White paper

Remote Proof-Testing Capabilities

Latest generation of level monitoring devices improves safety and efficiency

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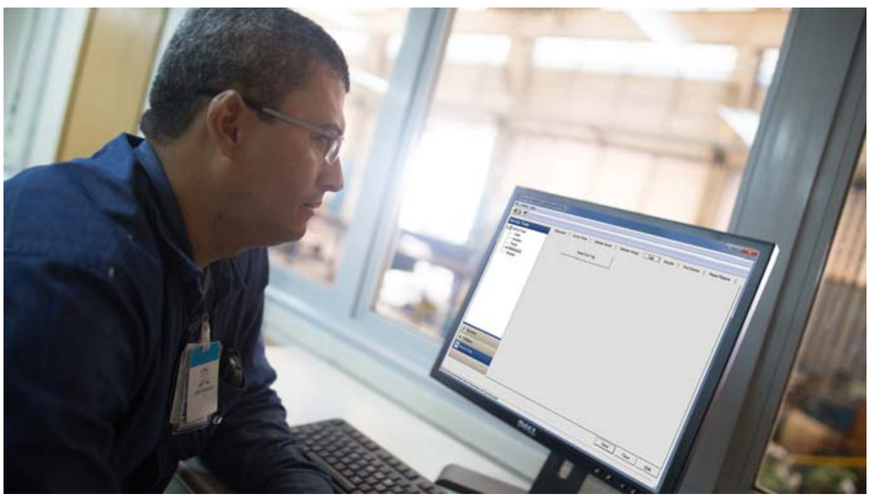
Abstract

This paper explains how the latest generation of non-contacting radars and vibrating fork level detectors enables in-process partial proof-testing on safety instrumented systems (SIS) in liquid level measurement applications to be performed remotely. It describes how this enables the task to be carried out much quicker, while also improving safety and efficiency compared with traditional testing methods. The paper reveals why periodic proof-testing is necessary in safety-related systems and details the difference between full and partial proof-testing procedures. It also explains how a remote in-process partial proof-test justifies a time extension between full proof-tests.

Introduction

Regular proof-testing is an essential requirement for SIS in liquid level measurement applications, as it ensures that they are operating to the necessary safety integrity level (SIL). Traditionally, proof-testing has been performed with multiple technicians in the field and one in the control room, verifying the safety system reaction. This requires a considerable amount of time and effort, can pose safety risks to workers who need to climb tanks to perform the test, could take the process offline for an extended period and can be prone to errors. However, the technological advances of the latest generation of non-contacting radars and vibrating fork level detectors are now enabling proof-testing to be performed remotely and without interrupting the process, making the procedure much quicker, safer and more efficient.

Figure 1-1. Conducting a Remote Proof-Test



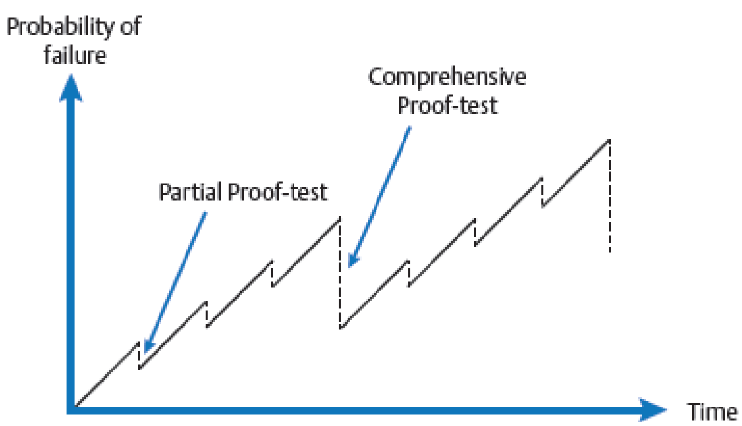
Why periodic proof-testing is necessary

A proof-test is a periodic procedure performed to verify the integrity of an installed device and detect random hardware failures which would otherwise remain undetected by the devices' built-in diagnostics. The frequency of testing varies across different industries and facilities, based on the required safety integrated level and the safety system's undetected dangerous fail rate. Dangerous failures are those which could put the SIS in a hazardous or fail-to-function state, and if undetected they could, for example, lead to an overfill and spill, with potentially disastrous consequences. Sometimes testing is performed annually, but often intervals are even longer. Testing frequency directly impacts regulatory compliance and safety calculations, such as SIL. A high-quality proof-test performed at regular intervals is critical in meeting SIL and regulatory requirements. Devices and systems across the entire safety function and associated equipment are involved.

Full and partial proof-testing

There are two levels of proof-tests for instruments. A full proof-test returns the probability of failure on demand (PFD) average back to or close to the instrument's original targeted level. A partial proof-test brings the PFD average back to a percentage of the original level.

Figure 1-2. Failure Rate Comparison of Proof-Tests



A full proof-test can be accomplished in two ways. In the first method, the level in the vessel can be raised to the activation point of the instrument being tested, providing functional proof that the instrument still works. The danger of this approach is that if the instrument is a critical-high or high-high level sensor for overfill prevention, and it does not activate during the test, a spill is likely, which could constitute a safety risk. Operators would also have to fill the tank just to test the instrument, which is not practical as well as being potentially unsafe.

The second approach is to remove the instrument from the vessel and insert the device in to a bucket filled with the product. This method may require the process to be taken offline, which may interrupt the overall production process, and manpower will be required to run the test. It is important to understand that not all level switches can be tested in this manner. Some technologies, such as capacitance, rely on the reference to ground geometry inside the vessel. Removing the instrument from the vessel for testing would therefore not represent the installed state, so it would not be a valid test.

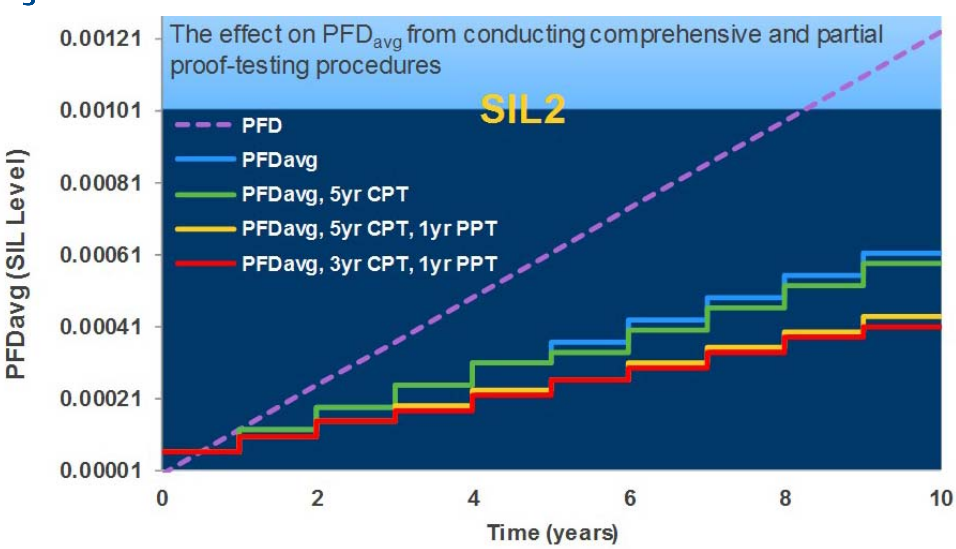
Given the various issues that performing a full proof-test can cause, it can be beneficial for operators to find a means of extending the period between full proof-tests, while remaining within regulatory requirements. This can be achieved by performing a partial proof-test.

Partial proof-testing involves the level switch or transmitter being tested to ensure that it has no internal problems and all functions are operating properly. In partial proof-testing, the level instrument remains installed, and testing is done through a function test performed either locally, typically via a push button or magnetic test point, or initiated remotely via a command transmitted from the control room.

A partial proof-test has reduced diagnostic coverage compared with the full proof-test, in that it is limited to exercising the electronics and verifying that there are no faults causing a higher output current than desired, preventing the device driving to low values, or issues preventing the device from driving to higher values.

As partial proof-testing does not fully return the PFD to the instrument's original state, a full proof-test must eventually be performed. However, performing a partial proof-test can justify an extension of the length of time between full proof-tests.

Figure 1-3. Partial-Proof Test Results



Standards for best practice and requirements for proof-testing

The API 2350 standard outlines the minimum requirements for atmospheric bulk liquid storage tanks to comply with modern best practices. Its main purpose is to prevent overfills and improve safety. API 2350 does not compete with other, more generic, safety standards, but is intended to complement them. For the process industry, the standard for designing a SIS is IEC 61511. Many companies apply both standards, to ensure consistency in their approach to safety.

Both standards place high importance on regular proof-testing. API 2350 states that all overfill prevention systems that are required to terminate receipt must be tested annually, while the high-high sensor alarm must be tested semi-annually. Additionally, continuous level sensors should be tested once a year, and point level sensors semi-annually.

High-level alarm testing in process applications can require the fluid level in the vessel to be raised to the high-level alarm limit. The fluid must be moved in and out of the tank under test - increasing the risk of overfills. The process can take up to half a day to complete, which could interrupt normal activities. It would also require supervision, with operators monitoring the tank level. This can pose health and safety risks due to the possibility of exposure to the tank contents. While this may have been an acceptable practice in the past, the latest version of API 2350 does not recommend that the tank level be raised above the maximum working level.

Advanced functionality of next generation devices

New technology within the latest non-contacting radar and vibrating fork level detectors is now enabling operators to undertake in-process partial proof-testing remotely. This eliminates the need for workers to climb tanks and/or be exposed to tank contents, and therefore provides significant safety benefits.

For some level monitoring technologies, the regulations permit simulating overfill conditions to activate the detector and generate an alarm signal. This simulation eliminates the need for fluid to be moved in and out of the tank to perform the test, avoids the risk of spills, saves a significant amount of time, and increases worker safety and efficiency.

Figure 1-4. Next Generation Vibrating Fork Level Detector

The latest generation of vibrating fork level detectors, for example, can be remotely proof-tested by issuing a HART® command from the control room. Upon receiving the command, the device then enters test mode. This cycles the output through wet, dry and fault states, then returns into normal operation. If the partial proof-test detects an issue, it is reported on completion of the test. Since the test can be performed in-process it can take less than one minute to complete, although the duration is user-programmable in case a longer test is required. This remote in-process testing not only makes the procedure much quicker, it also makes it safer, as workers no longer need to visit a potentially dangerous environment to perform the test.

Next generation, SIL 3-capable non-contacting radar level transmitters can be remotely proof-tested using dedicated software. This enables operators to perform the proof-test simply by inputting a straightforward sequence of settings and commands from their interface. As with the vibrating fork level detector, this remote method of proof-testing brings considerable benefits in terms of reducing risk and errors, saving time, and increasing safety and efficiency.

Figure 1-5. Next Generation Non-Contacting Radar Level Transmitter

Guided wave radar (GWR) sensors do not feature overfill simulation technology. However, recognising the benefits that this feature would provide has led to the introduction of an automated high-level alarm testing function for GWR transmitters. This does not require the device to be removed from the tank, or the level in the tank to be manually raised, therefore increasing the safety of both plant and workers.

Verification reflector functionality is designed for applications requiring periodic transmitter integrity tests to ensure that the level measurement device is functioning correctly. In addition to meeting the recommendations of API 2350, it reduces the risk of accidental spills, and the high-level alarm testing process can be completed more quickly. It also tests the loop from the device to the DCS as well as testing the device itself.

Compared with traditional diagnostics, which only monitor the transmitter electronics, the verification reflector can also be used to diagnose problems with the upper parts of the probe inside the tank, such as product build-up, corrosion monitoring and other process-related conditions.

How verification reflector functionality works

In a GWR installation, the device is mounted on top of the tank or chamber with a probe extending the full depth of the vessel. A low energy pulse of microwaves is sent down the probe and when it reaches the media surface, a reflection is sent back to the transmitter which measures the time taken for the pulse to reach the media surface and be reflected back. An on-board microprocessor accurately calculates the distance to the media surface using ‘time-of-flight’ principles.

The verification reflector function uses an adjustable reference reflector fitted to the probe of the guided wave radar at a desired height to generate a unique echo signature. The device constantly tracks the reflector echo to determine if the level is above or below the alarm limit.

A ‘test’ function built into the device software verifies that the GWR has been correctly configured and is correctly tracking the reflector echo. It also confirms that the alarm loop is working with a high-level alarm being displayed in the control room. This ‘test’ function can be accessed remotely using software packages, as well as locally using a hand-held device.

Summary

New technology within the latest level measurement devices provides plants with the ability to remotely perform in-process partial proof-testing to prove the safe operation of a SIS. By simulating overfill conditions to activate the detector and generate an alarm signal, this method of proof-testing eliminates the need for fluid to be moved in and out of the tank to test level sensors, and therefore delivers important benefits. It saves time, significantly reduces the amount of process interruption necessary, reduces the risk of accidental spills, and eliminates the need for workers to climb tanks and be exposed to tank contents, therefore increasing safety.

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