Attacking the LNG

In this the final part of our LNG response series author John Frame provides practical advice on extinguishing media usage, and recommends that industry issue a definitive set of fire and control test results for LNG. An impossible dream, perhaps?

Use of water spray for LNG incidents

Water spray is useful for protection from radiant heat but it should not be considered for direct flame engulfment, which implies liquid in depth, due to the water contacting the liquid and thereby increasing the rate of vapourisation, which in turn, increases the intensity and radiant heat levels from such a fire.

Water for LNG vapour migration control may be useful and effective for contained spills, but if this water enters the LNG itself, there will be immediate warming of the liquid which in turn leads to higher rates of vapourisation – basically, the incident will be escalated through greater vapour cloud migration distances.

While use of water wall or water curtains to minimise vapour migration can be effective for contained spills, responders need to be aware there are two weak links in this line of defence. Typically, water spray, water wall or water curtain nozzles carried by fire departments will have gaps at the interface between the ground and the lowest part of the spray curtain/wall. It is here that cold vapours may pass through to the other side of the curtain. In addition, if the curtains are not overlapping there will be gaps at the sides.

Much will depend on the type and design of water wall or water curtain in use, but it must be remembered that cold LNG vapours will be heavier than air initially and will therefore migrate at low levels. While water patterns will heat these vapours and cause the vapour to rise (since it is mainly Methane), if the curtain is not "solid" at the sides vapour can get through and the gaps at the lower part of the pattern can allow cold vapour through the "wall". It is only common sense not to place complete trust in any water wall or water curtain for preventing flammable vapour migration, and more so with LNG cold vapours at the lower "wall" areas.

An example of dry chemical monitors in action. Note visibility levels and wind effects. LNG ships may also have dry chemical systems for their cargo manifold area.

Use of foaming for LNG vapour control

Much is made of the need for foaming an unignited LNG spill with high expansion foam to reduce vapour emissions and thereby reduce the risk of ignition through less vapour migration to potential ignition sources – but only if it is in a contained trap or pit. The hazards of shifting wind direction, potential flash fire and potential contact with the cryo liquid tend not to rule in favour of a portable high expansion foam attack. If responders feel strongly enough that it can and should be part of the response, it is strongly recommended that it is extremely well pre-planned and the consequences fully understood and appreciated beforehand.

The author has attended and witnessed numerous tests which clearly demonstrated that use of high expansion foam on a LNG filled pit can reduce flammable vapour emissions downwind. However, we are then faced with how often to re-apply foam to maintain this vapour reduction. This is an issue that applies to foaming for fire control, which is discussed below, and on which there is currently little guidance to help the emergency responder.

Foaming for fire control

Foam is not as effective on LNG as it is on say, gasoline, naphtha or kerosene spill fires, because of the interface between the warm foam and the cryogenic LNG creating increasing vapourisation which then breaks through the foam. One of the reasons for minimising the surface areas of spill catchment pits is to optimise the depth of the high expansion foam blanket, so there is an effective barrier against heat reflected back into the LNG pool and the general insulating effect on the pool is as effective as possible.

It has been said that if there is a high enough application rate, any flammable liquid fire can be extinguished with firefighting foam. The author cannot subscribe to this theory where LNG is concerned. This is because low and medium expansion foams contain too much water (between 97-99%) which obviously warms the liquid and thereby increases the vapourisation process, which in turn intensifies the burning process. (Conversely, low and medium foams are of course easier to apply from a fire department viewpoint.)

It is also because application of high expansion foam into a pit needs good freeboard – or space – to fill above the spilled liquid level; is also affected by rainfall; and lastly because high expansion foam is very susceptible to wind losses.

The reality is that only high expansion foam can provide an effective vapour reduction (unignited contained spills) or radiant heat reduction (burning contained spills).

Portable application of high expansion foam is not advised for LNG pit fires, since it means close approach to set-up, and time delays for foam application. The temperatures involved in an LNG fire, especially a high Methane content LNG fire, can reach 1,300°C. The radiant heat levels from such a fire mean that responders trying to move portable pourers into the pit edge can

only approach under water spray protection – yet this water may find its way into the pit and thereby increase fire intensity.

High expansion pourers must be over the pit edge to be effective. In addition, hardened stainless steel pourers can withstand LNG fire effects and should have preference over light alloy material. Most portable high expansion foam pourers are alloy and will not resist such a fire for more than a few minutes.

If there is adequate land space, pit locations may be such that radiant heat emissions are harmless and therefore a burn-out strategy can be achieved safely. The reality is that land is always at a premium and therefore the majority of pits will have a fixed high expansion foam system fitted.

By the way...

As an interesting aside, we work in an industry where – at least in the fire response field - companies do not talk to each other. As LNG becomes more commercially lucrative, more companies are focusing on LNG as part of their future business strategy and will be carrying out their own tests to determine hazards and consequences, usually resulting in a different set of foam application rates!

In fact, considerable fire testing and foam application test work has already been done. For instance in the 1960s the USA Bureau of Mines tested at Lake Charles, Louisiana, with Tokyo Gas also testing in Japan around the same time. In the 1970s further test work was carried out by Philadelphia Gas Works, then the American Gas Association in the USA, then British Gas in the UK. As LNG became more commercially viable other oil and gas companies appeared and in the 1980s, and Shell's research centre in Thornton began testing in the UK.

Gaz de France followed with tests at Montoir-de-Bretagne, France, followed by both them and Shell joint testing in the 1990s – it's no secret that most of the current knowledge of rapid phase transitions stems from Gaz de France's fire testing work. The latest company to run tests was BP between 2004 and 2006 (although it is possible others are now underway).

A sad part of all this is that we cannot, as an industry, get together and issue definitive fire and fire control test results to which all agree. Different test criteria, different LNG grades, different burn times and different high expansion foam rates and applied foam application rates have ensued and although these can no doubt be defended by the different groups involved, it would make life simpler if we had a single, universal set of rates to think about – an impossible dream perhaps, since although close, there are differences in existing low and medium expansion foam application rates between countries.

Having said that, given the scenarios involved, it is not really envisaged that an emergency responder will be setting up portable high expansion pourers when a serious incident occurs in LNG terminals or, indeed, in liquefaction plants. The vagaries of weather conditions, wind speed and high radiant heat levels mean that portable high expansion application is highly unlikely and is not recommended.

Foam application duration

The question of foaming, for either vapour reduction or radiant heat reduction, needs to consider for how long the vapour will continue to be produced or, if ignited, the fire will continue to burn. Applying a single foam application to either an unignited spill or a fire will not work due to breakdown of the high expansion foam blanket. It needs to be re-applied fairly regularly if it is to be effective in maintaining the required vapour reduction or radiant heat reduction figure.

Some ad hoc work was done on this a few years ago but the outcomes and results were not at all well defined. If there has been some recent guidance produced then it is most welcome and readers are invited to share and contribute accordingly. Some

Trailer or skid mounted dry chemical monitors may also be considered on some sites. Although definitely useful in trained hands, again, the visibility issue must be considered. It is preferable to have a "spotter" at right angle to the stream application to indicate stream direction in much the same way as using a large capacity foam cannon on an oil storage tank fire.

standards mention reapplication three times as part of their test regime, but no more than this. The challenge is therefore to establish guidance for responders that will allow them to re-apply foam for effective vapour or fire reduction at frequent intervals where the depth of liquid is known, as in (say) a containment pit with a defined level.

Adhering to a fire protection standard that, perhaps, calls for a 15-minute application time for a flammable liquid spill fire does not consider the duration of application over time to maintain fire reduction to a given radiant heat level.

If there is a two-metre depth of LNG and the burn off rate is 12.5mm/minute, the fire will burn for around two hours and 40 minutes. A single high expansion foam application of some minutes will not resist the burning LNG for too long. If there are no further applications possible, the fire will simply return to its maximum size as the foam breaks down and burns off. In many instances, this question of re-application is not fully addressed.

One practical aspect to determine whether re-application is needed will be to play water streams over those exposures that may be close to the pit. Again, if it steams, the radiant heat levels are not being reduced and foam needs to be re-applied. However, this will only happen if there are enough appropriate foam concentrate reserves.

It will be a great service to emergency responders if guidance on re-application of foam can be provided – and preferably universally.

A final and important point for responders is that for pits which are level with the ground and where high expansion foam has been applied – for vapour control – the edges of the pit will be hidden by the depth and spread of foam applied. Personnel should not attempt close approach for vapour monitoring as they may fall into the pit!

Extinguishment using dry chemical

LNG fires can be extinguished by using dry chemical, provided, of course, that there is enough dry chemical; it is applied correctly; and the subsequent vapourisation or vapour cloud, post-extinguishment, will not create a greater hazard.

Containment pits

For smaller surface area pits eg up to 15m^2, portable 12kg dry chemical extinguishers may be used safely and effectively, in pairs. Beyond this size, large wheeled extinguishers are advised, from 75kg up to 125kg for greater coverage, for each pit and always a minimum of two for each pit. Note that standards may call for more than the above, dependent on country of location.

Tank relief valve vents

Single walled tanks may still be in use in some locations but the more modern plants and terminals will have double-walled tanks, referred to as "full containment tanks". These have an inner 9% nickel steel tank and an outer tank of pre-stressed concrete. The tanks are operated at atmospheric pressure.

In some cases, the tops of LNG storage tanks may have dry chemical systems fitted at the tank safety valves, should these valves lift and release vapour which is then ignited. Given the difficulties of hauling extinguishers up to the tank top, and risk considerations of moving and working on tank tops, this is obviously an advantage for responders – provided, of course, that the system maintenance is effective.

The principal reason for the dry chemical system at the vents is because of the previously mentioned rollover hazard. The relief valves will be found at the top of the tank on a valve platform at one end. It should be noted that such tanks can be >25 metres high, which is quite a vertical climb carrying portable extinguishers, should risk assessment consider such a deployment.

Jetties dry chemical systems

Some LNG terminals berths/jetties may have tower-mounted dry chemical monitors, specifically for the loading/discharge manifold area, where there is higher potential for releases. One of the drawbacks of using large quantities of dry chemical is that visibility may be greatly reduced and in some cases, the user of the system may assume extinguishment when in fact the flame continues unseen.

Trailer or skid mounted dry chemical monitors may also be considered on some sites. Although definitely useful in trained hands, again, the visibility issue must be considered. It is preferable to have a "spotter" at right angle to the stream application to indicate stream direction in much the same way as using a large capacity foam cannon on an oil storage tank fire.

Ship cargo operations response

LNG ships have a number of protection systems, including a drift limiting envelope which, if exceeded, will actuate an emergency shutdown. This can include automatic closure and disconnection of the loading/unloading arms. The connection is known as Power Emergency Release Couplers (PERCs), either automatically or manually actuated.

Ships usually load and unload with a water spray running under and around the potential spill area at the manifold. This will vapourise minor spills and prevent contact with the ship's deck of carbon steel. Cracks in decking have occurred through contact with LNG. Stainless steel containment is also used under the manifold and over decking for catching minor spills and directing overboard.

There should be a catchment pit in case of a serious liquid release from the loading arms and pipes and this may be at dolphins or end of jetty or other area away from the loading manifold arms. The spill routing is sometimes interesting but so long as the liquid ends up in the pit, the routing channels will not

The spill containment pit is at left centre. Note the close proximity of the ship to the pit, which is unavoidable and the reason why high expansion foam is provided for the pit.

normally present a residual fire hazard.

The spill containment pit for thie jetty pictured above is at left centre. The braced stainless steel ducting on the lower right of the pit is used as the flow "bridge". Note the close proximity of the ship to the pit, which is unavoidable and the reason why high expansion foam is provided for the pit

LNG ships also have the following fire protection systems:

- Water spray for fire prevention, cooling and personnel protection, which covers:
  - Exposed cargo domes
  - Deck storage tanks for flammable products
  - Cargo lines and control valves
- Boundaries of accommodation blocks, compressor and pump rooms, cargo control rooms and store rooms containing flammable materials that face the cargo area;
- Fixed dry chemical for firefighting in the exposed manifold cargo area with at least two hoses or monitors capable of reaching the manifold area.

Summation

LNG is probably the cleanest of the fossil fuels, and in fairness is now probably the safest fossil fuel (in comparison to others) that is produced, transported by sea, stored in terminals for vapourising and distribution to industry and housing. The hazards thus far are fairly clearly defined and obvious and in the main are protected against, both in terms of preventative, containment and reactive measures.

In closing, the author hopes that the relatively safe record of LNG continues for the lifetime of this fuel's availability, and that responders are faced with no more than minor incidents.

However, responders should always know what to expect when an emergency is declared at LNG facilities and it is hoped that the above information will provide some guidance for this. Just as importantly, responders should also know that there is a time to intervene, and a time to stand off. This, of course, is a matter for pre-planning and not waiting for the event before deciding what actions to take.

All responders are encouraged, always, to be proactive and discuss scenarios and response actions according to their respective sites and facilities.

Article author John Frame has not only created and delivered LNG fire response training courses but he also produced the original book "LNG Fire Protection & Emergency Response", available from IChemE.