Point level switches for safety systems

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Point level switches are often used in applications designed to prevent accidents. Industries that manufacture or store materials that are potentially hazardous employ point level switches to protect people and the environment. These industries include Oil and Gas, Chemical, and Petro chemical manufacturing. Some examples of these safety switches are overfill - spill prevention, retention dike level alarms, and seal pot low level indication. These critical safety applications require careful consideration to make certain the best technology is provided for the given application. Technologies that are robust with few or no moving parts are preferred. Additionally, a procedure for testing the integrity of the switch is critical.

Figure 1: Preventing overfilling of chemical storage tanks requires proper selection of point level High High level switches.

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Providing safe and reliable facilities is a moral and financial responsibility. Accidents such as Buncefield 2005, Texas City refinery 2005, and the Elk River spill 2014 can and must be avoided. By providing safety systems and instruments to prevent or mitigate accidental spills and releases, we protect against injury to people, damage to equipment, environmental damage, and ensure that the availability of the process is maintained.

Due to the nature of the safety requirement for these point level switches, they are typically placed in a position where they should never be used. That is, for example, a switch for high level overfill prevention is located above the highest point the level should ever reach. These switches are often called High High level because they are above the stop fill high level instrument in the vessel (See figure 2). These High High switches may go for years without ever having the level reach them because reaching the High High switch is an accidental occurrence or noncompliant condition. Because of this, it is imperative that the safety switch has a means of testing on a regular basis to ensure it will operate in the event of an actual emergency. This test must exercise the switch to expose any potential failures and should not require raising the level to the switch point. Raising the level up to a High High switch can potentially cause a spill and therefore is considered bad practice. Raising the process to an unsafe level to test the safety of the process is very counter intuitive. It is also a specifically not permitted API 2350 (American Petrochemical Institute) recommended practices for above ground storage tanks. API 2350 states that High High level switches must be tested on a regular basis without raising the level to a dangerously high condition.

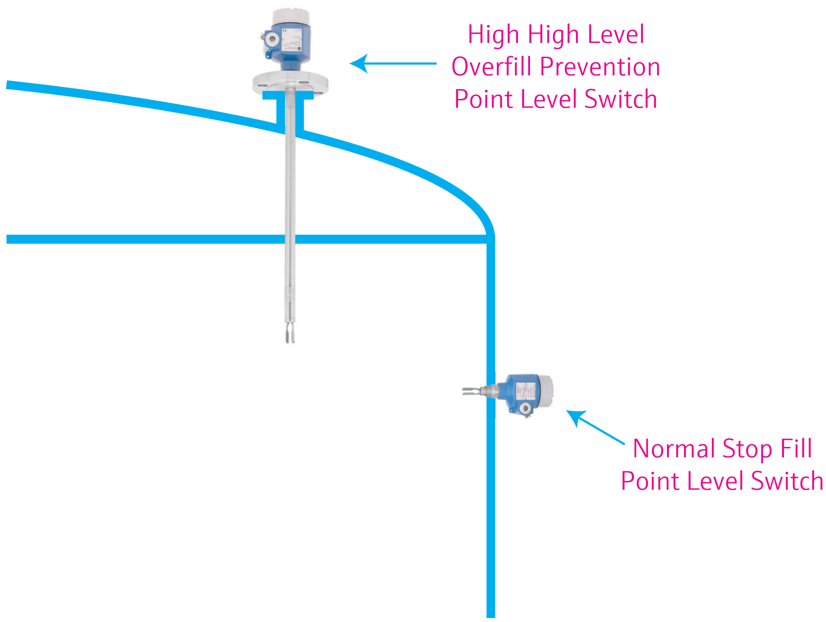

Figure 2: Located above the normal stop fill control, High High Level Switches may go for years without seeing the liquid in the vessel.

Depending on the type of point level switch being used, the only accepted method to ensure the performance of the switch may be to remove it from the vessel for testing. Removing a switch for testing incurs cost through downtime/lost production, personnel to remove the switch, perform the test, and reinstall the switch. There is also the concern that the switch could be damaged during removal and reinstallation or that the switch is not reinstalled correctly. Either of these would negate the test and the switch failure may not be detected. For these reasons, employing a point level switch that can be tested In-Situ (in place) should be the first choice for safety applications.

Testing the switch exercises the point level switch and may bring to light any potential failures. The intent is to validate the switch with the goal being to return the switch as close as possible to its original installed condition. That is, the switch should be validated to “New” condition or, as close as is reasonably possible. Conceptually, this refers to Probability of Failure on Demand (PFD). When a point level switch is first installed it has a low PFD. Over time the PFD increases. Testing the switch re-establishes the PFD to a lower number.

A good analogy of the PFD concept would be the purchase of a brand new car. You park the car in your driveway and retire for the evening. The next morning you get up and go to start your car. The expectation is that the car will start. This represents a low PFD. Now, leave that same car in your driveway for a year without starting it or performing any maintenance. Trying to start that car after a year may be difficult. This represents a higher PFD. PFD increases with time. Testing provides a way to return to a lower PFD.

Generally speaking, In-Situ testing may only validate a percentage of the potential failures. This is known as a Partial Proof Test (PPT). As such, the PFD recovery is dependent on the Proof Test Coverage (PTC). The PTC is based on the percentage of failures exercised by the proof test. The higher the PTC percentage, the higher the recovery and the result is a lower PFD. Since the partial proof test recovers a percentage of the PFD, it does not return to the entire original installed state. The result is that with each partial proof test the PFD will be a little higher after each test. To correct for this “drift”, a full proof test will be required after a determined number of partial proof tests. A full proof test will typically require removing the switch from the process for testing. Clearly, a point product with a high Proof Test Coverage will allow for a longer period of in-situ partial proof testing resulting in savings and process availability.

There are many point technologies available that can be used for level indication. Because of the critical nature of safety switches, some technologies are better than others for this task. Let’s take a look at some of these technologies and why they may or may not be good choices for safety applications.

Figure 3: The ability to test “In-Situ” validates the functionality of the safety switch while reducing maintenance and downtime.

Float Point Level Switch

Float switches, as the name implies, utilize a float which changes position due to buoyancy and indicates presence of a liquid. The float may move on a vertical shaft and trip a magnetically coupled reed switch or may pivot on an access providing a mechanical internal switch to activate.

The appeal of float switches is that they are simple devices and relatively inexpensive. However, the mechanical nature of a float and the moving parts that can hang up or bind due to coatings makes them questionable for use in safety applications.

The ability to test a float switch is also suspect. Some manufacturers provide a lift arm to physically move the float to make it change state from normal to alarm. This test is insufficient to exercise potential failures such as leaking floats and may not identify binding or heavy coatings. Some test arms are fitted with magnets that will release if the float is heavy due to leakage but, even this precaution is suspect. As such, the only true way to test the float switch is to remove it from the vessel for testing, as raising the product level to the high high switch is not permitted.

Floats are best suited for simple non-critical applications. Moving parts and the potential for a lack of buoyancy are critical failure points. From the standpoint of safety applications, floats should be avoided.

Ultrasonic Gap Point Level Switch

Ultrasonic gap switches are comprised of two piezo electric crystals situated on opposite sides of a gap. One crystal is excited electrically and generates acoustic energy that is directed across the gap towards the second crystal. With air or gas in the gap, the energy is not strong enough to reach the second crystal. Once the gap fills with a liquid the acoustic energy is coupled through the liquid molecules, reaches the second crystal and completes the circuit indicating that the liquid is present.

Ultrasonic gap switches have no moving parts to wear or hang up which is an advantage over mechanical switches such as floats. However in-situ (in process) testing of ultrasonic gap switches that validate all potential failures is not possible. Some manufacturers provide test buttons that are used to test the switch. This test operates in one of two ways. In some products there is a second set of crystals that are wired together. These crystals are in addition to the crystals used for the actual measurement and when the test button is depressed, an acoustic frequency travels from one crystal through a wire to the second crystal indicating a valid test. The pretense is that if the two test crystals operate properly, so will the measurement crystals. The second approach to this test is to increase the frequency on the actual measuring crystal which allows the acoustic energy to travel through the metal in the gap to the second crystal completing the circuit and validating the test. Neither of these tests address one of the most common failures in ultrasonic gap switches. That being coating of the crystal or plugging of the gap itself. Coatings in the gap or material plugging the gap will prevent the acoustic energy from crossing the gap and indicating when the liquid is present. Performing a valid test on an ultrasonic gap switch requires removing it from the vessel and testing it in a sample of the material in the vessel.

For these reasons, ultrasonic gap switches are best suited for general, non-critical level applications. They should not be used for High High safety / spill prevention applications.

Capacitance Point Level Switch

Capacitance point level switches are based on a capacitor. A capacitor is made of two conductive plates separated by a dielectric insulator. The capacity of the capacitor is based on the size of the plates, the distance between them, and the dielectric constant of the insulating material between them. In a capacitance point level switch, one plate of the capacitor is the active center rod of the sensing element, the second plate of the capacitor is the vessel wall or an added ground rod/ plate. As the material in the vessel rises it covers the sensing element and the capacitance increases. The output of the electronic unit changes state to indicate presence of material once the capacitance exceeds a preset switch point.

Capacitance point level switches have several advantages over previously discussed technologies. There are no moving parts to wear or hang up. Internal diagnostics monitor data such as the base capacitance. Reduction of the base capacitance would indicate a wiring failure or a sensing element that has lost mass due to damage or corrosion. Failures can result in a switch going into fault mode or activating an “alarm” contact.

One disadvantage to capacitance switches is that they require calibration. Initially the base capacitance needs to be balanced and then an additional set point capacitance is added. There are capacitance switches that “calibrate” themselves. These switches follow the same procedure with the exception that it is done internally in the electronic unit. If the calibration is not performed correctly it is possible that the switch will not respond to increasing material level in the vessel.

There are products available that incorporate testing features so in-situ testing can be performed to ensure the functionality of the switch. The Proof Test Coverage percentage for a capacitance switch partial proof test tends to be low. The result is that the intervals between a required full proof test tends to be fairly short.

Depending on the application requirement capacitance point level switches may be the best choice for a safety installation. This is particularly true of extremely viscous materials that coat sensing elements heavily. It is important to make sure the capacitance switch selected provides active coating rejection technology to compensate for the coatings.

Vibronic (Tuning Fork) Point Level Switch for liquids

Vibronic point level switches, also called tuning forks, operate by vibrating the fork at a specific frequency in the uncovered state. When process material covers the fork it causes the frequency to shift down indicating the presence of the liquid and changes the output of the switch.

There are a number of advantages to vibronic switches. First, vibronic switches are an active technology. Because they are constantly vibrating ,additional diagnostics are possible. The frequency of the fork is monitored to determine the covered or uncovered state. But, changes in frequency can also indicate damage or corrosion to the fork, heavy coatings, and objects jammed between the forks. Any of these conditions will result in a fault output. The electronic unit is constantly running self-test routines to identify these and other potential faults.

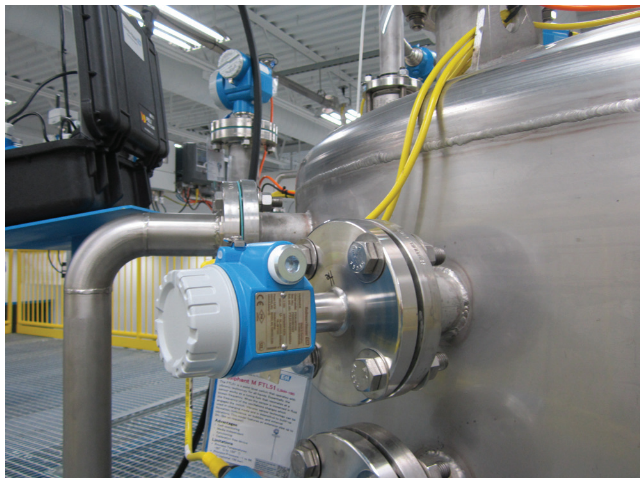

Figure 4: Vibronic point level switches are an active technology with constant self-check function to ensure functional integrity.

Some manufacturers have developed additional functions to ensure the operation of the switch in safety systems. One such function is to provide a live signal superimposed on the current signal. This live signal is constantly switching from one current to another and back. This switching current certifies that the current signal is not stuck and ensures that the current will shift when the fork changes from the uncovered to covered state.

Vibronic point level switches have no moving parts to hang up or wear out. Additionally, there is no calibration required so you can be sure the switch is set up properly.

Another advantage to vibronic point level switches is the ability to perform in-situ partial proof tests. The sophistication in design of these switches employs redundant circuitry along with the diagnostic capability previously discussed. These features added together result in an extremely high proof test coverage percentage. The high proof test coverage provides the ability to test in-situ for a number of years. Some manufacturers provide products that will not require a full proof test for as many as twelve years greatly reducing testing cost and ensuring process availability.

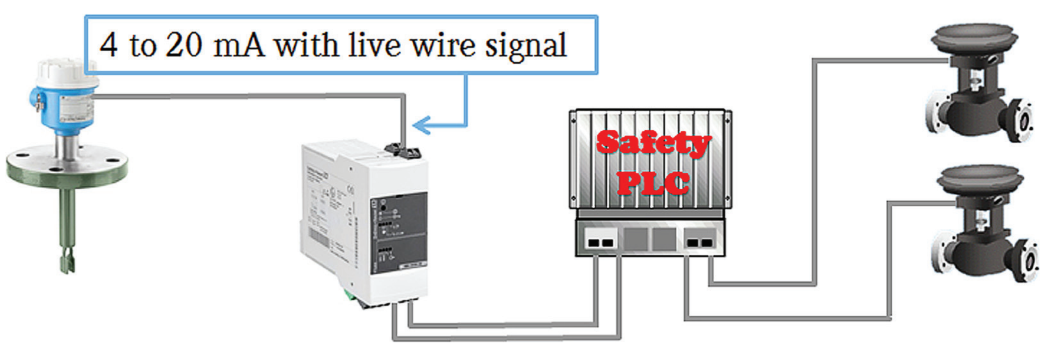

Figure 5: Vibronic Tuning Forks with continuous live signal provide the highest in reliability and maximum in-situ proof test coverage.

Some plants rely on continuous level technologies like free space radar, guided radar or ultrasonics to provide for overfill prevention or function as a point level device. Their thought process is that with a continuous level technology they would know if something was wrong with the transmitter as they have a continuous output. In reality it is possible that upset conditions in the process like foam, condensation, and build-up can lock up the signal to a false value. It should also be noted that API2350 states that instruments used to prevent accidental overfilling and spills must be separate from the instruments used for tank gauging the vessel. Using a point level switch for High High indication is recognized as a "Best Practice" and should be followed for safety overfill applications. The reliability of a point level with continuous live signal will exceed other technologies in demanding critical services. As always, the application will determine the best technology for safety devices.

Summary

There are many point level switches available in the market today. We have reviewed some of the most common types in this article. As we have discussed, some technologies are better suited for safety systems than others. Technologies with moving parts and those that cannot be easily tested are best suited for non-critical level applications.

From an overall standpoint of sophisticated diagnostics, ease of commissioning with no calibration, vibronic point level switches are excellent choices for safety systems. The extremely high proof test coverage and long intervals between full proof test requirements result in the highest cost savings and plant availability. From these standpoints, vibronic point level switches are the clear choice for most safety system applications.

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