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STATIC/LIGHTNING PROTECTION FOR TANKS

On occasion in our industry, certain types of tanks explode or catch fire, sometimes, but not always, during electrical storms. These tanks include SWD, produced water, frac tanks and distillate tanks. The problem occurs with steel, lined-steel and fiberglass tanks. The two possible causes of these incidents point to static discharge and/or lightning. Lightning may be the cause of some incidents, but it is not the likely culprit in most cases. It is unlikely that lightning attachment caused burn-through or heating ignition of vapor in these tanks. Therefore, the most likely cause is static discharge. The source of static may be the result of normal operations such as filling or draining, or it may be secondary effect from a direct or nearby lightning strike. Secondary effect arcing is also static discharge, albeit high energy and occurring over a short time frame. This arcing is produced by the inrush of ambient ground charge toward the point of a lightning strike. The inrushing charge can arc across gaps in its path, thus providing both a static charge and a static discharge. Therefore, the ideal protection system would address both causes.

PROBABILITY VERSUS CONSEQUENCES

The probability of this type of incident is unpredictable. It could be years between incidents or years without incidents, followed by a single or series of catastrophic events. The consequences of this type of incident include lost production, the cost of replacement, the damaged facility, environmental impact and clean up, and bad press, especially if the subject tanks are located in a populated area or a local fire company responds.

CONDITIONS LEADING TO IGNITION

According to API 2003, A.7, in order for an electrostatic charge to become an ignition source, four conditions must be met:

1. A static charge must be generated
2. The charge must be accumulated to the level at which it is capable of producing a incendive spark (A.6.2), that is, a spark with adequate energy to ignite
3. An appropriate gap across which the accumulated charge may arc (source of ignition),
4. An ignitable gas mixture must be present around the source of ignition

SOURCES OF STATIC CHARGE (RUB TWO MOLECULES TOGETHER)

The primary source of static charge appears to be turbulence from mixing fluids either from through pumping, particularly through non-metallic pipe, or from filling, especially splash filling with the falling fluid penetrating standing fluid. Air/foam injection to increase flow rates may also be a primary source. A secondary source may be bubbling of the air/gas mixture. This leads to a suspicion that the boundary layer between the liquid and gas may play an expanded role in this problem. There are also miscellaneous sources such as clothing on people. This factor is humidity sensitive similar to touching a doorknob on a dry day, and the charge does not usually build to the level where it becomes incendive.

ACCUMULATION OF STATIC CHARGE

Charge dissipates from a fluid into points and sharp edges, not flat surfaces. That is why charge does not readily dissipate into the shell of a metal tank — it is flat. This allows the charge to accumulate at a rate faster than it dissipates. The presence of a carbon veil in a fiberglass tank does not accelerate charge dissipation. It still presents a flat surface to the bound charge on the liquid. An epoxy-lined steel tank is similar to a fiberglass tank regarding static charge dissipation. Because the static charge eventually relaxes, an incendive spark is most likely while the charging mechanism is active.

SOURCE OF IGNITION (SPARKING)

When the static charge exceeds the dielectric of the intervening medium, the medium breaks down and a potential equalizing arc occurs. The arc may occur between masses of inductance such as piping, fittings, the thief hatch and its collar (if it's loose enough to rattle, it's loose enough to arc), electronic sensors on the tank, and vacuum trucks, or between the bound charge on the stored protect and any of the above.

IGNITABLE MIXTURE

The likely source of gas is the "Coca Cola" effect. Gas is suspended in the fluid underground. When it reaches the wellhead, the reduction in pressure allows the gas to escape much like carbon dioxide escapes from Coca Cola when you first open the can. The turbulence involved with further handing allows more gas to escape, much like drinking Coke through a straw, then blowing it back into the can and drawing it out again. Splash filling, while helping to accelerate molecular breakdown and speeding the separation process, also allows additional gas to escape. Air/foam injection to increase flow rates also generates gas. To allow combustion, oxygen must be available in sufficient concentration. Oxygen may enter the tank from atmospheric vents or from a thief hatch left open. Oxygen may be introduced to prevent a vacuum in the tank during the process of emptying. Therefore, the conditions for combustion may be high just after a tank is emptied, as static has been generated by the flowing liquids and oxygen that have been introduced into the system.

LIGHTNING CAUSED IGNITION

Ignition due to lightning is caused by the ground charge induced by the cloud base charge on the surface of the earth beneath the storm. The storm cloud generates charges within the storm cloud, and a charge on the base of the cloud. This charge induces an opposite charge on the surface of the earth beneath it. The attraction of opposite charges attempts to pull this ground charge off the surface of the earth, so it is dragged along the surface of the earth beneath the cloud. When lightning strikes the surface of the earth, it relatively vacates the ground charge at the point of the strike. The surrounding area remains highly charged, so the remaining ground charge flows toward the point of the strike. If this inrush of charge crosses a gap, it may arc. This all happens very quickly, with the storm cloud providing the source of the charge and a sufficient accumulation of charge to form an incendive spark. The tank structure and appurtenances provide the source of ignition and the ignitable mixture.

SOLUTIONS

The most common lightning fix is a catenary (overhead wire) system. This system consists of grounded masts or poles supporting a wire or wires over the site. Based upon the above description of the problem, this system is far from ideal. The catenary wire is intended to "get in the way of" a lightning strike and convey it to ground. When used to protect tanks and similar structures this system cannot mitigate secondary effect arcing — the primary cause of ignition. In fact, if a catenary performs exactly as designed, it brings the lightning energy to ground near the base of the tank, thereby maximizing the likelihood of secondary effect arcing across the tank and appurtenances. The catenary system has no effect on the bound charge on the stored product, does not provide bonding to miscellaneous masses of inductance on the tank, and does not affect the likelihood of a direct strike by influencing streamer formation. Other solutions to control the conditions necessary for an electrostatic charge to become an ignition source have been tried, but none have proven totally adequate.

NEW APPROACH

The wild card in tank protection has always been equalizing the bound charge on the stored product. Charge dissipates from a liquid onto points and edges. In a steel tank there are no points and edges to help dissipate the bound charge on the stored product. The liquid simply lies against the side of the tank and the charge must inductively couple onto the flat surface. It takes time for the potential to relax, allowing the static charge to accumulate faster than it dissipates. A remedy for this condition on a steel tank is an in-tank static drain consisting of a stainless steel cable with stainless steel electrodes inserted into the wind of the cable. This type of drain, installed through the thief hatch and secured to the top of the tank, introduces thousands of electrically sharp points into the stored product, offering a low-resistance path for bound charge to leave the liquid and vapor space. It "sucks the charge" out of the product, allowing it to relax much more quickly. This allows the charge to dissipate faster than it accumulates. On a steel tank, the only additional bonding required is a jumper between the thief hatch and collar. A solution for fiberglass tank protection is to install a conductor system that bonds the top vent pipe or manifold, the in-tank static drain, thief hatch collar, walkway handrail system, and tank conductive elements such as a carbon veil and the drain pipe, at the base of the tank.

The bonded mass of the tank system is then electrically bonded (grounded) through existing electrically continuous metallic piping or with dedicated conductors on non-conductive piping to the injection well, truck load-out, and site electrical service ground. This brings all site components and structures to the same potential and to ground potential, thus reducing the possibility of arcing. Truck drivers should be trained to bond their trucks to the site bonding system without exception. The truck bonding system may consist of a retractable reel grounding wire, or may be as simple as a flexible cable with a spring pressure clamp attached to its end. In either case, provide a means of strain relief to compensate for the driver who drives away with the grounding clip still attached to the truck.

CONCLUSION

In controlling the problem, it is generally only possible to mitigate — not eliminate — the production of a static charge and the creation of a flammable mixture. So consider implementing a system for steel and fiberglass tanks that dissipates the charge, bonds all the masses of inductance, and includes air terminals. It certainly will enhance the safety of employees, contractors and the public.

ABOUT THE AUTHORS: Alan Roachell is currently the HSE director for both Rosewood Resources and Advanced Drilling Technologies (ADT). He received his bachelor of science degree in occupational safety and health from Columbia Southern University and is accredited as a board certified safety professional. Roachell is an innovative leader in the HSE arena and has been recognized for his work on many occasions. He has contributed to the safety profession on many topics and feels his most important work is researching and developing

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