Overfill prevention and leak detection in chemical storage vessels

Companies setting up a spill prevention, control, and counter measure plan often need to update their instrumentation

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In most industries that manufacture, use or store chemicals and other hazardous liquids, a Spill Prevention, Control, and Counter Measure plan (SPCC) is required as part of the normal operation for storage vessels (Figure 1). For industries where it is not mandated or required, it is clearly a best practice to incorporate an SPCC plan into the standard procedures of the facility to prevent possible injury to personnel, damage to facilities, and contamination of the environment.

As the name implies, an SPCC plan is designed to first prevent a spill from happening, control a spill if one happens, and employ counter measures to mitigate the damage and extent of the spill. All this usually requires the installation of new or an upgrade of existing level instrumentation.

Figure 1: Spill prevention in these chemical storage tanks usually requires improved level instrumentation

Overfill Prevention

The best solution to mitigating the damage and extent of spills is to prevent them from happening in the first place. Instrumentation exists to monitor the contents of the vessel and provide an alarm in the event of an overfill event or leak. These products have been used for years and are well established and reliable.

High level overfill prevention switches such as vibrating tuning forks (Figure 2) provide an alarm when the material in the vessel reaches a dangerously high condition. This switch is often called a high-high level switch as it is mounted above the high level switch used to indicate the normal stop fill point of the tank. If the high level switch fails, the high-high level switch is there to prevent the tank from overfilling. High-high level switches should include a function test feature to ensure integrity.

Figure 2: A high-high level switch, such as this Endress+Hauser Model FTL81, is mounted above the level switch that detects the normal maximum fill point. The FTL81 can be tested in-situ to ensure proper operation

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Because high-high level switches are mounted above the normal maximum fill point, they can be in service for years without activating from a high level. Therefore, the ability to test the switch and verify functionality is critical. Testing these switches on a regular basis to ensure their integrity should be part of the SPCC spill prevention plan.

However, raising the process to an unsafe level to test the switch is not a good idea. It is also specifically not permitted according to API (American Petroleum Institute), API 2350 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.

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. This is typically done in a bucket test, where the switch is immersed in process liquid to ensure it works. Removing a switch for testing incurs costs due to downtime and lost production—and personnel must be available to remove the switch, perform the test and reinstall the switch.

The switch could be damaged during reinstallation, and it may not work correctly when reinstalled, negating the test. For these reasons, it's better to use a point level switch that can be tested in-situ (in place) for these and other critical safety-related applications (Figure 3).

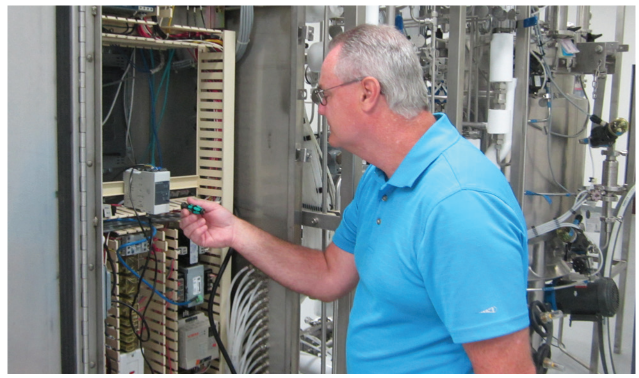

Figure 3: The ability to test a Model FTL81level switch "in-situ" from the control room validates the functionality of a high-high switch while reducing maintenance and downtime

Some plants rely on continuous level technologies like free space radar, guided wave radar or ultrasonic transmitters to provide overfill prevention. Their reasoning is that with a continuous level measurement they would know if something was wrong with the level instrument—but upset conditions in the process like foam, condensation and build-up can cause false readings.

For this and other reasons, recommended best practices dictate instruments used to prevent accidental overfilling and spills should be separate from the instruments used for gauging the vessel level.

There are a number of level switch technologies for high-high overfill prevention applications including vibrating tuning forks, capacitance, ultrasonic gap switches, floats, etc. It's important to make certain the technology selected for the high-high switch is appropriate for the application and, as previously indicated, can provide a functional in-situ integrity check to ensure it will operate in an actual emergency.

Even the best overfill prevention plan can sometimes go wrong, resulting in a spill. Vessels, pumps, pipes, valves and fittings can also leak. It's important to be able to detect a spill or leak as quickly as possible to mitigate the extent of the release and potential damage.

Leak Detection

The first line of defense in vessel leak detection is a continuous level instrument. The level instrument must be very accurate to provide an indication if the level decreases when the liquid in the tank is not actively being lowered. If the level starts to decrease during inactivity, it would indicate a leak in the tank, and the monitoring system could then provide an alarm.

For example, in a 10-meter diameter storage tank, an unexpected drop in level of just 3 millimeters represents about 235 liters of fluid that has leaked out.

Because of this, accuracy needs to be measured in fractions of millimeters. Radar level gauges (Figure 4) can provide accuracy of 0.5 millimeters. For many hydrocarbons and chemicals, it's important to include temperature compensation as part of the tank gauging instrumentation. This is required because the volume of many hydrocarbons and chemicals expands or contracts with changes in temperature. Without compensation, these changes in volume will look like changes in level when, in fact, the actual contents of the tank have not changed. Accuracy of the temperature measurement is very important in providing proper compensation. Temperature sensors with multiple measurement

Figure 4: An accurate level instrument, such as this Endress+Hauser radar level transmitter, can detect when the level is dropping during inactivity, indicating a leak or spill

points and accuracy of 0.1 degree centigrade are required for this application.

Using a software program to monitor the level instrument measurement is the best way to detect these small changes and determine when the level is dropping when it shouldn't, alerting operators of a possible leak or spill. Modern PC-based tank monitoring software, such as Endress+Hauser's Tankvision, has this capability.

Watching the Dike

The second line of leak detection is to provide a level switch inside the retention dike. Even rain water accumulating after a storm should be detected as it's necessary to remove this water to maintain the volume of the dike at an appropriate amount in the event of an actual spill or leak.

Essentially, any accumulation of liquid within the dike, be it water or a chemical, requires a response. As such, switches to reliably indicate any liquid, such as tuning forks, are best suited for this application.

There are also specialty instruments that can not only indicate the presence of the liquid within the retention dike, but can indicate if the liquid is conductive or nonconductive. This helps determine if the liquid is accumulated rain water, or a spill of a hydrocarbon or nonconductive chemical. An example of this type of instrument incorporates two level switch technologies mounted on a float (Figure 5). By combining a vibrating tuning fork and a conductivity switch, it is possible to indicate what liquid is present.

When the dike is empty of all liquid, both the tuning fork and the conductivity switch report an absence of liquid. If the dike is full of water, both the tuning fork and the conductivity switch indicate liquid presence. This assumes the water is conductive, as is typically the case in retention dikes due to the accumulation of rain water. When the dike is filled with a nonconductive liquid, the tuning fork shows presence of a liquid but the conductivity switch does not, indicating a spill or leak of a hydrocarbon or a nonconductive chemical.

If there is an accumulation of rain water and a spill of a nonconductive liquid occurs and floats on the surface of the water, the floating design of the sensor assembly still indicates the nonconductive liquid.

Figure 5: The Endress+Hauser Model NAR300 leak detection switch combines vibration and conductivity detection to provide indication of conductive and nonconductive liquids

Control and Counter Measure

Clearly, the quicker a spill or leak can be identified, the faster the facility can control the incident and respond appropriately. The level instruments reviewed above can provide this early indication. Once an incident occurs, a well-defined response to mitigate potential damage is required.

To ensure a proper response, planning and training prior to an incident is required. A risk assessment of each storage vessel's contents and the potential damage that a spill or leak could produce needs to be considered, and the plan needs to react to each type of hazard. Personnel need to know how to respond, and know what equipment is at their disposal to mitigate the incident.

Equipment would include spill clean-up products, floating dikes, absorption material, pumps to move vessel contents to a safe storage vessel, etc. Along with the facility's personnel, notification of regional emergency groups and authorities should also be included. A well-planned and well-practiced response plan will limit the damage and reduce the hazard.

Tank inventory management software can help in this regard. For example, the software can detect the leak or spill, and direct emergency procedures such as shutting off pumps, alerting personnel and documenting the spill.

Summary

The primary goal of an SPCC plan should be to prevent spills from happening. Proper selection of instruments for overfill prevention provides the best solution to prevent spills. A procedure for testing these high-high level instruments is imperative to ensure the switch will operate when needed.

Using tank gauging instruments to watch vessel contents for level changes is the next objective, as this will detect leaks and minor spills. Prompt notification of a leak or spill will allow for a rapid response and limit the damage.

Monitoring liquids accumulating in the retention dike will provide a timely indication that an incident has occurred so a response plan can be quickly executed.

Finally, a comprehensive response plan and training will reduce the severity of the incident damage to a minimum.

About the Author

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