A new era in tank protection

When Lightning Eliminators invented the Retractable Grounding Assembly (RGA) at the beginning of the new millennium, it was received with accolades. Once patented in 2006 – the RGA has been installed in thousands of tanks worldwide and it has attempted to be copied by several vendors around the world.

Over the past 16 years with the advent of new materials, substances and processing – new challenges have arisen in the storage of volatile liquids and the tanks that house them. With the growth, changes and technologies, throughout the petroleum and related industries, it became clear that Lightning Eliminators needed to grow and change with the times and environments. With input from our customers, our engineers, experts and scientists, Lightning Eliminators has taken all the variables into account and has been able to enhance the RGA to better fit the demands of storage operators today.

The original RGA 75 and RGA 55 models will soon be a thing of the past. Although stellar products, which have shown huge success and are working in tanks around the world, a new era of the RGA is here.

In June, Lightning Eliminators (LEC) will release its new, optimised RGA 750.

New features of the RGA 750

- One size fits all
- Designed with stronger springs to retract the cable, resulting in an average increase in retraction force over the entire cable payout range of 340% over the RGA 75 and 600% over the RGA 55. In addition, also reduces twisting and flexing of the cable caused by wind
- Employs aluminum cable originally developed for marine use which will greatly improve corrosion resistance and is highly resistant to hydrogen sulfide (H_2S) and meets API 545
- Pre-tensioned at the factory, reducing the complexity and time required to install the unit
- Weighs less due to the use of aluminum cable

Material performance for tank bonding cables in a hydrocarbon environment

Floating roof tanks (FRTs) are commonly used in the oil and gas industry to store various petroleum products. The roof of these tanks floats directly on the stored product to minimise vapour space and loss, and correspondingly rises and falls as product is pumped into or out of the tank. A non-conductive rubber/fabric seal is utilised at the roof-tank shell interface in order to contain the vapours.

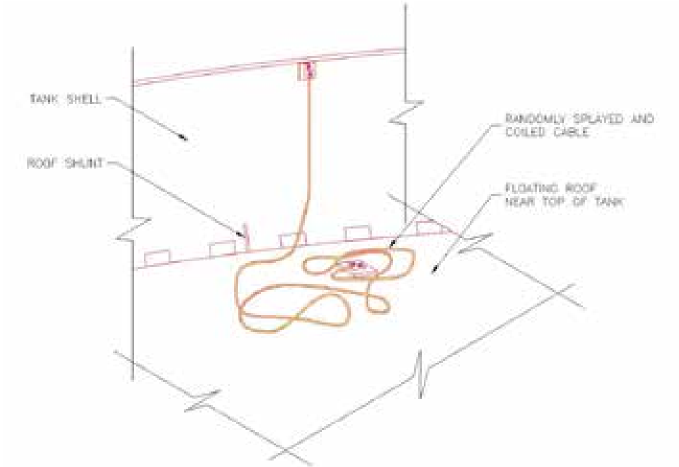
Although the roof positioning system (scissors, shoes, etc) is made of metal, product, rust and waxy residue on the tank shell has the effect of electrically isolating the floating roof from the shell. During a direct or nearby lightning strike, high electrical currents will flow in all directions from the strike termination location and attempt to bridge the electrical gap between roof and tank shell.

If a low resistance path is not available between the tank shell and roof, then a spark may be created which could ignite flammable vapors and ultimately lead to a catastrophic fire or explosion. Historically, shunts and static bonding cables have been used to electrically connect the roof and tank shell, but shunts frequently lose contact with the shell and will produce sparking across the shunt/shell gap when transferring lightning currents.

Typical shunt which has lost contact with tank shell

Traditional static bonding cables must necessarily be long enough to accommodate the lowest position of the roof, are therefore not of the shortest possible length or lowest possible resistance, and are subject to entanglement and breakage.

To address this bonding challenge, LEC developed the Retractable Grounding Assembly (RGA) in 1999.



Static bonding cable randomly splayed and coiled on tank roof

Since its introduction, the RGA has evolved to increase functionality, effectiveness and lifespan. A new model, the RGA 750, has now been developed that offers significant upgrades in corrosion resistance and cable longevity.

Electrical cables in a hydrocarbon storage environment

Electrical bonding cables in an FRT storing volatile petroleum products must offer low resistance and sufficient longevity in a harsh environment. While bare copper provides a very low electrical resistance, it is susceptible to corrosive attack from the stored product, any released vapors, natural atmospheric elements such as chlorides and complex combinations of all of the above.

Petroleum products inherently and naturally contain sulfur, either bonded to carbon atoms or in the form of hydrogen sulfide (H_2S) gas. Natural gas itself may contain up to 90% H_2S. The amount of sulfur found in crude oil determines whether the oil is classified as 'sweet' or 'sour'.

By definition, sweet crude oil contains less than 0.5% sulfur, while sour crude contains more than 0.5% and will have a higher concentration of hydrogen sulfide gas. H_2S is a colorless, highly toxic and corrosive gas which smells like rotten eggs at lower concentrations. It may escape past an aging or poorly maintained seal, and can accumulate in the semi-confined space formed by the foam dam and tank shell as the gas is heavier than air.

H_2S attacks copper by forming thin layers of sulfides on the surface of the material. These surface sulfides are cathodic to the underlying copper, further magnifying the corrosion process. The copper sulfidation process progresses rapidly, resulting in copper sulfides and hydrogen gas, as shown in the chemical equation below.

$$Cu + H_2S \longrightarrow CuS + H2$$

In addition to direct loss of material in the cable, the bare copper is also subject to embrittlement. As hydrogen breaks down granular boundaries in the copper in a process known as Sulfide Stress Cracking (SSC), the cable loses its ductility and individual wire strands fracture. As the cable is under mechanical stresses due to wind, gravity and the retraction force applied by the RGA spring, the combined effects of sulfidation will result in accelerated and premature cable failure.

Tinning the copper cable has been found to offer improved corrosion resistance as tin is less prone to hydrogen sulfide attack than copper. However, tin is still subject to H_2S attack and it has been found that the tin plating on a braided cable is lost over time due to spalling and friction between individual wire strands caused by cable twisting and flexion in the wind. Once the bare copper underneath the tin coating is exposed, it is aggressively attacked by H_2S. Other coatings have been considered, but were discarded due to practical considerations such as commercial availability and cost.

Although the tin plated copper cables used on RGAs since 2005 have proven sufficiently robust against the effects of H_2S in the vast majority of installations, a few highly aggressive tank environments exposed the limitations of tinned braided copper cables for this use. After an extensive search for a more robust and suitable cable material, research and testing was conducted to examine the suitability of an aluminum cable in the FRT environment. As noted above, a technical literature search revealed the susceptibility of tin and copper to embrittlement when exposed to sour gas. Conversely, no literature was located to suggest that aluminum shares this embrittlement susceptibility. 5154A aluminum alloy was found to be commercially available in a braided cable configuration and appeared to be a likely candidate for use on an FRT.

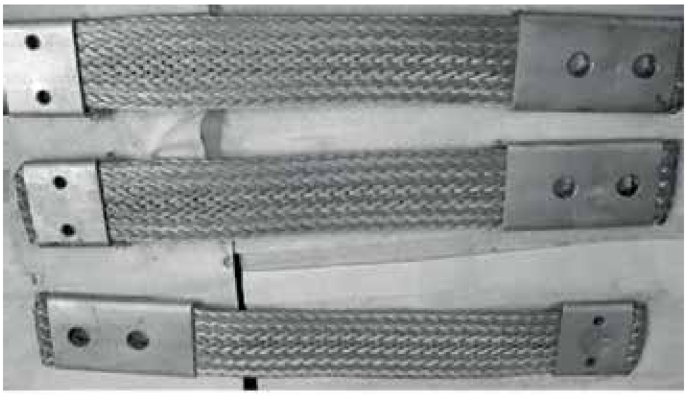
Any proposed material for an RGA cable must meet API 545 which requires a maximum end to end bonding cable resistance of 0.03 ohms. Electrical resistance measurements taken using a Megger DLRO 200-115 digital low resistance ohmmeter revealed a total resistance of 26.7 milli-Ohm for the entire length of 1,056/30 flat braided cable and RGA assembly, as measured from the free end of the cable to the base of the RGA frame. As the material appeared suitable from an electrical perspective, testing was performed to determine its resistance to H_2S.

Testing was guided by the National Association of Corrosion Engineers (NACE) Test Method TM0177, Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments. Multiple braided cable samples were prepared to compare the corrosion resistance of bare copper, tinned copper and aluminum. The cable specimens were submersed in an H_2S saturated aqueous solution of 5 wt.% sodium chloride and 0.5 wt.% glacial acetic acid (NACE Method A solution). This solution is intended to provide a severe sour gas environment, which

Tinned and bare copper cable sample prior to exposure

The aluminum cable samples are in nearly identical condition before and after 14 days of immersion in the H_2S saturated test solution, see below

Aluminum cable sample prior to exposure



Aluminum cable samples after 14 days of exposure may exceed the environment found during drilling operations and may be considered very severe as compared to what the cable may be expected to encounter on an oil storing FRT.

The cable samples were rinsed with methanol, carefully blotted and photographed after 7 and 14 days of exposure. As shown in the photographs, the bare and tinned copper samples show significant discoloration and have obviously sustained general corrosive damage. This is not a surprising finding given the susceptibility of copper to SSC attack when exposed to H_2S. The severity of this attack will only increase with increased exposure time, and is significant when taking into account the performance of these cables in an environment containing H_2S.

As revealed by the comparative corrosion testing, the aluminum cable samples significantly outperform both bare and tinned copper cables when exposed to a severe H_2S environment. The aluminum is highly resistant to this sour gas environment and, unlike copper, is not subject to embrittlement. It may therefore be expected that the aluminum cable offers a significant improvement in operational lifespan over bare and tinned copper cables in an FRT environment.

5154A aluminum was originally developed by Alcoa for use in marine environment applications requiring high strength and a high level of corrosion resistance. Strength testing of the 1,056/30 braided aluminum cable yielded an ultimate strength of 2,180 lb. [9.7 kN], or about 25% higher than an 864/30 braided copper cable which failed at 1,750 lb. [7.8 kN]. In addition, the modulus of elasticity, or resistance to elastic (non-permanent) deformation, of the aluminum is less than the stiffer copper (70.5 GPa vs. 117 GPa).

In addition to cable material improvements, the strength of the internal springs have been increased in order to improve the amount of cable tension between the RGA Reel (mounted at the tank lip) and free end of the cable (secured to the floating roof). Over the entire payout range of the RGA 750 (80 ft. [24.4 m]), cable retraction force has been increased 340% over the RGA 75 and 600% over the RGA 55 on average, with tension increasing significantly toward the limits of cable payout to a maximum of approximately 87 lb. [39.5 kg]. Greater tension in the RGA cable will result in a reduced amount of cable movement and a corresponding increase in life expectancy.

In conclusion, 5154A braided aluminum cable outperforms copper and tinned copper in a sour gas environment, while meeting the requirements of API 545, Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids. Further, unlike copper and tin, aluminum is not subject to sulfide stress cracking. Finally, with improvements in available spring retraction force of 340 – 600% over previous models, a great reduction should be seen in cable flexion and twisting due to wind currents within the confines of the tank shell. Therefore, it is expected that the new RGA 750 will outperform previous models and offer substantial upgrades in the operational lifespan of the cable.

For more information:

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