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**7. Author(s)**
G.G. Back, E.W. Forssell, C.L. Beyler, P.J. DiNenno, R. Hansen, and D. Beene

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Hughes Associates, Inc.
3610 Commerce Drive, Suite 817
Baltimore, MD 21227-1652

U.S. Coast Guard
Research and Development Center
1082 Shennecossett Road
Groton, CT 06340-6096

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The R&D Center's technical point of contact is Mr. Richard Hansen, 860-441-2866, email: rhansen@rdc.uscg.mil. The Headquarters' Project Officer is Mr. Matt Gustafson of the Marine Safety and Environmental Protection Organization.

**16. Abstract (MAXIMUM 200 WORDS)**

This report provides an evaluation of four gaseous halon alternatives (CEA-308, NAF-SIII, FM-200, and Inergen) in full-scale machinery space applications. The primary objective of this investigation was to evaluate the IMO's test protocol for gaseous halon alternative fire extinguishing systems for use with an "inert" gaseous agent (Inergen), with discharge systems containing 180º (Sidewall) nozzles, and with agent discharge cylinders conditioned to low temperatures. The evaluation focused on whether the protocol requires modification to properly evaluate these systems.

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## EXECUTIVE SUMMARY

Four total flooding gaseous halon alternatives (CEA-308, NAF-SIII, FM-200, and Inergen) were evaluated in full-scale machinery space applications. The primary objective of this investigation was to evaluate the International Maritime Organization's (IMO) test protocol for gaseous halon alternative fire extinguishing systems for use with an "inert" gaseous agent (Inergen), with discharge systems containing 180º (Sidewall) nozzles, and with agent discharge cylinders conditioned to low temperatures. The evaluation focused on whether the protocol requires modification to properly evaluate these systems.

The Montreal Protocol, an International Treaty, established production bans on Halon fire suppression agents. The ban was based on Halon's contribution to the destruction of the earth's stratospheric ozone layer. For most of the industrial world, this production ban became effective in 1994. Halon fire suppressant agents, particularly Halon 1301, had become a common fixed fire protection choice on marine vessels. With this production ban came an important need to find acceptable alternatives for these fire suppression applications. Several alternative gaseous agents have been proposed to replace Halon 1301. The IMO drafted a test protocol for these replacements. The U.S. Coast Guard, as part of its regulatory duties, needed to evaluate the effectiveness of the test protocol across a variety of agents and configurations.

The tests were conducted in a simulated machinery space aboard the test vessel, STATE OF MAINE, at the U.S. Coast Guard Fire and Safety Test Detachment located at Little Sand Island in Mobile, AL. The agents/systems were evaluated against five fire scenarios. Two of the five scenarios consisted of small heptane pan fires (telltales) located in the corners of the space to evaluate the mixing characteristics of the system. The remaining three scenarios were large fires consisting of combinations of pan and spray fires produced using either heptane or diesel fuel. One test included a small wood crib. To meet the protocol requirements, the systems were required to extinguish all of

the test fires within 30 seconds of the end of agent discharge, and limit the mass loss of the wood crib to 60% of it's original weight.

The results of these tests suggest that the protocol provides a reasonable basis for evaluating both halocarbon and inert gas extinguishing agents. The lack of a definition in the protocol for the end of agent discharge required clarification from the U.S. Coast Guard in order to judge the performance of the inert gas extinguishing agent (Inergen). It was recommended that the protocol be revised to include a uniform definition of discharge time based on 95% of the agent having been delivered to the protected space. This definition should serve for both the measurement of discharge time and to designate the end of agent discharge.

The addition of a new nozzle design/type or new nozzle spacing was fairly evaluated by the protocol using a single telltale fire test. Additional large fire tests should not be required. However, it was recommended that two additional telltales be added to the center of the space (one on the engine mockup and one in the bilge under the engine mockup). This would further validate the mixing of the agent throughout the compartment.

The effects of the low temperature discharge cylinders varied from system-to-system, and were observed to be related to a number of system parameters (i.e., fill density and percent of agent in pipe). Due to the lack of a general understanding of how these various design parameters affect the discharge characteristics of the system, a systematic study was recommended to bound the problem. Provisions (although not yet defined) should be added to the test protocol for evaluating systems that have agent storage cylinders located in unconditioned spaces.

Based on the U.S. Coast Guard's interpretation of the IMO requirements, five agent/hardware combinations successfully completed the test protocol. These agent/hardware combinations include; Inergen with Ansul hardware, CEA-308 with TEPG hardware, and FM-200 with Hygood hardware, Kidde-Fenwal hardware, and Chemetron hardware.

These results demonstrate that IMO's test protocol, with the proposed recommendations, can effectively evaluate a variety of agents and configurations. The protocol can evaluate different gases, different piping layouts, as well as systems where the agent storage cylinders are at low temperatures.