Whims of the weather

When responding to an LNG spill, aside from life safety issues there are typically two major goals. These are vapour control and fire control – and the key word here is "control", because with large LNG spills and pool fires, vapour suppression and extinguishment are unlikely to be an option. World expert Kirk Richardson answers some questions on tackling LNG incidents with high-ex foam.

High-ex foam applied on an LNG fire will neither smother the fire nor suppress vapours, but it will lower the intensity of the fire.

What are the main characteristics of LNG?

LNG is a cryogenic material that is stored at around -160 °C, and this dictates how it behaves during a spill and the subsequent emergency response. When it spills onto the ground it boils and creates vapour, at a high expansion rate of 600 to 1, so it creates a significant vapour cloud. If it does ignite, you get an LNG pool fire, with a high burn rate of 12.5mm per minute, hence significant heat output, compared to a 4mm per minute burn rate with gasoline.

If LNG spills on water the rate of vapourisation is much higher, at around 50 cubic feet of vapour per minute per square foot of LNG. If LNG spills on the ground – say dry asphalt – the initial vapourization rate is slower at around 10 cubic feet per minute. Moderate but still a decent problem.

What are typical LNG spill control facilities?

The idea normally is to drain LNG into a containment pit and hold it in one spot – that is critical. When it first contacts that pit, you get relatively rapid heat transfer from the concrete into the LNG, and it boils as mentioned before. This relatively rapid heat transfer will create the typical LNG vapour cloud. It is this vapour cloud drifting down wind that is likely to cause the most concern to first responders. If the LNG is held in one location, such as a containment pit or impoundment basin, the concrete and the surrounding earth will get very, very cold, and due to the subsequent reduction in heat transfer after a short period of time you will see a gradual but significant reduction in the vapourization rate. But the question is, can you wait that long? Hence the high-ex.

Why can't we wait?

Many articles state that an LNG cloud can travel a considerable distance before the concentration of LNG vapour mixed with air in the cloud falls below the lower flammable limit (LFL) – how far the cloud travels before this happens is the debate. My opinion is that the distance that LFL travels is weather dependent, and that there are many variables, the most significant being wind speed.

If I spill LPG, the resultant vapour cloud will tend to hug the ground until it dissipates due to its density. When LNG is spilled onto the ground however, the initial vapour cloud – due to its extreme low temperature – also tends to be denser than the surrounding atmosphere and therefore hugs the ground initially. As the LNG vapour cloud warms, primarily through mixing and contact with the surrounding atmosphere, it becomes buoyant and tends to rise vertically. This is usually a good thing for the first responder as most ignition sources are near the ground. If I can cause the cloud to warm faster and rise then I'm happy.

There are research papers and magazine articles that state that a vapour cloud never becomes buoyant before it falls before LFL (lower flammable limit), there are articles that say it does. 24 years of pouring LNG onto the ground and into concrete pits tells me that sometimes it does and sometimes it doesn't. It is all weather dependent. In high winds it will likely dilute before it becomes buoyant and rises vertically, in low winds I have seen it lift off the ground before there was significant dilution. I tell students that in any LNG incident, you are at the mercy of the weather gods.

Why use high expansion foam on the vapour cloud?

High ex foam is a tool that you can use to control LNG vapour – not to eliminate it. Typically high expansion foam is applied using fixed foam application systems, operated automatically or manually. The high expansion foam generators are typically

What makes LNG so special?

Liquefied natural gas or LNG is natural gas (odourless, colourless, non-toxic and non-corrosive) that has been converted temporarily to liquid form for ease of storage or transport. It typically contains more than 90% methane, and it takes up about 1/600th the volume of natural gas in the gaseous state.

Where moving natural gas by pipelines is not possible or economical, it can be transported by specially designed cryogenic sea vessels (LNG carriers) or cryogenic road tankers.

The natural gas is condensed into a liquid at close to atmospheric pressure by cooling it to approximately -162 °C (-260°F). Once delivered to a regasification terminal, the LNG is reheated and turned into gas.

Regasification terminals are usually connected to a storage and pipeline distribution network to distribute natural gas to local distribution companies or independent power plants. The most important infrastructure needed for LNG production and transportation is an LNG plant consisting of one or more LNG trains, each of which is an independent unit for gas liquefaction. The largest LNG train in operation is now in Qatar. Until recently it was the Train4 of Atlantic LNG in Trinidad and Tobago with a production capacity of 5.2 million metric ton per annum (mmtpa), followed by the SEGAS LNG plant in Egypt with a capacity of 5mmtpa.

located at the LNG containment pits. When the foam system is activated the hi-ex foam on top of the LNG in the concrete pit. The foam immediately forms a thick light weight blanket of relatively dry foam bubbles over the pool of LNG. My students' first reaction, when witnessing the application of high expansion foam onto a pool of LNG that is not on fire, is normally, "yes, I can see that we've reduced the vapourisation rate." I'm not so sure. When you look at a white LNG vapour cloud you are looking at ice crystals and water vapour condensed out of the atmosphere by the cold temperature of the LNG vapour. Once the LNG vapour has warmed sufficiently, it will no longer condense moisture out of the atmosphere and it will no longer be visible. The hi-ex foam blanket cannot suppress the formation of vapour over the surface of a liquid that boils at -160°C. The reduction of the visible vapour cloud is due to the fact that the vapour has gained significant heat as it migrates up through the foam blanket and is no longer condensing significant amounts of moisture out off the atmosphere. The LNG is still boiling, the vapour is just not visible.

What happens next?

All foam drains out eventually. In order to minimise the contact of water with the LNG you want a foam with a slow drain time. Once it drains the water hits the LNG, and it freezes on top creating a crunchy ice layer. The LNG boils at -160°C, and as stated earlier, you are not stopping the vapourisation, it still percolates up through the foam blanket forming frozen foam tubes. As the foam drains out and the blanket slowly collapses, the frozen foam tubes become visible as the LNG vapours pour out of the frozen openings. As the foam drops in temperature and freezes due to contact with the cold LNG vapour, the vapour warms and becomes buoyant. It rises and disperses while the downwind plume of LNG vapour, the biggest concern, diminishes.

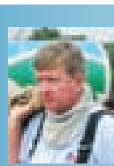
As with vapour cloud movement, high expansion foam application is affected by weather conditions. Both high winds and precipitation will negatively affect high expansion foam operations.

What happens if there is an LNG pool fire?

Then it is a fire control issue. Water (or low expansion foam) cannot be used to suppress an LNG fire. The addition of water (at ambient temperature) onto or into a pool of LNG will only add considerable heat to the LNG making it boil faster and produce significantly more vapour. This will only intensify the fire.

Even if you add high expansion foam you are not going to suppress vapours, and neither is it going to smother the fire. But what it does do is knock down the intensity of the fire. Prior to ignition, the majority of heat being introduced into the LNG and causing it to vaporize was coming from the surrounding concrete or ground. After ignition, the majority of heat being introduced into the LNG is coming from radiation feedback from the flames above the surface of the LNG. The foam acts as a layer of very effective insulation that blocks the radiation feedback, thereby reducing the vapourization rate and the intensity of the fire. What you end up with is a controlled burn. With the application of high expansion foam by itself, that is all you will get. Various testing conducted over the years has shown that proper high expansion foam application on a burning pool of LNG can reduce the heat output by as much as 85 or 90%. And if that reduction in heat output prevents damage to surrounding infrastructure then you have solved a problem.

ABOUT THE AUTHOR



Kirk Richardson is currently the Training Manager for the Marine Firefighting and LNG Spill Control and Fire Suppression Program with the Emergency Services Training Institute (ESTI) in College Station, Texas. Richardson joined ESTI in 1986 and has been a Marine Firefighting and LNG Emergency Response Instructor with ESTI for the past 23 years. The Marine and LNG Programs specialise in hands-on emergency response training.