SOLIDS LEVEL MEASUREMENT APPLICATION GUIDE

2025 EDITION

This book aims to provide the reader with an overview of the solid materials found in many common industries. These may be bulk raw materials, key ingredients, intermediary products or final products. All have different measurement requirements and characteristics.

Suggestions are given here for suitable technology choices based on the conditions and measurement requirements.

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Section 1 | An Introduction to Solids Measurement

1.1 Solids Measurement Characteristics

Typical Solids Application Characteristics

Uneven surface

All level measurement instruments are affected by the uneven surfaces in solids applications. The material characteristics and silo size will affect the structure of the surfaces, which affects the preferred installation location and choice of technology. Most technologies for measuring the continuous level of solid materials are top-down measurements and depend on a signal reflecting from the surface back to the device.

Non-contacting radar is affected by uneven surfaces, as some of the signal may not be reflected directly back but instead redirected away from the device. To address this, non-contacting radar transmitters collect multiple smaller echoes from its footprint on the surface and merges them into a single echo that represents an average of the measured area. As the antenna size increases, the radar signal becomes more concentrated. While the overall surface area measured is reduced, the return signal is strengthened. The larger antennas are best suited for long measuring ranges.

Guided wave radar is less affected by uneven surfaces since the microwave signal is more compact, guided by the probe and reflected from the contact point on the surfaces.

When installing solids switches or Guided Wave Radar, it's good to consider where the level will be changing, since level is inferred from a single point.

Best practice is to have both continuous and point level measurement instrumentation to ensure a safe and reliable operation.

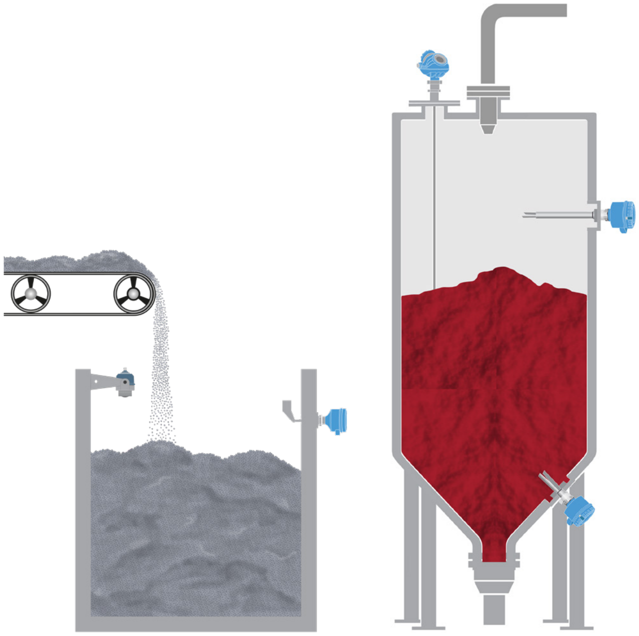


Figure 1.1. Continuous and point level measurement instrumentation in solid applications

Typical Solids Application Characteristics

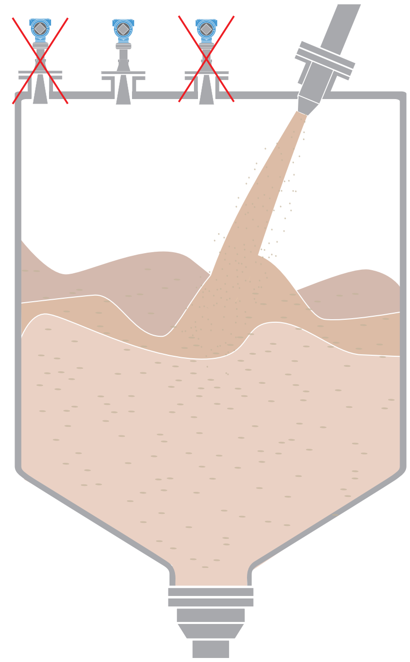


Figure 1.2. Non-Contacting Radar Technology Mounting Location Example on a Filling Application

Dielectrics and bulk density

Materials with very low dielectric constant and low density may attenuate the measurement signal so that it becomes insufficient. The dielectric constant of many solids is fairly low. For radar technology, this is a key factor of the amount of signal that will be reflected back to the gauge and thereby the possible measuring range. For level switches, capacitance technology is also affected by the bulk solid dielectric constant.

Both radar and capacitance can easily manage low dielectrics. Unlike many solid switches, radar remains reliable regardless of variations in bulk density. Consequently, bulk density is a crucial factor in selecting the appropriate technology for point level measurement.

Filling

The mounting location in relation to the filling location is important for most measuring technologies. The closer the device is mounted to the filling point, the larger the risk that the device will be affected. There are also cases where the material is blown into a silo through a pneumatic process. Dust and the actual stream from the filling can disturb the measurement to a large extent.

Dust

There is often a considerable amount of dust created during the fill cycle of solid materials. The amount of dust depends on the type of filling and the material. Both radar and level switches can handle dust in the vapor space without being disturbed. Other technologies such as ultrasonic and laser devices are less suitable since their signal is significantly impacted by dust.

Although a heavy layer of dust on the radar antenna can block the signal in applications where the dust is especially sticky, this can be compensated for by alternatives such as non-stick antenna materials and air-purging.

Condensation

In many solids applications, condensation is present. Since the vessel ceiling is normally the coldest spot, it is a common location for condensation. Unfortunately, this is typically the location of top-down measurement devices, so consideration needs to be made regarding the effects of condensation on the technology. Condensation can also tie up dust and create a layer on the wetted parts, which may cause problems if no action is taken.

Open air applications

Open air applications include measurements on piles and distance control between conveyor belts and the pile. These types of applications have different properties compared to standard bin or silo applications. There are no walls or roof to install instruments onto so the biggest challenge in these applications is to find an installation point. Protection from external factors like wind and rain can also be a challenge. Note that any non-contacting radar needs to comply with the national radio directives when installed in open air. Thus ensure that the device can be ordered for “open air” applications.

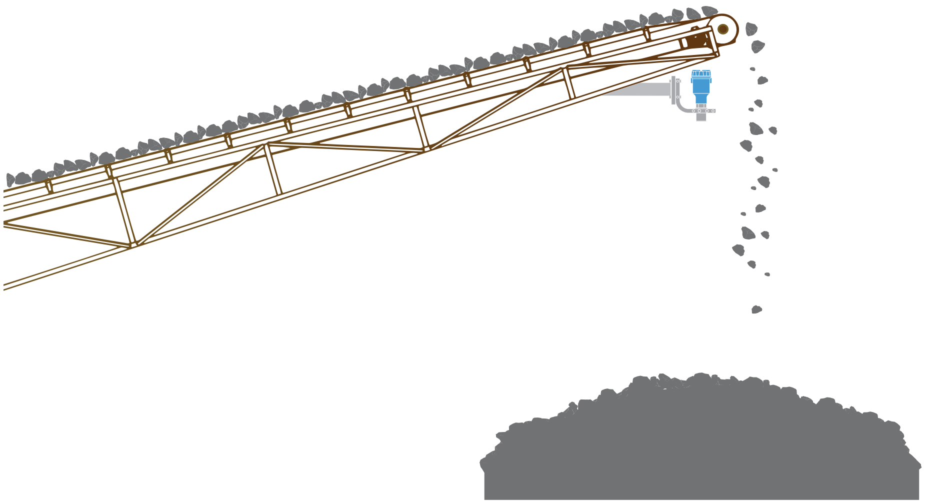


Figure 1.3. Level Measurement in an open air application in the Metals and Mining Industry

1.2 Selecting the Right Technology

All of the different characteristics and challenges found in solids level measurement will affect the preferred choice of technology. No technology is perfect for all applications and the choice of technology is most often application dependent.

Guided wave radar is well suited for very low dielectric constants and long ranges. The flexible probe antenna together with probe-end-projection makes guided wave radar ideal for silos with low reflective media, such as plastic powder or pellets. It is however less suitable for heavier large particle solids, as the stress from the material weight may break the probe.

Non-contacting radar is an all-around technology for use in a large variety of applications. It can provide precise measurements over a smaller surface area or work equally well even in large storage silos. Since there is no contact with the material, it has no restrictions with respect to media weight and may be used in applications where guided wave radar may be prone to probe breakage. However, guided wave radar gives higher signal return thanks to direct switch technology, meaning increased reliability in very tall silos with low reflective materials.

Many point level technologies can be used in most applications, but they differ from each other to cover all applications, including even extreme conditions. An overview of the different technologies, their advantages and limitations is described in the following chapter.

Figure 1.4 Guided Wave Radar Technology (Continuous Level Measurement)

Figure 1.5 Non-Contacting Radar Technology (Continuous Level Measurement)

Figure 1.6. Solids Level Switches (Point Level Measurement)

Section 2 | Technology Selection

2.1 Non-Contacting Radar Level Technology

Emerson provides an extensive selection of Non-Contacting Radar Level Measurement Transmitters designed to address the diverse needs of our customers across various industries. Our portfolio includes the Rosemount 1208 Level and Flow Transmitter, the Rosemount 1408 Level Transmitter, the Rosemount 3408 Level Transmitter, and the Rosemount 5408 Level Transmitter. These transmitters leverage Frequency Modulated Continuous Wave (FMCW) technology to deliver superior measurement accuracy and reliability. They are suitable for a wide array of applications and maintain their precision despite fluctuations in temperature or pressure, or the presence of dust inside the tank. This makes radar transmitters more reliable and versatile than, for example, ultrasonic level transmitters.

Signal Processing

The superior signal processing of Rosemount Non-Contacting Radar transmitters effectively disregards false echoes while always maintaining track of the surface echo, providing you with accurate and precise level measurements. This feature is called Smart Echo Supervision and is integrated into all Rosemount Non-Contacting Radar devices. Thanks to this algorithm, reliable data is ensured by disregarding false echoes from internal obstructions inconveniently placed nozzles, empowering more informed and confident decision-making.

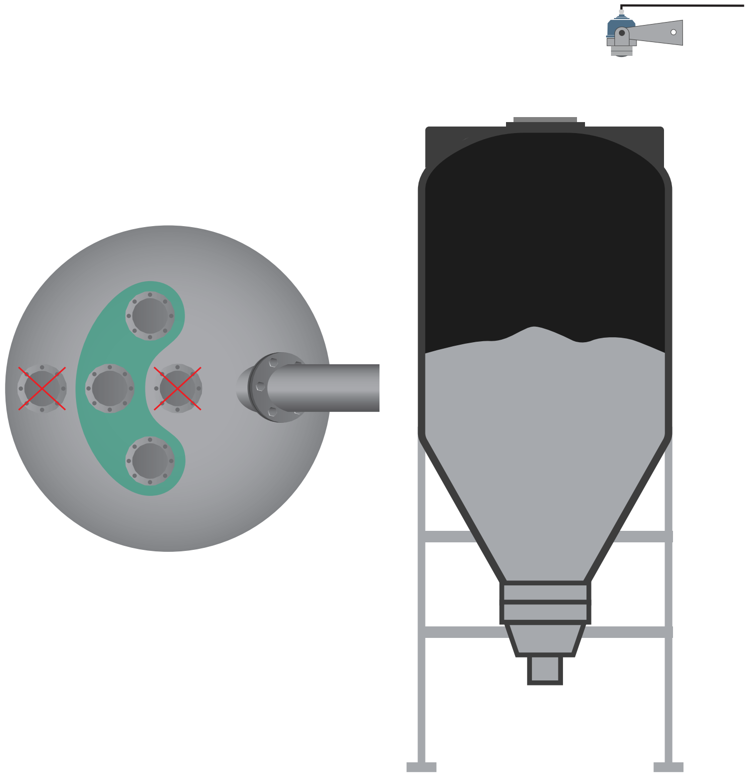
Typical Applications

Non-contacting radar is versatile and suitable for a wide range of applications. Unlike guided wave radar, it is not constrained by the weight of the material, making it ideal for scenarios where pull forces or probe breakage are concerns. Additionally, non-contacting radar offers superior surface visibility, ensuring greater accuracy. Its rapid response to level changes makes it highly effective for both process applications and small vessels.

Mounting Considerations

Positioning

The recommended practice is to mount the non-contacting radar at a distance that is two-thirds of the tank's radius from the wall. Avoid placing the radar at the center of the silo or too close to the tank wall. The inlet stream of the product will interfere with readings if it is in the path of the radar beam. For some applications, choosing a tank that does not corrode over time is key, especially in outdoor settings. For plastic tanks and drums, non-contacting radar devices' measurements can penetrate the plastic roof, thus allowing installation above a plastic tank.



Nozzle

For solids applications, it is essential to minimize potential disturbances from the nozzle. A shorter nozzle typically results in a stronger surface reflection. This is applicable to all antenna types.

Dust Management

Dust is often present in solids applications. Non-contacting radar may not be affected by the dust in the vapor space, but dust can be sticky and create a layer on the antenna. If this layer becomes too thick, it may affect the measurement. Of all the radar antennas available, the process seal antenna is the one that is least affected by dust and/or condensation, due to its all PTFE design. In extreme cases air purging can be used, and this options is available for Rosemount 5408 and Rosemount 3408 Level Transmitters.

Rosemount 5408 Non-Contacting Radar Level Transmitter

Reliable and Robust in Tough Environments

The Rosemount™ 5408 and 5408:SIS are ideal for challenging solids applications in different industries. It features a unique solids algorithm that enables reliable measurement on uneven surfaces with low dielectric constant. The Rosemount 5408 also offers flexible installation on silos or bins and the FMCW technology provides outstanding signal to noise ratio and allows measurements on low DC products over long ranges.

Application Considerations

Advantages

- Small vessel intrusion
- Internal obstructions
- 2-wire
- Process seal antenna provides an all PTFE solution
- Signal Quality Metrics to predict maintenance requirement for dust build-up
- A unique solids algorithm emphasizes the reflection from rough and inclined surfaces
- Flexible installation on the silo or bin with connections as small as 2 in. (50 mm)
- Easy to install and configure
- Measuring range up to 130 ft (40m) in safety mode
- The parabolic antenna option on the Rosemount 5408 can be used in silos as tall as 295ft (90m)
- Smart Echo Supervision™ makes the sensor less sensitive to internal obstructions and inconveniently placed nozzles by disregarding false echoes
- Wireless level measurements via THUM adapter

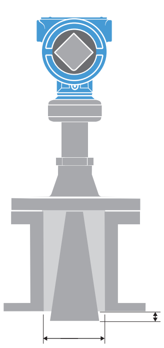
Limitations

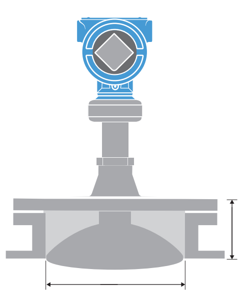
- May need purging
- Inferred volume

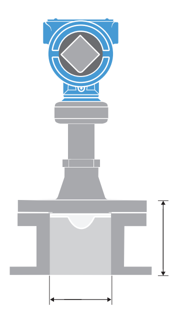
Mounting Considerations

Antenna Options

The antenna types available for the Rosemount 5408 Non-Contacting Radar Level Transmitter are: cone antenna, parabolic antenna, and process seal antenna.

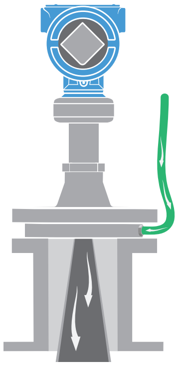






Dust Management
An air purge connection can prevent clogging of the antenna in extreme applications with dirt or heavy coating. To determine if air purging is needed, inspect the tank internal conditions at the location intended for the transmitter. If there is normally a thick layer of product build-up there, air purging is most likely needed. Typical purging media to use is air.

All parabolic antennas come with an integrated air purge connection, for process seal antennas, flushing connection rings are available as accessory for use, and for cone antennas there's a need to have a flanged connection.



Rosemount 3408 Non-Contacting Radar Level Transmitter

Accurate and intuitive for a wide range of applications

The Rosemount 3408 is a versatile radar transmitter that can be used for a wide range of solids media, which makes it suitable for a large variety of applications in medium to small silos, vessels and piles. With smart features, the Rosemount 3408 helps users to save time and maximize efficiency for trouble-free operations, simplifying commissioning, operation and testing. Additionally, it addresses buildup challenges with air-purging and the Smart Echo Supervision™, and Signal Quality Metrics facilitate predictive maintenance in highly dusty environments.

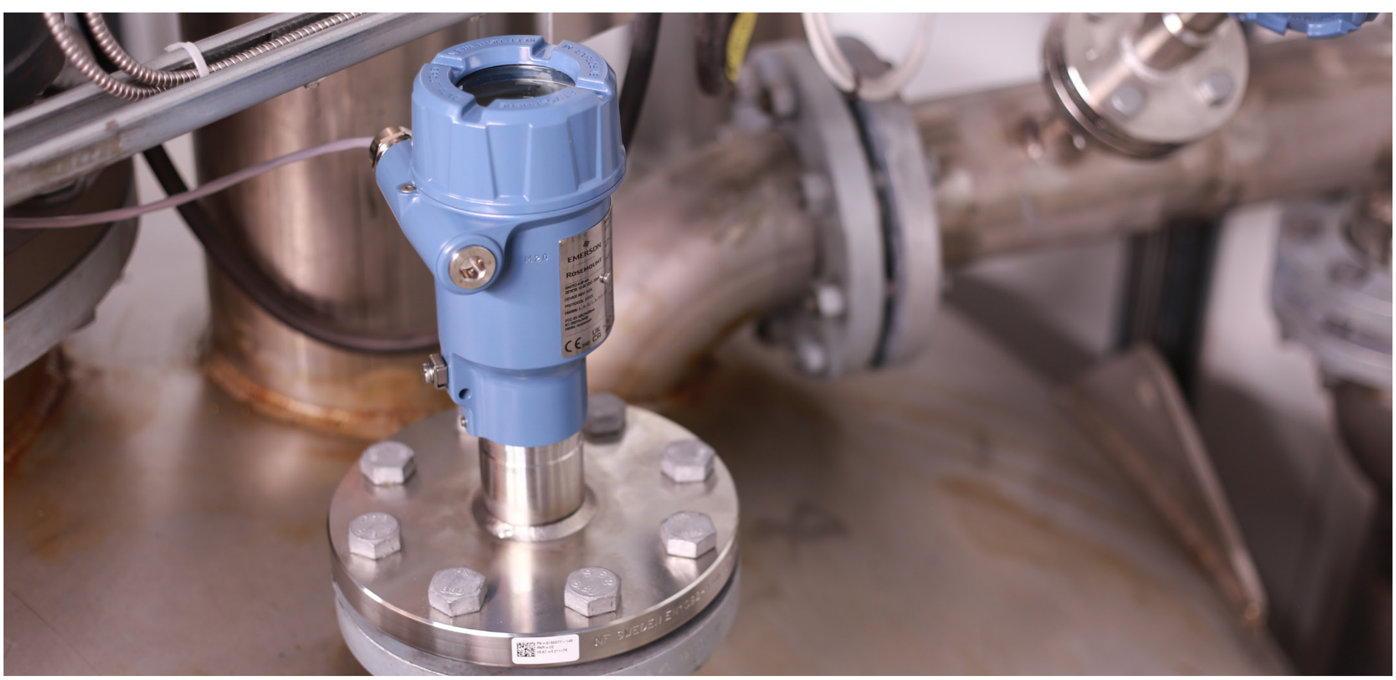
Application Considerations

Advantages

- Air purging option to prevent clogging on the antenna
- Signal Quality Metrics to predict maintenance requirement for dust build-up
- Smart Echo Supervision makes the sensor less sensitive to internal obstructions and inconveniently placed nozzles by disregarding false echoes
- A unique solids algorithm emphasizes the reflection from rough and inclined surfaces
- Anti-stick process seal antenna
- Wireless level measurements via THUM adapter
- Convenient configuration and maintenance using optional Bluetooth® technology

Limitations

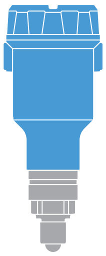
- 98 ft. (30 m) measurement distance for most applications
- 49 ft. (15 m) for fine plastic powders with process seal antenna
- Not suitable for the very tall silos
- Inferred volume



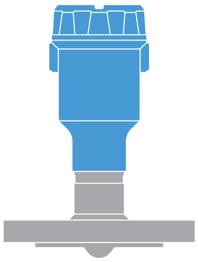
Mounting Considerations

Antenna Options

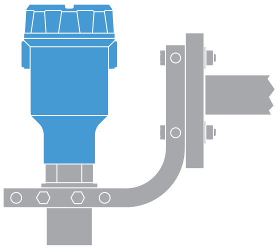
The antenna types available for the Rosemount 3408 Non-Contacting Radar Level Transmitter are: lens antenna, process seal antenna, and Atmospheric Temperature and Atmospheric Pressure (ATAP) lens antenna on a bracket.



The lens antenna is ideal for small process fittings.



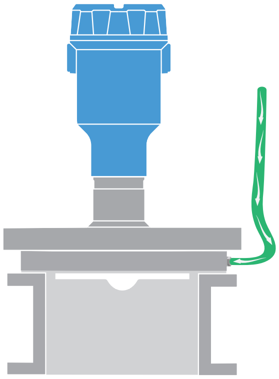
Process seal antennas with wetted parts in all-PTFE design are least impacted by dust or condensation.



The ATAP lens antenna is designed for open air installations and non-pressurized tanks.

Dust Management

There are available air purging connections for the Rosemount 3408 Level Transmitter, which help to prevent clogging on the antenna in applications with dirt or heavy coating. Thus, users are able to prevent build-up, reduce maintenance needs and protect their measurement devices.



Rosemount 1208 Non-Contacting Radar Level and Flow Transmitter

Compact and easy-to-use for simple applications

The Rosemount 1208 is a compact and robust radar transmitter that has been developed to maximize operational efficiency and reduce manual rounds in utility applications within different industries. It is a great option for applications with limited space and, thanks to its fully encapsulated housing design in PVDF, it withstands corrosion and outdoor conditions.

Application Considerations

Advantages

- Bluetooth® wireless technology as well as HART and IO-Link communication for easy integration into any system
- Easy and quick to install
- Avoid buildup thanks to the PVDF lens antenna
- 80 GHz and FMCW technology allows the radar to collect more data, providing better reliability and accuracy
- Smart Echo Supervision makes the sensor less sensitive to internal obstructions and inconveniently placed nozzles by disregarding false echoes
- Fast Sweep Technology provides continuous surface tracking for greater measurement reliability and accuracy, especially in fast filling applications

Limitations

- 32.8 ft (10m) measuring range*
- Lack of advanced diagnostics that can be needed in very dusty applications, such as Signal Quality Metrics
- Approved for Class I Division II / Zone 2
- Inferred volume

**49 ft. (15m) in applications with a dielectric constant>10)*

Rosemount 1408 Non-Contacting Radar Level Transmitter

Compact and with stainless-steel housing for hygienic applications

The Rosemount 1408 Level Transmitter is a compact and robust radar that features a polished stainless-steel housing, thus matching hygienic requirements in the food and beverage industry. It provides accurate continuous level measurement and it is equipped with hygienic certifications, and the ability to withstand CIP and SIP cleaning and external washdown procedures.

Application Considerations

Advantages

- Available in two versions: 1408H for hygienic applications and 1408A for general level measurement and flow calculations
- HART and IO-Link communication for easy integration into any system
- Easy and quick to install
- 80 GHz and FMCW technology allows the radar to collect more data, providing better reliability and accuracy
- Fast Sweep Technology provides continuous surface tracking for greater measurement reliability and accuracy, especially in fast filling applications
- Smart Echo Supervision makes the sensor less sensitive to internal obstructions and inconveniently placed nozzles by disregarding false echoes
- Available with both hygienic (3-A, EHEDG, FDA) and open-air certifications

Limitations

- 32.8 ft (10m) measuring range*
- Lack of advanced diagnostics that can be needed in very dusty applications, such as Signal Quality Metrics
- Inferred volume

**49 ft. (15m) in applications with a dielectric constant>10)*

2.2 Guided Wave Radar Level Technology

Rosemount 5300 Guided Wave Radar Level Transmitter

Perfect fit for Solids Control Management Including Rapid Changes

Guided wave radar can be used in many different applications. It is especially suitable for vessels containing powders and small granular materials and low DC, where the installation area is restricted, and levels are changing rapidly. It is virtually unaffected by dust, moisture, density changes, and temperature.

Typical Applications

Guided wave radar measurement is suitable for level control measurements in smaller silos, bins and hoppers with restricted access and, with its probe end projection feature, it is ideal for media with low dielectric properties.

Mounting Considerations

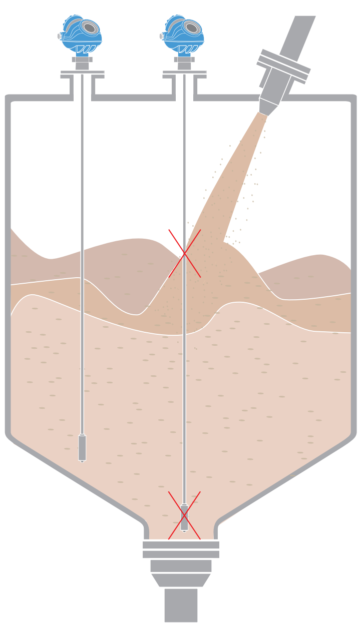
Guided wave radar is especially well suited for smaller vessels with diameter <33 ft. (10 m) and connections as small as 1 in. (25 mm), containing powders and small granular materials and where the installation area is restricted. As vessel height increases, wear on the probe becomes more of a factor in the suitability of its use. Always install the probe in an empty silo and regularly inspect the probe for damage.

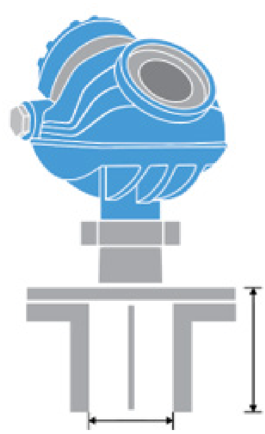
Positioning

Mount the probe as far away as possible from filling and emptying ports. This will minimize load and wear and will help to avoid disturbances from the incoming product

Nozzle

Keep the nozzle as short as possible (maximum recommended height = 4 in. (102 mm) + nozzle diameter). With taller nozzles, a long stud is recommended to prevent the probe from contacting the nozzle. Avoid larger diameter nozzles, especially in applications with low dielectric constants.





Application Considerations

Advantages

- High filling and emptying speeds
- Enhanced signal strength for more reliable and robust measurements with Direct Switch Technology
- Handles long ranges and low DC down to 1.1 with Probe End Projection
- Signal Quality Metrics will aid in detection of dirty probes
- Reliable and accurate level measurements even under high-temperature conditions

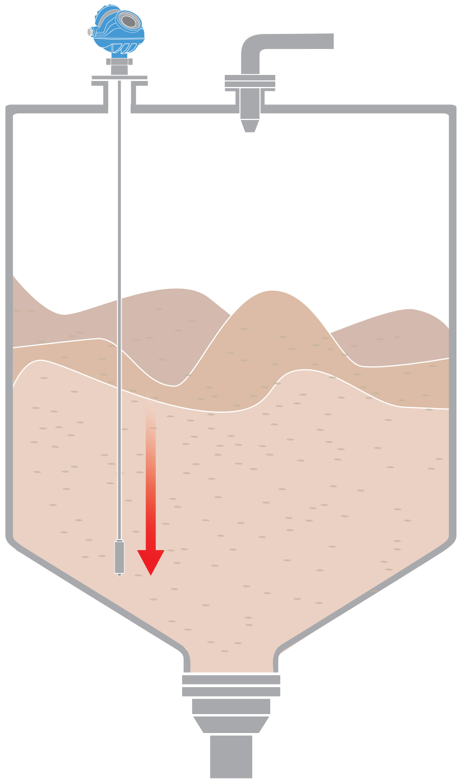
Limitations

- Pull force dependent
- Wear on probe
- Inferred level/volume from one single point

Probe anchoring
Best practice is to have a free-hanging probe, but an anchored probe is sometimes needed for application reasons. The probe end should not be fixed for 98 ft. (30 m) or longer probes. The probe must be slack when anchoring the probe to reduce the risk of probe breakage.

Electrostatic discharges
In some applications, such as plastic pellets, electrostatic charges can build up and eventually discharge. Although the Rosemount 5300 electronics can withstand some static charge, grounding the electronics effectively by securing the end of the probe will reduce the risk of further discharges affecting the system.

Pull forces
Exposing a flexible cable to moving solid material may result in excessive pull force on the cable that could result in probe breakage or roof collapse. These pull forces will vary with the material properties, height, and cable size and could impact the technology choice. It is also important to remember that the roof must withstand the probe's maximum tensile load. In general, this is more of a concern for taller vessels (> 49 ft./15 m) or heavier material (rocks, cement and lime powders, etc).



2.3 Level Switches – Rotating Paddle

Rosemount 2501 Solids Level Switch – Rotating Paddle

Point Level Detection of All Types of Bulk Solids

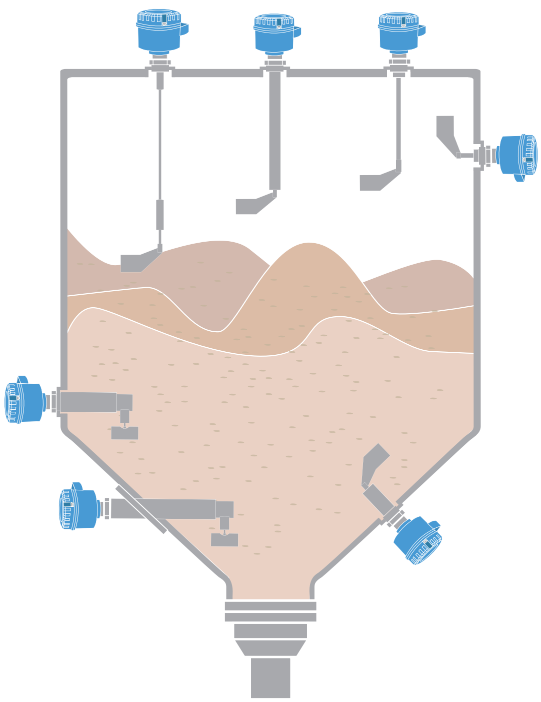
The simple electromechanical measuring principle withstands heavy loads and extreme temperatures, and is suitable for full, demand, or empty detection for all bulk media in all types of vessels. It is a simple, robust, and reliable technology that is insensitive to dust, electrical charge, adhesion, extreme temperature, and pressure.

Typical Applications

- Particularly suitable for small process vessels and most bulk solids
- Solids applications with high temperatures
- Solids applications with heavyweight media

Mounting Considerations

Simple and reliable measuring principle, easy and fast installation.



Positioning

Vertical, horizontal, and oblique installation

Application Considerations

Advantages

- Self diagnostics through optional device fault relay
- Adjustable switching delay prevents false switching
- Patented mechanical hysteresis for extended product lifetime
- Robust device that is unaffected by dust, electrostatic charging, and caking
- Withstands heavy loads, sticky products and high temperatures
- Rotatable electronics housing for easy installation
- Mechanically stable shaft-bearing design
- Robust die-cast housing with IP66
- Brushless protected motor that is more responsive, generates less heat and has a long lifespan
- Adjustable spring sensitivity for lighter or heavier product
- Universal voltage electronics available
- Approved for use in hazardous locations

Limitations

- Only measures level at one specific point
- Not suitable for very light products < 0.9 lb/ft^3 (15 g/l) (depending on the vane size and process connection)
- Limitations for high vibrations in the process

2.4 Level Switches – Vibrating Fork

Rosemount 2511/2521 Solids Level Switch – Vibrating Fork

Versatile Point Level Detection of Most Bulk Solids

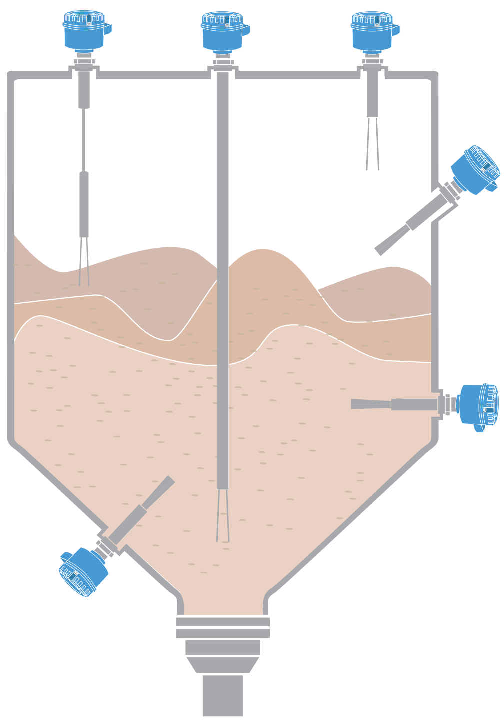
Vibrating fork technology is suitable for fine-grained and powdered media in storage and process vessels. It is a robust technology, easy to operate, and has high sensitivity version for very light bulk media. It has flexible options via configurable specifications for different applications. With an adjustable switching delay, false switching can be prevented.

Typical Applications

- Widely used in storage silos and process vessels/containers with limited space
- Materials with light product density, fine-grained, and powdered products
- Applications requiring pneumatic filling storage and process vessels where high sensitivity is required

Mounting Considerations

Simple and reliable measuring principle, easy and fast installation.



Positioning

Vertical, horizontal, and oblique installation

Application Considerations

Advantages

- Able to withstand high mechanical loads due to short extension length
- Adjustable sensitivity (Rosemount 2521)
- Adjustable switching delay prevents false switching (Rosemount 2521 only)
- Approved for use in hazardous locations
- Reliable, simple, and maintenance free measurement principle
- All wetted parts made from stainless steel
- Robust die-cast housing with IP66 protection
- The enhanced sensitivity version in the Rosemount 2521 can handle densities below 0.3 lb/ft^3 (5 g/l)
- Fork tines are tip sensitive for very precise high/low level measurement points
- Remote housing is available for high vibration in the process

Limitations

- Only measures level at one specific point
- Bridging if larger particles get stuck between forks
- Limited to particle size < .39” (<10mm)
- Risk of bridging between fork tines in sticky products
- Concerns about forks bending under heavier products

2.5 Level Switches – Vibrating Rod

Rosemount 2535 Solids Level Switch – Vibrating Rod

Reliable For Light Bulk Media And Powders

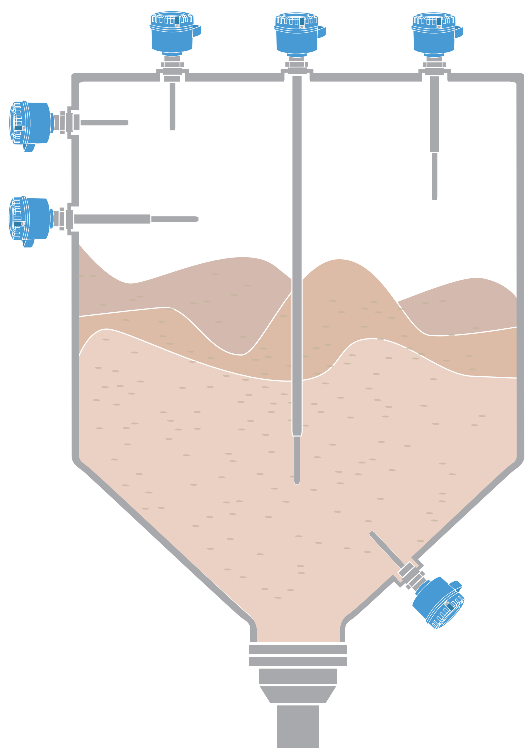
Vibrating rods are particularly suited for full, demand, and empty detection of fine grains and powders in storage and process vessels. They handle light solids and powders with ease and are suitable for use in hazardous and dusty environments. The simple design makes them reliable, maintenance-free, and less prone to clogging.

Typical Applications

- Widely used in storage silos and process vessels/containers with limited space
- Dry materials with light product density, fine-grained, and powdered products
- Applications requiring pneumatic filling

Mounting Considerations

Simple and reliable measuring principle, easy and fast installation.



Positioning

Vertical, horizontal, and oblique installation

Application Considerations

Advantages

- No particle size limitation
- Not affected by bridging
- Approved for use in hazardous locations
- All wetted parts made from stainless steel
- Good resistance to caking and clogging; reliable and maintenance free
- Reliable, simple, and maintenance-free measurement principle
- Small process connections
- Robust die-cast housing with IP66 protection

Limitations

- Only measures level at one specific point
- Build-up can still be an issue for very stick processes
- Low mechanical load capabilities

2.6 Level Switches – Capacitance Probe

Rosemount 2555 Solids Level Switch – Capacitance Probe

Advanced Level Switch for Bulk Materials in Virtually Any Application

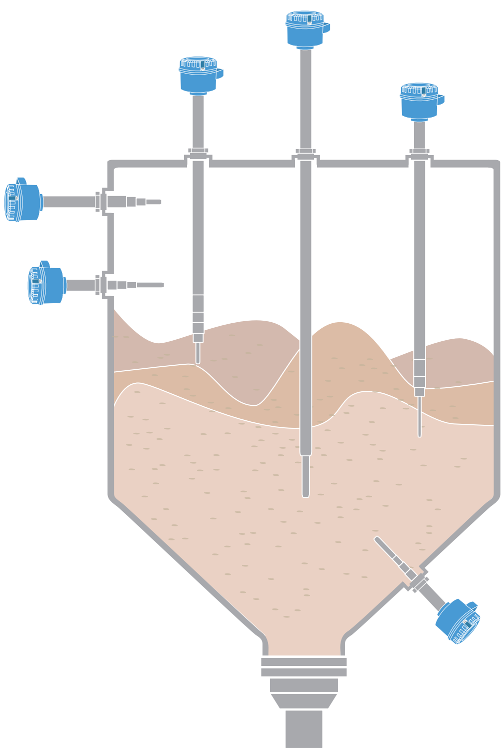
Operates by measuring the capacitance between the probe and container wall. It is robust and suitable for all bulk media. It can be used for full, demand, or empty detection and is designed for low dielectric media and extreme conditions such as high temperatures, high mechanical stress, and high tensile forces.

Typical Applications

- Bulk solids applications, particularly suitable where there is risk of coating or if high vibration is present
- Ideal for sand, cement, and mining applications
- Suitable for use in extreme conditions, such as high temperature 932 °F (500 °C) and pressure applications

Mounting Considerations

Simple and reliable measuring principle, easy and fast installation.



Positioning

Vertical, horizontal, and oblique installation

Application Considerations

Advantages

- “Active Shield Technology” protects against media build-up or caking to ensure complete reliability
- Approved for use in hazardous locations
- Withstands sticky media, heavy loads and high temperatures and pressure
- Simple, automatic calibration via push button
- Continuous self-diagnostic probe function
- Easy to access parameters and configure via local display and buttons
- Electronics housing made of plastic or die-cast aluminum, protection class IP67
- Measurement of low dielectric values (from 1.5)
- Fits into small process connections
- Remote housing available
- Fully PFA coated version for aggressive and/or adhesive media

Limitations

- Only measures level at one specific point
- Limited to media with a dielectric constant higher than 1.5
- Has to be calibrated upon installation

2.7 Technology Specifications

Specification and Selection Guide: Continuous Level Measurement **KEY** 🟢 **Recommended** 🟡 **Application dependent** 🔴 **Not recommended**	**Rosemount 5300 Guided Wave Radar**	**Rosemount 5408 Non-Contacting Radar**	**Rosemount 3408 Non-Contacting Radar**	**Rosemount 1208 Non-Contacting Radar**	**Rosemount 1408 Non-Contacting Radar**
Measurements					
Unaffected by dust generation	🟢	🟢	🟢	🟢	🟢
Particle size					
Large particles	🔴	🟢	🟡	🔴	🔴
Pellets and large granules	🔴	🟢	🟢	🟡	🟡
Granules	🟢	🟡	🟢	🟢	🟢
Heavy powders	🔴	🟢	🟢	🟢	🟢
Fine powders	🟢	🟡	🟢	🟢	🟢
Output					
4-20 mA with HART®	🟢	🟢	🟢	🟢	🟢
FOUNDATION™ Fieldbus	🟢	🟢	🔴	🔴	🔴
RS-485/MODBUS®	🟢	🔴	🔴	🔴	🔴
*Wireless*HART® with Emerson Wireless 775 THUM™ Adapter	🟢	🟢	🟢	🔴	🔴
Performance					
Maximum measuring range	164ft/50m	295 ft/90m	98ft/30m	33ft/10m[1]	33ft/10m[1]
Reference accuracy	±0.1in/3mm	0.04in/1mm	0.04in/1mm	0.08in/2mm	0.08in/2mm
Features					
Air purging	🔴	🟢	🟢	🔴	🔴
Probe end projection	🟢	n/a	n/a	n/a	n/a
Process conditions					
Operating temperature	-320 to 752 °F (-196 to 400 °C)	-76 to 482 °F (-60 to 250 °C)	-76 to 392 °F (-60 to 200 °C)	-40 to 176 °F (-40 to 80 °C)	-40 to 302 °F (-40 to 150 °C)
Operating pressure	Full vacuum to 5000 psi (Full vacuum to 345 bar)	-15 (-1) to 1450 psig (100 bar)	-15 to 363 psig (-1 to 25 bar)	-15 to 43.5 psig (-1 to 3 bar)	-15 to 116 psig (-1 to 8 bar)
Diagnostics					
Advanced software diagnostics tools	Signal Quality Metrics, Probe End Projection	Smart Meter Verification, Signal Quality Metrics, Proof Test Wizards, Smart Echo Level Test	Smart Meter Verification, Signal Quality Metrics, Proof Test Wizards, Smart Echo Level Test	n/a	n/a

[1] 49 ft. (15m) in applications with a dielectric constant>10

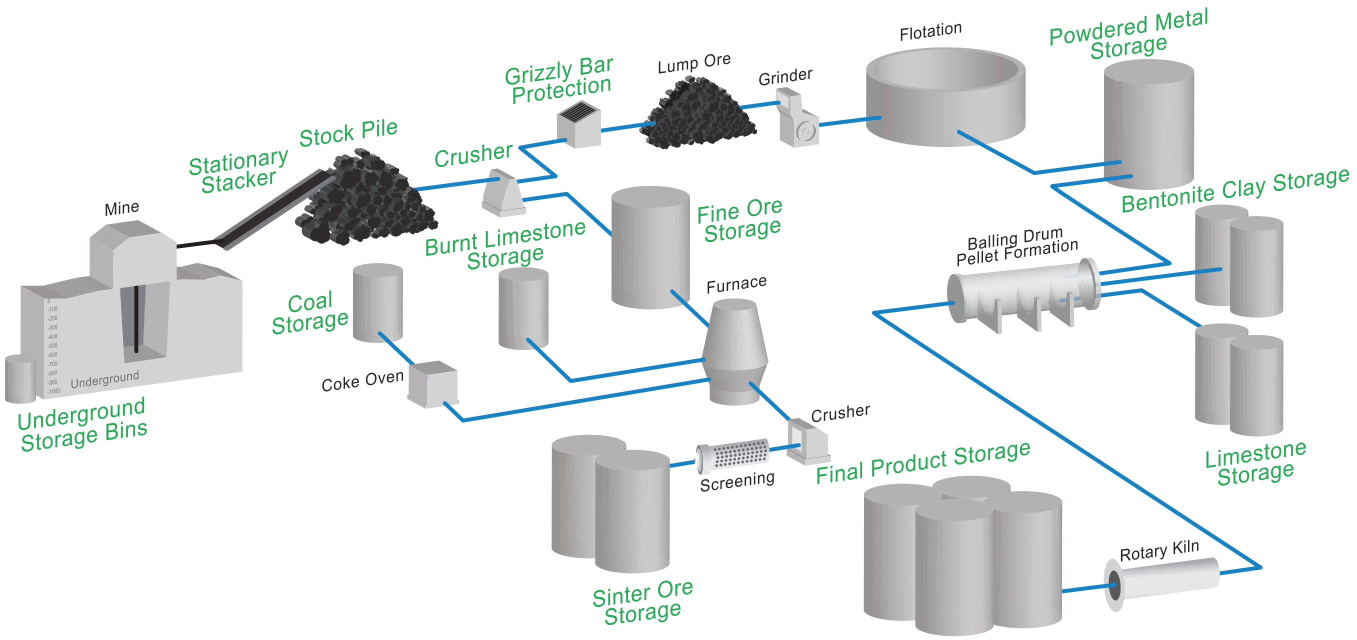
2.7 Technology Specifications

Specification and Selection Guide: Point Level Measurement KEY 🟢 Suitable 🟡 Application dependent 🔴 Not recommended	Rosemount 2501 Rotating Paddle	Rosemount 2511 Vibrating Fork	Rosemount 2521 Vibrating Fork*	Rosemount 2535 Vibrating Rod	Rosemount 2555 Capacitance Probe
Material properties					
Large particles/pellets	🟢	🔴	🔴	🟡	🟢
Granulate/fine powders	🟢	🟢	🟢	🟢	🟢
Heavy powders	🟢	🔴	🟡	🟡	🟢
Prone to caking / build-up	🟢	🔴	🔴	🔴	🟢
Abrasive material	🟢	🟢	🟢	🟢	🟡
Process conditions					
Sensitivity (bulk density/dielectric constant)	≥ 15 g/l	30 g/l or 150 g/l	>5 g/l, 20 g/l, 50 g/l <5 g/l (optional)	≥ 20 g/l	DK value ≥ 1.5
Operating temperature	-40 to 1100 °C -40 to 2012 °F	-40 to 150 °C -40 to 302 °F	-40 to 150 °C -40 to 302 °F	-40 to 150 °C -40 to 302 °F	-40 to 500 °C -40 to 932 °F
Operating pressure	10 bar	16 bar	16 bar	16 bar	25 bar
High mechanical load	🟢	🟡	🟡	🔴	🟢
High humidity	🟢	🟡	🟡	🟡	🟢
High vibration in process	🟡	🟡	🟢	🟡	🟢
Specification					
Housing (powder coated)	Aluminum IP66	Aluminum IP67	Aluminum IP66	Aluminum IP67	Aluminum IP67
Material of construction	Aluminum or Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel and PPS or Ceramic
Output	Relay	Relay, 3-wire PNP	Relay, 3-wire PNP, Direct Load, NAMUR	Relay, 3-wire PNP	Relay

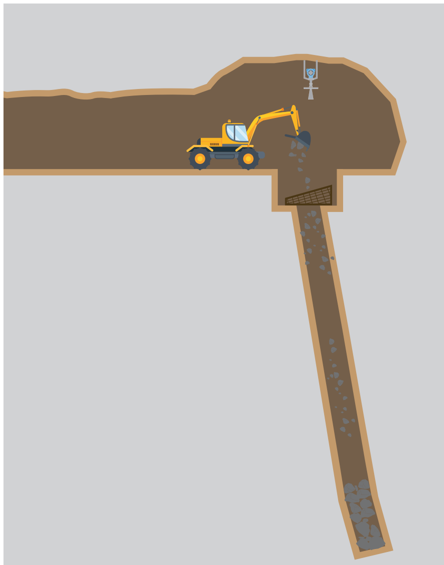
* *High sensitivity model*

Section 3 | Mining Industry

3.1 Metal Ore Processing

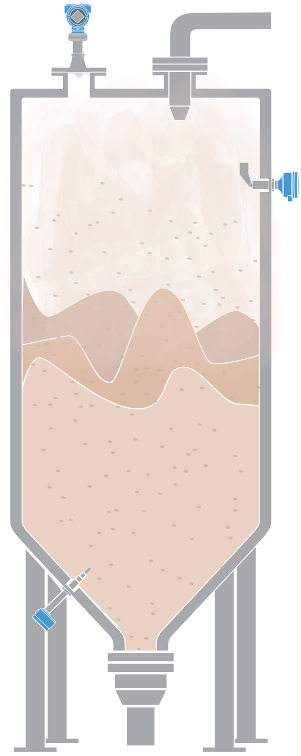


Metal mining and processing works to separate a specific metal from ore using a wide range of different processes. The result can sometimes be a purified form of the metal that is sold at market price to meet demand in the form of jewelry, investments, industry, and dentistry, depending on the type of metal and the conditions involved. While specific metals require some variations in the process, there are many common steps among them. The ore is crushed to reduce the size of the material and the finer ore is separated to concentrate the metal from the rest of the ore.



Underground Mine Ore Pass

- **Application:** The ore pass is a large bin carved into the rock with a steel frame (grizzly) at the bottom to control feed of the ore into cars for transportation to the top. The walls are uneven and overall distance to the feed frame can be around 225 ft (68 m).
- **Challenges:** It is important to know the level measurement as it drops to the area near the feed frame. The level must not go below a minimum level above the frame so that it acts as a buffer from falling rocks and prevents damage to the frame. The ore can be of different grades and sizes and very dusty.

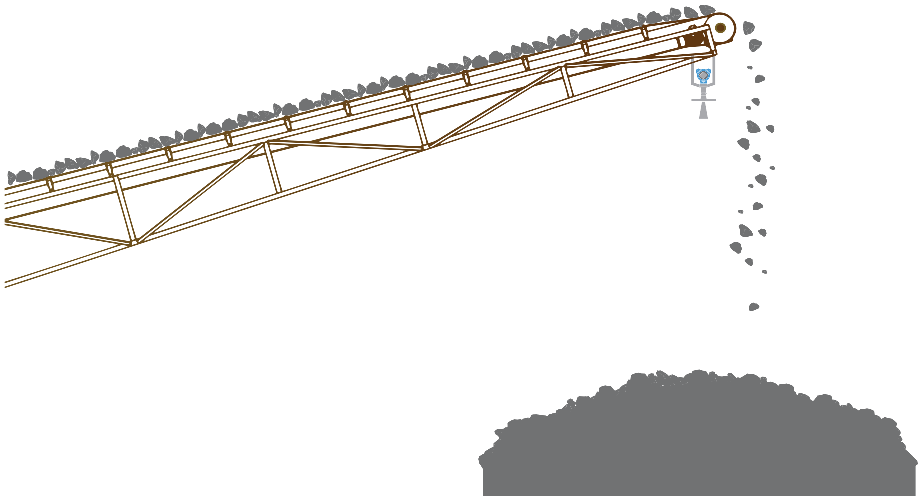


Underground Storage Bins

- **Application:** The underground storage bins provide short term storage and movement of materials. The contents are smaller rocks and finer materials. A typical height is 35 m (115 ft).
- **Challenges:** It is important to know the level measurement as it drops to the area near the bottom. The level must not go below a minimum level to protect the equipment at the bottom. The environmental conditions can be harsh with high heat and humidity and large amount of dust and vibrations.

Stockpiles

- **Application:** Incoming material such as coal and raw ore are stored in large outdoor piles. The large quantities of material are essential to have on hand for production and may include several weeks of supply.
- **Challenges:** How the material is transported into the area varies with the mine, but it is often handled with conveyor belt systems that transport the material into a large holding area. It could be deposited directly underneath a stationary stacker system into a large pile or it could be spread over an area with the use of a radial stacker system.

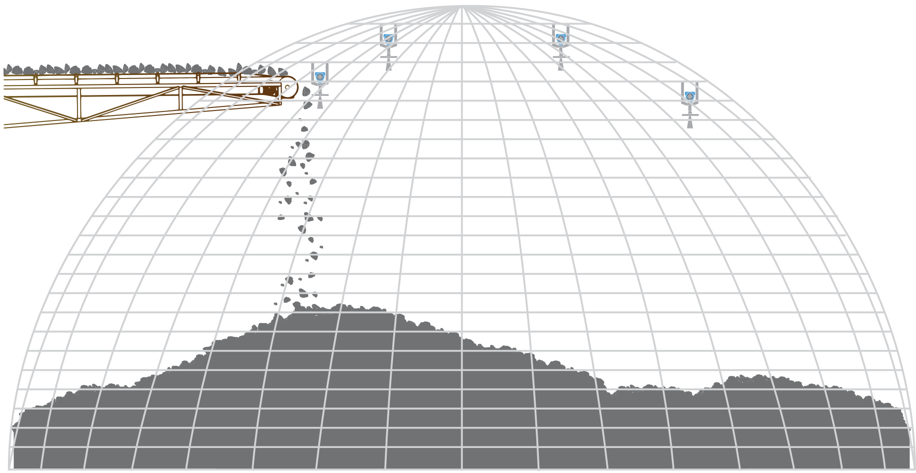


Stationary Stacker System

- **Application:** With stationary stackers, the material is transferred into an area and deposited directly underneath the stacker.
- **Challenges:** It is important to determine the size and shape of the uneven pile and to know when the pile is reaching the maximum height. The material is in the open air and can be very dusty. The conveyor system vibrates and there are often rocks hitting the equipment.

Radial (Rotary)Stacker System

- **Application:** With radial stacker systems, the material is deposited as the stacker moves slowly across a defined area.
- **Challenges:** It is important to know when the material has reached a predetermined height so that the stacker can be moved to an open area. The material is in the open air and is very dusty and the pile has an uneven surface. In addition, the equipment and potential mounting location for a device is limited and subject to vibration and flying rocks. The combination of the movement of the stacker and the increasing height of the rock piles requires fast response area with the use of a radial stacker system.



Grizzly Bar Protection

- **Application:** Grizzly Bars are grates that are used over conveyor systems to protect them from damage and to screen the rock sizes. They are found throughout the mine where the materials are falling to a conveyor system. They control the ore feed as smaller rocks and dust fall through the grizzlies and the larger rocks are held back. Grizzly bars can be damaged if large boulders drop directly on it. Grizzlies are used in crushers as well as larger storage feed silos where rocks are fed out of a silo onto a conveyor
- **Challenges:** The areas above the Grizzly bar are subjected to a lot of rocks, dust, and vibration. The distance may be as much as 35 m (115 ft). Within the crushers, the ore may be ground quickly and the level change can be rapid. The targeted area of interest of the level surface may be relatively small. In a large feed silo, the level change movement may be slower and the area of interest may be within the full expanse of the silo with a very uneven surface.

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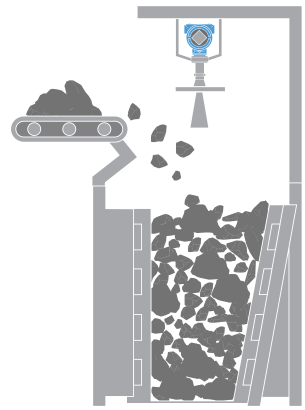
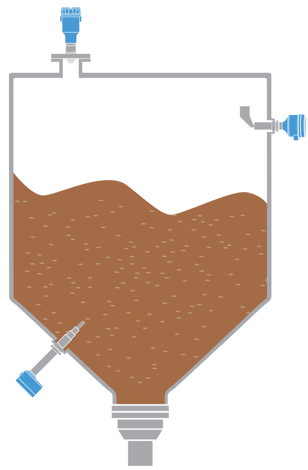
Crusher



- **Application:** Raw material is brought into the crusher for initial grinding and size reduction. Trucks or conveyor systems will bring material into the crusher where it is ground into smaller pieces. A screen (grizzly) may be included below the crusher to sort the rocks so that the smaller pieces go through and the larger pieces are caught for re-grinding. A minimal amount of material should be maintained on the screen to act as a buffer to protect the screen from the impact of larger rock.
- **Challenges:** As the material is brought into the crusher, it moves quickly through the crushing process. The fast- moving level must be monitored to determine when the material reaches a minimum level so that the next load can be started. The material is irregularly shaped and very dusty. The overall distance may be a far as 30 m (98 ft).

Fine Ore Bins



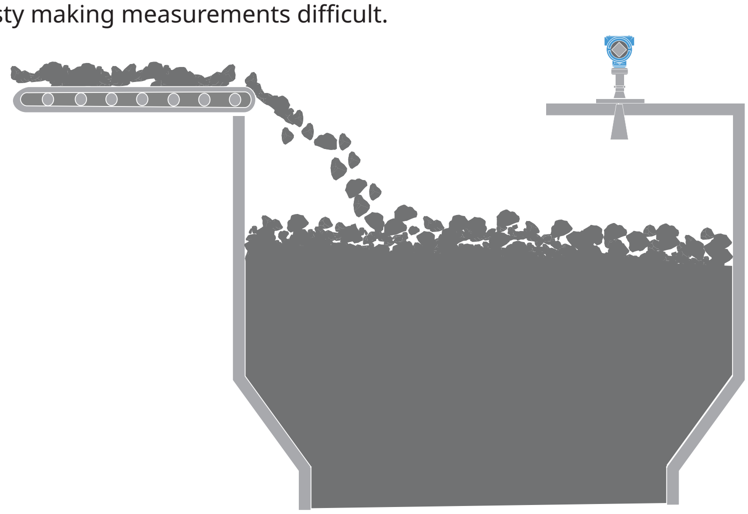
- **Application:** Fine ore bins are part of an ore sifting process. The materials are fed into the bins and filter out through sieves onto conveyor systems. The particle size varies but tends to be smaller rocks and dust. The bins are used as a surge for the process, so the contents may not move until there is a need for them. At that time, the level change can be rapid as the bin empties onto conveyor belts.
- **Challenges:** The contents of the bin are dusty and with uneven surface. The level changes can be fast for both the filling and emptying portions of the sequence.

Production Supply Day Bins and Additive Silos

- **Application:** Materials found in these supply bins and silos may include products produced by different stages of the mining process such as copper concentrate powder, alumina, silica granules, or fly ash. This could also include materials that are brought into the mine to be used as additives in the production such as cement, lime, bentonite clay or other dry materials.

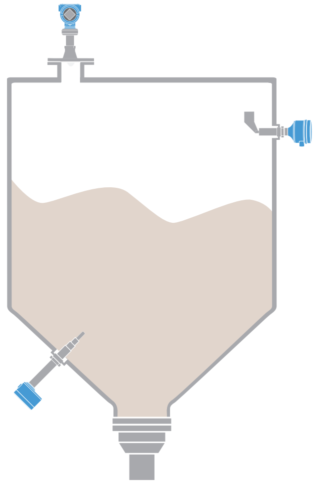
In both situations, it is important to know how much material is available for production or if it needs to be re-supplied. Automation of the inventory management is highly desired so that production needs are met.

- **Challenges:** In production and additive bins the level may change quickly as the silos empty and refill making a responsive level measurement critical to determine adequate supplies for production. In addition, the dry materials are very dusty making measurements difficult.



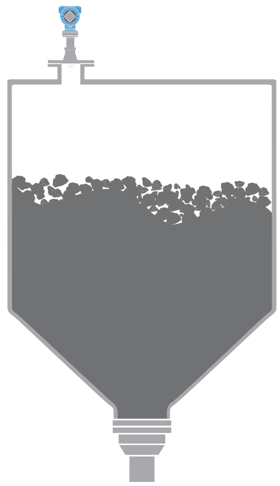
Fine Ore Storage

- **Application:** Fine ore is stored in silos before being processed.
- **Challenges:** The silos hold a supply of fine ore that can be continuously supplied to a furnace in the event of a problem downstream in the ore handling system. If the fine ore silos feeding a furnace are completely empty, the furnace must be shut down. End-users, therefore, require the best technology to ensure continuous and accurate measurements of the material stored in a given silo, to ensure smooth production.



Burnt Limestone Storage

- **Application:** The burnt limestone is stored in silos before being processed.
- **Challenges:** Burnt limestone generates dust during the filling process and tends to stick to the silo walls, creating rat holes and build-up. As it is a critical material for the process, users need to control and monitor the actual level in the silo to prevent process stoppage. Knowing how the burnt limestone is distributed inside the silo allows detection of build-up. This facilitates scheduling of timely maintenance and cleaning to avoid unexpected interruptions of the process and associated losses in time and money.



Coal and Coke Storage

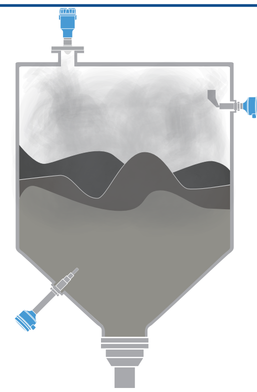
- **Application:** Coal is stored in silos that feed the coke oven which feeds the coke to the furnace. There will be at least one silo for each furnace. Coke may be mixed with ore in the sintering process. There will be at least one silo for each furnace.
- **Challenges:** If the silos are empty, the furnace would need to be shut down. As the fuel is critical for the process, end-users need to control and monitor the actual level in the silos, to prevent process stoppage.

Sinter Ore Storage

- **Application:** Sinter ore is stored in silos prior to being transferred /shipped.
- **Challenges:** Sinter ore creates a very dusty environment during the filling process and tends to stick to the silo walls, forming build-up inside the silo. Sinter ore storage silos are typically very large. The combination of large silos and harsh storage environment makes it difficult for the user to continuously monitor inventory levels.

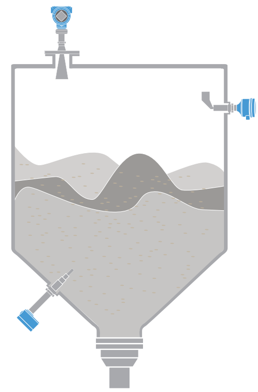
Powdered Metal

- **Application:** Iron powder is stored in a silo before it is mixed with bentonite clay/dolomite and limestone in the balling drum.
- **Challenges:** Iron powder generates heavy dust during the filling process and tends to stick to the silo walls, creating rat holes and build-ups. As it is a critical material for the process, users seek to control and monitor the actual level in the silo to prevent process stoppages.



Bentonite Clay Storage

- **Application:** Bentonite clay is stored in silos before processing.
- **Challenges:** Bentonite generates a great deal of dust during the filling process and tends to stick to the walls of the silo, creating irregular build-up and rat holing. Because bentonite is an essential raw material for the production process, it is important.

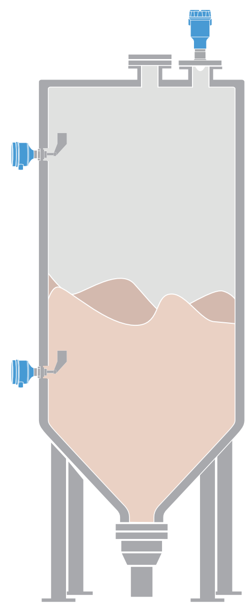


Limestone Storage

- **Application:** Limestone is stored in silos before processing.
- **Challenges:** Limestone generates a great deal of dust during the filling process and tends to stick to the walls of the silo, creating irregular build-up and rat holing. Because limestone is essential to the production process, it is important to quantify the amount of raw material available in the silo to ensure continuous production.

Final Product Storage (Iron Pellets)

- **Application:** Iron pellets (the final product) are stored in silos before being transferred / shipped.
- **Challenges:** Iron pellets are usually stored in wide silos. A typical iron ore processing site will have multiple silos for the pellets. It is very difficult for operators to closely monitor overall inventory levels across all silos in the field, in order to ensure sufficient supplies for efficient delivery schedules of the final product.



READ OUR CASE STUDY

SCAN OR CLICK

Final and Intermediate Product Storage

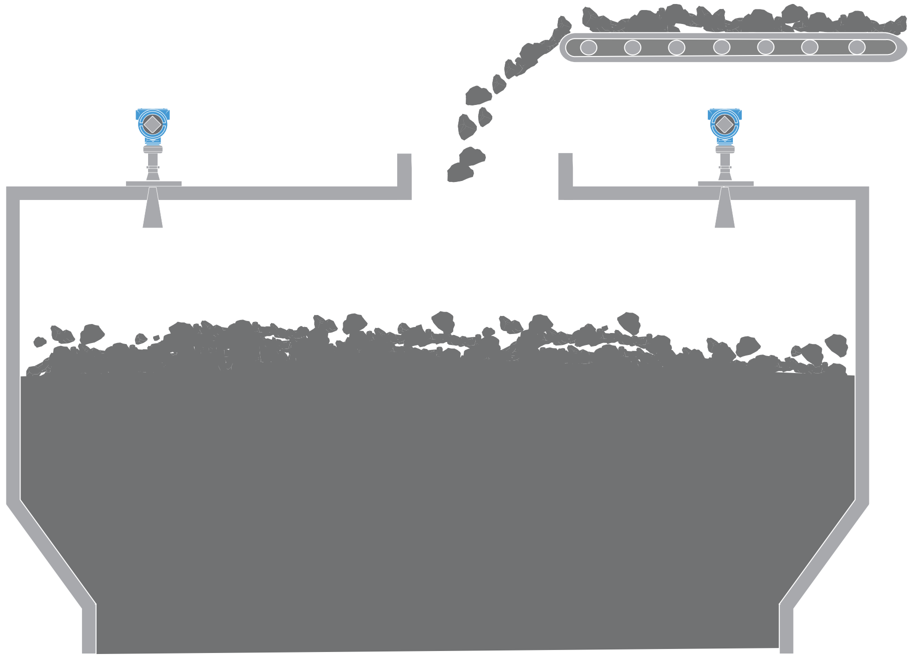
Depending on the mine of materials processing, final and intermediate product storage may be filled into large silos or contained within storage warehouses. In all cases, knowing the total amount of product is important for the efficacy of the mine.

Silo Storage

- **Application:** Iron pellets and manganese are examples of products usually stored in silos before being transferred or shipped. Knowing the amount (tonnage) of final product helps to determine the efficiency of the process.
- **Challenges:** The material surface is likely to be uneven making it is very difficult for operators to closely monitor overall inventory levels across all silos and to know the tonnage of available material for shipment. Some materials can still be very dusty as they are added to the silos.

Warehouses, Shelters and Bunkers

- **Application:** With large volumes of materials, dedicated warehouses and large shelters are used for storage of the final or intermediate product. The warehouse not only stores the material but protects it from rain and wind keeping it dry and contained. In these storage systems, the material is often deposited into the area with dump trucks or conveyor car systems that drop the material into open areas. Materials can be removed from the warehouse by similar means or through floor level grates and filter systems. It is important to know the total amount of material in inventory. An example of materials stored in warehouses may be copper concentrate powder or fine ore powders. Coal may be stored in bunkers.
- **Challenges:** Materials stored in the warehouse can be very dusty and form uneven surfaces. The surface changes as the material is moved in and out of the area. It is important to know the level of the available material as well as the location of areas that could be filled in with more materials. The warehouses can be very large areas such as 120 m long and100 m high.



Recommended Technology – Continuous Level

Recommended Solution	Under-ground Ore Pass	Under-ground Storage Bins	Stockpile	Stationary Stacker	Rotary Stacker	Grizzly Bar Protection
Non-Contacting Radar						
26 GHz radar transmitters	●●●	●●●	●●●	●●●	●●●	●●
80 GHz radar transmitters	●●	●●	●●	●●	●●	●●●
Guided Wave Radar	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)

Recommended Solution	Crusher	Fine Ore Storage	Production Supply Day Bins and Additive Silos	Burnt Limestone Storage	Coal Storage	Sinter Ore Storage
Non-Contacting Radar						
26 GHz radar transmitters	●●●	●●	●●●	●●●	●●●	●●●
80 GHz radar transmitters	●●	●●●	●●●	●●	●●	●●
Guided Wave Radar	● (red)	●●	●●●	● (red)	● (red)	● (red)

Recommended Solution	Powered Metal Storage	Bentonite Clay Storage	Limestone Storage	Final Product Silos	Final Product Warehouse
Non-Contacting Radar					
26 GHz radar transmitters	●●	●●	●●●	●●●	●●●
80 GHz radar transmitters	●●●	●●●	●●	●●●	●●●
Guided Wave Radar	●●	● (yellow)	● (red)	● (yellow)	● (red)

KEY
- ●●● **Preferred Technology**
- ●● **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

Recommended Technology – Point Level

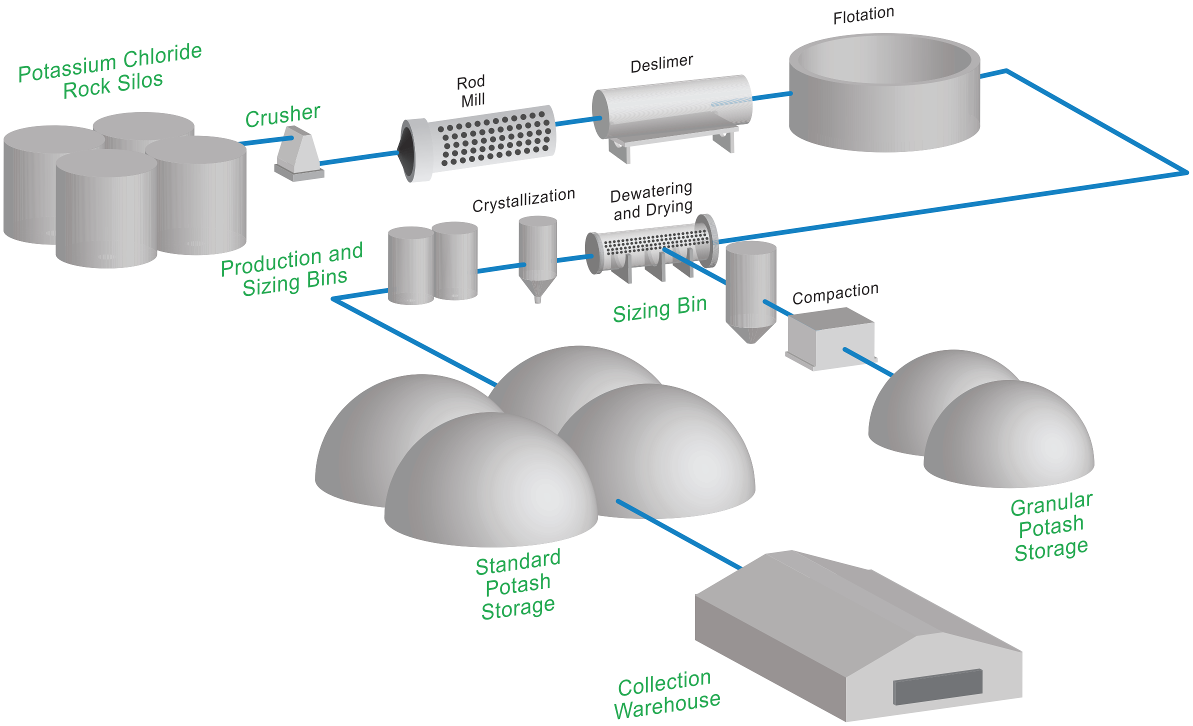
Recommended Solution	Underground Ore Pass	Underground Storage Bins	Stationary Stacker	Rotary Stacker	Grizzly Bar Protection
Rotating Paddle	Suitable	Application dependent	Not recommended	Not recommended	Application dependent
Vibrating Fork	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Vibrating Rod	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Capacitance Probe	Application dependent	Application dependent	Not recommended	Not recommended	Not recommended

Recommended Solution	Crusher	Fine Ore Storage	Production Supply Day Bins and Additive Silos	Burnt Limestone Storage	Coal Storage	Sinter Ore Storage
Rotating Paddle	Not recommended	Suitable	Not recommended	Suitable	Suitable	Suitable
Vibrating Fork	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Vibrating Rod	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Capacitance Probe	Not recommended	Application dependent	Not recommended	Suitable	Suitable	Suitable

Recommended Solution	Powered Metal Storage	Bentonite Clay Storage	Limestone Storage	Final Product Silos	Final Product Warehouse
Rotating Paddle	Suitable	Suitable	Suitable	Suitable	Suitable
Vibrating Fork	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Vibrating Rod	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Capacitance Probe	Application dependent	Suitable	Suitable	Suitable	Suitable

KEY
- Suitable
- Application dependent
- Not recommended

3.2 Potash Production



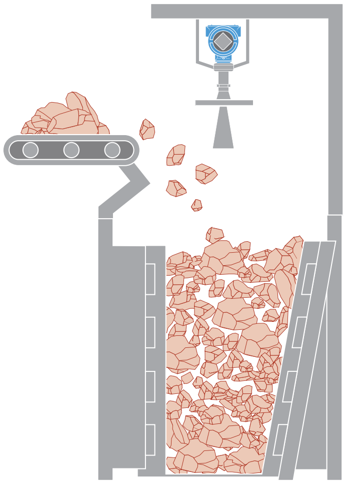
Potash is a salt that is naturally and abundantly found in deposits of old sea-beds. It is a rich source of the potassium that is required for plant growth and is sold as a fertilizer. Potash is crushed to reduce the size of the materials, washed to remove clay and separated to concentrate the potash from the rest of the salt. It is then dried, and the particles are sized. Under- and over-sized particles are collected in day hoppers to be recycled back into the process. Granular potash results from compaction of the finely ground material and has very regular size and shape. Standard potash is more irregular. Both are available in several grades and are stored separately. Very fine powders may be used in liquid fertilizer or a specialty dry fertilizer.

Potassium Chloride Rock Silos

- **Application:** Salt rock is stored in big silos for the producing process.
- **Challenges:** It is difficult to assess the true inventory of salt rock remaining in the silo; therefore operators can't ensure continuous salt supply to the brine making process, which is essential for the production of potash.

Crusher

- **Application:** Raw material is brought into the crusher for initial grinding and size reduction. Trucks or conveyor systems will bring material into the crusher where it ground into smaller pieces. A screen (grizzly) may be included below the crusher to sort the rocks so that the smaller pieces go through and the larger pieces are caught for re-grinding. A minimal amount of material should be maintained on the screen to act as a buffer to protect the screen from the impact of larger rock.
- **Challenges:** As the material is brought into the crusher, it moves quickly through the crushing process. The fast- moving level must be monitored to determine when the material reaches a minimum level so that the next load can be started. The material is irregularly shaped and very dusty. The overall distance may be a far as 30 m (98 ft). amount of dust and vibrations.



Production and Sizing Bins

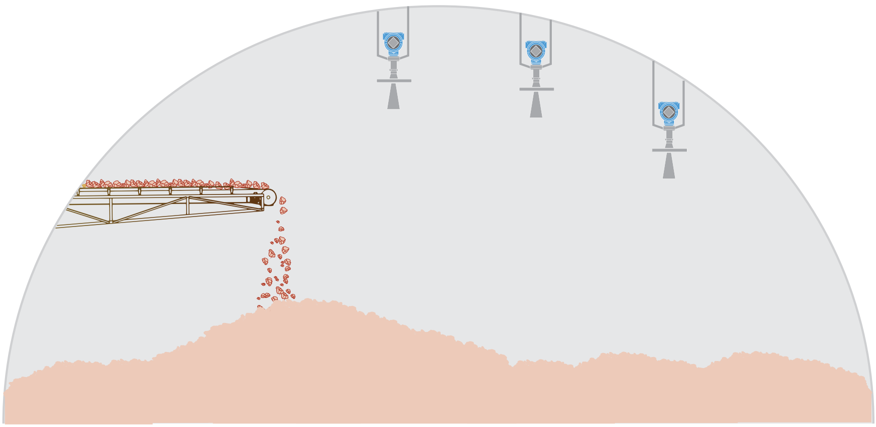
- **Application:** As potash material proceeds through the cleaning and grinding process it is collected in production bins at various points In the sizing process, material that is over or under-sized is recirculated for additional processing. Oversized material may be re-ground. Undersized material may be sent to the compaction area to become granular potash Very fine power is sent to the crystallization area to be made into a liquid or a finer powered fertilizer.
- **Challenges:** In production and sizing bins the level may change quickly as the silos empty and refill making a responsive level measurement critical to determine adequate supplies for production. In addition, the material is very dusty making measurements difficult.

Granular and Standard Potash Storages

- **Application:** The finished granular potash product is transferred to on-site warehouses/ large silos. Different grades of potash are stored separately.
- **Challenges:** The granular potash is stored in large domes that can reach 50m (165 ft) in diameter making accurate measurement of the dome's contents very difficult, impacting on inventory management and control capabilities.

Collection Warehouses

- **Application:** Standard-grade potash is transferred to on-site warehouses/ large silos/ domes. Different grades of potash are stored separately.
- **Challenges:** Standard-grade potash is stored in large domes that can reach 50m (165 ft) in diameter, making accurate level measurement of the dome's contents very difficult and impacting on the end-user's inventory management and control capabilities.



Recommended Technology – Continuous Level

Recommended Solution	Potassium Chloride Raw Material Silo	Crusher	Production and Sizing Bins	Storage Domes and Large Silos	Collection Warehouses
Non-Contacting Radar					
26 GHz radar transmitters	●●	●●●	●●	●●●	●●●
80 GHz radar transmitters	●●●	●●	●●●	●●●	●●●
Guided Wave Radar	●●	● (red)	●●	● (red)	● (red)

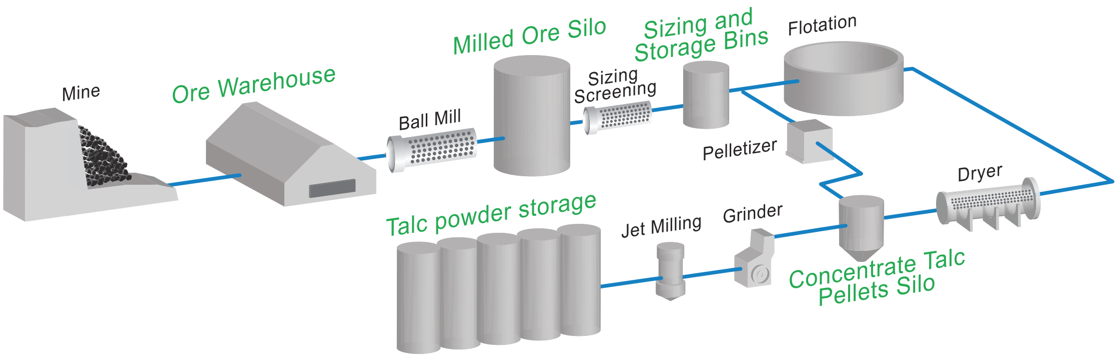
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Potassium Chloride Raw Material Silo	Crusher	Production and Sizing Bins	Storage Domes and Large Silos	Collection Warehouses
Rotating Paddle	● (green)	● (green)	● (green)	● (green)	● (green)
Vibrating Fork	● (red)	● (red)	● (red)	● (red)	● (red)
Vibrating Rod	● (red)	● (red)	● (red)	● (red)	● (red)
Capacitance Probe	● (green)	● (green)	● (green)	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

3.3 Talc Production



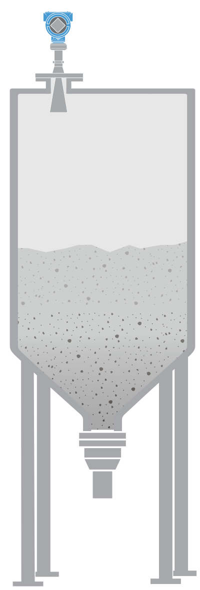
Talc is a soft hydrous magnesium silicate that can be ground into a fine powder which has many uses in industry such as in ceramics, paints, paper and roofing asphalt. Much of it is sourced from open pit mines. The talc ore is crushed, milled, and dried. The particles are screened for size and may go through a flotation process to remove trace amount of nickel, iron, cobalt and other minerals. While most of the product is ground into a fine powder, some of the material may be pelletized to meet certain application specifications.

Ore Warehouse

- **Application:** Talc ore is delivered from the mine to a warehouse at the start of the milling process.
- **Challenges:** Talc ore is stored in piles in large warehouses. End-users need to accurately measure the inventory level on a daily basis.

Milled Ore Silo

- **Application:** Concentrate slurry is dried under pressure and stored before being further processed into powder.
- **Challenges:** Concentrate slurry, an intermediate product, is stored in silos where it tends to stick to the silo walls, often creating build-up which is difficult to measure. This impedes the ability to manage and control inventory in order to ensure continuous production upstream.



Sizing and Storage Bins

- **Application:** As the talc moves through the crushing and milling process, there are holding tanks for smaller quantities of the talc as it is sized and sorted for the next stages.
- **Challenges:** Throughout these stages, the talc is dusty with uneven surfaces and the tanks may fill and empty quickly.

Concentrated Talc Pellets Silo

- **Application:** Talc is mixed with water to form a thick paste. It is then extruded into pellets, dried and stored in bins.
- **Challenges:** Talc pellets will have an uneven surface and some dust.

Talc Powder Storage

- **Application:** The final fine talc powder is stored in silos until it is packed or shipped in bulk.
- **Challenges:** Talc powder generates a great deal of dust during the filling and emptying processes, leading to harsh dusty conditions in the silo. The user needs to accurately measure the quantity of talc powder stored to meet delivery schedules and to satisfy the plant's inventory reporting requirements.

Recommended Technology – Continuous Level

Recommended Solution	Ore Warehouse	Milled Ore Silos	Sizing and Storage Bins	Concentrated Talc Pellets Silo	Talc Powder Storage
Non-Contacting Radar					
26 GHz radar transmitters	●●● (green)	●●● (green)	●●● (green)	●●● (green)	●● (green)
80 GHz radar transmitters	●● (green)	●● (green)	●● (green)	●●● (green)	●●● (green)
Guided Wave Radar	● (red)	● (yellow)	●● (green)	●● (green)	●●● (green)

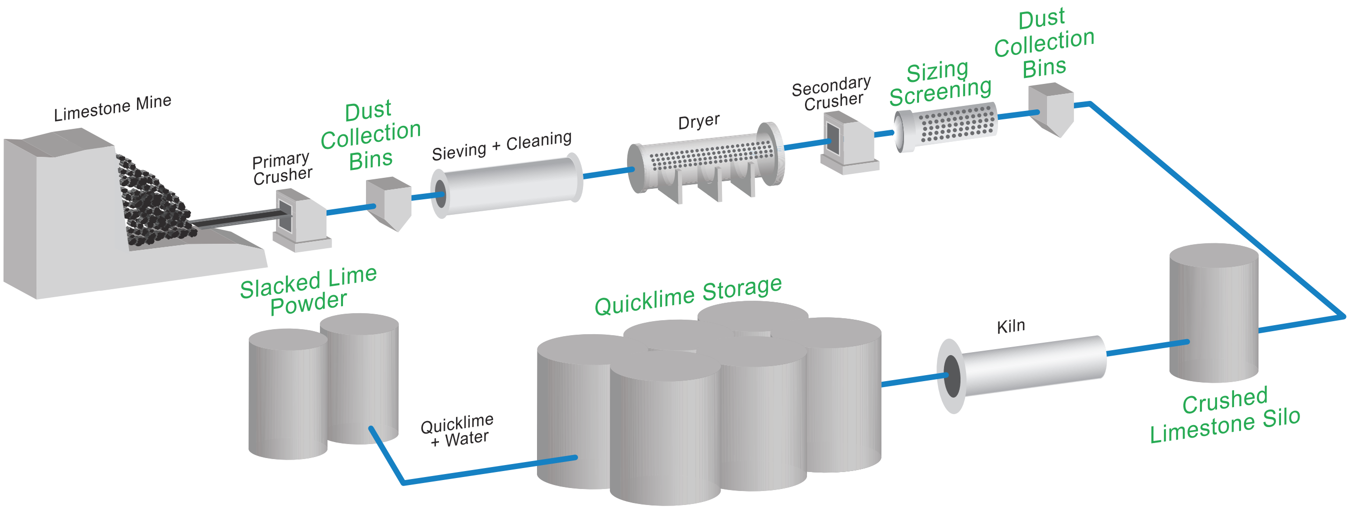
KEY
- ●●● (green) Preferred Technology
- ●● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Ore Warehouse	Milled Ore Silos	Sizing and Storage Bins	Concentrated Talc Pellets Silo	Talc Powder Storage
Rotating Paddle	● (yellow)	● (green)	● (green)	● (green)	● (green)
Vibrating Fork	● (red)	● (red)	● (red)	● (red)	● (yellow)
Vibrating Rod	● (red)	● (red)	● (yellow)	● (yellow)	● (yellow)
Capacitance Probe	● (yellow)	● (green)	● (green)	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

3.4 Lime Production



Lime is primarily calcium oxide and calcium hydroxide that is derived from limestone. Lime has multiple applications including building and road construction, neutralization, agricultural, cleaning and baking. The quicklime products are used in the manufacturing processes of steel, in upgrading processes of sulfide ore, in making paper pulp, and for cleaning drinking and waste water. Flue gases in coal-fired power plants are also cleaned with quicklime. Slaked lime is used for cleaning drinking and wastewater as well as in the metallurgical and building industries.

Limestone is an abundant sedimentary rock containing the calcium compounds as well as magnesium carbonate, dolomite and some minerals.

Limestone is transported to the plant from the mine and goes through primary crushing and sieving. The crushed limestone goes through a washing and drying process and enters a secondary crusher to extract limestone for chemical usage (that will be additionally processed) and aggregates for construction.

Quicklime is made by heating crushed and sorted limestone in either a rotary or shaft kiln. The limestone ($CaCO_3$) breaks down into calcium oxide, i.e. quicklime, (CaO) and carbon dioxide (CO_2). This reaction, termed calcination, requires temperatures of approximately 1100 degrees Celsius. In a rotary kiln the heating process lasts about six hours; in a shaft kiln calcination takes about 24-36 hours. When the quicklime comes out of the kiln it is in lumps, grains and powder.

The handling and storage of quicklime requires great care since it is very reactive. Mixing calcium oxide with water transforms it to calcium hydroxide ($Ca(OH)_2$), i.e. slaked lime, which is a dry, light-colored powder.

Dust Collection Bins

- **Application:** Crushing and sorting of the lime can generate a lot of particulate matter, or dust. This material is collected at various points in the process to minimize its release in emissions from the plant.
- **Challenges:** The powder of the collected dust is very dry, fine and lightweight.

Sizing Screens

- **Application:** After crushing, the rocks and granules are sorted for size before transport to the next stage or for re-crushing.
- **Challenges:** Lime generates a great deal of dust during the screening process. This can be a faster moving stage requiring a responsive measurement.

Crushed Limestone Silo

- **Application:** After mining, the limestone is crushed and then stored in silos before entering the kiln.
- **Challenges:** Lime generates a great deal of dust during the filling and emptying process. The material tends to become sticky and creates build-up on the silo walls. Since it is an essential raw material, operators need to continuously monitor inventory levels to ensure an ongoing supply to the limestone production process.

Quicklime Storage

- **Application:** The quicklime, both in powder and granular form, is stored in silos before being shipped for various applications.
- **Challenges:** Both quicklime powder and quicklime granules generate a great deal of dust during the filling and emptying process and tend to become sticky, creating rat holes and build-up. Operators need to monitor and control the actual level of the material remaining in the silo in order to prevent disruptions of delivery schedules or the production process.

Slacked Lime Powder

- **Application:** Slacked lime is stored in silos prior to being packed and shipped.
- **Challenges:** The size of the lime silos vary from site to site and even within the same site. What they have in common though is that the lime is a very fine powder which is very dusty and commonly heavily build up on everything within the silo atmosphere. Due to the rather heavy weight of the lime particles, the lime piles up unevenly and steep in the silo.

Recommended Technology – Continuous Level

Recommended Solution	Crushed Limestone Silo	Sizing Screen Bins	Dust Collection Bins	Quicklime Storage	Slacked Lime Powder
Non-Contacting Radar					
26 GHz radar transmitters	●●	●●	●●	●●	●●
80 GHz radar transmitters	●●	●●	●●●	●●●	●●●
Guided Wave Radar	● (yellow)	● (yellow)	●●●	●●	●●●

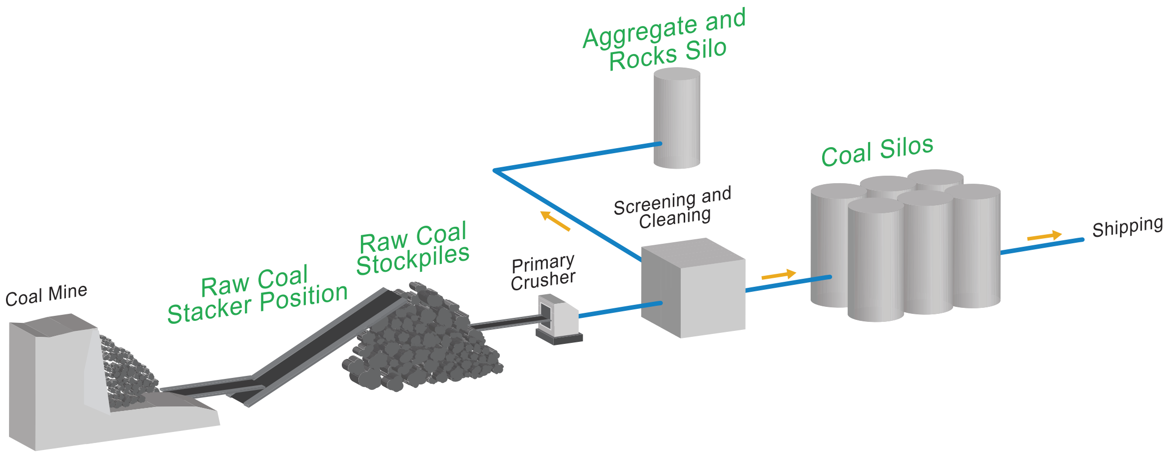
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Crushed Limestone Silo	Sizing Screen Bins	Dust Collection Bins	Quicklime Storage	Slacked Lime Powder
Rotating Paddle	● (green)	● (green)	● (yellow)	● (green)	● (green)
Vibrating Fork	● (red)	● (red)	● (green)	● (red)	● (red)
Vibrating Rod	● (red)	● (yellow)	● (yellow)	● (red)	● (red)
Capacitance Probe	● (yellow)	● (green)	● (green)	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

3.5 Coal Processing



Coal is a fossil fuel extracted in a solid form from the earth. Coal mines can be underground or open-pit style. Its primary use is as a source of energy for electricity generation and within many industries to fire production kilns. It is also an important component in steel production.

Raw Coal Stacker Position

- **Application:** Coal is collected in large piles as it is extracted and crushed from the mine. A positionable conveyor belt (stacker) moves the incoming coal to an open area. As the area fills up, the stacker moves to a new area.
- **Challenges:** The coal is fast moving and dusty as it is dumped on the pile. Operations need to know when the pile reaches a pre-determined distance from the stacker so that it can be moved.

Raw Coal Stockpiles

- **Application:** Raw coal yard/warehouse - Raw coal is delivered to a coal yard in aggregate pieces of approximately 15 cm (6”) that are later reduced in size by a crusher to approximately 4 cm (1.5”).
- **Challenges:** The raw coal is stored in stockpiles in huge yards.

Coal Silo

- **Application:** Following a screening and grinding process, coal is typically delivered to large storage silos via rail or conveyor belt.
- **Challenges:** The coal silos are large in size, containing thousands of tons of material. If the user wishes to know the real time inventory of raw coal and have it connected to the ERP systems in addition to being able to make room for raw coal coming into the silos, and getting shipments ready, then an accurate measuring system is required.

Aggregates and Rocks

- **Application:** As the coal is screened, extra materials are diverted to a separate silo.
- **Challenges:** The aggregates and rocks create a very uneven surface. It is important to know the available storage capacity of the silo.

Recommended Technology – Continuous Level

Recommended Solution	Raw Coal Stacker Position	Raw Coal Stockpiles	Coal Silo	Aggregates and Rocks
Non-Contacting Radar				
26 GHz radar transmitters	●●● (green)	●●● (green)	●●● (green)	●●● (green)
80 GHz radar transmitters	●● (green)	●● (green)	●● (green)	●● (green)
Guided Wave Radar	● (red)	● (red)	● (red)	● (red)

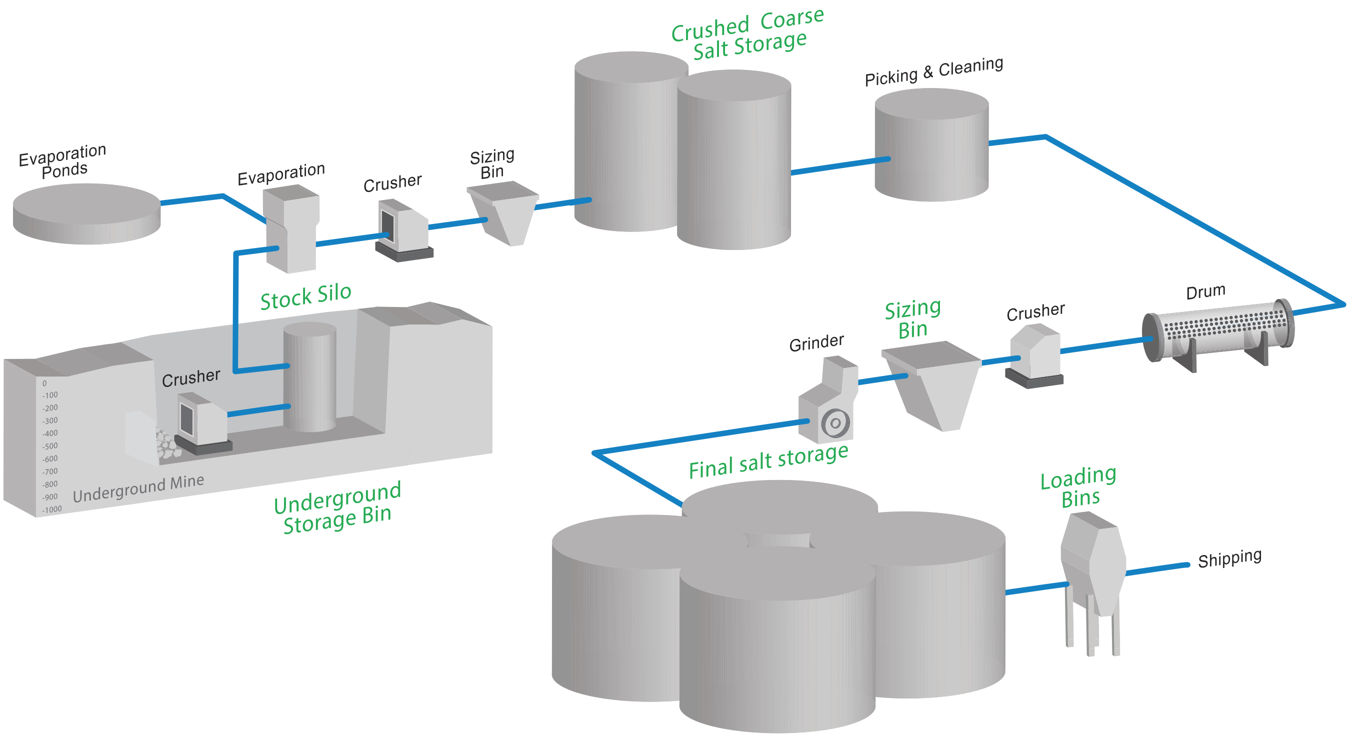
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Raw Coal Stacker Position	Raw Coal Stockpiles	Coal Silo	Aggregates and Rocks
Rotating Paddle	● (red)	● (red)	● (green)	● (green)
Vibrating Fork	● (red)	● (red)	● (red)	● (red)
Vibrating Rod	● (red)	● (red)	● (red)	● (red)
Capacitance Probe	● (red)	● (red)	● (green)	● (yellow)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

3.6 Salt Production



Salt is an abundant mineral that occurs naturally in the seas and in underground deposits. It has a multitude of industrial uses as well as medicinal uses, food preservation, and seasoning.

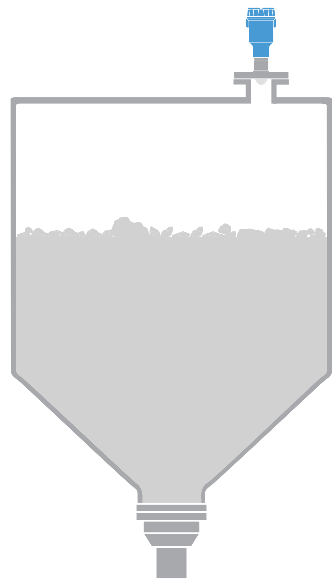
Salt is produced by three different methods: underground mining, solar evaporation and vacuum evaporation. In the mining method, the underground rock salt is blasted into smaller bits and gathered. The rocks are crushed and screened for size and placed into storage bins until it is hauled to surface for additional processing. Once above ground, the salt is further crushed, sorted for size, and shipped.

Solar evaporation ponds are the oldest and most common method where salt water is spread over large areas and salt is harvested after crystallization occurs. Another procedure is use vacuum evaporation which yields the highest quality salt. In this operation, the salt solution is created by pumping water into the underground salt deposit. The resulting liquid brine is then moved into holding tanks. The solution is moved through a series of evaporation pans where steam is applied to induce boiling. The pans are in series of higher vacuum conditions which lowers the boiling point and produces solid salt crystals.

Salt production areas tend to be very corrosive environments. Stainless steel and/or plastic housings are commonly required for the instrumentation.

Stock Silo

- **Application:** Primary crushed salt rocks are further crushed in an underground mine prior to being processed and stored in large underground silos.
- **Challenges:** The primary crushed rock storage silo is the initial stage in the production of salt, feeding a secondary crusher, and therefore needs to be monitored to provide consistent production supply. Since the silo is underground, it is usually created by controlled explosions and the walls are not smooth, making accurate measurement of the stored salt rocks inside very difficult. Early detection of build-up that forms inside the silo is important to the user to allow timely maintenance and to reduce risk of material collapse to the bottom of the silo, which could cause damage to the silo, the crusher and other mechanical parts.



Crushed Coarse Salt Storage

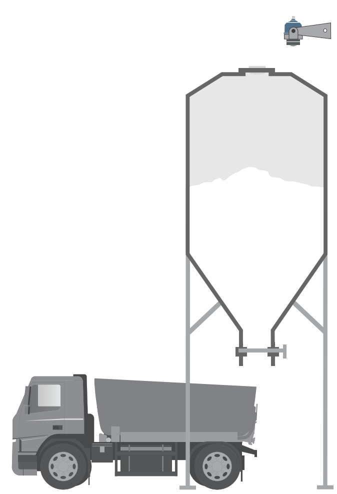
- **Application:** Smaller-sized secondary crushed salt rocks (approximately 2 cm (1 in.) in diameter) from the secondary crusher are stored in production silos, allowing better control of the process.
- **Challenges:** The secondary crushed rock storage silo is located outside the mine and feeds the finished material production process; therefore it needs to be monitored to allow a smooth production cycle. Early detection of build-up that forms inside the silo is important to allow timely maintenance that will reduce risk of damage to the silo and unexpected interruptions to production.

Sizing Bins

- **Application:** The crushed salt is sorted through a screening process and diverted into smaller storage bins. A slow moving agitator may be used to stir the granules. Monitoring of the level is needed to sustain production.
- **Challenges:** The bins may see constant slow movement with dust laden salt granules.

Final Salt Storage

- **Application:** Ground salt is stored in large silos for shipment to consumers from various industries.
- **Challenges:** The salt storage silos are wide (often exceeding 25m (80 ft) diameter) and the user faces constant difficulties trying to closely monitor the salt's inventory levels. Understanding the accurate amount of salt stored in each silo allows production optimization.



Loading Bins

- **Application:** Rock salt is loaded onto trucks or rail cars for shipment.
- **Challenges:** This can be a fast-moving application as the loading bin is filled and emptied quickly.

Recommended Technology – Continuous Level

Recommended Solution	Stock Silo	Crushed Salt	Sizing Bins	Final Salt Storage	Underground Storage Bins	Loading Bins
Non-Contacting Radar						
26 GHz radar transmitters	●●	●●	●●	●●	●●	●●●
80 GHz radar transmitters	●●●	●●●	●●●	●●●	●●	●●●
Guided Wave Radar	●●	●●	●●	●●	●●●	●●●

KEY
- ●●● (green) Preferred Technology
- ●● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

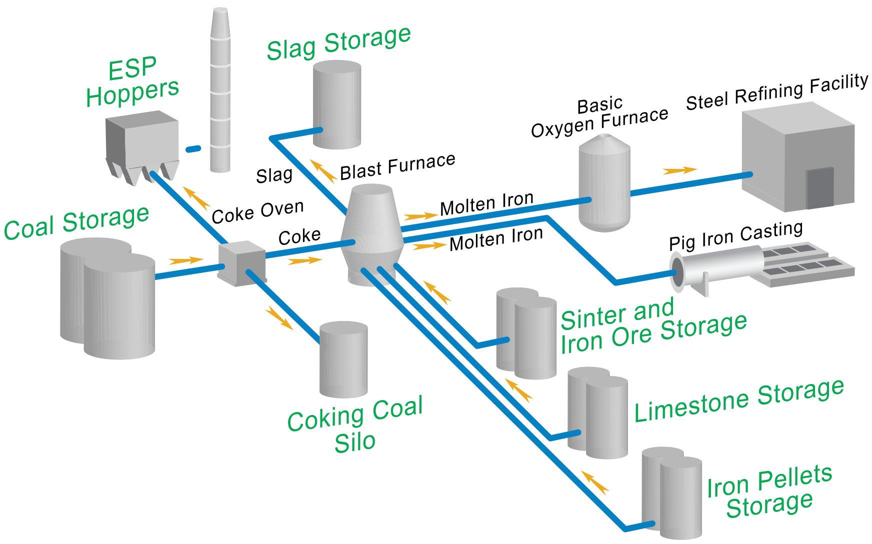
Recommended Technology – Point Level

Recommended Solution	Stock Silo	Crushed Salt	Sizing Bins	Final Salt Storage	Underground Storage Bins	Loading Bins
Rotating Paddle	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)
Vibrating Fork	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)
Vibrating Rod	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)
Capacitance Probe	● (green)	● (green)	● (green)	● (green)	● (green)	● (yellow)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Section 4 | Metal Industry

4.1 Steel Production



Steel is an alloy of iron and carbon and may be produced in a basic oxygen furnace. Coal is distilled (or purified) to become coke, which is subsequently used in the steelmaking process. The iron is created in a blast furnace by combining carbon, a source of iron such as pellets, iron, or sinter, and other components such as limestone. The molten iron is then sent to basic oxygen furnace to create steel. The production of coke requires coal as a raw material and coal as a fuel source.

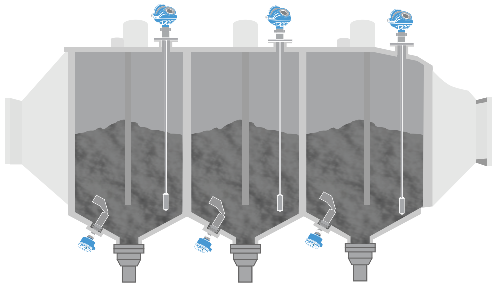
Coal Storage

- **Application:** Coal is stored in silos that feed the coke oven, which feeds the coke to the furnace. There will be at least one silo for each furnace.
- **Challenges**: If the coal silo were completely empty, the furnace would need to be shut down. As coal is critical for the process, it is vital to control and monitor the actual inventory of coal in the silo in order to prevent process stoppages.

ESP Hoppers

- **Application:** Fly ash is captured and removed from flue gas by electrostatic precipitators (ESP) or fabric bag filters at the furnace outlet, collected in hoppers below, and periodically removed.
- **Challenges**: ESP hoppers continuously fill with hot fly ash. Humidity and temperature cause fly ash to stick to the hopper sides, leading to build-up and clogging, potentially damaging the ESP plates.

Monitoring fly ash distribution is crucial for timely hopper emptying, cleaning, and maintenance to prevent clogging and damage, which can pose environmental and health risks. This is essential in order to prevent clogging and risks of damage to the ESP plates. Damaged plates can create environmental and health concerns as well.



Coking Coal Silo

- **Application:** The coke is mixed with iron in the blast furnace to form the steel alloy. As it is a major component its supply to process is critical.
- **Challenges**: The coke material generates a great deal of dust during the filling and emptying processes, leading to harsh dusty conditions in the silo. The coke also tends to adhere to the silo walls creating build-ups and rat holes. These attributes significantly challenge operators' ability to accurately measure inventories .

Limestone Storage

- **Application:** Limestone is stored in silos before entering the production process.
- **Challenges**: The limestone material generates dust during the filling and emptying processes, is stored under harsh dusty conditions, and tends to adhere to the silo walls creating build-up and rat holes. These significantly challenge the user's ability to accurately measure inventories, which is important because the limestone is essential to the steel production process.

Sinter Ore Storage

- **Application:** Sinter ore is stored in silos before entering the production process.
- **Challenges**: Sinter ore creates a very dusty environment during the filling process and tends to stick and form build-up along the silo walls. Sinter ore storage silos are typically very large. The large size of the silos and the harsh storage environment make it difficult for the end-user to continuously monitor inventory levels.

Iron Pellets Storage

- **Application:** Iron pellets can be used in the iron blast furnace and is stored in silos.
- **Challenges**: Iron pellets must be continuously supplied to the furnace. Monitoring of their inventory is essential.

Recommended Technology – Continuous Level

Recommended Solution	Coal Storage	ESP Hoppers	Coking Coal Silo	Limestone Storage	Sinter Ore Storage	Iron Pellets Storage
Non-Contacting Radar						
26 GHz radar transmitters	●●●	●●	●●●	●●●	●●●	●●●
80 GHz radar transmitters	●●	●●●	●●	●●	●●	●●
Guided Wave Radar	● (red)	●●●	● (red)	● (red)	● (red)	● (red)

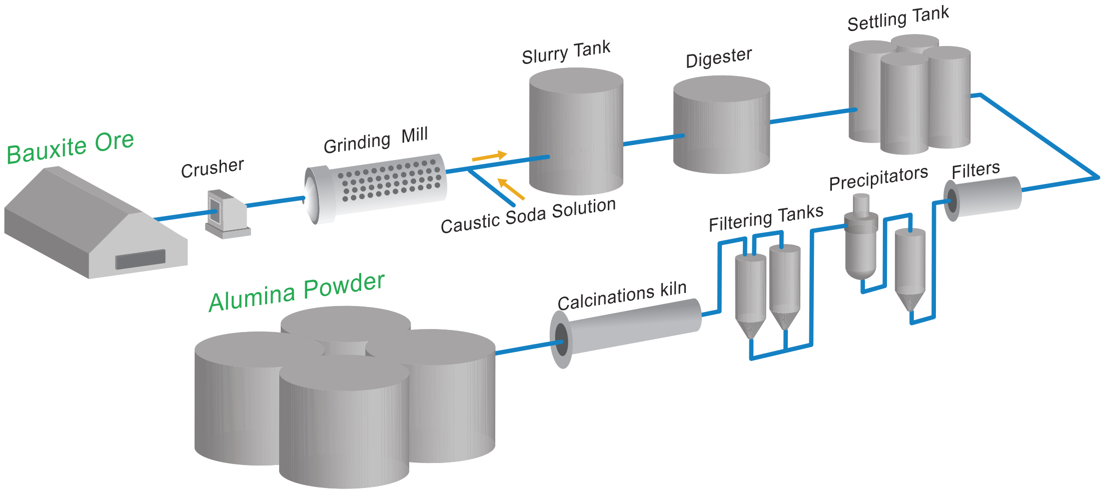
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Coal Storage	ESP Hoppers	Coking Coal Silo	Limestone Storage	Sinter Ore Storage	Iron Pellets Storage
Rotating Paddle	● (green)	● (yellow)	● (green)	● (green)	● (green)	● (green)
Vibrating Fork	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)
Vibrating Rod	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)
Capacitance Probe	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

4.2 Alumina Production



Alumina powder is extracted from bauxite ore which is a mineral containing aluminum oxide along with some other minerals such as iron oxide. The bauxite is crushed and dissolved in caustic soda solution at high temperatures. When the temperature drops, the aluminum hydrate crystallizes and precipitates. The particles are filtered out of the solution and washed with water. They are then dried and calcined. The end result is alumina powder. The alumina powder is then transported to aluminum smelters for production into end products.

Bauxite Ore

- **Application:** Bauxite ore is delivered from the mine to a warehouse at the start of the process.
- **Challenges**: Bauxite ore is stored in large warehouses where its level is difficult to measure.

Alumina Powder Storage

- **Application:** The final product, powdered alumina, is stored in big silos prior to shipment.
- **Challenges**: The alumina powder is stored in silos that reach 30m (100 ft) in diameter and 60m (200ft) in height. In addition to the size and quantity of material stored, these silos have multiple filling and emptying points, making it difficult to monitor the silo's inventory level.

Recommended Technology – Continuous Level

Recommended Solution	Bauxite Ore	Alumina Powder Storage
Non-Contacting Radar		
26 GHz radar transmitters	●●● (green)	●● (green)
80 GHz radar transmitters	●● (green)	●●● (green)
Guided Wave Radar	● (red)	●● (green)

KEY
- ●●● (green) Preferred Technology
- ●● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

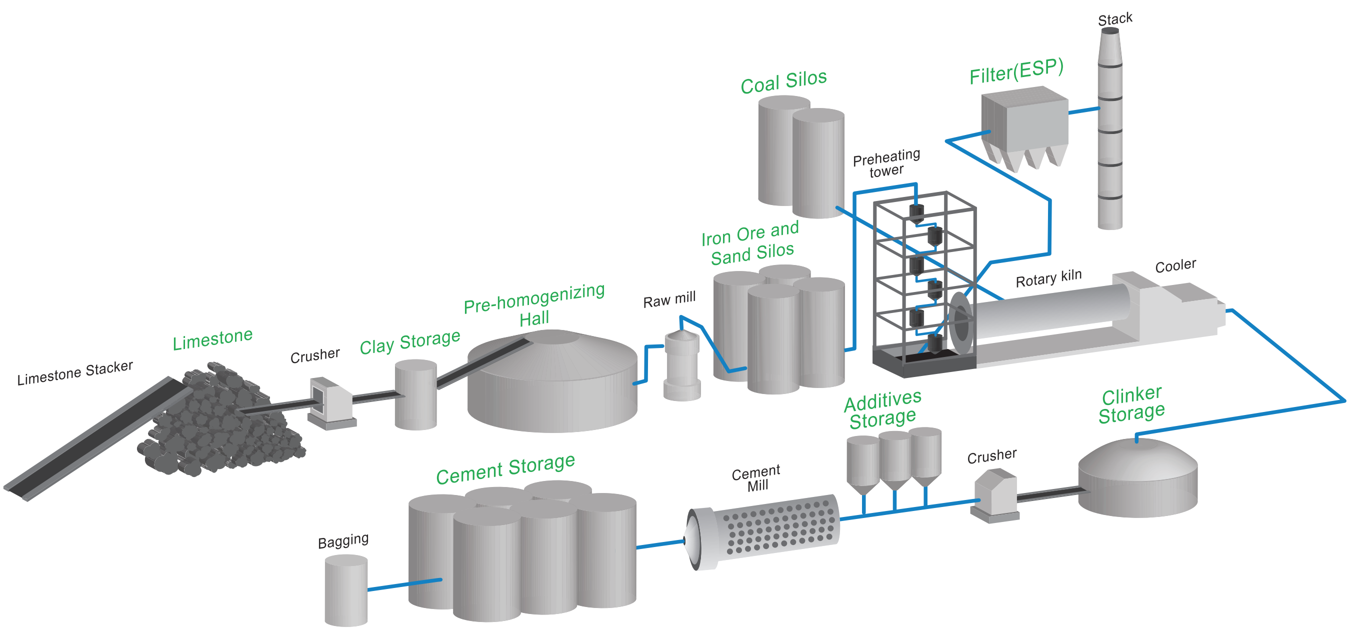
Recommended Technology – Point Level

Recommended Solution	Bauxite Ore	Alumina Powder Storage
Rotating Paddle	● (green)	● (green)
Vibrating Fork	● (red)	● (red)
Vibrating Rod	● (red)	● (green)
Capacitance Probe	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

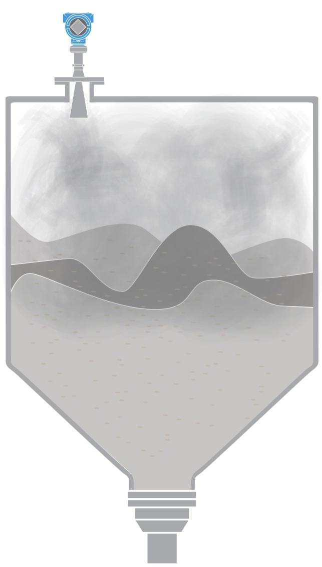
Section 5 | Construction Industry

5.1 Cement Production



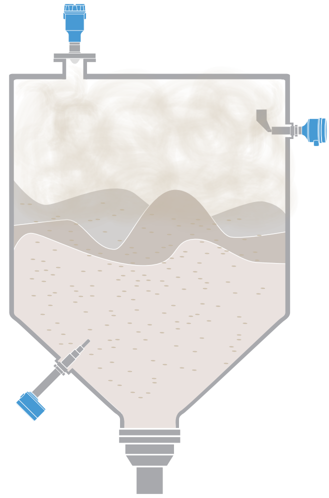
Limestone and clay are blasted from rock quarries by boring the rock and setting off explosives with a negligible impact of the environment, due to the modern technology employed. Once the huge rocks have been fragmented, they are transported to the plant in dump trucks or by conveyor belt. The quarry stone is delivered through chutes to the crushers, where it is reduced by crushing or pounding to chunks approximately 1 ½ inches in size.

Limestone Storage



- **Application:** Limestone is stored in silos before being processed.
- **Challenges:** Limestone generates a great deal of dust during the filling process and tends to stick to the walls of the silo, creating irregular build-up and rat holing. Because limestone is essential to the production process, it is important to quantify the amount of raw material available in the silo to ensure continuous production.

Clay Storage

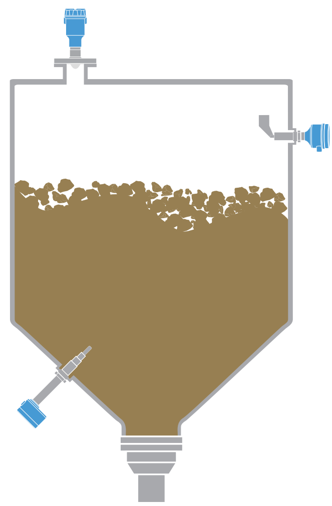


- **Application:** Clay is an essential component of the cement and is mixed with the limestone prior to the pre-homogenizing hall.
- **Challenges:** Clay is dry and dusty with various particle sizes.

Pre-homogenizing Hall

- **Application:** The raw materials required to manufacture cement are limestone and clay. Rocks extracted from the quarry are routed to the nearby cement plant on a conveyor belt and are routed to a grinding plant where they undergo initial milling before being reduced to a fine powder. The raw materials (80% limestone and 20% clay) are then stored in the pre-homogenization hall. This mixture is called the raw mix.
- **Challenges:** The raw materials are stored in very large silos/warehouses. The material is in piles, often settling in irregular shapes, making it difficult for users to assess true inventory levels.

Iron Ore and Sand Silos



- **Application:** Homogeneous mix of the material is stored in silos as part of the raw meal homogenization process.
- **Challenges:** The raw materials are stored in silos. The material settles in irregular shapes, making it difficult for operators to assess true inventory levels.

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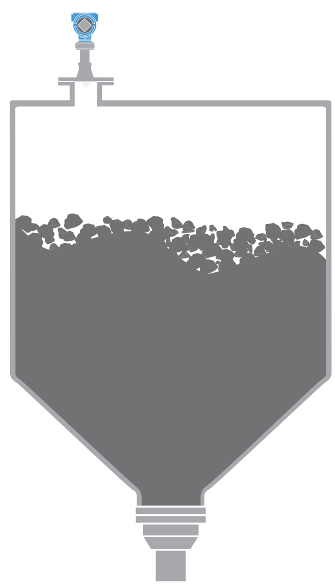
Coal Silo



- **Application:** Coal is stored in silos which feed the coal to the kiln.
- **Challenges:** The silos hold several hours supply of coal and can continue to supply coal to the kiln in the event of a downstream problem in the coal handling system, since the kiln would need to be shut down if the coal silo was completely empty.

Users require technology that will give them continuous and accurate readings of exactly how much material is in a given silo.

ESP Hopper

- **Application:** Fly ash is captured and removed from the flue gas by electrostatic precipitators (ESP) or fabric bag filters located at the outlet of the furnace and before the induced draft fan. The fly ash is collected in hoppers below the precipitators or bag filters and periodically removed.
- **Challenges:** ESP hoppers are continuously filled with hot fly ash. The combined effect of humidity and temperature causes the fly ash to stick to the sides of the hopper. This can cause material build-up and clogging of the hopper which in turn can damage the ESP plates.

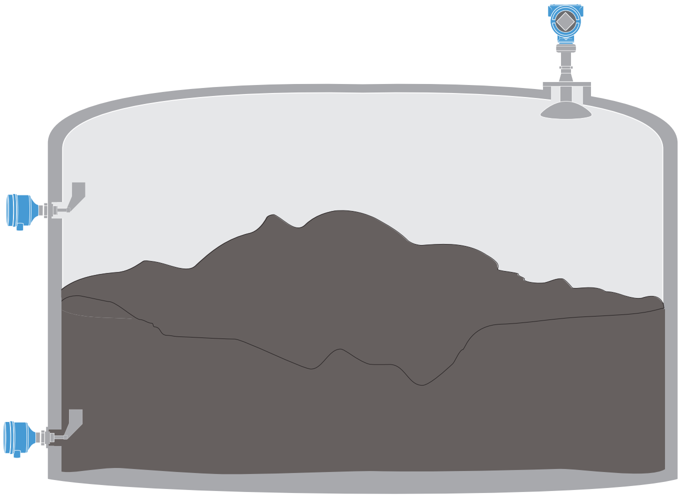
Continuously monitoring and understanding of the distribution of fly ash in the hoppers is very important. With accurate real-time information at hand, preventative action can be taken to empty the hoppers on time, and to clean and perform maintenance work if and when necessary. This is essential in order to prevent clogging and risks of damage to the ESP plates. Damaged plates can create environmental and health concerns as well.

Clinker Storage

- **Application:** The raw mix is fed into a pre-heating tower and reaches 1470 °F (800 °C) before returning to the vertical rotary kiln where it is heated to a temperature of 2640 °F (1450 °C). Combustion causes a chemical reaction called de-carbonation which releases CO_2 contained in the limestone.

The fired materials take the form of hard granules called clinker, which resembles pellets about the size of marbles. Following re-cooling, clinker is stored in silos, and then transformed into cement according to production requirements.

- **Challenges:** Clinker silos usually have very large diameters and hold tens of thousands of tons of material. The material is very dusty and fed into the silo at relatively high temperature of approximately 100 °C (210 °F). The main problem is knowing the quantities of clinker stored in the silo at all times.



Additives Storage

- **Application:** Limestone is combined with clay and other secondary additives such gypsum and bottom ash. The limestone, clay and additives are in carefully controlled proportions and ground together with the clinker into a fine powder in a roller mill.
- **Challenges:** Materials such as iron ore are expensive and the customer's main challenge is to carefully control the amount of additive that is added to the cement manufacturing process.

Cement Storage

- **Application:** Cement is stored in silos before being packaged into bags or delivered in bulk using tanker trucks.
- **Challenges:** The finished cement is a fine powder-like material, creating a very dusty environment during the filling process, and is usually stored in large silos. Build-up occurs from time to time making inventory management and control even more challenging.

Recommended Technology – Continuous Level

Recommended Solution	Limestone Storage	Clay Storage	Pre-homogenizing Hall	Iron Ore and Sand Silo	Coal Storage
Non-Contacting Radar					
26 GHz radar transmitters	●●●	●●	●●	●●	●●●
80 GHz radar transmitters	●●	●●●	●●	●●●	●●
Guided Wave Radar	● (Not recommended)	● (Application dependent)	● (Not recommended)	● (Not recommended)	● (Not recommended)

Recommended Solution	ESP Hopper	Clinker Storage	Additives Storage	Cement Storage
Non-Contacting Radar				
26 GHz radar transmitters	●●	●●●	●●●	●●
80 GHz radar transmitters	●●●	●●	●●●	●●●
Guided Wave Radar	●●●	● (Not recommended)	●●●	●●

KEY
- ●●● **Preferred Technology**
- ●● **Suitable**
- ● **Application dependent** (yellow)
- ● **Not recommended** (red)

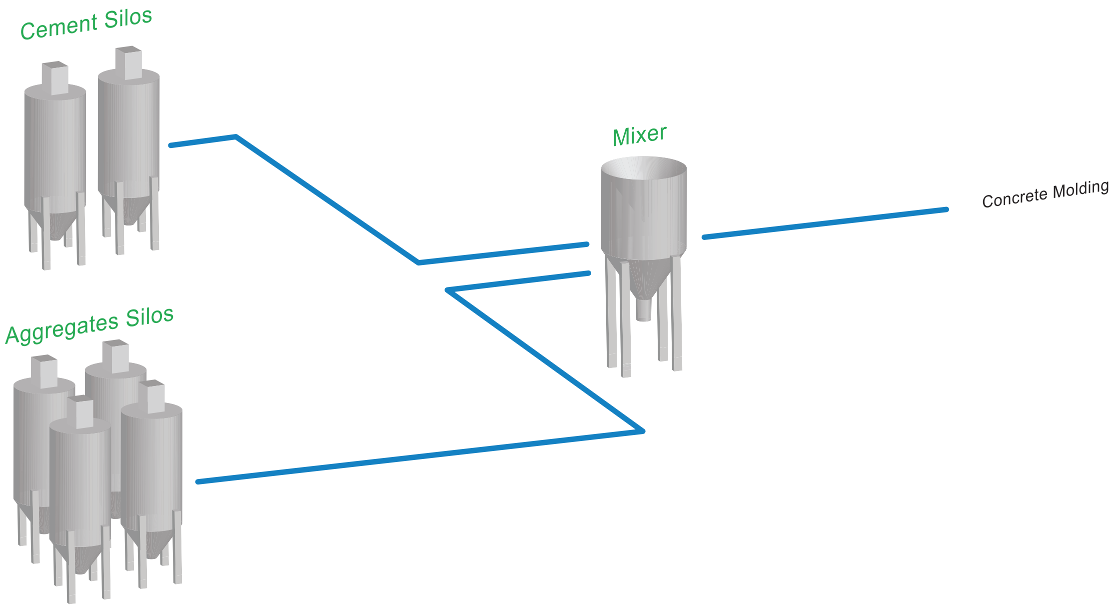
Recommended Technology – Point Level

Recommended Solution	Limestone Storage	Clay Storage	Pre-homogenizing Hall	Iron Ore and Sand Silo	Coal Storage
Rotating Paddle	● (Suitable)	● (Suitable)	● (Suitable)	● (Suitable)	● (Suitable)
Vibrating Fork	● (Not recommended)	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Not recommended)
Vibrating Rod	● (Not recommended)	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Not recommended)
Capacitance Probe	● (Suitable)	● (Suitable)	● (Suitable)	● (Suitable)	● (Suitable)

Recommended Solution	ESP Hopper	Clinker Storage	Additives Storage	Cement Storage
Rotating Paddle	● (Application dependent)	● (Suitable)	● (Suitable)	● (Suitable)
Vibrating Fork	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Application dependent)
Vibrating Rod	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Application dependent)
Capacitance Probe	● (Suitable)	● (Suitable)	● (Suitable)	● (Suitable)

KEY
- ● **Suitable** (green)
- ● **Application dependent** (yellow)

5.2 Concrete Production



Concrete is an essential material for building houses, bridges and tunnels as well as for the production of slabs. Job sites are supplied via stationary or mobile mixing equipment. All materials needed for the production of concrete are temporarily stored in silos.

Concrete is made from a mix of cement (mostly Portland cement), aggregates (sand, gravel or crushed stones) and water. Aggregates make up the majority of the concrete's volume and the cement provides resistance.

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SCAN OR CLICK

Cement Silos

- **Application:** Cement is stored in large silos before entering the mixing process.
- **Challenges:** The process creates a very dusty environment inside the silo. Build-up and rat holes tend to occur, risking damage to the silo. Knowing the quantity of material is important to ensure continuous production process.

Aggregates Silos

- **Application:** Aggregates including sand, gravel, small rocks are stored in silos before entering the mixing process.
- **Challenges:** Concrete is produced by a mixture of fixed amounts of raw materials coming from different silos, so it is essential to have sufficient quantities of all raw materials on hand to avoid unnecessary and unexpected production stoppages. Therefore knowing the accurate amounts of the different types of materials stored in each silo is crucial to control the overall production cycle.

Mixer

- **Application:** Cement, aggregates, and water are added into mixer to form wet cement.
- **Challenges:** Mixing the various components creates a lot dust and the level will change quickly as the mixer is filled. Once water is added the mixture will form wet cement. Due to the presence of the mixer blades a non-contacting solution is preferred.

Recommended Technology – Continuous Level

Recommended Solution	Cement Silos	Aggregate Silos	Mixer
Non-Contacting Radar			
26 GHz radar transmitters	●●● (green)	●●● (green)	●●● (green)
80 GHz radar transmitters	●●● (green)	●●● (green)	●●● (green)
Guided Wave Radar	● (red)	● (red)	● (red)

KEY
- ●●● (green) **Preferred Technology**
- ●● (green) **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

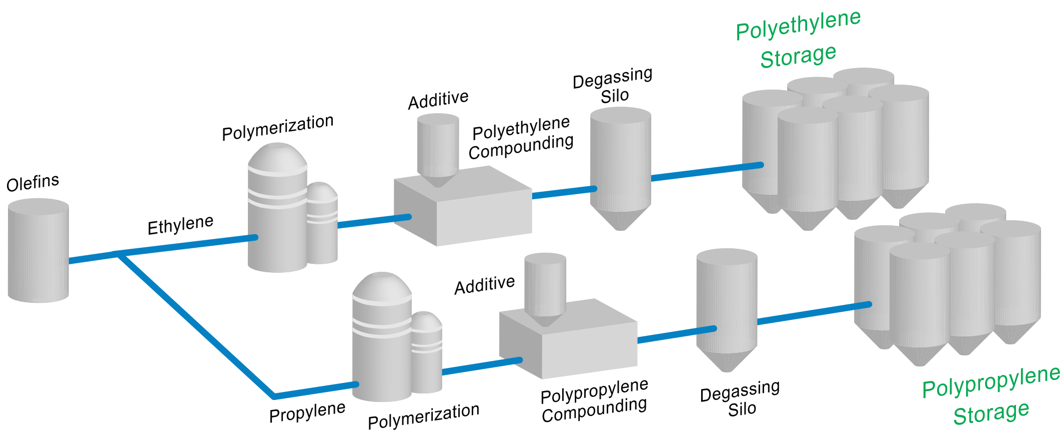
Recommended Technology – Point Level

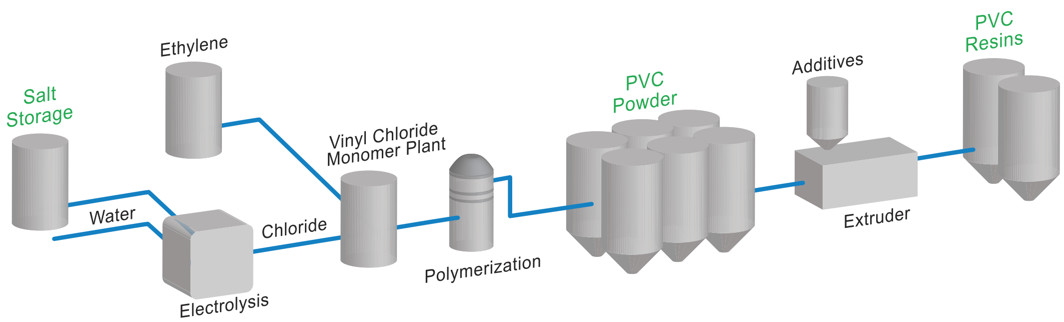
Recommended Solution	Cement Silos	Aggregate Silos	Mixer
Rotating Paddle	● (green)	● (green)	● (yellow)
Vibrating Fork	● (yellow)	● (yellow)	● (red)
Vibrating Rod	● (red)	● (red)	● (red)
Capacitance Probe	● (green)	● (green)	● (green)

KEY
- ● (green) **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

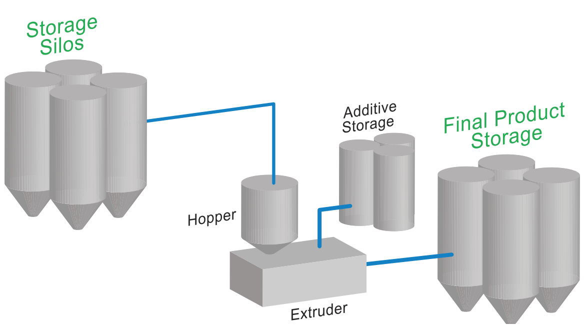
Section 6 | Chemical Industry

6.1 Plastics Production





Plastics are generally produced in petrochemical polymerization plants. The most common plastics produced globally include polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC).

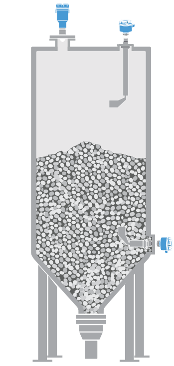


To give the end plastic product its properties, the polymers are melted and mixed in an extruder together with additives. This process is called compounding, and changes the physical, thermal, electric, or visual characteristics of the plastic.

LEARN MORE ABOUT PLASTICS RECYCLING IN OUR EBOOK

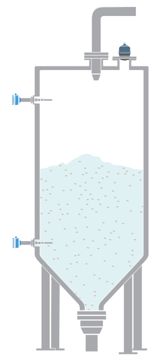
SCAN OR CLICK

PP/PE Pellets Storage



- **Application:** The final granular product is stored in silos before being shipped to plastic product manufacturing plants or packed in bags.
- **Challenges:** PP and PE pellets have a low dielectric constant and the environment can be quite dusty, leading to issues with build-up and risk of static heat and charges.

Salt Storage



- **Application:** Salt is a key raw material for PVC production. It is mixed with water, and via electrolysis the chloride atom is separated and used in the production of the vinyl chloride monomer.
- **Challenges:** Salt can be stored in silos or large piles. It can be very abrasive and corrosive. As a key component, an adequate supply must be available at all times. If stored in large piles, it can be difficult to know the inventory, making a robust level measurement necessary.

PVC Vinyl Resins

- **Application:** PVC is stored in storage silos prior to being delivered or packed.
- **Challenges:** PVC in a PVC production facility is an end product. Operators seek to monitor the inventory levels closely, but the great amount of dust generated during the filling process complicates the task. The relatively low dielectric constant makes measuring the true level of the stored PVC very challenging.

PVC Powder

- **Application:** PVC powder is stored in silos prior to being delivered or packed. The silos can be very large in size containing thousands of tons per silo.
- **Challenges:** PVC powder is the end product in a PVC production facility. Operators seek to closely monitor the inventory levels, but the great amount of dust generated during the filling process complicates the task.

READ OUR CASE STUDY

SCAN OR CLICK

Recommended Technology – Continuous Level

Recommended Solution	PP/PE Pellets	Salt Storage	PVC Resin	PVC Powder
Non-Contacting Radar				
26 GHz radar transmitters	●● (green)	●● (green)	●● (green)	● (yellow)
80 GHz radar transmitters	●●● (green)	●●● (green)	●●● (green)	●●● (green)
Guided Wave Radar	●●● (green)	●● (green)	●●● (green)	●●● (green)

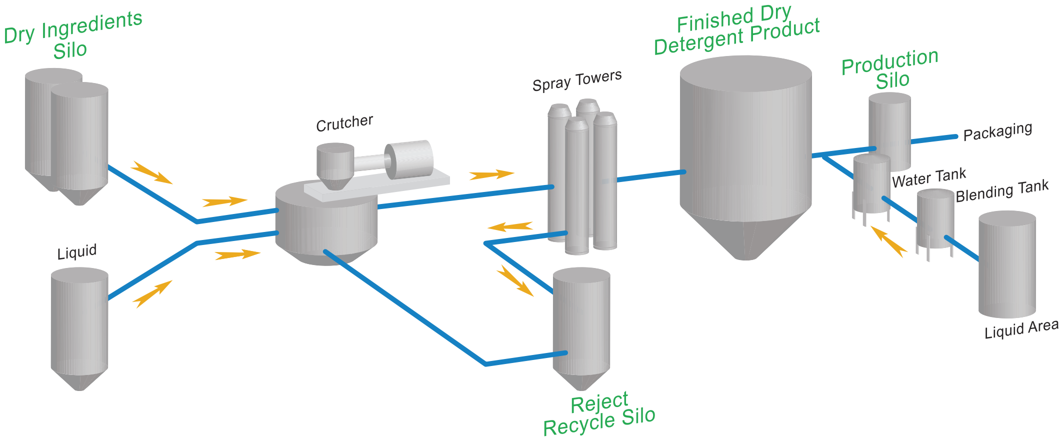
KEY
- ●●● (green) **Preferred Technology**
- ●● (green) **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

Recommended Technology – Point Level

Recommended Solution	PP/PE Pellets	Salt Storage	PVC Resin	PVC Powder
Rotating Paddle	● (green)	● (yellow)	● (green)	● (green)
Vibrating Fork	● (yellow)	● (yellow)	● (yellow)	● (green)
Vibrating Rod	● (yellow)	● (yellow)	● (yellow)	● (green)
Capacitance Probe	● (green)	● (green)	● (yellow)	● (yellow)

KEY
- ● (green) **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

6.2 Specialty Chemicals – Detergent Production



Detergents are manufactured using a synthetic surfactant in place of the fatty acid salts that is used in soaps. Most of the powder detergents have soap in their mixture of ingredients.

There are two basic processes commonly used. The blender process is typically used by small volume producers while the agglomeration process is used for high volume production. Liquid detergents are an additional step where the dry detergent is mixed with water and solubilizers to create a stable solution. Blending is a batch process whereby the dry ingredients are mixed and then moved to packaging.

Agglomeration is a continuous process where the dry ingredients are mixed and pulverized to a fine powder. In the agglomerator, the blended powder is sprayed with liquid ingredients where a reaction occurs and a thick viscous liquid is formed. As it flows out of the agglomerator, the material dries and moves into a crusher where it is made into the powdered product. From here it can into storage or packaging or to the liquid detergent production area.

Dry Ingredients Silo

- **Application:** Raw materials are stored in silos before being transferred to the production process. Dry (Sodium sulphate, Sodium tripolyphosphate (STP), Zeolite and others) and liquid ingredients are first combined into a slurry, or thick suspension, in a tank known as crucher.
- **Challenges:** As the raw materials are processed together, it is important to accurately measure the content of the silos to ensure continuous production.

Finished Product Silo

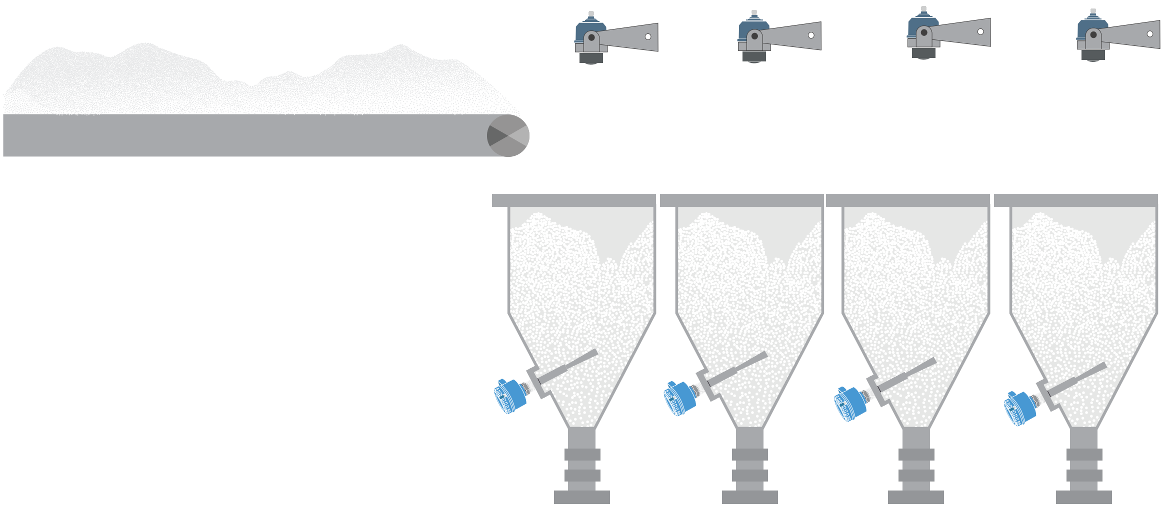
- **Application:** The final product is stored in silos before being packed and shipped.
- **Challenges:** Accurately measuring the inventory of the final product is a continuous necessity for operators.

Reject Recycle Silo

- **Application:** The dried granules are screened to obtain a relatively standard size; unscreened material is transferred to a storage silo, and is later sent back to the process as part of the ingredients.
- **Challenges:** The material generates dust during the process and tends to create build-up at the bottom of the silo. The user's main challenges are to continuously monitor the silo for the amount of stored material and also to discover build-up as early as possible. Maintenance can then be scheduled and cleaning performed to avoid damage to the silo and costly interruptions to the production process.

Production Silos

- **Application:** Some of the final product powdered detergent is sent to the liquid detergent area to be blended with water and solubilizers to make liquid product.
- **Challenges:** A supply of powdered detergent must be available at all times to feed the production. These silos can be filled and emptied frequently requiring a responsive measurement.



Recommended Technology – Continuous Level

Recommended Solution	Dry Ingredients Silo	Finished Product Silo	Rejected Recycle Silo	Dry Ingredients Production Silo
Non-Contacting Radar				
26 GHz radar transmitters	●●	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●	●●●
Guided Wave Radar	●●●	●●●	●●●	●●●

KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

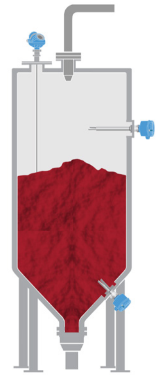
Recommended Technology – Point Level

Recommended Solution	Dry Ingredients Silo	Finished Product Silo	Rejected Recycle Silo	Dry Ingredients Production Silo
Rotating Paddle	● (green)	● (green)	● (green)	● (red)
Vibrating Fork	● (green)	● (green)	● (yellow)	● (green)
Vibrating Rod	● (green)	● (green)	● (red)	● (green)
Capacitance Probe	● (green)	● (green)	● (green)	● (yellow)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

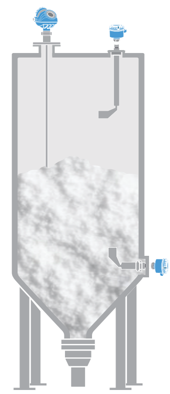
6.2 Specialty Chemicals – Color Pigments, Silica, Absorbents

The specialty chemical industry is very diverse with many different solids applications. This section highlights a few examples.



Color pigments

- **Application:** After being processed, finished pigment powders are conveyed into packing silos. To control the filling process, the levels in the silos need continuous monitoring, and high-level detection switch is used for safety shutdown in case of overfilling. The pigment powder is then filled into packaging via the bottom outlet.
- **Challenges:** Finished pigment powders often have a low dielectric constant and with a low bulk density they generate dust when they are moved to silos or extracted from them.



Silica

- **Application:** Silica powder is used in many industries, such as plastics, paints, foundries, cosmetics, food, pharmaceutical, agricultural or technological. It is stored in silos with adequate ventilation and in controlled environments.
- **Challenges:** Silica powder has a low dielectric constant and generates heavy dust and build-up. The temperature in process can be high when drying processes are active.

Adsorbents

- **Application:** Adsorbents can be used to remove contaminants from fluids or gases or separate molecules in different processes. There are various types of adsorbents, including activated carbon, clays, zeolites and resins. The production processed varies depending on type of adsorbents, but the end steps often consists of sieving of final product and storage before packaging.
- **Challenges:** When storing adsorbents, it is important to control the moisture in the environment especially for adsorbents like silica gel or zeolites that are used for drying applications.

Recommended Technology – Continuous Level

Recommended Solution	Color Pigments	Silica	Adsorbents
Non-Contacting Radar			
26 GHz radar transmitters	●● (green)	● (yellow)	● (yellow)
80 GHz radar transmitters	●●● (green)	●● (green)	●●● (green)
Guided Wave Radar	●●● (green)	●●● (green)	●● (green)

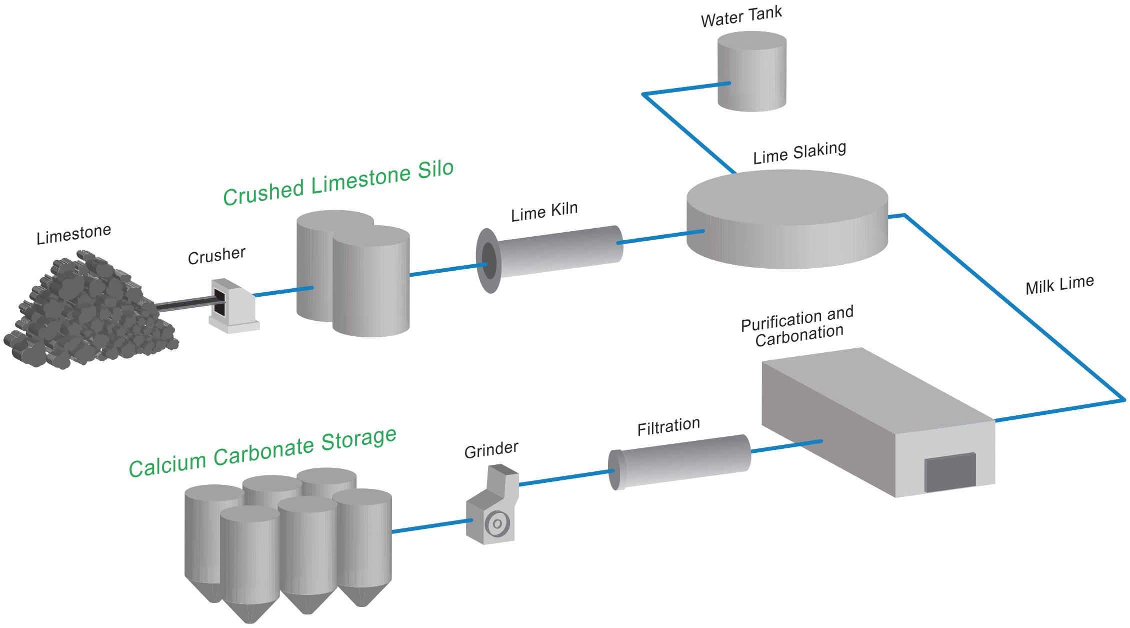
KEY
- ●●● (green) **Preferred Technology**
- ●● (green) **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

Recommended Technology – Point Level

Recommended Solution	Color Pigments	Silica	Adsorbents
Rotating Paddle	● (green)	● (green)	● (green)
Vibrating Fork	● (green)	● (yellow)	● (yellow)
Vibrating Rod	● (yellow)	● (yellow)	● (yellow)
Capacitance Probe	● (green)	● (green)	● (green)

KEY
- ● (green) **Suitable**
- ● (yellow) **Application dependent**
- ● (red) **Not recommended**

6.3 Calcium Carbonate Production



Calcium carbonate is the end product resulting from a purification process of limestone. Limestone is brought into the facility and crushed into a powder. The limestone powder is sent through a kiln at a high temperature where carbon dioxide is driven off of the crushed lime, creating calcium oxide. The calcium oxide is slacked with water producing a lime slurry or lime milk. The lime milk is re-carbonated with recovered carbon dioxide to produce a concentrated liquid solution of purified calcium carbonate. This solution is filtered and dried into solid cake. The solid cake is then ground into a purified calcium carbonate product.

Crushed Limestone Silo

- **Application:** Crushed limestone is stored in silos before entering the production process.
- **Challenges**: Limestone generates a great deal of dust during the filling process and tends to stick to the walls of the silo, creating irregular build-up and rat holes. It is important to quantify the amount of raw material available in the silo to ensure continuous production.

Calcium Carbonate Storage

- **Application:** The final product, calcium carbonate, is stored in silos before being shipped in bulk or packed.
- **Challenges:** Calcium carbonate is a very fine, powder-like material that creates a great deal of dust during the filling process, and also tends to stick to the walls of the silo as well as to the measurement devices.

The sticky nature of the product creates build-up on the silo walls, making it difficult to continuously monitor and accurately measure the level of the stored inventory.

Recommended Technology – Continuous Level

Recommended Solution	Crushed Limestone Silo	Calcium Carbonate Storage
Non-Contacting Radar		
26 GHz radar transmitters	●●● (green)	●● (green)
80 GHz radar transmitters	●● (green)	●●● (green)
Guided Wave Radar	● (red)	●● (green)

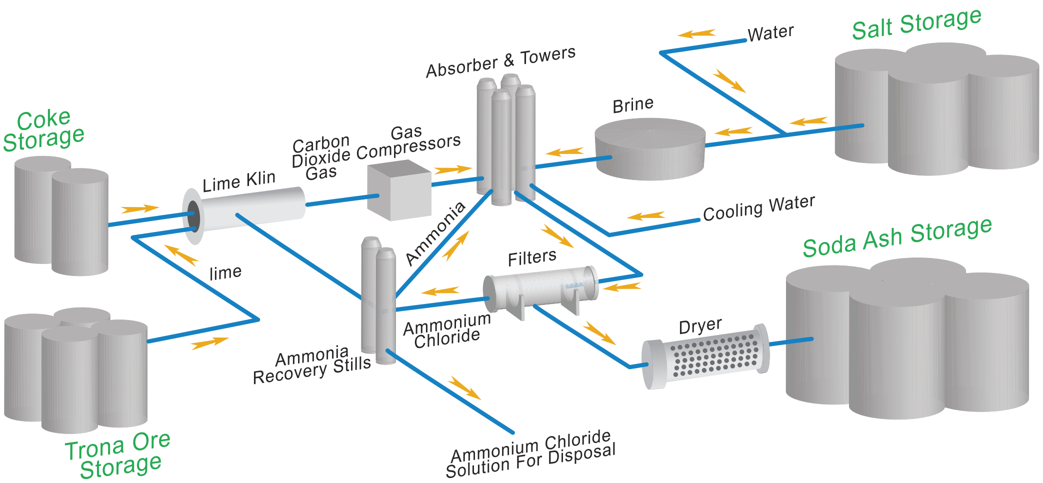
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Crushed Limestone Silo	Calcium Carbonate Storage
Rotating Paddle	● (green)	● (green)
Vibrating Fork	● (red)	● (red)
Vibrating Rod	● (red)	● (yellow)
Capacitance Probe	● (yellow)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

6.4 Soda Ash Production



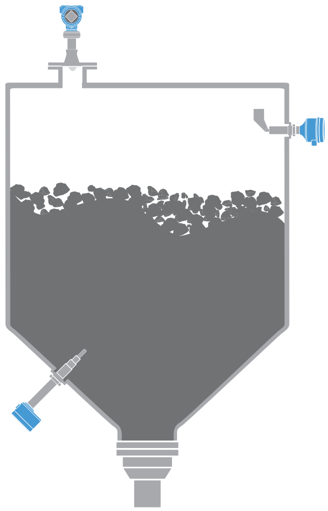
Soda Ash (sodium carbonate) is a strong alkali commonly produced from trona ore. It has many industrial and commercial applications including the manufacturing of glass, many chemicals, soaps and detergents and as a neutralizing agent for emission and water treatment.

A series of refining steps are required to produce soda ash from trona ore, a primary source of sodium carbonate. First the raw ore from the mine is crushed and screened. The material is then fed to rotary calciners and heated. In this process, the trona decomposes to form crude soda ash, which is dissolved in water. The insoluble shales are separated from the solution by a combination of settling and filtration steps and the resulting insoluble tailings are taken back into the mine as backfill. The soda ash solution is treated to remove organic materials yielding a high-purity saturated solution of sodium carbonate. To make soda ash, trona and coke are mixed in proper proportions and charged into large kilns to produce carbon dioxide gas and lime.

Brine, a mixing of rock salt and water in a controlled manner, is purified, saturated with ammonia gas, and then carbonated in towers with the gas recovered from the lime kilns. A slurry leaving the bottom of the carbonating towers contains ammonium chloride in solution and sodium bicarbonate as a solid.

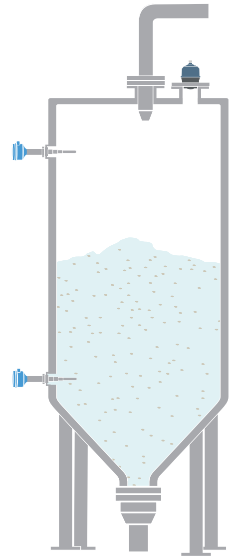
Coke Storage

- **Application:** The coke is stored in silos before processing.
- **Challenges:** The coke material generates a great deal of dust during the filling and emptying processes, leading to harsh dusty conditions in the silo. The coke also tends to adhere to the silo walls creating build-up and rat holes. These attributes significantly challenge the ability to accurately measure inventories. This is important since coke is essential to the soda ash production process.



Trona Ore Storage

- **Application:** Trona ore is stored in silos before being processed.
- **Challenges:** Trona ore generates a great deal of dust during the filling process and tends to stick to the walls of the silo, creating irregular build-up and rat holes. Since trona ore is essential for the soda ash production process, quantifying the amount of trona ore available in the silo is essential for ensuring continuous production.

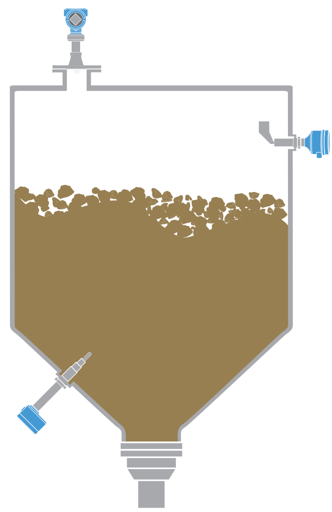


Salt Storage

- **Application:** Rock salt is stored in big silos for the brine producing process. Operators must ensure continuous salt supply to the brine making process, which is essential for the production of soda ash.
- **Challenges:** The surface tends to be irregular and build-up on the walls is not uncommon.

Soda Ash Storage

- **Application:** Final product (usually in powder form) is stored in big silos until it is shipped for industrial uses.
- **Challenges:** Soda ash is stored in large silos and generates a great deal of dust during the filling and emptying processes. The soda ash also tends to adhere to the silo walls creating build-up and rat holes, making it difficult for operators to continuously and accurately monitor the inventory levels in these silos.



Recommended Technology – Continuous Level

Recommended Solution	Coke Storage	Trona Ore Storage	Salt Storage	Soda Ash Storage
Non-Contacting Radar				
26 GHz radar transmitters	●●●	●●●	●●	●●
80 GHz radar transmitters	●●	●●	●●●	●●●
Guided Wave Radar	● (Not recommended)	● (Not recommended)	●●	●●●

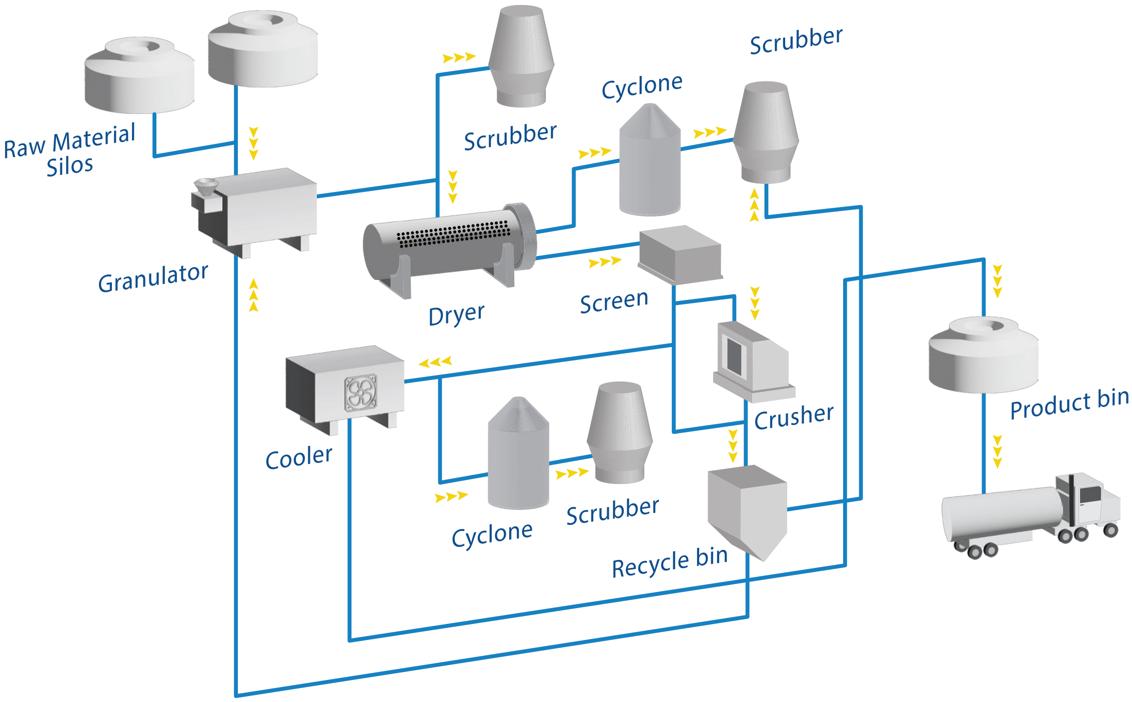
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● Application dependent
- ● Not recommended

Recommended Technology – Point Level

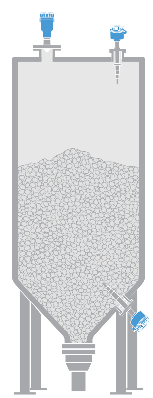
Recommended Solution	Coke Storage	Trona Ore Storage	Salt Storage	Soda Ash Storage
Rotating Paddle	● (Suitable)	● (Suitable)	● (Application dependent)	● (Suitable)
Vibrating Fork	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Application dependent)
Vibrating Rod	● (Application dependent)	● (Not recommended)	● (Application dependent)	● (Suitable)
Capacitance Probe	● (Suitable)	● (Suitable)	● (Suitable)	● (Suitable)

KEY
- ● Suitable
- ● Application dependent
- ● Not recommended

6.5 Fertilizers

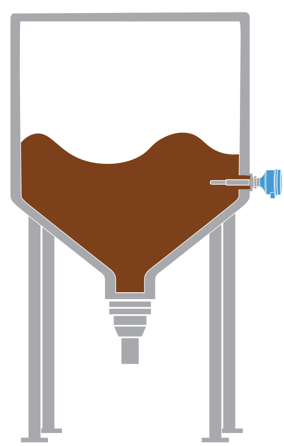


Many fertilizers are sold as solids (granulates). MAP & DAP are two major phosphorous fertilizer granulates.



MAP/DAP Granules

- **Application:** Monoammonium phosphate (MAP) and Diammonium phosphate (DAP) granules need to be stored in dry and ventilated areas in silos, containers or warehouses.
- **Challenges:** Both MAP and DAP materials require precise moisture control during production to ensure consistent granulation and prevent issues like caking. Level solutions need to be robust to handle the often dusty environment.



Fertilizer Filled Dosing Tanks

- **Application:** Manufacturers of soil mixed with fertilizers often dose their products in fertilizer-filled dosing tanks. These tanks are typically filled with different varieties of soil, each with their own characteristics and properties.
- **Challenges:** One common challenge operators face during production with all soil types is caking. Operators need a level measurement solution that offers reliable low-level detection, helps prevent buildup and caking, and can stand up to high mechanical exposure, heavy loads, and dusty environments.

READ OUR CASE STUDY

SCAN OR CLICK

Recommended Technology – Continuous Level

Recommended Solution	MAP/DAP granules	Fertilizer Filled Dosing Tanks
Non-Contacting Radar		
26 GHz radar transmitters	●●	●●
80 GHz radar transmitters	●●●	●●●
Guided Wave Radar	●●	● (yellow)

KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

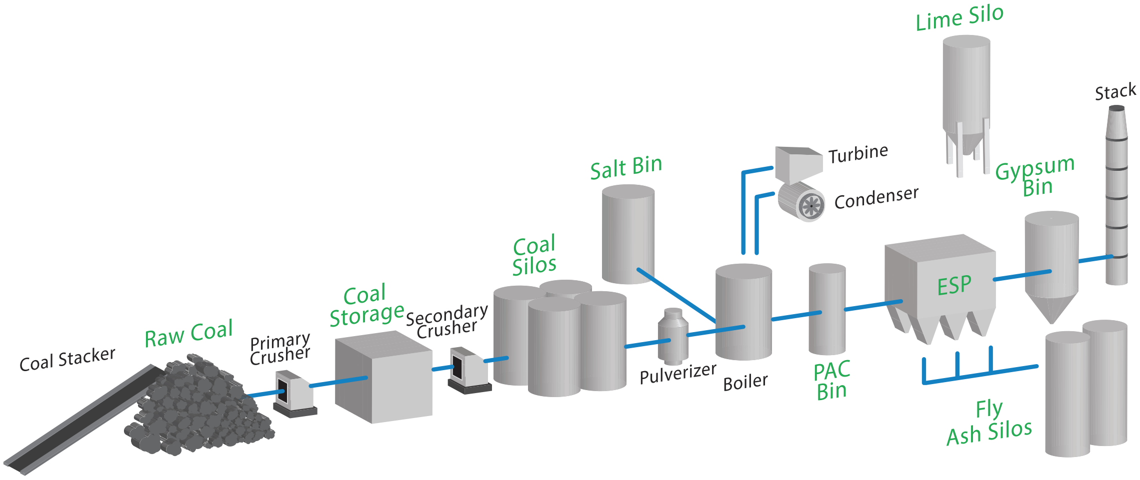
Recommended Technology – Point Level

Recommended Solution	MAP/DAP granules	Fertilizer Filled Dosing Tanks
Rotating Paddle	● (yellow)	● (yellow)
Vibrating Fork	● (red)	● (red)
Vibrating Rod	● (red)	● (red)
Capacitance Probe	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Section 7 | Energy Industry

7.1 Coal-Fired Power Plant



The coal goes through a moderate grinding process and then is stored in a coal bunker. Afterwards, the coal is typically delivered to a power plant via rail or conveyor belt.

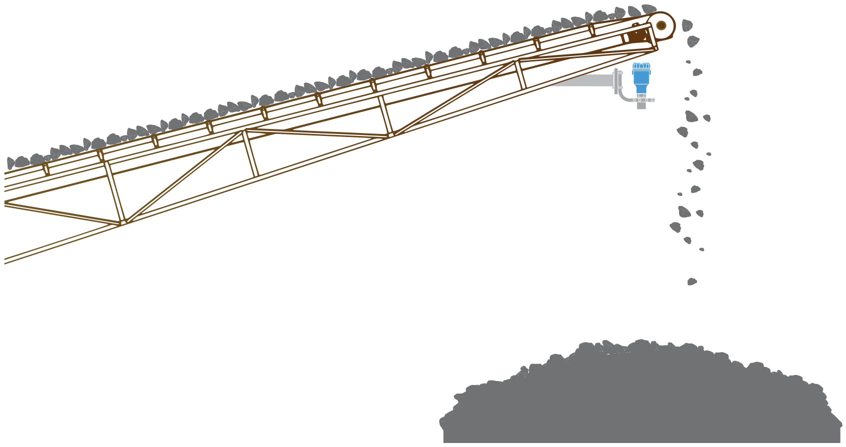
The coal is transported by conveyor and tripper cars to coal hoppers / silos. These hoppers feed ball mills which is turn fed the pulverized coal to the boilers. There will be at least one hopper for each boiler. Typically there are two boilers per unit.

After burning, the flue gas emissions must be cleaned before release into the environment. Cleaning includes filtration systems to remove particles and chemical treatment to remove sulfur, mercury and other hazardous materials.

On the water side, the water must be mineral-free before its use in the steam generation system.

Stacker Positioning Monitoring

- **Application:** Coal is collected in large piles in the outside yard. A positionable conveyor belt (stacker) moves the incoming coal to an open area. As the area fills up, the stacker moves to a new area.
- **Challenge:** The coal is fast moving and dusty as it is dumped on the pile. Operations need to know when the pile reaches a pre-determined distance from the stacker so that it can be moved.



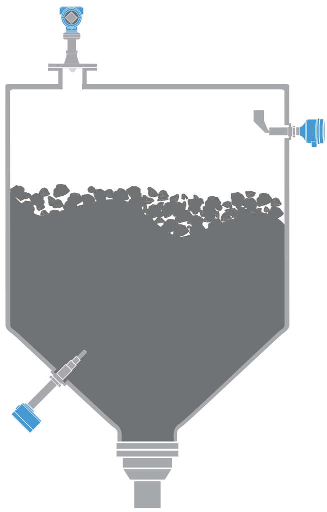
Raw Coal

- **Application:** Raw Coal Yard / Warehouse - Raw coal is delivered to a coal yard in aggregate pieces of approximately 15 cm (6") that are later reduced in size by a crusher to approximately 4 cm (1.5").
- **Challenges:** The raw coal is stored in stock piles which does not offer a flat surface to measure on.

Coal Storage

- **Application:** Coal Storage / Bunker / Coal Blending Facility - The coal goes through a moderate grinding process and then stored in a coal bunker.
- **Challenges:** Coal bunkers can contain thousands of tons of material. Their size and the dusty conditions make it difficult to accurately measure the amount of coal in the bunker or blending facility. There are also safety risks to personnel who enter the storage areas to "guesstimate" levels.

Coal Silos



- **Application:** Coal Hoppers / Coal Day Vessels / Coal Silos - Coal is transported by conveyor and tripper cars to coal hoppers. These hoppers feed ball mills which in turn feed the pulverized coal to the boilers. There will be at least one hopper for each boiler. Typically there are two boilers per unit.
- **Challenges:** Coal hoppers and silos storing pre-pulverized coal are large and very dusty. The silos hold several hours' supply of coal and can continue to supply coal to the boiler in the event of a problem in the coal handling system. As coal is critical for the continuous process, it is necessary to monitor and control the actual amount of coal in to prevent process stoppages.

Salt Bin

- **Application:** Salt is used as part of the water demineralization process for boiler feed-water.
- **Challenges:** Salt is a byproduct of the desalination process , when water source for the boiler is sea water . Its supply must be readily available at all times.

Powder Activated Carbon (PAC) Silo

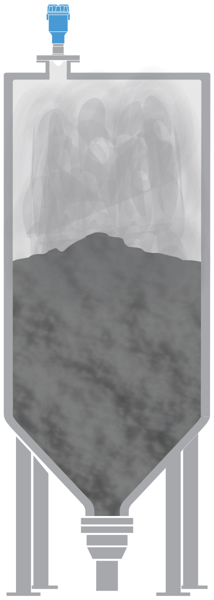
- **Application:** Is used to attract mercury to the fly ash to enhance its removal in ESP or baghouse.
- **Challenges:** PAC is a very fine lightweight dusty powder with a low DC.

ESP Hoppers

- **Application:** Fly ash is captured and removed from the flue gas by electrostatic precipitators or fabric bag filters located at the outlet of the furnace and before the induced draft fan. The fly ash is collected in hoppers below the precipitators or bag filters and periodically removed from them.
- **Challenges:** ESP hoppers are continuously filled with hot fly ash. Along with high temperature, fly ash tends to stick to the sides of the hopper, causing build-up and clogging which may damage the ESP plates.

Users need to continuously monitor the content and distribution of fly ash inside the hopper so that they can be emptied on time, maintained and cleaned when necessary. This is essential in order to prevent damage to the ESP plates. Damaged plates can also create environmental and health concerns.

At coal-fired power plants where level measurement is not used in ESP processes, the hopper emptying is disconnected from the filling. With no reliable way to measure the fly ash in the hopper, a timer is set to turn on the emptying process regardless of the amount of fly ash in the hopper, making the process inefficient.



Fly Ash Silo

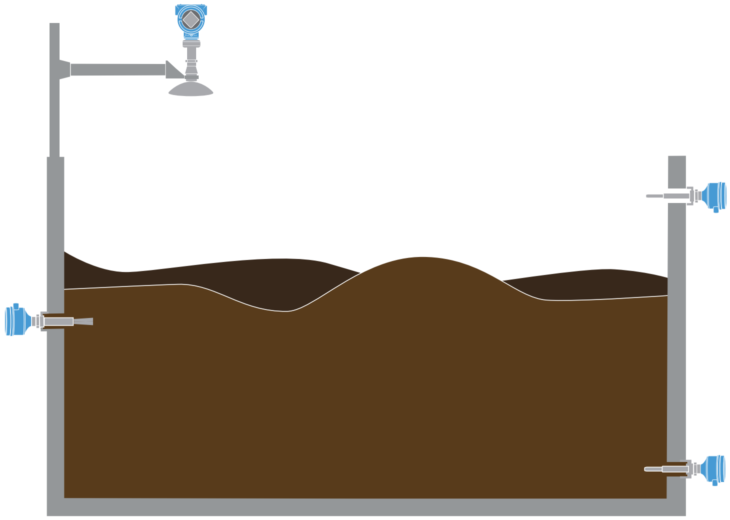
- **Application:** The contents of the fly ash hopper are pneumatically conveyed to a fly ash storage silo. The silo is emptied on to trucks that then haul the material off for use in other applications.
- **Challenges:** Fly ash derived from burning coal creates a very dusty environment and tends to stick, creating build-up inside the silo. Fly ash silos are typically very large to allow continuous flow from the hoppers. Density and dielectric constant of fly ash is low. Users need to continuously monitor the amount of fly ash inside the silo so that it can be emptied on time, and maintained and cleaned when necessary.

Lime silo

- **Application:** A lime supply is needed for flue gas desulfurization. Sulfur in the flue gas is removed by spraying with lime slurry and fine limestone powder is used for creating the slurry.
- **Challenges:** The size of the lime silos vary from site to site and even within the same site. What they have in common though is that the lime is a very fine powder which is very dusty and commonly builds up on everything within the silo atmosphere. Due to the rather heavy weight of the lime particles, the lime piles up unevenly and steep in the silo.

Gypsum Bin

- **Application:** Gypsum is a by product of the flue gas desulfurization and is sold as a commodity.
- **Challenges:** Depending on facility, the gypsum could be stored in large silos or in large piles on the ground. In both situations, it is important to know the amount of gypsum as it is produced.



Recommended Technology – Continuous Level

Recommended Solution	Stacker Position Monitoring	Raw Coal	Coal Storage	Coal Silo	Salt Bin
Non-Contacting Radar					
26 GHz radar transmitters	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢
80 GHz radar transmitters	🟢🟢🟢	🟢🟢	🟢🟢	🟢🟢	🟢🟢🟢
Guided Wave Radar	🔴	🔴	🔴	🔴	🟢🟢🟢

Recommended Solution	PAC Silo	ESP Hopper	Fly Ash Silo	Lime Silo	Gypsum Bin
Non-Contacting Radar					
26 GHz radar transmitters	🟢🟢	🟢🟢	🟢🟢	🟢🟢	🟢🟢
80 GHz radar transmitters	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢
Guided Wave Radar	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢	🟢🟢

KEY
- 🟢🟢🟢 Preferred Technology
- 🟢🟢 Suitable
- 🟡 Application dependent
- 🔴 Not recommended

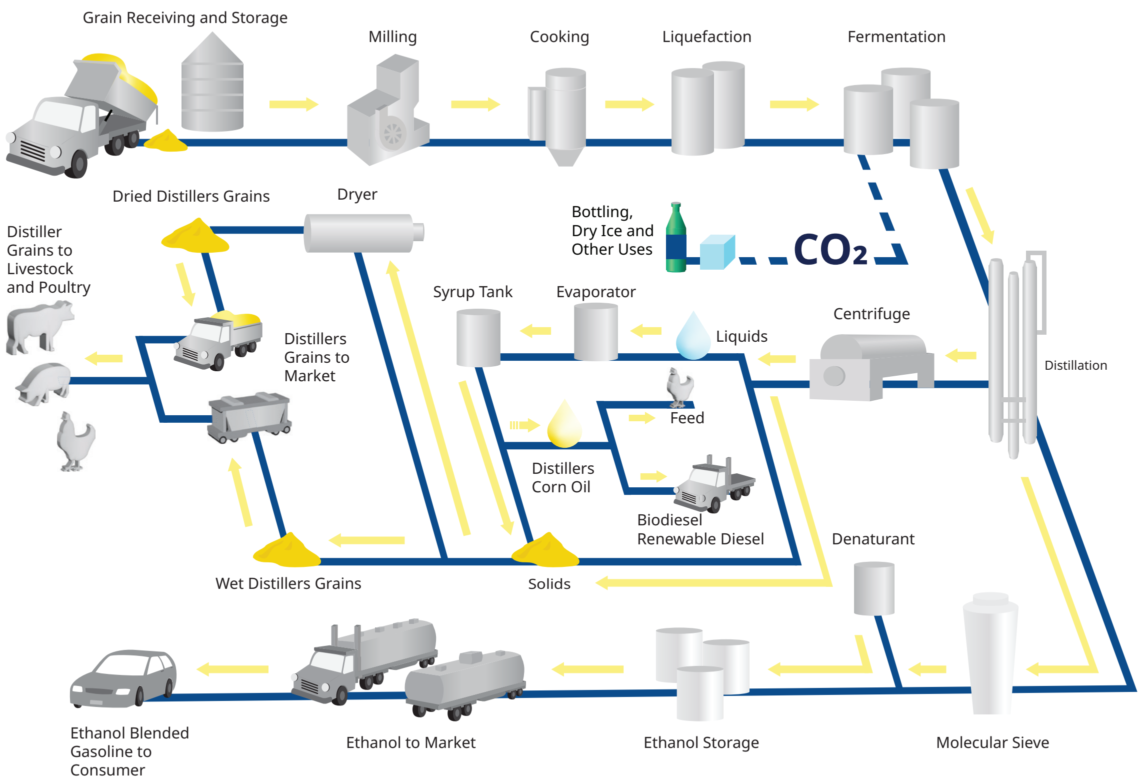
Recommended Technology – Point Level

Recommended Solution	Stacker Position Monitoring	Raw Coal	Coal Storage	Coal Silo	Salt Bin
Rotating Paddle	🔴	🟢	🟢	🟢	🟢
Vibrating Fork	🔴	🔴	🔴	🔴	🟡
Vibrating Rod	🔴	🔴	🔴	🔴	🟡
Capacitance Probe	🔴	🟢	🟢	🟢	🟢

Recommended Solution	PAC Silo	ESP Hopper	Fly Ash Silo	Lime Silo	Gypsum Bin
Rotating Paddle	🟡	🟡	🟢	🟢	🟢
Vibrating Fork	🟢	🔴	🟡	🟡	🔴
Vibrating Rod	🟢	🔴	🟡	🟡	🟡
Capacitance Probe	🟡	🟢	🟢	🟢	🟢

KEY
- 🟢 Suitable
- 🟡 Application dependent
- 🔴 Not recommended

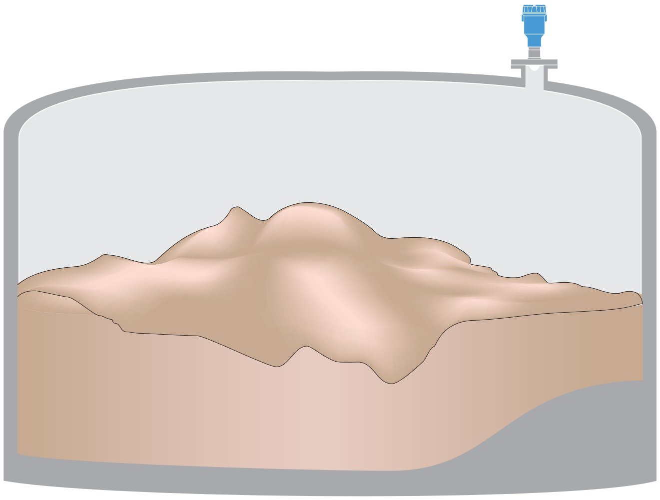
7.2 Ethanol Production



During the ethanol production process, two by-products are created: carbon dioxide and distillers grains.

The stillage from the bottom of the distillation tanks contains solids from the grain and added yeast as well as liquid from the water added during the process. It's sent to centrifuges for separation into thin stillage and wet distillers grain. Before the ethanol is sent to storage tanks, a small amount of denaturant is added, making it unfit for human consumption.

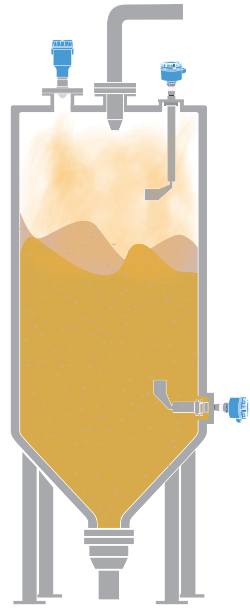
Grain Storage



- **Application:** Grain is delivered by truck or rail to the plant where it is analyzed, unloaded and pre-cleaned prior to loading into storage silos designed to supply the plant for 7-10 days.
- **Challenge:** Grain storage silos are large in size and it is essential to know the silo contents in order to closely monitor inventory levels and ensure ongoing production process.

Accurate grain inventory measurements give plant managers an understanding of how much grain was used in the manufacturing process of the ethanol, allowing them to better calculate the cost of goods sold and the profitability of the plant. The size of the silos can make it problematic for conventional instrumentation to yield accurate measurements of the stored material.

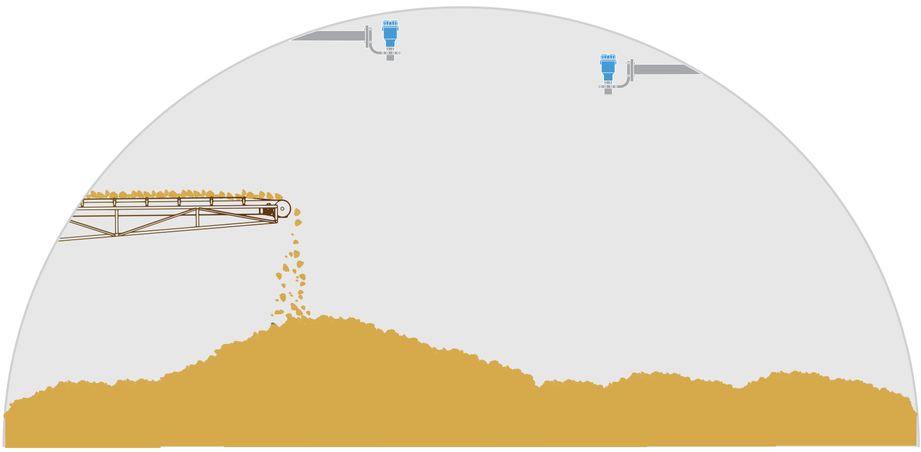
Corn Surge Bin



- **Application:** The corn kernels are held in the storage bin, then they are sent to the hammer mills at the front end of the dry-grind, ethanol process. There is a need to optimize throughput by increasing the amount of corn stored in the bin.
- **Challenges:** The corn is dry, dusty, abrasive and fast moving.

Dried Distillers Grain (DDG) Storage

- **Application:** Wet distiller grains are often sent through a drying system to remove moisture and extend shelf life. These dried distillers grains (DDGs) are commonly used as high-protein ingredients in cattle, swine, poultry and fish diets. The DDGs are removed from site by a conveyor to an adjacent dedicated storage silo/ warehouse.
- **Challenges:** The DDGs are stored in very large silos/warehouses/open bins. The material (containing about 10% fat and corn oil) is sticky and can settle in irregular shapes. This combination presents a real problem for end-users trying to assess inventory levels.



Recommended Technology – Continuous Level

Recommended Solution	Grain Storage	Corn Surge Bin	DDG Storage
Non-Contacting Radar			
26 GHz radar transmitters	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●
Guided Wave Radar	●●	●●	● (red)

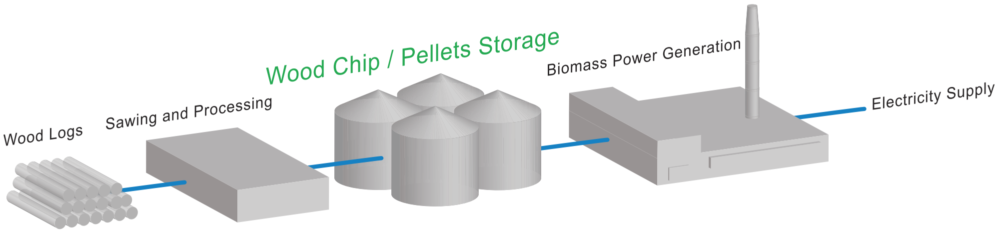
KEY
●●● (green) **Preferred Technology**
●● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

Recommended Technology – Point Level

Recommended Solution	Grain Storage	Corn Surge Bin	DDG Storage
Rotating Paddle	● (green)	● (green)	● (green)
Vibrating Fork	● (green)	● (green)	● (yellow)
Vibrating Rod	● (green)	● (green)	● (yellow)
Capacitance Probe	● (green)	● (green)	● (green)

KEY
● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

7.3 Wood Biomass Production

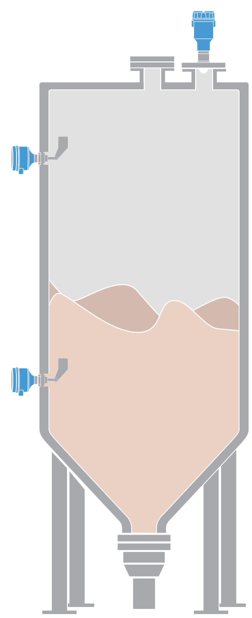


The simplest way to obtain energy from wood is through a process called "direct combustion" (in other words, by burning it). Energy from burning wood can produce power, electricity, or heat. To produce power, wood can be burned in a boiler, a large combustion chamber, to heat water and generate steam. In some cases, this steam is used directly to power machines or to heat buildings.

In addition, steam can be used to turn large, rotating engines called turbines, which generate electricity. Refer to the power plant solid application for applications in electricity generation.

Wood Chips/Wood Pellets

- **Application:** These primary source materials are stored in silos or warehouses before entering the production process.
- **Challenges:** Wood chips, wood pellets or sawdust is stored in silos or warehouses. It tends to stick together creating irregular settling of the material and often causes problems when emptied through nozzles along the silo bottom. The combination of large silos and irregular settling makes it difficult for operators to assess the stored inventory.



Recommended Technology – Continuous Level

Recommended Solution	Wood Chips/ Wood Pellets/Sawdust
Non-Contacting Radar	
26 GHz radar transmitters	●●
80 GHz radar transmitters	●●●
Guided Wave Radar	●

KEY
- ●●● **Preferred Technology**
- ●● **Suitable**
- ● **Application dependent**
- ● **Not recommended**

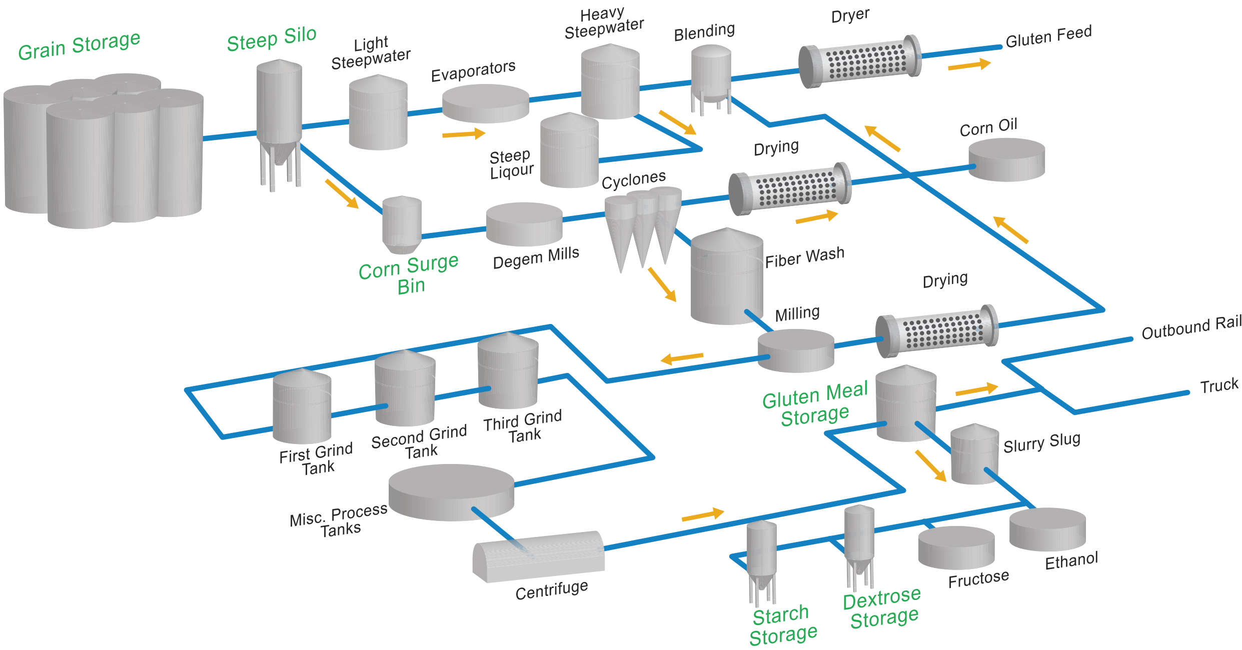
Recommended Technology – Point Level

Recommended Solution	Wood Chips/ Wood Pellets/Sawdust
Rotating Paddle	●
Vibrating Fork	●
Vibrating Rod	●
Capacitance Probe	●

KEY
- ● **Suitable**
- ● **Application dependent**
- ● **Not recommended**

Section 8 | Grain and Raw Material Processing

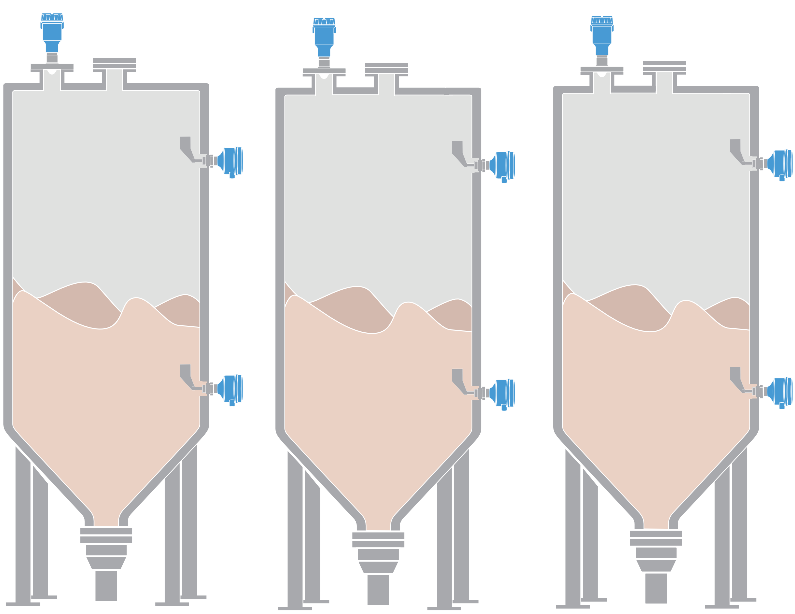
8.1 Corn Wet Milling



Grain Processing is one of the oldest industries used to produce both human and animal food. While flour milling exemplifies a common form of grain processing, other forms may be exemplified by corn wet milling and pulse (legume or seed oil) processing. Grain processing can be characterized by both cold and hot processes but with the overall goal being to dehull, clean, and break-open the grain to make it into a usable form. The products and by-products are numerous and are used for both consumption and industrial uses.

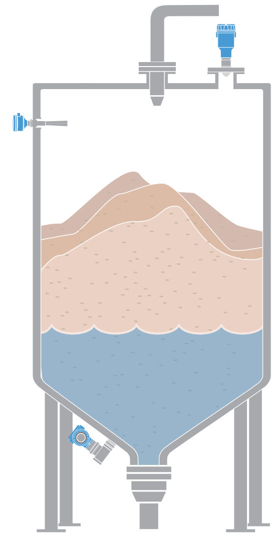
Grain Storage

- **Application:** Incoming material is stored in large bins or silos.
- **Challenges:** The dusty dry corn must be measured so that the required amount of material is available for processing.



Steep Tank

- **Application:** Dry corn is dropped into the steeping bins up to a set level before liquid is added.
- **Challenges:** The dusty dried corn moves rapidly into the tall steep tanks. The level of the incoming corn must be accurately measured to prevent overfilling and to allow space for addition of steeping liquid. The measurement device must be able to measure both dry and liquid stages of the mixture.

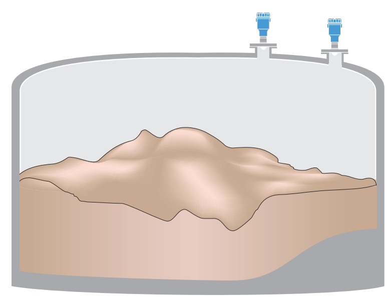


Corn Surge Bin

- **Application:** Wet softened corn is moved into the corn surge bin.
- **Challenges:** The corn moves rapidly into and out of the surge bin. The availability of space in the hopper is necessary to prevent overfill and to ensure availability of corn to the degerming mills.

Gluten (Protein) Meal Storage

- **Application:** After grinding and centrifuging steps, the separated gluten meal accumulates in the storage tank.
- **Challenges:** As this is a final product, the inventory of the gluten meal is needed to schedule its shipments.

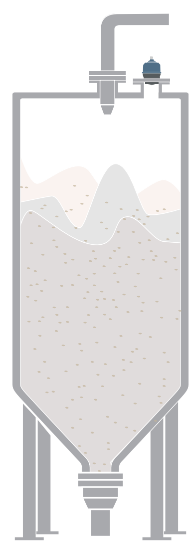


Dextrose Storage

- **Application:** Dextrose is one of the sugars produced from corn wet milling.
- **Challenges:** Dextrose is a final product and its inventory must be known for shipment scheduling. It tends to be a sticky substance, so it can build up on vessel walls. Being able to detect the build-up enables appropriate maintenance to be scheduled.

Starch Storage

- **Application:** Corn starch is a final product of the corn wet milling process. It is a commodity product with both consumption and commercial uses.
- **Challenges:** Corn starch is a fine dry powder. Its amount must be known for scheduling shipments to end users.



READ OUR CASE STUDY

SCAN OR CLICK

Recommended Technology – Continuous Level

Recommended Solution	Grain Storage	Steep Tank	Corn Surge Bin	Gluten Meal Storage	Dextrose Storage	Starch Storage
Non-Contacting Radar						
26 GHz radar transmitters	●● Suitable	●● Suitable	●●● Preferred	●●● Preferred	●● Suitable	●● Suitable
80 GHz radar transmitters	●●● Preferred	●●● Preferred	●●● Preferred	●●● Preferred	●●● Preferred	●●● Preferred
Guided Wave Radar	●● Suitable	● Application dependent	●●● Preferred	●●● Preferred	●● Suitable	●● Suitable

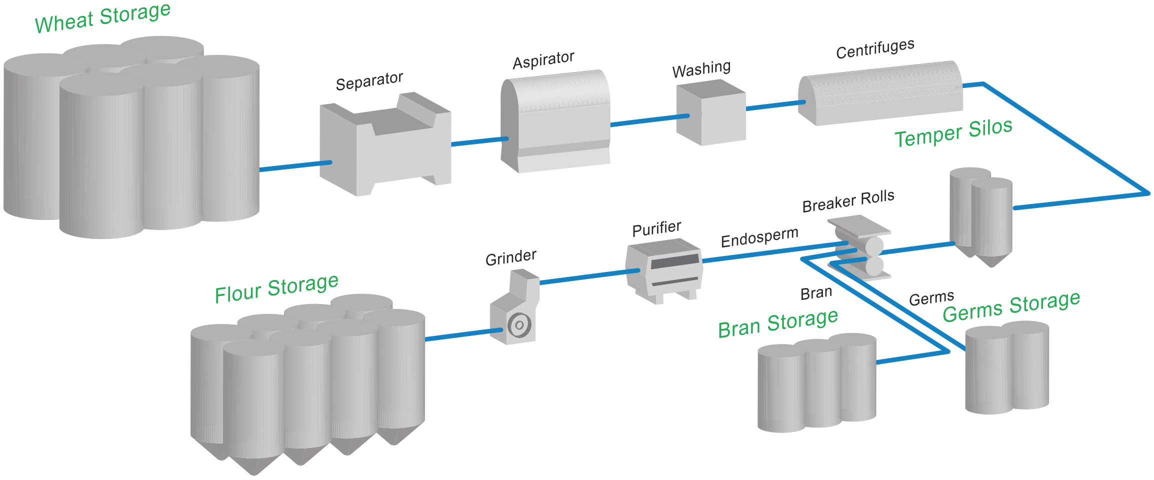
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Grain Storage	Steep Tank	Corn Surge Bin	Gluten Meal Storage	Dextrose Storage	Starch Storage
Rotating Paddle	Suitable	Not recommended	Application dependent	Suitable	Suitable	Suitable
Vibrating Fork	Suitable	Not recommended	Not recommended	Suitable	Not recommended	Suitable
Vibrating Rod	Suitable	Not recommended	Application dependent	Application dependent	Not recommended	Application dependent
Capacitance Probe	Suitable	Application dependent	Suitable	Suitable	Application dependent	Suitable

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

8.2 Flour Production



Wheat is received at the flour mill and inspected. The wheat is stored in silos with wheat of the same grade until needed for milling. Before wheat can be ground into flour it must be free of foreign matter. This requires several different cleaning processes. At each step of purification the wheat is inspected and purified again if necessary.

Wheat Storage

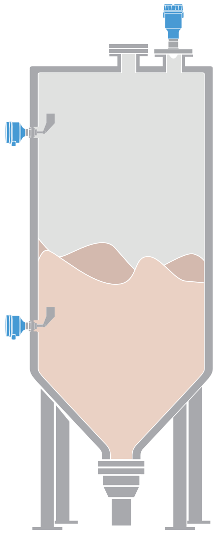
- **Application:** Wheat is classified by grade and each grade is stored separately in different silos.
- **Challenges:** Wheat is stored in large silos, generating a great deal of dust during the filling operation. Different grades of wheat should not be mixed together, so continuous monitoring of level of each grade of wheat remaining in each silo is required. The large sizes of the silos, normally with multiple emptying points, promote the creation of irregular formations and build-up inside the silo, making it difficult to measure inventory accurately.

Having accurate and reliable level measurement permits early detection of build-up, facilitating scheduling of maintenance and cleaning to avoid unexpected interruptions of the production process and associated losses in time and money.

Temper Silos

- **Application:** Tempered wheat is stored in bins for a specific time, depending on the type of wheat: soft, medium or hard.
- **Challenges:** The humid condition of the material, along with the time it lingers inside the vessel, creates build-up. The additional dust generated during the process makes the measuring of the actual content difficult.

Bran Storage



- **Application:** Bran is a by-product of the wheat milling process used to enrich breads and breakfast cereals as well as producing whole wheat flour. Following milling, the bran is stored in silos before shipment to bakeries and other entities for further processing. Flour manufacturers need to accurately monitor the bran inventory to avoid unexpected interruptions to the flour production process or delivery schedules.
- **Challenges:** Bran is sold and shipped in bulk, and flour manufacturers need to accurately monitor the inventory remaining in the silo to ensure that packing and delivery schedules can be met without interruptions to the process.

Germs Storage

- **Application:** Wheat germ, like bran, is a by-product of wheat milling and serves as an additive to different types of baked goods. Following the milling process, it is stored in silos prior to being shipped.
- **Challenges:** Wheat germ is sold and shipped in bulk, and flour manufacturers need to accurately monitor the inventory remaining in the silo to ensure that packing and delivery schedules can be met.

Flour Storage

- **Application:** Flour is stored in silos both for bulk shipping and bagging.
- **Challenges:** In order to ensure efficient delivery from the production process, through the storage silos and to the bulk deliveries or bagging, accurate level tracking of the flour remaining in the silos is crucial. Since flour generates a great deal of dust during both filling and emptying, and since it tends to form build-up on the silo walls, true estimates of the are hard to achieve.

READ OUR CASE STUDY

SCAN OR CLICK

Recommended Technology – Continuous Level

Recommended Solution	Wheat Storage	Temper Silos	Bran Storage	Germs Storage	Flour Storage
Non-Contacting Radar					
26 GHz radar transmitters	●●	●●	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●	●●●	●●●
Guided Wave Radar	●●	●●●	●●	●●●	●●●

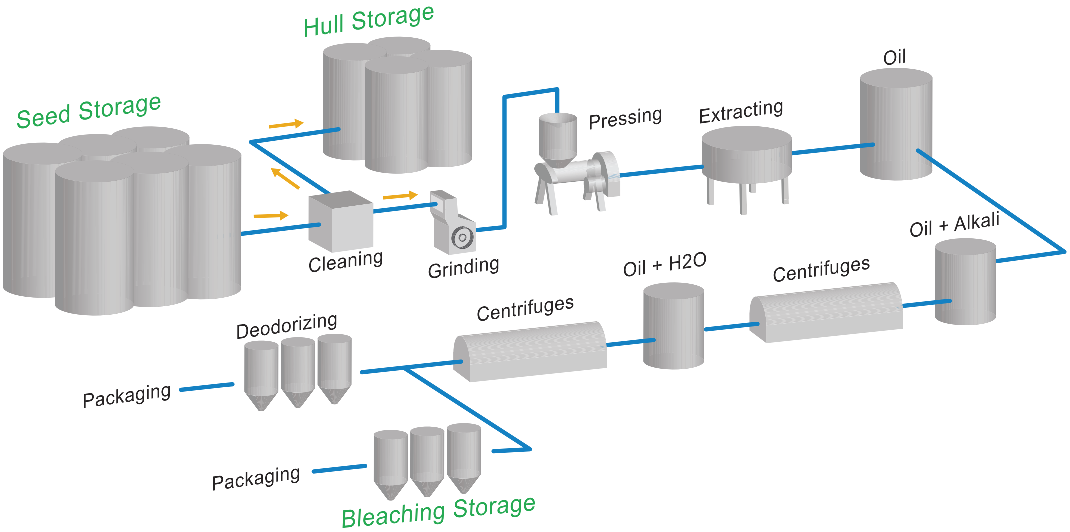
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Wheat Storage	Temper Silos	Bran Storage	Germs Storage	Flour Storage
Rotating Paddle	● (green)	● (green)	● (green)	● (green)	● (green)
Vibrating Fork	● (green)	● (yellow)	● (yellow)	● (green)	● (yellow)
Vibrating Rod	● (green)	● (yellow)	● (yellow)	● (green)	● (yellow)
Capacitance Probe	● (green)	● (green)	● (green)	● (yellow)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

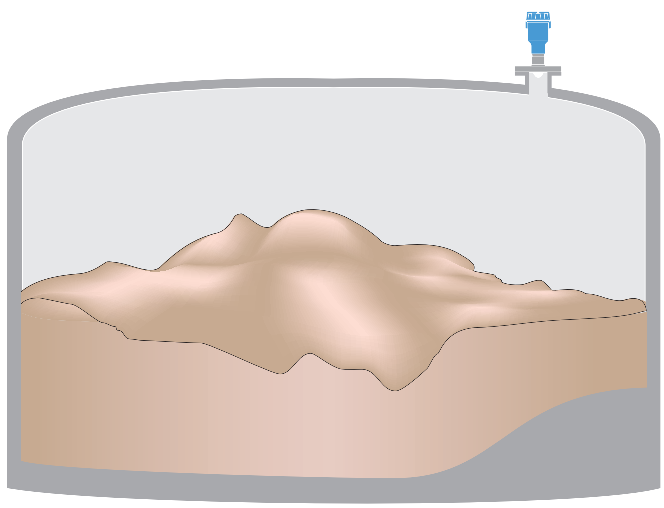
8.3 Seed Oil Production



Some oils, such as olive oil, are cold-pressed. This method, which entails minimal processing, produces light, flavorful oil suitable for some cooking needs. Most oil sources, however, are not suitable for cold pressing, because it would leave many undesirable trace elements in the oil, causing it to be odoriferous, bitter tasting, or dark. These oils undergo many steps beyond extraction to produce bland and consistent oil.

Seed Storage

- **Application:** Prior to being processed into various kinds of oils, seeds such as sunflower, palm kernel, safflower, soybeans, sesame, and canola, or nuts such as peanuts, almonds, and walnuts, are delivered to the plant and stored in big silos to ensure a continuous production process.
- **Challenges:** The sizes of the silos that carry these raw materials can have diameters greater than 15m (50 ft) and may be over 40m (132 ft) tall. Knowing the exact amount of raw material entering the oil extracting machines is the key to tracking and controlling production efficiency. Build-up of the material occurs inside the silo and can damage the quality of the beans. Since the temperature inside the build-up rises over time, the seeds inside the build-up get burnt and stick to each other, forming hard bulks that cannot be used. Therefore, operators need to detect the build-up as soon as it begins to form.

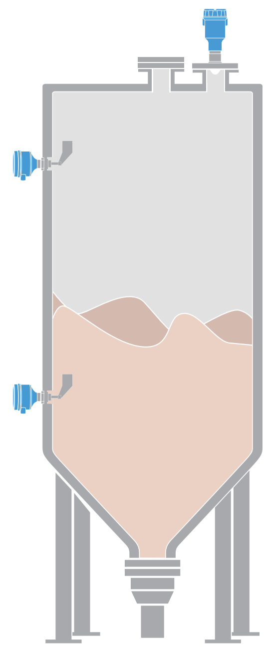


Accurate inventory control is required to ensure a sufficient supply of raw materials to meet the specific production plan, taking into account delivery times which can vary considerably.

Hull Storage

- **Application:** By-products from oil processing (meals, hulls, lecithin, hominy/ dried maize and others) are stored in silos before being shipped for use in the production of fertilizers, animal feeds, cosmetics and other products.
- **Challenges:** A major challenge, apart from continuous measurement of the material inside the silo, is early identification of material build-up. This can damage the quality of the product since the temperature inside the build-up rises over time, the by-products inside get burnt and stick to each other, forming hard bulks that cannot be used. To eliminate the loss, operators need to surmount this challenge by being able to detect the build-up as it begins to form.

By seeing the allocation of material inside the silos in real time, users can facilitate the scheduling of any required maintenance and cleaning before damage is caused to the product or unexpected interruptions of the production process occur.



Bleaching Storage

- **Application:** The bleaching step removes pigment, oxidation products, and trace contaminants. Fullers clay is the most common material used, but some oils may use other components such as activated carbon, diatomaceous earth, trisyl (small glass beads) or rice hulls. The bleaching agent is mixed with the oil where it is used to as an absorption cleansing process.
- **Challenges:** The bleaching agents tend to be very dusty and are introduced into oil to create a slurry. Fresh bleaching clays are fine powders that can be very dusty. There must be an adequate supply available for oil finishing.

Recommended Technology – Continuous Level

Recommended Solution	Seed Storage	Hull Storage	Bleaching Storage
Non-Contacting Radar			
26 GHz radar transmitters	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●
Guided Wave Radar	●●●	●●	●●

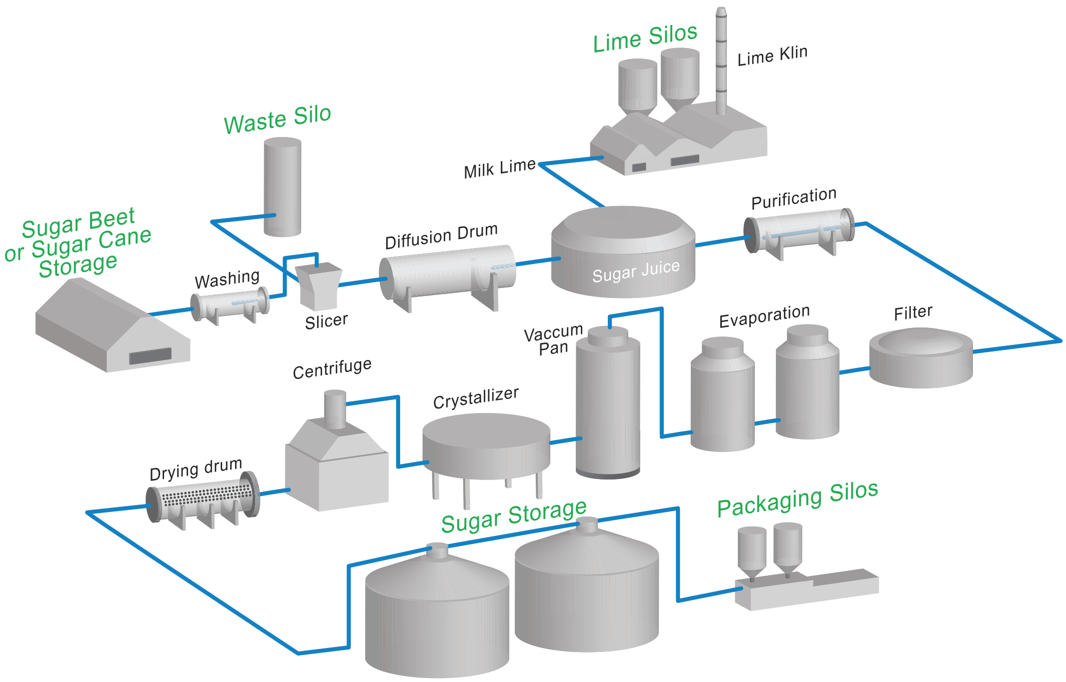
KEY
●●● **Preferred Technology**
●● **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

Recommended Technology – Point Level

Recommended Solution	Seed Storage	Hull Storage	Bleaching Storage
Rotating Paddle	● (green)	● (green)	● (green)
Vibrating Fork	● (green)	● (yellow)	● (green)
Vibrating Rod	● (green)	● (yellow)	● (green)
Capacitance Probe	● (green)	● (green)	● (green)

KEY
● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

8.4 Sugar Production



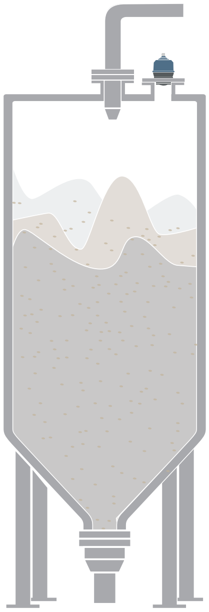
Sugar is produced from both sugar cane and sugar beets. Sugar cane is grown in warmer climates such as Latin America, Asia and southern USA while sugar beets are grown in cooler, more northern climates such as Canada, and northern portions of the US and Europe. Once the sugar beet or cane is shredded or sliced to get the high sugar bearing material into a solution, then the rest of the process is very similar. Concentrating the Juice is done by boiling off water from the Juice in large vessels known as evaporators. Centrifuges are used to separate the sugar from the syrup. The syrup is spun off and the sugar crystals remain. The wet sugar is then dried, screened, cooled and sent to large bulk storage silos.

Sugar Beet or Sugar Cane Storage

- **Application:** Sugar beet is stored in warehouses prior to being transferred to processing.
- **Challenges:** The material stored in the warehouse feeds the entire process. Accurate measurement to ensure continuous production and accurate inventory readings are the main challenges for the end user.

Waste Silo

- **Application:** Waste material from both sugar beets and sugar cane is diverted to storage silos for use in other areas such as feedstock.
- **Challenges:** The irregular shaped raw materials form uneven surfaces. It can become vaporous and sticky.



Lime Silos

- **Application:** A lime solution is added to raw sugar juice to remove impurities. Lime is stored in silos before being sent to the kiln and made into a milk solution to add to the sugar juice.
- **Challenges:** Continuous monitoring of lime inside the silo is challenging since lime generates heavy dust during the process, with a tendency to adhere to the silo walls, creating build-up and rat holes.

Sugar Storage Silos

- **Application:** After the wet sugar is dried, screened and cooled it is sent to large bulk storage silos/ domes, each of which can contain up to 50,000 tons. From the storage silos, the sugar is either delivered via trucks or transferred to a packaging silo to be packed in bags.
- **Challenges:** Raw sugar is stored in very large silos or domed warehouses where it is widely distributed in order to use maximum capacity. The stickiness of the sugar leads to random formations of material build-up and rat holes inside the silo or dome. Both silo or dome size and the material properties make it extremely challenging for users to continuously assess sugar inventory levels.

Packaging Silos

- **Application:** Sugar is delivered to the packaging silos where it is packed in bags and packages.
- **Challenges:** Sugar and sugar dust tend to accumulate, creating build ups and rat holes, so understanding actual material content continuously becomes very difficult. The materials' sticky nature challenges level measuring systems which need to operate even if sugar sticks to the antenna.

Recommended Technology – Continuous Level

Recommended Solution	Lime Silo	Sugar Beet/ Cane Storage	Waste Silo	Sugar Storage Silos	Packaging Silos
Non-Contacting Radar					
26 GHz radar transmitters	●● (green)	●●● (green)	●● (green)	●● (green)	●● (green)
80 GHz radar transmitters	●●● (green)	●● (green)	●●● (green)	●●● (green)	●●● (green)
Guided Wave Radar	●● (green)	● (red)	●● (green)	●●● (green)	●●● (green)

KEY
●●● (green) **Preferred Technology**
●● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

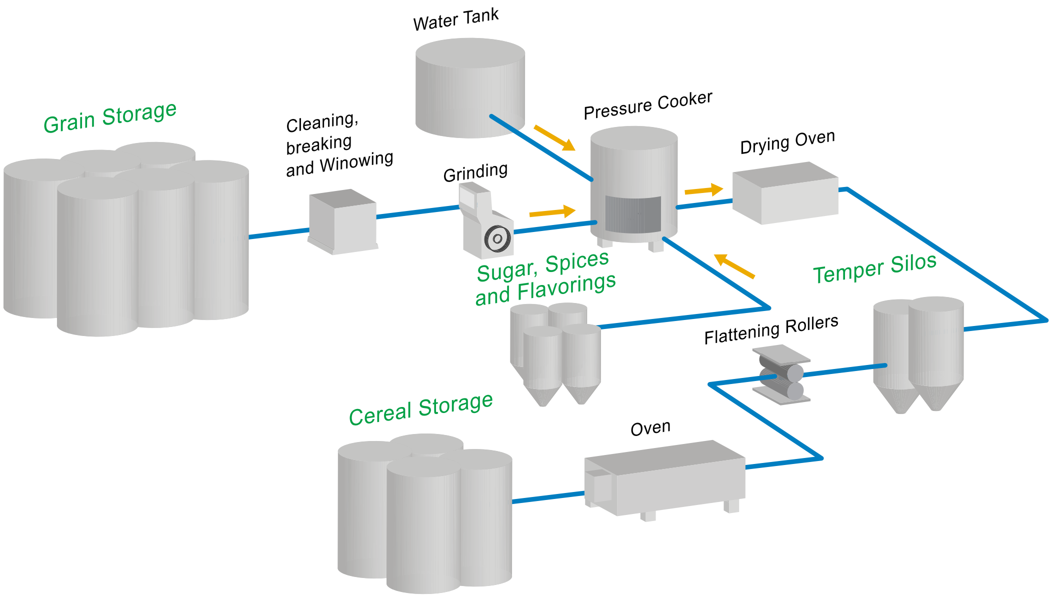
Recommended Technology – Point Level

Recommended Solution	Lime Silo	Sugar Beet/ Cane Storage	Waste Silo	Sugar Storage Silos	Packaging Silos
Rotating Paddle	● (green)	● (green)	● (green)	● (green)	● (green)
Vibrating Fork	● (yellow)	● (yellow)	● (yellow)	● (green)	● (green)
Vibrating Rod	● (yellow)	● (yellow)	● (yellow)	● (green)	● (green)
Capacitance Probe	● (green)	● (green)	● (green)	● (yellow)	● (green)

KEY
● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

Section 9 | Food and Beverage Industry

9.1 Cereal Production



Cereal is one of the most popular breakfast foods today. It is made of processed grains that are mixed with flavoring agents, vitamins, minerals, sweeteners, salt, and water in a large rotating pressure cooker. The mixed product is then dried and finished for packaging or transport.

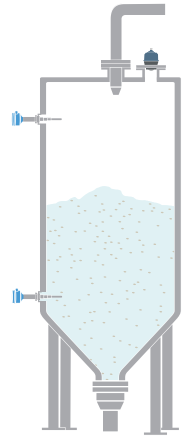
Grain Storage

- **Application:** Grains (wheat, corn, rice etc) arrive at the plant and are stored in silos before being further processed.
- **Challenges:** The grains are stored in large silos, making it difficult to accurately measure the inventory available to ensure continuous supply for the cereal production process. Knowing the exact amount of grain entering and exiting the silos is also important for correctly calculating material costs to meet quarterly and annual financial reporting requirements.

Temper Silos

- **Application:** Cooked grains are allowed to cool for several hours, stabilizing the moisture content of each grain.
- **Challenges:** The humid condition of the cooked grains together with the time the grain remains stored inside the temper silo promotes the formation of build-up on the silo walls. The additional dust generated during the process further complicates accurate measurement of the inventory.

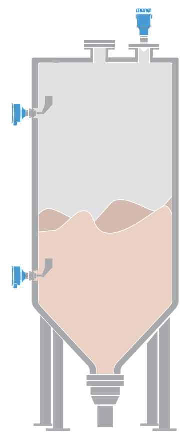
Sugar Storage



- **Application:** Sugar is an important ingredient in the production of cereal and is stored in silos before being mixed with the grains.
- **Challenges:** Sugar and sugar dust tend to accumulate, creating build-up and rat holes. Moreover, the materials sticky nature challenges level measurements as they need to operate even when wetted parts become coated. To continuously assess sugar inventory levels is very challenging.

Spices and flavorings

- **Application:** Spices and flavorings are needed to blend into the cereal depending on it recipe. The overall amounts are small but adequate supply is necessary. These often have smaller production silos and bins.
- **Challenge:** Availability of adequate supply, materials may be lightweight and dusty.



Cereal Storage

- **Application:** Final products are stored in production bins prior to final packaging. An adequate supply must be available as the cereal is moved into packaging.
- **Challenge:** The cereal can be very lightweight product which limits the use of technologies dependent on mass or density.

Recommended Technology – Continuous Level

Recommended Solution	Grain Storage	Temper Silos	Sugar Storage	Spices and Flavoring	Cereal Storage
Non-Contacting Radar					
26 GHz radar transmitters	●●	●●	●●	●●	●●●
80 GHz radar transmitters	●●●	●●●	●●●	●●●	●●
Guided Wave Radar	●●	●●●	●●●	●●●	●●

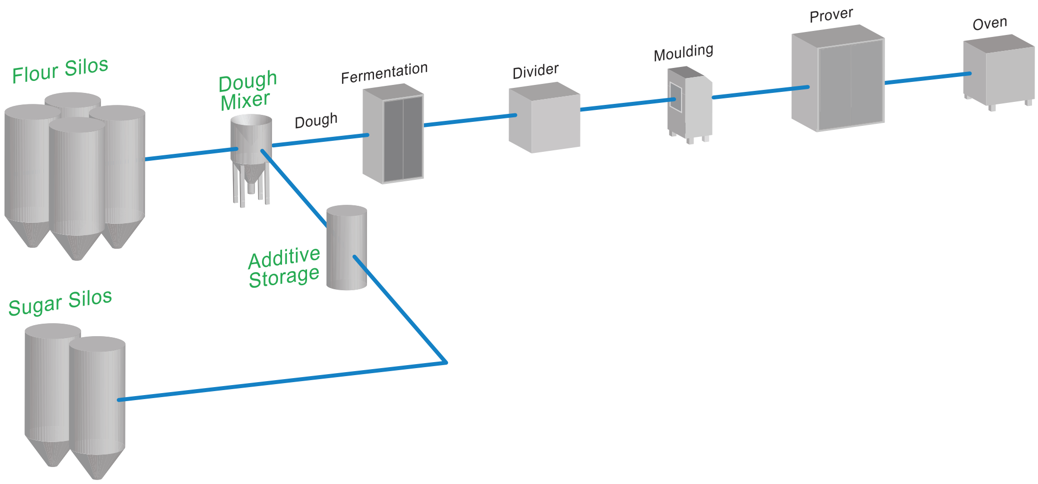
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Grain Storage	Temper Silos	Sugar Storage	Spices and Flavoring	Cereal Storage
Rotating Paddle	● (green)	● (green)	● (green)	● (yellow)	● (yellow)
Vibrating Fork	● (green)	● (yellow)	● (yellow)	● (yellow)	● (yellow)
Vibrating Rod	● (green)	● (yellow)	● (yellow)	● (green)	● (green)
Capacitance Probe	● (green)	● (green)	● (green)	● (yellow)	● (yellow)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

9.2 Pastry Production



The sifted flour is poured into an industrial mixer. Temperature-controlled water is piped into the mixer. A pre-measured amount of yeast is added. Yeast is actually a tiny organism which feeds off the sugars in the grain, and emits carbon dioxide. The growth of the yeast produces gas bubbles, which leaven the bread. Depending on the type of bread to be made, other ingredients are also poured into the mixer.

Flour Storage

- **Application:** Flour is stored in silos before being transferred into the production process.
- **Challenges:** Knowing the amount of stored flour is critical for the production flow since a lack of insight could interrupt or even stop production altogether. Enabling on-time ordering of the right quantities will prevent overflows as well as wasted production time. Flour tends to stick to the silo walls, creating build-ups and rat holes. Early detection will ease maintenance, reduce maintenance cost and allow optimal use of the silo content. Different types of flour cannot be mixed together in some cases, and knowing the inventory of stored flours can be crucial to the quality of the final product.

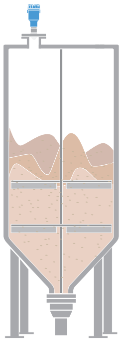
Sugar Storage

- **Application:** Sugar is stored in silos before being added to the mixture.
- **Challenges:** Sugar and sugar dust tend to accumulate, creating build ups and rat holes, so understanding actual material content continuously becomes very difficult.

The materials' sticky nature challenges level measuring systems which need to operate even if sugar sticks to the antenna or other system parts.

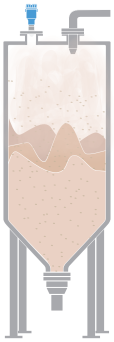
Dough Mixer

- **Application:** Flour, sugar, yeast and flavorings are mixed to create dough.
- **Challenges:** The dough mixer is a constantly moving process where mixing blades are used to mix in the additives and to create a smooth blended product. As the blades are present a non-contacting level measurement is mandatory.



Additives Storage

- **Application:** Yeast, salt and other flavoring agents are added to the dough mixture.
- **Challenges:** Accurately measuring the additive vessel content is needed to ensure an adequate supply of material. The storage vessels tend to be smaller than the main ingredients but the contents can be dusty and sometime sticky.



Recommended Technology – Continuous Level

Recommended Solution	Flour Storage	Sugar Storage	Dough Mixer	Additives Storage
Non-Contacting Radar				
26 GHz radar transmitters	●●	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●	●●●
Guided Wave Radar	●●	●●	● (red)	●●

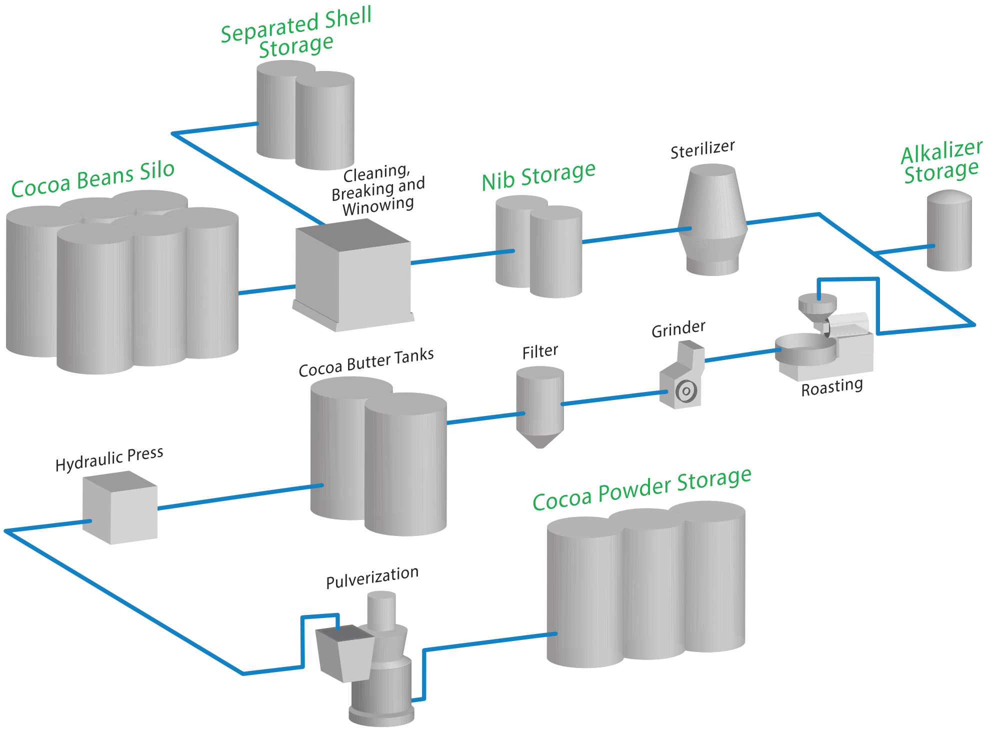
KEY
●●● Preferred Technology
●● Suitable
● (yellow) Application dependent
● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Flour Storage	Sugar Storage	Dough Mixer	Additives Storage
Rotating Paddle	●	●	●	●
Vibrating Fork	● (yellow)	● (yellow)	●	●
Vibrating Rod	● (yellow)	● (yellow)	●	●
Capacitance Probe	●	●	●	●

KEY
● (green) Suitable
● (yellow) Application dependent
● (red) Not recommended

9.3 Cocoa Processing



Raw Cocoa beans are turned into raw cocoa powder and cocoa butter which are the base material for many chocolate products. The cocoa beans are stored in large storage bins and then distributed into smaller vessels as they are separated and processed. The filling and emptying is often performed by conveyor systems that transport the media from the large external silos. Reliable level measurements are needed to control the filling and emptying sequences at the different stages.

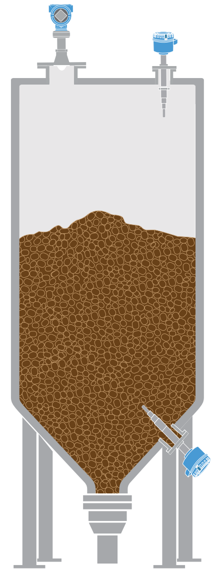
Cocoa Bean Storage

- **Application:** Cocoa beans are stored in large silos prior to being transferred onward for further processing.
- **Challenges:** The large sizes of storage silos combined with the dusty environment and the irregular allocation of material inside the silo make accurate measurement of the stored level very difficult. Accurate level measurement is the basis for continuous inventory tracking to ensure the supply of beans to the production.

Separated Shell Storage

- **Application:** Separated shells are stored in silos before being shipped for use, often in agricultural mulch or to fertilizer producers.
- **Challenges:** Humidity and temperature cause build-up and irregular formations and can generate damage to the silo and the quality of the product, since the internal temperature during build-up rises over time and the shells inside get burnt and stick to each other, forming hard bulks that cannot be used. The ability to view the build-up as it occurs and knowing how much material is available are both crucial to the end user.

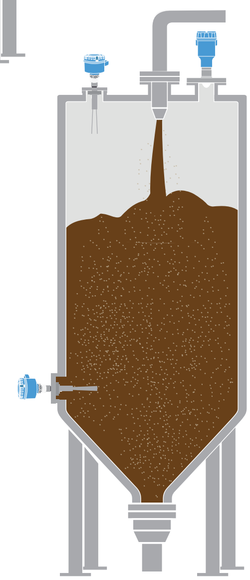
Nib Storage



- **Application:** Nibs are stored in silos prior to entering the cocoa production process. The nibs feed the entire cocoa production process, so end-users need to accurately monitor inventory levels both to ensure a continuous supply and to avoid unexpected interruptions of the process and their associated losses in time and money.
- **Challenges:** The Nibs can be dusty which can lead to coating of silo walls and build-up. In smaller silos, the level may change quickly as the silos empty and refill making a responsive level measurement critical to determine adequate supplies for production.

Alkalizer Storage

- **Application:** Potassium Carbonate is sometimes used in cocoa processing to produce higher pH (more alkaline) cocoa powder. It is mixed with the nibs prior to roasting.
- **Challenges:** Potassium carbonate is a granular powder. The bins tend to be smaller than the cocoa beans and nibs storage and thus more restricted in what level technology can be used.



Cocoa Powder Storage

- **Application:** Final material is stored both for bulk and bagging.
- **Challenges:** Accurately measuring the silos' content is important for efficient delivery from the production to the final silos.

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SCAN OR CLICK

Recommended Technology – Continuous Level

Recommended Solution	Cocoa Bean Storage	Separated Shell Storage	Nib Storage	Alkalizer Storage	Powder Storage
Non-Contacting Radar					
26 GHz radar transmitters	●●●	●●	●●●	●●	●●
80 GHz radar transmitters	●●	●●●	●●●	●●●	●●●
Guided Wave Radar	●●	● (yellow)	●●	●●●	●●●

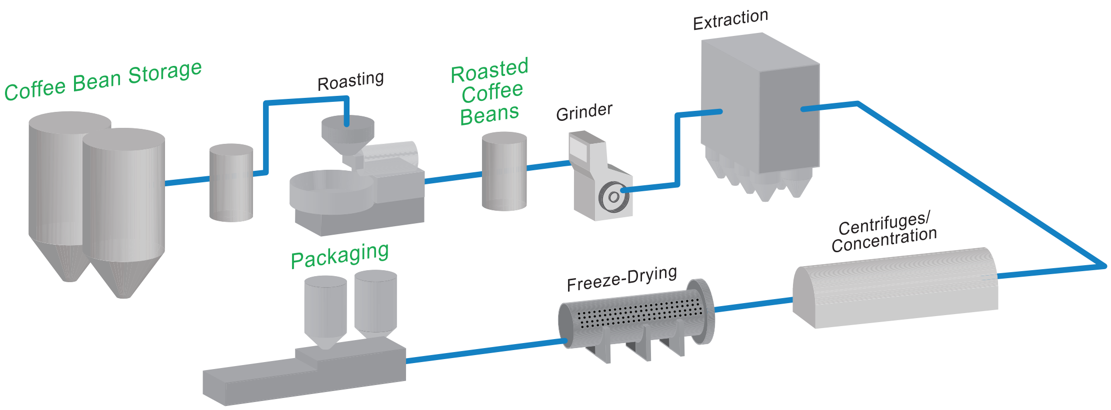
KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Cocoa Bean Storage	Separated Shell Storage	Nib Storage	Alkalizer Storage	Powder Storage
Rotating Paddle	●	●	●	●	●
Vibrating Fork	●	● (yellow)	●	●	●
Vibrating Rod	●	● (yellow)	●	●	●
Capacitance Probe	●	●	●	●	●

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

9.4 Coffee Processing



Green coffee beans are turned into roasted coffee beans, ground coffee and instant coffee. Variations of the process could include decaffeination or the manufacture of freeze dried or instant coffee granules. Reliable level measurements are needed to control the filling and emptying sequences at the different stages.

Coffee Bean Storage

- **Application:** Green coffee beans are received and stored in silos prior to being transferred onward for further processing.
- **Challenges:** Large storage silos and the irregular allocation of material inside the silo make accurate measurement of the stored beans' very difficult. Accurate level measurement is the basis for continuous inventory tracking to ensure the supply of beans to the production.

Roasted Coffee Beans

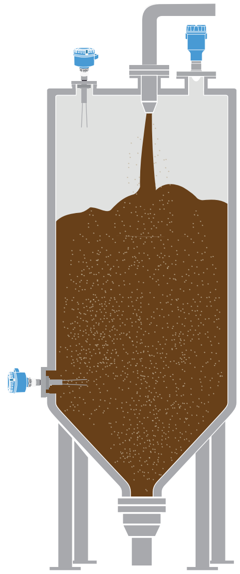
- **Application:** Roasted beans are sorted in to low, medium and dark levels of roasted beans.
- **Challenges:** The ability monitor level and know how much material is available is important for final inventory.

Ground Coffee

- **Application:** Roasted beans are ground and packaged for sale or further processed for creation of concentrated liquid coffee for creation of instant coffee.
- **Challenges:** In the larger silos, the control of the level of ground coffee is critical. The level may change quickly as the silos empty and refill making a responsive level measurement critical to determine adequate supplies for production or packaging.

Instant Coffee Granules or Powder

- **Application:** Concentrated liquid coffee is either evaporated for instant coffee powder or frozen and dried in a vacuum for freeze-dried coffee granules.
- **Challenges:** Accurately maintaining and knowing the bin's content is important as the dried coffee is accumulated and delivered to packaging.



Recommended Technology – Continuous Level

Recommended Solution	Green Coffee Bean Storage	Roasted Coffee Storage	Ground Coffee	Instant Coffee
Non-Contacting Radar				
26 GHz radar transmitters	●●●	●●●	●●	●●
80 GHz radar transmitters	●●	●●	●●●	●●●
Guided Wave Radar	●●	●●	●●●	●●●

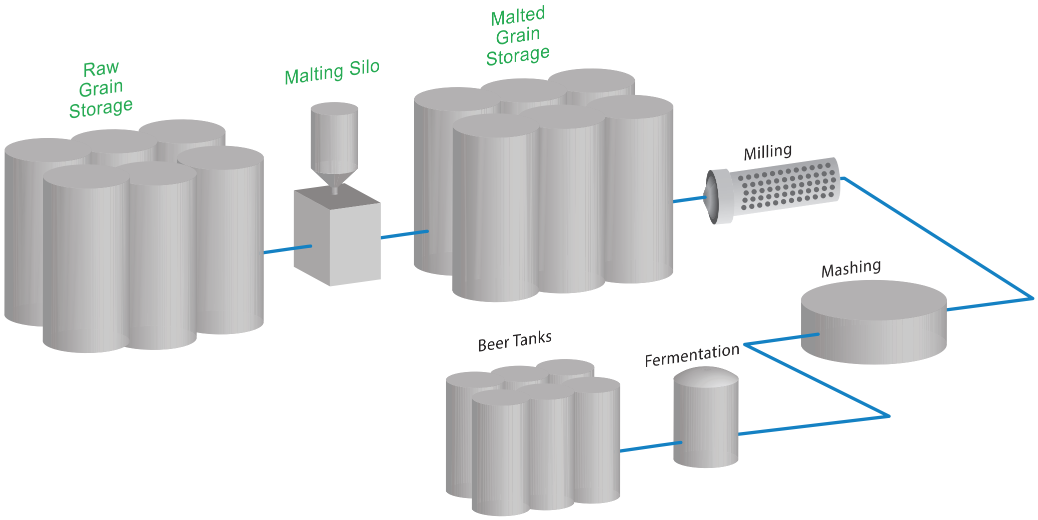
KEY
●●● **Preferred Technology**
●● **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

Recommended Technology – Point Level

Recommended Solution	Green Coffee Bean Storage	Roasted Coffee Storage	Ground Coffee	Instant Coffee
Rotating Paddle	●	●	●	●
Vibrating Fork	● (yellow)	●	●	●
Vibrating Rod	●	●	●	●
Capacitance Probe	●	●	●	●

KEY
● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

9.5 Spirits and Beer Production

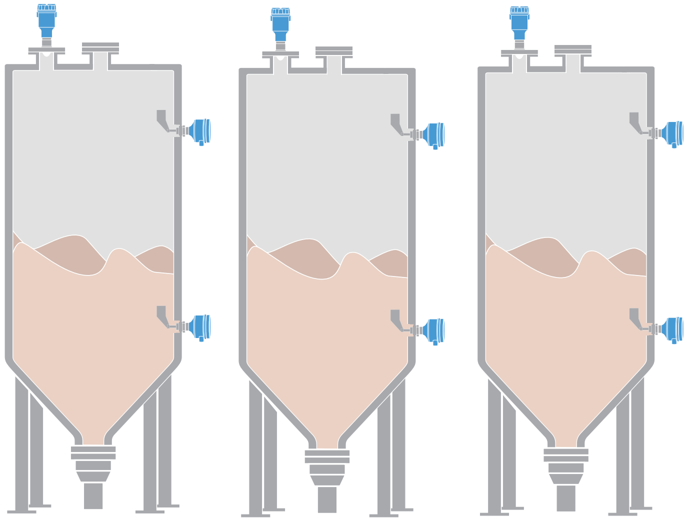


The first ingredient to come into play in a brewery or distillery is grain (most commonly barley, but other grains such as rice or wheat may also be used). The grain goes through a chemical and malting process. At the end of this process, it is milled into a coarse powder called grist. The grist is then transferred to a large vessel called a mash tun, where it is mashed with hot water to extract the fermentable sugars. The natural sugars in the malt dissolve in the water, creating a sugary liquid known as wort.

For beer production, the wort is boiled with hops to add bitterness, flavor, and aroma, then cooled and fermented with yeast into beer. For whisky production, the wort is fermented with yeast into wash, which is distilled and aged in barrels to develop its flavor.

Raw Grain Storage

- **Application:** Prior to being processed the grains are delivered to the plant and stored in big silos to ensure continuous production process.
- **Challenges:** Silos can reach more than 15m (50 ft) in diameter and over 40m (132 ft) in height. Knowing the exact amount of raw material entering the malting process is the key to tracking and controlling production efficiency. Raw material delivery times can vary considerably; therefore it is essential to ensure the raw material is sufficient for the production plan.

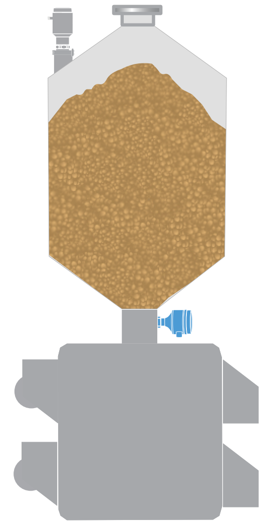


Malting Silo

- **Application:** The seeds go through a chemical and malting process before being further processed.
- **Challenges:** The humid condition of the cooked grains together with the time the grains remain stored inside the malting silo promotes the formation of build-up on the silo walls. The additional dust generated during the process further complicates accurate measurement of the inventory.

Malted Grain Storage

- **Application:** Malted grains (grist)/distiller's rice are stored in large silos prior to entering the beer brewing or whisky production processes.
- **Challenges:** Malted grains / distiller's rice have a tendency to form build-ups and rat holes, and also create a great deal of dust during the filling process.



Recommended Technology – Continuous Level

Recommended Solution	Raw Grain Storage	Malted Grain Storage	Malting Silo
Non-Contacting Radar			
26 GHz radar transmitters	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●
Guided Wave Radar	●●	●●	●●

KEY
●●● **Preferred Technology**
●● **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

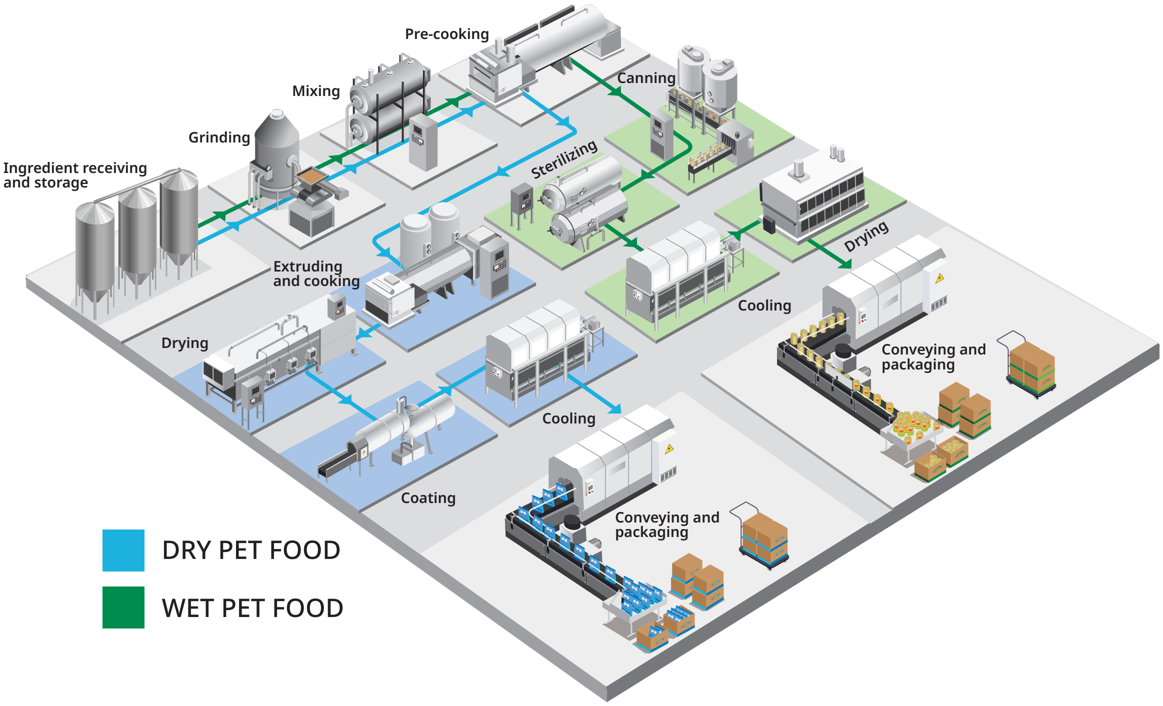
Recommended Technology – Point Level

Recommended Solution	Raw Grain Storage	Malted Grain Storage	Malting Silo
Rotating Paddle	● (green)	● (green)	● (green)
Vibrating Fork	● (yellow)	● (yellow)	● (yellow)
Vibrating Rod	● (green)	● (green)	● (yellow)
Capacitance Probe	● (green)	● (green)	● (green)

KEY
● (green) **Suitable**
● (yellow) **Application dependent**
● (red) **Not recommended**

Section 10 | Pet Food Production

10.1 Pet Food Production

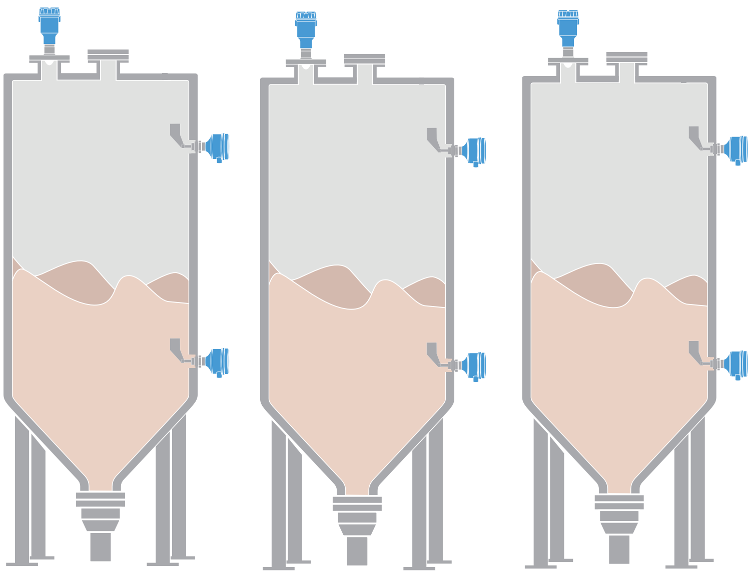


When combined, food for dogs and cats accounts for the vast bulk of pet food production. The two main product categories cover wet (canned) and dry (bagged kibble, dog biscuits, etc., hereafter referred to as kibble).

Initial manufacturing begins with the receiving and storage of wet and dry ingredients. These ingredients are then ground and cut to the desired size before being mixed and cooked. Wet food moves directly to packaging after cooking. Dry food undergoes further processing, including cooking, extruding into kibble shapes, and drying. Kibble is then coated with flavors, colors, and binders in a tumbler mixer before being bagged. A soft dry food variant is also produced, which is partially dried and requires packaging that retains moisture.

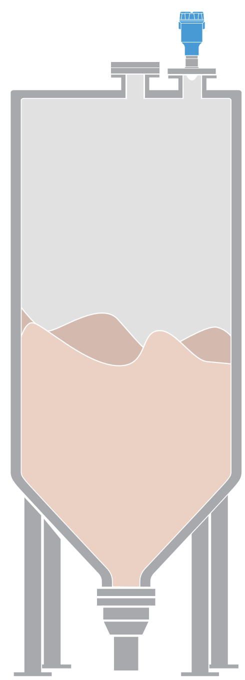
Dry Ingredient Receiving and Storing

- **Application:** Incoming ingredients, particularly those that make up the bulk of a recipe, are stored in silos or tanks. Monitoring level is critical, and the measurements solution must be appropriate for the product. Precise measurements are also important for effective inventory management of both dry and liquid ingredients.
- **Challenges:** Fast-moving levels and dusty environments that can create safety issues or manual rounds.



Cooking Processes

- **Application:** Once ingredients are in the cooker, a radar level instrument can verify that the desired total volume has been achieved, which helps maximize production capacity.
- **Challenges:** Clogging and high temperatures that generate unsafe situations for operators.



Recommended Technology – Continuous Level

Recommended Solution	Dry Ingredient Receiving and Storing	Cooking Processes
Non-Contacting Radar		
26 GHz radar transmitters	●●●	●●●
80 GHz radar transmitters	●●●	●●●
Guided Wave Radar	●●	●●

KEY
- ●●● Preferred Technology
- ●● Suitable
- ● Application dependent
- ● Not recommended

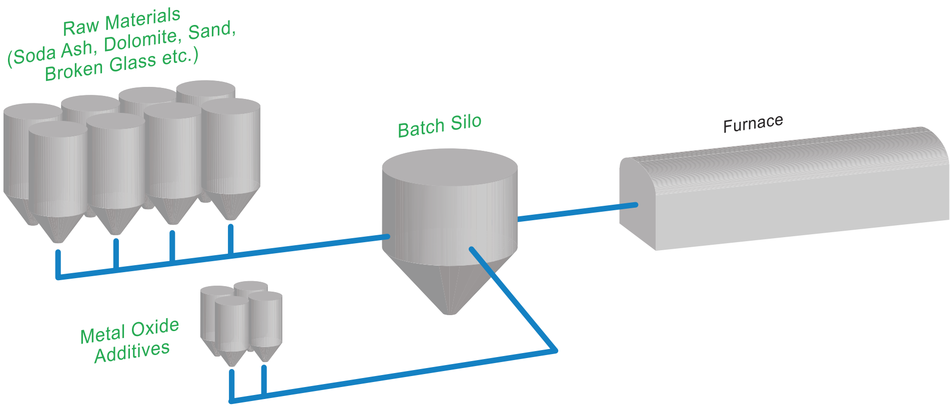
Recommended Technology – Point Level

Recommended Solution	Dry Ingredient Receiving and Storing	Cooking Processes
Rotating Paddle	● (green)	● (yellow)
Vibrating Fork	● (yellow)	● (yellow)
Vibrating Rod	● (yellow)	● (yellow)
Capacitance Probe	● (yellow)	● (yellow)

KEY
- ● Suitable
- ● Application dependent
- ● Not recommended

Section 11 | Glass Industry

11.1 Glass Production



Batch processing is one of the initial steps of the glass-making process. The batch house simply houses the raw materials in large silos. Some batch systems include material processing such as raw material screening/sieve, drying, or pre-heating (i.e. cullet). Whether automated or manual, the batch house measures, assembles, mixes, and delivers the glass raw material recipe (batch) via an array of chutes, conveyors, and scales to the furnace.

Raw Materials Storage

- **Application:** Raw materials used for the production of glass (sand, dolomite, soda ash, broken glass, and manganese oxide) are stored in silos before entering the batch processing.

Raw materials include: Recycled glass (cullet), sand, sodium oxide from soda ash, calcium oxide from limestone or dolomite, magnesium oxide from dolomite, and aluminum oxide from feldspar. In addition, small quantities of metal oxides are needed to impart color to the glass.

- **Challenges:** Batches that feed the furnace are produced by mixing fixed amounts of the different raw materials that come from the different silos. Therefore, it is essential to have sufficient quantities of all the materials before the batching starts. When operators know how much of each material is available, they can avoid unnecessary and unexpected production stoppages.

Batch Silo

- **Application:** Different raw materials are mixed using a specific recipe for each glass production cycle and are kept in the batch silo before entering the furnace.
- **Challenges:** The batch silos feed the furnace. Since the furnace needs to be fed continuously it is crucial to control the batch silo inventory for the on-going process. Operators need to ensure continuous production and to avoid unnecessary and unexpected production stoppages and associated losses in time and money.

Metal Oxides Storage

- **Application:** Metal oxides are added to impart color to the glass.
- **Challenges:** Dusty, granular material where the available amount is required for production.

Recommended Technology – Continuous Level

Recommended Solution	Raw Material Storage	Batch Silos	Metal Oxide Storage
Non-Contacting Radar			
26 GHz radar transmitters	●●	●●	●●
80 GHz radar transmitters	●●●	●●●	●●●
Guided Wave Radar	●●	●●	●●

KEY
- ●●● Preferred Technology
- ●● Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

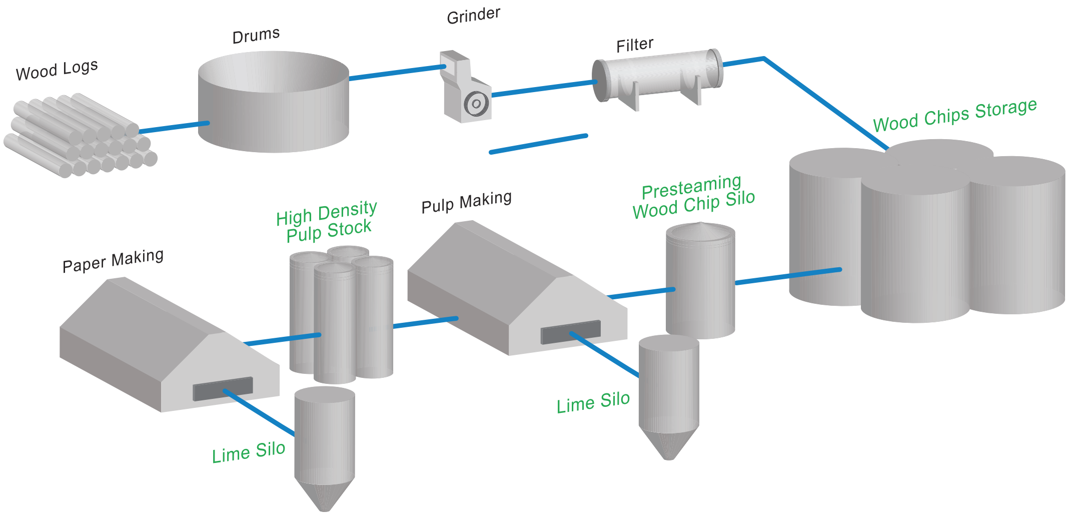
Recommended Technology – Point Level

Recommended Solution	Raw Material Storage	Batch Silos	Metal Oxide Storage
Rotating Paddle	● (green)	● (green)	● (green)
Vibrating Fork	● (yellow)	● (yellow)	● (green)
Vibrating Rod	● (yellow)	● (yellow)	● (yellow)
Capacitance Probe	● (green)	● (green)	● (green)

KEY
- ● (green) Suitable
- ● (yellow) Application dependent
- ● (red) Not recommended

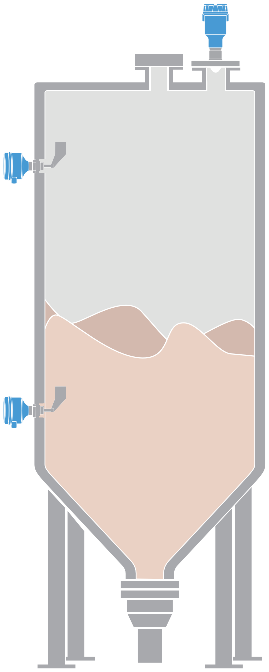
Section 12 | Pulp and Paper Production

12.1 Pulp and Paper Production



Pulp and paper production is a complex process that has many sub-processes within it. Two basic methods are used to create pulp: chemical or mechanical. The final pulp product can be shipped to a paper making facility or transferred to the paper making portion of the same mill.

Trees are typically used as raw material for paper making, although many non-woody plants can be used as well as recycled paper products. Plants used for paper making include cotton, wheat straw, sugar cane waste, and more. However suitable these other sources may be, the bulk of the raw material for paper making comes from trees.



Wood Chip Storage

- **Application:** Wood chips are stored in large silos or in open air (in piles) before being processed into pulp.
- **Challenges:** Wood chip storage facilities are usually very large, the material tends to stick and the emptying process is carried out through nozzles along the silo bottom which create irregular formations inside the silo. As the storage silos feed the pulp-making process, it is important to make sure enough material is available for production. Continuous level measurement is critical to allow smooth operation.

High Density Pulp Stock

- **Application:** These tall vessels are filled with accumulating damp pulp stock.
- **Challenges:** The material is wet and warm and creates a very wet, steamy vapor space. Material often clings to exposed surfaces. As the stock is essential to paper making process, measurements of adequate supply is essential.

Metal Oxides Storage

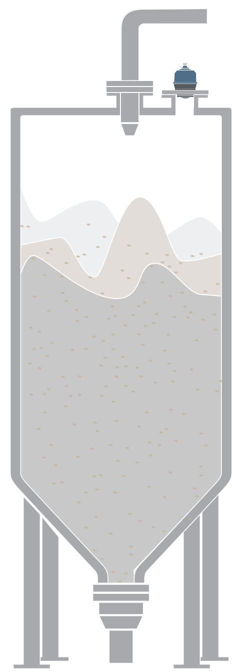
- **Application:** Metal oxides are added to impart color to the glass.
- **Challenges:** Dusty, granular material where the available amount is required for production.

Wood Chip Manufacturing Silos, Pre-steaming Silos

- **Application:** This kind of silos are typically narrow and less than 20m tall. Wood chips are continuously fed from the top, steam/lye is injected at the bottom and the product is brought out from the vessel from the bottom.
- **Challenges:** This is a continuous process, where the level should stay within 20-80%. The environment in the silo is very rough, as wood chips continuously are falling from the top, generating dust and debris in the air, steam is causing heavy condensation and the pile of wood chip is rapidly moving.

Lime Silo

- **Application:** Very fine lime powder is used the pulp and paper plants for neutralization.
- **Challenges:** The size of the lime silos vary from site to site and even within the same site. What they have in common though is that the lime is a very fine powder which is very dusty and commonly builds up on everything within the silo atmosphere. Due to the rather heavy weight of the lime particles, the lime piles up unevenly and steep in the silo.



Recommended Technology – Continuous Level

Recommended Solution	Wood Chip Storage	Pre-steaming Wood Chip Silo	Lime Silo	High Density Pulp Stock
Non-Contacting Radar				
26 GHz radar transmitters	●●● (Preferred Technology)	●●● (Preferred Technology)	●● (Suitable)	●● (Suitable)
80 GHz radar transmitters	●●● (Preferred Technology)	●●● (Preferred Technology)	●●● (Preferred Technology)	●● (Suitable)
Guided Wave Radar	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Not recommended)

KEY
- ●●● Preferred Technology
- ●● Suitable
- ● Application dependent (yellow)
- ● Not recommended (red)

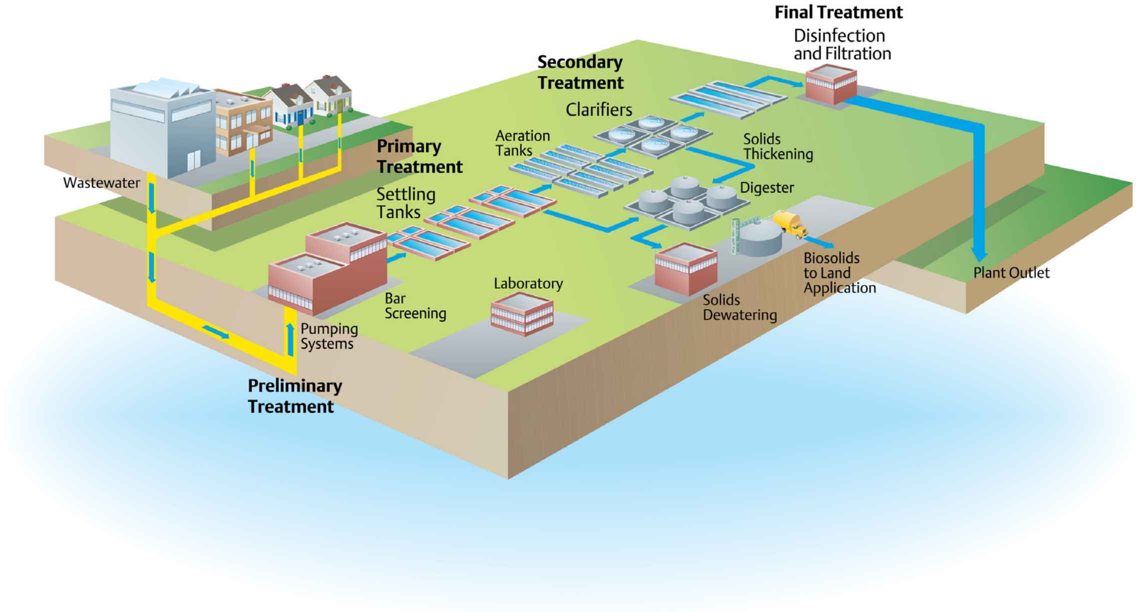
Recommended Technology – Point Level

Recommended Solution	Wood Chip Storage	Pre-steaming Wood Chip Silo	Lime Silo	High Density Pulp Stock
Rotating Paddle	● (Suitable)	● (Suitable)	● (Suitable)	● (Not recommended)
Vibrating Fork	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Not recommended)
Vibrating Rod	● (Not recommended)	● (Not recommended)	● (Application dependent)	● (Not recommended)
Capacitance Probe	● (Suitable)	● (Suitable)	● (Suitable)	● (Application dependent)

KEY
- ● Suitable (green)
- ● Application dependent (yellow)
- ● Not recommended (red)

Section 13 | Wastewater

13.1 Wastewater



Wastewater treatment plants purify water from urban and industrial sources, allowing it to be reused. The treatment process involves four main stages: preliminary, primary, secondary, and tertiary. In the preliminary stage, large objects are removed using coarse screens or sieves. During primary treatment, gravity is used to settle and remove suspended solids. The secondary stage involves bacteria breaking down organic matter and nutrients, with the activated sludge method being the most common, where aeration occurs in a tank over several days. Finally, the tertiary treatment uses advanced processes to eliminate pathogens, improving water quality before returning it to the environment.

Fly Ash Storage

- **Application:** Wastewater treatment plants incinerate waste collected during the preliminary and primary treatment stages, reducing it to ash. This ash is stored in tall silos and, after additional processing, can be repurposed for uses like construction.
- **Challenges:** Fly ash generates significant dust during filling and emptying, which can interfere with optical, ultrasonic and laser-based level measurements. Fly ash also tends to stick to surfaces, causing buildup on sensors in contact with the material and on tank walls.

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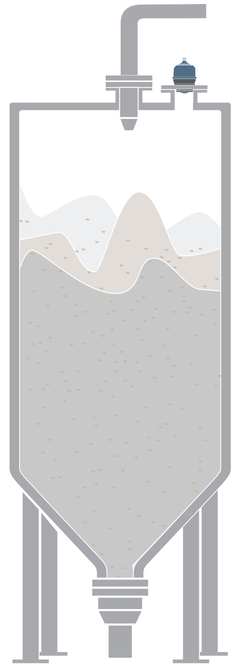
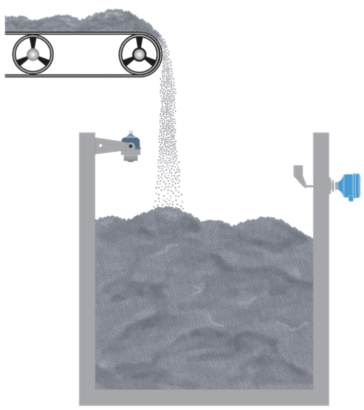
Lime Silo



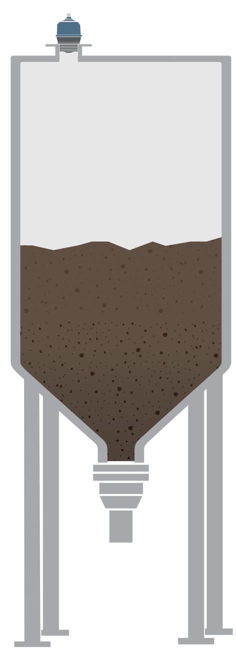
- **Application:** Lime silos are used to store hydrated lime or quicklime, key chemicals in the water and wastewater treatment process. Lime is then dispensed from the silo into the treatment process to adjust pH levels for optimal water quality, or to neutralize acidic wastewater. Lime also aids in softening hard water by removing calcium and magnesium ions, helps in odor control by neutralizing sulfides, and stabilizes sludge treatment through phosphorus removal.
- **Challenges:** Similar to fly ash, lime also generates large amounts of dust, primarily during filling, which may cause issues for optical and ultrasonic level sensors. When humidity is a factor, lime is also one of the worst level applications build-up wise. As a result of this, bridging and rat-holing is common, as well as sensor build up, which may result in false readings.

Containers for Solids

- **Application:** After screening, solid particles that have been caught by the screen are transported by conveyor belts and then to containers where it is stored prior to being transported away for recycling/disposal.
- **Challenges:** Could be just about any material that has made it downstream, making it difficult to predetermine the composition / size of the solid material.



Sludge Storage Tank



- **Application:** Sludge processes are important because they help water treatment plants become self-sufficient by generating their own electricity. Level measurement can help to accurately monitor the entire sludge handling process from wastewater, to sludge, to gas. Sludge can be stored in open vessels, silos or plastic tanks.
- **Challenges:** Sludge can vary greatly in density and viscosity, from more liquid forms to thick sold material. Solid sludge also tends to settle at the bottom, while the liquid portion stays on top, sometimes requiring mixers to keep the sludge homogenized. Sludge also often contains corrosive chemicals and abrasive particles (e.g. sand, grit or metals).

Recommended Technology – Continuous Level

Recommended Solution	Fly Ash Storage Tank	Lime Silo	Containers for Solids	Sludge Storage Tank
Non-Contacting Radar				
26 GHz radar transmitters	●● (green)	●● (green)	●● (green)	●● (green)
80 GHz radar transmitters	●●● (green)	●●● (green)	●●● (green)	●●● (green)
Guided Wave Radar	● (yellow)	● (yellow)	● (red)	● (red)

KEY
●●● Preferred Technology
●● Suitable
● (yellow) Application dependent
● (red) Not recommended

Recommended Technology – Point Level

Recommended Solution	Fly Ash Storage Tank	Lime Silo	Containers for Solids	Sludge Storage Tank
Rotating Paddle	● (green)	● (red)	● (yellow)	● (red)
Vibrating Fork	● (yellow)	● (red)	● (red)	● (red)
Vibrating Rod	● (yellow)	● (red)	● (red)	● (red)
Capacitance Probe	● (green)	● (yellow)	● (yellow)	● (yellow)

KEY
● (green) Suitable
● (yellow) Application dependent
● (red) Not recommended

For additional information, visit: www.Emerson.com/RosemountSolidsLevel

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