Meeting Spill Prevention Regulations using RF Admittance and Ultrasonic Level Measurement Technologies

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Introduction

New Regulations have created liabilities and fines which far outweigh costs of spill prevention systems. These systems typically consist of high and high-high level alarms in conjunction with some final control elements and/or control interlocks. Since they are safety devices they are rarely called upon to do their job. The most important point is that alarm systems always works when something goes wrong. Compete reliability, even though they have not been called on to work for years, is essential. This presentation will explore the pros and cons of Floats, RF Admittance (Capacitance) Sensors and Ultrasonic Gap Switches. Guidelines for a complete spill prevention system are laid out.

Regulations from the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and National Fire Protection Agency (NFPA) and Recommended Practices from the American Petroleum Institute all require forms of spill prevention devices for aboveground storage tanks (AST's) containing materials which are hazardous to the environment or plant personnel, or flammable. Spill prevention devices are often regarded as tools to meet regulatory requirements, when they in fact are effective cost avoidance devices. Consider the costs which are incurred in a spill which could have been avoided with a high level alarm system: Loss of product, loss of production time, clean-up costs, regulatory agency fines, and loss of good will if the spill becomes publicized. When everything is considered, the cost of a spill prevention system far outweighs the risk of leaving aboveground storage tanks un-protected.

Regulations and Recommended Practices

The following are regulations and recommended practices for overfill protection are summarized below:

- API Recommended Practices
- NFPA 30
- EPA Oil Pollution Prevention Act of 1990
- Superfund Amendment & Reauthorization Act (SARA) Section 313
- EPA Stormwater Runoff Requirements
- EPA Spill Prevention Control & Countermeasure (SPCC) Plan
- OSHA Process Safety Management of Highly Hazardous Chemicals

American Petroleum Institute Recommended Practices 2350

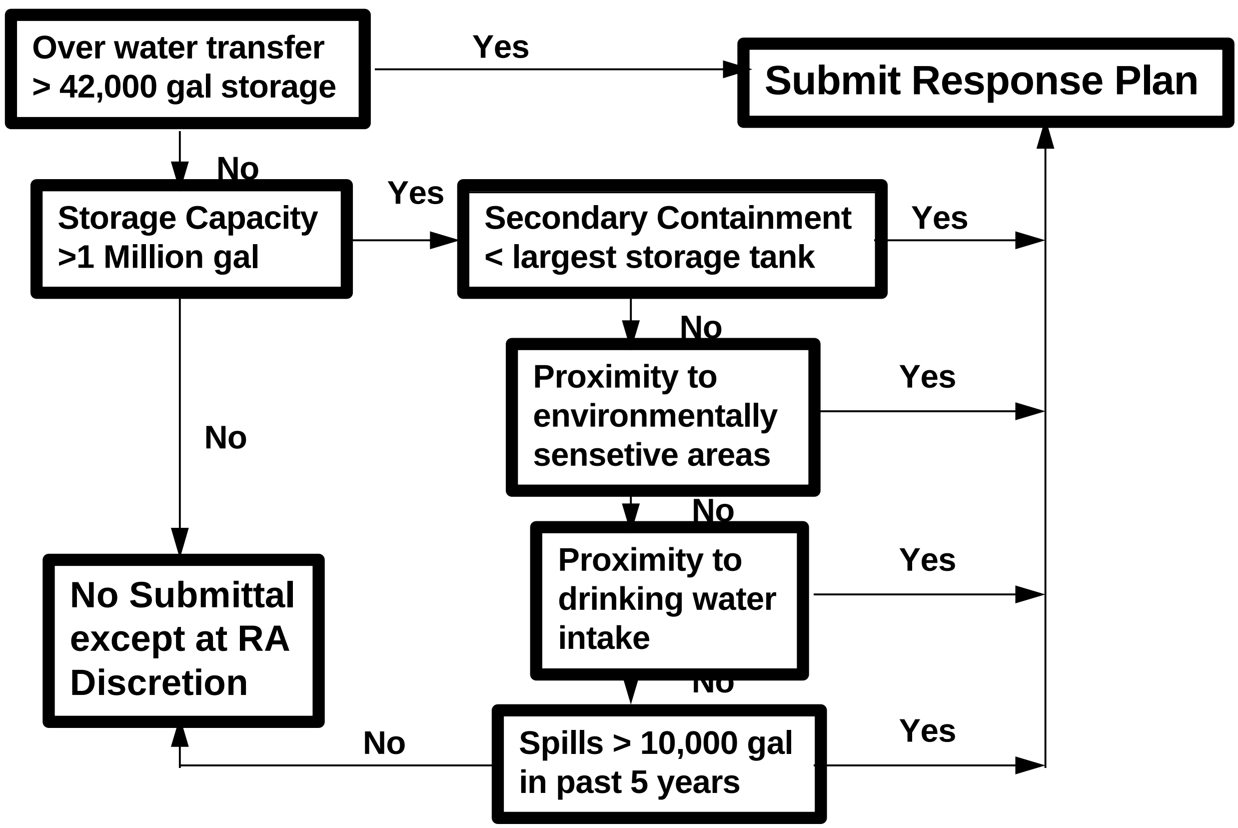
API 2350 may be considered the role model for many government regulations, and is referenced in several of these. Recommended practices state that for spill prevention , you should have high level alarm independent of any gauging system. "Testing should easily duplicate an actual high-liquid-level situation as closely as possible; however, the test should not require filling the tank above its normal fill level."

National Fire Protection Agency NFPA 30, Section 10.2 (Preventing of Overfilling of Tanks)

This regulation requires spill prevention measures for flammable and combustible liquids. Methods of protection include frequent personnel gauging, alarm sounding high level detection devices independent of any tank gauging equipment, high level detection device with automatic process shut-downs, and alternatives where approved by local authorities. Typically, local authorities have more stringent requirements than set by the NFPA. There must also be scheduled testing of high level detection devices.

EPA Oil Pollution Prevention Act of 1990

The Oil Pollution Act of 1990 requires companies which transfer oils and other hydrocarbons over navigable waters or which have oil and hydrocarbon storage in areas with runoff accessible to navigable waters, to have a plan for responding to a worst case discharge or “substantial threat” of discharge of oil or hazardous substance. The following decision tree is used to determine if your oil or hydrocarbon are considered a substantial threat and a response plan must be submitted.

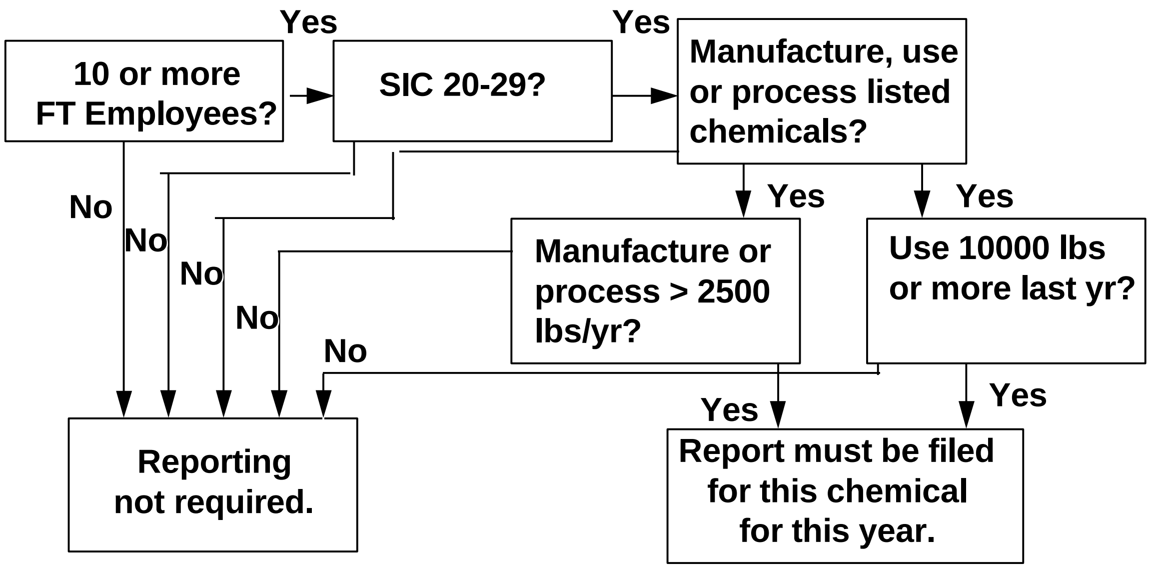


EPA Spill Prevention Control & Countermeasure (SPCC) Plan

SPCC’s, like most federal programs are implemented at the state level. Typical state regulations might require the registering of tanks which contain hazardous or polluting materials and the reporting of spills. A Downstream Notification Plan takes into account where a spill might travel to through rivers, lakes and underground water. Any companies and municipalities in the path of the escaped materials must be notified as soon as the spill incident has been detected. Any clean-up activities must then be handled by state certified clean-up organizations.

Superfund Amendment & Reauthorization Act (SARA 313)

Also known as the Right-to-Know Act, companies must file Annual Release Reports detailing any spilling, leaking...emitting into the environment of materials from its compiled list of hazardous chemicals. If a spill has occurred, source reduction activities which include installation of overflow alarms or automatic shutoff valves and improved procedures for loading, unloading, and transfer operations must be outlined to reduce the probability of spills in the future. Use the following decision tree to determine if your company has to comply with SARA 313.



EPA Permit Requirements for Stormwater Runoff

Stormwater runoff permits are issued by the states based on federal guidelines. These guidelines require companies to identify key individuals who are held responsible for complying with the permit. First, an assessment of the site, inventory, spill history, and discharge testing must be made to identify potential pollutant sources & risks. Then a site plan with Best Manufacturing Practices (BMP's) must be developed. This plan should include spill prevention and controls (Overflow controls leak detection devices) where appropriate. A schedule for periodic inspections or test of equipment & systems (Storage tanks, bins, pressure vessels) must be created and implemented and results of inspection must be tracked and records adequately maintained.

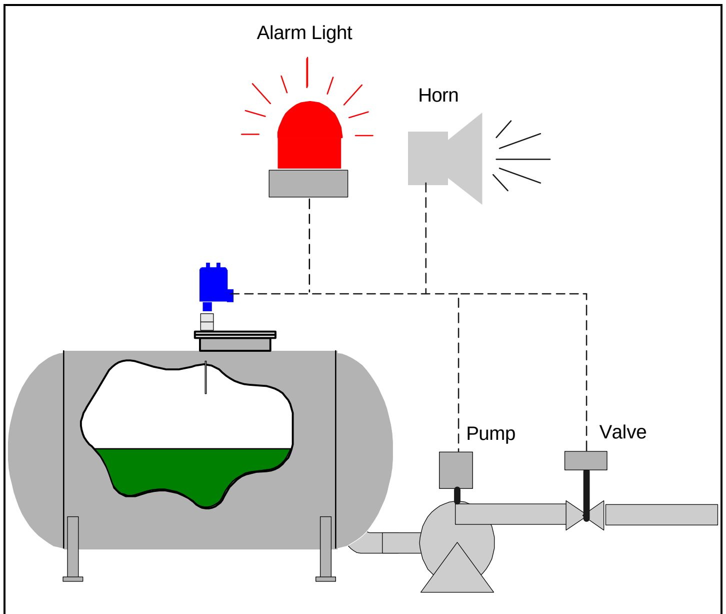
OSHA Process Safety Management for Highly Hazardous Chemicals

The Key to Process safety management according to OSHA is employee participation. The company in conjunction with its employees must identify all process safety information and conduct a process hazard analysis. Based on this analysis, operating procedures must be established and the information transferred to all employees through comprehensive training. This training should include a pre-startup safety review of the process. Management of Change must take into consideration an changes in the process which may affect safety considerations in the process. If a spill occurs, an incident investigation must be conducted within 48 hours of the incident.

Regulations Summary

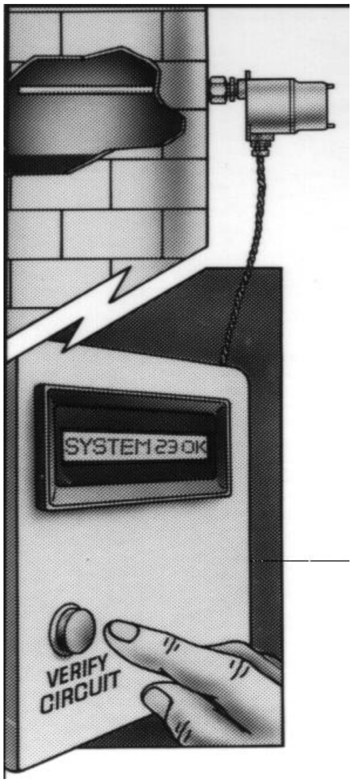
Many of the regulations outline what companies must do after they have had a spill. They also spell out fines and punitive measures in great detail. Many of the details on spill prevention and overfill protection are not spelled out. Regulators believe that the fines and punishments are enough incentive for private industry to determine the best way to avoid these situation in the first place. Following are viable solutions for spill prevention and overfill protection.

Spill prevention devices are high level alarms which protect aboveground storage tanks from spilling over. They detect the presence of level when it reaches a pre-determined dangerously high level. The systems have output functions ranging from an alarming horn or light causeing operating personnel to take corrective action to signals sent to control interlocks or final control elements, such as pumps and valves. In the latter case the corrective action is automatic and occurs electronically. A combination of these two alarm outputs is the most effective form of spill prevention. Automatic corrective action, such as a pump shutting down or a valve diverting flow in conjunction with a high level indication such as a horn or an indicating light, giving plant personnel notification of an abnormal process condition or potential emergency. **Frequently, alarms will go for years without being called on to work. The most important point is that the alarm system will work when something goes wrong.**



Spill Prevention System showing Final Control Elements

Both RF Admittance (Capacitance) switches and Ultrasonic gap switches meet high level alarm requirements, being independent of any gauging equipment. Both technologies claim to have some form of built-in testing features determining if a high level alarm system is functioning properly. This is important because during normal operation, a high level alarm condition is never reached, and may not be reached for years. So how do you know that the spill prevention device on the top of that tank will actually work when a high level reaches it?



RF Admittance (Capacitance)- Handles widest range of process conditions

It is important to differentiate between 2 terminal devices (often called capacitance) and 3 terminal RF Admittance devices. 2 Terminal Capacitance devices may experience false alarms due to drifts in the alarm set point, caused by temperature changes and time. These systems are unreliable and cannot be depended upon. 3 Terminal RF Admittance devices are temperature stable and also ignore the build-up of coatings, another problem for 2 terminal capacitance devices.

RF Admittance devices detect a change in the amount of capacitance exhibited by the medium between the sensor and the tank wall. The tank itself is turned into a measuring capacitor with one plate of the capacitor being the sensor and the other plate being the tank wall. The capacitance generated by this "overgrown" tank capacitor is compared in the electronics to a calibrated tuning capacitor. If the capacitance "seen" by the electronics is larger than the tuning capacitor, level is present. When air is between the two "plates" the electronics attached to the sensor "see" a very low capacitance. When the level comes in contact with the sensor, the electronics "see" a much higher capacitance. This higher capacitance is enough to trip the system into alarm and cause the spill prevention system to jump into action.

The RF Admittance device is an electronic device which has no moving parts and needs no maintenance. It can measure liquids, slurries and granulars for spill prevention. To insure that the system is functioning and able to complete its task during a high level condition, these systems are equipped with verify circuits which simulates a high level. This circuit adds capacitance to the sensor electrically, and simulates an identical capacitance signal which an actual high level would produce. With this high level simulation, an alarm should occur and cause the entire spill prevention system (including final control elements) to react. Should the verify simulation not cause an alarm, the system is not functioning and ready to react to a high level condition. Possible causes for failing a verify test include:

- Loss of sensing element (disconnected from electronics)
- Corrosion of connecting terminals between sensor and electronics
- De-tuning of the electronics calibration
- Mis-wiring of the electronic unit or sensor, or
- Simply a bad electronic unit

The verify test is an on-demand test which allows an operator to test a spill prevention system prior to filling a tank. But how do you know that this system is still ok after the test is completed? You don't...until you test it again. The market has demanded a spill prevention system that not only can be tested on demand, but should continuously test itself. The solution is an automaric verification system, which simulates a high level on the sensor every 10 seconds. The simulation causes the electronics to detect a high level during the test, but not to activate any relay outputs. Otherwise, alarms and final control elements would be activated every 10 seconds, becoming a nuisance within minutes. Any continuous self-checking system only tests the electronic unit and possibly the measuring sensor, but not the full spill prevention control system and therefore does not meet the intent of regulatory requirements and recommended practices. For instance, the alarm may be disconnected from the alarm relays of the electronic unit, but since this part of the control loop is not tested, an automatic verification test does not guarantee that the full control loop will be activated during a high level alarm condition. You still need an on-demand full system testing option, which is available with AutoVerification of some RF admittance devices.

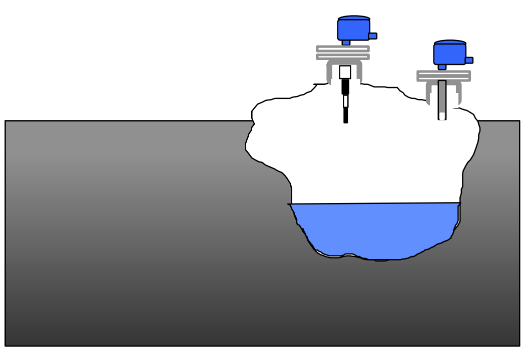
Ultrasonic Gap Switches

Before ultrasonic gap switches are discussed, we must differentiate between three different types, only one of which is completely reliable. The three are 1. Gap switches with gain adjustments, 2. Gap switches without gain adjustments, and 3. Gap switches without gain adjustments and reliable self-checking circuitry. First, be aware of any gap switch with adjustments or gain type controls. These adjustments allow for calibration error, which could cause false alarms or actually ignore a high level. These systems are not 100% reliable. Secondly we have Gap switches without gain controls. This system is better than the previous, but still not absolutely reliable. The technology of the gap switch is inherently a low level fail-safe device. The measuring circuit (a feedback loop) is active when liquid is present in the gap and passive when a low level occurs. For this reason, it is imperative to use the third category of gap switches: No gain control and built in self-checking circuitry to insure that a high level fail safe gap switch is truly reliable.

The point level ultrasonic device is probably most commonly called a gap switch because of the appearance of the sensor. Ultrasonic gap switches are also electronic instrumentation, which require virtually no maintenance, and in this case absolutely no calibration. The gap switch works by the transmission of acoustic energy from one side of a gap in the sensor to the other. Two piezo electric crystals are mounted and sealed into a metal tube with a slot or “gap” in the end. An acoustic signal is applied to one of the crystals. If there is liquid in the gap or slot the energy is transmitted to the other crystal which controls a relay. If there is air in the slot the energy is not transmitted and the relay is not tripped. Since the gap trips on liquids and ignores air, no electrical or chemical changes in the liquid affect the unit and no calibration or gain adjustment is needed. This makes it a very easy and reliable instrument to install. Screw it into the tank, connect all wiring and you are done. There is no dependency on the instrumentation personnel or operations personnel to calibrate this system.

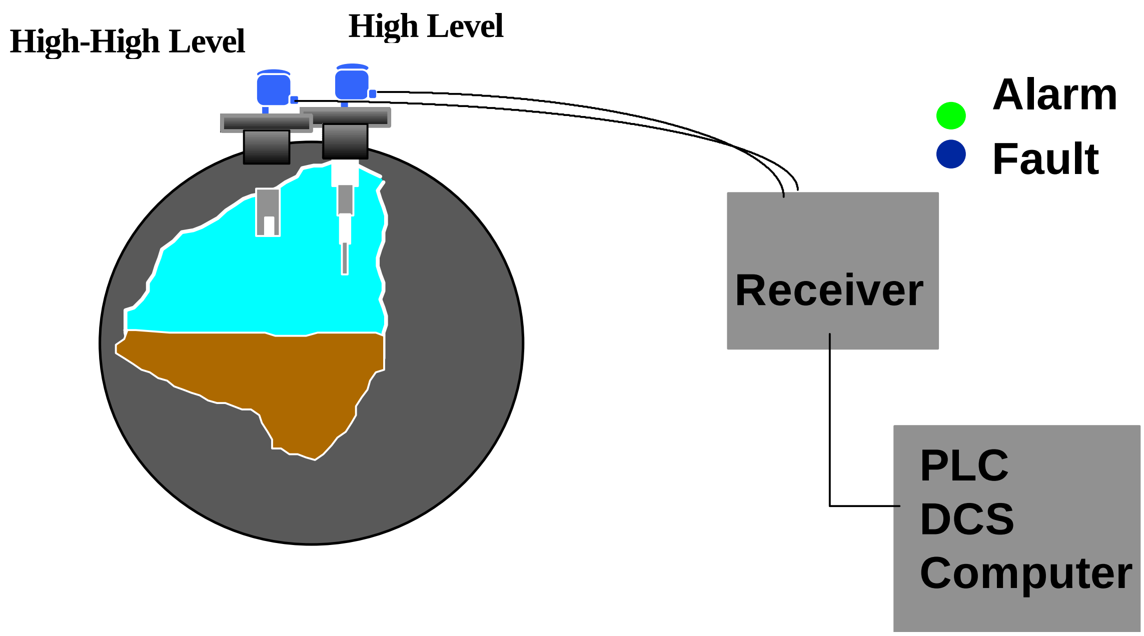
The gap switch also has a verify circuit of its own, which simulates a high level condition and tests the electronics and complete control loop for spill prevention. The ultrasonic version of the verify concept is a two part test, which first tests the integrity of the crystals, insuring that they are connected to the electronics and fully bonded the gap walls. If the crystal integrity is proven, then all of the components of the measuring circuit are checked.

The Complete Spill Prevention System



Everyone knows that sooner or later everything will fail. In the event of a failure of any part of the spill prevention system, a fault alarm should result, stopping the fill of a tank. The system for spill prevention must be absolute. API recommended practices state that “A Spill Prevention system should be easy to test. The testing should duplicate an actual high-liquid-level situation as closely as possible; however, the test should not require filling the tank above its normal fill level.”[i] This means that the system, which should be independent of any gauging system, should have a reliable verify feature. For critical applications, industry experts recommend using high and high-high alarms, preferably of different technologies. The idea is that if a condition exists within the tank which could cause one technology to fail, it would be possible that the other technology, making a measurement on different principles, may not be caused to fail under the same process conditions. The most reliable among the commonly accepted technologies are RF Admittance sensors and Ultrasonic Gap Switches. RF Admittance devices have a broader band of applicability. They can be used for liquids, granulars and slurries, where the gap switch is only recommended for clean liquids. High temperature and pressure would also favor the RF Admittance technology. The major advantage of the gap switch is that it does not need to be calibrated, removing the possibility of human error during calibration. For clean liquids, the gap switch is the preferred technology. By using the RF device as a high level device and the gap as a high high device, you have created the safest spill prevention control available on the market, given todays technologies.

It is also possible to use both of these instruments in the loop powered (4-20mA output) form. Two-wire 4-20mA systems add the additional benefit of intrinsic safety, centralized control and overall lower installation cost when compare to line-powered instrumentation.



[1]API Recommended Practice 2350, Overfill Protection for Petroleum Storage Tanks, Section 4.7.1.