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Heat transfer modeling of high expansion foam application for vapor risk mitigation of Liquefied Natural Gas (LNG) spills

Pratik Krishnan, Bin Zhang, Salma Akhter, M. Sam Mannan
Mary Kay O'Connor Process Safety Center, Artie McFerrin Department of Chemical Engineering, Texas A&M University, United States
Emails: pratik@tamu.edu, drsalma@tamu.edu

Abstract

The consumption of natural gas is expected to increase significantly over the next few decades due to much less carbon dioxide emission per unit of energy, when compared to other sources like oil or coal. This has also been facilitated by availability of a large number of reserves and improvements in fracking technologies. Liquefaction of natural gas enables ease of storage and transportation because of a high ratio of liquid to vapor density, especially over long distances when constructing pipelines is economically infeasible. While presenting many advantages, there are several safety concerns involved in the handling of LNG. A spill of cryogenic LNG can absorb heat from the surroundings and form a vapor cloud which has the potential to ignite and presents an asphyxiation hazard. In addition, this vapor cloud can migrate downwind near ground level because of a density greater than air. The National Fire Protection Association suggests application of high expansion foam to mitigate LNG vapor risk. Foam blocks the effects of convection and radiation on an LNG pool and warms rising LNG vapors. Understanding the heat transfer mechanisms between the applied foam and LNG is important to quantify its mitigation effect and determine the amount of foam to be applied for effective vapor risk mitigation. This work aims to address some of the gaps observed in previous efforts towards heat transfer modeling of foam applied on LNG spills.

Keywords: Liquefied Natural Gas (LNG); vapor cloud; high expansion foam; mitigation; heat transfer