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# 2021 GUIDE TO LEVEL MEASUREMENT

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There is a variety of technologies available for continuous level measurement, including capacitance, free space radar, guided wave radar, gamma, pressure and ultrasonic. IPP/T's Level Handbook contains a number of articles that provide expert advice and applications that work best for each of these technologies.

Accuracy is paramount when choosing the right level measuring technology, and there are many factors to consider before purchasing, such as the existence of foam or gas fumes associated with the process, the dielectric or specific gravity of the process, pressure and temperature, and the use of an agitator, or the existence of a turbulent surface.

Point and continuous level measurement sensors play an important role in level measurement, and these technologies will be explained as to how they are applied in a plant environment. An important component of level measurement is the integration of an inventory management system into a plant using wireless communication devices and cloud-based software, making operations more efficient.

**IPP/T's Level Handbook** provides specific applications and product information to executives, engineers and plant personnel who are looking to improve their industrial processing operations.





GUIDE TO **LEVEL MEASUREMENT**

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# LASER LEVEL MEASUREMENT – Review of Applications and Benefits

## Introduction

The laser was invented 60 years ago. It is a unique technology that has been used in a growing number of applications ever since. From laser surgery to industrial processing, lasers are making our lives better and easier. Introduced more than 15 years ago, lasers are also changing the way to perform level measurement. As we will see in this article, lasers present many benefits over other non-contact level measurement technologies in numerous applications.

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LLT100 industrial laser transmitter from ABB Inc.

### Review of applications and benefits of using lasers

In non-contact level measurement, ultrasonic and open-path radar sensors are well known in the industry. However, in recent years, laser level measurement has been gaining popularity in several applications due to its versatility and ease-of-use.

Laser transmitters send short pulses and measure the time of flight of pulses that are reflected from a surface to determine distance. The laser has a very narrow field of view (<0.3°), so it only detects returns from the surface to be measured and is not impacted by surrounding objects.

Rugged laser level transmitters designed to meet all industrial applications are available on the market as illustrated below.

## LASER BENEFITS

| Applications | Industrial Laser | Ultrasonic | Open-path radar |
|---|---|---|---|
| Long range | ✓ | ✗ | ✗ |
| Presence of obstructions, agitators | ✓ | ✗ | ✗ |
| Any type of vessel shape, even conical bottoms | ✓ | ✗ | ✗ |
| Presence of waves and turbulence | ✓ | ✓ | ✓ |
| Any solid material surface angle | ✓ | ✗ | ✗ |
| Presence of gases, foam | ✓ | ✗ | ✓ |
| Low dielectric constant materials | ✓ | ✓ | ✗ |
| Fast changes, abrupt changes <1s | ✓ | ✗ | ✗ |
| Heavy dust & fog | ✗ | ✓ | ✓ |

Laser transmitters provide non-contact level measurement of any material, solid or liquid, independently of their properties or conditions. With their narrow laser beam, lasers can avoid obstructions and can be installed near vessel walls or in tanks with mixing blades, grids, or obstructions. Laser transmitters measure continuously and provide rapid surface change tracking.

In addition, their advanced signal processing delivers reliable measurements in the presence of mixers and in dusty, foggy, and narrow environments. Even clear liquids are measurable and are no longer a limitation for laser level devices.  Lasers are easy to use and configure and are well suited for applications in challenging environments.

### Lasers in the mining industry

Crusher level control is a typical application for lasers in the mining industry. Feed control is crucial as crushers must be fed continuously to prevent serious damages to the equipment and optimize productivity. It is imperative to maintain a 'choke' level and to avoid running the crusher empty. Level measurement prevents overfilling and dropping rocks directly on metal in the surge bin or crusher, both of which will cause damage and loss of up time. The laser beam detects the rocks level accurately, even in the presence of dust.

Crusher level measurement with laser in the mining industry.

This technology is immune from the effect of noise, vibrations, ambient air conditions, and the material angle. Furthermore, since the laser beam is narrow, being only a few centimeters in diameter even at more than 30 m (100 ft), it does not interfere with the vessel side or other obstructions. With thousands of installations around the world, industrial laser products have been providing accurate and reliable control of crusher operation for many years.

### Lasers in the oil & gas industry

API oil-water separators are used to separate oil and suspended solids from refinery wastewater effluents. Oil and water are then stored in tanks, which need monitoring. Industrial lasers are used in API separators

Oil tank level measurement through a long narrow pipe with laser.

to measure water and oil levels in storage tanks. Measurements are independent of the dielectric constant of the material, and the laser is not affected by droplets of water on its window. It provides reliable, simple, non-contact level measurement.

Tanks of all sorts need monitoring and they can contain a wide variety of materials. Laser level measurement provides efficient measurement of any liquid. Should the liquid in the tank change, no recalibration is required with laser, as accuracy will not be affected.

### Lasers in water & wastewater applications

Level measurement with laser in digesters.

Laser transmitters have been used successfully in some of the most demanding applications in the water and wastewater industry such as stilling wells, pumping and lift stations, sump tanks, and digesters.

Measuring dirty water level in a stilling well is a difficult application. Over the course of a few days, the dirty water will coat everything.

This buildup on the tank wall or surfaces creates significant problems for most level technologies. For instance, measurement products in contact with the water will require costly maintenance every week. When using laser measurement, it is possible to measure water level until buildup is so severe that it almost completely blocks the stilling well, which will typically take about six weeks. The use of lasers for level measurement lead to significant maintenance cost reductions.

The lift station is specifically designed for the pumping of waste or sewage material to a higher elevation. Sewage has water intermixed with various solids and often has stringy debris.

Sewage generates poisonous gases, creating a hazardous location. Contrary to other sensors, laser transmitters are positioned above lift station providing increased safety and easy access to the device. Another benefit is that due to their very narrow laser beam, lasers can measure all the way to the bottom of the well even in the presence of internal structures within the well.

In digesters, the organic components of the sludge are decomposed. Combustible gases such as methane are released from the sludge. The laser provides reliable level measurement and is unaffected by density changes, foam, gas concentration and pressure fluctuations. Also, lasers can work reliably even in the presence of agitators which is a key benefit for this application.

## Lasers in the plastics industry

Plastic manufacturers are typically large petrochemical and chemical companies which produce and supply to the rest of the chain raw plastic material, mostly in the form of pellets. Plastic manufacturers and plastic converters will typically store these plastic pellets in storage silos and use level measurement solution for live inventory reporting. Narrow and tall storage silos present a challenge for any beam spread technology.

Top of foam measurement with laser in the brewing industry.

Laser level measurement has been used with great success in this application due to its narrow beam and ability to measure to the complete silo bottom. Another important advantage of using lasers in these applications is that silos or day bins are usually identical as illustrated below. So, contrary to other technologies, laser levels only need to be configured for the first silo. This configuration can then be used for all remaining silos which makes installation and commissioning easier, faster, and less costly.

Laser level measurement of plastic pellets in tall and narrow storage tanks.

## Lasers for foam measurement and control

Foaming can be present in many industrial processes. Foam can be an integral part of the manufacturing process or it can be an undesirable side effect. The production of foam can be the source of costly problems such as environmental pollution, reduced yields, production downtime, and cleaning costs in case of overfills. Excess foam can cause significant damages to equipment such as pumps and filters. So, the use of an accurate and reliable foam measurement technology is needed as it can bring substantial savings to businesses through reduce use of foaming agents, better process control, increased throughput, reduced product losses and fewer equipment failures. Laser is the best technology to measure the top of dense foam and much more reliable than anything else on the market. Ultrasonic or open-path radars will lose signal from time to time, not the laser.

## Conclusion

In conclusion, laser transmitters innovative technology makes possible level measurement in the most demanding applications in all industries. It is a very simple instrument to use, as no echo mapping is required. It is an easy to use, easy to install, and very reliable product that is not affected by local structures or changes in the properties of the material to be measured.

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Easy Setup

# Cloud-Based Inventory Software

## Transforms the Industrial Internet of Things

**BinMaster**

Solutions for Industry

## Learn how the Cloud and IIoT make your plant more efficient

Implement strategies that leverage the power of the latest level sensor technology and simple software to reduce material shortages and production stoppages.

# It's time to change the way you work

Monitoring inventory contained in bins, tanks, and silos can be a time consuming, unsafe, and tedious task. But knowing how much material is in each vessel is critical to operations. Plants processing solids, powders, and liquids stored in bins, tanks, silos, or IBCs are fraught with unwanted inventory discrepancies that create production headaches and negatively impact profitability.

## Don't live this scenario:

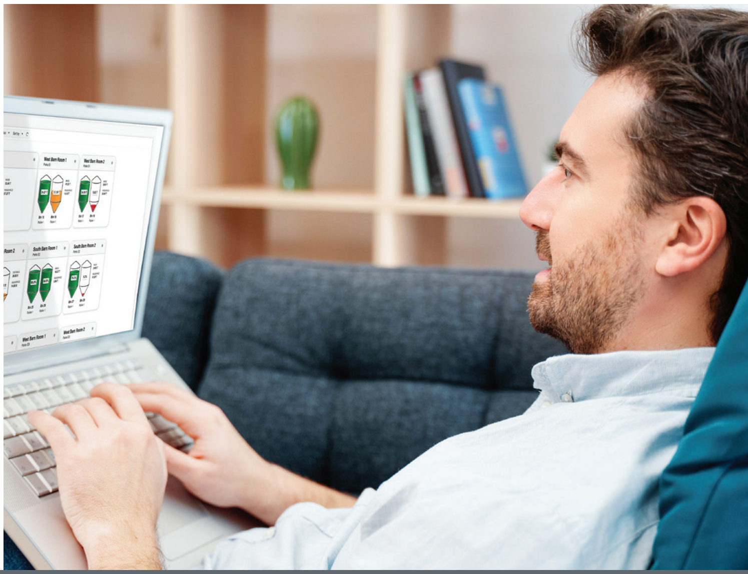
Grab your coat. Go outside. Climb every silo. Write down the measurements. Go back in the office. Open your spreadsheet. Enter today's readings (if you can read them).

Download the spreadsheet and email it to everyone who needs it. Two hours later, inventory is inaccurate. Freak out placing last-minute orders and running out of material.

## Instead imagine this scenario:

Grab your coffee. Sit down at your desk. Log in. View your silo inventory company wide. Address low level alerts. Your coworkers do the same. Rest easy knowing inventory is updating continuously and you're alerted when materials get low.

*Here comes the transformation . . .*



# How Cloud Computing Helps You

Combining cloud-based Software-as-a-Service and advanced level sensor technology makes inventory and supply chain management easier.


**Accessibility:** Information is portable and available anywhere there is internet access from a phone, tablet, or PC.

**Accurate Information:** Total transparency, fewer discrepancies, and more information leads to better decisions. Know what to buy and when to order it.

**Better Control:** Automation brings centralized digital control, minimal human intervention, faster and timelier outputs.

**Cost Containment:** Direct and indirect. Less overtime, automation of daily tasks, fewer inefficiencies, no emergency or late delivery charges.

**Historical Reporting:** Manage and segregate high-turn, long lead time, and materials with strict reporting requirements.

**Improved Monitoring:** Real-time reports of on-hand supply, forecast when you will run out, data is continuously updated effortlessly.

**Job Satisfaction:** Less mundane work, more time for planning and problem solving.

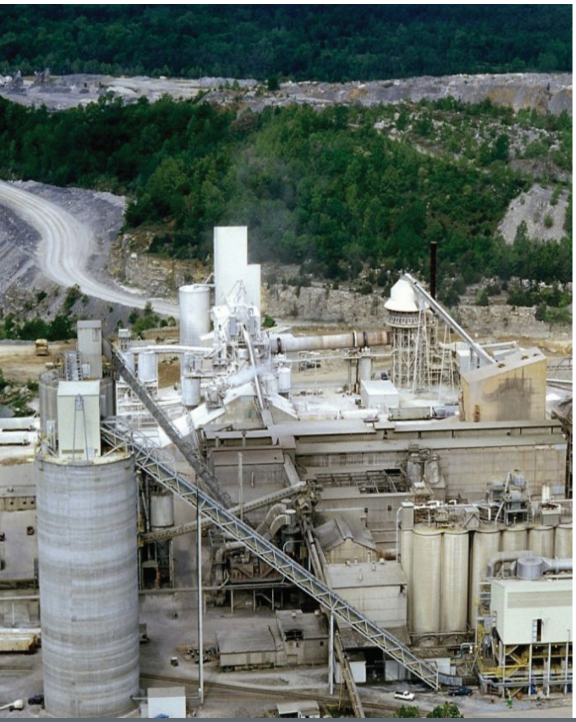
**Optimize Production Processes:** Streamline vital communication between people and devices and get everyone on the same page.

**Process Improvements:** Reduce material outages, production stoppages due to shortages, fewer batch processing errors leads to better quality.

**Security:** Data—both past and present—is stored securely and safely.

**Simplicity:** No servers, no IT department, programming updates done by host provider, no need-to-know programming to use software.

**Time Savings:** Less time on the phone, managing spreadsheets, fewer trips to the control room, less time doing routine or redundant tasks.



# How the Cloud Benefits Industry

***Here are real-life examples of how the Cloud helps plants. Imagine how it can help you.***

**Feed:** By projecting consumption growers can better manage rations, eliminate feed outages, late delivery charges, and ensure there is less feed leftover at closeout to reduce vacuuming and disposal charges.

**Plastics:** Real-time monitoring of resins going into the production process, improved supply chain management using vendor managedinventory with resin suppliers, optimizing scheduling of deliveries.

**Cement:** Centralized monitoring of multiple batch plant locations, improved logistics and scheduling of drivers' routes, ensuring entire truckload with fit into silos, improved coordination with fly ash suppliers.

**Food Processing:** Managing inventory of raw ingredient, WIP, and finished product silos, leveraging buying power by ordering for multiple plants on a single contract, batch processing of foodstuffs.

**Fertilizer:** Tracking inventory of solid, powder, and liquids chemicals, using historical reporting to track inventory turns and carrying costs, preparing for seasonal production and distribution.

**Chemicals:** Tracking inventory of regulated chemicals, ensuring chemicals are used before shelf-life expires to reduce disposal costs, creating an automated audit trail of chemical usage.

**Wood Pulp Paper:** Pellet production facilities, hog fuel storage bins, emptying sawdust bins to prevent production stoppages, ensure pulp, water, and bleach level levels are adequate for paper production, managing mill-to-mill transfers.

**Agriculture:** Optimizing capacity of storage bins, preparing audits and USDA reporting, eliminating spreadsheets at grain elevators, valuing grains, oilseeds, and other commodities for export, railcar logistics.

**Propane:** Historical reporting to project impact of weather on consumption, supply planning for storage facilities, tracking stored propane at multiple depot locations, routing of commercial and residential deliveries.

**Video:** Monitor Inventory in Tanks and Silos with BinCloud

**Cement Case Study:** Concrete Colossus brings in BinMaster Solutions

**Brochure for Plastics:** ResinView™

**Brochure for Cement:** CementView™

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# STATE-OF-THE-ART TANK GAUGING: high accuracy with a big payoff

From a cost-benefit perspective, there has never been a better time for tank farms and other bulk storage operators to upgrade their tank gauging infrastructure. Adopting a holistic strategy combining the latest measurement and communications technologies and analytical components can provide compelling arguments to move off of legacy devices or manual measurement. Today's state-of-the-art servo and radar tank gauging instrumentation generates data in real-time, with unprecedented accuracy – as precise as ±0.4 mm for servo gauge or ±0.5 mm for free-space or stilling well radar. The high quality data derived from that provides great reliability, consistency and visibility in calculating inflows and outflows, estimating inventory in storage and available capacity, on a per-tank and facility-wide basis.

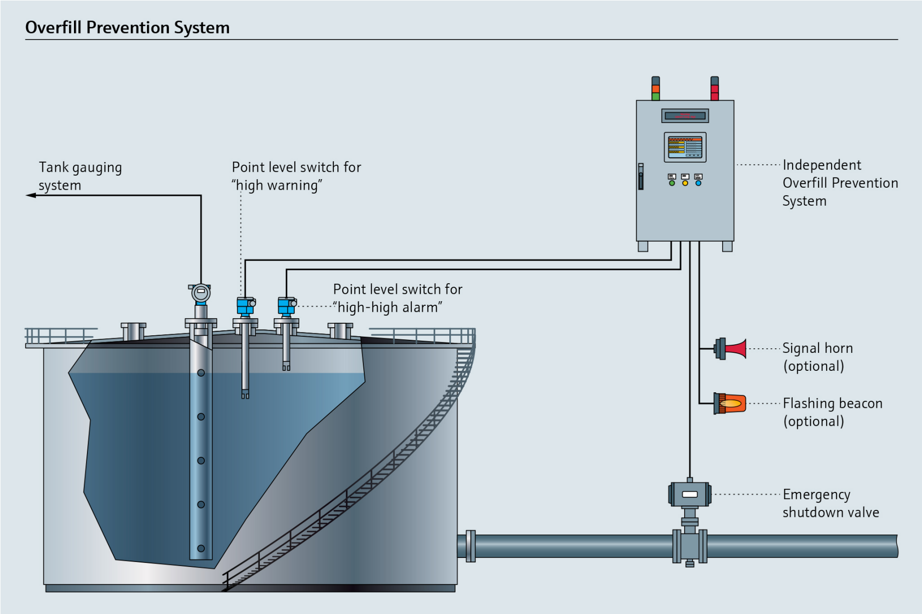
Yesterday's tank gauging methods produce large variances in measurement data and reconciliation of inventories. That, in turn, widens the exposure to business risks like shortfalls of inventory or capacity that affect deliveries to customers, on-time acceptance of new product, uncertainty about custody transfer and revenue accounting, or losses due to as-yet undetected leakage.

These risks tend to be greatest with manual measurement. Critical information such as product temperature, density or water bottoms in fuel storage tanks can't be adequately measured or anticipated. Manual measurement is labour intensive and must be performed in all types of weather. It also relies on manual reconciliation of inflows and outflow data, generally resulting in wide variances in inventory and capacity tracking.

As for legacy tank gauging devices, a facility full of complex variants from different vendors is a step up from manual tank gauging depending on how the data is reconciled, but still provides limited visibility about inventories when compared with today's state-of-the-art systems.

The optimal configuration forupgrading to best-of-breed is based on single-vendor uniformity and simplicity across all field instrumentation. In supporting such a project, Endress+Hauser specialists would suggest how best to combine high measurement accuracy with a site-optimized communications strategy for real time wired or wireless data transfer, monitoring and analysis. The extremely high accuracy provided by the latest technology assures improved inventory and capacity control, and greatly increases the potential for early recognition of anomalies pointing to leakage. The highest environmental and safety considerations can be incorporated into the plan, like an overfill protection system to prevent spills of volatile or toxic substances. This holistic approach is conceptually the best from a risk management standpoint. It minimizes business risk; the efficiency and reliability improvements feed through to the bottom line. The uniformity and simplicity in field instrumentation make the system easier and more cost-effective to manage and maintain. Reducing on-site safety and environmental risks demonstrates a tangible commitment to the operator's Corporate Social Responsibility (CSR) program. Other soft benefits include reinforcing relationships with suppliers, customers, investors, employees and local communities.

Such a comprehensive solution can be developed for a wide range of storage situations – liquid, gaseous and solids like slurries and bituminous substances.




Using a single solutions provider such as Endress+Hauser adds value during the planning stage. One size – or one type of measurement technology – doesn't necessarily fit all situations. Factors such as tank geometry and contents and the site size and layout are taken into consideration. For measuring storage of a high value product, premium, high accuracy radar measurement would likely be recommended; the larger such a tank, the greater the need to limit financial exposure. For lesser products, standard accuracy radar might suffice.

Endress+Hauser's new platform of high-performance tank gauging instruments supports both radar and servo technologies, each with a range of sensing elements and process connections to ensure accurate and reliable measurement in almost any process and environmental condition. State-of-the-art level and temperature measurement technologies with industry-proven communication protocols allow accurate measurements and data collection. Endress+Hauser's tank gauging instruments, Micropilot, Proservo and Prothermo meet the NMi and PTB requirements and also have local approvals according to OIML R85. The uncompromising usage of web server technology allows easiest access to tank data and comprehensive data presentation to anyone in need.

It's the world's first platform of both typical tank gauging measuring principles designed according to IEC 61508 and certified SIL2/SIL3 capable. The platform also includes unique Endress+Hauser management and analysis features for highest reliability as well as fast, easy commissioning, maintenance and diagnostics. Endress+Hauser can propose process instrumentation and software packages for pressure, flow and temperature devices, loading metering skids as well as data interfaces and its inventory management software solutions: Tankvision®, Terminalvision® and SupplyCare®.

Upgrading of sites with an existing tank gauging architecture accumulated over the years may not be financially feasible. In that case, a gradual upgrading strategy can be applied. Operators can migrate their existing instruments and advance their tank farm to state of the art step by step. Endress+Hauser will help managers determine how migration can be managed without losing the existing installed base but allow progression into an easier maintainable and flexible site architecture.

**For more information, CLICK HERE**

**To watch our Tank Gauging video, CLICK HERE**


**Improve your processes with our comprehensive portfolio of measuring instruments:**

Levelflex FMP51:
Guided radar device with bypass solution saves costs and is unaffected by the density of the medium.

Deltabar PMD75B:
Differential pressure transmitter for the highest demands on functional safety and measuring accuracy.

Promass Q:
Best in class flow measurement in custody transfer applications in mass or volume including cryogenic liquids

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# Level Measurement with Time Domain Reflectometry Guided Radar Offers Significant Advantages

## Avoids disturbances due to tank shape and noise issues in steamy applications

By Gilles Knobloch, KROHNE Inc.

Level measurement of tanks and silos is a critical part of manufacturing and processing industries. Of the many available level measurement technologies, time domain reflectometry (TDR) guided radar stands out for its accuracy, reliability, and safety.

Now, new technology is available with a powerful 2 gigahertz (GHz) signal, the strongest signal for low dielectric applications, and a variety of probe options to meet application and process-specific needs. The devices come in compact and remote versions and are equipped with new features that promise even more accurate level measurement.

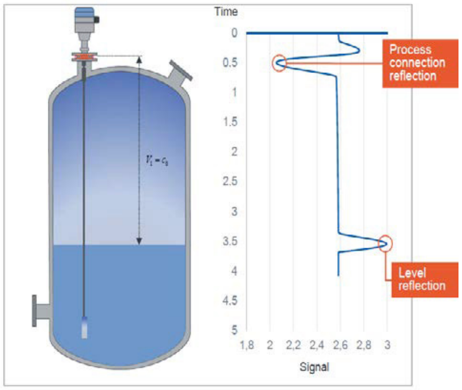
### Ensuring level measurement accuracy and reliability

Continuous measurement of level, distance, volume, mass or liquid-liquid interface is critical for processing industries. For maximum accuracy and reliability, operators should take several different measurements on each tank – one continuous level measurement; four switch points (low, very low, high, very high); and one local measurement of the level.

A variety of level measurement technologies are available, including TDR guided radar, frequency-modulated continuous wave (FMCW) radar, ultrasonic, displacer, potentiometric, and hydrostatic pressure.

Selecting the right instrument is based on the dielectric constant of the headspace (Ɛr) and reflectivity of the medium in the tank TDR guided radar is considered the best option for high pressure/high temperature applications; very low dielectric media; heavy steam applications; and for measurement of the interface between two liquids. The (Ɛr) influences the reflectivity of the electromagnetic pulse. The (Ɛr) is frequency independent. Installation details are also critical elements in selecting the right instrument. The tank/silo design, nozzle dimensions, and process connection information (size, pressure, and temperature) are the key items to be considered.

With TDR, electromagnetic pulses are emitted at the speed of light and guided along a probe. Each pulse is reflected with an intensity that depends on the dielectric constant of the product. The distance is calculated by measuring the transit time of the pulse and this distance is then converted into the tank's level. The TDR measurement principle was originally developed in the 1990s for use in cable testing. Companies used the method to troubleshoot signal break issues with underground telephone, telecommunications, and electricity cables. When a cable was broken, the electromagnetic technique was used to determine the breaking point. The difference




The TDR image principle.

in the time between emission and reception was shorter at the break, enabling engineers to quickly find the location of the broken cable. By using a formula, engineers could pinpoint the location of the break to a very specific distance from where they generated the signal.

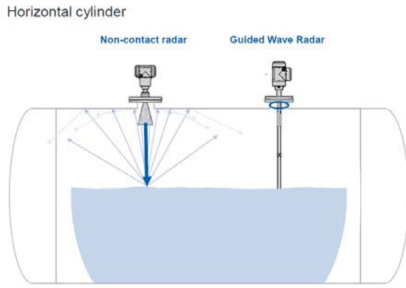
KROHNE was a pioneer in adapting this TDR measurement principal for use in level measurement of tanks. Their engineers reasoned that if distance could be measured by using a cable, why not place the cable directly into a tank to determine its level? The company produced the market's first guided wave radar transmitter level measurement device in 1996 and has since expanded the technology for use in measuring solids or liquid levels in tanks.

## Advantages of TDR level instruments over other non-contact radar options

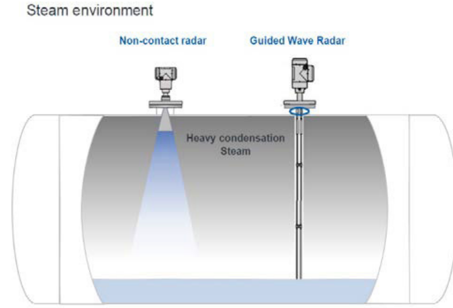
TDR level instruments have several advantages over other non-contact radar options, especially for tanks with a horizontal cylinder shape, and in environments with heavy steam or condensation.

When using a non-contact radar, a horizontal cylinder can create a signal disturbance because it multiplies reflections. When the liquid level is at low or very high levels, a non-contact radar signal can be affected by multiple reflections. Using guided radar avoids this issue, because the signal always stays along the line of the probe.

In applications with high levels of steam or condensation, non-contact radars using horn antenna can result in signal noise issues, with the signal trans-mitting slower and slower. By contrast, TDR guided wave radar is less disturbed by steam; the signal stays strong from the process connection all the way to the probe end. This option provides the full energy of the signal from top to bottom of the tank.




TDR guided wave radar has advantages over non-contact radar for horizontal cylindrical tanks.




TDR guided wave radar is preferable to non-contact radar for steamy environments.

## Selecting the right TDR instrument

KROHNE offers a variety of TDR instruments in its OPTIFLEX product portfolio for level and interface measurements (those that measure levels of interface between two liquids in the tank). Different models have been developed for applications processing liquids with hygienic requirements; solids – from granulates to powders; liquids in storage and process applications; and liquids at high temperature and pressure.

The figure above shows the available models, which have been recently updated. The new models include a powerful 2 GHz signal for a more accurate level measurement and smaller dead zones. They offer the strongest signal for low dielectric applications. Loop powered compact (C) or remote (R) versions are available for all models. Each model offers level or interface measurement without additional charge (except the OPTIFLEX 1100).

Ceramic process sealing (single or dual for more safety features) is offered. A new multi-variable switch output has been incorporated in the housing, which reduces wiring costs by providing information on level, interface, dielectric, volume, diagnostics status, and SIL 2/3. Finally, the devices include a new interface reverse measurement for measuring the interface in a vessel containing two liquids. In most measurements, the low dielectric is the upper liquid, and the high dielectric is the lower liquid. With the new reversed probe, users can measure the interface when the upper liquid is the high dielectric and the lower liquid is the low dielectric.

The instruments are available with three different probe types. The most commonly used is a single probe (rod or cable). Twin probes are also available (rods or cables), to reduce the signal diameter to minimize disturbances in a tank and to get a better reflected signal for low dielectric media. The third option is a coaxial probe, in which a rod is protected by a tube to ensure that the entire pulse signal stays within the tube. With a coaxial tube, obstacles located inside the tank such as a ladder, level switch, or heating coils, will not disturb the measurement.


OPTIFLEX TDR guided wave radar models updated for even more accurate level measurement and smaller dead zones.

## Application examples

As noted, selecting the right instrument must consider the dielectric constant and reflectivity of the medium in the tank as well as the tank tank/silo design, nozzle dimensions, and process connection information.

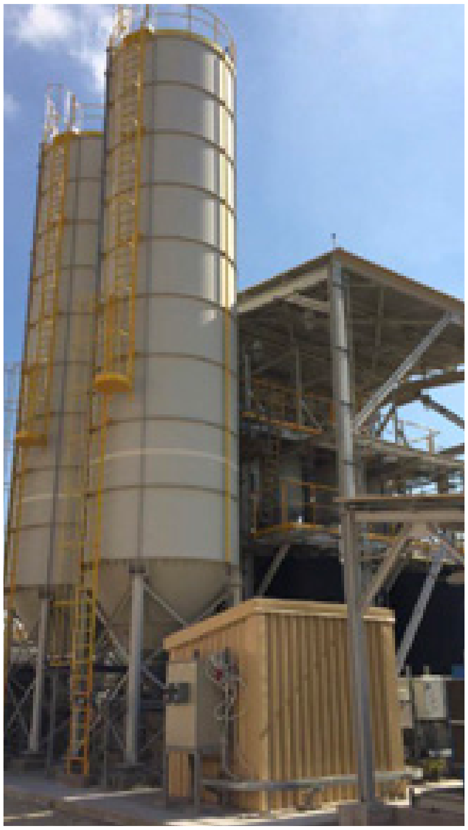
For example, for level measurement at a water purification system (skid), the OPTIFLEX 1100 C was used with Ø2 millimeter (mm); 0.08-inch single cable probes.

For level measurement of pharmaceuticals mixed with pure water stored in vertical cylinder tanks with 4-foot agitators, the operators selected an OPTIFLEX 3200 C with stainless steel housing, and a 0.32-inch single rod probe.

The OPTIFLEX 6200 C was selected for level measurement of hydrated lime (powder) at a desalinization plant using vertical cylinder silos.

OPTIFLEX 1100 C used at a water purification system skid.

OPTIFLEX 3200 C used at a pharmaceuticals plant.



OPTIFLEX 6200 C used for level measurement of hydrated lime powder in vertical cylinder silos.

At a waste treatment plant with a 6-foot (1900 mm) vacuum tank holding cleaning water containing small amounts of acids and suspended particles, operators opted for an OPTIFLEX 7200 installed on stilling wells inside the chambers.

For level measurement of sugar condensate at a sugar refinery, an OPTIFLEX 7200 F (remote) with 4-foot (1.2 m) probe was selected.

OPTIFLEX 7200F used for measuring sugar condensate.

OPTIFLEX 7200 used for measuring cleaning water at a waste treatment plant.

OPTIFLEX 8200C used for level measurement of softened water in industrial boilers.

A final example is level measurement of softened water (alkaline) in industrial boilers (LP), where the OPTIFLEX 8200 C with single ceramic process seal system and coaxial probe was selected for the 5-foot (1.5 m) horizontal cylinder tank.

### Signal strength and options for wide range of applications

For continuous measurement of level, distance, volume, mass or liquid-liquid interface, new OPTIFLEX TDR technology offers the signal strength and probe options to meet a wide range of application and process-specific needs.

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For more information about these or any other level applications please reach out to KROHNE by phone at **1-800-356 9464** or email at **info@krohne.com.**

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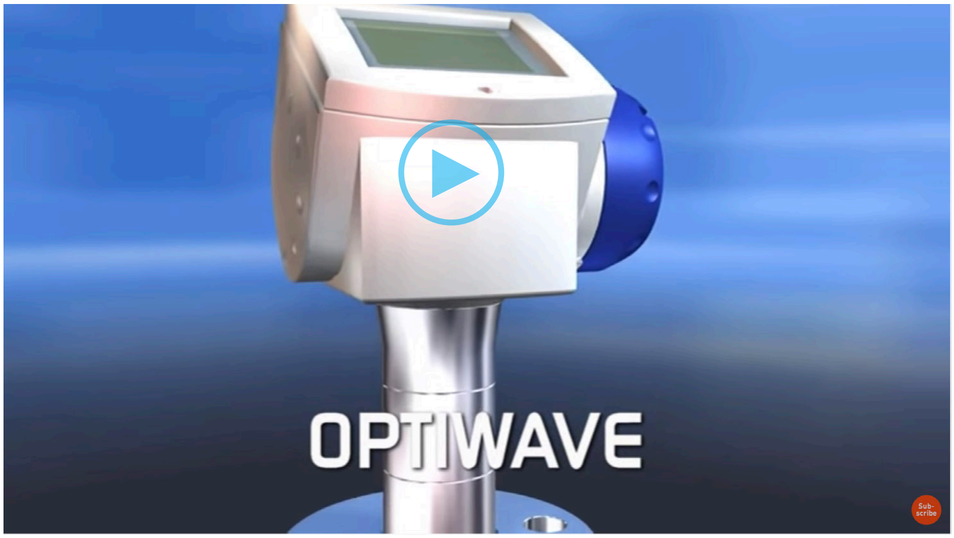
http://ca.krohne.com

## ALSO, LOOK AT THESE VIDEOS FOR MORE:

### OPTIFLEX 2200 from KROHNE – The modular TDR level measurement solution


### OPTIWAVE and OPTIFLEX from KROHNE – Microwave Level Measurement



SIEMENS FRANKLIN EMPIRE

# Cement.

## Answers for industry.

### Radar technology easily solves the level measurement challenges in the cement industry

**Franklin Empire** is the exclusive Siemens distributor for most of Ontario and Quebec. Their team provides more than 75 years of industrial instrumentation experience and field application knowledge of the equipment available from premier manufacturers. Franklin Empire provides comprehensive services including start-up and commissioning, field support, yearly service and maintenance, and annual calibrations on any industrial instrumentation application. Solutions are used in numerous industries including cement, steel, mining, aggregates, pharmaceutical, food & beverage, power & energy, water/wastewater, district metering, pulp & paper, chemical, petrochemical, and automotive.

The full range of process instrumentation Franklin Empire offers covers everything you need from level, flow, pressure, temperature, mass dynamics, and pneumatics to communication and display.

Given Franklin Empire's expertise and local presence, St. Marys Cement Group contacted them to provide a solution to measuring long distances in very dusty cement silos.

St Marys Cement is part of the North American operations of international building materials supplier, Votorantim Cimentos, based in Sao Paulo, Brazil. Votorantim Cimentos operates 31 cement plants in 10 countries around the world. Its St Marys Bowmanville plant near Toronto, Canada, produces approximately 1.8 million tons of clinker and 1.2 million tons of Portland cement annually. In operation since the late 1960's, it is currently one of the most modern facilities in North America.

The plant has used many technologies for level measurement in the past 40 years with marginal success. The environment for level measurement in a cement production facility is brutal:

> it includes extreme levels of dust, high temperatures, and mechanical wear and tear. Since most of the level measurement sensors are located at the top of the silos – and some of these silos are approaching eighty meters in height – access to the sensors is diffi cult, especially if an elevator is not available.

In the past, maintenance of level measurement transmitters has been costly, and consisted of either cleaning or replacing sensors on a shutdown schedule or during an unplanned maintenance event.

## Challenge

Siemens has been involved with the cement industry for over 100 years, providing all types of process instrumentation, and is well aware of the level measurement challenges of the cement processing plant. Due to high abrasion and high bulk density of the solids materials found in the cement plant, contacting type transmitters prove to have a number of disadvantages: excessive wear and maintenance, and cables can break and fall into the process. A cable falling into the vessel will cause damage to the feeding device under the silo, resulting in expensive repairs and a potential costly production stop. Extremely dusty filling cycles have been a challenge for ultrasonic level measurement, with signal loss due to severe attenuation. Additionally, high temperatures of material such as clinker in the silos limit the choice of sensors considerably.

Siemens introduced 25 GHz radar technology for solids in early 2000. A non-contacting technology, radar uses electromagnetic waves traveling at the speed of light to determine the distance to the target. Radar is virtually unaffected by intense dust and extreme temperatures, and is therefore most suitable for the cement industry. Once considered expensive and difficult to set up, radar today offers cost-effective, 2-wire loop powered technology that is simple to commission and can be used throughout the entire process. From raw material storage, homogenization, clinker cooling bed level, to finished cement,
25 GHz radar has become the standard level measurement technology for the majority of cement producers worldwide.

Over the next few years it is expected that the new higher frequency 78 GHz radar will replace the 25 GHz technology, as it offers a smaller antenna and a narrower beam, yielding decreased installation and commissioning costs, and even better performance.

## Homogenization silo

The homogenization silo has been the most challenging of all level measurement applications in the plant. In the spring of 2000 Siemens tested the very first SITRANS LR in North America on this silo. This
80 meter high silo – referred to as 'CF' silo for continuous flow – is continuously filled with multiple air slides, making it extremely dusty:

St Marys Bowmanville is one of the most modern cement producing facilities in North America. SITRANS LR560 is designed for high temperatures and extreme dust levels, and easily measures the 80-meter-high CF silo. It provides the operators with real time trend data.

a light source lowered from the top is invisible beyond five meters.

The CF silo feeds production directly. Monitoring the level is critical because the CF silo is used to mix the raw material into a homogenous state, and requires a minimum level to maintain uniform quality. The silo is constantly aerated to mix the material, producing a fluidized surface. The silo is constantly filled and emptied at the same time which makes reliable level measurement even more critical. Production not only uses the level readings to control the level in the silo and to optimize quality, but also to plan production quantities, and to schedule shutdown periods.

Although it is a critical process, obtaining reliable continuous measurement was impossible in the past. The company has tried both a plumb-bob system and ultra-sonic systems without success. Turbulence inside the vessel caused the weight from the end of the plumb-bob cable to break off, and even the most powerful ultrasonic sensors could only measure distances of ten meters. Siemens radar technology has proven to be the perfect solution for this most difficult application.

Currently, a 2-wire SITRANS LR560 FMCW (Frequency Modulated Continuous Wave) radar transmitter is providing continuous reliable trend data of the material in the silo.

SITRANS LR560 is the first radar level transmitter operating at 78 GHz frequency: higher than other radar transmitters. Using the 78 GHz frequency electromagnetic waves (microwaves), SITRANS LR560 has a measurement range of 100 meters (328 ft), and is unaffected by the extreme dust in the silo. Reliable level measurement trends optimize production efficiency, and even yield an increase in product quality as the level in this silo can be maintained more accurately.

### Raw material additive silos

Raw meal used in the production of Portland cement primarily consists of the raw materials limestone, ash, sand and iron. All of these raw materials are effectively measured with radar. The sand additive silo is currently monitored reliably with a SITRANS LR560 level transmitter. The angle of repose of sand in a silo poses a challenge even for 25 GHz radar transmitters, as it tends to disperse the reflected signals away from the transmitter. This is another application where the 78 GHz of SITRANS LR560 demonstrates its advantages. The location of the sensor was tricky, as there is a structural member close to the sensor. However the narrow beam of the SITRANS LR560 did not even 'see' this steel obstruction, and no fi netuning was required.

The SITRANS LR560 transmitter, with a small diameter lens antenna emitting a narrow four degree beam avoids silo wall obstructions and other installation interferences, can be installed practically anywhere on the top of the silo. Operating at 78 GHz frequency, it emits a short wavelength to provide exceptional signal reflection even from solids with a steep angle of repose, like sand.

### Clinker silo level

Clinker at St Marys Cement is either stored on-site in two 229 feet (70 meter) coarse silos or conveyed to the two dock silos ready for loading onto ships. The clinker is still very hot and extremely dusty as it is loaded into the silos. The high temperature and extreme dust were a challenge for the ultrasonic technology that was previously used. St Marys presently has four SITRANS LR radar transmitters monitoring clinker silo levels reliably. Over-filling the clinker silo is a safety concern, and the radar transmitters ensure this will never occur.

### Clinker cooler bed level control

The clinker exits the kiln at temperatures of over 1800 ºF (1000 ºC) and must be cooled before moving on conventional rubber belts to the clinker silos. The clinker is pushed with a metallic grate and air is directed from below to cool the clinker. The depth of clinker on the cooler grate affects not only the production rate of the facility, but also the quality and consistency of the final product. Traditionally, the bed depth of clinker on the cooler is 'inferred' by measuring a secondary effect. The two most common secondary measurements are:

- The hydraulic pressure on the grate drive: the higher the pressure, the more material the grate is moving.
- The cooling air pressure: the higher the back pressure, the more material is present.

The problem with using secondary measurements for clinker bed depth control is that the response rate is slow, as there is an inherent time lag between the inferred measurement and the control device. Accuracy is also compromised, as the measured secondary effect is rarely linear or even repeatable. Direct measurement of

the clinker depth has traditionally been fraught with problems, especially due to the extreme high temperature of the product and the ambient environment directly in front of the kiln.

To gain better control and lower their operating cost, St. Marys uses radar technology to measure the clinker level directly on the clinker bed. Directly measuring the level of the clinker means that measurements are immediate, and there is no lag time. Also, it is more accurate as measurements are not inferred from a secondary source. Lastly, since there is only one instrument that is measuring the level, it costs less than using a secondary measurement device. The extreme temperature inside the kiln is reduced to nominal levels at the radar transmitter by using a one meter long pipe extension. The very narrow beam of the 78 GHz SITRANS LR560 can operate effectively in this extension pipe.

## Benefits

SITRANS LR560 proves its value through-out the production process at St. Marys Cement in Bowmanville. With its unique 78 GHz frequency and narrow, four degree beam, SITRANS LR560 measures level reliably in applications with extreme dust and high temperatures, and over the long ranges customary in the cement industry.
Reliably monitoring inventory levels means production can be planned efficiently, and raw materials levels can be maintained.

Reliable process control of the level applications like the CF silo, allows for increased product quality. Maintaining reliable clinker bed level yields lower operating costs, and increased safety. Maintenance costs have been significantly reduced, and in some cases eliminated, and unlike contacting cable technology there is zero risk of any cable breaking off and falling into the process.

SITRANS LR560 is easy to install and commission. The graphical Quick Start Wizard guides the user to get Sitrans LR560 operational in minutes for accurate and reliable level measurement readings without any additional fine-tuning. In addition, reliability and minimal need of maintenance have significantly reduced safety hazards to employees as daily trips to the top of the silos have been eliminated.

"Siemens latest radar unit, the SITRANS LR560, has proven very reliable and robust in some of our toughest silo measurement applications. The 2-wire unit reduces installation costs with its smaller, lighter design, while providing valuable real-time silo measurements critical to our production needs. As such we have spec'd this unit for upcoming projects where silo measurement is required." states Kevin Hodgins, Electrical Supervisor, St Marys Cement, Bowmanville Plant.

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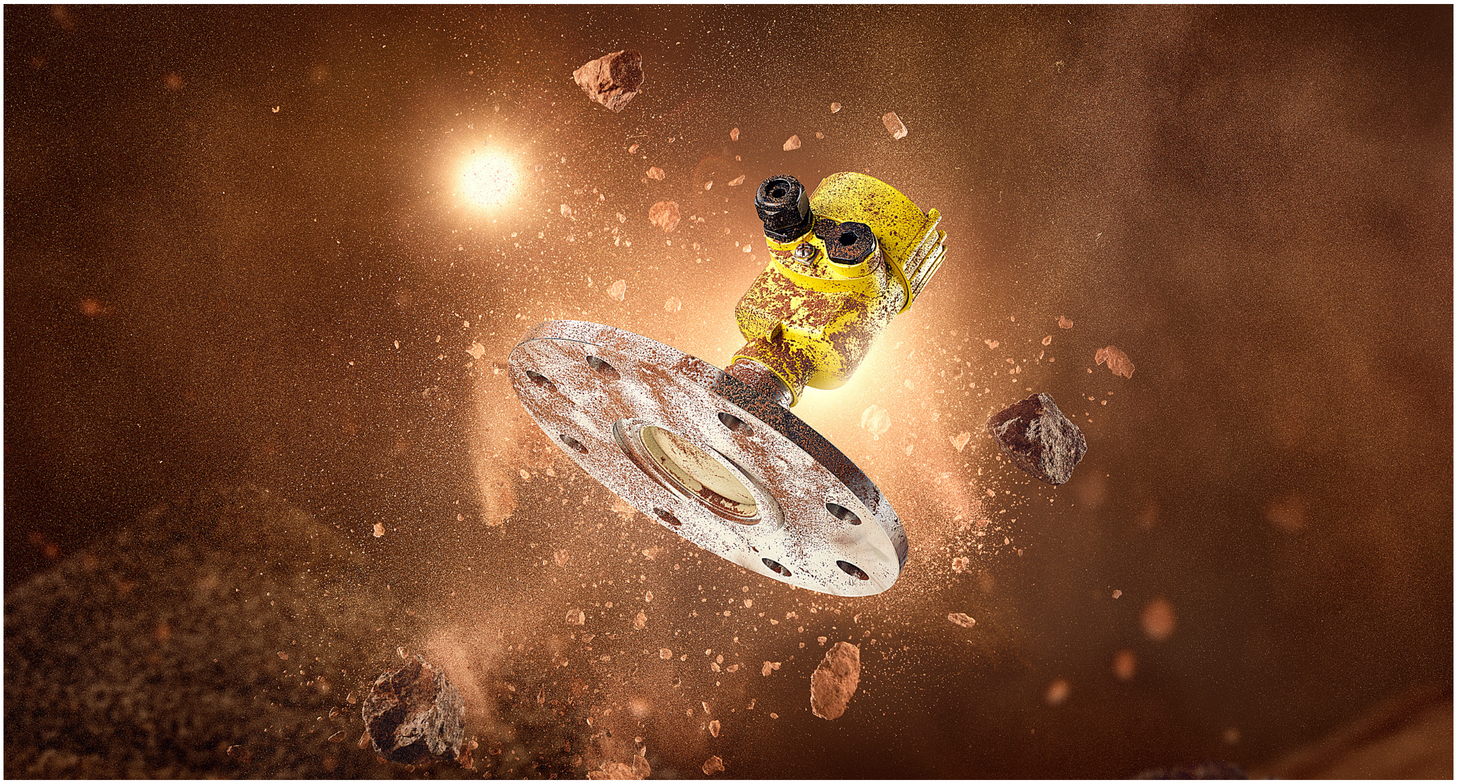


# 3 Things to Consider When Choosing a Level Measurement for Bulk Solids

There are certain foundational things all operators need to know about their process instrumentation. Degree of accuracy, installation ease, and maintenance frequency are just three must-have pieces of info users should consider when seeking a level technology. Once the broad, basic needs are met, users can start considering the specific needs of their application.

This paper will review three of the most common considerations users make when choosing a level measurement technology for a bulk solids application. It's important to note that this paper will not cover every consideration that operators and engineers use to make decisions. Instrument cost, for example, is an important factor that deserves serious deliberation; however, we will focus on the compatibility of common characteristics and level measurement technology. In the interest of space, some basic operational knowledge is assumed.

## Product properties

When one is choosing a bulk solid level measurement, it's wise to begin with the product one is trying to measure. Some solids, like coal and sand, are highly reflective and easily measured by radar sensors. Conversely, poorly-reflective products—polystyrene pellets, for example—may require a guided wave sensor or a through-air radar with high dynamic range.

Particle size is also a consideration in bulk solids level measurement. The absorption properties of a material are related to particle size, and can go a long way in determining available measurement technologies. Historically, radar sensors have had trouble detecting small particles, but new, high-frequency sensors measure them reliably. Radiation-based systems and yo-yo instruments also perform well in applications with small particles.

Abrasive solids are a nightmare for mechanical devices and other level instruments that operate by contact as they can damage the intrusive parts of the device.

Buildup is also no picnic for yo-yos and other technologies with moving parts, as it typically creates costly and time-consuming maintenance programs. On the other hand, radar and other non-contact technologies are unaffected by abrasive solids, and those with the latest STC functions and high dynamic range can filter out signals caused by buildup as well. This is particularly advantageous for users who want to continue level measurement during dusty filling cycles.

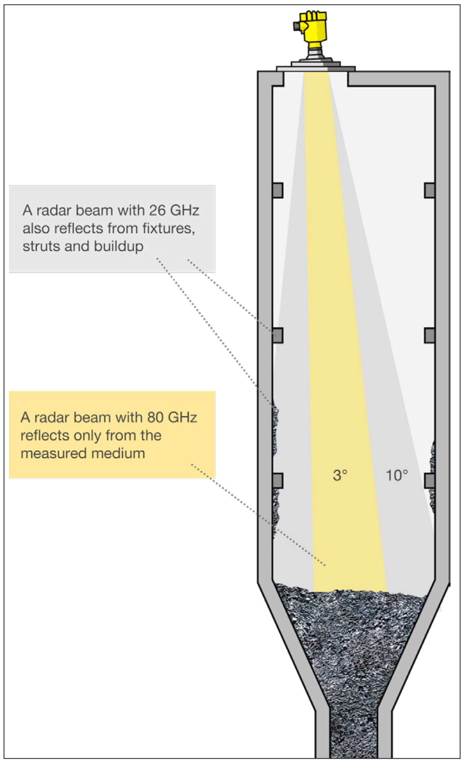
The near photo shows the antenna of a VEGAPULS 69 sensor used to measure hydrated lime. Even through that mess, the product gives an accurate, reliable level reading.

## Process conditions

The phrase "process conditions" can mean just about anything. It might refer to ambient temperature, process temperature, pressure inside or outside of a vessel; just about any reality of a process can fall under the catch-all label of process conditions.

Different process conditions can eliminate level technologies from consideration. Non-contact radar, guided wave sensors, and yo-yo instruments for example, perform better in extreme temperatures than ultrasonic devices. Radiation-based level technology is immune to process pressure limitations, while yo-yo systems only perform reliably in low-pressure applications.

Some level technologies perform better in challenging conditions than others. Before making a purchase decision, users should educate themselves on how their current level instruments historically hold up in process conditions like theirs. What they'll likely find is instead of choosing between a dozen or so level measurement options, they will only have to choose between two or three.




Radar sensors using a higher 80 GHz frequency have better focus, which helps to provide a more accurate level measurement.

## Vessel construction

The shape and construction of a vessel in a bulk solids application is easy to overlook, but incredibly important. Internal fixtures and struts are a challenge for some level instruments because they can create false readings and, by extension, a much more demanding experience for the user. Even within categories of level technology, performance with obstructions is a problem. Take radar sensors, for example: Some instruments emit a wide beam angle that contacts internals. Conversely, modern, high-frequency sensors miss them by releasing a more focused beam. Struts and other vessel obstructions are of little concern with guided wave radar, radiation-based systems, or yo-yo instruments.

The location of process connections is also a crucial consideration when choosing a level instrument, as modifying a vessel so it's compatible with an instrument can come at a great expense. There's an optimal vessel placement for every level technology. Through-air radar, ultrasonic sensors, and yo-yo systems work only from the top-down. On the other hand, mechanical paddles and vibrating switches that are common in point level applications are often installed on a vessel's side. Mounting location is also very important to radiation-based systems.

## Conclusion

All level technologies have their strengths and weaknesses, and different conditions may narrow the field of compatible process instruments. It's in the best interests of operators and engineers to consider product properties, process conditions, and vessel construction when assessing level measurement options. They may find that there is a better technology available for their bulk solids process.

▶ The radar sensor for bulk solids

▶ Better level measurement technology prevents quarry process stops and starts

▶ VEGAPULS 69 radar sensor measures the level reliably in small dosing vessels

▶ The influence of build up on the VEGAPULS 69