What's in My Bin?

20' HEADROOM?

40' VOLUME?

80' MASS?

Understanding Accuracy in a Bin Level Monitoring System

When it comes to monitoring inventory in bins, tanks and silos, one of the first questions often asked is "How accurate is it?" Unfortunately, that's a loaded question that can't be answered easily. Here we discuss why it's a tough question and what you can and cannot expect from your level monitoring system.

Accuracy of a Single Point Inventory Measuring System

One consideration is the type of device you're using to measure the material level. Bobs, guided wave radar, open air radar, and ultrasonic level sensors are commonly used devices. What they all have in common is they all measure a single point in the vessel. Although each device has its pros and cons (see our paper on Selecting Continuous Level Sensors), when installed properly they all perform well to their stated or printed measurement accuracy that appears in their literature.

But, what does printed measurement accuracy mean? For a single point measurement device the printed accuracy stated on a web site or in the literature is the distance measured from the sensor on the top of the tank to the material surface. This distance is often referred to as headroom, because it tells you how much space you have left in your bin. So, the printed accuracy is the accuracy of that distance in feet or meters. That one measurement is generally highly accurate within ± 0.25% of the total distance measured. However, this is not the accuracy of the volume or mass of material in the bin; it is simply the accuracy of that one measurement of distance.

Volume

Volume is very different than level. Volume is the amount of three-dimensional space the material takes up. When using the distance measured from the sensor to the material surface to estimate volume, the calculation is based on the internal vessel dimensions and the distance to that one point on the material surface. Therefore, it's essential to have accurate vessel dimensions as mistakes in geometry will increase the overall error in the volume calculation. Material flow, buildup, or bridging can affect volume calculations. The placement of the sensor and the location of the filling and discharge points also have an impact on the overall accuracy of volume.

Mass

Accuracy can be further impacted when attempting to use a single point measurement device to estimate mass or weight. When converting volume to mass, the bulk density of the material – stated in pounds per cubic foot or lb./ft.[3] – can have a significant impact on accuracy. Although there are resources available that provide general information about the bulk density of a particular material, the bulk density of the material that is actually in the bin could be quite different than what's posted on the Internet.[1]

Attributes such as particle shape, size and moisture content can profoundly impact bulk density. Compaction of material can also cause very different bulk densities of the same material in the top or the bottom of the bin. A cubic foot of material at the top of the bin could weigh less than that same material at the bottom of the bin, where the bulk density is greater due to compaction by the weight of the material above it.

When using bulk density to calculate mass in a bin for a particular material, it is very important to establish an average bulk density based upon the actual material handled at the facility, and not the stated amount given to a material's general name referenced on a table. One way to accomplish this is by taking a measurement before and after a "known-weight" load is put into the bin, and adjusting the bulk density in lb./ft.[3] to reflect this weight.

What to Expect

When using a single point level measuring system, there will always be an increasing level of error associated as you progress through the conversion of distance to volume and then mass. The measured distance of most single point technologies is quite accurate and will be around ± 0.25% of the distance measured.

However, when level is used to estimate volume, accuracy will be dependent upon the correctness and completeness of the vessel dimensions, sensor placement, and the location and number of filling and discharge points. A vessel that is center fill, center discharge with material that flows freely and symmetrically will give you the best results when using a single point measuring device.

When converting volume to mass there will always be inherent inaccuracies due to variations in bulk density, regardless of whether you are using a single point or multiple point measuring device. The accuracy of the volume calculation will also impact the accuracy of the mass calculation.

Since there are so many variables, it is very challenging for any manufacturer of single point level measurement devices to pinpoint how accurate the calculated value of the mass will be. With accurate vessel geometry, strategic placement of the sensor, and a good average bulk density, the accuracy of the mass may be around 8% to 15%.

Accuracy of a Multiple-Point Inventory Measuring System

Unlike traditional devices that measure one point and determine a single distance, a 3DLevelscanner takes measurements from multiple points within the silo. These points are used to determine the volume of material in the bin. Measurement points are not averaged to calculate bin volume. Instead, each point is given a "weight" or relevancy rating and a complex algorithm is used to calculate the true volume of material within the bin. This technology takes into account variations that can occur across the topography of the material surface by measuring and mapping the high and low points.
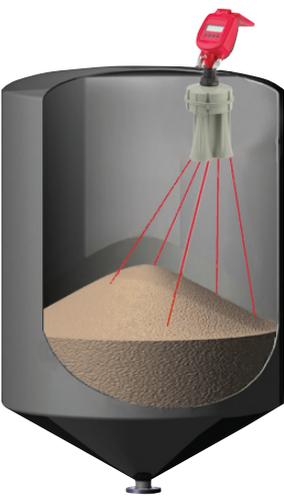
The 3DlevelScanner provides an accurate three-dimensional profile of the top surface within a storage vessel. This is beneficial when there are variations in the material surface due to multiple fill and discharge points, or with materials such as powders that do not fill/discharge symmetrically.

With the 3DLevelScanner as with single point measurement sensor, the volume accuracy is still dependent upon the accuracy of the vessel dimensions and sensor placement. When converting the volume to mass there will still be inherent inaccuracies due to bulk density variables. But, the improved accuracy of the volume calculation will improve the accuracy of mass calculation.

In the case of a 3DLevelScanner, "more is better" with multiple measurement points contributing to a higher degree of accuracy. Given correct vessel geometry and proper sensor placement, you can expect volume accuracy of 3% to 5%. When combined with a good average bulk density, the accuracy of the mass may be around 5-10%.

[1] By performing a keyword search for "bulk density table," "bulk density chart," or "bulk density guide," you will come up with a variety of reference charts for bulk density of a variety of materials.