Aerosol Can Explosion

Behavior of BTP and HFC-125 When Subjected to a Simulated Aerosol Can Explosion

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Outline

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Objective

- This presentation discusses the results of the simulated aerosol can explosion tests conducted to evaluate the explosion suppression performance of bromotrifluoropropene (2-BTP) and pentafluoroethane (HFC-125).

Background

- 2-BTP was selected by members of the IASFPWG as a possible candidate to replace Halon 1301 as the suppression agent used in an aircraft cargo compartment.

- Testing of 2-BTP in Europe showed favorable test results in four different test scenarios: crib fire, scaled bulk-loaded fire, cup-burner and inerting.

- According to the 2-BTP Material Safety Data Sheet, this chemically acting agent is a colorless volatile liquid that has a slight ether-like odor. It has a boiling point of 93°F, a liquid density of 99.9 lb/ft^3 at 77°F, and a molecular weight of 174.95.

- At the time of this testing, bromotrifluoropropene (CH_2CBrCF_3) was not on the Environmental Protection Agency (EPA), Clean Air Act, Significant New Alternatives Policy (SNAP) program.

Background

- 2-BTP has an ozone depletion potential (ODP) of 0.0028 and has an atmospheric lifetime (ALT) of 0.008 year, or 2.9 days. The global warming potential was not reported.

- The only toxicology data reported for 2-BTP was its Lethal Concentration: 5.1% - 9.7% (for an exposure of 4 hours)

- The reported inert concentration of 2-BTP, when evaluated against propane, is 8.5% volumetric concentration. 2-BTP is 1-BTP with very small concentrations of stabilizer additives.

- Since HFC-125 is an acceptable halon replacement agent for some applications in aviation, the explosion suppression performance of this agent was also investigated.

Tech Approach

- Before running the MPS Aerosol Can Explosion test with BTP-2 and HFC-125 in the required 2000 ft^3 aircraft cargo compartment, a preliminary test series was conducted at the FAA's Pressure Fire Modeling Facility.

- This facility had a 402 ft^3 pressure vessel that was rated for a maximum working pressure of 600 psig.

- The pressure vessel was instrumented with thermocouples, pressure transducers, gas analyzers, and a video camera.

Tech Approach

The following procedures were used during the simulated aerosol can explosion test.

1. Prior to commencing the test, the analyzers were calibrated against a calibrated gas, the instrumentation was checked for functionality and accuracy, and the support equipment was activated to check for normal operation.

2. To identify the test, a test sign, with the test identification number, was displayed in front of the video camera and recorded.

3. The data acquisition systems were configured and readied.

Tech Approach

4. The fire bottle was filled with the required amount of agent, and the aerosol can simulator was charged with propane, water, and alcohol.

5. The pressure vessel door was shut after plumbing the fire bottle to the pressure vessel's discharge lines, after cleaning the discharge nozzles, and after mounting the aerosol can simulator inside the vessel.

6. All the valves on the pressure vessel were closed to seal it, with the gas-sampling probe creating the only temporary leak. At this point, the setup was ready for testing.

7. Before the countdown, the fan inside the pressure vessel was turned on.

Tech Approach

8. After the countdown, the test was initiated by starting the 1-Hz data acquisition system and discharging the agent. The agent was introduced, either at a low or high rate of discharge, in the pressure vessel until the desired volumetric concentration was reached.

9. Once the desired concentration was reached, the aerosol can simulator was heated to increase its pressure to 240 psig.

10. When the required pressure was achieved, a second countdown was initiated to activate the aerosol can simulator. During the second countdown, the video camera was started, the high-speed data acquisition was tripped, the fan was turned off, the arcing electrodes were energized, and the aerosol can simulator pneumatic valve was opened.

Tech Approach

11. After the test, the data was saved, all the equipment was turned off (with the exception of video camera), and the pressure vessel ventilated and monitored.

Results

BENCHMARK

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

Results

2-BTP

- It was decided by the testing team that the initial agent volumetric concentrations should be below 8.5% (inert conc.) to determine if 2-BTP would be as effective as Halon 1301 in this particular test scenario.

- The initial volumetric concentration selected for the first explosion test was 2.5% 2-BTP. This first explosion test resulted in an estimated overpressure of 49.3 psig (pressure transducer was saturated).

- After replacing the pressure transducer, other tests were conducted that included 3%, 4%, 5%, and 6% volumetric concentrations. Their associated overpressures were 63, 63, 100, 93 psig, respectively.

Results

2-BTP (CONT.)

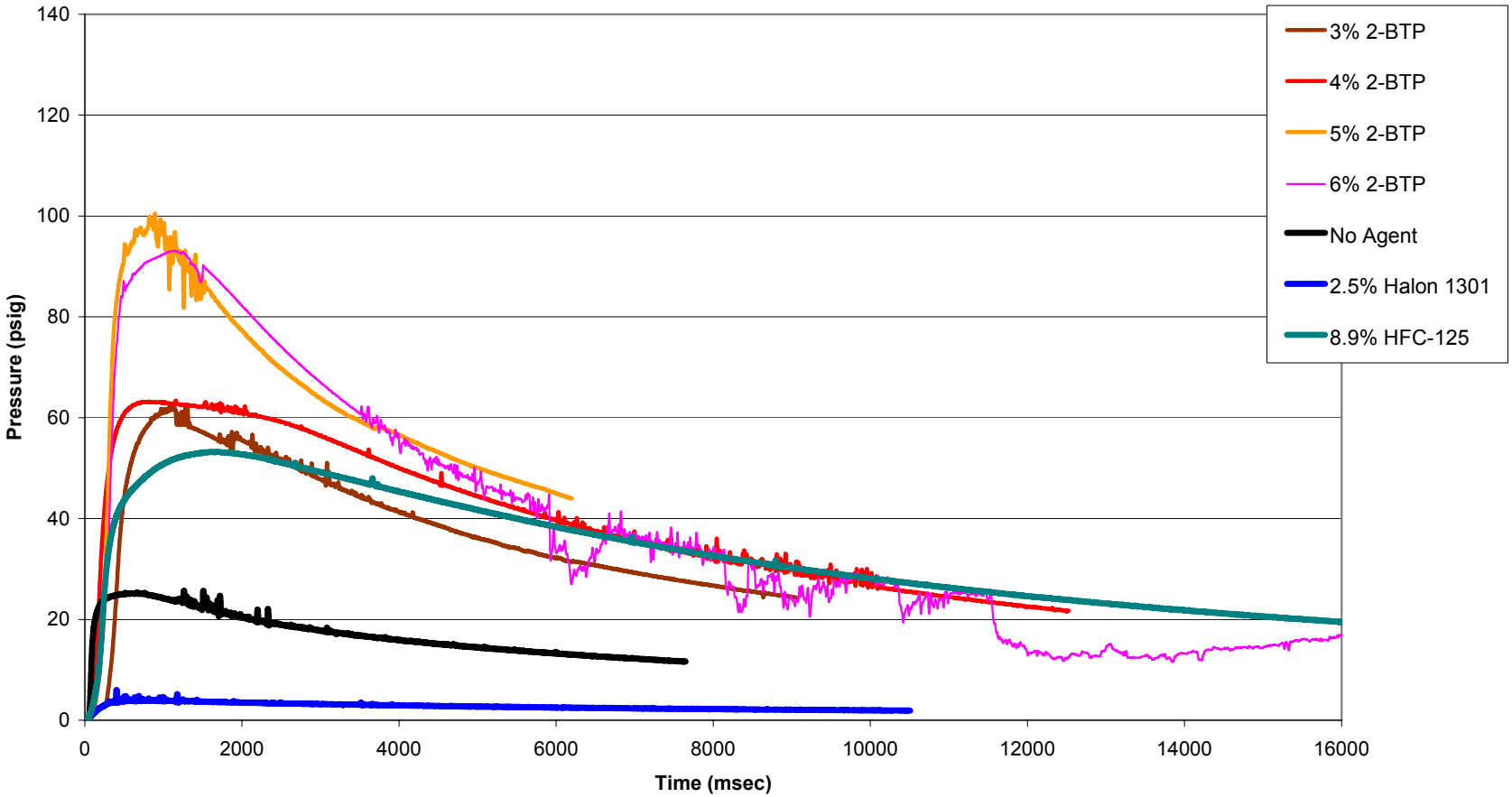
- 2-BTP enhanced the explosion event as much as 4 times greater pressures than the unsuppressed event and 23 times greater than the Halon 1301 benchmark concentration (2.5%).

Results

HFC-125

- HFC-125 also enhanced the explosion event when it was below 11.0%. It doubled the blast pressure pulse peak.
- The agent produced explosion overpressures of 53 psig, at 8.9% and 11%, respectively.
- There was no explosion event with the simulator when the volumetric concentration of HFC-125 was 13.5%. Its reported inert concentration for a propane explosion is 15.6% (at a stoichiometric fuel-to-air ratio).

AEROSOL CAN SIMULATION TEST



Final Remarks

- Unless a means can be found to avoid the problem of introducing subinerting concentrations of extinguishing agent in the cargo compartment, 2-BTP and HFC-125 would not be suitable candidates for halon replacement extinguishing agents for aircraft cargo compartments.

- Report No. DOT/FAA/AR-TN04/4 – “Behavior of Bromotrifluoropropene and Pentafluoroethane When Subjected to a Simulated Aerosol Can Explosion” is available on the FAA Fire Safety web site.