

Radar vs Ultrasonic

A practical guide to radar vs ultrasonic, covering the reader intent, the relationship to radar vs ultrasonic, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next step.



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In industrial process automation, selecting the correct level measurement technology is a critical decision that impacts operational safety, inventory accuracy, and maintenance costs. Two of the most prevalent non-contact technologies used today are radar and ultrasonic level meters. While both serve the same fundamental purpose—measuring the distance from a sensor to the surface of a material—they rely on entirely different physical principles.

Understanding the nuances of radar vs ultrasonic is essential for engineers and plant managers working in water treatment, chemical processing, oil and gas, and general manufacturing. This guide provides a detailed technical comparison to assist in the selection process, ensuring the chosen instrument aligns with the specific requirements of the application environment.

| The Physics of Level Measurement: How They Work

Before comparing their performance in specific environments, it is necessary to understand the underlying measurement principles of each technology.

| Ultrasonic Measurement Principles

Ultrasonic level sensors function by emitting high-frequency sound waves (mechanical energy). These waves travel through the air or gas space above the medium, reflect off the surface of the liquid or solid, and return to the sensor's transducer.

The instrument calculates the distance based on the "Time-of-Flight" (ToF) principle. The formula used is:

$$\text{Distance} = (\text{Speed of Sound} \times \text{Time}) / 2$$

Because sound requires a medium (air or gas) to travel, the speed of sound is a critical variable. The speed of sound in air is approximately 343 meters per second (1,125 feet per second) at 20°C (68°F). However, this speed changes significantly with temperature fluctuations. Consequently, most industrial ultrasonic sensors include an integrated temperature sensor to compensate for these changes. If the temperature is not uniform across the measurement path, accuracy may degrade.

| Radar Measurement Principles

Radar level meters utilize electromagnetic (EM) waves rather than sound. These waves travel at the speed of light—approximately 300,000 kilometers per second. Unlike sound, EM waves do not require a physical medium and can travel through a vacuum.

There are two primary types of non-contact radar technology:

1. **Pulse Radar:** Similar to ultrasonic, it sends a pulse and measures the time it takes to return.
2. **FMCW (Frequency Modulated Continuous Wave):** The sensor emits a continuous signal with a constantly changing frequency. The difference in frequency between the emitted and reflected signal is proportional to the distance. FMCW is generally preferred in modern industrial applications for its higher accuracy and signal-to-noise ratio.

Radar performance is influenced by the Dielectric Constant (DC) of the material being measured. Materials with a high DC (like water, $DC \approx 80$) reflect radar waves very well, while materials with low DC (like oils or plastic pellets, $DC < 2$) reflect less energy, requiring more sensitive electronics or specialized antennas.

| Environmental Factors Influencing Performance

The choice between radar vs ultrasonic often comes down to the atmospheric conditions inside the vessel or tank.

| Temperature and Pressure

Ultrasonic sensors are limited by the physics of sound. High temperatures (typically above 80°C or 176°F) and high pressures can alter the air density to a point where sound waves are distorted or attenuated. Furthermore, ultrasonic sensors cannot function in a vacuum because there is no medium to carry the sound wave.

Radar is virtually unaffected by temperature and pressure variations within the vapor space. Because EM waves do not rely on air density, radar is the standard choice for high-temperature reactors, high-pressure boilers, and vacuum tanks.

| Dust, Vapor, and Steam

In applications like cement silos or grain bins, heavy dust is common. Dust particles can absorb or scatter ultrasonic sound waves, leading to signal loss. Similarly, heavy steam or chemical vapors can change the speed of sound, leading to measurement errors in ultrasonic systems.

Radar waves have a much shorter wavelength and are not significantly affected by dust or vapor. This makes radar superior for challenging environments like asphalt tanks, chemical storage with fuming liquids, or dusty solids processing.

| Foam and Turbulence

Foam is a challenge for both technologies, but they react differently. Ultrasonic waves are often completely absorbed by thick, airy foam, resulting in a "lost signal" error. Radar can sometimes penetrate thin foam to reach the liquid surface, though thick, dense foam (especially if it is conductive) may still reflect the radar signal prematurely or attenuate it. In cases of extreme foam, guided wave radar or contact-based methods like magnetic level gauges may be required.

| Comparing Radar and Ultrasonic Technologies

The following table summarizes the technical capabilities and limitations of radar vs ultrasonic level measurement.

Feature	Ultrasonic Level Meters	Radar Level Meters
Medium of Travel	Sound waves (Mechanical)	Electromagnetic waves
Vacuum Compatibility	No	Yes
Temperature Sensitivity	High (Requires compensation)	Negligible
Pressure Sensitivity	High	Negligible
Effect of Dust/Vapor	Significant attenuation	Minimal impact
Dielectric Constant	Not applicable	Critical for signal reflection
Typical Range	Up to 15-30 meters	Up to 30-120 meters
Accuracy	0.25% to 0.5% of range	1mm to 3mm (FMCW)
Relative Cost	Lower (Economical)	Higher (Premium)

| Installation Requirements and Best Practices

Correct installation is as important as technology selection. Both radar and ultrasonic sensors have specific mounting requirements to ensure a clear line of sight to the material surface.

| Dead Zones (Blocking Distance)

Every non-contact sensor has a "dead zone" or "blocking distance" directly beneath the sensor face where it cannot measure. For ultrasonic sensors, this is typically 0.2m to 0.8m (8 to 31 inches), depending on the frequency. For radar, the dead zone is usually much smaller, often less than 0.1m, allowing for measurement closer to the top of the tank.

| Beam Angle and Obstructions

The beam angle determines the spread of the signal. If the beam hits internal tank structures like ladders, agitators, or heating coils, it will create "false echoes."

Ultrasonic: Typically has a wider beam angle (around 10° to 15°).

Radar: High-frequency radar (e.g., 80GHz) offers a very narrow beam angle (as low as 3°), which allows it to avoid internal obstructions and be installed in narrow nozzles.

| Mounting Position

Sensors should never be mounted in the center of a tank with a domed roof, as this can concentrate reflected signals and cause interference. They should also be positioned away from the fill inlet to avoid measuring the falling stream of material rather than the actual level.

| Application-Specific Recommendations

| When to Choose Ultrasonic

Ultrasonic sensors are the preferred choice for simple, atmospheric applications where cost is a primary factor.

Water and Wastewater: Open channel flow measurement, pump stations, and chemical storage tanks at ambient temperatures.

Small Tanks: Short-range liquid level monitoring in plastic tanks.

Non-Critical Solids: Measuring levels in small hoppers where dust is minimal.

| When to Choose Radar

Radar is the professional choice for complex process environments or when high precision is required.

Chemical and Petrochemical: Storage of volatile liquids, solvents, and hydrocarbons where vapors are present.

High-Temperature Processes: Molten materials, bitumen, or reactors.

Large Silos: Measuring grain, minerals, or cement over long distances (up to 100+ meters).

High-Precision Inventory: Custody transfer or applications where millimeter accuracy is required.

| Frequently Asked Questions

Q: Can radar measure the level of a material with a very low dielectric constant?

A: Yes, but it requires careful selection. For materials like plastic pellets or certain oils ($DC < 2$), a high-sensitivity radar or a guided wave radar (GWR) is often more reliable than standard non-contact radar.

Q: Does the speed of the agitator affect ultrasonic sensors?

A: The physical movement of the agitator doesn't affect the sound waves, but the resulting surface turbulence and splashing can scatter the signal. Radar is generally more robust in agitated tanks due to its faster sampling rate and sophisticated signal processing.

Q: Is radar always better than ultrasonic?

A: Technically, radar can handle almost any application an ultrasonic sensor can, but it is more expensive. Ultrasonic remains a highly effective and cost-efficient solution for straightforward water-based applications.

Q: How does 80GHz radar differ from 26GHz radar?

A: 80GHz radar uses a higher frequency, which results in a narrower beam and better focus. This makes it easier to install in tanks with many internal obstructions or small nozzles. 26GHz is still widely used for many standard industrial applications.

| Conclusion

Choosing between radar vs ultrasonic requires a thorough analysis of the process temperature, pressure, vapor composition, and the physical properties of the medium. While ultrasonic sensors offer an economical solution for stable, atmospheric water applications, radar provides the versatility and reliability needed for challenging industrial environments.

For engineers looking to implement these technologies, it is important to partner with a manufacturer that provides both options and understands the specific needs of industrial automation. To explore a wide range of reliable, accurate, and cost-effective level measurement instruments, including radar, ultrasonic, and hydrostatic solutions, professionals can Review product options and application support on the Welk Main Page. By selecting the right technology and following proper installation guidelines, plants can achieve long-term measurement stability and improved process control.