UNITED STATES

COAST GUARD

FULL-SCALE SHIPBOARD TESTING

OF

ALTERNATIVE GASEOUS AGENTS

Presented at

HALON OPTIONS TECHNICAL

WORKING CONFERENCE

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INTRODUCTION

The United States Coast Guard has been actively involved in the research effort to identify alternative total-flood agents. The Marine Fire ti Safety Research Branch (MF&SRB) of the Coast Guard's Research and Development Center has been conducting a research project in this area. This effort is sponsored by the office of Engineering and Logistics (G-ENE). The project's sponsor is LCDR John Hautala (G-ENE-2A). The project has funded small-scale, intermediate-scale and most recently full-scale tests on selected total-flood gaseous agents. The full-scale tests were conducted between April 20, 1994 and April 28, 1994 at the Coast Guard's Fire & Safety Test Detachment in Mobile, AL.

OBJECTIVE

The objective of the Coast Guard's effort to identify a Halon replacement for installation in the engine rooms (and possibly other spaces) on newly designed Coast Guard cutters. Presently the cutter designs incorporate the use of carbon dioxide (CO_2) as the total-flooding agent since Halon is no longer considered a viable agent. Carbon dioxide is an effective fire extinguishing agent, however the lethal atmosphere created by the discharge of a system is well known. Through this effort the Coast Guard hopes to identify an effective agent (s) that will fulfill their fire protection requirements and obviate the need to use of CO,.

The Coast Guard's requirements consist of the agent being effective against all typical machinery space fire casualties, be effective for the largest engine rooms, be safe with no toxicity problems and not create a space/weight problems. Typical machinery space fires consist of three types: fuel spray, bilge and electrical. Typically flammable hydrocarbons fuels and gases as well as electrical components and cabling are the main threat. The agent must be effective against each separately, or a combination of the three. Typical engine rooms are large and open vented through the annulus space in the exhaust stack. The agent must be both environmentally safe and have no adverse affects on the space's occupants.

AGENT SELECTION

The Coast Guard funded an effort by Hughes Associates, Inc. and the University Of New Mexico's New Mexico Engineering research Institute (NMERI) that compared the available Halon substitute gaseous agents with respect to the above Coast Guard requirements. All available agents were reviewed and compared, using Halon 1301 as a baseline. The agents were evaluated against each of the stated requirements and scored. Each requirements was assigned a weighting factor. The total weighted score was used to evaluate and select candidate agents for inclusion in the full-scale testing, see Figure 1. Four agents were selected to be included in the full-scale test series. The selected agents were CEA-410, FE-13, FM-200 and NAF-SIII. CEA-410 is a product of 3M Performance Chemicals, FE-13 is a patented product of Dupont Fluoroproducts, FM-200 is a patented product of Great Lakes Chemical Corporation, and NAF-SIII is a product of North American Fire Guardian Technology, Inc.

FULL-SCALE TESTS

The full-scale tests were conducted at the Coast Guard's Fire & Safety Test Detachment aboard the test vessel MAYO LYKES located at Little Sand Island in Mobile, AL. The number four cargo hold was modified to create test a compartment similar to a "typical" machinery space. The space is 11.1 meters long by 6.9 meters wide by 7.3 meters high ($560m^3$), see Figure 2. It is constructed of steel with a diesel engine mock-up centered in the compartment. There is a 60 centimeter diameter exhaust stack located in the overhead. The exhaust stack has a water spray scrubber to remove dangerous decomposition products. The space has a 46 centimeter diameter ventilation supply duct which branches high and low into the compartment. The ventilation blower provides approximately 15 air changes per hour with a $170m^3$ flow rate. This is approximately the number of air exchanges for a typical Coast Guard machinery space. Catwalks and other obstructions were added to make a more realistic machinery space.

The agent distribution system was designed using a two-phase flow model developed by Hughes Associates, Inc. for NASA and the Coast Guard. The model is currently being validated. Intermediate-scale validation testing has been performed. The results of flow, temperature and pressure readings taken during the full-scale tests will be used for full-scale validation of the model. The agent distribution system is shown in Figure 3. The flow rates of the agents were controlled by orifice plates in the nozzles. The nozzles used were 2.0 inch NPT Fenwal pendant nozzles. Agent requirements for the tests are shown in Figure 4.

INSTRUMENTATION

The tests were instrumented as shown in Figure 5. Temperature, pressure and air sample measurements were taken throughout the test space. The distribution system was instrumented at numerous locations to take fluid temperature and pressure as well as pipe surface temperatures. During cold discharge tests (tell tale fires but no test fires) thermal conductivity meters were used to measure agent distribution throughout the test compartment. Species concentration measurements were taken by Fourier Transform Infrared (FTIR) Spectroscopy. Two instruments were used for the tests, one internal and one external. The internal measurements were taken by Hughes Associates, Inc. using a KVB/Analect Diamond *20* FTIR with calcium fluoride (CaF_2) windows. The instrument was installed to allow the beam to sample internal to the space. The external measurements were taken by New Mexico Engineering Research Institute using a Perkin Elmer System **2000** Infrared Spectrometer. Samples were drawn from six locations within the test compartment to the instrument via heated monel sample tubes. Samples were continuously drawn out of the chamber and a computer controlled manifold would select the sample to be analyzed. Differences were noted between the two measurement technicques (internal verses external) which must be correlated before the data can be used.

FIRE SCENARIOS

Five tests were conducted on all but one agent. Due to agent availability and problems encountered during testing of NAF-SIII, only two tests were conducted on this agent. Cold tests were conducted on three agents and Halon (baseline) to measure agent distribution and verify discharge times. Tell tale fires (small cups of heptane) were used to verify distribution in all tests, including the cold tests.

Fire Scenario **1** was a **500** KW heptane spray fire and a 500 KW heptane pane fire, see Figure 6. A Halon baseline test was conducted against this scenario. Fire Scenario **2** was a **2 MW** heptane spray fire and a 500 KW heptane pan fire, see Figure 7. **A** fast discharge test (approx. 7 seconds verses 10 seconds) was also tested against this scenario. Fire Scenario **3** was a 5 MW diesel (two **112** cm X **112** cm pans) and a 500 KW spray fire impinging on a cable way, see Figure *8.*

CONCLUSION

Due to the test series completing just before the start of this conference test results and conclusions are not available. **A** final report on the test series will be completed by the end of September and the report distributed shortly there after.

On tests where visual extinguishment was possible, all agents extinguished the spray fires within **22** seconds and the pan fires within **20** seconds. Quick look data on decomposition products indicated their appeared to be correlations between acid generation, fire size, and extinguishment times. Further review and analyses are required before this can be quantified.

EIGHTED ATTRIBUTES CANDIDATE ASSESSMENT MATRIX
OCCUPIED, TOTAL FLOODING APPLICATION

ATTRIBUTE	ATTRIBUTE WEIGHT	HALON 1301	CEA-410	FE-13	FM-200	NAF-SIII
EXTING. EFF.	4	5	2	3	3	3
BOILING POINT	3	5	4	5	4	4
VAPOR PRESS.	4	5	5	1	5	5
RESIDUE	3	5	5	5	5	3
ODP	5	0	5	5	5	3
GWP	3	1	1	1	2	3
ATM. LIFETIME	4	2	1	1	3	3
AVAILABILITY	3	1	3	5	3	4
COST	3	1	2	5	3	4
STORAGE STAB.	3	5	5	5	5	5
MAT. COMPAT.	4	5	4	4	4	4
LC50	4	5	5	5	5	4
CARDIAC THRESH. TO EXTING. CONC.	5	5	5	5	3	4
CONDUCTIVITY	5	5	5	5	5	5
RECYCLABLE	2	5	5	2	5	2
TOTALS		0	213	213	221	209

FIGURE 1

TEST COMPARTMENT

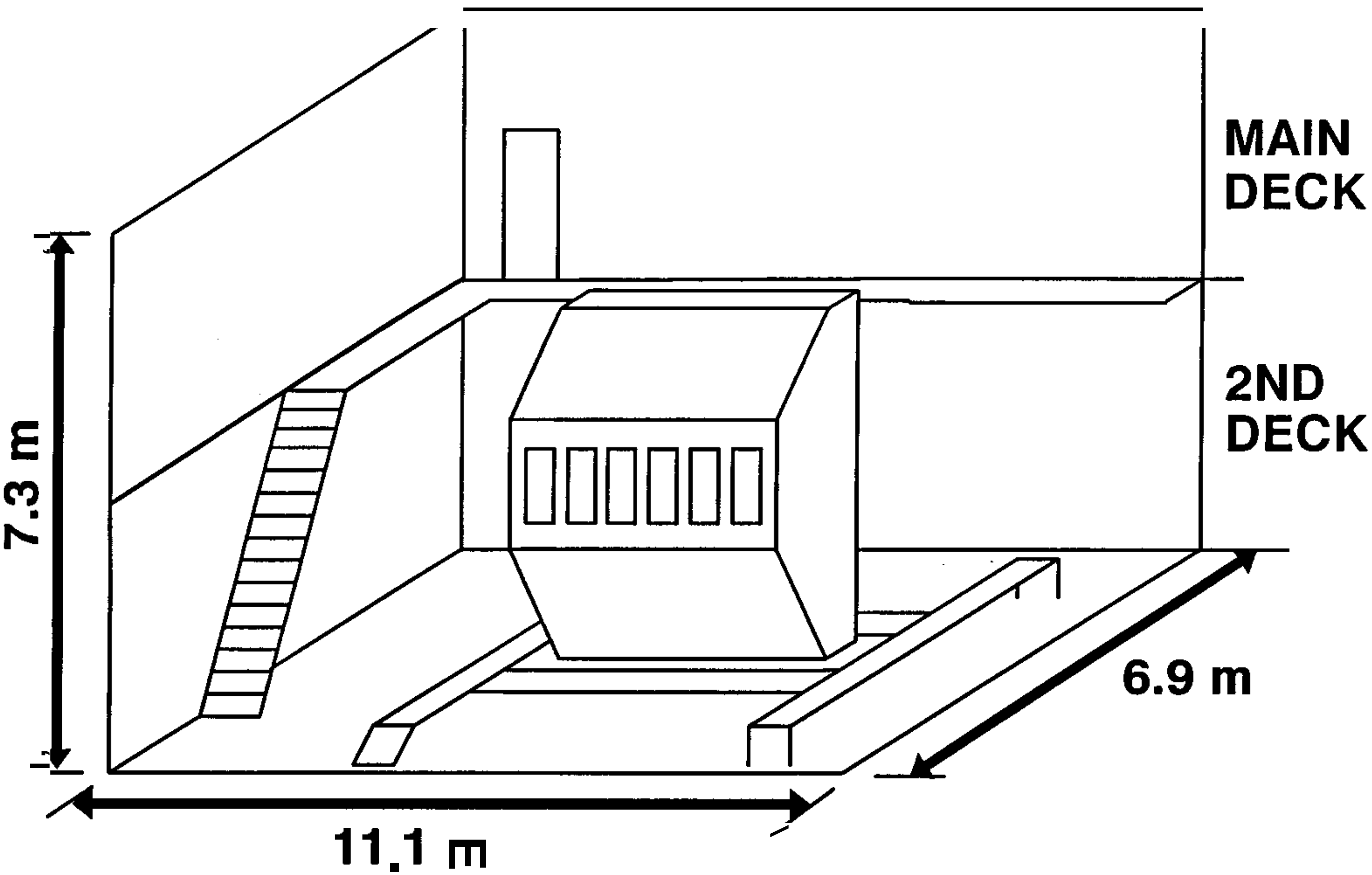

FIGURE 2

DISCHARGE SYSTEM

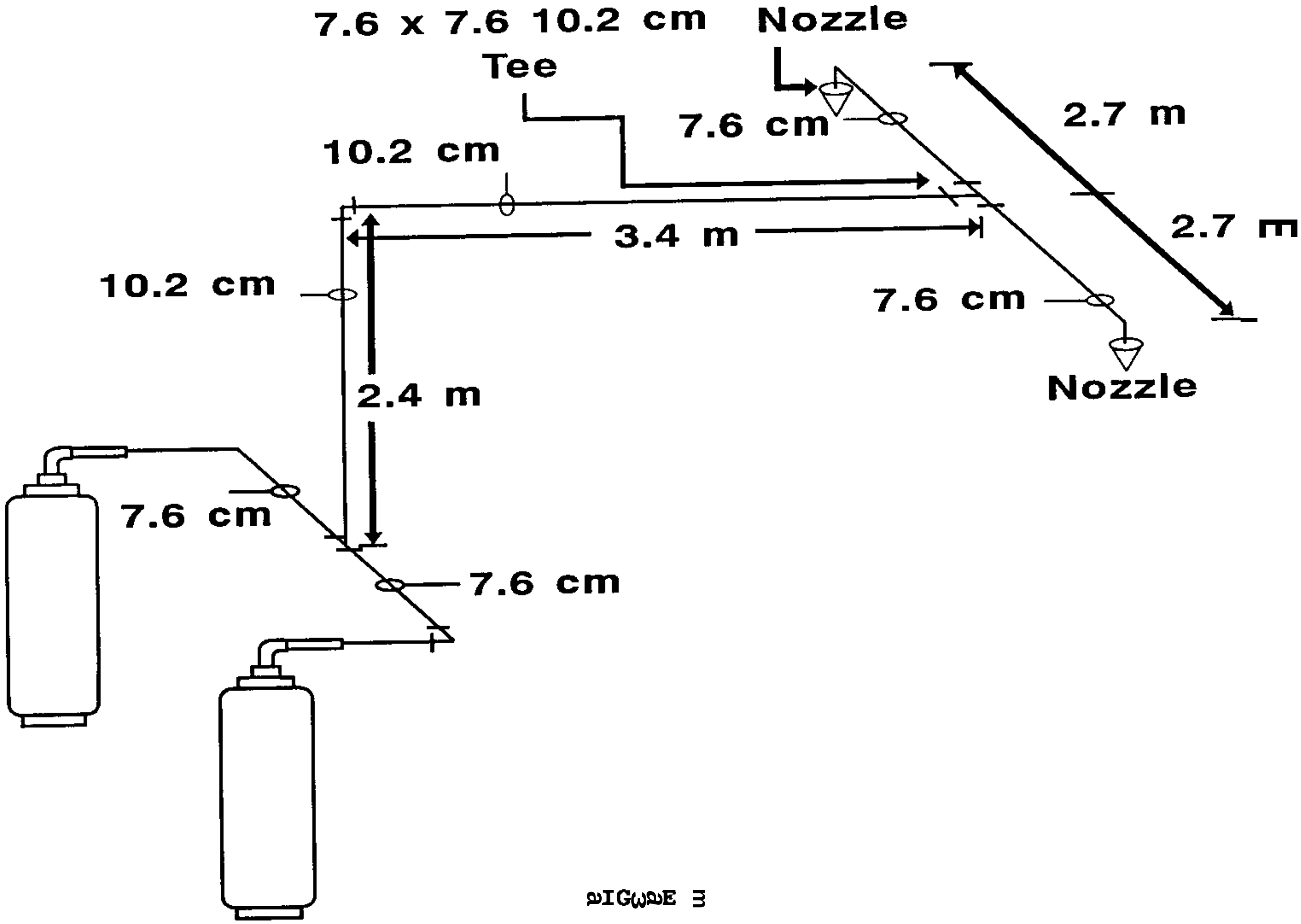

FIGURE 3

AGENT REQUIREMENTS TO PROTECT 560 m^3 SPACE

AGENT	MANU. REC. DESIGN CONC. (% BY VOL.)	MASS REQ. kg/lbs	NUMBER OF 0.05 m^3 CYLINDERS
HALON 1301	5.0	173/382	3
CO_2	35.0	558/1,230	17
FM-200	7.0	282/621	5
CEA-410	6.0	333/734	6
FE-13	16.0	298/657	8
NAF	8.6	200/440	4

FIG E 4

INSTRUMENTATION PLAN

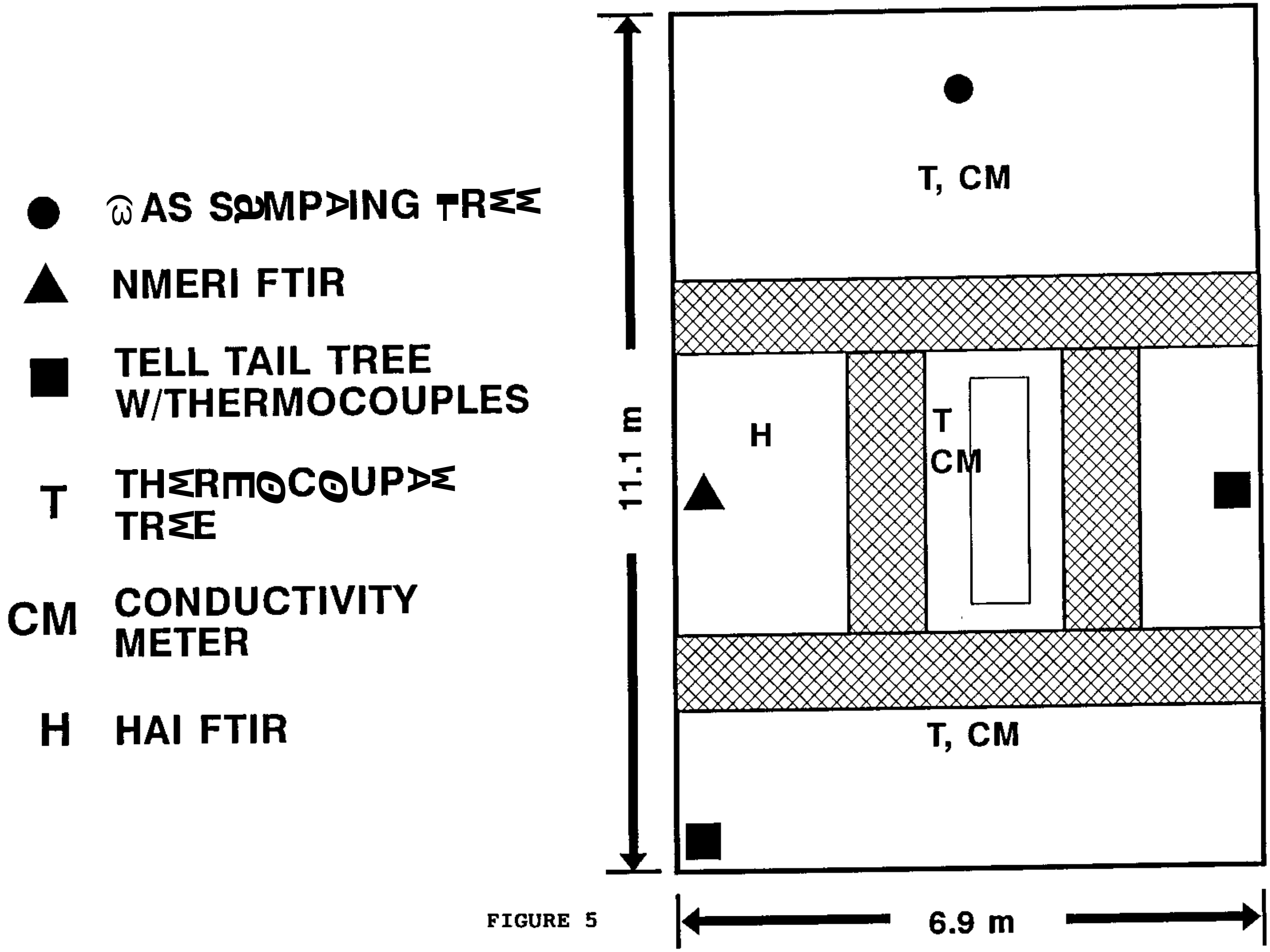

FIGURE 5

H:KW SCENARIO 1

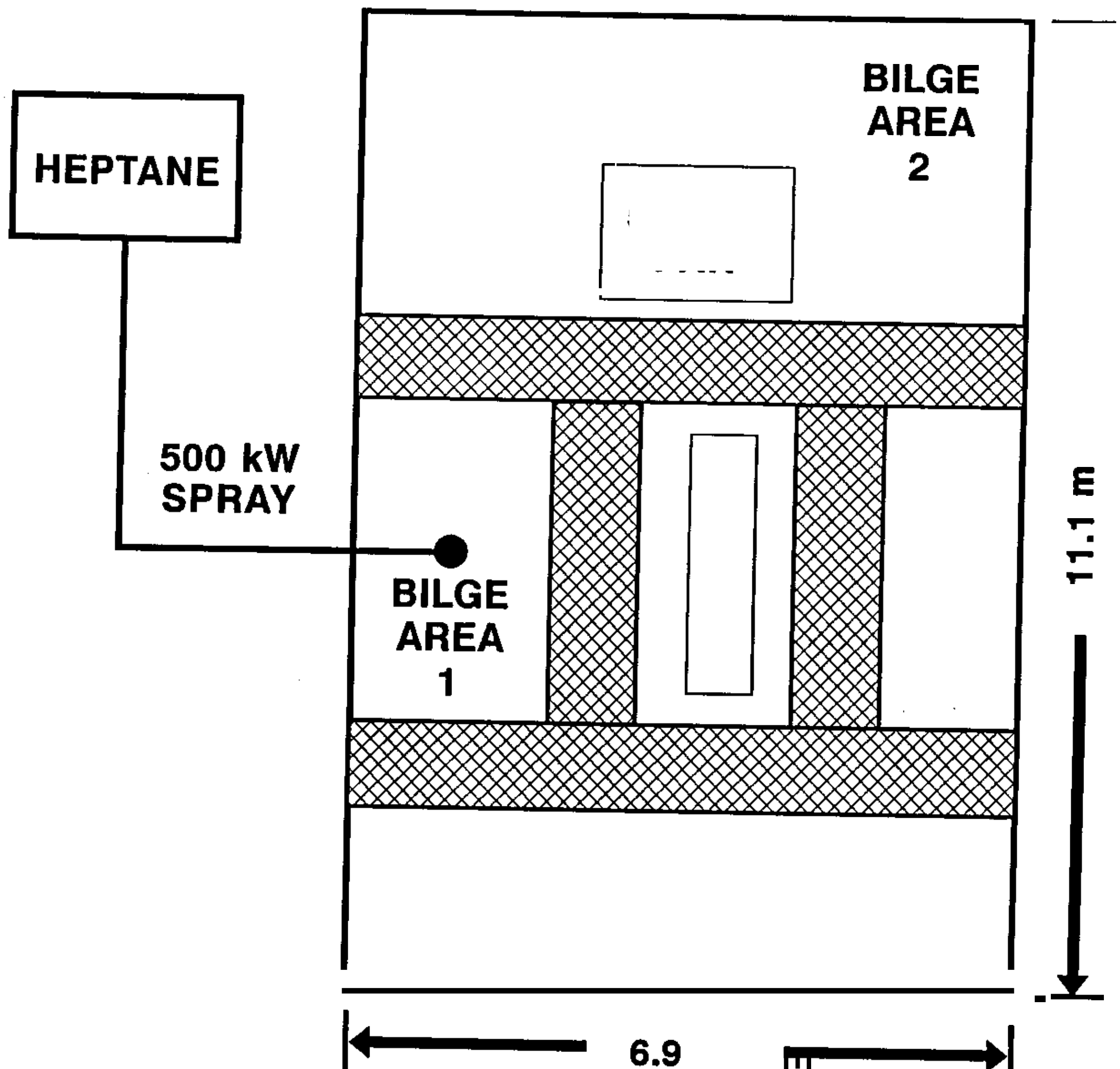

FIGURE 6

FIRE SCENARIO 2

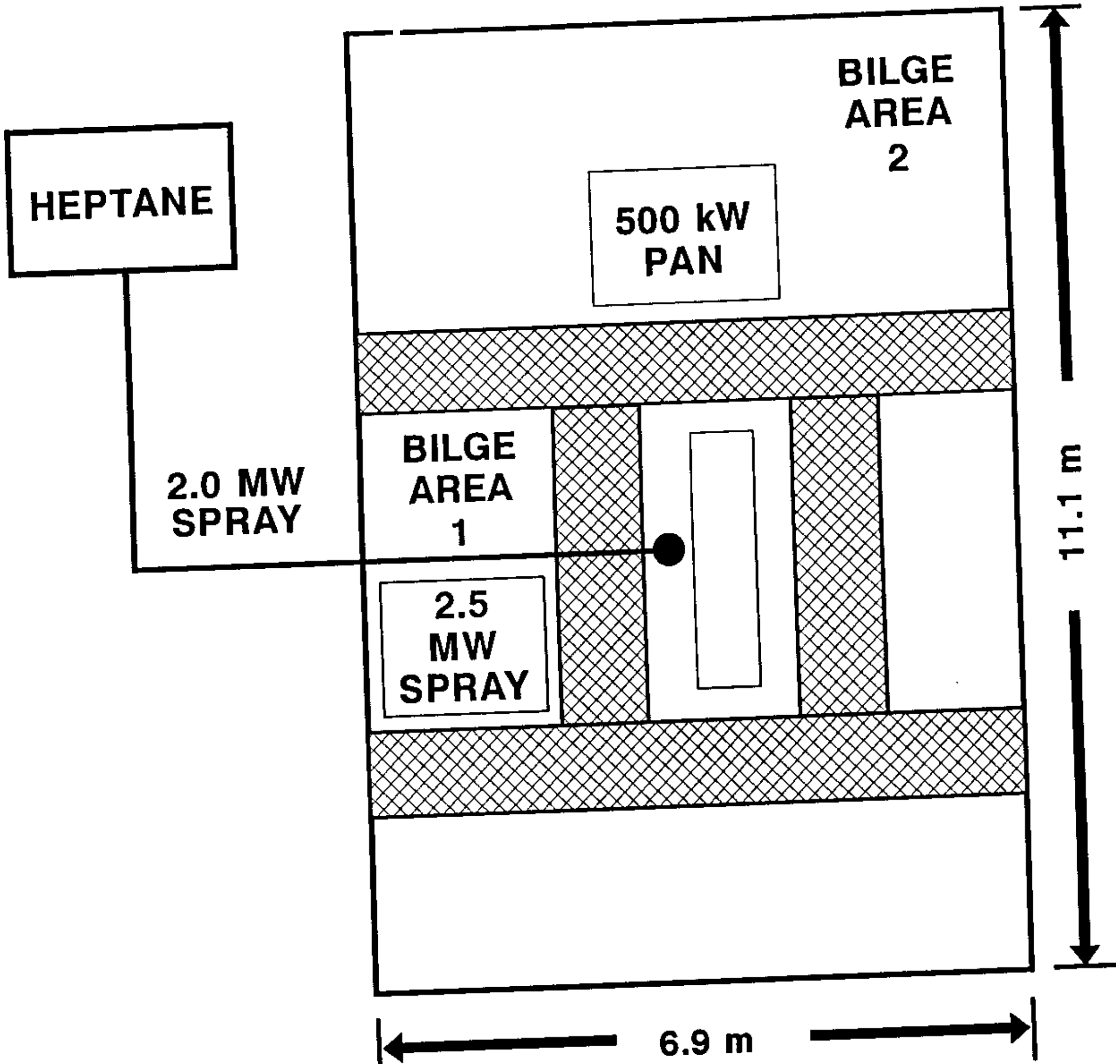

FIGURE 7

FIRE SCENARIO 3