White paper

Reducing the Complexity of Proof-Testing

with New Generation Point Level Detectors

EMERSON

Reducing the Complexity of Proof-Testing

with New Generation Point Level Detectors to Improve Plant Safety and Reduce Costs

Abstract

Proof testing is performed to test the components of a safety system and identify failures not detected by any online diagnostics. Periodic proof-tests are a necessity for point level switches that form part of a safety instrumented system (SIS) in liquid level measurement applications. This white paper describes traditional and modern methods of performing proof-tests and examines how new methods of partial proof-testing can be performed remotely with multiple devices tested simultaneously, increasing safety and shortening test time. It compares the different test methods and explains how integrated functionality within the latest devices can reduce complexity and save significant operational cost.

Minimizing accident risk

Ensuring the safety of assets and personnel is always a high priority for manufacturing and process organizations but, unfortunately, accidents do still happen. To help minimize the risk of accidents in liquid handling and storage applications, companies must implement properly designed SIS. The primary functions of SIS are to bring processes to a safe state and to prevent safety incidents, such as, overfills from happening. These systems include the liquid level sensors, logic solvers, and the final control elements for each of the safety instrumented functions (SIF) they perform.

Proof-testing requirement

Devices and systems that are part of a SIS must be proof-tested periodically to ensure they will work properly when there is a safety demand, and to verify that SIFs are operating at the necessary safety integrity level (SIL) for their application. Proof-tests are operational tests conducted in accordance with the safety manual of an individual installed device to evaluate its ability to perform its safety function and to uncover random hardware failures. These are failures that prevent the device from performing its primary function and which would otherwise remain undetected by its built-in diagnostics during normal operation. Such failures could put the SIS in a hazardous or fail-to-function state and if undetected could, for instance, lead to an overfill and spill, with potentially disastrous consequences.

There are standards in place that address overfill prevention and safety improvements for petroleum storage tanks, IEC 61511, the process industry's standard for designing a SIS.

This standard places high importance on regular proof-testing with recommended schedules and procedures for inspection and testing of gauging equipment and high-level instrumentation and related systems.

The latest generation of level devices makes it easier than ever before to meet stringent requirements and helps plants operate more safely and more efficiently.

Proof-testing methods

For level measurement devices deployed in SIS applications such as overfill prevention, proof-tests have traditionally been carried out by multiple technicians in the field, with another worker stationed in the control room to verify the reaction of the system. This method can involve workers having to climb tanks to access instruments and perform the proof-test, within a potentially hazardous environment with increased safety risks. As well as being prone to errors, performing proof-tests in this way also consumes a significant amount of time and manpower and can lead to the process being offline for an extended period, with significant cost implications.

Figure 1-1.

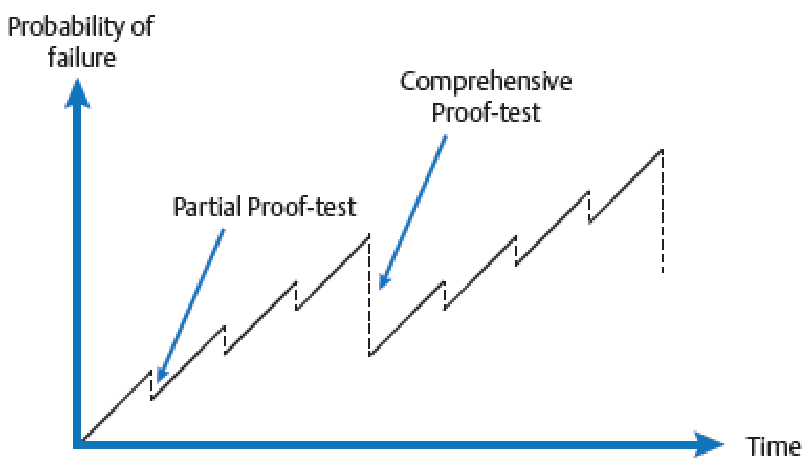
Traditional proof-testing methods require operators to enter hazardous location or work at height to access devices, which poses a potential risk to their safety.

Increasingly fierce competition within industries means that companies are constantly seeking ways to optimize processes and improve efficiency, while maximizing safety. The digital technology available in modern instrumentation facilitates this by enabling proof-testing to be performed remotely with only very minor interruption to the process. This makes the procedure faster, safer, and more efficient than the traditional 'on-location' approach.

Full and partial proof-testing

For point level switches and detectors installed in SIS applications, two types of proof-tests may be performed to comply full and partial. While a full proof-test will return the instrument's probability of failure on demand (PFD) average back to, or close to, its original targeted level, a partial proof-test will bring the PFD average back to a percentage of the original level.

Figure 1-2.



The effect on probability of failure after carrying out a comprehensive (full) proof-test and a partial proof-test.

During a full proof-test, a point level switch can remain installed, or it may be removed from the vessel. When left installed, the fluid level in the vessel is raised to the activation point of the instrument, providing 'proof' that it is operating correctly. However, the danger of this approach is if the switch is a critical-high or high-high level sensor for overfill prevention, and it fails to activate during the test, a spill could occur, which would constitute a safety risk. Also, the process of moving fluid in and out of a tank under test can be time consuming and requires supervision. This can pose health and safety risks due to the possibility of exposure to the tank contents.

Alternatively, the instrument is removed completely from the tank and tested in a simulated vessel – known as an immersion test. To do this the process is often taken offline, which may interrupt the production process during this time-consuming procedure. Also, several workers will be required to perform the test. It is important to understand that not all level switches can be tested in this way. Some technologies, such as capacitance-based devices, rely on the reference to ground geometry inside the vessel.

Removing instruments from the vessel means that they are not being tested in their installed state. Not only is the tank geometry altered, but the device may be immersed in a fluid with different properties – often in water. Pressure, temperature and density may differ from the real process fluid, so the test may not be completely representative.

Because of the various issues that performing a comprehensive proof-test can cause, it can be beneficial for plants to find a means of extending the period between comprehensive proof-tests to five or even ten years, while still meeting regulatory requirements. This can be achieved by partial proof-testing, whereby the point level switch remains installed on the vessel during the procedure, yet requires no immersion. The diagnostic coverage of a partial proof-test is reduced compared with a full proof-test because the sensor does not see a true change in state, but it is a useful functional check to verify there are no internal problems and the electronic functions of the switch are operating correctly.

Typically, a partial proof-test is limited to exercising the processing and output electronics and verifying there are no faults preventing the device switching from the on to the off state, or vice versa. The input electronics are usually excluded from the test, since the device's wet-side does not see a physical change in state, i.e., going from wet to dry.

Partial proof-testing does not necessarily replace a comprehensive proof-test, but it can provide justification for extending the time interval between comprehensive tests. This minimizes interruptions to the process and production, improves output, and reduces worker exposure to hazardous environments without sacrificing SIL capability and functional safety.

Local and remote partial proof-test initiation

There are two ways in which a partial proof-test can be initiated – either locally from the switch itself, or remotely. Different automation technology suppliers offer different mechanisms for conducting tests.

A local test can be activated either by pushing a button or via a magnetic test-point located on the side of the housing by holding a magnet to the test-point. This causes the output state to change, simulating the alarm condition and enabling a functional test of the switch and the system connected to it.

Some manufacturers offer a remote test feature via an electronic signal being transmitted to the device. This signal can be transmitted from the control room or IO cabinet, typically through a HART command. This means workers do not need to physically access the device to perform the test, keeping them off the tanks.

External switching units

Another way in which partial proof-tests can be initiated remotely is by transmitting a signal from a separate switching unit installed in a control panel or cabinet. In this solution, one-channel or multi-channel versions are available that are wired to up to three switches. Consideration must be given to how much space is available in the panel, since in a large plant or tank farm, tens or even hundreds of these switching units may be required. When multi-channel units are installed, operators must carefully identify which switch is wired to which channel to ensure the correct switch is tested. This can be challenging if tag identifications – indicating which switch corresponds to which channel – go astray.

To prevent accidental use, test buttons are accessed through pinholes at the front of the switching unit. One drawback is that activating the buttons can be difficult, requiring the use of a small instrument. This procedure can create a potential risk of shorting the switching unit should the instrument contact exposed circuitry. Opening the panel provides easier access but prevents operators from seeing the identification labeling. This can lead to confusion over which diagnostics correspond to which switch. Ultimately, these complexities could lead to an operator mistaking which device has been tested, climbing the wrong tank to service the wrong overfill prevention device, or shutting down the wrong tank.

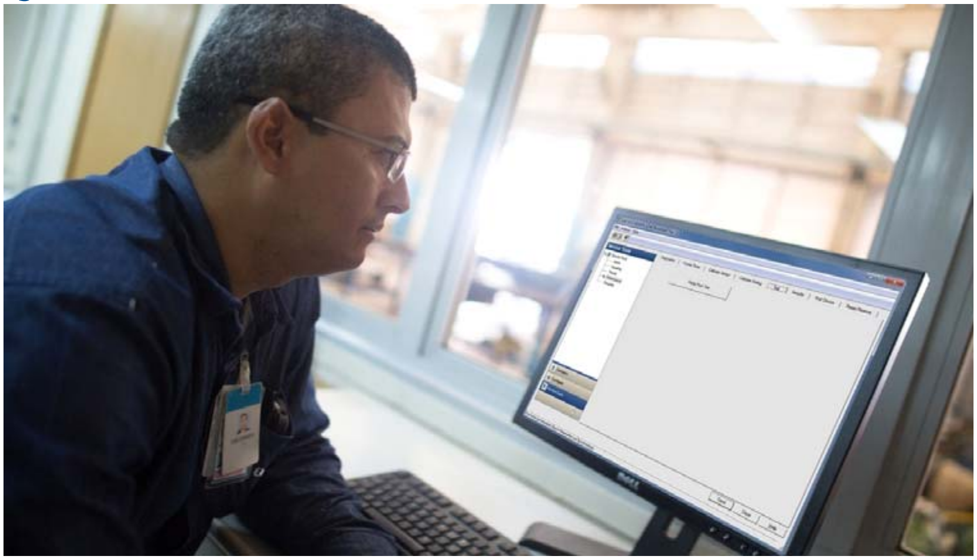
Reducing complexity

Having remote proof-testing integrated into the switch itself enables an operator to issue a command from the control room without the need to install a separate switching unit in the control panel. This integrated functionality is provided by the latest generation vibrating fork switch from Emerson, the Rosemount™ 2140:SIS Level Detector.

Figure 1-3.

Rosemount™ 2140:SIS Level Detector

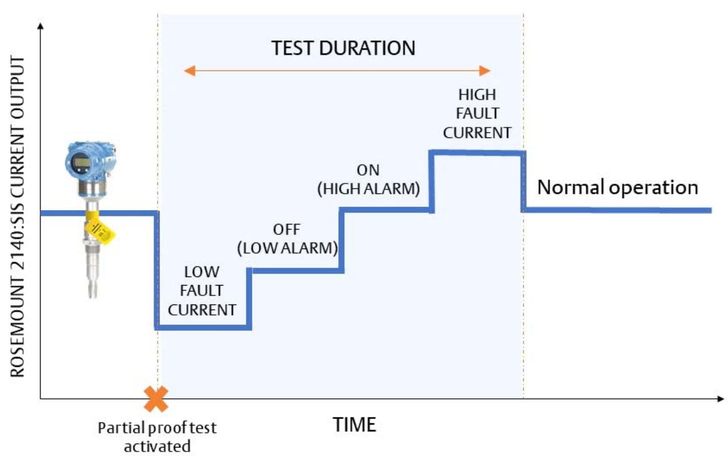
Figure 1-4.



Integrated functionality of Rosemount 2140:SIS Level Detector enables partial proof-tests to be remotely initiated by an operator issuing a command from the control room, without the need to install a separate switching unit in the control panel.

When the Rosemount 2140:SIS receives the command, it enters test mode, the fork frequency is simulated for on, off, and alarm conditions. The device enters test mode and cycles though the different current output levels verifying there are no faults preventing the device from switching from the on state to the off state, or vice versa. The test exercises the processing and output electronics of the device, and since it is performed in-process, it takes only minutes to complete the test cycle, thereby providing a significant time reduction compared to other proof-testing methods.

Figure 1-5.



On receiving the command from the control room to activate a partial proof-test at T=x, the point level detector enters test mode and cycles through its current output levels to verify correct device functionality before returning to normal operation.

On completion of the proof-test, a status is displayed within the control room to show whether it was successful or not. The device then automatically returns to operational mode, thereby eliminating the risk of it accidentally being left in test mode.

This integrated remote testing helps to reduce installation complexity by eliminating the need for extra wiring and control panel space and makes the procedure simpler and quicker to perform compared with the external switching unit solution. It is also possible to test multiple devices simultaneously via ‘multi-dropping’, saving even more time and resulting in significant operational cost savings. Furthermore, it provides significant safety benefits, as workers no longer need to enter a potentially dangerous environment to perform the test.

Conclusion

Modern methods of proof-testing increase plant and personnel safety and may provide cost savings. The remote partial proof-testing capability of the latest vibrating fork level detectors provides a safe, quick, simple, and cost-effective way to establish their integrity in an environment representative of normal operation. This method can enable full proof-test intervals to be safely extended to five or even ten years, thereby providing the freedom to schedule such tests around planned shutdowns and securing significant operational cost savings.

Various options are available as a means of remotely initiating a proof-test, but consideration should be given to which methods are easiest to use and reduce the risk of human error. Solutions using external switching units provide a means of remotely initiating partial proof-tests, but this method involves various extra complexities. In contrast, the latest generation of vibrating fork level detectors with integrated remote proof-testing functionality are less complex, reducing the risk of human error and saving maintenance costs.

Case study: Midstream Oil and Gas Company in North America

One of the largest full-service providers of midstream logistics in the United States was looking for ways to make efficiencies and reduce costs by upgrading the technologies it employs.

The company operates a large number of compressor stations across several sites, and each compressor has two to four scrubber bottles to eliminate any residual fluid from the gas stream before it enters the compressor. The company had been using float switches to provide a high-level alarm, preventing damage to the compressor, with a separate switch operating the dump valve to remove fluid build-up. They performed annual testing to verify that the high-level float switch was functional, and this testing required the unit to be shut in. The testing procedure was taking up to two hours to complete and involved removing the switch and immersing within a bucket of water to check whether it was operating correctly. This was resulting in lost time and production and required maintenance scheduling.

To optimize its scrubber bottle maintenance procedures, the company replaced these float switches with Rosemount 2140:SIS Level Detectors. The device's unique remote proof-testing capability enabled high-level alarm operation to be confirmed without having to remove the device and shut in the scrubber bottle or compressor, thereby saving maintenance time and reducing lifecycle costs. Instead, the remote proof-test can now be performed in-process – initiated either by pushing a button or issuing a HART® command – and is typically completed in only minutes rather than hours, as with the previous immersion method.

By installing 220 Rosemount 2140:SIS devices throughout its compressor stations, the company was able to free up approximately 1000 hours of maintenance time per year and reduce its maintenance budget by $264,000. Avoiding shutdowns enabled the company to increase profit by $1,144,000, and the project's payback period was approximately four months, with a return on investment of 28 percent.

To learn about the remote partial proof-testing capability of Emerson's Rosemount™ 2140 Vibrating Fork Level Detector, visit Emerson.com/Rosemount-2140-detector-vibrating-fork.

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