

Flammable Liquid Storeroom
Halon 1301 Replacement Testing - Phase 1:
Testbed Design and Instrumentation
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B.H. Black^a, A. Maranghides^a, R.S. Sheinson, and Robert Darwin^b
Naval Research Laboratory, Code 6185, Washington, DC 20375-5342, USA.

tel: (1-202) 404-8101, telefax: (1-202) 767-1716

e-mail: bblack@ccf.nrl.navy.mil (Internet)

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^a GEO-CENTERS, Inc., Ft. Washington, MD, USA

^b US Naval Sea Systems Command 03G2, Crystal City, VA, USA



ABSTRACT

During the past twenty years the Navy Technology Center for Safety and Survivability (NTCSS) at the Naval Research Laboratory (NRL) has conducted extensive research on Halon 1301 replacements and alternatives. This research has been presented with a variety of obstacles to be surmounted, in test design, instrumentation, and execution before valid results could be obtained. Much of what has been learned over the years has been incorporated into Phase 1 of Flammable Liquid Storeroom (FLSR) testing at NRL.

Phase 1 testing investigates the use of Heptafluoropropane (HFC-227ea, HFP), with limited baseline studies using Halon 1301, in a 28m³ (1000ft³) steel enclosure representative of smaller FLSRs in the Fleet. This presentation describes the design and construction of FLSR 1, systems installed, and instrumentation used. This presentation is also intended to give additional guidance in designing and conducting full scale tests based on our experiences.



OBJECTIVES

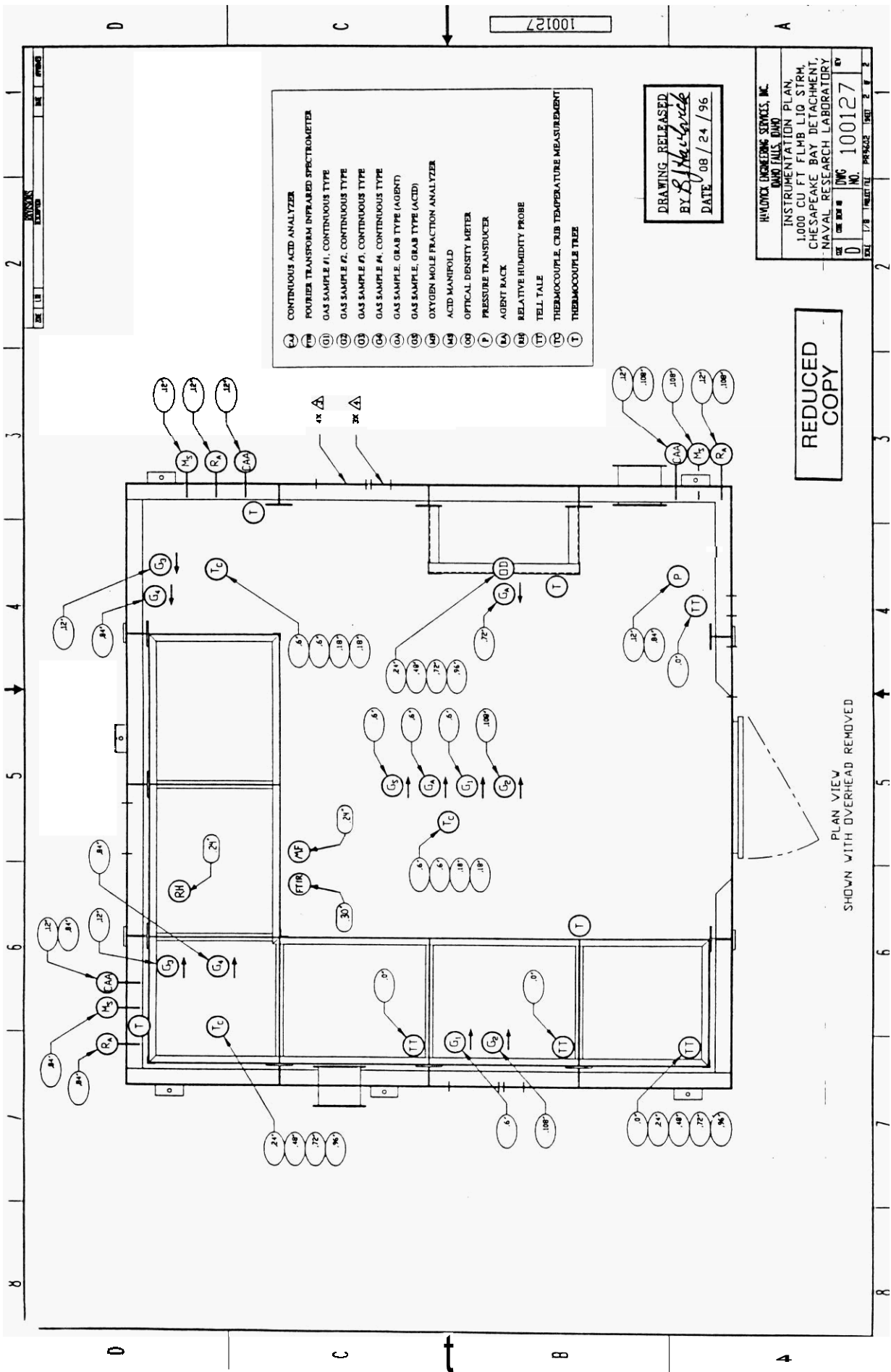
- ▶ Quantify Heptafluoropropane (HFC-227ea, HFP) performance in terms of fire suppression, reignition protection, and quantities of decomposition products generated. Overall system performance will be characterized for agent concentration, number and placement of discharge nozzles, obstruction effects, fuel and fire types.
- ▶ Compare the performance of HFP with base line tests conducted with Halon 1301.
- ▶ Investigate the performance of the Water Spray Cooling System to enhance gaseous agent performance by reducing toxic byproducts, enhancing fire suppression, reducing compartment temperatures, and enhancing reignition protection.



INSTRUMENTATION

- ▶ Pressure: Agent discharge system, WSCS, compartment
- ▶ Temperature: Agent discharge system, trees, shelving, fire and telltales fuel storage containers
- ▶ Continuous Atmospheric Analyzers: 4 loops each with O₂, CO₂, CO, and gaseous agent
- ▶ Continuous Atmospheric Hydrogen Halide Analyzers: 5 locations
- ▶ Intermittent Atmospheric Grab Samples: 6 x 6 locations for gas chromatographic analysis (O₂, CO₂, CO, gaseous agent)
- ▶ Intermittent Hydrogen Halide Grab Samples: 7 x 4 locations for ion chromatographic analysis
- ▶ Optical Obscuration Meters: 4
- ▶ Radiometers: 3
- ▶ Fourier Transform Infrared Spectrometer (FTIR): 1
- ▶ Continuous Relative Humidity Probe: 1
- ▶ Zirconium Oxide Mole Fraction Oxygen Analyzer: 1
- ▶ Video Camers: Visible wavelength (2), infrared wavelength (2)





INSTRUMENTATION LAYOUT: FLSR 1

COMPLEMENTARY AND REDUNDANT SYSTEMS

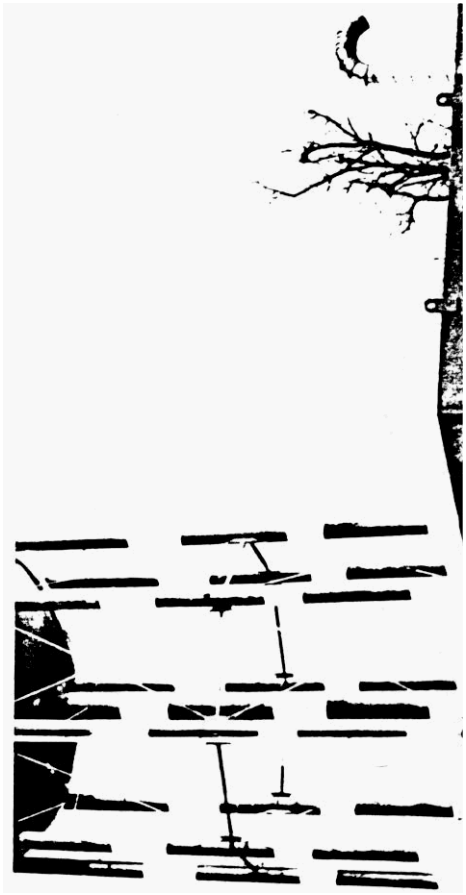
- ▶ **Complementary Systems** are two or more systems whose data output complement each other.
 - ▶ Example: Continuous atmospheric analyzers and intermittent atmospheric grab samples.
 - Continuous atmospheric analyzers allow for accurate measurement of equilibrium atmospheric concentrations, but do not yield reliable temporal measurements during rapid concentration changes such as agent discharge.
 - Intermittent atmospheric grab samples allow for accurate measurement of rapid concentration changes, but are too labor intensive for multiple sampling during equilibrium.
- ▶ **Redundant Systems**, which may also be complementary, are those that measure similar parameters, and are used to assure data collection if one system should fail.
 - ▶ Example: Hydrogen halide quantification by ion chromatography, continuous hydrogen halide analyzer, and FTIR.



FACILITIES

- ▶ **Mobile Control Room (MCR)** - A refurbished 1978 Winnebago that contains the continuous atmospheric analyzers, video equipment, and the ERPC.
- ▶ **Instrument Shed (IS)** - A centralized shed from which instrumentation and thermocouple cables lead from the FLSR and to the MCR. It also houses power supplies and the optical obscuration electronics.
- ▶ **Power Shed (PS)** - A centralized shed that houses the main breaker panel, solid state relay panel, electrical distribution circuits, and continuous atmospheric analyzer pumps, filters, and traps.
- ▶ **Flammable Liquid Storeroom (FLSR)** - The 28m³ (1000ft³) steel enclosure in which all tests are conducted.
- ▶ **Supplemental Instrumentation Laboratory (SIL)** - A laboratory that houses the GCs, IC, and standard preparation/pump-down manifold.





FLSR 1 TEST BITE: MCR, IS, PS, FLSR 1 (left to right)



MAJOR SYSTEMS

▶ **Ventilation**

- ▶ Supply: 7.1m³/min (250cfm), single high port side entry
- ▶ Exhaust: 7.1m³/min (250cfm), two exhaust ports leading to a single exhaust duct. Two-thirds exhausted high starboard side, one-third low starboard side.

▶ **Gaseous Agent Discharge System**

- ▶ Able to discharge Halon 1301 or HFP through three different nozzle configurations.
- ▶ Utilizes Standard Navy Hardware.
- ▶ Can be used with one or two bottles.

▶ **Water Spray Cooling System**

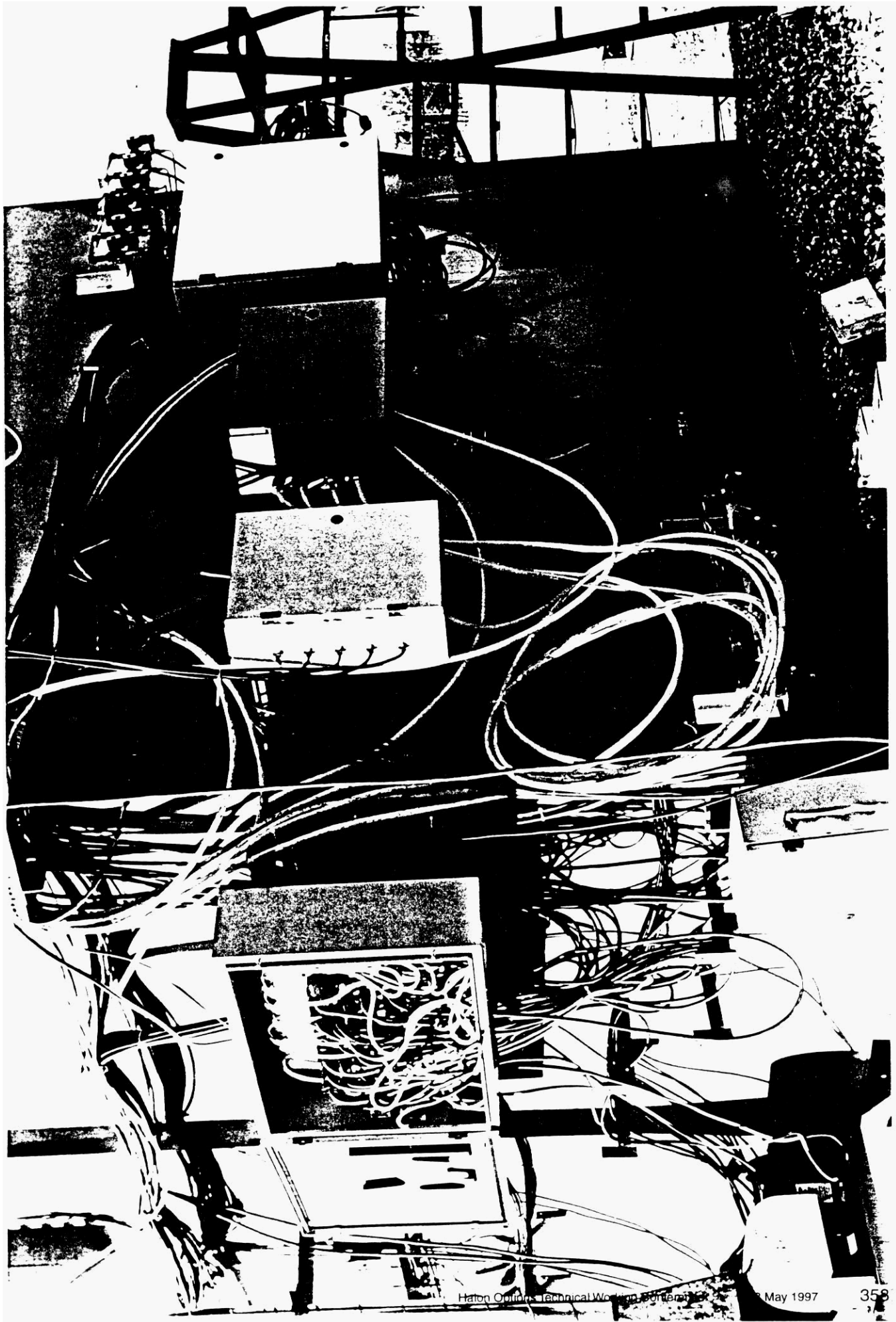
- ▶ Compartment WSCS can be used in either a single or dual nozzle configuration.
- ▶ Additional WSCS nozzle located in the ventilation exhaust duct.



MODULAR DESIGN APPROACH

- ▶ The modular design approach allows for component interchangeability with other testbeds.
- ▶ Enclosures
 - ▷ Pressure Transducers
 - ▷ Thermocouples
 - ▷ Switched Electrical Circuits
 - ▷ Continuous Electrical Circuits
 - ▷ Intermittent Hydrogen Halide Grab Samples
- ▶ Instrumentation, Activation, and Sampling
 - ▷ FTIR
 - ▷ Zirconium Oxide Oxygen Analyzer
 - ▷ Radiometers
 - ▷ Intermittent Atmospheric Grab Sample Racks
 - ▷ CO₂ Activation System
- ▶ Quick Connection to MCR
 - ▷ Instrumentation, Thermocouple and Video Cables
 - ▷ Continuous Atmospheric Analyzer lines





FLSR 1 MODULAR INSTRUMENTATION DESIGN: ENCLOSURES

EXPERIMENT RUNNING PERSONAL COMPUTER (ERPC)

- ▶ 150 MHz Pentium Micro Alliance Industrial Computer
- ▶ LabVIEW Full Development Data Acquisition Software
- ▶ National Instruments Modular Interface
- ▶ Controls Data Acquisition, Instrument and Component Control
- ▶ Controls the Sequence of Events from Fire Detection through Test Completion
- ▶ The ERPC Controls:
 - ▶ Ventilation Shut-Down
 - ▶ Damper Closure
 - ▶ WSCS Activation and Shut-Down
 - ▶ Agent Discharge
 - ▶ Intermittent Grab Sample Collection
 - ▶ Damper Opening
 - ▶ Ventilation Reactivation

