A one-two punch for pool fires

Brandon Stambaugh, Owens Corning, USA, considers the application of multi-prong insulation to reduce LNG pool fires, improving safety and reducing facility footprint.

New LNG facilities are being built to support the increasing global demand for energy, prompting a focus on the safety of these facilities. As companies look to shrink facility footprints, maintain safety, and operate in new ways – or in more populated areas – now may be the time to consider a multi-pronged approach to LNG pool fire suppression and cryogenic spill protection.

Although every site must have a spill containment area, taking a systematic approach to managing the risks generated by LNG may provide a cost-effective way to reduce thermal radiation and flame height while shrinking exclusion zones and maintaining facility and employee safety. Looking holistically at steps to manage fire risks includes examining ways to cap or cover spilled LNG, reducing and extinguishing flames, and planning to limit the amount of vaporised LNG available to burn by using a combination of tools such as the FOAMGLAS® PFS™ Generation 2 pool fire suppression system and FOAMGLAS® Cryo Spill™ Protection System. Using both technologies together to cover and line the LNG containment pit can deliver improved and cost-effective passive fire suppression.

LNG pool fire risk

One of the major hazards considered in the LNG industry is a pool fire – where a flammable vapour cloud of natural gas ignites. Natural gas can be ignited from multiple sources, including static electricity or the lighting of a match. Pool fires also may cause additional fires at a facility, explosions, or could potentially endanger employees.

When LNG spills – either from low-source pressures or in pressurised releases – the liquid can vaporise and generate invisible, flammable clouds of gas. In low pressure incidents, LNG can be moved to an impounding area or a sump can be used to reduce the amount of LNG that vaporises when the cold liquid boils upon coming into contact with the (comparatively warmer) ground, warm air, or solar radiation.

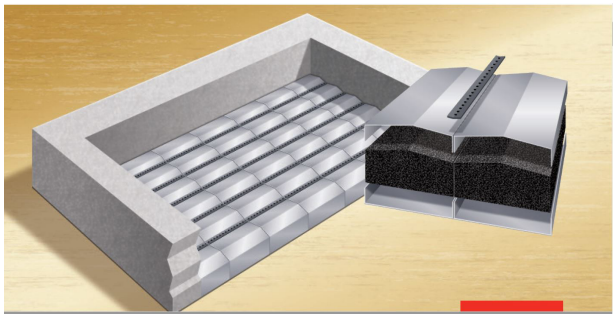

Figure 1. FOAMGLAS® PFS™ (gen. 2) cladded insulation is longer lasting then previous iterations and has simplified maintenance requirements.

High-pressure releases may generate flashing jets or sprays of the liquid. If the liquid is spilled, it can produce a visible cloud of water vapour, suggesting the presence of vaporised natural gas.

LNG vapour is flammable in specific concentrations (5 - 15%), meaning it can travel away from a storage pit or containing facility before it reaches the correct concentration to ignite. That movement may create a travelling fire hazard that could be blown toward ignition sources. These conditions make fires above a pool of LNG an industry concern. A large pool fire is considered one of the most serious hazards LNG presents.

According to a US Congressional report on the industry, in the period from 1944 - 2009, there have been approximately 13 major accidents globally at LNG facilities specifically related to the liquid.[1]

Installing and using the pool fire suppression system

As fire is a commonly acknowledged risk of LNG facilities, methods and standards used to prevent, suppress or manage pool fires were developed to limit identified hazards and improve facility safety. High-expansion foam is a commonly used technology. However, the FOAMGLAS PFS (gen. 2) system has been rapidly adopted as an alternative option to increase the speed at which fires are suppressed and improve facility and employee safety. Its ability to manage radiant heat and flames has been favourable compared to results from a traditional foam suppression system when used as the only method involved in addressing pool fires.

The second-generation insulation-based suppression system can be used to help an LNG facility meet both the US Federal Energy Regulatory Commission (FERC) and the National Fire Protection Association (NFPA) requirements for thermal exclusion zones and passive mitigation systems.

Once installed, the system remains in an empty containment pool until LNG enters the pit, at which point the modules are designed to uniformly rise to the top of the pool where they act as an insulating cap to help reduce vaporisation of the LNG. Should ignition occur, the insulating cover helps reduce radiation and flame height.

The function of the improved, second-generation system can be complemented with the FOAMGLAS Cryo Spill protection system. The PFS (gen. 2) system can also be applied in a retrofit and work in conjunction with other fire suppression tools such as fire-fighting foams.

The PFS (gen. 2) system is designed to provide a cost-effective, reliable, long-lasting, and low-maintenance passive option to limit thermal radiation, flame height, fire size, and view in contained LNG fires. The second-generation fire suppressant also supplies immediate mitigation of thermal flux. Unlike fire-fighting foams, which require frequent replacement, it was designed to remain in place indefinitely, providing an automatic response and reducing the potential for deployment delays. The system also potentially allows new facilities to reduce exclusion zones, shrink distances between operational zones, or trim the protective material used on piping.

The second generation of the PFS system builds off the first generation's bagged option with improved resistance to weather conditions – including precipitation and UV exposure – and remains relatively straightforward to install. The modules are now clad in stainless steel, simplifying maintenance efforts such as snow removal.

System modules link together to provide a uniform cover for an impounding sump or other containment area. The system does not require unique skills or equipment to place and maintain.

The modules contain a FOAMGLAS insulation core and are intended to be deployed to provide a buoyant and continuous cover for a containment area. The insulation is comprised of a low-density cellular glass, which is fibre-free, non-absorbent, and has a high compressive strength while remaining non-flammable.

Rigorous testing of both systems proves performance

Testing was undertaken for both gen. 1 and gen. 2 systems. Vapour and fire control tests carried out with Resource Protection International at Centro Jovellanos and commissioned by TOTAL indicated that the FOAMGLAS PFS (gen. 2) system was able to limit radiant heat flux and help manage LNG and liquefied petroleum gas (LPG) pool fires.[2] Shell Research Ltd conducted a scale test on the system and found that 200 mm (8 in.) of cellular glass was comparable to the use of 1 - 2 m of high-expansion foam in providing real-time, automatic control of a fire.[3]

Experiments conducted at Texas A&M University's Emergency Services Training Institute demonstrated that the system could be used to reduce the visibility of an LNG pool fire to a degree beyond what can be achieved with high-expansion foam, which helped protect equipment and personnel from thermal radiation. As maximum flame height fell in the trial, thermal radiation dropped to a lower temperature zone ranging from 200°C - 500°C (392°F - 932°F).[4]

The system was also tested in field extinguishing trials, which found that firefighters using 20 lb dry chemical extinguishers were able to approach the edge of a 100 ft^2 (9.2 m^2) LNG test pit and put out the flames. Only a partial charge was needed to tamp the flames in that trial.[2]

Testing the pool fire suppression system demonstrated that, when used as a passive system, FOAMGLAS insulation could reduce flame height and radiant heat and perform favourably when compared to foam-based suppression systems used as the sole method of managing pool fires. Trial outcomes suggest that facility employees would be better

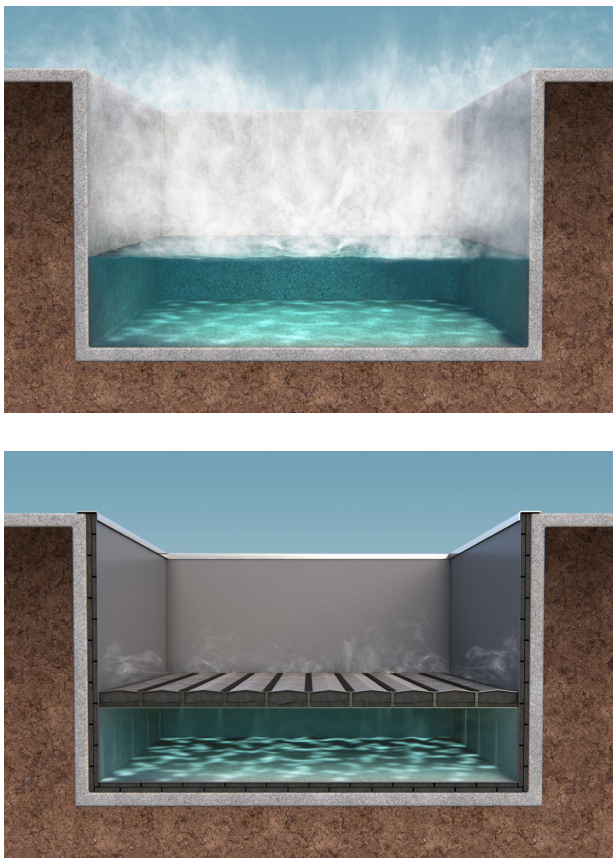

Figure 2. Combining the FOAMGLAS PFS (gen. 2) and Cryo Spill systems can protect pit walls and reduce the amount of flammable vapour generated.

able to manage a fire and less likely to be caught in a large scale blaze.

However, combining the floating insulation layer with the FOAMGLAS Cryo Spill system can provide facilities with additional safety by further limiting the production of flammable, natural gas vapours.

Reducing vaporisation by combining insulation systems

The FOAMGLAS Cryo Spill system is straightforward to install and can be used as an additional passive security and cost-effective measure to reduce the amount of flammable LNG vapour in the event of a spill. Lining containment pits with the insulation in conjunction with using the FOAMGLAS PFS (gen. 2) system provides additional hurdles for pool fires.

When LNG at -265˚F (-165˚C) is released into a 15 ft × 15 ft × 10 ft (4.57 m × 4.57 m × 3 m) LNG containment pit with 6 in. (152.4 mm) concrete walls, it interacts with ground and air temperatures. In moderate conditions – when the ground is approximately 68˚F and the air temperature is 75˚F – the vaporisation rate for LNG is 220 Btu/lb if no insulation is used in the spill pit. This amounts to approximately 8.4 lb of liquid boiling off every minute and a total heat gain of 110 803 Btu/h.

However, that rate can be reduced. If LNG spills into a containment tank where the FOAMGLAS PFS (gen. 2) system is used as a cap, the total heat gain falls to 30 856 Btu/h and approximately 2.34 lb boil-off every minute.

In addition, if LNG spills into a containment pit with the FOAMGLAS Cryo Spill system and topped with the FOAMGLAS PFS (gen. 2) system, total heat gain shrinks to 13 943 Btu/h and the boil-off drops to 1.06 lb/min.

In other words, lining and capping a spill pit with the FOAMGLAS passive fire suppression system can reduce LNG boil-off by 88%, providing much less fuel for a potential pool fire.

Insulation use and economic benefit

In addition to reducing the production of flammable vapour during a spill, there can be a financial advantage to insulating containment areas with the FOAMGLAS Cryo Spill system. Both steel and concrete can be sensitive to rapid changes in temperature, such as exposure to cryogenic liquids at or below -160˚C (-256˚F). A sudden cold shock may induce structural changes that reduce the load-bearing capacity of either material.

Suddenly exposing concrete to subfreezing temperatures can damage the material, as it may contract or expand when water inside the concrete freezes – both types of movement can generate microfractures. Similarly, rapidly exposing carbon steel to temperatures below -29˚C (-20˚F) can induce the metal to become brittle and fracture, although some types of low-temperature stainless steel can tolerate temperatures down to -48˚C (-54˚F).

If concrete pit walls are not insulated, cryogenic steel may need to be used as reinforcing rebar in LNG containment pits. However, rebar made from cryogenic steel is far more expensive than traditional rebar. By insulating concrete walls – keeping them from sinking to cryogenic temperatures – containment areas may be able to save money and use traditional rebar.

Benefits from a systematic approach to fire suppression

Using the FOAMGLAS PFS (gen. 2) system as a passive prevention can improve facility and employee safety, reduce the vaporisation of LNG, and limit thermal radiation and flame height if the LNG pool ignites.

Combining use of the FOAMGLAS PFS (gen. 2) system with a spill pit lined with the FOAMGLAS Cryo Spill system can further reduce the amount of LNG able to boil-off during a spill and limit the flammable vapour produced.

Additionally, lining spill pits with FOAMGLAS cellular glass insulation may provide a cost savings, as the insulating effect of the material can help protect concrete walls and allow for the use of traditional rebar in place of more expensive alternatives like cryogenic steel reinforcing rebar. **LNG**

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