The Importance of Overfill-Safe Operation for Accurate Level Detection Using Guided Wave Radar

MAGNETROL®

Although approvals like the German Federal Water Act (WHG) obtained from TUV, or the Flemish Regulation on Environment (VLAREM), certify **Overfill-proof Protection**, defined as the tested, reliable operation when the transmitter is used as overfill alarm, it is assumed in the analysis that the installation is designed in such a way that the vessel or side-mounted cage will not physically overfill. In other words, transmitters can obtain overfill-proof approval, without necessarily having the capability to measure level to the top of the probe. The only requirements are that the transmitters be installed properly and used within their defined measuring range.

However, there are practical applications where a guided wave radar (GWR) probe can be completely flooded with level all the way up to the process connection (face of the flange). Due to the physics of the technology, when this occurs, there can be adverse interaction between the desired level reflection and residual reflections at the top of the probe. This affected area at the top of a GWR probe is dependent not only on the probe itself, but also on the application and installation. Typical GWR probes have a transition zone (or possibly even a dead zone) at the top of the probe where interacting signals can either affect the linearity of the measurement or, more dramatically, result in a complete loss of signal.

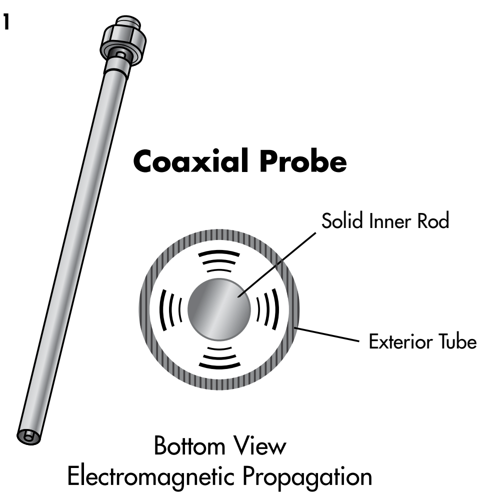
While some manufacturers of GWR transmitters may use special algorithms to "infer" level measurement when this undesirable signal interaction occurs and the actual level signal is lost, the Eclipse® Model 706 transmitter offers a unique solution by utilizing a concept called **Overfill-safe Operation.** An overfill-safe probe is defined by the fact that it has predictable and uniform characteristic impedance all the way down the entire length of the waveguide (probe). With a probe physically designed to be overfill-safe, signal loss will not occur when level reaches the top of the probe. Inferring level measurement instead of actually measuring true product level always comes with some assumptions. But does making assumptions in an industrial process control environment make sense?

Magnetrol® takes the stance that true level measurement should be the primary goal, and overfill-safe probes are offered in a variety of coaxial and caged designs.

Coaxial Probes

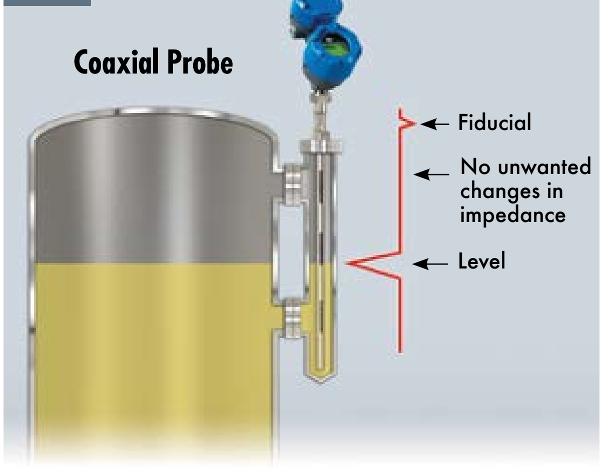
The coaxial probe is the most efficient of all GWR probe configurations and should be the first consideration in all applications. Analogous to the efficiency of coaxial cable, a coaxial probe allows almost unimpeded movement of the high-frequency pulses throughout its length. The electromagnetic field that develops between the inner rod and outer tube is completely contained and uniform down the entire length of the probe. (Refer to **Figure 1**.) This means that the coaxial probe is immune to any proximity effects from other objects in the vessel and, therefore, can be used anywhere it can mechanically fit.

Figure 1



This unimpeded movement of pulses is critical to the concept of overfill-safe probes. With this unimpeded movement and careful design of the upper probe seal assembly comes the fact that there is simply no adverse interaction of signals. With no adverse interaction of signals, the true level signal can always be accurately detected. As shown in **Figure 2**, the level signal is shown unaffected all the way up to the process flange.

Figure 2



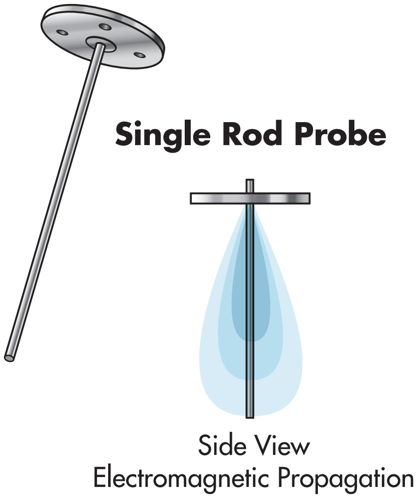
The efficiency and overall sensitivity of a coaxial configuration yields robust signal strength, even in extremely low dielectric ($\varepsilon r \geq 1.4$) applications. The sensitivity of this "closed" design, however, also makes it more susceptible to measurement error in applications that can have coating and buildup. Even though the predictable coaxial signals allow for simpler configuration and commission, single-element probes are becoming increasingly popular due to their immunity to coating and buildup.

Single Rod Probes

Single-element GWR probes act quite differently than coaxial designs. With only one conductor, the pulses of energy develop between the single rod probe itself and the mounting nut or flange. In other words, the pulse propagates down and around the rod as it references its ground at the top of the tank.

Figure 3 shows the single-element design and how the electromagnetic pulse effectively expands into a teardrop shape as it propagates away from the top of the tank (the inherent ground reference). This single-element configuration (rod or cable) is the least efficient GWR probe style.

Figure 3



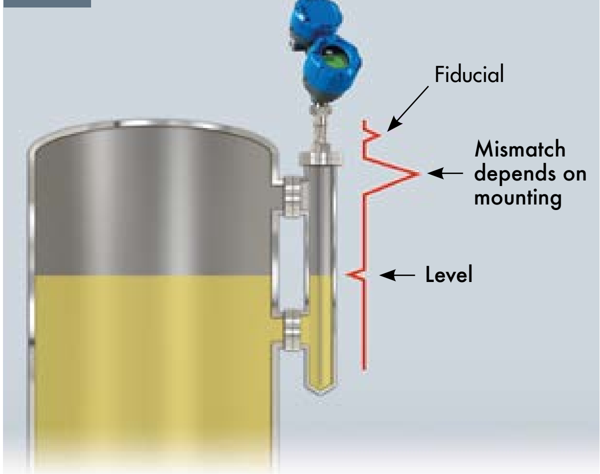
Because the design is "open," it exhibits two strong tendencies:

- It is the most forgiving of coating and buildup.
- It is most affected by proximity issues.

As these tendencies are application/installation dependent, top of probe effects can only be described in general terms with respect to single rod probes.

To illustrate the effect, refer to **Figures 4** and **5**. Unlike **Figure 2**, where the level signal was not influenced by any other signals on the probe, **Figure 4** shows that there is an impedance mismatch at the top of the probe that can influence the level signal as it rises into that area. **Figure 5** shows the level signal actually lost before reaching the process flange.

Figure 4



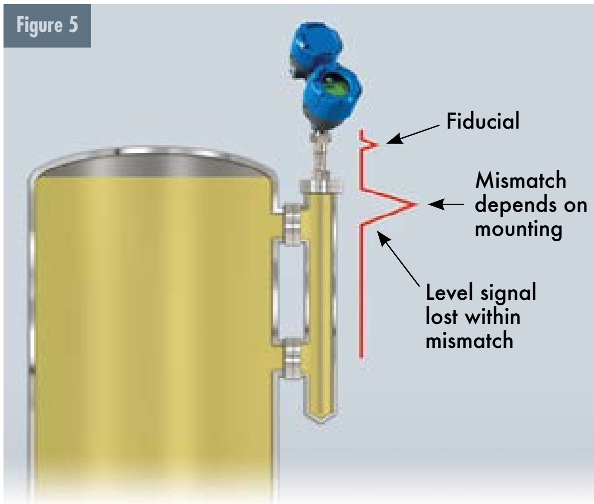


Figure 5

As shown in **Figure 5**, this adverse interaction is application/installation dependent, but is always a concern nonetheless. Because of this, standard GWR single rod probe designs cannot be classified as overfill safe.

However, by properly matching the single rod probe to a cage/chamber, the impedance mismatch, and the corresponding adverse effects, can be eliminated. By utilizing the cage as the second conductor, a properly sized and installed single rod can yield overfill safe performance.

Caged Coaxial Probes

The ECLIPSE Model 706 broad offering of caged probes combines the performance/sensitivity advantages of a coaxial probe and the viscosity immunity of a single rod probe.

Unique to MAGNETROL, the caged GWR probe is a single rod probe which uses an existing or new cage, bridle, or stillwell as the second conductor to re-create the same signal propagation of a coaxial GWR probe. Caged GWR probes are designed for 2" (DN50), 3" (DN80) or 4" (DN100) diameter chambers and utilize a specially designed impedance matching section that results in the same overall characteristic impedance of a coaxial style GWR probe. Caged GWR probes offer the same sensitivity and performance as coaxial GWR probes, but the single conductor design allows it to be used in applications with viscosities up to 10,000 cP.

As shown in **Figures 6 and 7**, these probes allow the ECLIPSE Model 706 to measure accurate levels up to the process flange without any non-measureable zone at the top of the GWR probe, and their signals look very much like those of a coaxial probe.

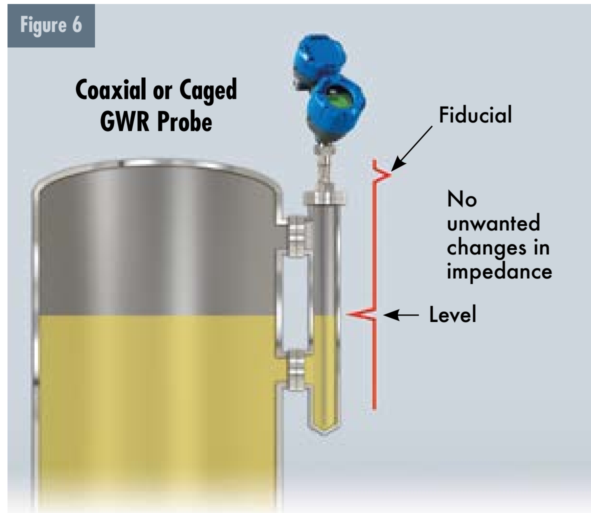


Figure 6

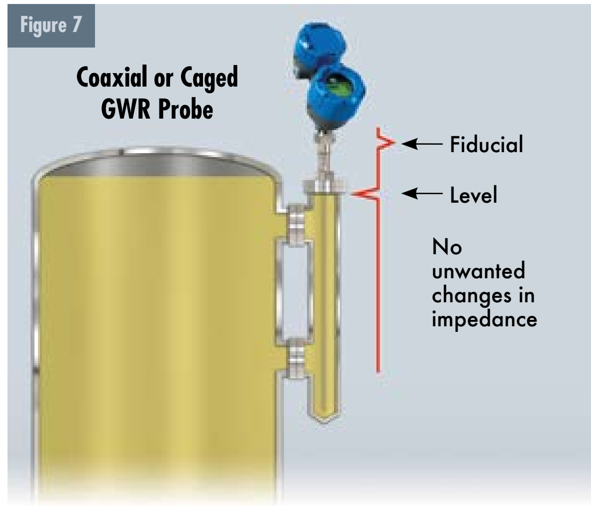


Figure 7

Summary

Overfill-safe GWR probes are unique to MAGNETROL ECLIPSE guided wave radar transmitters. Instead of using algorithms to infer level readings in uncertain areas of a GWR probe, MAGNETROL takes pride in the innovative design of probes so that actual, true product level can always be measured.

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