Modern level devices offer safer and more efficient compliance

Advanced guided wave radar technology provides electronic verification of operation without climbing to the top of a tank

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Oil & gas and chemical companies have tank inventory measurement points requiring compliance testing and periodic calibration of level instrumentation per industry regulations. Traditionally, these calibrations have required a company to dispatch an employee to the top of the tank roof (Figure 1) with a portable level gauge.

Level measurement devices have greatly improved with respect to calibration and verification in recent years. The latest state-of-art technology offers a safer and more efficient way to maintain compliance. Advances in sensor technology now provide device self-checking diagnostics and storage of reference data from previous verification events to address compliance with state and industry test requirements.

Figure 1: Smart level instruments no longer require an operator to climb to the top of a tank roof when calibrating or verifying level instrument operation

Reducing risks

Portable level gauging requires an employee to access the top of the storage tank, open a thief hatch, and determine tank level by means of a plumb bob or hand gauge.

Falls are among the most common causes of serious work-related injuries and deaths, especially in environments subject to inclement weather such as snow, ice, rain and/or high winds. Whenever an employee climbs a tank to check a gauge—whether during installation, calibration or inspection of an instrument—employers must work to reduce risk.

For a cautious employer, this may involve setting up adequate fall protection systems: constructing guardrails and platforms at the top of the tank, providing safety ropes and harness equipment, and/or erecting scaffolding on the side of the tank. Each operation adds cost in manpower and capital, and increases the time required to perform the task.

Tank gauging and sampling activities can expose workers to high concentrations of hydrocarbon gases and vapors (HGVs), in some cases at levels immediately dangerous to life and health. Any time a thief hatch is opened, HGVs and oxygen-deficient components are released through the hatch into the employee's breathing zone. There is also the potential for life-threatening concentrations of hydrogen sulfide gas to be released where "sour" oil and gas operations are conducted. The vapor space in such storage tanks can have hydrogen sulfide concentrations in the hundreds of parts per million. Hydrogen sulfide concentrations above 10 ppm are considered immediately dangerous to life or health.

The consequences of such occupational injuries can be considerable for the employer in terms of lost production, insurance costs and compensation costs. And for the employee, the results can be lost work time and income, medical expenses, and possible long-term health problems or disability.

The better way

Electronic verification of level and other instruments is widely accepted by regulatory bodies for Safety Instrumented Systems. Today's advanced sensor technology allows a functional proof-test that can be conducted without interrupting the production process. Independent of the process conditions, the proper function of the safety system can be simulated in-situ with a functional proof test. TÜV, one of the most respected authorities in its field, recognizes in-situ electronic verification as a means to prove the safety function of guided wave radar (GWR) level instruments as an alternative to wet testing.

Recent technology advances in GWR level measurement technologies include internal diagnostics similar to those offered in many Coriolis mass flow meters. Modern GWRs offer many features to fulfill the requirements of electronic verification.

With electronic verification, the level instrument and its supporting software are capable of determining instrument accuracy and detecting problems. This means that no employee has to climb to the top of a tank unless the verification requires maintenance or replacement of the instrument.

Figure 2: A guided wave radar transmitter sends a microwave pulse that reflects off the surface of the material. The time it takes for the pulse to return determines the level

Guided Wave Radar Technology

GWR, also known as time-domain reflectometry, is a time-of-flight level measurement technology. GWR operates with a microwave launch pulse sent from the transmitter which follows a wave guide to the surface of the material being measured (Figure 2). The varying impedance created by the change from the gas phase to the material being measured causes the microwave pulse to reflect and return to the transmitter. The time the pulse takes to reach the material surface and return is divided by two, providing the distance to the material being measured, and allowing the level to be calculated.

Even more information can be extracted by reviewing the reflection curve of the return signal because changes in impedance create negative and positive reflections.

A negative pulse is created when microwaves travel from a higher to a lower dielectric constant (DC), such as the launch signal where the microwave pulses travel from the process connection to the air at the top of the tank. This negative pulse is commonly referred to as the fiducial pulse.

A positive reflection is caused when microwaves travel from a low to a high DC media, such as a level reflection from air to oil.

Positive and negative pulses also occur in the "Internal Area" (the arrow to the left in Figure 2) due to impedance changes caused by the instrument's internal high-frequency module and cable. This reflection curve is a "finger print" of the particular instrument and will change when installed in a tank, providing a unique base line reflection curve for the particular application.

Base Line Reference Curve

More advanced GWR instruments have the ability to locally store the base line reference curve (Figure 3). This reference curve duplicates the current reflection curve recorded for a particular installation at a specific time. The reference curve is saved and access-protected by a user password, with a time stamp reference to operation time since the instrument was first powered up and put into operation.

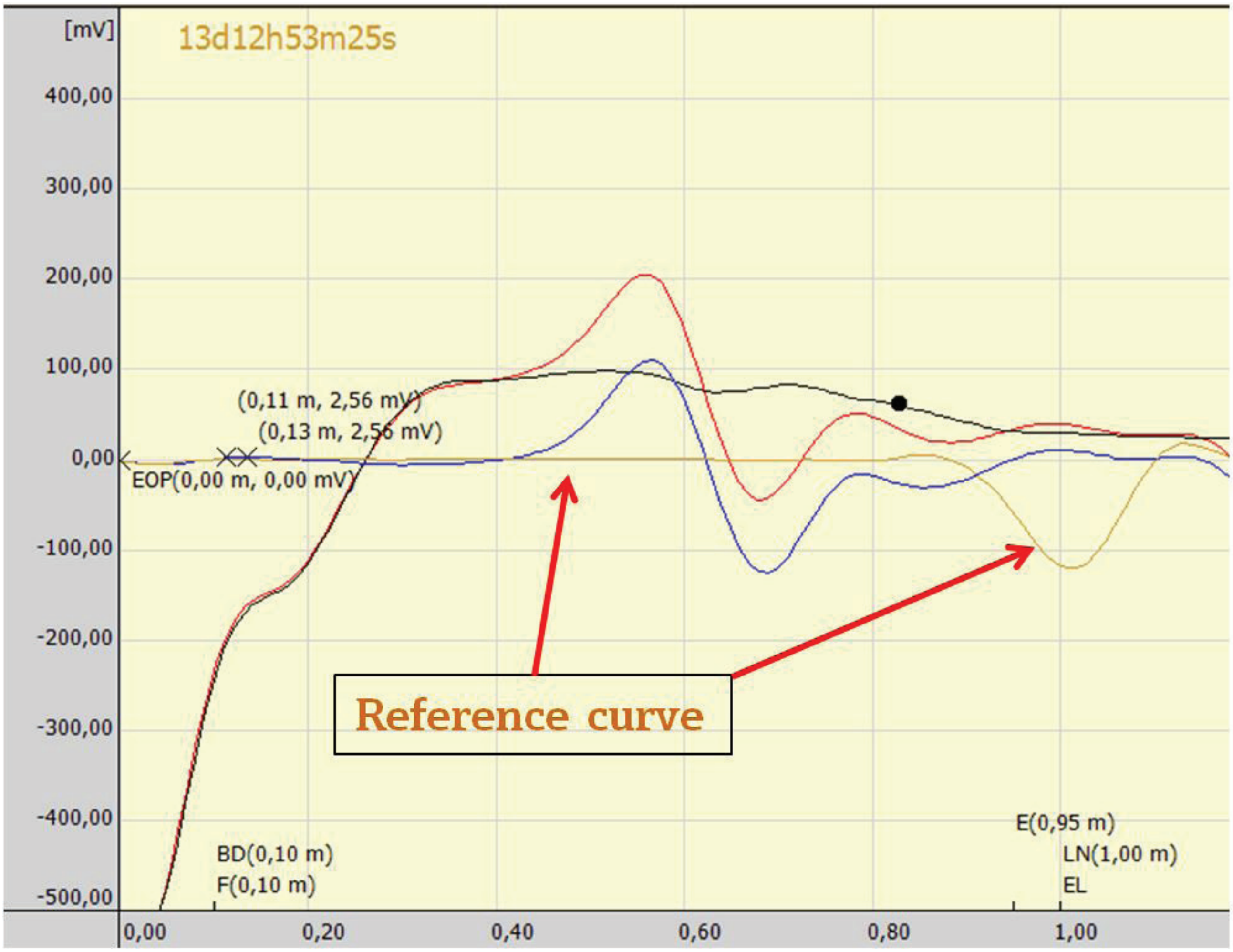


Figure 3: The base line reference curve (green line) matches the current reflection curve at the time of commissioning. A new current reflection curve (red line) is recorded every time the level transmitter is verified. Any significant difference between the two curves indicates problems. The mapping curve (black line) identifies obstacles in the tank.

Comparing the current reflection curve to the base line reference curve with software—such as Endress+Hauser's DeviceCare—at the time of the initial recording confirms the difference between the two curves. At the next required verification, a new reflection curve is recorded and compared to the reference curve recorded initially.

Any differences in the relative amplitude in the area of the fiducial pulse or level reflection would indicate either problems, such as material build up on the transmitter, or that the instrument has been removed and re-installed.

Sensor Integrity Diagnostics

GWR instruments include enhanced diagnostics of the device itself and advanced process diagnostics. Some of the device diagnostics include monitoring the reference pulse, check sum RAM, cycle time, probe breakage, and terminal voltage to check the quality of the electrical wiring.

Advanced process diagnostics include the calculation of process media DC (where a change could be related to product quality) and monitoring of relative echo amplitude (where a change could indicate build-up on the sensor as described above). A modern GWR has more than 80 diagnostic routines permanently running in the background, continuously self-checking and monitoring for correct functionality.

A modern GWR instrument incorporates the latest NAMUR NE107 recommendation for enhanced device diagnostics. Within this recommendation, four categories are defined to classify the diagnostics information (Figure 4).

F	"Failure" A device error is present. The measured value is no longer valid
C	"Function Check" The device is in service mode (e.g., during a simulation)
S	"Out of specification" The device is operated: ▪ Outside of its technical specifications (e.g., during startup or a cleaning) ▪ Outside of the configuration carried out by the user (e.g., level outside configured span)
M	"Maintenance required" Maintenance is required. The measured value is still valid

Figure 4: NAMUR NE107 recommended error messages

This enables the operator and service technician to quickly identify the problem, work on the root cause analysis, and take the right actions to avoid unplanned plant shut downs. The NAMUR error message and information can be displayed on the local indicator, and transmitted via a digital fieldbus protocol (4-20mA HART, Foundation Fieldbus, Profibus PA, etc.) to the automation system, to diagnostic software or to an asset management system.

Most modern GWR level instruments incorporate all these functions, and approach the solution in different ways. The following describes advanced functions available in a particular GWR instrument.

Event logbook

An event logbook is a chronological overview of the event messages generated by an instrument, saved for access through an "events history logbook." The event history includes entries for every diagnostic and information event. In addition to the operation time of its occurrence, each diagnostic event indicates when it occurred and ended.

For example, if power is lost, the event log has a reference to the operation time when power was restored, as well as any new or changed parameter settings. When the reflection from product surface is lost (echo lost), it shows up in the event log.

The event logbook stores all events occurring between two verification events, typically for a period of one year. A minimum of 20, but preferably as many as 100 event messages, can be displayed in chronological order.

Self–Device Check

This function checks whether the hardware and firmware is working correctly, and also verifies proper installation. Device check functionality on a GWR evaluates the quality of several signals: launch (fiducial), level and interface signals.

In addition, the following pre-conditions have to be fulfilled:

- Basic setup has to be done in a correct way
- Probe should be covered by process media, which means the tank has to be at least partially filled
- Initialization of the device check is made either through the keys on the local display or, preferably, through commissioning software
- According to the evaluation results, the GWR qualifies the signal strengths into groups and combines the evaluated signals in the parameter "result device check."

Electronic Verification Procedures

Commissioning is performed according to the GWR manufacturer's recommended procedures. Initial electronic verification after the GWR has been commissioned and tank level is confirmed include:

- Perform a self-device check, which will confirm basic set-up is correct and analysis of signal reflections (fiducial, level)
- Record a baseline reference curve, capturing level reflection, fiducial and the internal area reflections and relative echo amplitude of level reflection
- Record last entry in device Event Log
- Save the commissioning parameter and reflection curve

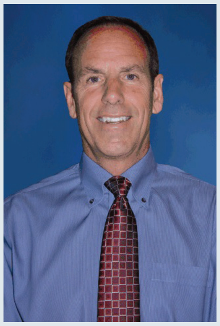
Verification must also be performed per the manufacturer's recommendations:

- Review device event log. If changes to the configuration or faults have occurred since the last verification, this may indicate a need for further investigation
- Review base line reference curve and current reflection curve for changes of relative signal amplitudes, and in the near field between the fiducial and the level reflection. If changes are present, then further investigation may be required
- Perform a self-device check
- Record last entry in device Event Log

If everything is the same as when the device was commissioned and all tests passed, a Verification Report can be printed.

Summary

Today's advanced GWR level technology allows for electronic verification to ensure compliance in a quick and efficient manner. This technology also offers the highest degree of safety because there is no need to climb vessels or be exposed to hydrocarbon gases and vapors or oxygen-deficient atmospheres. With electronic verification, the level instrument and its supporting software are capable of determining instrument accuracy and detecting problems.



About the Author

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