Evaluation of Halon Replacement Agents in Protecting Against an Aerosol Can Explosion

In December 2003, the Fire Safety Branch at the FAA William J. Hughes Technical Center evaluated two halon replacement agent candidates (fire suppression agents) to determine their effectiveness in protecting against an aerosol can explosion. Bromotrifluoropropene (BTP) and pentafluoroethane (HFC-125) were selected by members of the International Aircraft Systems Fire Protection Working Group as possible candidates to replace Halon 1301 as the suppression agent used in an aircraft cargo compartment.

The simulated aerosol can explosion test is one of four fire test scenarios required by the FAA Minimum Performance Standard (MPS) for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems (DOT/FAA/AR-TN03/6, Reinhardt, J., April 2003). Before running this particular MPS test with the candidate agents in the required 2000-ft^3 aircraft cargo compartment, a preliminary test series was conducted in a 353-ft^3 pressure vessel (see figure 1) located in the FAA William J. Hughes Technical Center Pressure Fire Modeling Facility. This pressure vessel is capable of withstanding a working pressure of 600 psig. The objective of this test series was to determine if the candidate agents had any unusual behavior before proceeding with the required MPS tests inside the 2000-ft^3 aircraft cargo compartment, which is a weaker structure than the pressure vessel.

Baseline tests were conducted to establish a comparison benchmark. These baseline tests were conducted by letting the simulated aerosol can explode without the presence of a suppression agent. The results showed

Figure 1. Pressure Vessel

overpressures between 23 and 25 psig. A second benchmark test was conducted using 2.5% volumetric concentration Halon 1301, which is below its inerting concentration. At this volumetric concentration, a subdued explosion event occurred, resulting in an overpressure of 4 psig.

The reported inert concentration of BTP, when evaluated against propane, is 8.5% volumetric concentration. It was decided by the testing team that the initial agent volumetric concentrations should be below 8.5% to determine if BTP would be as effective as Halon 1301 in this particular test scenario. Testing at the FAA William J. Hughes Technical Center has shown that Halon 1301 is capable of suppressing this particular propane explosion with as little as 3.1% volumetric concentration. (The published inert concentration value for Halon 1301 is 6.7% at stoichiometric fuel (propane) to air ratio.) The initial volumetric concentration selected for the first explosion test was 2.5% BTP.

The first explosion test resulted in an estimated overpressure of 49.3 psig (the pressure transducer was saturated). After replacing the pressure transducer, other tests were conducted that included 3%, 4%, 5%, and 6% volumetric concentrations. Figure 2 shows that their associated overpressures were 63, 63, 100, and 93 psig, respectively.

Thus, BTP enhanced the explosion event (as much as 4 times greater pressures than the unsuppressed event and 23 times greater than the Halon 1301 benchmark concentration).

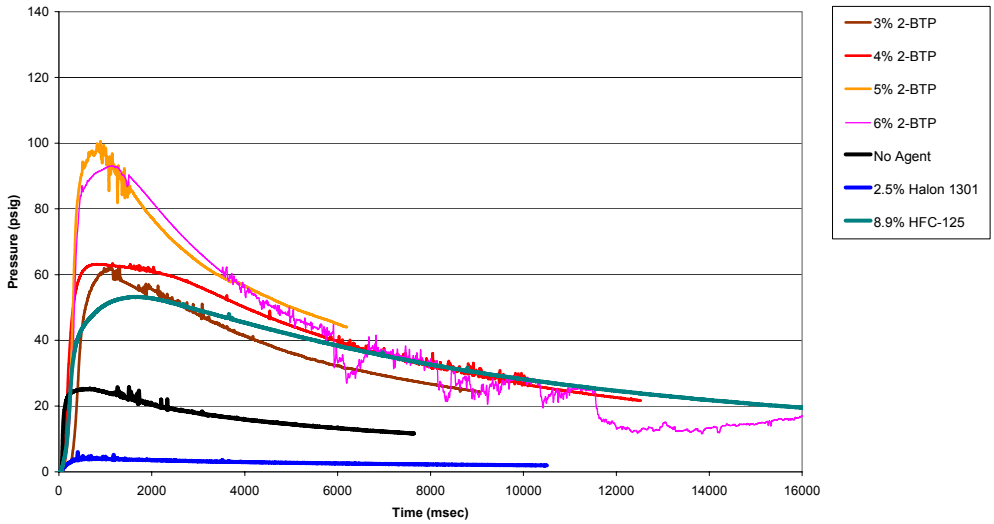

Figure 2. Comparison of Agent Explosion Suppression Capability at Below Inert Concentrations

After the BTP explosion events, HFC-125 was evaluated to determine if it would behave in the same fashion. HFC-125 also enhanced the explosion event when it was below its inert concentration (15.6%). The agent produced explosion overpressures of 53 psig at 9% and 11% volumetric concentrations. Another test was conducted with 13.5% of HFC-125, but there was no explosion event after the simulated aerosol can was activated. Thus, HFC-125 prevented the blast at 13.5%, even though its reported inert concentration for a propane explosion is 15.6% (at a stoichiometric fuel-to-air ratio).

In summary, at concentrations below the inerting level, both BTP and HFC-125 enhanced explosions by creating higher overpressures than measured in air alone. In contrast, Halon 1301, the currently used aircraft cargo compartment fire suppression agent, mitigated the explosion, even though it was below its inert concentration. It reduced the overpressure of the event. Since aircraft cargo compartment suppression agents may be present at subinerting design concentrations, because of stratification or larger than normal leakage, it is important that replacement agents be selected that do not increase the overpressure caused by an exploding aerosol can at concentrations below the inerting value. Unless a means can be found to avoid the problem of subinerting concentrations of extinguishing agent, BTP and HFC-125 would not be suitable candidates for halon replacement extinguishing agents in the cargo compartment.

The test results are documented in an FAA technical note titled "Behavior of Bromotrifluoropropene and Pentafuoroethane When Subjected to a Simulated Aerosol Can Explosion," DOT/FAA/AR-TN04/4, Reinhardt, J., May 2004. The MPS standard is currently being modified to address this behavior in the acceptance criteria section.

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