Introduction to Bulk Solids

The Basics

Glossary of Terms

- Angle of Repose
  - This is the angle that material will naturally mound up when filling a tank, or down when discharging a tank.
- Dielectric Constant
  - All materials have a dielectric constant greater than Dry Air (Dk = 1). This term refers to the capacitive properties of a material. Materials such as plastics have a range of 1.2 to 3.0. Oils usually range between 2.0 – 3.0, while water (moisture) is usually 40 – 80.

Glossary of Terms

- Hazardous Areas
  - Area of a plant determined to be hazardous typically due to gases, vapors, or dust
- Explosion-Proof Enclosures
  - Contains an explosion within the enclosure
  - Does not allow a secondary explosion or ignition outside of the enclosure
- Intrinsic Safety (IS)
  - IS Barriers limit the amount of current to a device, preventing any ignition source
  - The IS Barrier must be located in a safe (General Purpose) area

Glossary of Terms

- Bulk Density
  - Weight of the material per volume such as pounds per cubic foot (lb/cu.ft.) or grams per cubic centimeter (g/cc).
- Hygroscopic
  - Material will absorb moisture, some examples include starch, flour, fly ash, clays and cement.

Glossary of Terms

- 4-20mA
  - The 4-20 mA current loop is a very robust sensor signaling standard. Current loops are ideal for data transmission because of their inherent insensitivity to electrical noise.

Glossary of Terms

- Guided Wave Radar
  - A low powered, nanosecond-wide pulse is sent along an electrically conductive cable. When the pulse reaches the material a pulse is reflected back and then detected. The pulse is detected as an electrical voltage signal and processed through the electronics. Level distance is proportional to flight time of the pulse.
- Time Domain Reflectometry (TDR)
  - Is a measurement technique used to determine the characteristics of electrical lines by observing reflected wave forms.
- Capacitance
  - Is the ability of a body to store an electrical charge.

Glossary of Terms - Vessels

Silo – Type of construction could be welded, bolted, corrugated or spiral wound

Welded Silo

Bolted Silo

Corrugated Silo

Glossary of Terms - Vessels

Hopper – Usually refers to the conical portion of a silo where the diameter decreases in size down to the discharge point. Sometimes refers to vessels which have very little or no straight side wall.

Glossary of Terms - Vessels

Surge tank or surge hopper – Similar to hopper but usually closed top and under pressure.

Glossary of Terms

- Rotary Air Lock (Star Valve or Rotary Valve)
  - Isolates air in pneumatic conveying systems
  - Can be used as a feed device when used with a variable speed motor.

Glossary of Terms

- Slide Gate Valve (Knife Valve)
  - Used to regulate discharge rate from silos or hoppers

Glossary of Terms

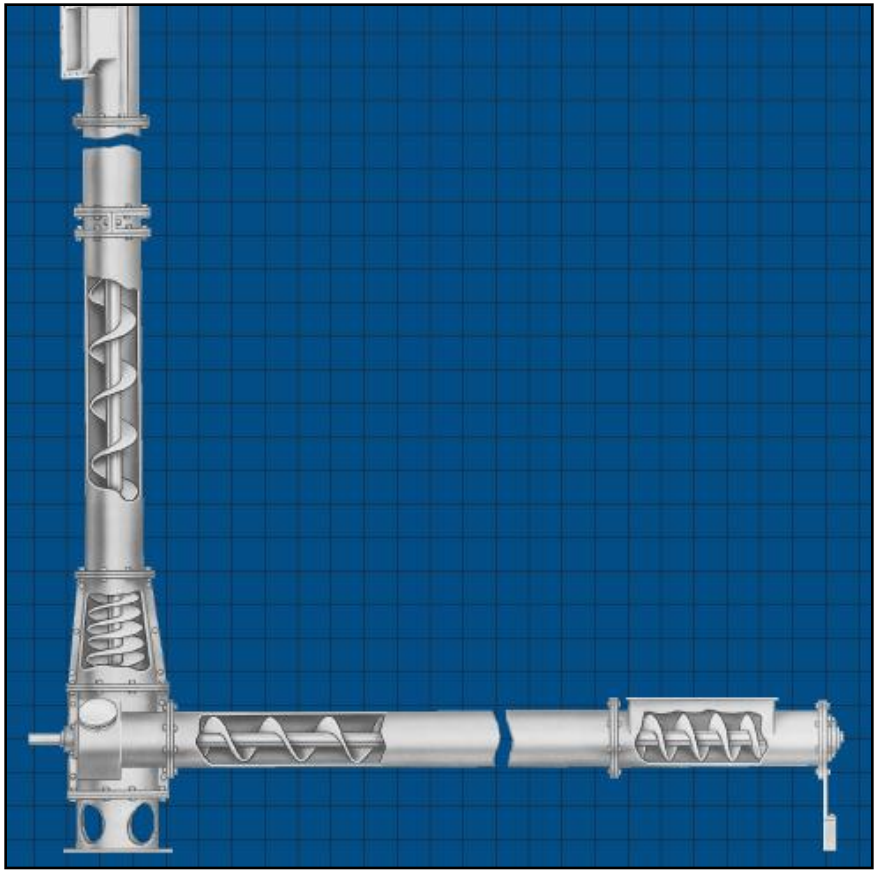
- Diverter Valve
  - Used in pneumatic conveying systems to “divert” material from the discharge of a hopper or silo to the top (fill point) of a hopper or silo.

Glossary of Terms

- Conveyor Types: Screw, Pneumatic, Drag, Belt, and Bucket Elevators
  - Used to move bulk materials.
  - Bulk materials are always filled from the top of a bin, and emptied from the bottom.

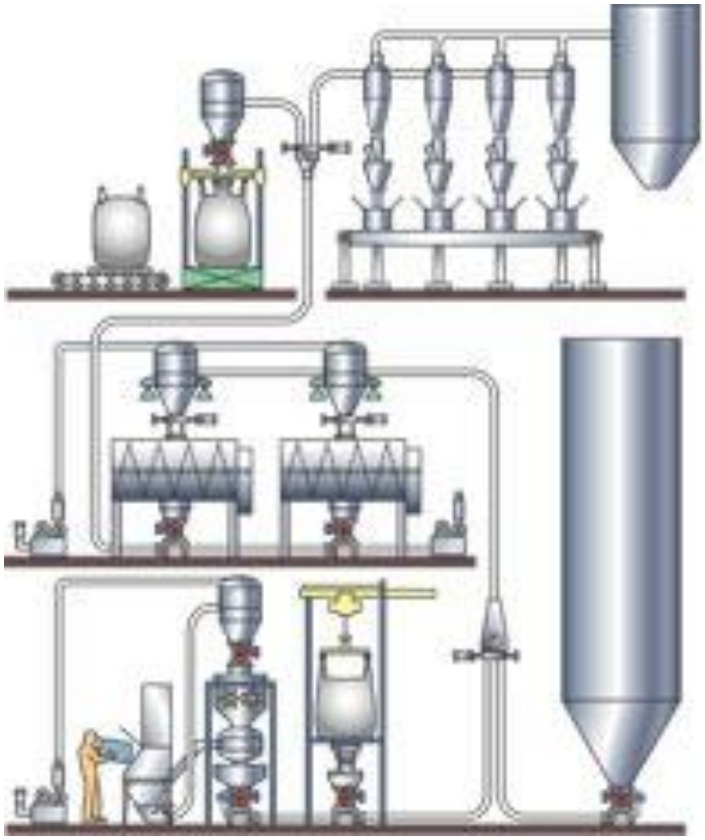
Glossary of Terms

Screw Conveyor



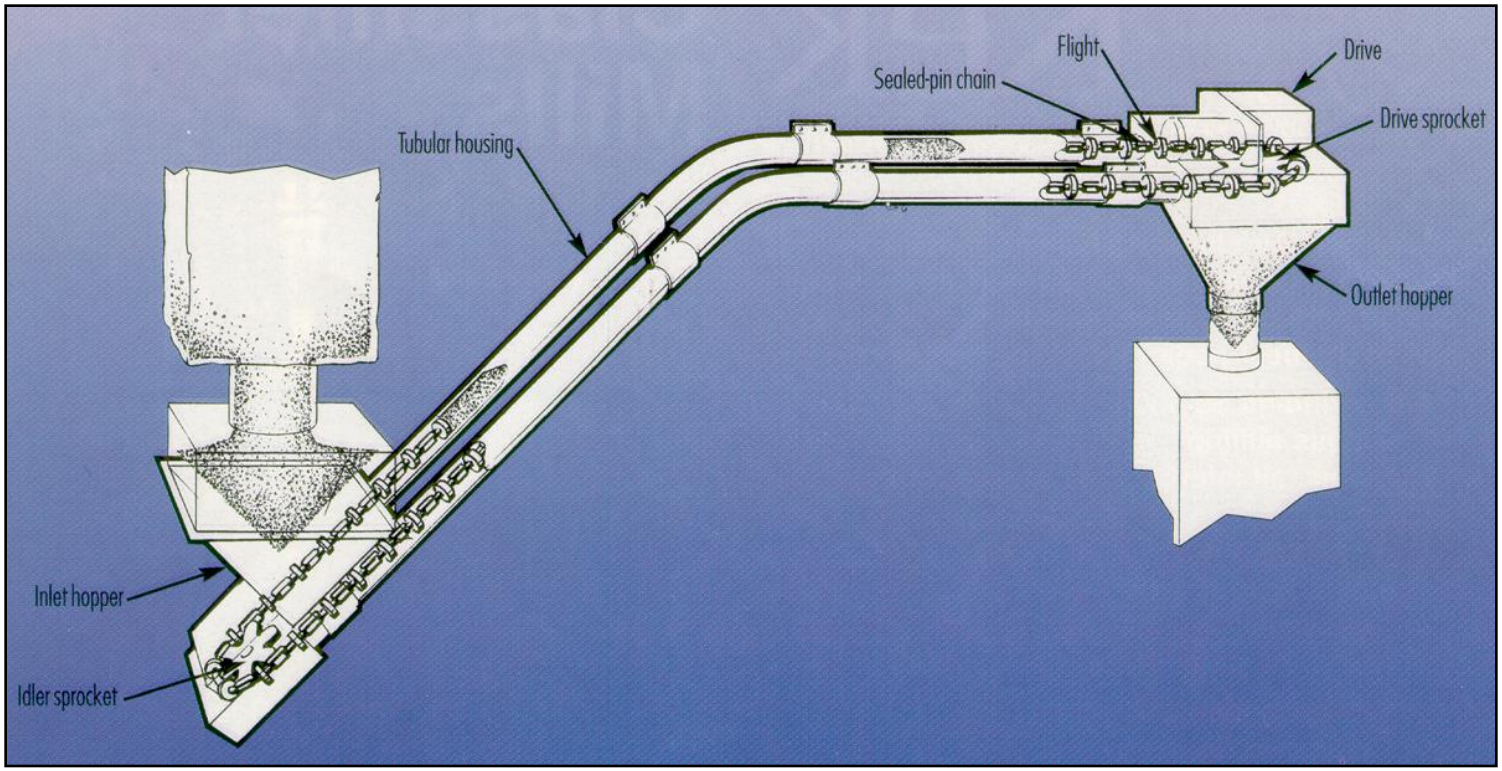
Glossary of Terms

Pneumatic Conveying System



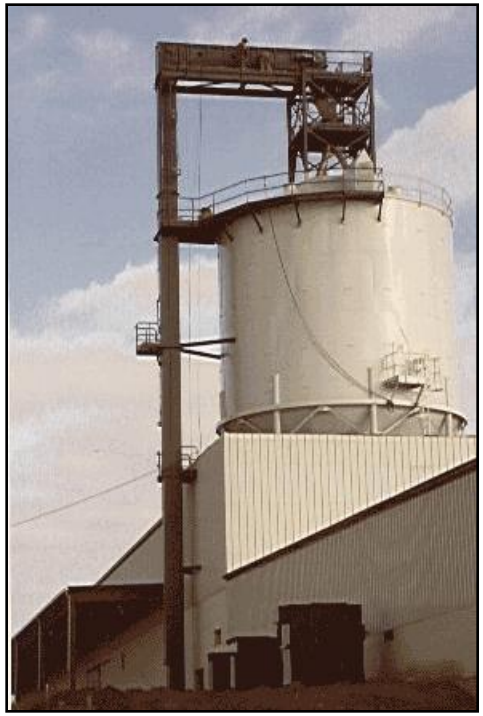
Glossary of Terms

Tubular Chain Drag Conveying



Glossary of Terms

Bucket Elevators



Level Measurement Characteristics

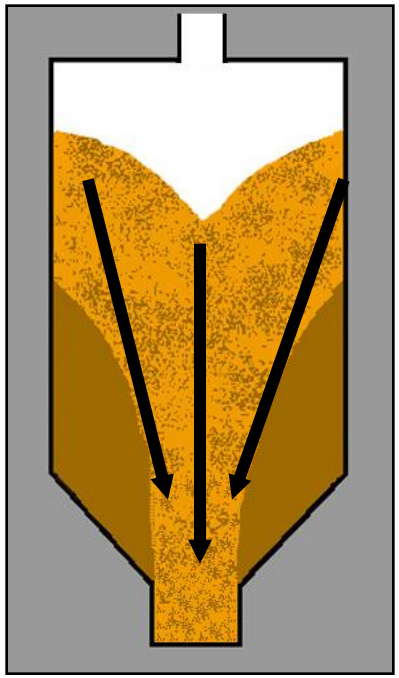
- Liquid Level Measurement
  - Liquids always lay flat in the tank
  - Liquids usually flow in and out of the tank easily
  - Liquids do not aerate, settle, or compact in a tank
  - Liquid seeks it's own level
  - Steam and vapors may be present with liquids
  - Liquids are often under pressure

Level Measurement Characteristics

- Dry Bulk Level Measurement
  - Material rarely lays flat in a silo or tank. Angle of repose varies with different materials
  - Flow of material into and out of the tank must be considered. Level indicating device cannot be located near the fill stream. Mass flow discharge in a tank can destroy a side mounted level indicator.
  - Dry bulk materials can be aerated; can settle and compact over time; bridge; rat hole. In order to solve flow problems, aeration or vibration may be introduced.
  - Dust in a silo is created by filling, discharging or aerating the material in it. Dust can “blind” ultrasonic or laser measuring devices. It can also coat point level devices, causing false readings.

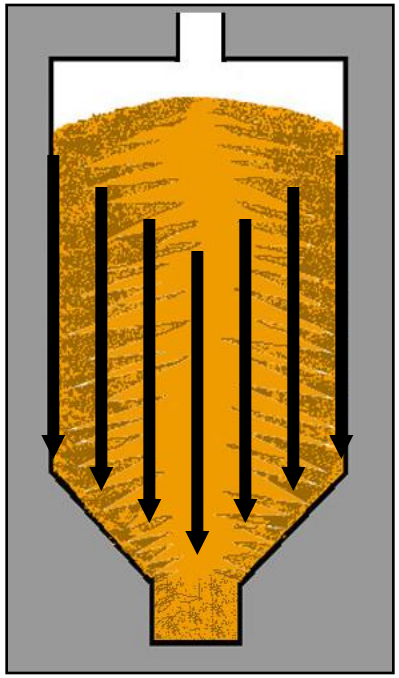
Flow Characteristics

- Funnel Flow
  - Material flows from the side walls into the middle of the tank when discharging.
  - Material does not move down the side wall of the tank.
  - First material entering bin usually is the last material out
  - Can cause material to remain in tank when tank appears to be empty.



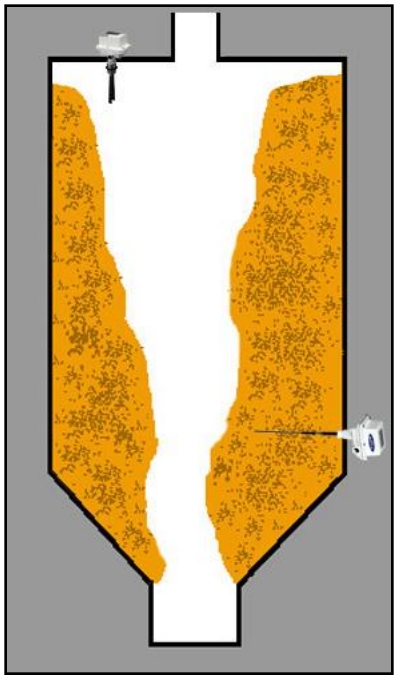
Flow Characteristics

- Mass Flow
  - Material flows down the side wall of the vessel as it discharges. All material in the tank is in motion when any is withdrawn.
  - Angle of repose flattens as material is discharged.
  - First material in, first material out
  - Vibrators, live bottom bins, air slides, or aeration pads are usually used to help create mass flow.



Flow Challenges In Silos

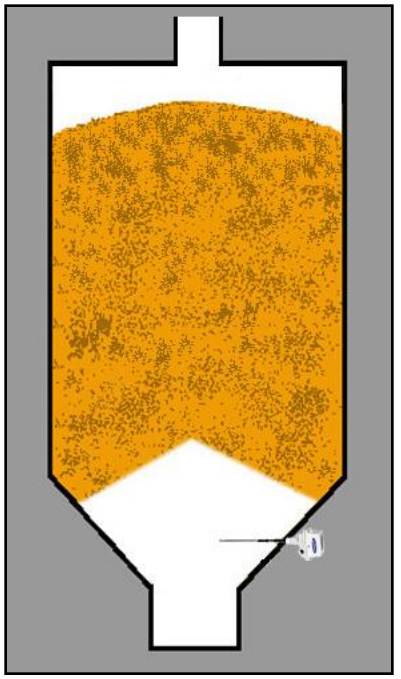
- Rat Hole
  - Material above discharge point empties out of bin, leaving material around the outside walls.
  - Can be several feet in diameter down to a few inches.
  - Problem: If a level instrument is located above the rat hole, the tank may appear empty. If the level instrument is located anywhere on the side wall, the tank will appear to have material at that point.



Flow Challenges In Silos

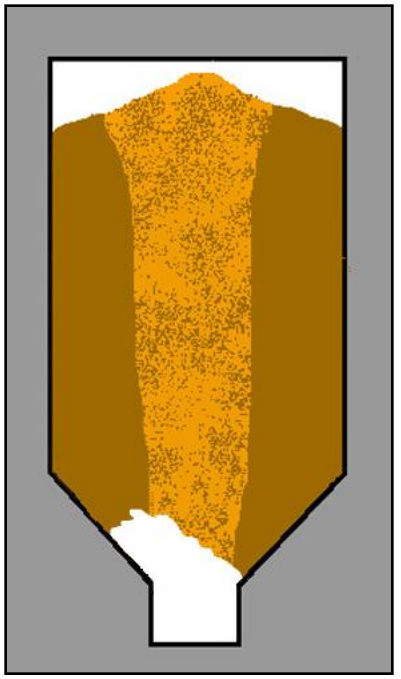
- Bridging
  - Silo discharge valve is open, but material does

    not discharge.
  - Can be caused by cohesive material, undersized discharge opening, shallow hopper (cone) section, or inadequate aeration.
  - If a low level switch is located below the bridged material, it will indicate that the silo is empty.



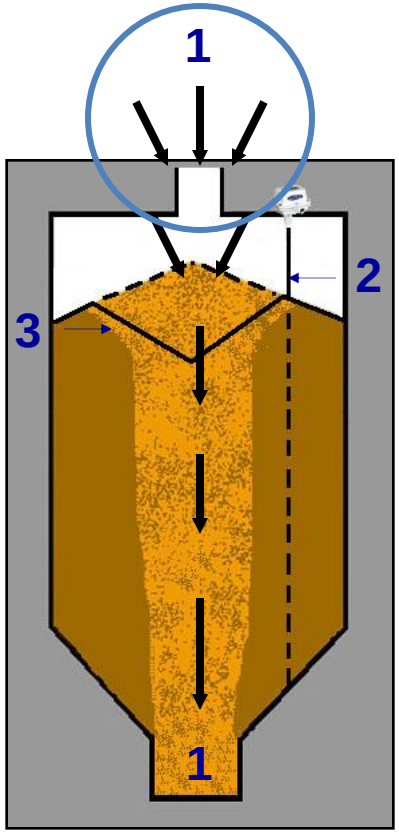
Flow Challenges In Silos

- Problem Combinations
  - Funnel flow can lead to a material bridge or a rat hole.
  - Cohesive materials (materials that stick to themselves) such as Bran, Cement, and Flour are more likely to bridge or rat hole.



Level Measurement Challenges In Silos

- (1) Center Fill / Center Discharge Tank
- (2) Mount level control 1/6 diameter or 1/3 from side wall. This is the average level point due to angle of repose.
- (3) In Funnel Flow silos there is no change in level reading until the positive angle of repose of material becomes completely negative



Applications Questions to Ask

- Point Level or Continuous Level?
  - Does the customer want a switch (point level) or a continuous measurement (read 0% – 100%)?
- Output Requirement?
  - Related to above…Does the customer want a switch or relay output? Does the customer want a local readout, 4/20mA output, digital communication?
- Area Classification?
  - Will the instrument be in a General Purpose area or a Hazardous area?
  - Intrinsic Safety or Explosion-Proof?

More Applications Questions

- Temperature?
  - Most integral level switches can be applied in materials up to 200°F (93°C). Above this temperature, electronics housings must be separated from the heat source
  - What are the maximum, minimum, and normal temperatures the level instrument will be exposed to? Many dry bulk materials are hot..
- Vibration?
  - Materials that do not flow well usually require some assistance. Vibrators or “Live Bin Bottoms” are used to assist material discharge.
  - Does the tank have a live bin bottom, or is there a vibrator on the tank? Where is it in relation to the level sensor?

More Applications Questions

- What is the material?
- What is the material's bulk density?
- What is the material's moisture content?
- What is the range of material size?
- Does the material coat the side walls?
- Is the material a food or drug?