

LNG Hazards Mitigation Using High Expansion Foam

The development of horizontal drilling and hydraulic fracturing has enabled the production of shale gas. The natural gas liquefaction process reduces the volume 600 times to facilitate storage and transportation. Since LNG is handled in a huge volume in the facilities, the release will be a high consequence incident. The research topics associated with LNG on land release include LNG vapor and pool fire hazards, as well as hazards mitigation using high expansion foam.

The mitigation effects of high expansion foam on LNG vapor and fire hazards were studied experimentally. An LNG spill on land will be followed by vigorous vaporization. Due to the dense gas behavior, the LNG vapor cloud travels to a long distance at the ground level if it is not mitigated, which is the vapor hazard. Once the vapor cloud is ignited, the fire flashes back to the pool and causes a pool fire hazard. NFPA 59 A requires mitigation measures to achieve an acceptable risk in LNG facilities. High expansion foam was recommended by NFPA 11 and NFPA 471 for LNG spill hazards mitigation. For LNG vapor hazard mitigation, high expansion foam has three effects as shown in Figure 1, which are boil-off effect, warming effect and blocking effect. The boil-off effect and blocking effect are combined together as the blanketing effect, since both effects affect the vaporization rate of LNG. The blanketing effect, an effect to reduce LNG vaporization rate by blocking convection and radiation, was studied in a wind tunnel, where convection and radiation were provided by a fan and a bulbs panel. The results concluded that the blanketing effect could reduce 70% of the heat from convection and radiation for LNG vaporization. The warming effect, an effect to increase LNG vapor buoyance by warming the vapor, was studied in the lab with a self-built foam generator and a foam test apparatus. The results confirmed that high expansion foam application increased vapor temperature.

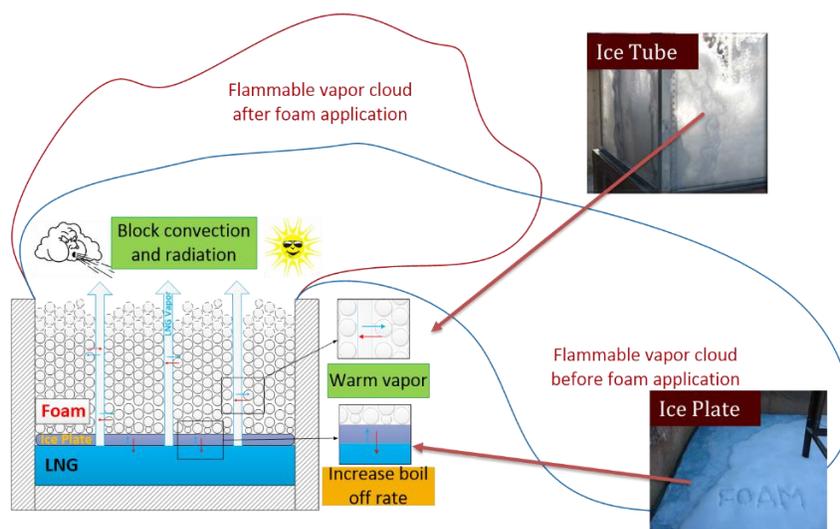


Figure 1 LNG vapor hazard mitigation using high expansion foam

For the LNG pool fire mitigation, a large scale field test was conducted using an industrial foam generator as shown in Figure 2. The mitigation effect was studied in terms of mass burning rate, thermal radiation, flame temperature, flame size and other parameters. The work enhanced the understanding on the physical mechanisms of expansion foam mitigation effect on LNG vapor

and pool fire hazards. The findings can be used to guide high expansion foam application in industry and develop a CFD model of LNG and foam system for risk analysis.



Figure 2 LNG pool fire control using high expansion foam (left: fire without foam, right: fire with foam)