

CHEMICAL PROCESSING

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Know When to Use Guided Wave Radar

This level measurement technology suits a wide variety of applications

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LEVEL IS among the most frequently measured process variables. The actual level readings are used for local indication, process automation and visualization in control systems. Additionally, level measurements are crucial for managing inventory and enforcing safety limits for overflow, leak detection or dry-run protection of pumps. Other applications include automated ordering systems and communicating low limits to suppliers to streamline the logistic process.

Guided wave radar (GWR) based on time-domain reflectometry technology is one of the fastest growing methods for level measurement at chemical plants. Its popularity has risen sharply over the last twenty or so years. GWR now is handling applications that previously have used technologies such as capacitance, hydrostatics or ultrasonics. In this article, we will look at why the acceptance of the technology is increasing, as well as the applications that can benefit most from this approach to level measurement.

Changes in temperature, pressure, density, dielectric constant or the measured material are just a few parameters that affect the choice of level measurement technology. Agitation, foaming, corrosive properties, dust and construction of the tank also influence the choice. Another factor can be the desire to use a single type of instrument for all level measurements. Finally, the selection also depends upon unit price, lifecycle cost, ease of mounting, maintenance, accuracy, relevant certifications, and the ease of integrating the device into the control system.

KEY DRIVERS

The growing cost of labor and the increasing demand for uninterrupted production are spurring interest in electronic measurement technologies. Their design, which involves no moving parts and features built-in diagnostics, results in reduced maintenance costs and higher reliability. Electronic measurement technologies also

provide significantly lower lifecycle costs than traditional mechanical and electromechanical level instruments.

Besides GWR, electronic level measurement technologies include bubbler, hydrostatic and differential-pressure instruments. Products based upon these other technologies avoid some of the maintenance issues associated with mechanical technologies. However, they share a common disadvantage: sensitivity to changes in the density of the measured product. Capacitance level measurement, in some applications, may become sensitive to changes in dielectric constant of the measured product.

Ultrasonic level measurement is an excellent way to measure level — provided the path of the ultrasonic signal is clear of obstacles and foams, dust or heavy vapors, and the application falls within its limited operating pressure and temperature ranges.

These limitations demonstrate the need for a reliable and maintenance-free level measurement technology that can cope with a wide range of pressures and temperatures while being insensitive to changes in density or dielectric constant. It would be ideal if the measurement device had maximum immunity to heavy vapors, dust or foaming, and the turbulent surface of the measured product. Non-contact radar (NCR) and GWR technologies have the potential to meet these challenges. Moreover, the recent drop in prices of radar devices makes them competitive with the more economical ultrasonic level instruments. Their benefits in performance and application range justify their higher price.

INSTRUMENT OPERATION

Both NCR and GWR sensors are mounted at the top of a tank facing down. They send electromagnetic pulses toward the measured product and use the reflected signal to calculate the level in the tank. NCR relies on a sophisticated antenna to send the measured signal and retrieve it after reflection. With GWR, the measured signal travels along a waveguide that can be made of a stiff

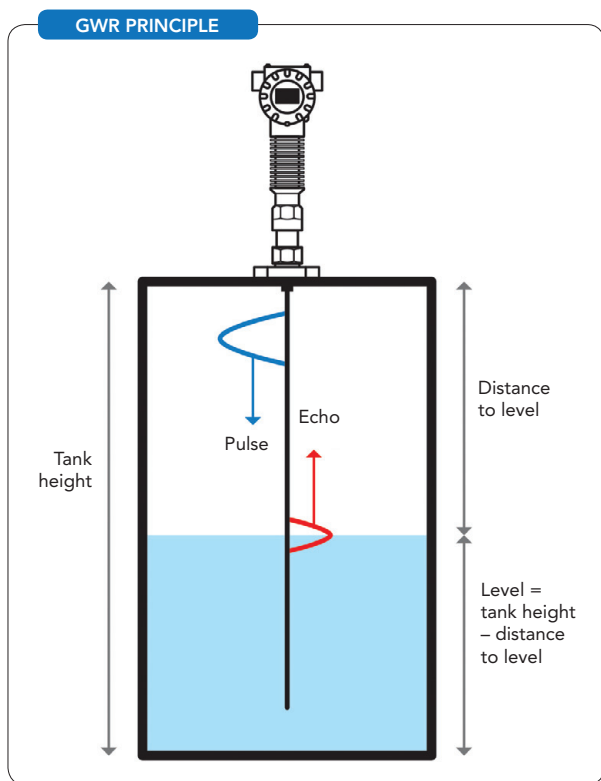


Figure 1. Unit sends electromagnetic pulse along waveguide and measures echo (reflected signal) from material surface.

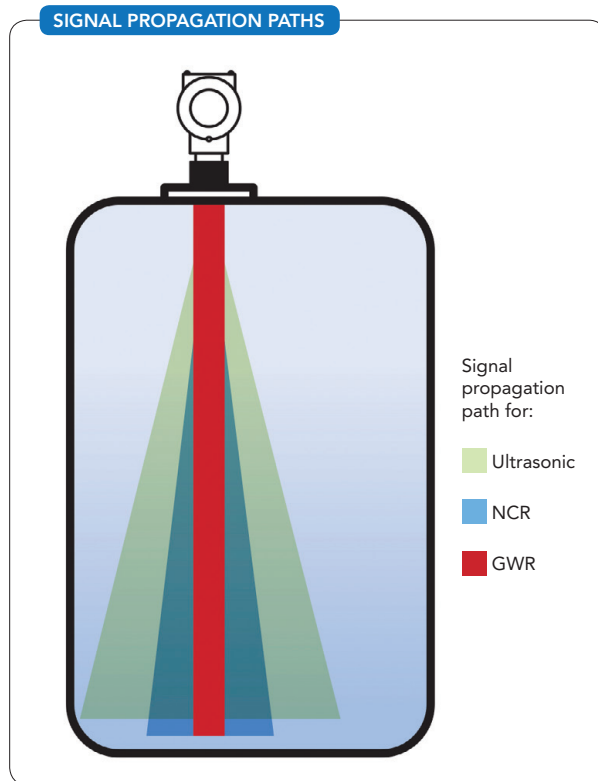


Figure 2. Different instrument types produce different paths: ultrasonic (green cone), NCR (blue cone) and GWR (red cylinder).

metallic rod, flexible wire or a coaxial construction. Figure 1 illustrates the electromagnetic pulse sent by the GWR along the waveguide and the echo (reflected signal). Both technologies are available with certification for hazardous areas and with safety-integrity-level ratings.

As with any measurement technology, the waveguide approach offers both advantages and disadvantages.

Advantages. The measuring signal and reflection are concentrated around the waveguide or inside the waveguide (in the coaxial option). This narrow path of signal propagation minimizes the potential impact of stray signals caused by construction elements or obstacles in the tank. The concentration of the signal along the waveguide also results in a cleaner, stronger signal of the echo reflection.

Figure 2 compares signal propagation paths for ultrasonic (green cone), NCR (blue cone) and GWR (red cylinder) instruments. This illustration provides a general overview; the propagation angles for ultrasonic and NCR instruments depend on the type of transceiver (for ultrasonic devices) or antenna and frequency (for NCR ones). Every vendor publishes detailed specifications on wave propagation angles.

Lacking an antenna, the GWR's waveguide can be installed easily through narrow mounting holes or nozzles.

The waveguide offers an advantage in applications subject to dust, foam and heavy vapors. In cases of interface measurement (for example oil on water), it allows the measuring signal to penetrate the upper product and provide measurement of the lower product. The waveguide can be mounted on an angle or even formed to follow the contours of an irregularly shaped tank.

Disadvantages. Because the waveguide is in constant contact with the product in the tank, the potential for corrosion exists. Vendors address this concern by offering a variety of process connections and waveguides constructed of corrosion-resistant materials such as Type-316 stainless steel, high-nickel alloys or rods coated with perfluoroalkoxy (PFA) polymer.

Movement of the product in the tank can subject the waveguide to pulling and bending forces acting on it. However, readily available calculation formulas enable checking that the forces are within the operating limits for a given type and length of waveguide.

SELECTION CONSIDERATIONS

GWR provides reliable and accurate measurements for a broad range of services. The common accuracy specification is ± 10 mm to ± 5 mm (basic models) and ± 3 or ± 2 mm (advanced models), with a typical repeatability

of ± 1 mm. Moreover, the technology boasts superior performance when an application involves considerations such as:

Mechanical layout. Due to the cylindrical shape of the measuring signal, GWR is ideal for tall and narrow tanks. It can provide measurements in excess of 200 ft (up to 70 m) with a radius of the measuring beam as small as 1 ft (30 cm). This property makes finding a spot in a tank where the measuring beam is free of potential interference from obstacles or moving parts easy.

The variety of process connections and waveguides available simplifies mounting of the probe through narrow openings and nozzles. Many probes can be installed on nozzles as narrow as 50 mm (2 in.), and a 22-mm coax probe can be mounted in a $\frac{3}{4}$ -in. nozzle.

Rigid waveguides (rod and coax) allow for angled installations. The probe can be mounted through an opening on the side of the tank or on an angle from the top. An internal formula in the instrument can automatically recalculate the level in the tank based on the mounting angle.

A coax probe can handle small or complex tanks with many obstacles; it even can touch internal objects of the tank without affecting the quality of the measuring signal.

For installations with an existing stillwell or a bypass (bridle), a GWR instrument readily can replace dated measurement technologies such as displacers. Many new tank designs also employ bypass (bridle) constructions that facilitate easy mounting and separation of the GWR from the process.

Broad operating conditions. Current GWR instruments can withstand a tremendous range of pressures and temperatures. Depending on supplier and model, the operating pressure starts from -1 bar and goes up to 400 bar (-14.5 psi to 5,800 psi). The operating temperature goes from -196°C to 450°C (-321°F to 842°F). Because GWR measurements aren't sensitive to changes in temperature and pressure, this technology especially suits applications where conditions vary during startup or operation. A good example is a steam boiler that experiences only moderate temperature and pressure during startup but constantly high values during full operation; precise level measurement is very important at each phase of boiler operation. Additionally, GWR offers a steam-compensation function to ensure reliable measurement even with saturated steam above the liquid in the tank.

Internal algorithms of GWR devices (which differ depending on vendor and instrument model) provide reliable operation in a variety of environments from those with foam on the surface of the measured liquid to a turbulent, bubbling surface. Also, compensation can adjust for any thick and persistent buildup on the waveguide; in such situations, single-wire or rod probes are preferred.

Measured product characteristics. Due their high signal-to-noise ratio and advanced algorithms, today's GWR instruments can be used to measure the level of almost all industrial liquids and powders. The minimum dielectric constant starts at about 1.2, which enables level measurement of even low dielectric products like liquefied gases or polymer powders.

Multiple-phase systems. Some processes require simultaneous measurement of two liquids in a tank, e.g., a light hydrocarbon on top and water underneath. Although hydrostatic or capacitance technologies can measure the interface level, both require that the total level of the two liquids stays the same. GWR measurement is free of this restriction, providing reliable level measurement for both the upper and lower product.

Additionally, retrofitting GWR devices into displacer cages is easy — and offers a significant benefit. Unlike displacers, the GWR doesn't require adjustments each time the density of the measured material changes. Also, because it lacks moving parts, GWR typically doesn't require periodic maintenance. Even in applications with heavy coating products, the cleaning can be reduced up to 60% compared to displacers.

ATTRACTIVE APPLICATIONS

Because of the features described above, GWR level measurement offers unique advantages in numerous applications in the chemical industry. Here's a sampling of applications and benefits:

- Accumulators — easy level and interface measurement for products with changing density, pressure and temperature.
- Chemical storage and small additive tanks — simple-to-install level measurement in tanks of various sizes and shapes. The measurement stays accurate and reliable even if the tanks are pressurized or heated and when the product in the tank changes from batch to batch as can happen in multipurpose tanks.
- Lube oil pots and reservoirs — precise measurement in small volumes, even with extreme pressure variations. The small size of the process connection and the option for angled mounting is a big advantage.
- Separators — reliable level and interface measurement enables precise process control.
- Distillation and rectification towers and reflux drums — level measurement in trays (using bypass installation), measurement of bottoms' liquid, and direct measurement in reflux drums results in reliable measurement during startup, when the pressure and temperature vary.
- Reactor tanks and scrubbers — high immunity to vapors, turbulence and foaming on the surface of the measured product; simple integration into bypass (bridle) design.

- Liquefied gas containers — natural gas liquids, propane and other liquefied gases with low dielectric constant, high pressure and storage temperature down to -196°C (-321°F).

- Boiler and feedwater systems, condensate return tanks and cooling towers — immunity to condensation, steam-compensation algorithms, high pressure and temperature ranges of 400 bar (5,800 psi) and 450°C (842°F). Stable measurement during startup conditions with varying temperature and pressure.

- Sumps and pits (including pressurized ones) — broad measurement range with minimal maintenance requirements; algorithms to compensate for buildup and coating.

- Raw-material and polymer powders — strong measuring echo signal enhanced by the use of waveguide; advanced algorithm to track reflection from the end of waveguide for powders with extremely low dielectric constant.

FREQUENTLY ASKED QUESTIONS

Now let's turn to a few common questions:

Question: How do I know which of the many probe (waveguide) constructions to use?

Answer: The selection of the correct probe is well documented by most vendors and should be an easy task. The flexible wire probe is most universal and suitable for common applications. It also provides the longest measuring range. The rigid rod probe is recommended for flowing liquids or angled installations. A coaxial probe often is used for clean liquids with low dielectric constant and with turbulence or foam on the surface of the product. It also is suggested for installations where the probe is near obstacles or the tank wall. Every supplier provides calculations to verify strength of a specific probe for the planned application.

Question: Can I use GWR in a tank with an agitator?

Answer: Yes, although you must consider a few things. You must keep the probe from coming into contact with the agitator blades and you must confirm the probe's capability to withstand the forces created by the flowing medium. Highly turbulent surface may decrease measurement accuracy. Therefore, installing the GWR instrument in a stillwell or in a bypass chamber for an agitated tank often is recommended.

Question: What happens if emulsions are in the tank?

Answer: GWR instruments detect changes in the

property of a product (dielectric constant) on its boundary. With an emulsion, the boundary change is fuzzy and takes place over some distance. Depending on the internal level detection algorithm and its settings, you may configure the instrument to detect level at the top or the bottom of the emulsion layer.

ORDERING AND INSTALLATION

Besides assessing the technical and performance aspects of an instrument, you should evaluate the capabilities and experience of the GWR supplier. It always is recommended to consult with a supplier that can provide clear guidance on the selection process and is willing to closely collaborate in choosing the best configuration of the instrument. With growing acceptance of GWR technology, a variety of selection guides, success stories and catalogs are available. Some vendors provide intuitive online selection and collaboration tools that help streamline the selection and ordering process.

Given the digital interface and communication capabilities of today's GWR instruments, installation should be quick and simple. Some suppliers can provide preprogrammed instruments direct from the factory based on the ordering data of the instrument; any further changes easily can be made in the field with the local user interface or using HART or Fieldbus digital communication.

A GOOD OPTION

GWR deserves consideration for a wide variety of level measurement applications and, indeed, is an excellent fit for many demanding services. The increasing availability of flexible configurations, selection of probes, materials, process connections, certifications, and competitive pricing make it a natural and preferred choice for many applications.

Some vendors offer GWR instruments as a part of broader product platforms that include instruments for pressure, temperature and flow. This can be a big advantage because it allows standardization of spare parts, programming tools and training. ●

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