U. S. NAVY HALON SIMULANT IDENTIFICATION PROJECT

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BACKGROUND

The Navy, like all other users of aircraft fire suppression systems, requires qualification testing of their suppression system designs. The accepted method of qualifying halon-based systems has historically been a relatively simple discharge test of the system during a mock fire emergency scenario (shut down the affected engine and activate the suppression system). Success or failure is determined by the system's ability to deliver six percent of halon for half a second throughout the protected volume, as monitored by a gas concentration analyzer. Meeting these requirements provides a high level of confidence that, if a fire had been present in the volume, it would have been extinguished. Due to the infrequent requirement for qualification (only one aircraft is tested per platform, not every plane), the quantities of halon actually discharged during qualification testing is minimal. A historical evaluation of discharge testing conducted on Naval aircraft testing showed a magnitude of only a few hundred pounds of halon discharged in the last *decade*. Note that there is no actual fire present during the suppression system qualification testing. The effort described here is a test project to identify an acceptable **simulant** for halon, not a **replacement.** *An* acceptable simulant must exhibit similar physical characteristics to halon but need not be capable of putting out a fire.

PROBLEM STATEMENT

In accordance with the U.S. Clean Air Act, and more stringent Naval requirements, intentional releases of halon during maintenance is prohibited, as halon is an extremely effective ozone depleter. In addition, several states have enacted regulations that preclude discharge of halon during system qualification testing. It is, therefore, essential that another chemical be identified as an acceptable test simulant to be used in future testing.

The Navy has embraced a proactive position to have an acceptable simulant identified in time to adhere to these zero emission halon standards.

The need for a halon simulant, while limited, is nonetheless imperative. The Navy currently has approximately 3000 aircraft protected with halon-based fire suppression systems. These systems offer protection for those areas on the aircraft identified as fire zones (engine nacelles, auxiliary power units, etc.) While environmental concerns preclude halon as an option for use in new aircraft designs, existing systems must be maintained. Should any changes to existing aircraft be made which could affect the size, shape, airflow, pressure profile, etc. of the protected zone, the fire suppression system may be required to undergo new qualification testing to ensure that these changes have not compromised the system's ability to suppress a fire. For example, when it was intended to add an Infra-Red suppressor to the engines of the AH-1W helicopter, different backpressures leading to different airflows through the nacelle drove a requirement for retest of the fire suppression system. Also, when the **F-14** was upgraded with a new engine, temperature and airflow differences realized in the nacelle drove a retest of its fire suppression system.

PROGRAM MILESTONES

Through all phases of the Halon Simulant Identification Project, Navy-Lakehurst served as Project Manager, responsible for: defining project objectives; providing technical guidance; establishing required team membership and individual activity responsibilities; maintaining team focus; and providing overall project leadership.

The simulant project was initiated with Phase I, a detailed investigation into the many halon-like chemicals. This analytical investigation was intended to narrow the scope of testing to the three chemicals that offered the most promise as halon simulants. The National Institute of Standards and Technologies (NIST) was the principal investigator during this phase, with technical input also provided by Walter Kidde Aerospace. From NIST analyses, Navy-Lakehurst down-selected three chemicals for detailed discharge tests: **SF6, HFC-125,** and **HCFC-22.**

Actual testing of the candidate chemicals first began in Phase II of the simulant project. This testing was conducted on three different test fixtures designed to offer insight into various characteristics of each chemical. Numerous aspects of bottle discharge dynamics, fluid flow through piping, and dispersion from nozzles were evaluated. Both **MST** and Walter Kidde participated in Phase II testing, with their respective contributions coordinated to provide the most meaningful final analysis. At the completion of this phase of the project, defined correlation parameters for each agent were compiled, and one of the chemicals, HFC-**125,** demonstrated superior simulant qualities when compared with the others.

During Phase III, small scale wind tunnel testing was conducted on all three chemicals to evaluate their flow characteristics through various clutter arrangements. Also during this phase of testing, a gas analyzer was utilized to provide agent concentration curves thoughout the cluttered volume. It was intended that this small scale concentration testing would provide clear distinction among the agents and identify the one chemical to enter Phase IV full scale testing. Based upon discharge characteristics and plumbing flow data generated in Phase II, and the Phase III despersion qualities thoughout the wind tunnel clutter section, HFC-125 was shown to clearly surpass the other chemicals and it alone received Navy-Lakehurst approval for continued testing.

Phase IV, the final test phase of the simulant project, was established to identify any scaling factors that might become evident as use of the simulant went from laboratory scale (1' x 1' x 3' test section) to full scale application (aboard an aircraft, discharged into an engine nacelle). Also, it was intended to better quantify the slight differences in discharge time and peak concentrations shown in phase III testing. Only HFC-125 was tested during Phase IV, which was conducted on an F/A-18D provided by Naval squadron VFA-106. The test series was conducted at Naval Air Station, Cecil Field with technical assistance from Naval Aviation Depot, Jacksonville personnel. Concentration data collected during the twelve bottle discharges showed the exceptional simulant qualities of HFC-125 and served to finalize acceptance of HFC-125 as an excellent halon simulant.

PROJECT RESULTS

Detailed analyses of all four phases of the halon simulant identification project offer extensive insight into the applicability of HFC-125 as an excellent halon simulant. Discharge testing results were very repeatable and proved the underlying basis that optimal simulation is achieved when equivalent liquid fraction is applied. That is, to properly simulate a halon bottle filled with Y pounds of halon, 0.77Y pounds of HFC-125 should be used to fill the bottle. Identical pressure heads should be used, as maintaining the contribution of the nitrogen head is critical to proper simulation between chemicals.

Remaining efforts in this area include the preparation of guidance documentation stating instructions on simulant use and the results that can be expected during use. Technical guidance will also be available through Navy-Lakehurst as private industry approaches the approval stages of a halon simulant for its applications.

SIMULANT APPLICATION

The identification of an acceptable halon simulant for use in aircraft systems qualification testing has been greatly anticipated throughout both government and industry. The simulant will find immediate use in all future fire suppression system qualification tests. In fact, immediately upon completion of the Navy's simulant identification project, the

F/A-18E/F community followed the recommended test procedures associated with using HFC-125 as a halon simulant and successfully completed qualification of their onboard engine fire suppression system. Commercial aircraft manufacturers have begun petitioning the FAA for modifying the testing procedures to accept a simulant. Navy-Lakehurst is working closely with Boeing Aircraft Company to exchange test data detailing respective simulant testing efforts. With the identification of an acceptable halon simulant, future fire suppression system qualification tests will continue to be conducted, ensuring safe aircraft designs, in a manner safe for the environment.