The Effect of Flight Dynamics on Current Aviation Fuel Tank Inerting Requirements

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Abstract

Reducing the threat of accidental or intentional ignition within an aircraft fuel tank has received considerable attention over the past decade due to the TWA 800 accident as well as the increased terrorist threat to commercial aviation. In fact, reduction of fuel tank vulnerabilities maintained an elevated spot on the NTSB Most Wanted List until the issuance of the FAA regulation for fuel tank flammability reduction in July of 2008. The most common methodology for fuel tank reduction is nitrogen-based inerting, which displaces the oxygen within the tank below a flammable level. The current established criteria for the limiting oxygen concentration (LOC) is 12% oxygen by volume for commercial applications, which has been well documented by the FAA and other organizations, primarily under stationary tank conditions.

The current project investigates this limit and its applicability to realistic flight conditions. A state-of-the-art flight simulator was constructed and evaluated for simulating simple aircraft maneuvers with a 500 gallon capacity rectangular tank payload. The goal of the study was to determine flight conditions and identify key fluid structures that can lead to enhanced fuel/air mixing and determine their collective effects on the current commercial inerting requirement. The study was conducted in three phases:

- **Phase I**: Characterize the liquid dynamics within the tank
- **Phase II**: Determine the LOC for aviation kerosene fuel under static conditions
- **Phase III**: Implement different dynamic conditions and determine effect on LOC

Phase I results demonstrated that even under low frequency, low amplitude movements; a critical transitional region exists from simple, bulk fluid movement to highly dynamic hydraulic jumps and enhanced spray production. Within these critical regions, it was observed that a solitary wave forms, breaks and ejects liquid from the surface as well as air entrainment. In Phase II, baseline testing of aviation kerosene fuel yielded LOC results of 12% and matched existing published data. During the Phase III coupled aircraft dynamics and ignition study, results showed that liquid/air interactions reduce the LOC below 11% for elevated fuel temperatures. This suggests that the currently established LOC requirements may not be sufficient to prohibit ignition in realistic applications and that the military requirement of 9% should be considered.