

API 2350 5th Edition Non-contact Radar Guided Wave Radar Sil

A practical guide to api 2350 5th edition non-contact radar guided wave radar sil, covering the reader intent, the relationship to api 2350 5th edition non-contact radar guided wave radar sil, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next



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The American Petroleum Institute (API) Standard 2350, specifically the 5th edition, represents a critical shift in how the petroleum industry manages overfill prevention for atmospheric storage tanks. As industrial facilities strive for higher safety standards and environmental compliance, the integration of advanced level measurement technologies—specifically Non-contact Radar (NCR) and Guided Wave Radar (GWR)—has become the cornerstone of modern Automated Overfill Prevention Systems (AOPS). When these technologies are paired with Safety Integrity Level (SIL) certifications, they provide a robust framework for risk mitigation in high-stakes environments.

Selecting the right instrumentation requires a deep understanding of the measurement physics, the specific requirements of the API 2350 5th edition, and the functional safety requirements of IEC 61508/61511. This guide explores the technical nuances of these systems to assist engineers in making informed decisions for their petroleum storage applications.

| Measurement Principles: NCR and GWR

Before evaluating compliance with API 2350, it is essential to understand how radar-based level transmitters operate. Both technologies utilize microwaves, but their method of propagation differs significantly.

| Non-contact Radar (NCR)

Non-contact radar transmitters, often utilizing Frequency Modulated Continuous Wave (FMCW) or pulse technology, emit electromagnetic waves from an antenna located at the top of the tank. These waves travel through the vapor space, reflect off the liquid surface, and return to the sensor. The distance is calculated based on the time-of-flight or frequency shift.

FMCW Radar: This type emits a continuous signal with a constantly changing frequency. The difference between the emitted and received frequency is proportional to the distance. It offers high accuracy (often ± 1 mm) and is ideal for custody transfer and high-precision overfill monitoring.

Pulse Radar: This emits short microwave pulses. It is generally more energy-efficient and suitable for simpler applications, though it may struggle with very low dielectric constant (ϵ_r) fluids compared to high-frequency FMCW.

| Guided Wave Radar (GWR)

Guided Wave Radar operates on the principle of Time Domain Reflectometry (TDR). Instead of broadcasting waves through the air, the microwave pulses are guided along a physical probe (rod, cable, or coaxial tube). When the pulse hits a medium with a different dielectric constant than the air/vapor, a portion of the energy is reflected back up the probe.

GWR is particularly effective in applications where the vapor space is turbulent, contains heavy dust, or has varying steam levels, as the probe ensures the signal remains focused and minimizes energy loss. For more detailed technical specifications on these sensors, engineers can Review product options and application support at the Welk Main Page.

| API 2350 5th Edition: Key Requirements

The 5th edition of API 2350 focuses on the prevention of overfills in tanks receiving Class I and Class II petroleum liquids. It categorizes tanks into three levels of automation:

1. Category 1 (Manual): Requires a high-level alarm and manual intervention by an operator who is constantly present during receipt.
2. Category 2 (Semi-Automated): Includes high-level alarms and requires an operator to be available but not necessarily at the tank. It relies on both an Independent Alarm System and a separate level gauge.
3. Category 3 (Automated): Utilizes an Automated Overfill Prevention System (AOPS) that can automatically shut down the flow without operator intervention. This category often requires SIL-rated instrumentation.

| The Role of Independence

A fundamental tenet of API 2350 is the requirement for an independent overflow prevention sensor. This means the sensor used for high-high level alarms or AOPS must be separate from the sensor used for routine tank gauging or inventory management. This redundancy ensures that a single point of failure in the inventory system does not disable the safety system.

| SIL (Safety Integrity Level) Integration

Under API 2350 5th edition, many facilities are performing formal Risk Assessments (RA) that lead them toward SIL-rated systems. SIL is a measure of safety system performance, defined by the IEC 61508 and IEC 61511 standards.

SIL 2: Often the baseline for high-risk petroleum storage. It implies a Probability of Failure on Demand (PFD) of 0.01 to 0.001.

SIL 3: Required for extremely critical applications where a spill could result in catastrophic environmental or human loss. Achieving SIL 3 usually requires hardware redundancy (e.g., 2oo3 voting logic).

When selecting a radar meter for an API 2350 application, the device must have a "Safety Manual" provided by the manufacturer, detailing its SFF (Safe Failure Fraction) and the proof-testing intervals required to maintain its SIL rating.

| Selection Criteria: Non-contact vs. Guided Wave Radar

Choosing between NCR and GWR for API 2350 compliance depends on the tank geometry, fluid properties, and internal obstructions. The following table provides a comparison for petroleum applications:

Feature	Non-contact Radar (NCR)	Guided Wave Radar (GWR)
Installation	Top-mounted, no contact with media.	Requires probe to reach tank bottom.
Media Contact	Non-invasive; ideal for corrosive fluids.	Invasive; probe must be compatible with fluid.
Internal Obstructions	Can be affected by agitators or baffles.	Immune to obstructions outside the probe area.
Dielectric Constant	Requires $\epsilon_r > 1.4$ (typically).	Can detect ϵ_r as low as 1.1 with coaxial probes.
Vapor/Foam	High-frequency radar can penetrate light foam.	Probe guides signal through foam and heavy vapor.
Maintenance	Low; no moving parts or wetted probes.	Minimal, but probe may require cleaning in sticky media.
Accuracy	Extremely high (up to ± 0.5 mm).	High (typically ± 2 mm to ± 5 mm).

Practical Selection Guidance

For Large Crude Oil Tanks: Non-contact radar is often preferred due to the ease of installation on large tanks and the lack of a long probe that could be damaged by internal tank currents.

For Small Process Tanks with Agitation: Guided Wave Radar is superior because the probe prevents the signal from reflecting off the agitator blades.

For High-Pressure/High-Temperature LPG: GWR with a coaxial probe provides the most reliable signal despite the dense vapor phase.

Installation and Engineering Best Practices

To ensure compliance with API 2350 and maintain the integrity of a SIL loop, installation must follow strict guidelines:

1. **Nozzle Geometry:** For NCR, the nozzle should be as short as possible. The beam angle must be calculated to ensure it does not hit the tank wall or internal ladders. A 100 mm (4-inch) nozzle is standard, but high-frequency radars (80 GHz) can use smaller 50 mm (2-inch) nozzles.
2. **Stilling Wells:** In tanks with heavy turbulence or surface foam, installing the radar (NCR or GWR) inside a stilling well or bypass chamber can stabilize the surface and provide a cleaner signal. API 2350 requires these wells to be properly vented to ensure the level inside the well matches the tank level.
3. **Proof Testing:** Both API 2350 and SIL standards mandate periodic proof testing. Modern radar units often feature "Remote Proof Testing" capabilities, allowing the operator to simulate a high-level condition via software without climbing the tank or manually raising the liquid level.
4. **Response Time:** The AOPS must have a total system response time (sensor + logic solver + valve) that is fast enough to stop the flow before the "Critical High" level is reached. Radar sensors typically have a response time of <1 second, which is well within requirements.

| Limitations and Operational Challenges

While radar is the gold standard for API 2350 compliance, engineers must be aware of specific limitations:

Minimum Dielectric Constants: Very light hydrocarbons (like certain condensates) have low dielectric constants. If the ϵ_r is too low, the signal may pass through the liquid and reflect off the tank bottom instead. In these cases, GWR with a coaxial probe or NCR with a stilling well is necessary.

Antenna Clogging: In heavy oil or bitumen applications, condensation or product buildup on the NCR antenna can attenuate the signal. Integrated air purging or PTFE-faced antennas can mitigate this.

False Echoes: Internal structures like heating coils or support beams can create false echoes. Advanced radar units use "Echo Mapping" or "False Signal Suppression" to ignore these fixed reflections.

| Frequently Asked Questions (FAQ)

Q: Does API 2350 5th edition require SIL certification for all tanks?

A: No. SIL certification is only required if the Risk Assessment (RA) determines that the target risk reduction cannot be met by standard industrial-grade equipment. However, for Category 3 tanks (AOPS), SIL 2 is becoming the industry standard.

Q: Can I use the same radar for inventory and overfill protection?

A: According to API 2350, the overfill prevention system must be independent. While you can have two radars on one tank, they should be separate units. Some advanced radars have dual-channel electronics, but true independence usually requires two separate physical instruments.

Q: How does 80 GHz radar differ from 26 GHz radar in this context?

A: 80 GHz radar has a much narrower beam angle. This makes it easier to install in tanks with many internal obstructions and allows for smaller nozzles, which is a significant advantage in retrofitting older tanks for API 2350 compliance.

Q: Is Guided Wave Radar better than Non-contact Radar for LPG?

A: Generally, yes. GWR with a coaxial probe is less affected by the high-density vapors found in LPG/LNG tanks, which can sometimes slow down the microwave signal in non-contact applications, leading to measurement errors.

| Conclusion

Implementing API 2350 5th edition standards through the use of Non-contact Radar and Guided Wave Radar is a proven strategy for enhancing terminal safety. By understanding the measurement principles and selecting SIL-rated instruments that match the specific physical characteristics of the stored media, operators can significantly reduce the probability of overfill incidents. For technical support and a wide range of compliant level measurement solutions, visit the Main Page of Welk's industrial catalog.