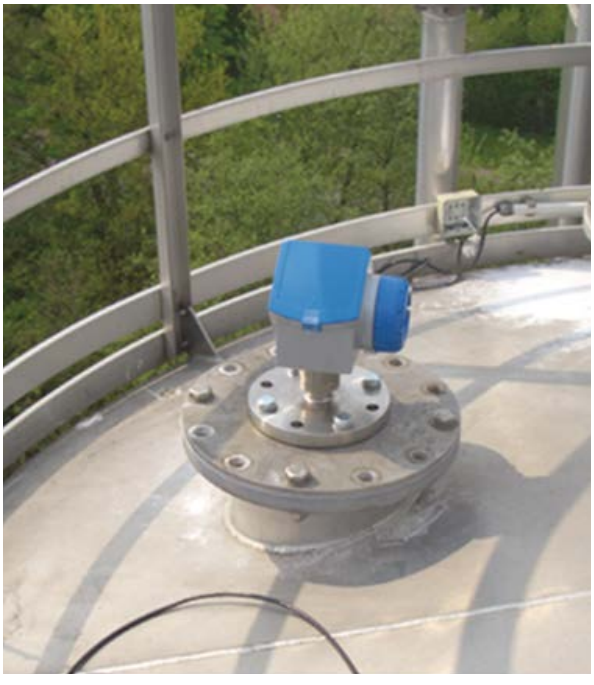
Furthermore, because no compressed air supply had been installed on the tanks to flush the antenna, the customer was interested in noncontact radar measurement that did not require antenna cleaning. To find a suitable device, radar measuring devices from different manufacturers were installed as test units.

THE WINNING DEVICE

After the tests were completed, the company selected a frequency-modulated continuous wave (FMCW) radar level measurement instrument for use in these applications (Figure 2). When it came to the antenna, it chose a 3-in. (80-mm) polypropylene drop-shaped antenna (designed specifically for solid applications) for the irregularly shaped PVC granulate silos. It selected a larger drop antenna measuring 6 in. (150 mm) in diameter for the particularly minimally reflective PVC powder tanks because the antenna features an even greater dynamic signal strength than the smaller diameter version, which the fine powder substance requires.

FMCW is one of two popular radar level measurement techniques. When compared to the pulse method, it features a wider dynamic range and better signal strength, and those advantages benefit these types of challenging solids and powder applications as well as difficult process liquid level tanks and reactor vessel applications.

The unique drop antenna (Figure 3) has proven beneficial in powder applications because it is somewhat self-cleaning. Perhaps more important, it focuses the available signal more than a horn can,



FMCW RADAR
Figure 2. A frequency-modulated continuous wave radar gauge was installed on top of the silo. This measurement technique offers better signal strength and improved dynamic range.

which also improves performance in tall, narrow vessels.

ACCURATE, MAINTENANCE-FREE OPERATION

In the comparative test, these devices provided a reliable and stable measurement for all PVC granulate shapes, especially at low tank levels even without an antenna aiming kit, which had been necessary for the older instruments. Aiming kits were needed only for the extremely fine PVC powder applications to ensure more stable measurement. After the radar was set at startup, the antenna needed no further aiming adjustments.

Even though the PVC dust sticks permanently to the antenna, the egg-shaped solid design prevents any negative impact on measurement. Thanks to the antenna's large radiating surface and the measured PVC product's low dielectric value, the radar wave can pass through easily with minimal effect on the signal strength so no antenna flushing or special antenna dust protection is required, They effectively are maintenance-free during operation.

DROP ANTENNA
Figure 3. The drop antenna shape is unaffected by powder buildup, resulting in reliable signal strength.

This setup allows the company to monitor the level in the silos at any time. It also eliminates any chance of running on empty and thus putting the production processes at risk.

JOE INCONTRI is director of marketing, North America for KROHNE, Inc. Email him at j.incontri@krohne.com.

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3D Level Sensors Help Address Storage Challenges

Technology and software advances provide greater visibility into a vessel's inventory

By Jenny Christensen, BinMaster

For almost a decade, 3D level sensors have been providing highly accurate level and volume measurement in challenging materials contained in bins, tanks and silos. The only type of sensor to both measure and map a material surface, the 3D scanners send pulses in a 70° beam angle, taking multiple level measurements and accounting for uneven surface topography when calculating volume.

Sensor data is fed to software that reports the lowest and highest points detected; the average level is based on a weighted average of all measurements in the bin. Some models — such as BinMaster's MV and MVL 3DLevelScanners — feature colorful graphical representations indicating where high and low spots exist in the silo (Figure 1).

3D scanners keep pushing the boundaries — and addressing the concerns — of increasingly complex storage operations. This article shares a few of the newest innovations.

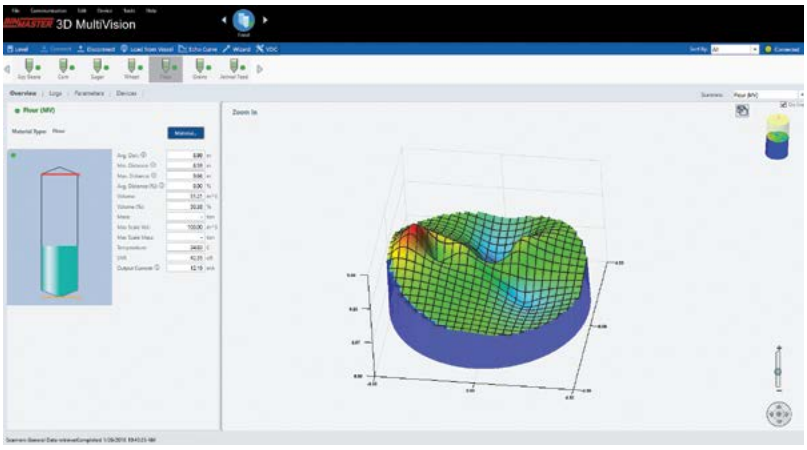
VIEW MULTIPLE SILOS ON A SINGLE SCREEN

Inventory management affects multiple departments across a chemical processing operation. Plant personnel need accurate volume to manage storage and sales, and finance needs accurate valuation for financial statements.

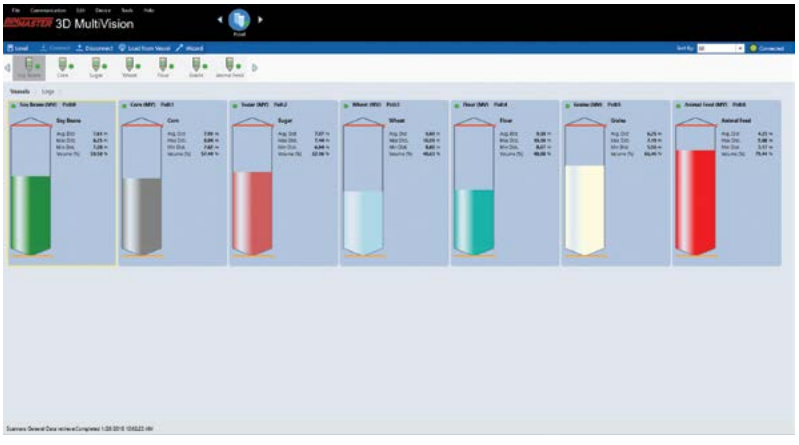
3D scanners integrated with software systems such as BinMaster's 3D MultiVision provide corporate-wide visibility, enabling users to view data for multiple vessels in a single window (Figure 2). Vessel grouping

features and level alerts allow users to customize information to meet their needs, improving efficiency, especially in large operations.

Windows-based software can be configured for 24/7 access via an organization's Local Area Network (LAN). Using advanced multi-view software with a 3D scanner can make it easy for multiple users at varying locations to view level and volume data. Additionally, software with permission-based roles make it possible to share real-time inventory data across an entire organization — or with vendors using vendor managed inventory (VMI) — on a need-to-know basis, ultimately improving purchasing, logistics, operational decisions and financial management.



DETAILED INFORMATION
Figure 1. Users can get specific details about minimum, maximum and average volume and see the 3D visual.



MULTIPLE SILOS ON ONE SCREEN
Figure 2. Users can look at multiple silos on a single screen, getting an overview of inventory for their operation.

DETECT AND ALERT TO CENTER OF GRAVITY DANGER

Powders are known to build up on sidewalls and pile unevenly in storage vessels. Not only does this make monitoring the volume of material inside a vessel challenging, but uneven material disbursement can take its toll on the storage vessel itself.

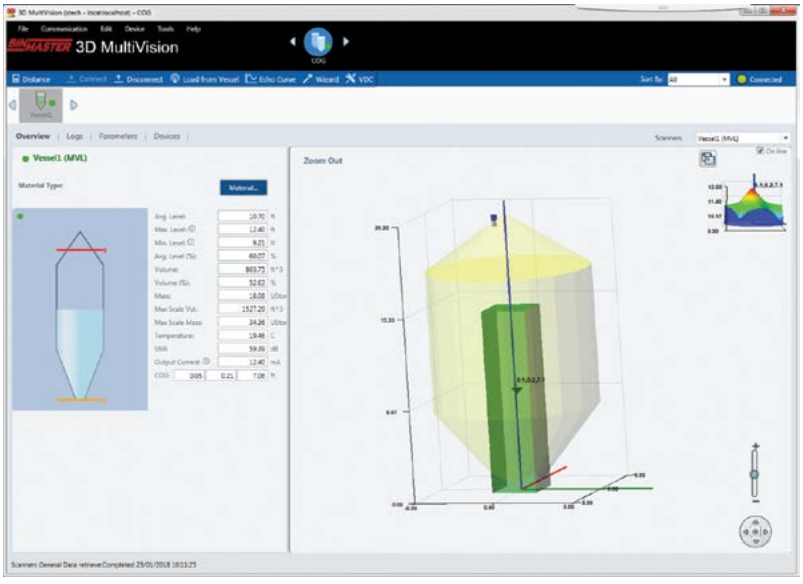
Over time, silo walls have been known to wear or fail, causing cracking, denting, buckling and bending. In the most severe cases, it can lead to catastrophic silo collapse.

For plant operations that want to detect uneven

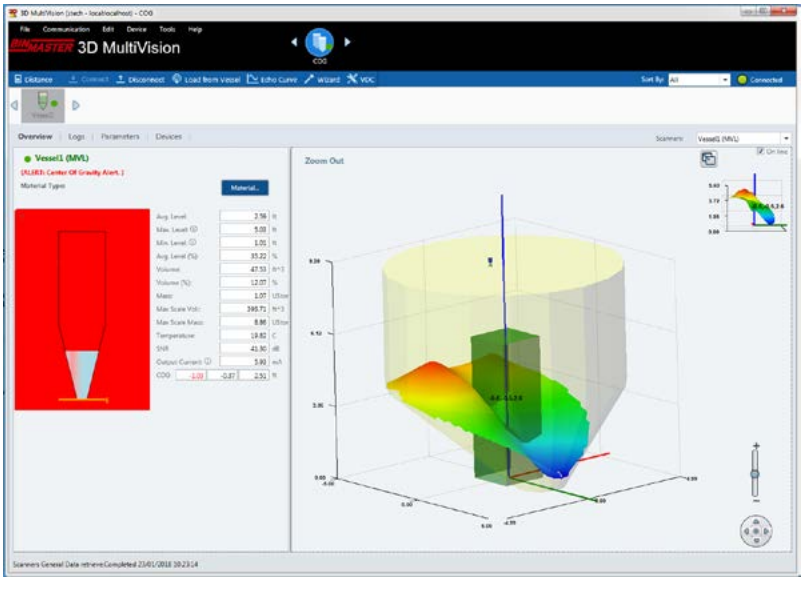
loading of silos that contributes to structural wear or failures, 3D level sensors can identify the center of gravity's location, display it graphically via software and alert when the center of gravity falls outside of a predefined area (Figure 3).

A 3D level sensor is mounted on the roof of the silo in an optimal location to view the material surface. Level measurements are used to determine the X, Y and Z coordinates of the center of gravity based on the material topography. The coordinates are processed using advanced software features. Users define the alert parameters and accepted area into which the center of gravity must fall. A 3D visual will indicate where the center of gravity is located and show whether the current center of gravity falls in the acceptable area (Figure 4).

Operations can use this unique solution to help reduce structural stress

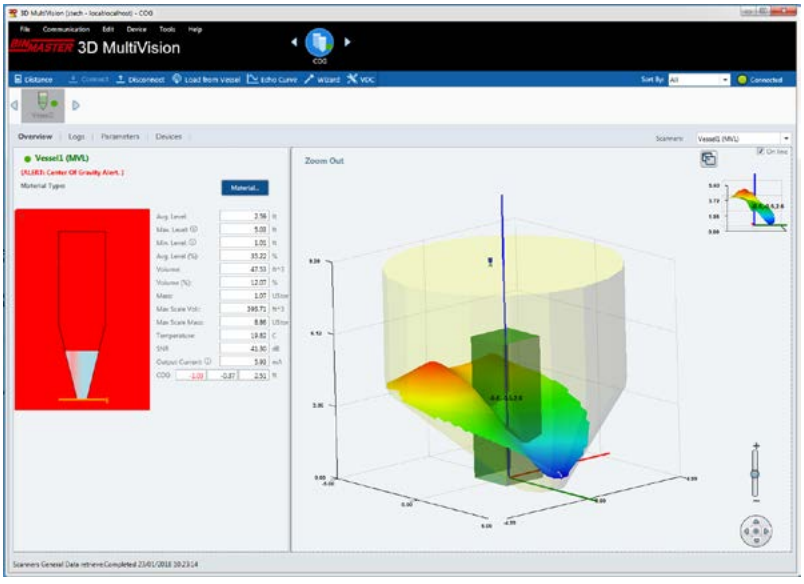


EVENLY DISBURSED MATERIAL
Figure 3. The 3D graphic indicates material is disbursed evenly and the cone is up. The average, minimum and maximum levels are displayed, along with the volume and mass, volume as a percentage full, the maximum volume, and the acceptable zone for the center of gravity is indicated in green.



UNDESIRABLE CENTER OF GRAVITY
Figure 4. The 3D visual indicates that material has built up on one side of the vessel. The center of gravity has fallen outside of set parameters and displayed in red. Plant operations or maintenance can be alerted to aerate or clean the vessel before damage occurs.

when loading or emptying a silo. It is a valuable preventive maintenance tool that can alert to the need for inspection or cleaning. Use over time can prolong silo integrity and create a safer environment by identifying potential structural stress caused by uneven loading.



UNEVEN PILES IN A SILO SEGMENT
Figure 5. This illustration shows material piled unevenly in a silo segment and how the 3DLevelScanner measures multiple distances across the material surface to account for irregularities when calculating volume.

MEASURE VOLUME IN A WEDGE OR PIE-SHAPED SILO

The use of segmented silos for storage can be beneficial for both space and flow; however, tracking inventory by volume in these irregularly shaped spaces can be tricky, especially for materials that want to build up along the interior walls or the outer silo perimeter. New technology exists that provides more accurate volume data to plant operations or purchasing personnel burdened with managing inventory in pie-shaped segments of silos. 3D level sensors can measure and model the topography of material contained in these unusual pie-shaped wedges (Figure 5).

Other measurement sensors, such as non-contact radar, guided wave radar or weight-and-cable style sensors, measure only a single distance in these formidably shaped segments. The location of the filling or emptying points or lack of material flow can result in uneven material piling, which could cause inventory estimates based upon a single measurement to be inaccurate.

By comparison, the 3D sensors map the material surface accounting for variations or buildup and then factor in the radius and height of the segment being measured, making the volume accuracy very precise.

Using a system that provides accurate data about the amount and dollar value of material on hand

can help reduce safety stocks, increase inventory turns and pay for itself by freeing up cash that could be tied up in inventory. Additionally, buildup on the outer perimeter of the silo segment or along on the interior walls of each segment can be detected, accounted for in inventory and addressed by maintenance if needed. The same 3D sensor can be used for either segmented or round silos, making it a versatile choice over its long sensor life.

TEFLON-COATED SENSOR FOR CLINGY MATERIALS

For materials that want to cling to the sensor, a Teflon-coated transducer can be a great option. The Teflon coating resists dust buildup, ensuring the scanner performs optimally in challenging materials such as powders or solids that generate excessive dust when the bin is filling or active. This special finish also extends the maintenance cycle by significantly reducing the need to clean the device after prolonged periods of use.

Some common applications for a Teflon-coated transducer include powdered materials that are prone to cling to surfaces. It is especially appropriate for chemical processors in industries such as detergents and industrial cleaners, pesticides and food additives in which cross-contamination is a concern. Manufacturers of coatings, inks and polymers also will benefit from the Teflon-coated 3D level sensors' non-stick properties.

In 2009, 3D scanner technology started a revolution in precise inventory management. This evolution continues to address the unique needs of industry as the worlds of sensor hardware and software intersect with new solutions. ●

JENNY CHRISTENSEN, MBA, is the vice president of marketing for Garner Industries, home and manufacturer of BinMaster Level Controls. She can be reached at jchristensen@binmaster.com.

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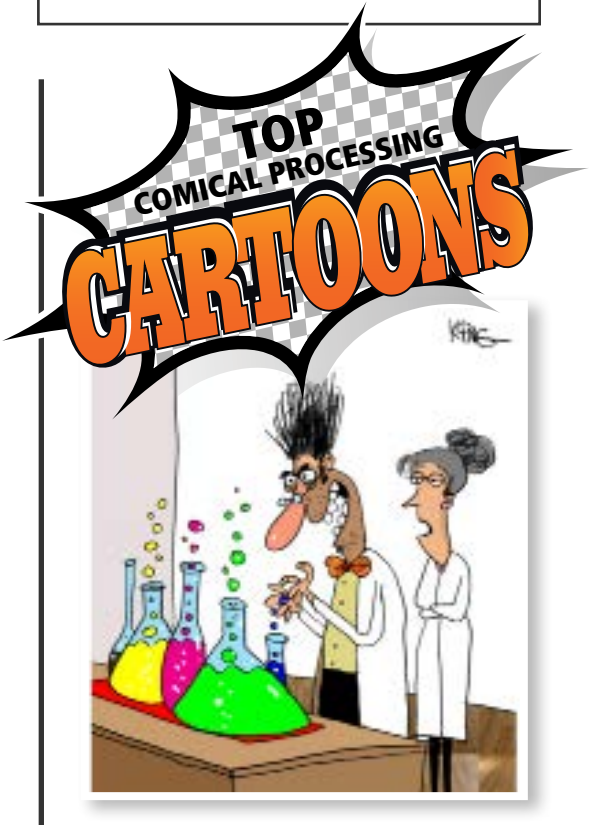

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