



Understanding Accuracy in a Bin Level Monitoring System

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What is Accuracy?



Noun: accuracy

ac·cu·ra·cy /'akyərəsē/

- the quality or state of being correct or precise.

Synonyms: correctness, precision, preciseness, exactness, exactitude

Technical: the degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard.

Greater inventory accuracy has been increasingly requested by the grain, feed, seed and ethanol industries. The amount and value of inventory is essential to financial performance and continuous production.

And, the boss said we need more accuracy!

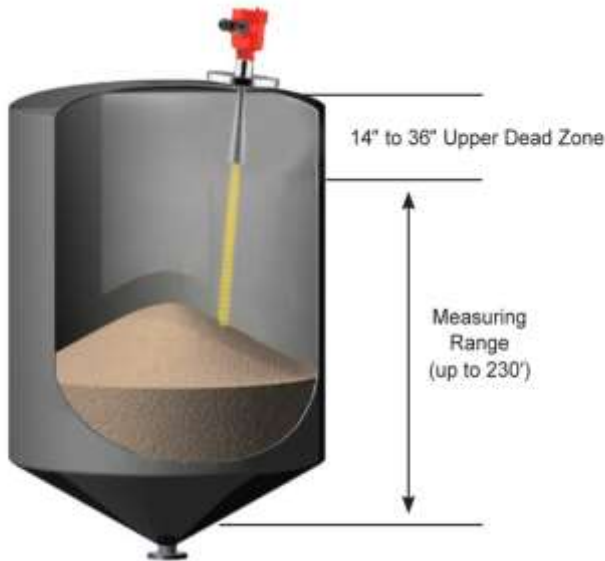
Bob



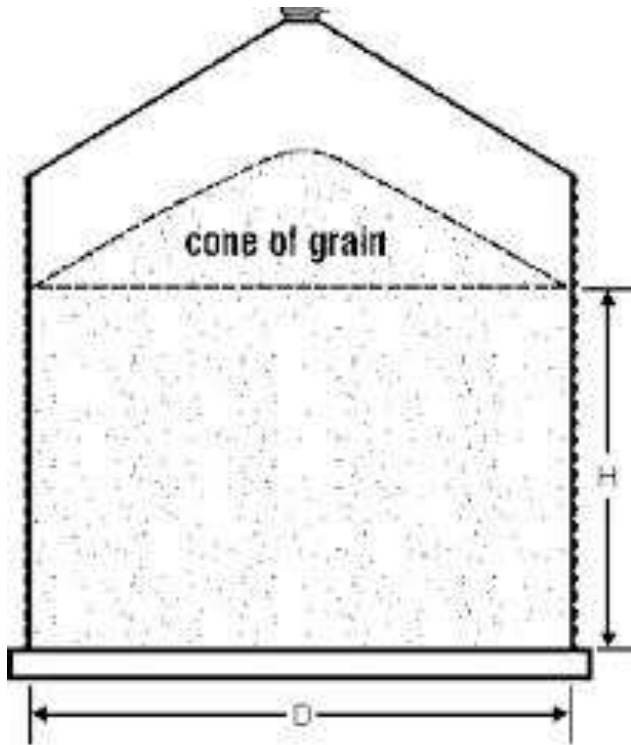
Level

- The distance from the device to the material surface
- Different types of devices have different dead zones and measuring ranges
- The upper dead zone is an area at the top of the bin that isn't measured
- The distance measured starts at the bottom of the dead zone
- The device cannot "sense" material in the dead zone
- Some devices also have a lower dead zone where material is not measured below a certain point

Open Air Radar



Volume



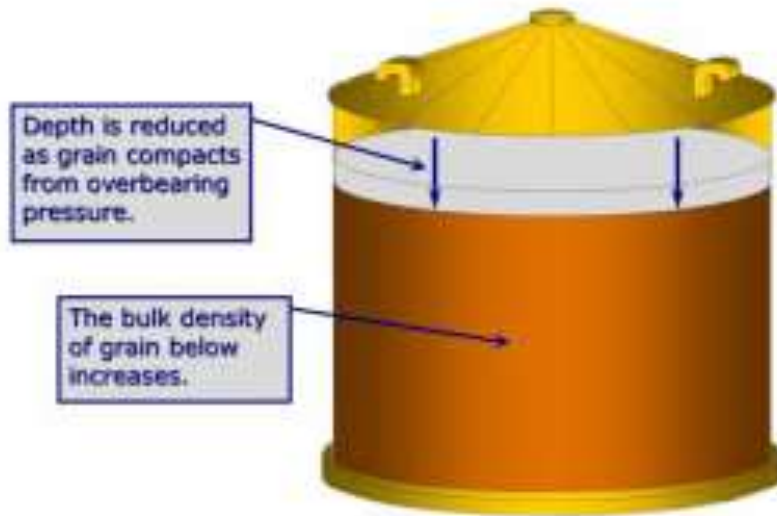
Correct dimensions are vital for volume calculations to be accurate.

- The amount of three dimensional space the material takes up
- A calculation based on the internal vessel dimensions and the distance to the material surface
- If the bin dimensions are incorrect, the volume calculation will be as well
- Material flow, buildup, and bridging can also affect volume calculations
- Other factors impacting volume include location of filling and discharge points

Volume estimates can be inaccurate, even when level is extremely accurate.

Mass

Grain Compaction

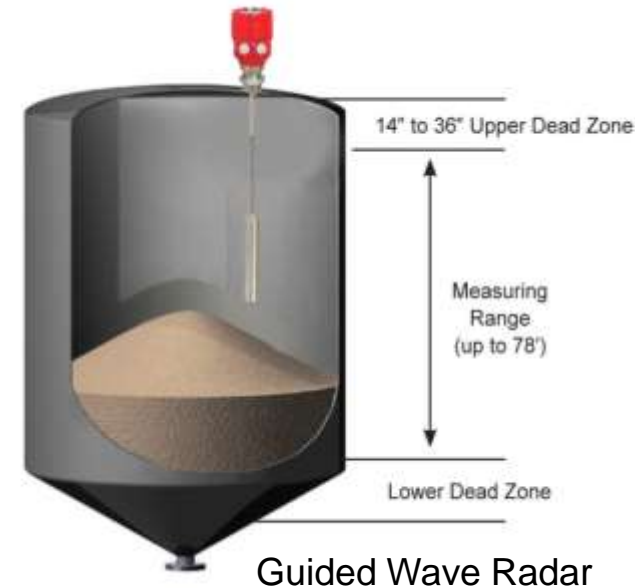


- An estimate of the weight of material in the bin (pounds, tons, metric tons)
- Mass is impacted by bulk density, which is how much a cubic foot of the material weighs
- The bulk density (lb./ft.³) of the material can vary significantly
- Moisture content impacts weight
- Compaction causes greater bulk densities at bottom versus top of bin
- Errors or fluctuations in bulk density impact mass estimates



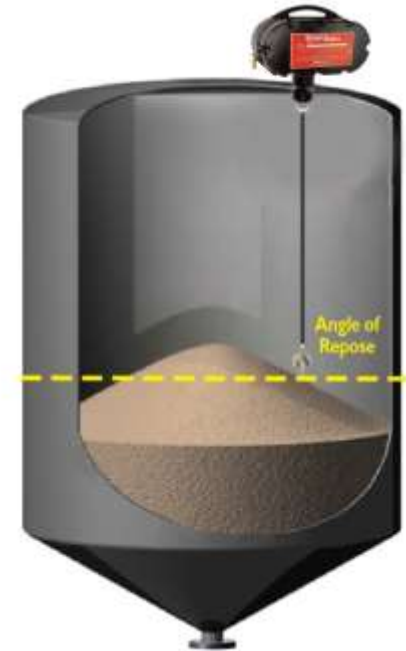
Single Point Measurement

- Devices such as bobs, guided wave radar, open air radar and ultrasonic
- Measure a single point in the vessel directly below the device
- Measures the distance from the sensor on the top of the tank to the material surface (Remember the dead zone!)
- Properly installed, accuracy is what is stated in the literature, $\pm 0.25\%$ of the total distance measured
- Like dropping a tape measure without climbing the bin
- Distance to material is referred to as headroom

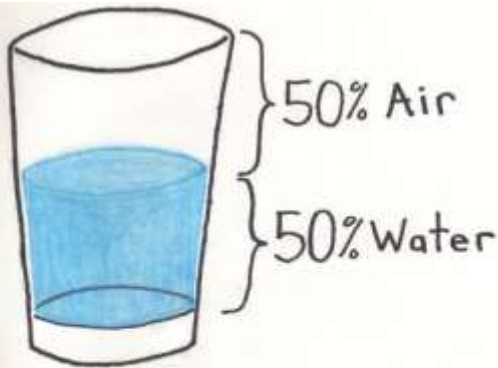
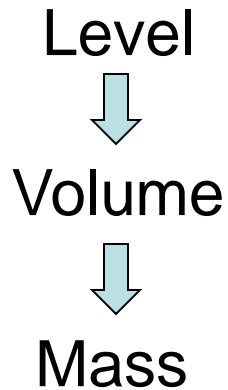


Angle of Repose

- Angle of material that forms when a bin is being filled or emptied
- Flowing material tends to pile symmetrically in a center-fill, center-discharge bin
- Generally referred to as “cone up” or “cone down”
- Draw a horizontal line from at a point $\frac{1}{6}$ from the outer perimeter
- If you take the material in the peak and fill in the voids, it will flatten out the angle of repose.
- **Mounting a single point device $\frac{1}{6}$ from the outer perimeter will provide the best volume estimate**
- In free flowing material in smaller bins, volume accuracy can quite good using a single point device



Single Point Device Accuracy

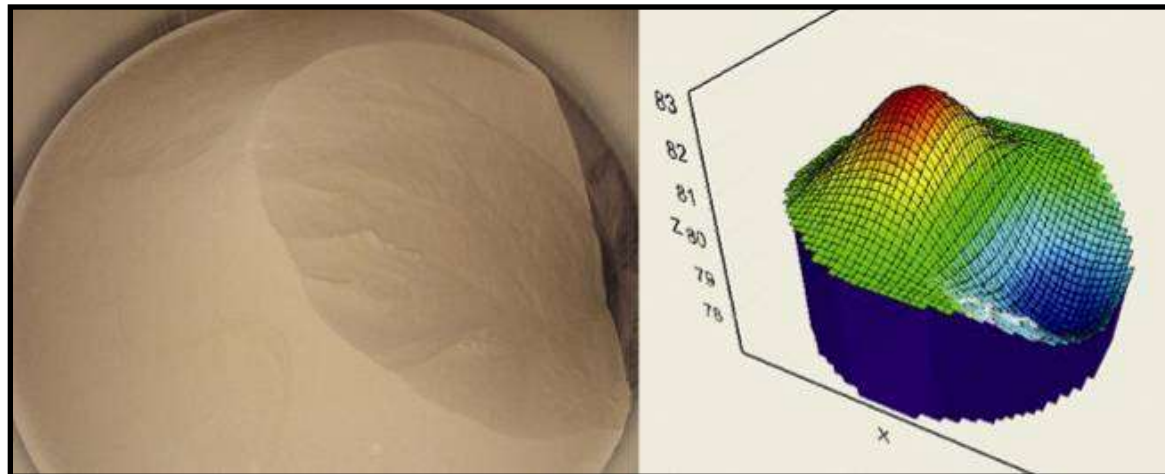


- As you progress from level > volume > mass, accuracy can begin to diminish due to a number of factors.
- Level – the distance to the material at that point – will be highly accurate
 - Don't forget dead zones
- Volume will be less accurate if –
 - Device is not installed at optimal location
 - Vessel dimensions are incorrect
 - Material is not free flowing
- Mass will be less accurate if –
 - Bulk density is incorrect
 - Compaction has occurred
- Accuracy is impacted by all of these variables

A level sensor is not a scale!

Multiple Point Measurement

- Devices include 3DLevelScanners and bob systems
- Measures the level of material at multiple points in the vessel
- Multiple measurements are used to calculate volume
- Takes into account variations that occur across the topography of the material
- Often used in large bins or bins with multiple filling and discharge sites
- Greater accuracy in powders (like flour) or materials that tend to form irregularly in the bin (soybean meal)



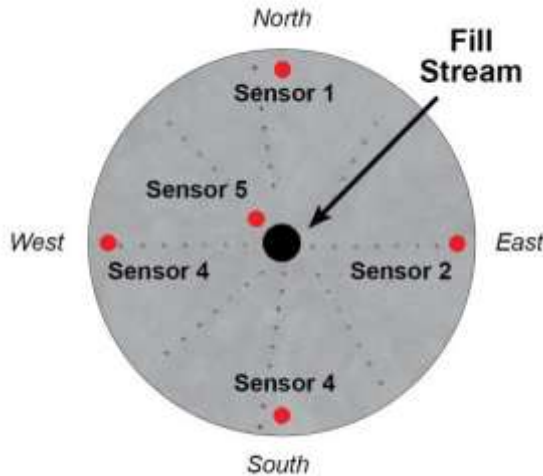
Multi-Bob System



- 2 to 32 bobs on top of a bin or building, taking measurements at scheduled time intervals
- Each sensor takes a measurement directly below its mounting location
- Software reports level data for each sensor and calculates average level and % full
- Strapping table for input of “weight to distance” data to adjust for compaction
- More data than a single bob system, but not recommended if volume and mass need to be accurate
- Can be an economical alternative where high levels of volume and mass accuracy are not needed



Sample Multi-Bob Configurations



Five sensor system ideal for 105', 132' or any bin where more data is desired

Two bob system detects cone up or down.



Single Scanner System



- Non-contact, acoustics-based technology
- Measures multiple points in a 70° beam angle
- Advanced algorithms assign a weight to each measurement based upon its relevance
- Best for bins under 60' in diameter
- Single scanner can be used in wider bins, but with decreased accuracy
- Minimal maintenance
- Performs reliably in high dust for more accurate readings
- Reports minimum, maximum and average levels and provides visualization of material surface

Multiple Scanner Systems

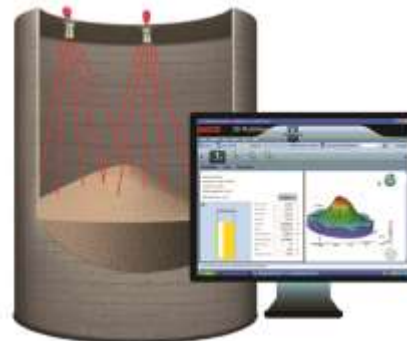
- Adding additional scanners provides more measurement points for even greater accuracy
 - More scanners cover more surface area
 - Needed to detect high levels in large bins
- Often used when a bin is over 60' in diameter and greater accuracy is desired
 - Especially when bin is filled to higher material levels
- Number of scanners needed is determined by vessel size, desired accuracy and your budget!
 - 2 or 3 scanners common in 90' and 105' diameter bins
 - 4 scanners for high accuracy in 132' and 160' diameter bins
- You can start with a single scanner and add additional scanners at a later time



Scanner #1 mounted near the center of the bin.



Scanner #2 mounted halfway between the center and sidewall.



Multiple Point Device Accuracy

- Recommended whenever –
 - There is a need for a high level of accuracy
 - Vessels are large or have multiple filling and emptying points
 - Material does not flow freely and tends to pile randomly
- Levels will be highly accurate
 - The distance to the material is measured at multiple points
 - Accounts for variation in topography across the material surface
 - Minimum, maximum and average levels reported
- Volume accuracy is best when –
 - Device is installed at optimal location on bin roof
 - Vessel dimensions are input accurately
 - There are adequate sensors to map the entire material surface
- Mass will most accurate if –
 - Bulk density is correct, best calculated when a known amount of material is loaded into the bin
 - Compaction has be accounted for

Volume accuracy of 3% can be expected.

Ethanol Plant Case Study

- The Beginning
 - Needed greater inventory accuracy in extremely active, dusty corn bins
 - Installed single MV scanners on two 75' corn bins for visualization of bin topography
 - Added single MV scanners on concrete DDG silos
- Upgrading the System
 - Upgraded to MVL-2 systems on 75' diameter concrete silos
 - Installed MVL-2 systems on two new 105' diameter steel bins
- Network Visibility
 - Installed MultiVision software for visibility of all bins in real time
 - Tracks level during filling and emptying
 - Reports volume and mass



Scanners are installed on all four large silos.



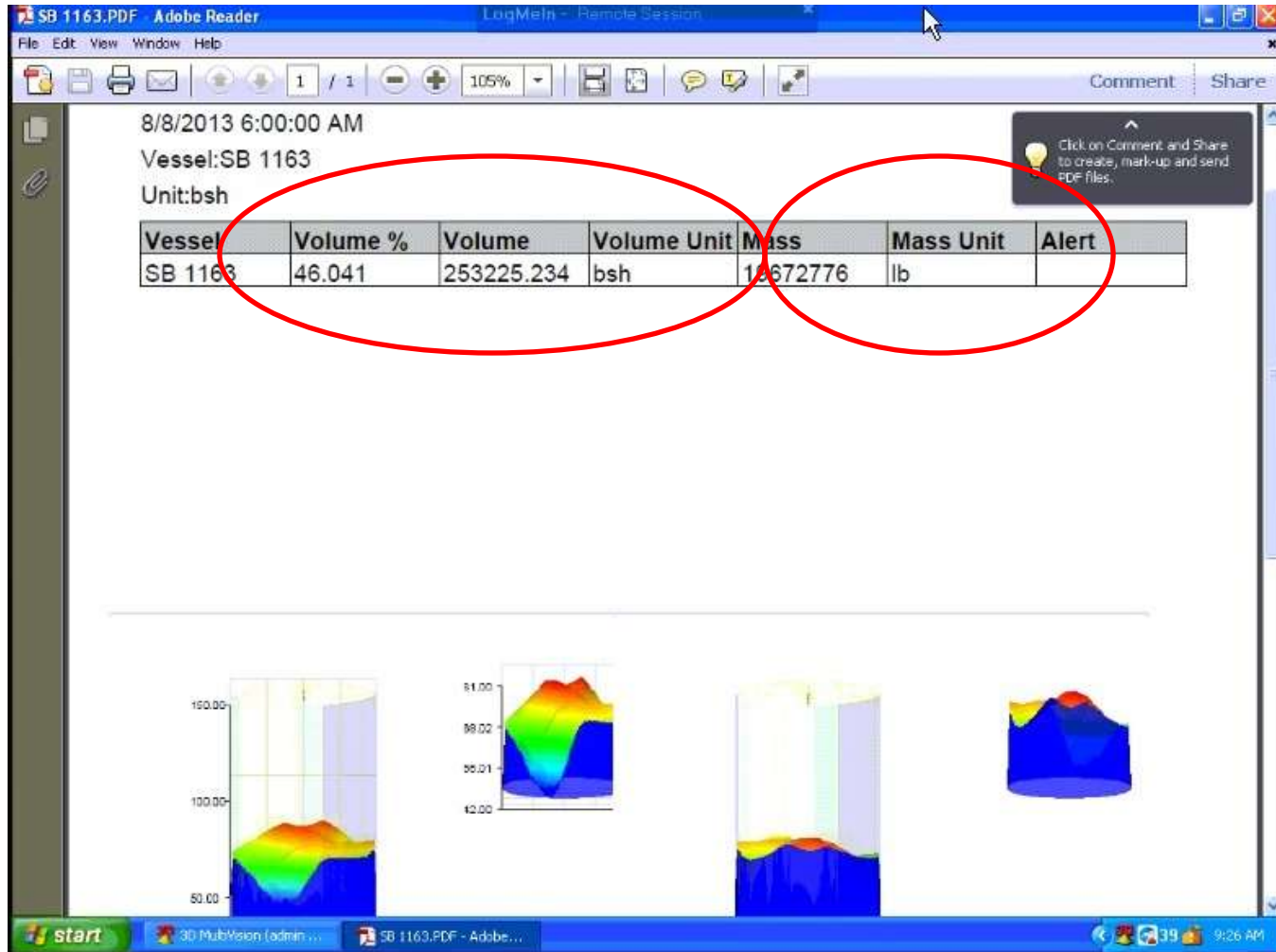
Real-Time Reporting in Corn & DDG Silos



Historical Reporting Shows Mass and Volume



Volume, Mass & 3D Visualization





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