

Radar Level Transmitter Accuracy

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



level-measurement

Main topic: Radar Level Meters

<https://www.level-meters.com/products/radar-level-meters/>

In industrial process control, the precision of level measurement directly impacts operational safety, inventory management, and cost efficiency. Among the various technologies available, Radar Level Meters have emerged as the industry standard for non-contact measurement in challenging environments. However, achieving high radar level transmitter accuracy requires a deep understanding of the underlying physics, the specific technology employed, and the environmental variables of the application.

This guide examines the factors that define accuracy in radar-based systems, compares different measurement principles, and provides practical selection criteria for engineering professionals.

Measurement Principles and Their Impact on Accuracy

Radar level transmitters operate by emitting electromagnetic waves (microwaves) toward a material surface and measuring the reflected signal. The two primary methods used to calculate distance are Pulse Radar and Frequency Modulated Continuous Wave (FMCW).

Time of Flight (Pulse Radar)

Pulse radar, often operating at 6GHz or 26GHz, emits short microwave pulses. The transmitter measures the time it takes for the pulse to travel to the surface and back. This is known as Time of Flight (ToF). While reliable for many standard applications, pulse radar accuracy can be limited by the resolution of the timer and the signal-to-noise ratio in turbulent conditions. Typical accuracy ranges from ± 3 mm to ± 10 mm.

| Frequency Modulated Continuous Wave (FMCW)

FMCW radar transmits a continuous signal with a constantly changing frequency. The distance is calculated by measuring the frequency difference between the emitted and received signals at any given moment. Because frequency shifts are easier to measure precisely than extremely short time intervals, FMCW technology—particularly in higher frequency bands like 80GHz—offers significantly higher radar level transmitter accuracy, often reaching ± 1 mm.

| Key Factors Influencing Radar Level Transmitter Accuracy

While a manufacturer may specify a base accuracy under laboratory conditions, real-world performance depends on several critical variables.

| 1. Dielectric Constant (ϵ_r)

The dielectric constant of the medium determines how much energy is reflected back to the sensor. High dielectric materials, such as water ($\epsilon_r \approx 80$), reflect strong signals, making them easy to measure accurately. Low dielectric materials, such as hydrocarbons or plastic pellets ($\epsilon_r < 2$), reflect very little energy. If the reflected signal is too weak, the transmitter may struggle to distinguish the true level from background noise, leading to decreased accuracy or signal loss.

| 2. Signal Beam Angle and Frequency

The frequency of the radar determines the beam angle. Older 26GHz models typically have a beam angle of 10° to 20° . Newer 80GHz models can achieve beam angles as narrow as 3° . A narrower beam is less likely to hit internal tank obstructions like agitators, ladders, or heating coils. By avoiding these "false echoes," the transmitter can maintain higher accuracy in complex vessel geometries.

| 3. Surface Conditions

Radar accuracy is highest when the surface is flat and calm. Turbulence, ripples, or heavy foam can scatter or absorb the radar signal. While advanced signal processing software can filter out some of this interference, extreme surface agitation can result in measurement fluctuations.

| 4. Vapor and Pressure

Unlike ultrasonic sensors, radar waves are generally unaffected by air temperature, pressure, or vacuum. However, extremely high concentrations of certain vapors (such as heavy steam or chemical gases) can slightly change the propagation speed of the microwaves. While this effect is negligible in most applications, it must be considered in high-pressure steam boilers to maintain millimeter-level precision.

| Technical Evaluation Criteria

When evaluating Radar Level Meters, engineers should distinguish between several related performance metrics:

Measuring Accuracy: The maximum difference between the measured value and the actual true level.

Repeatability: The ability of the sensor to provide the same measurement for the same level under identical conditions. High repeatability is often more important for process control than absolute accuracy.

Resolution: The smallest change in level that the transmitter can detect.

Linearity: The consistency of the accuracy across the entire measuring range, from the top of the tank to the bottom.

Technology Selection Table

The following table compares the typical performance of Welk’s radar level measurement solutions based on common industrial configurations.

Feature	80GHz FMCW Radar	26GHz Pulse Radar	Guided Wave Radar (GWR)
Typical Accuracy	±1 mm to ±2 mm	±3 mm to ±5 mm	±2 mm to ±5 mm
Measuring Range	Up to 120 m	Up to 30 m	Up to 75 m (cable)
Beam Angle	3° - 8° (Narrow)	10° - 20° (Wide)	N/A (Contacting)
Medium Type	Liquids & Solids	Primarily Liquids	Liquids & Powders
Process Complexity	High (Obstructions)	Medium (Clear path)	Low Dielectric/Foam
Installation Size	Small (1" nozzles)	Medium (3"+ nozzles)	Variable

Installation Considerations for Maintaining Accuracy

Even the most precise radar level transmitter accuracy can be compromised by poor installation. To ensure optimal performance, follow these engineering guidelines:

- Nozzle Geometry:** The radar antenna should ideally extend slightly below the mounting nozzle to prevent internal reflections. If the nozzle is very long or narrow, an 80GHz transmitter is preferred due to its narrow beam.
- Obstruction Clearance:** Ensure the signal path is clear of agitators, pipes, and inflow streams. The "keep-out zone" is defined by the beam angle; at 10 meters, a 10° beam has a diameter of approximately 1.75 meters, whereas a 3° beam is only 0.5 meters wide.
- Mounting Position:** Do not mount the transmitter in the center of a domed tank, as this can cause multiple reflections that confuse the sensor. Similarly, avoid mounting too close to the tank wall to prevent side-lobe interference.

4. Orientation: For solid materials, the angle of repose must be considered. In some cases, an adjustable flange is required to aim the radar beam perpendicular to the material surface to maximize signal return.

| Limitations of Radar Level Measurement

While highly versatile, radar technology has specific limitations:

Heavy Foam: Thick, dense foam can absorb the microwave signal entirely, preventing a reflection from reaching the liquid surface. In these cases, Guided Wave Radar (GWR) or hydrostatic transmitters may be more appropriate.

Extremely Low Dielectric Solids: Materials like dry plastic pellets or certain powders may allow the radar signal to pass through the material to the tank bottom rather than reflecting off the surface.

Antenna Buildup: While non-contact radar is low-maintenance, heavy coating or crystallization on the antenna lens can attenuate the signal and degrade accuracy over time. Welk offers lens-style antennas and air purge connections to mitigate this.

| Frequently Asked Questions (FAQ)

Q: Does temperature change affect radar level transmitter accuracy?

A: Generally, no. Radar waves travel at the speed of light and are not significantly affected by air temperature. This is a major advantage over ultrasonic sensors, which require temperature compensation because the speed of sound varies with air density.

Q: How often should a radar level meter be calibrated?

A: Most modern digital radar transmitters do not "drift" in the traditional sense. However, annual verification is recommended for regulated industries (such as oil and gas custody transfer) to ensure the electronics and signal processing remain within specification.

Q: Can radar measure through a plastic tank lid?

A: Yes. Because microwaves can penetrate non-conductive materials, radar can measure the level inside a plastic or fiberglass tank without a process opening, provided the material thickness does not cause excessive signal attenuation.

Q: What is the "Dead Zone" or "Blocking Distance"?

A: This is the area immediately below the antenna where the transmitter cannot accurately measure. For most Radar Level Meters, this ranges from 50 mm to 300 mm. It is essential to account for this when calculating the maximum fill level of a vessel.

| Conclusion

Selecting the right instrument requires balancing the required radar level transmitter accuracy with the physical constraints of the application. While 80GHz FMCW technology provides the highest precision and easiest installation in complex tanks, 26GHz and Guided Wave options remain cost-effective solutions for simpler liquid storage and low-dielectric media. By adhering to proper installation practices and understanding the dielectric properties of the process medium, engineers can ensure reliable, long-term measurement performance.