Experimental Studies on Discharge of Alternative Agent/Nitrogen Mixtures in a Simulated Dry Bay [1]

J. C. Yang, T. G. Cleary, R. McLane, and W. L. Grosshandler

Building & Fire Research Laboratory
National Institute of Standards & Technology
Gaithersburg, MD 20899 U.S.A.

ABSTRACT

Discharge of the three selected alternative agents for aircraft dry bay fire protection has been conducted in a simulated dry bay (i.e., in an unconfined space). The three selected agents are CF_3I, FC-218, and HFC-125. Halon 1301 is also included in the study for the purpose of comparison.

The experimental set-up consists of a pressure vessel, a release mechanism, pressure transducers, a series of lasers and detectors, and a high speed movie camera. The experimental procedure involves the following. The vessel was initially filled with a fixed amount of agent and was then pressurized with nitrogen to a specified equilibrium pressure at room temperature. The use of nitrogen was to facilitate the discharge of agent from the container. For dry bay protection, it is required that the discharge time has to be less than fifty milliseconds upon detection of a fire. A quick-action solenoid valve or a squib which was located in the bottom of the vessel was used to release the agent from the pressure vessel. The temporal variation of the internal ullage pressure was measured during discharge. The dispersion dynamics of the agent external to the vessel were characterized by high speed photography. A laser attenuation technique was used to measure the global average speed of the dispersion at various locations downstream of the vessel exit. A pressure transducer was also placed at approximately 1.3 m downstream of the vessel exit in order to measure the impact force and to obtain some qualitative two-phase behavior of the flashing spray.

The studied experimental parameters include: (1) vessel geometry (spherical *vs*. cylindrical), (2) nitrogen charge pressure, (3) initial amount of agent, (4) temperature of liquid agent, and (5) discharge orifice size. A cylindrical pressure vessel with sight windows is also used to observe the process inside the vessel during discharge.

Three distinct regions are noted in the temporal variation of the ullage pressure. The first corresponds to the discharge of the liquid agent/nitrogen mixture from the vessel, followed by a sudden pressure recovery which signifies the degassing of dissolved nitrogen from the liquid mixture. The pressure recovery is due to expansion of the liquid level caused by the growth of nitrogen bubbles, thus compressing the ullage space. The third region corresponds to the discharge of the remaining vapor mixture from the vessel. The duration of each region and the degree of nitrogen degassing appear to be dependent on the initial amount of agent and the equilibrium nitrogen charge pressure. Since the rate of nitrogen degassing depends on the amount of nitrogen dissolved in the liquid agent, the extent of degassing is less apparent at lower nitrogen charge pressure given the same amount of agent in the vessel. This is further substantiated by the experimental results obtained by partially saturated the liquid agent with nitrogen. In this case, the rate of nitrogen degassing is much slower than the rate of liquid discharge such that no pressure recovery is noticeable in the pressure trace. Partial saturation was

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obtained by simply bubbling nitrogen through the liquid agent to a specified pressure without attaining the final equilibration pressure.

Based on the observations from a high speed movie camera, the extent of flashing at the outlet of the solenoid valve during discharge at moderately low liquid temperature (-15°C) appears to be similar to that at room temperature. In addition, no discernable difference in the behavior of the flashing spray at the vessel exit was observed among the four agents studied when a large opening solenoid valve was used to discharge the agent at room temperature. Except at the beginning and close to the end of the liquid discharge, the spray angle at the valve exit remained close to 180° during a large portion of the liquid discharge time.

According to the measurements obtained from the laser attenuation, the dispersion of CF_3I was much slower compared to the other two selected agents when a quick-action solenoid valve was used to discharge the agent from the vessel.

Depending on the agent and nitrogen charge pressure, maximum downstream dynamic pressure could reach 2 MPa in some cases when a solenoid valve with a large opening was used.

Results obtained from a spherical bottle using a squib and other experimental parameters will be presented and discussed.