LIGHTNING STRIKE!

AN INCREASING RATE OF LIGHTNING ACTIVITY HAS IMPLICATIONS FOR THE PROTECTION OF STORAGE TANKS, WRITES JOSEPH A LANZONI, DIRECTOR OF SALES ENGINEERING, LIGHTNING ELIMINATORS & CONSULTANTS.

Lightning-related petroleum storage tank fires are more common than most people think. Prior to the development of the new energy regions in North America, the number of reported tank fires was in the range of 15-20 fires per year. For example, the Brandsforsk study [Ref. 1] covered a period from 1951 to 2003 and tallied reports of 480 tank fires, with about one-third being attributed to lightning.

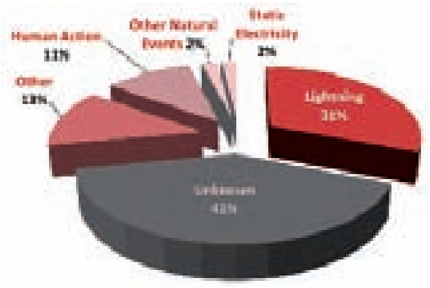

Figure 1: causes of tank fires.

The number of lightning-related tank fires is most likely greater than 20 per year owing to a confluence of factors, such as (1) increased production from hydraulic fracturing in the United States has increased the number of tanks in service, (2) the product from these new energy fields is more volatile than conventional crude oil and (3) not all tank fires are reported by a public agency.

Climate change, insurers and cost

Several recent climatology studies, including those by NASA, Stanford and Purdue, have reached similar conclusions about future rates of lightning: they all predict an increase in the global rate of lightning activity. For example, NASA researchers have predicted a 5-6% increase in lightning for every 1°C rise of earth temperature. Taken as a whole, these studies conclude that global climate change will lead to a greater number of thunderstorms.

Insurers are also facing increasing lightning-related costs. The Lloyds Insurance Institute reported a 15% increase in lightning-related losses from 2009 to 2010. In addition, the Association of British Insurers predicts that by 2040, the weather damage in the UK is likely to be double that of current years.

When a tank fire occurs, many large costs result, including costs due to lost product; damage to the physical plant; interruption of customer service; environmental harm; firefighting, cleanup and rebuilding; EPA, OSHA and regulatory fines and increased oversight; loss of community goodwill, etc. The total cost of one tank fire can easily exceed $10 million. Therefore it is imperative that lightning-related tank fires be prevented.

The lightning threat defined

A typical lightning stroke contains several components, shown in Figure 2. The fast component (Component A) is extremely brief yet contains the peak current. The long component (Component C) contains less current than Component A but lasts 500 to 2,000 times longer than Component A. Component C is responsible for the ignition of flammable vapours and therefore must be effectively managed during a lightning event.

Figure 3: lightning-initiated fire inside internal floating roof tank.

It is imperative that the floating roof be electrically bonded to the tank shell because the roof must be held at the same electrical potential as the tank shell to prevent sustained arcing between the two surfaces. The two most common methods to bond the roof and shell are to install (1) shunts or (2) bypass conductors. Shunts are made from spring-tensioned steel fastened to the roof and slide along the inside of the shell, as shown in Figure 4.

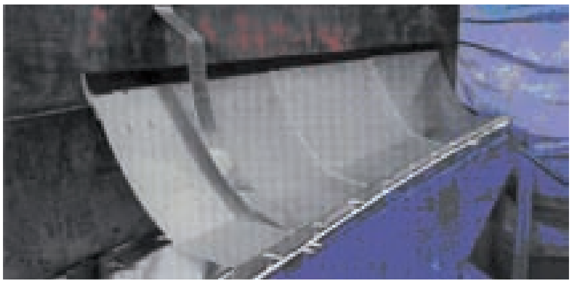

Figure 4: cutaway of FRT showing shunt above seals.

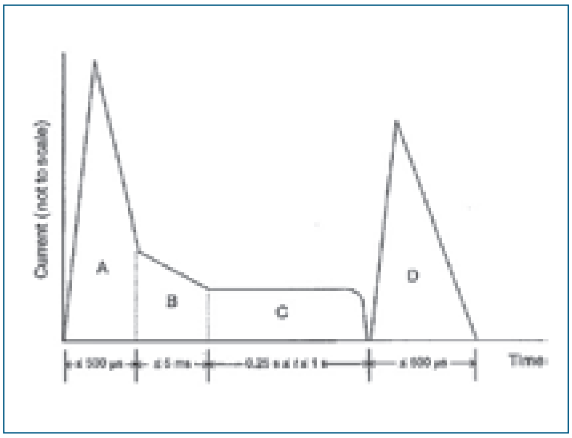

Figure 2: lightning flash components (not to scale).

Petroleum products are often stored in floating roof tanks (FRT). An FRT is a type of tank where the roof rests on pontoons that float on the product being stored. As the tank is filled or emptied, the roof moves up and down within the shell of the tank. Seals are fitted around the edge of the roof to prevent vapours from escaping. Unfortunately, these seals are not perfect and sometimes combustible petroleum vapour escapes from around the seals.

Lightning may endanger an FRT if a stroke terminates either on or near the tank. Lightning-related currents will flow across the roof-shell interface during all direct or nearby lightning strikes. If the impedance between the roof and shell is high, sustained arcing will occur across the seal interface.

Unfortunately, shunts do not provide a low impedance bond to the tank shell because (1) heavy crude oil components may coat the inside of the tank wall, (2) corrosion may form on the inside of the shell and (3) many FRT's are painted on the inside. API-sponsored testing showed that arcing will occur between the shunts and tank wall under all conditions.

A bypass conductor is a roof-shell bonding cable installed between the top of the shell and the roof. This conductor must be long enough to accommodate the roof in its lowest position. Installation of bypass conductors is critical because they are required to conduct Component C of the lightning strike.

Figure 5: lightning-initiated tank fire at the Helling saltwater disposal site, three miles south of Alexander, North Dakota, US.

Lightning presents a different type of problem to non-conductive and lined storage tanks. If a fibreglass tank is being used in a petroleum-related operation (such as saltwater disposal) and the tank is partially full, the space above the fluid typically contains a combustible vapour. In a grounded conventional steel tank, the conductive steel allows for charge equalisation between the tank's contents, the tank itself and the ground. However, for a non-conductive or lined tank, there is no charge transfer and equalization, and thus a differential between the combustible vapour and the ground could occur, as shown in Figure 6. A direct or nearby lightning strike will cause a rise in ground potential and all grounded objects. If the potential difference between a grounded object or surface exposed to the vapour and the vapour reaches the electrical breakdown strength of the vapour space, an arc will form and disaster will follow.

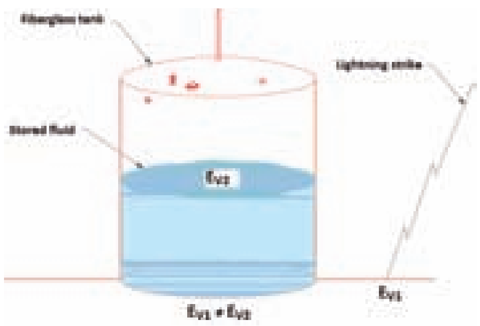

Figure 6: unequal electrical potentials from lightning strike near non-conductive tank.

Response from technical standards

Several national technical standards address the topic of lightning protection for tanks, including NFPA 780, NFPA 77, API 545 and API 2003 [Ref. 6]. As more is understood about the lightning phenomenon and how storage tanks interact with lightning, these standards have been revised to expand their recommendations. To reduce lightning-related risks and increase community safety, it is imperative for tank owners and operators to bring storage tanks into compliance with the latest versions of these standards.

Regarding floating roof tanks, both API 545 and NFPA 780 recommend installing multiple roof-to-shell bypass conductors on floating roof storage tanks. The bypass conductors will ensure that the roof and shell stay at the same potential during thunderstorms, thus mitigating the risk of a sustained arc between the roof and shell. Thousands of floating roof storage tanks are in currently use, but the majority of them lack sufficient bypass conductors, thus increasing their risk of lightning-related fires.

There are two types of bypass conductors available in the marketplace: (1) a conventional fixed length conductor or (2) a retractable conductor on a spring-tensioned reel. The conductor on a spring-tensioned reel automatically deploys and retracts as the roof moves up and down, thus keeping it as short as possible. During high-roof conditions, when the tank is most at risk, the conventional bypass conductor will be randomly splayed on the tank roof, while the retractable bypass conductor will be as short as possible, as shown in Figure 7.

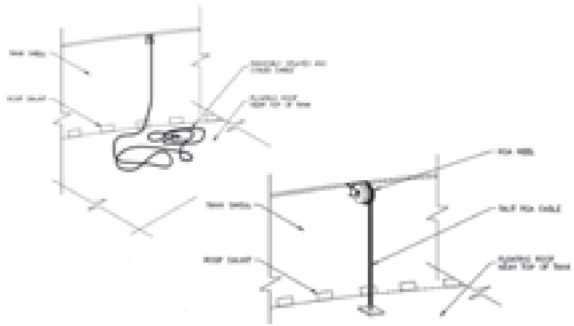

Figure 7: comparison of conventional vs retractable bypass conductor.

Regarding non-conductive and lined tanks, both API 2003 and NFPA 77 recommend against using non-conductive tanks to store flammable and combustible materials. In spite of these recommendations, many non-conductive tanks are being used in production sites. From an electrical viewpoint these tanks are unsafe because electrical charges can accumulate on the tanks' contents, but the charges are not equalized with ground potential as they would be in a steel tank.

In acknowledgement of this situation, both NFPA 77 and API 2003 recommend a grounding conductor inside all non-conductive or lined tanks. To neutralize any charge differentials that may exist between the tank contents and ground, this internal grounding conductor must be connected to the earth. In addition, all metal tank fittings, such as flanges, hatches, etc, must also be bonded and grounded.

Summary

Lightning Eliminators & Consultants manufactures a wide line of grounding and lightning protection equipment that will eliminate lightning-related risks. They manufacture the Retractable Grounding Assembly, which is a self-retracting bypass conductor made specifically for floating roof petroleum storage tanks, and also the In-tank Potential Equalizer, which is an internal grounding conductor made specifically for insertion into non-conductive or lined tanks in oilfield operations.

References

1. Henry Persson and Anders Lönnermark, Tank Fires, Review of Fire Incidents 1951–2003, Brandforsk Project 513-021.
2. Large Atmospheric Tank Fires (LASTFIRE), Project Analysis of Incident Frequency Survey, June 1997.
3. SAE ARP (Aerospace Recommended Practice) 5412, Aircraft Lightning Environment and Related Test Waveforms, SAE Publications, USA, 2000.
4. YouTube.com/watch?v=KGlwLC_1qOI, Wynnewood, Oklahoma, 2007.
5. Photo by Karolin Rockvoy, McKenzie County Emergency Services, Alexander, North Dakota, Nation & World, July 7, 2014.
6. NFPA 780 is the Standard for the Installation of Lightning Protection Systems; NFPA 77 is the Recommended Practice on Static Electricity; API 545 is the Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids; API 2003 is the Recommended Practice for Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents.