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An Experimental Investigation on Explosive Phase Change of Liquefied Propane During a Bleve Event

Authors : Frederic Heymes, Michael Albrecht Birk, Roland Eyssette

Abstract : Boiling Liquid Expanding Vapor Explosion (BLEVE) has been a well know industrial accident for over 6 decades now, and yet it is still poorly predicted and avoided. BLEVE is created when a vessel containing a pressure liquefied gas (PLG) is engulfed in a fire until the tank rupture. At this time, the pressure drops suddenly, leading the liquid to be in a superheated state. The vapor expansion and the violent boiling of the liquid produce several shock waves. This works aimed at understanding the contribution of vapor ad liquid phases in the overpressure generation in the near field. An experimental work was undertaken at a small scale to reproduce realistic BLEVE explosions. Key parameters were controlled through the experiments, such as failure pressure, fluid mass in the vessel, and weakened length of the vessel. Thirty-four propane BLEVEs were then performed to collect data on scenarios similar to common industrial cases. The aerial overpressure was recorded all around the vessel, and also the internal pressure changed during the explosion and ground loading under the vessel. Several high-speed cameras were used to see the vessel explosion and the blast creation by shadowgraph. Results highlight how the pressure field is anisotropic around the cylindrical vessel and highlights a strong dependency between vapor content and maximum overpressure from the lead shock. The time chronology of events reveals that the vapor phase is the main contributor to the aerial overpressure peak. A prediction model is built upon this assumption. Secondary flow patterns are observed after the lead. A theory on how the second shock observed in experiments forms is exposed thanks to an analogy with numerical simulation. The phase change dynamics are also discussed thanks to a window in the vessel. Ground loading measurements are finally presented and discussed to give insight into the order of magnitude of the force.

Keywords : phase change, superheated state, explosion, vapor expansion, blast, shock wave, pressure liquefied gas
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