NRL-CHESAPEAKE RAY DETACHMENT: FULL-SCALE FIRE TEST PLATFORM

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ABSTRACT

The United States Navy is investigating fixed fire-extinguishing systems for future use in Flammable Liquid Store-rooms (FLSR) where Halon 1301 total-flooding systems have been used. The two-phase program is conducted at the NRL Chesapeake Ray Facility (CBD). A new full-scale test platform was designed and constructed in part to perform the above-mentioned program. The test bed consists of two tests compartments, two support sheds, and a control room. The smaller test compartment, at 28 m^3 (1000 ft^3), is applicable to many smaller shipboard compartments. The larger test compartment, at 29X m^3 (10,500 ft^3) is representative of larger shipboard compartments such as large flammable liquid store rooms, paint issue rooms, or pump rooms. This paper will address the conceptual design of the site as well as its current capabilities in terms of large-scale fire testing. A sampling of various fire suppression technologies evaluated will also be highlighted as well as planed future testing.

CONCEPTUAL DESIGN

The primary objective was to design a test bed that can be used to screen and develop emerging fire protection and damage control technologies. The two test compartments of different sizes (Figure 1) allow for emerging technologies to he scoped out in the smaller test compartment, while the large test compartment can be uscd to get technologies developed and field ready for larger scalc applications.

Site Capabilities

The two test compartments can be used to evaluate, research, and develop systems for both Navy and commercial applications. Furthermore, the test bed can be utilized for evaluating systems for industrial, commcrcial, and other government applications. The following systems and procedures can he evaluated:

- Fire protection systems: detection/control/suppression
- Damage control performance criteria: fire, heat, smoke
- Damage control operating procedures and protocols

SITE LAYOUT

The site bed (14 by 13 m [46 by 43 ft]) consists of two test compartments, *28* m^3 (1000 ft^3) and 398 m^3 (10,500 ft^3), an Instrument Shed **(IS),** and a Power Shed (PS). A Mohile Control Room (MCR) is located next to the test site.

Supported by the US Naval Sea Systems Command.
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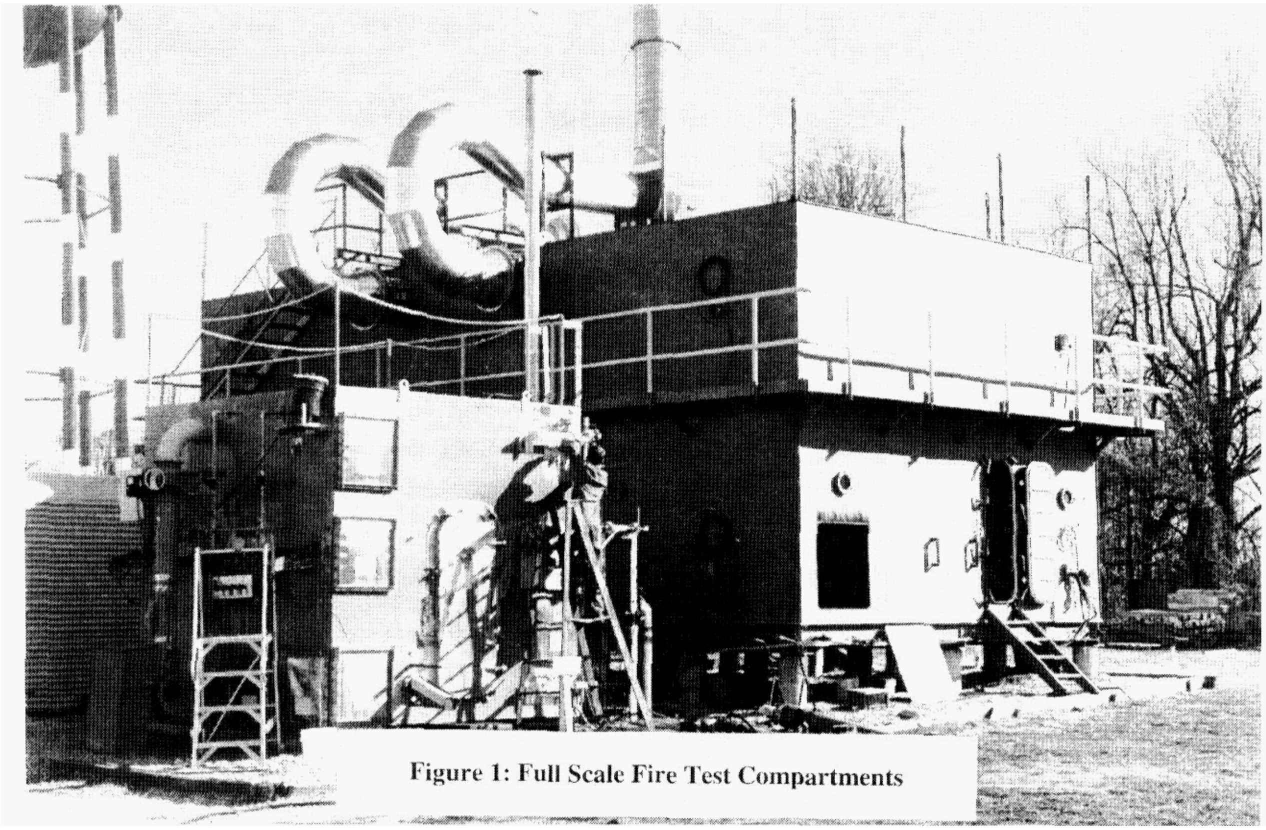

Figure 1: Full Scale Fire Test Compartments

Mobile Control Room (MCR)

The control room from which the Halon Substitute tests are run is a refurbished 1978 model Winnebago designated the Mobile Control Room (MCR). The MCR contains the Experiment Running PC (ERPC), the FTIR PC, video recorders, video monitors, and continuous analyzers for gaseous agents, CO, CO_2, and O_2. The MCR is directly linked to the support sheds.

Instrumentation (IS) and Power Sheds (PS)

The Instrumentation and Power Sheds are modified 2.4 by **3** by 2.4 m (8 by 10 by 8 ft) utility sheds. Mounted in the IS are thermocouple junction strips, instrumentation junction strips, and a DC power supply. Located in the PS are all the solid state electrical relays and circuit breakers for ERPC controlled devices, and also the pumps, filters, and water traps for the continuous sampling equipment.

REPRESENTATIVE INSTRUMENTATION AND EXPERIMENT CONTROL CAPABILITIES

- PC running Labview with capability to control systems sequencing during experiment, as well as data acquisition.
- Fourier Transform Infrared Spectrometer (FTIR)—for monitoring gaseous agents, CO, CO_2, and HX.
- Continuous sampling of CO, CO_2, O_2, gaseous agents. and **HX** concentrations performed at up to 12 compartment locations.

- Grab sampling for subsequent GC analysis. for CO, CO_2, O_2, and gaseous agents at multiple times and locations.
- Over 100 thermocouples for compartment air and surface tcmperatures.
- Pressure transducers for compartmcnt and discharge system pressures.
- Radiometers and Calorimeters.
- Video cameras (3 visible and *2* infrared wavelengths) w/ time stamp generators.

TEST COMPARTMENTS

Test Compartment 1—28 m^3 (1000 ft^3)

This test space (Figures *2* and **3)** is representative of smaller shipboard conipartmcnts requiring fixed fire protection systems such as smaller Flammable Liquid Storerooms (FLSR) and Paint Issue Rooms. FLSRs and Paint Issue Rooms are spaces where flammable liquids (including paints) and materials impregnated with them are stored. Test Compartment I can he used as ***a*** platform for screening and scoping out emerging fire protection technologies (including fire detection, control. and extinguishment). There is limited capability for studying agent interactions with larger fires due to the convolution with oxygen depletion effects.

Test Compartment 2—298 m^3 (10,500 ft^3)

This test spacc (Figure 4) is representative of larger shipboard compartments requiring fixed fire protection systems such as larger Flammable Liquid Storerooms (FLSR). Test compartment 2 is being used as a platform to develop fire protection technologies and ready them for the protection of larger applications. Bccause of the larger internal volume, and hence larger quantities of oxygen available. the oxygen depletion effects on the fires will less limiting. The larger internal volumc also allows the validation of scaling paramcters such as suppressant agent inhomogeneities and distribution around obstructions.

SYSTEMS

- Fuel Flow: Capability to simulate multidimensional fuel leaks and sprays.
- Agent Discharge: Capability to discharge gaseous halon replacemcnt agents, including gas/ aerosol hybrids.
- Water Spray Cooling System: Capability to provide emergency compartment cooling and mitigate possible deflagration scenarios.
- Ventilation: Forced vcntilation (intake and exhaust) with controllable flow rates up to onc air change every 4 min.
- Explosion Relief Vents: Designed to rupture at 0.14 atm *(2* psi) over-pressure.

COMPLETED WORK

FLSR Testing in 28 m^3 (1000 ft^3) Test Compartment—FLSR 1

Tests have been conducted in FLSR 1 to quantify 1,1,1,2,3,3,3 - heptafluoropropanc (HFC-227ea, HFP) performance in terms of fire suppression, reignition protection, and quantities of agent decomposition products generated. We have determined that small FLSRs, on the order of

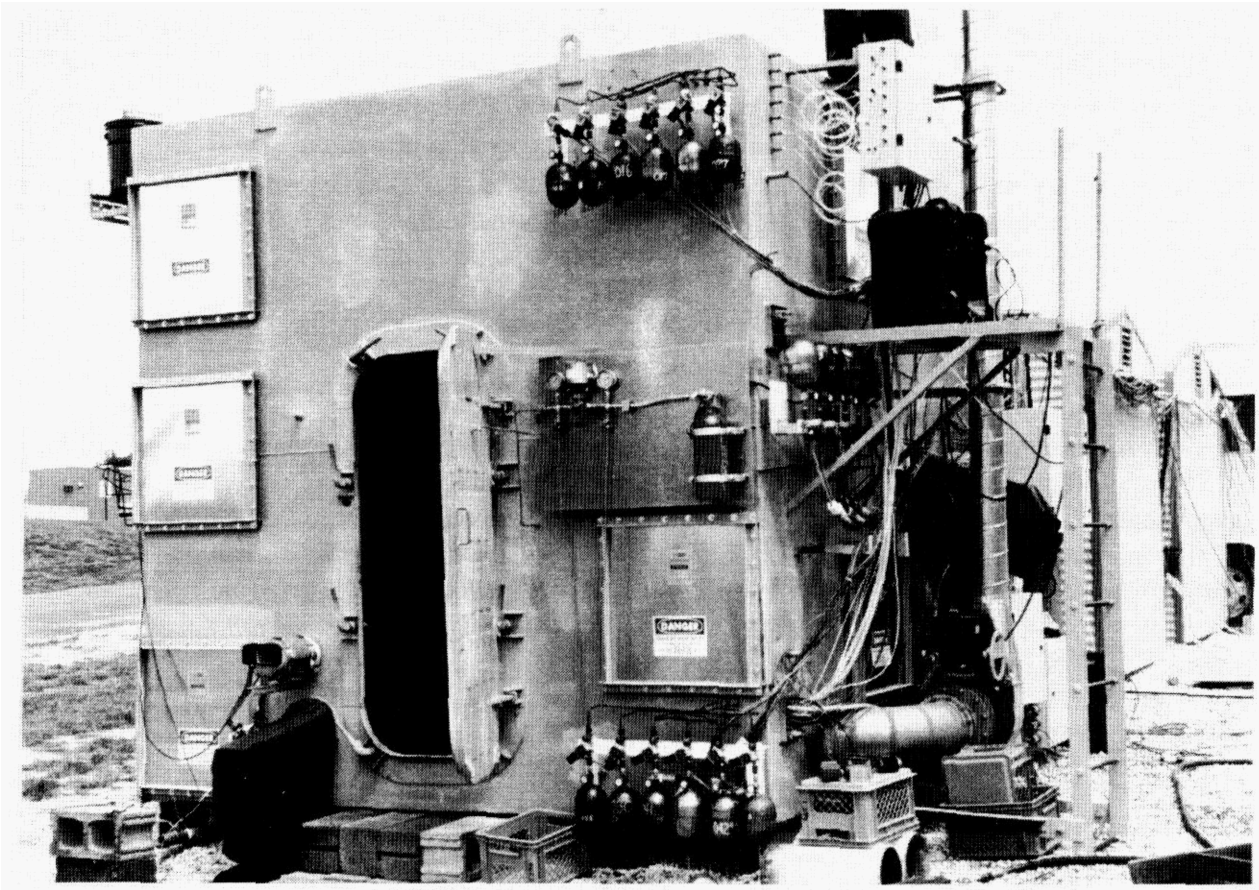

Figure 2: Test Compartment 1 - 2X m^3 (1.000 ft^3)

28 m^3 (1000 ft^3), can be protected by HFP with a design concentration of 11.5%. This elevated design concentration requirement is directly linked to the higher suppression requirements of methanol present in FLSRs. Although significant agent inhomogeneities can be expected, the oxygen depletion will significantly aid the fire extinguishment and hence enhance HFP performance. While reignition protection was achieved. the quantities of decomposition products generated remain a concern for rapid compartment reclamation.

CURRENT WORK

Self-contained Halon Alternatives Evaluation

The halon alternatives program has three main objectives. The first is to evaluate "non-traditional" primarily self-contained halon alternative technologies. The second is to quantify halon alternative suppression system performance in terms of fire suppression and reignition protection for Class B fire scenarios. The third is to compare alternative technologies to Halon 1301 performance. Technologies evaluated to date include hybrid gaseous/powder technologies and water mist.

Figure 3: n-Heptane Fire in Test Compartment 1

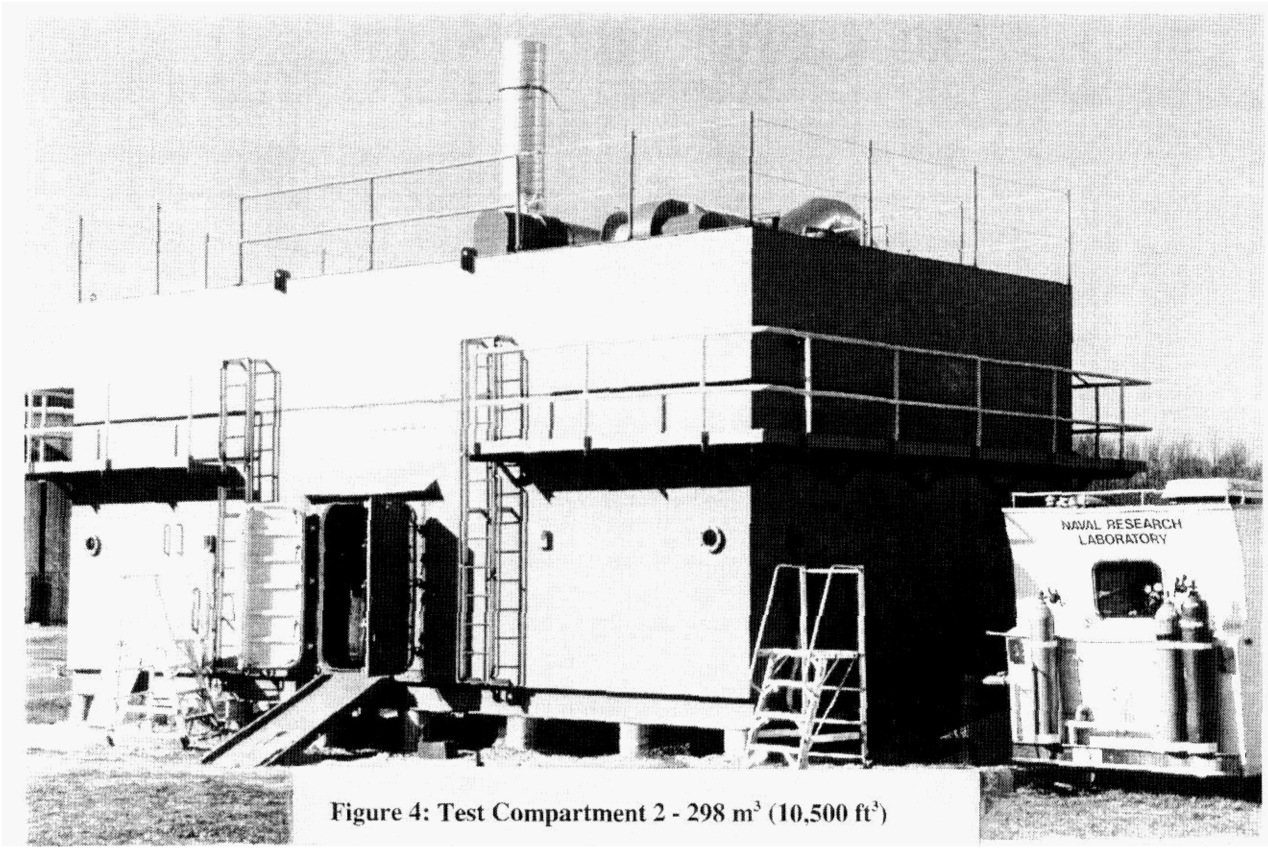

Figure 4: Test Compartment 2 - 298 m^3 (10,500 ft^3)

Halon Replacement HFP Evaluation

To ensure the protection of large FLSRs, several key issues need to be addressed. Agent inhomogeneities play an increasingly important role as nozzle coverage volume and throw distances are increased and agent distribution further hindered by free-standing (in addition to perimeter only) shelving and obstructions. Additionally, the larger quantities of O_2 available will limit oxygen depletion effects. Thus, achieving suppression will be more challenging.

The above-mentioned issues for the protection of larger FLSRs are being addressed by the scheduled tests in two sub-compartments within FLSR 2, Sub-Compartments 1 (63 m^3 [2230 ft^3]) and 2 (126 m^3 [4460 ft^3]). The tests are conducted to evaluate nozzle coverage volume, throw distances and nozzle interactions. as well as the effects of free standing shelving on agent distribution.

FUTURE WORK

Water Mist: Water mist technologies will continue to be evaluated in both the **28** m^3 and 298 m^3 test compartments.

FLSR Testing in 298 m^3 **(10,500 ft”) Test Compartment — FLSR 2:** Testing in FLSR 2 to validate scaling factors will be conducted.

Electronic Enclosures: With the increasing number of electronics onboard, the protection of shipboard “computer rooms” and electronics enclosures/cabinets is becoming increasingly important. Concepts for the shipboard protection of these assets will be investigated.

Advanced shipboard Protection Concepts: Compartment inertion may be a viable option for certain shipboard applications. This concept will be evaluated.

ACKNOWLEDGMENTS

A large number of government employees, contractors. and students have participated in the design, assembly. and use ofthe above described test bed.