



Selecting Continuous Level Sensors for Bulk Solid Applications

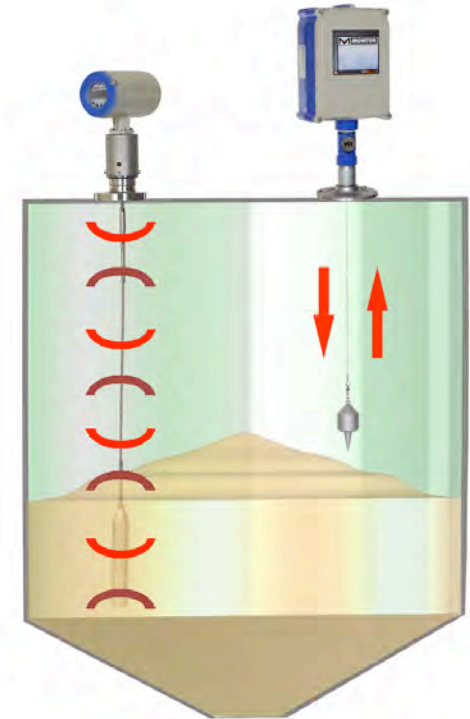
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Determining the Amount of Material in a Vessel

- One of the many challenges has to do with the material characteristics, there are many variables that will influence how well any device may perform.
- Most “level” devices target the surface of the material based on “mount locations” or “aiming”.
- Angle of repose, fill point, and discharge points all can effect sensor performance
- Accurate silo dimensions and accurate material bulk densities are important as calculations are made when “distance” is converted to “volume”.



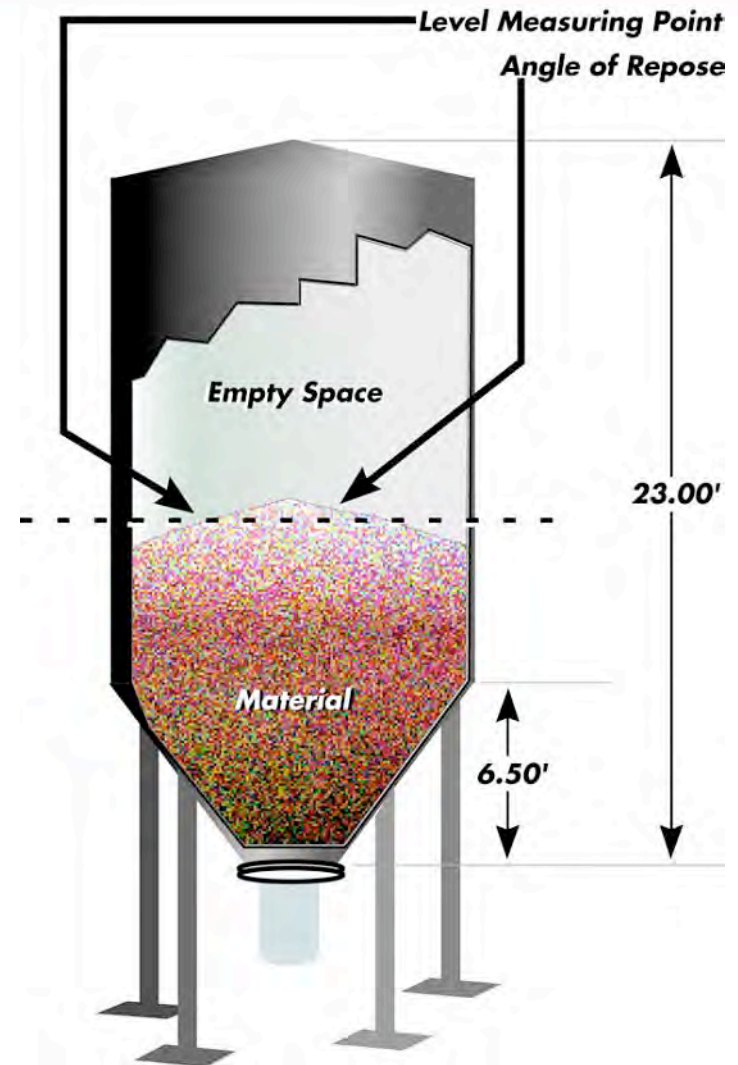
The Starting Point

- Do you need continuous or intermittent measurement?
What frequency of measurement do you need?
- Do you need to measure during fill?
- Do you need to know just the level of the material or also the volume and mass of the vessel? Is this in terms of the level of the material or volume/mass?
- What “real world” accuracy are you looking to achieve?

- How accurate is your vessel geometry?
- What are the physical properties and flow characteristics of the materials being measured?
- How is the vessel being filled and emptied? What are the fill/empty rates?
- What is the anticipated angle of repose? How may this change during fill/empty?
- Where is the sensor to be located?
- What kind of display/interface do you desire?
- How much do you want to spend?

Managing expectations

- “Real World Accuracy”
- Converting “distance to volume”
- “Targeting the surface of the material”
- Weighing the silo





Understanding “Printed Accuracy”

- The printed accuracy for level
“distance from sensor to material surface”
- The printed accuracy for mass
“measures the changes in force exerted on a sensor”

- **Weight and Cable Systems**



M O N I T O R T E C H N O L O G I E S
+ **PROS** - **CONS**

- ▼ Not affected by process conditions or material properties – no calibration.
- ▼ Distance measurement not affected by angle of repose (ranges ≤ 150 feet).
- ▼ Low purchase cost ($\geq \$1300$).
- ▼ Easy installation and set-up.
- ▼ Field repairable.
- ▼ New designs are very durable for many applications.
- ▼ Can be used on dusty powders.
- ▼ Can be used with signal absorbing materials.
- ▼ Can be used for high temps (≤ 500 o F).
- ▼ Explosion proof designs available.
- ▼ Good accuracy ($\pm 0.25\%$ to $\pm 0.50\%$) for ranges ≤ 30 feet.
- ▼ Wireless interface of sensors and operator interface is available.
- ▼ Advanced PC software available. Easy use for supplier managed inventory applications.
- ▼ Multiple outputs available.

- ▼ Does not respond instantaneously to a change in level.
- ▼ Momentarily Intrusive
- ▼ Periodic maintenance may be required on extremely dusty applications
- ▼ Mechanical parts can be abraded by some solids
- ▼ Measurement during filling not always recommended. Care must be taken not to bury weight during filling.
- ▼ Low pressures (≤ 30 psi).
- ▼ Moderate accuracy for ranges > 30 feet.

- **Ultrasonic Level Systems**



M O N **+** P R O S O R T E C H N O **-** C O N S G I E S

- ▼ Non-intrusive / Non-contact.
- ▼ Attractive purchase price (\geq \$1700)
- ▼ Auto-compensation for temperature changes.
- ▼ High temperatures (\leq 300o F).
- ▼ DSP (digital signal processing) techniques improve performance.
- ▼ Long ranges (\leq 260 feet).
- ▼ ± 0.10 to $\pm 0.25\%$ accuracy in measuring distance.
- ▼ Instantaneous response to changes in material height.
- ▼ Relatively easy installation in tight spaces.
- ▼ Sensors are self-cleaning.

- ▼ Sensor signal may be affected by changes in the angle of repose.
- ▼ Low pressures \leq 40 psi.
- ▼ Set-up requires care in aiming the sensor and mapping the vessel to eliminate false echoes.
- ▼ Performance may be affected by very lightweight aerated material due to sound absorbing nature of material.
- ▼ Performance may be affected by heavy dust during filling/emptying.
- ▼ Dead zone prevents material selection immediately in front of sensor.
- ▼ Negative perception that devices need to be continually "fussed" with.
- ▼ May not be recommended for angle of repose $\geq 45^\circ$ unless particle size is greater than 1 inch.
- ▼ Performance on large particles may be affected due to uneven shape of the solids surface.

- **Guided Wave Radar (GWR) Level Systems**



M O N I T O R  **PROS** T E C H N O L O G I E S  **CONS**

- ▼ Instantaneous response to changes in level.
- ▼ Distance measurement unaffected by dust, angle of repose, process conditions.
- ▼ High number of measurements taken per second.
- ▼ High accuracy, especially in short ranges.
- ▼ Ranges \leq 115 feet.
- ▼ High temperatures \leq 300o F.
- ▼ High pressures \leq 580 psi.
- ▼ Easy set-up.
- ▼ Ability to adapt to a variety of vessel shapes and probes can be cut to length in the field.
- ▼ No measurement dead zones.

- ▼ Intrusive.
- ▼ Material must have a dielectric constant \geq 1.3.
- ▼ High purchase price \geq \$2300.
- ▼ Maximum range may be limited on heavy solids by maximum pull strength of wave guide.
- ▼ Wave guide can be damaged by large particles, heavy solids and material movement.
- ▼ Large particles may be harder to sense.
- ▼ Not used for sanitary applications.

- **Thru-Air Radar Level Systems**



M O N I T O R T E C H N O L O G I E S



PROS



CONS

- ▼ Non-intrusive.
- ▼ High Temperature $\leq 700^{\circ}$ F.
- ▼ High Pressure ≤ 580 psi.
- ▼ Ranges ≤ 130 feet.
- ▼ High accuracy in distance measurement, especially in smaller vessel.
- ▼ Instantaneous response to changes in material level.
- ▼ No measurement dead zones.
- ▼ As safe as microwave ovens or cell phones.

- ▼ Requires material have a dielectric constant ≥ 1.8 .
- ▼ Set-up requires mapping the vessel.
- ▼ Installation requirements due to potential sensor size.
- ▼ Sensor is not self-cleaning on dusty applications.
- ▼ Time required to process pulse/echo limits sample rate.
- ▼ High purchase cost $\geq \$3000$.
- ▼ Range on low dielectric materials may be limited by ability to satisfactorily reflect pulse.

- **Laser Level Systems**



M O N I T O R T E C H N O L O G I E S
+ **PROS** - **CONS**

- ▼ No calibration.
- ▼ Ranges \leq 250 feet.
- ▼ Non-intrusive.
- ▼ New systems more competitively priced for ranges \leq 50 feet without heavy dust.
- ▼ Distance measurement not affected by angle of repose.
- ▼ Performance not affected by material or process conditions.
- ▼ Easy set-up and installation.
- ▼ High accuracy in distance measurement.
- ▼ Instantaneous response to changes in material level.
- ▼ No measurement dead zones.



- ▼ High cost for ranges $>$ 50 feet or high dust.
- ▼ Limited temperature and pressure limits for direct connection to process.
- ▼ Not recommended for high dust applications.

- **Weight Measurement Systems**

- Load Cells and Strain gauges



Load Cells

M O N I T O R  PROS	T E C H N O L O G I E S  CONS
<ul style="list-style-type: none">▼ Truly non-intrusive system.▼ Works even with severe applications involving material flow problems (ratholing, bridging, etc.)▼ Not affected by dusts or build-ups.▼ Safe method for handling hazardous materials.▼ Multiple sensor system – can provide redundancy – leaves vessel on-line while a failed sensor is replaced.▼ Provides highest accuracy.▼ Ranges from 100 lbs. to 1,000,000 lbs.▼ Sanitary applications – meets CIP/SIP requirements.	<ul style="list-style-type: none">▼ High purchase cost (> \$4000) plus installation cost.▼ Involved calibration procedure.▼ Potential issues and costs retrofitting existing vessels.▼ Potential accuracy limitations if material load is significantly lower than the dead weight of the vessel.▼ Measurement may require extra attention to details during operation to get maximum accuracy.▼ Structures connected to vessel may affect performance.

Strain Gauges

M O N I T O R	+	PROS	T E C H N O L O G I E S	-	CONS
<ul style="list-style-type: none">▼ Truly non-invasive system.▼ Easy to install – suited for retrofitting existing vessels.▼ Works even in severe applications involving ratholing and bridging.▼ Not affected by dust or build-up.▼ Safe method for handling hazardous or highly abrasive materials.▼ Sanitary applications; meet CIP/SIP requirements.▼ Cost effective means for mass measurement when accuracy is not critical.			<ul style="list-style-type: none">▼ High purchase cost (> \$2000).▼ Calibration critical to performance.▼ Typical “real world” accuracy of 1% to 5%.▼ Potential accuracy limitations if the material load is significantly lower than the dead weight of the vessel or lower than 75,000 lbs.▼ Measurement may require extra attention to details during operation to get maximum accuracy.▼ Structures connected to vessel or vessel bolted to concrete may produce accuracy and reliability issues.		

In Conclusion

- **No single technology offers a cost effective solution to every solids application**
- **Except for the simplest, most applications require “an engineered solution” by the instrument system manufacturer**

Fitting Application and Technology Together

“Four step guideline”

- 1) Define the requirements of the application**
- 2) Create a list of “potential candidates”**
- 3) Talk to leading manufacturers**
- 4) Make a final selection**

For more information level measurement resources please visit:

<http://www.monitortech.com/show.shtml>