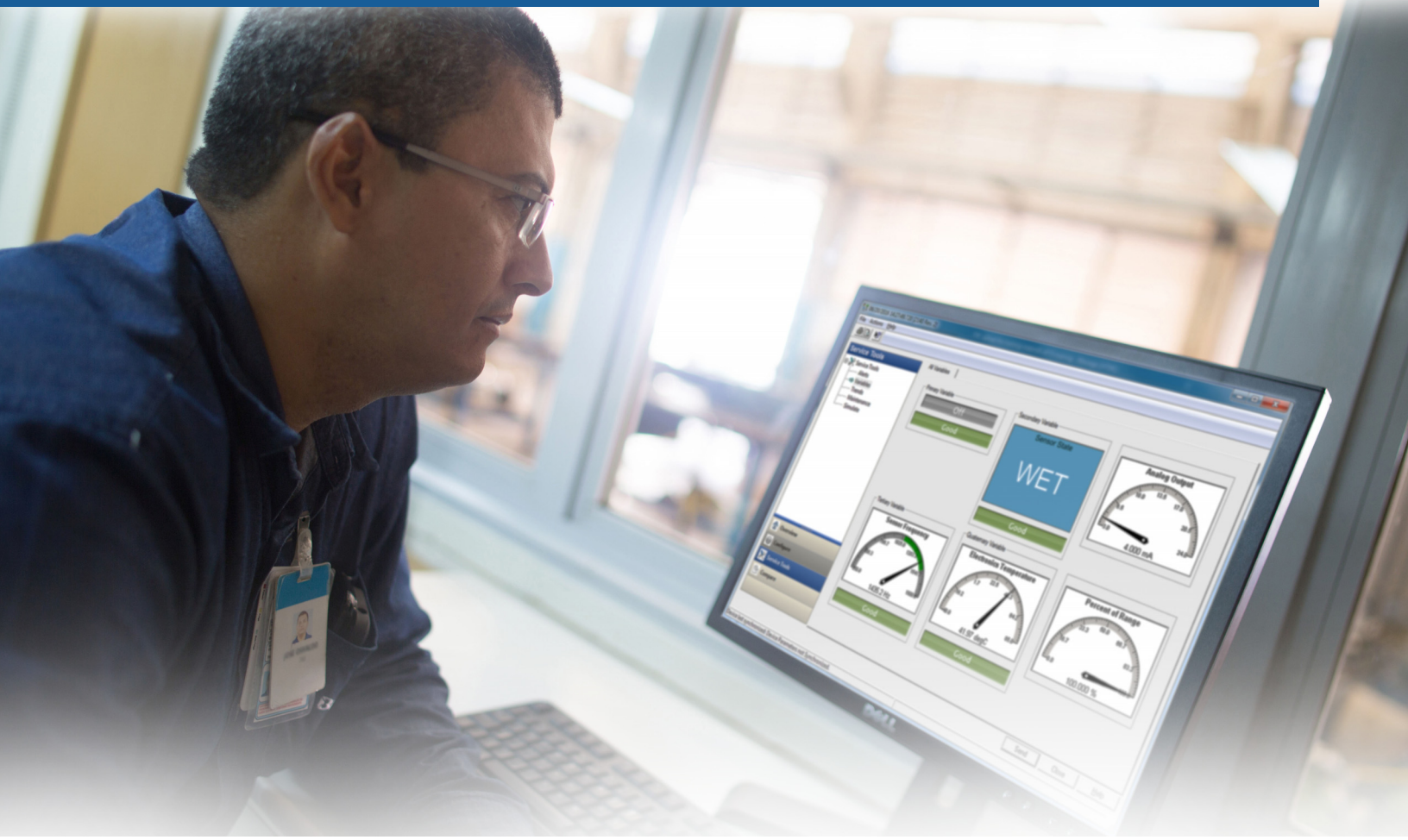
White Paper

Advanced Diagnostics, Increased Safety and Lower Operating Costs

The Latest Developments in Point Level Detection



EMERSON™

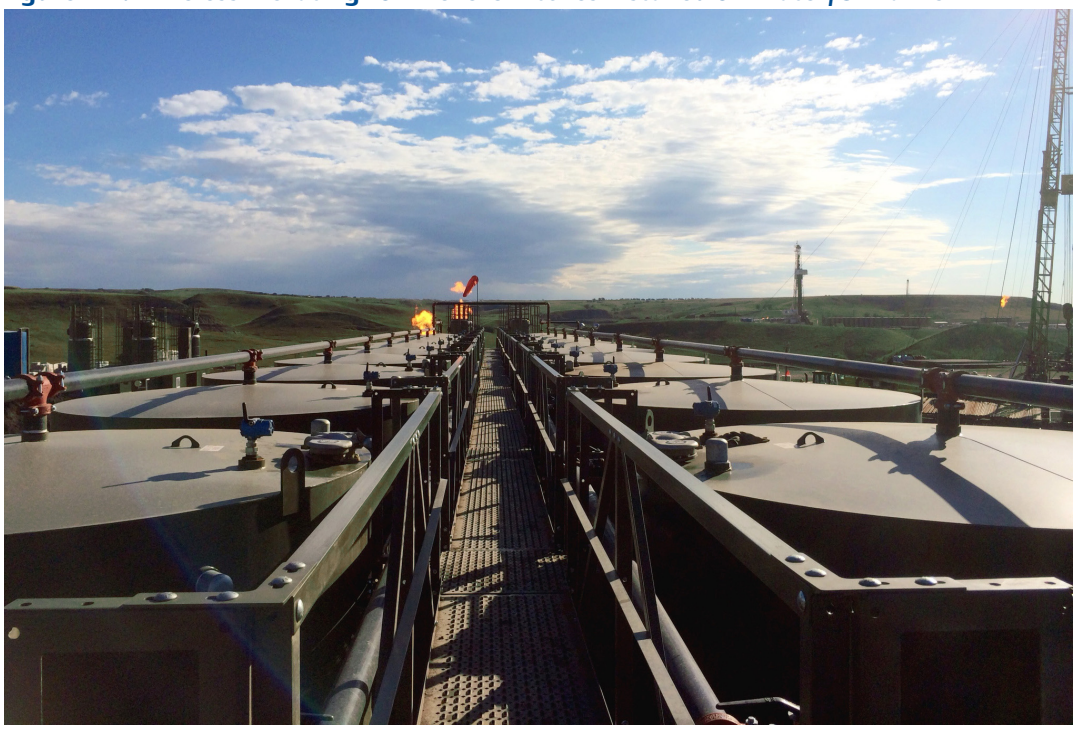
Introduction

Improving maintenance practices is vital in process industries, bringing significant gains in terms of safety, production “up-time” and reduction in unscheduled downtime. Increasing efficiency and profitability, and improving the ability for personnel to proactively plan their maintenance activities also help drive down operating costs.

This white paper explains how the latest generation of vibrating fork level detectors delivers benefits through Advanced and Smart Diagnostics, remote proof-testing and fork frequency monitoring.

The ability to detect a fault before a dangerous condition occurs is increasingly important especially in critical and functional safety applications. The latest devices are equipped with new functionality to deliver diagnostic data straight to the control room that can help plants plan effective and efficient preventative maintenance programs, as well as giving greater insight into their process.

Figure 1-1. Wireless Vibrating Fork Level Switches Installed on Water/Oil Tanks



The evolution of level switches and detectors

Mechanical float switches had a revolutionary impact on liquid level measurement when they were developed in the mid-20th century. Although effective and reliable, they did not have the facility for remote switching so the first electronic switches, based on capacitance and resistance technology were a major step forward. It was now possible to have the switch point on the tank and the control function somewhere else.

Highly reliable and simple to operate requiring only a power supply and two wires, these first electronic switches proved hugely popular. However, electronic switches could not match mechanical switches for application coverage, until the launch of the vibrating fork switch in the late 1990s.

Technological advances have made today's vibrating fork switches smarter; their built-in intelligence not only increases their reliability but they can do much more than simply detect point level. The latest devices provide greater insight into the process and monitor their health, providing an actionable alert in the event of something going wrong.

In recent years many plants have adopted the HART® communication protocol and with more than 40 million HART-communicating devices installed worldwide it has become a global communication standard for process automation. HART gives access to a wealth of real-time process and diagnostic information from the control room host, providing greater insight and eliminating the need for routine visual inspections, optimizing plant performance while increasing safety.

The latest generation of vibrating fork level detectors are equipped with HART communications and can now bring these benefits to point level and overfill prevention applications.

Next generation HART point level detection

The term “detector” rather than “switch” reflects the way in which HART communications function; the device monitors the process state while continuously checking its own health, transmitting process and diagnostic information across the wireless network to the control room.

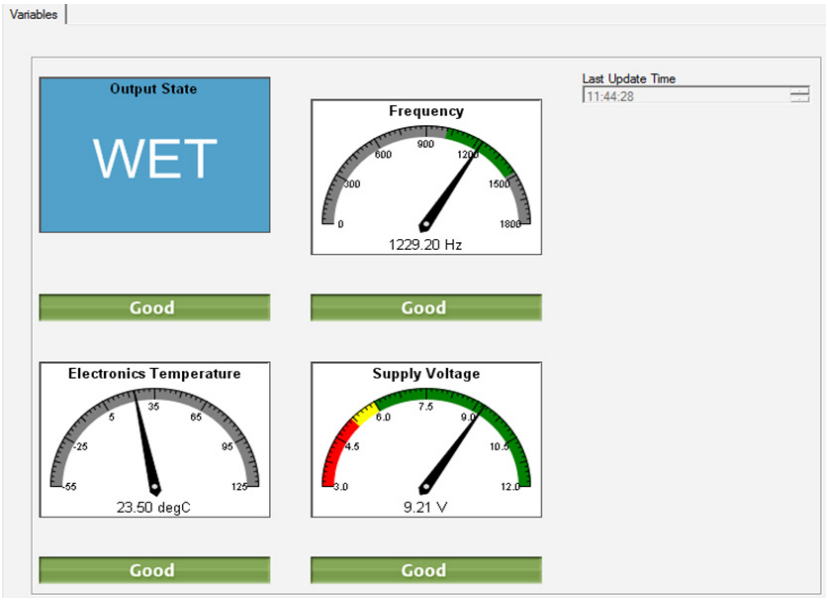
Figure 1-2. Level Detector with *Wireless*HART® Protocol

There are a number of reasons why “going wireless” has been an attractive option for many. Plants can be vast, with tank farms situated in remote, hostile and hard-to-reach

locations. Obstacles such as roads, drains, frozen or waterlogged ground can make them hard to access.

Challenging terrain makes the ability to automate processes attractive in itself, yet installing infrastructure in these locations is often prohibitively difficult or costly. Wireless instruments have no additional infrastructure needs and can be operational in a matter of minutes. Automating processes has never been more cost effective, with installation savings of up to 90 percent compared with traditional wired technology, giving insight in to your process and device health whether you are meters or miles from the vessel.

Figure 1-3. Access to HART Data



In spite of the latest technology offering such advantages there was also a demand for wired HART functionality, for example in critical control and functional safety applications. This need led to the development of the world's first wired HART vibrating fork level detectors for basic, control, critical control and overfill prevention applications.

Figure 1-4. World's First Wired HART Vibrating Fork Level Detectors

HART COMMUNICATION PROTOCOL

Benefits of vibrating fork level technology

Vibrating fork level switches and detectors operate using the basic yet reliable principle of a tuning fork. Functionality is largely unaffected by turbulence, bubbles, foam, coating or changing liquid properties. This effective, reliable and repeatable means of detecting presence or absence of liquids makes the technology ideal in low or high level alarm applications and overfill prevention, and it is often used as a secondary back-up to continuous level measurement technology.

Vibrating fork level switches and detectors are compact, light in weight and easy to install. They have an advantage over other level switch technologies in that they have no moving parts, making them virtually maintenance-free.

These benefits, coupled with advances in diagnostics capability, made possible with HART communications, have helped plants bring about improvements in safety, reliability and efficiency across many point level applications.

Why device monitoring is important

Since vibrating fork level switches are often used in safety critical applications, device failure can have serious consequences. A failure could lead to an overfill or overspill situation, or a pump running dry, with safety or environmental consequences. As a minimum, the process may need to be shut down while equipment is repaired or replaced.

Although vibrating fork level switches are a highly reliable means of detecting liquids, there are certain things that can affect their performance, such as electronics failure, fork bridging, severe corrosion or mechanical damage.

It is vital that devices operate reliably but should a problem occur, it must be diagnosed early so that maintenance can be scheduled, ideally during a pre-planned period of downtime.

To enable this, devices with integrated advanced diagnostic capabilities can now be installed, helping maintenance teams to identify potential problems earlier while at the same time removing the need for routine operator rounds and manual checks.

Diagnostic capabilities

The latest technology vibrating fork level switches and detectors are equipped with different diagnostics tools that continuously monitor the device's health, alerting operators to issues or emerging problems. Functionality ranges from basic status indicators through to analysis tools that constantly monitor and transmit changes in operating parameter trends.

Some devices are equipped with basic diagnostics. The state and health of the device is displayed locally via a visible 'heartbeat' LED, including status, calibration, internal electronics failure and load fault. The LED pulses at a different rate if a fault has been detected, signaling that attention is required.

More advanced devices are equipped with greater intelligence. Fully integrated Remote and Advanced Diagnostics can detect damage to the forks including severe corrosion, internal or external damage or breakages to internal wiring. If a fault affecting operation is identified, it is signalled via a dedicated output to the control room. The load is handled safely and the device switches to a 'safe' condition.

Using HART communications, advanced devices provide further diagnostic functionality. HART switches don't just provide an on/off/fault output - they report a number of additional HART variables such as fork vibration frequency, voltage and electronics temperature. Operators can configure an alert for rising or falling values, giving more insight to infer changes in their process or fork health, for example media build up or an issue with the power supply to the device - helping identify when maintenance really is required.

The ability to access this diagnostics information remotely from the control room eliminates the need for field trips to interrogate each device. Remote diagnostics access increases worker safety as well as efficiency, with no need to enter hazardous areas or work at height to access the instrumentation.

Smart Diagnostics capabilities

Some advanced devices are equipped with Smart Diagnostics Suite, a toolbox of new functionality providing even more insight into the health of the device. By monitoring changing trends in operating parameters. Smart Diagnostics Suite can point to an emerging issue which if left unchecked, may eventually lead to device failure with potentially severe consequences.

The Frequency Profiling function monitors changes in the fork sensor frequency over time and can identify emerging conditions such as media build up or corrosion, providing an indication that inspection and maintenance of the device may soon be needed - for example, if there is media build-up on the forks, cleaning may be

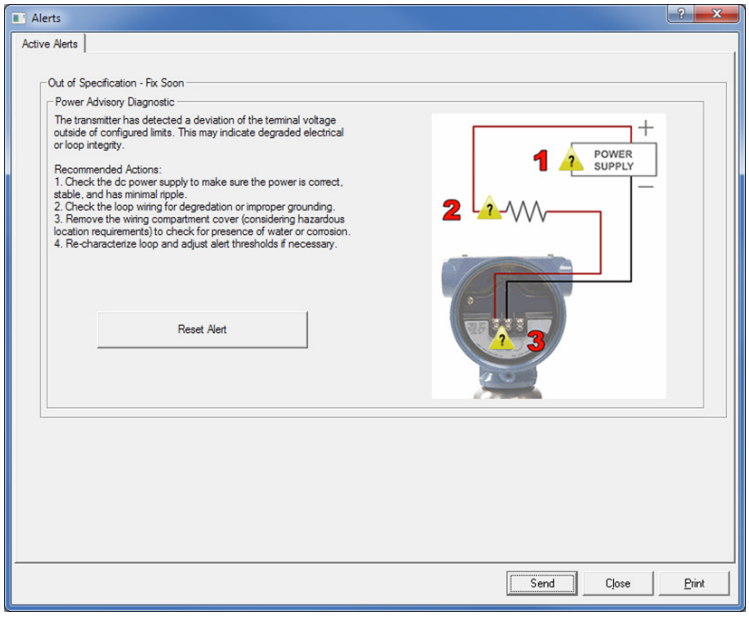
proactively scheduled during a period of planned downtime, minimizing process interruption. Continued build-up can result in bridging of the forks and affect reliability so this is a valuable tool to minimize risk.

Figure 1-5. A Vibrating Fork Showing Severe Build Up and Bridging. Diagnostics Can Help Indicate This Issue Before Operation is Affected

Figure 1-6. Predictive Maintenance Programs can be Implemented Based on Diagnostics Information to Proactively Schedule Cleaning

The Power Advisory function enables operators to identify potential problems with internal components and circuitry by continuously monitoring the loop power drawn and comparing with values from when the device was new. Any unusual behavior or trend which may indicate an emerging issue, for example internal corrosion, is alerted. This provides a significant benefit for plant managers, as internal corrosion can eventually lead to intermittent or complete failure.

Figure 1-7. Power Advisory Functionality Gives Operators Actionable Alerts Should an Issue be Detected with the Loop Power



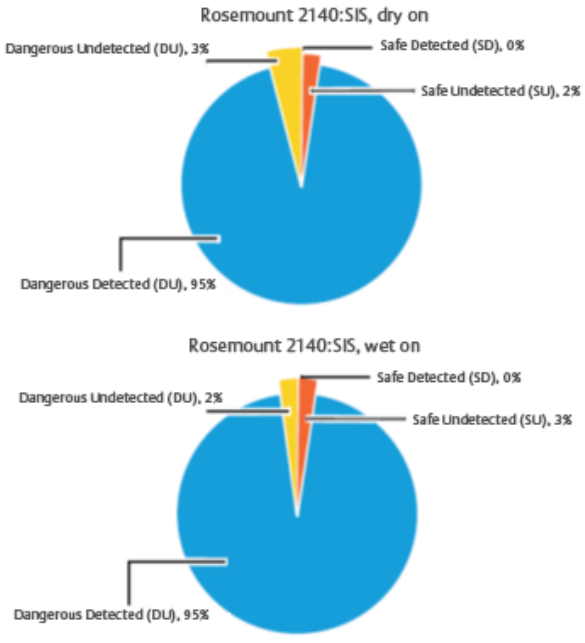
Using HART communications, devices transmit diagnostics data directly to the control room, enabling operators to proactively plan predictive preventative maintenance programs without the need for routine manual inspections.

Diagnostics in critical and functional safety applications

The latest technology in vibrating fork level detectors is a dedicated model for critical and functional safety applications. Assessed by third party Exida under the requirements of IEC61508 it is certified to provide a SIL2 level of integrity. The failure Modes, Effects and Diagnostics Report (FMEDA) recognizes the device's superior failure detection capability, publishing a diagnostics coverage greater than 90%.

Furthermore, the design and diagnostics capability of the 2140:SIS has resulted in an impressively low percentage of Dangerous Undetected Failures. These are failures which cannot be detected by the device's internal diagnostics but would prevent it from bringing a process in to a safe state - for example shutting down the process in the event of an overfill - so minimizing this number is key.

Figure 1-8. Internal Diagnostics can Detect Over 97% of all Failures



With a calculated dangerous failure rate of only thirteen “Failures in Time”, the most advanced devices have a probability of experiencing less than 1 dangerous undetected failure in 8,000 years.

Proof-testing

Regular proof-testing is an essential requirement in safety instrumented systems to verify that devices meet the necessary safety integrity level (SIL) by ensuring that the Average Probability of Failure on Demand (PFDavg) is within acceptable limits.

Traditionally, proof-testing of level devices has been performed with multiple technicians to verify the safety system reaction, taking a considerable amount of time, cost and effort. A comprehensive proof test procedure often involves removing the instrument from the process, and the process being taken off-line causing lengthy production downtime. Workers may need to enter a hazardous zone, climb tanks and work at height to access instrumentation. There may also be safety issues associated with exposing personnel to the process or exposing the process to the environment when the instrument is removed from the process.

Technological advances in modern smart devices now enable a partial proof-test to be performed with the device left 'in-process' which is a quicker, safer and more efficient alternative.

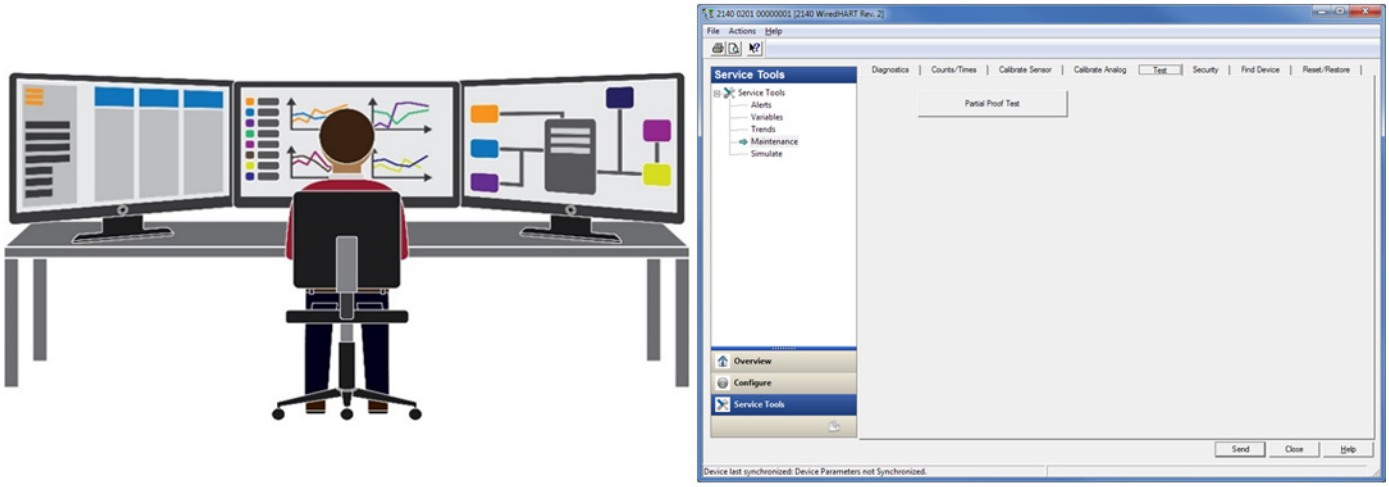
In-process partial proof-testing involves the 'exercising' of the level switch or transmitter, typically via a push button or magnetic test point, to test functionality of the processing and output electronics.

A partial proof-test tests a percentage of the device's potential failures since the forks do not see a change in 'state'. However, performing the test can justify extending the time interval between comprehensive proof-tests since it reduces the PFDavg by a percentage. This can give operators more flexibility to schedule comprehensive proof-tests around planned shutdowns.

Remote proof test: check device integrity safely and easily

There is a completely unique means of performing a partial proof-test remotely from the control room “on the bus”, by issuing a HART command. This can allow multiple devices to be tested simultaneously to save time.

Figure 2. Partial Proof Test can be Performed from the Control Room by a Single Operator



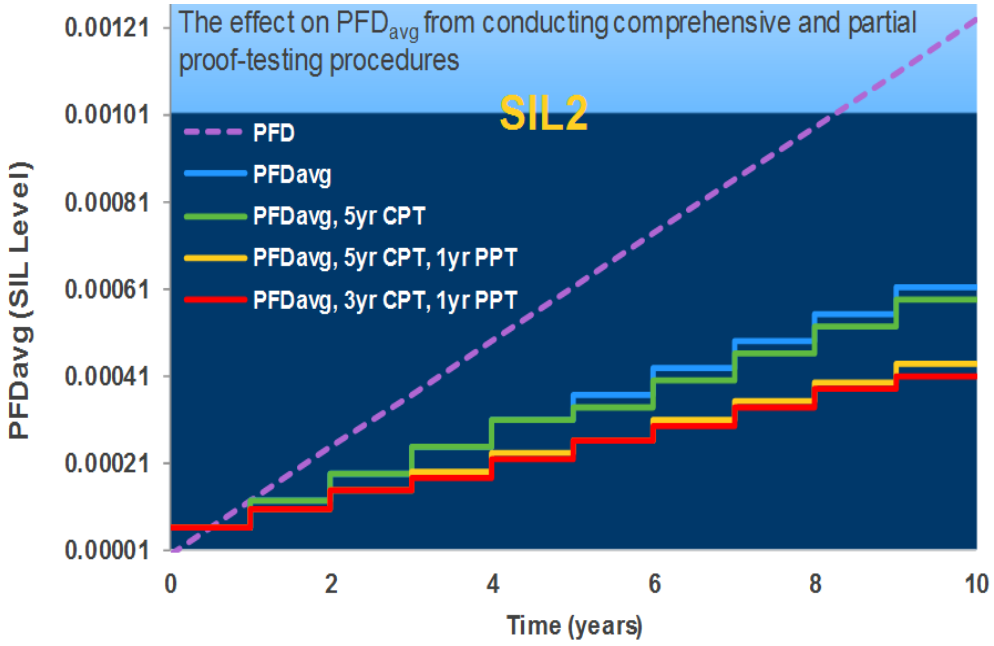
The procedure is safe, quick and easy, and with the functionality fully integrated within the device, no additional hardware or wiring is required to perform the test, reducing complexity and the risk of human error. Since the test is performed remotely, operators do not have to enter a hazardous area to access the device.

Upon receiving the HART command from the host, the device enters test mode. This cycles the output through the wet, dry and alarm states, verifying that there are no faults, before returning to normal operation, leaving no risk of the device being left in 'test mode'. If the partial proof-test detects a problem with the processing or output electronics, this is reported on completion of the test.

The process is continually monitored during testing and any change will be reported immediately on completion so there are no missed events. Since the test can be performed in process it can take less than a minute to carry out.

By performing a periodic partial proof-test, the device supports a comprehensive proof-test interval of 5 years, giving plants the freedom to plan them around their plant schedule.

Figure 1-9. Performing a Periodic Partial Proof Test Actively Reduces PFDavg, Ensuring the Device Remains Within Acceptable Limits for Longer



Remote monitoring of fork frequency to infer differing process characteristics

There are certain applications during which it becomes necessary to distinguish between liquids of differing properties at a given point in the process vessel. The most advanced devices can provide this distinction through monitoring the fork frequency HART variable.

The frequency of the vibrating fork changes depending on the medium in which it is immersed. The denser the medium, the lower the frequency. Oil, for example, generates a higher frequency than either water or air, so frequency monitoring functionality can provide a means of distinguishing between different liquids. Being able to do so remotely, without exposing plant personnel to a potentially hazardous environment, adds extra value. Two examples of how monitoring the fork frequency provides an effective application solution may be viewed here:

Product Consistency Improved Using Rosemount™ 2160 Wireless Level Switch For Interface Detection Proven result

BP Oil Implements Rosemount 2160 Wireless Switches for Floating Roof Tilt Detection Proven result.

Conclusion

Vibrating fork level switches and detectors provide industrial plant and process operators with an effective and reliable means of point level detection, making them ideal for use in safety-critical tasks such as low- or high-level alarm applications and overfill prevention. The latest generation devices deliver more status and diagnostics information than ever before, and many plants are now taking advantage of this to bring about increases in safety, reliability and efficiency, even in the most remote or hostile of locations.

The latest HART point level detectors can flag up potential problems, enabling managers to resolve them during periods of planned downtime, preventing unplanned shutdowns, damage to plant equipment or even a safety incident. These devices are equipped with greater intelligence, with Advanced and Smart diagnostics to diagnose issues such as fork damage, media build up or damage to internal electronics. Operating parameters are continuously monitored, and trend changes reported, since they may point to an emerging issue which if left unchecked could lead to a potentially unsafe situation.

Unique remote partial proof-testing capability gives operators the peace of mind that their overfill prevention device will work when it is needed. Using wired and wireless HART communications, the electronic and mechanical health of these point level detectors can be monitored continuously with data accessible remotely from the control room.

The ability to monitor - process and device health remotely not only maximizes efficiency since routine inspection rounds can be greatly reduced, but plant personnel are kept away from potentially hazardous environments, adding extra value in terms of safety.

For more information on Emerson's Rosemount 2100 Series liquid level switches, visit Emerson.com/Rosemount/Level.

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