INTERMEDIATE SCALE DETERMINATION OF EXTINGUISHMENT CONCENTRATION AND MEASUREMENT OF PRODUCTS OF DECOMPOSITION OF SELECTED ALTERNATIVES TO HALON 1301

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INTRODUCTION

It is becoming increasingly evident as research and data gathering progresses that Halon 1301 and Halon 1211 are powerful ozone depleters. As such it is extremely likely that further restriction on production and a more accelerated production phase out of thee materials will be required by the Montreal Protocol' or specific national legislation within the international community.

Several candidate replacement agents for Halon 1301 and Halon 1211 have been announced by the Halon agent manufactures. These materials by and large are drawn from a series of chemical compounds that are chemically similar and constitute the following:

HCFC - Hydrochlorofluorocarbons
HBFC - Hydrobromofluorocarbons
HFC - Hydrofluorocarbons
FC - Fluorocarbons

It is likely that whatever replacements for halons that do evolve will come from these classes of compounds.

It is important to recognize that the factors that need to be considered and reconciled are:

- Extinguishing (inerting) concentration
- Toxicity
- Environmental impact
- Corrosivity
- cost
- Commercial availability
- Compatibility with existing hardware

All of these properties are important but recent events are dictating a focus on the environmental impact. This impact is usually expressed **as** the ozone depletion potential (ODP) and is a calculated property of the compound in question. It is obviously desirable to have the ODP as small as possible and preferably zero **(0).** This would dictate a selection from only two (2) of the four identified groups:

- HFC - Hydrofluorocarbons
- FC - Fluorocarbons

This would be the preferred approach if one investigates the problem only from the environment aspect. Equally significant and important are the compounds ability to extinguish a fire (or inert an atmosphere) and the relative and absolute toxicity of the compound to humans.

STATEMENT OF THE PROBLEMS

Small scale laboratory tests for determining threshold extinguishing concentration[2] and inerting concentrations[3] were developed and refined in the 1970's. The small scale threshold extinguishing concentration test is commonly referred to as the "Cup Burner Method", while the inerting tests is referred to as the "Spherical Bomb Method". The cup burner method was further refined to down size the apparatus in the late 1980's[4].

The basic problem was then to develop a reasonably sized intermediate scale test apparatus. Previous intermediate scale tests were conducted in enclosures ranging from 1000 to 10,000 ft^3 with fuel area sizes varying from 1 ft^2 to 10 ft^2[5].

The approach taken in this investigation was to develop an intermediate scale apparatus with volumes between 100 x 200 ft^3 and using fuel sizes from .0077 ft^2 to *2.0* ft^2.

EXPERIMENTAL DESIGN

The intermediate scale apparatus used in this investigation is shown on Figure 1. It consists of a 3/4" plywood enclosure 4'1 x 4'w x 8'h. The enclosure is lined with 10 mil thick teflon. The seams are formed with adhesive then heat treated to form a continuous liner enclosure. Previous tests conducted without a liner resulted in extraneous levels of halogen acids due to absorption and desorption from the plywood. This resulted in non-reproducible measured levels of the halogen acids.

The enclosure was filled with several sampling probes to measure concentration of halogen acids as well as temperature and pressure. These include:

- Temperature at 2', 4', and 6' above the floor
- Concentration sampling at 2', 4', and 6' above the floor
- Temperature of the bulk fuel
- Flame zone temperature
- Real time HF sensors at 2.5' & 5'
- Nozzle temperature and pressure
- Fuel weight loss by load cell

All of the sensors signal except remote concentrations were incorporated into a data acquisition system. This system is based upon a Keithly Instrument Model 500A Measurement and Control System used with a Compaq Desk Pro 286 micro computer.

Remote concentration samples were taken at various times after discharge of agent or extinguishment of fire into evacuated teflon cylinders. The cylinders contained a TSIBA fixing solution to stabilize bromide, chloride, and fluoride ions until analysis could be made. The preferred method of analysis involved a specific ion electrode determination of the species in question[6]. Detailed protocols for all of the analytical procedures including operation of the data acquisition system are given in the final project report[7].

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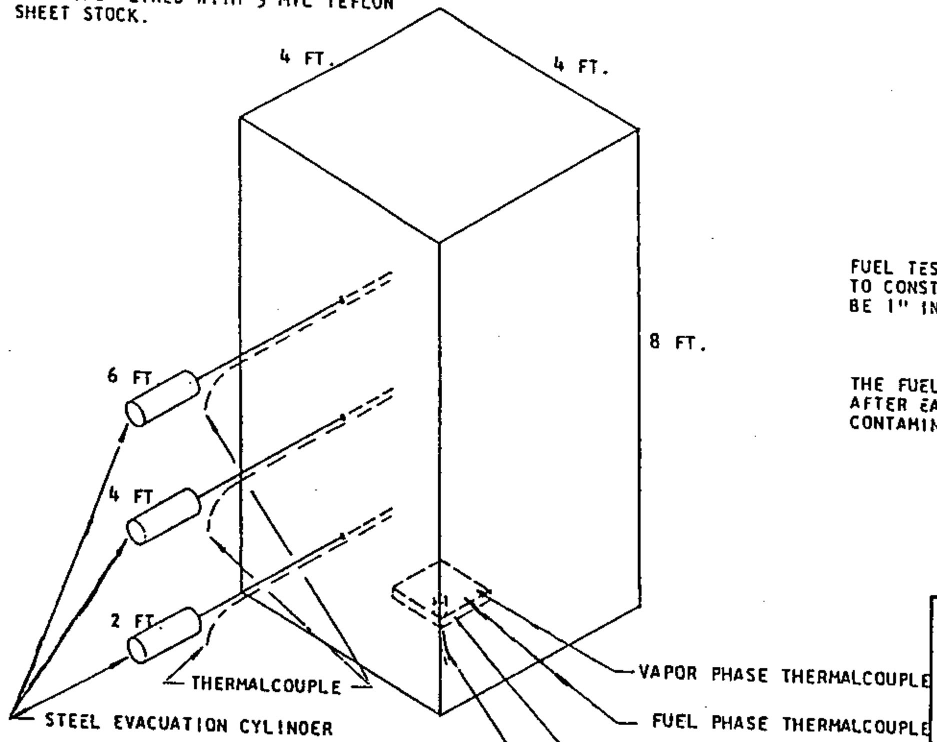
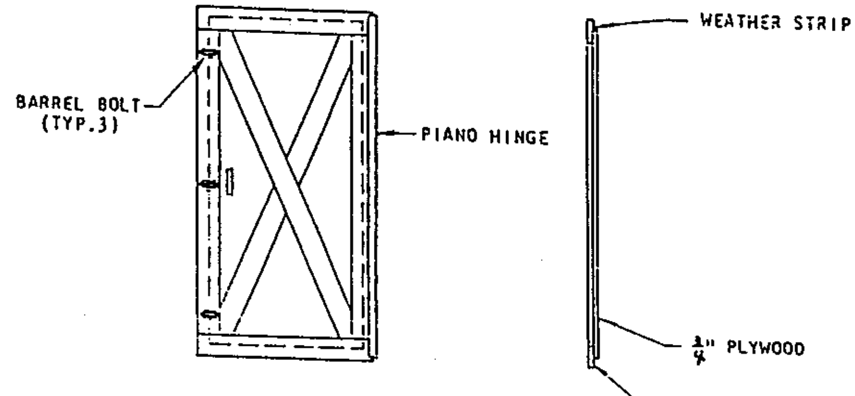
REVISION	DATE	BY	APP'D BY	RELEASE NO.

TOTAL VOLUME OF TEST CONTAINER 128 FT.^{3}
CONTAINER LINED WITH 5 MIL TEFLON
SHEET STOCK.



SAMPLE LINES AND THERMALCOUPLES EXTEND 1 FT. IN FROM SIDE WALL OF STRUCTURE. SAMPLE LINES ARE ¼" DIA. 316.S.S.



DOOR ON REAR OF CONTAINER

FUEL TEST PAN RESTS ON A PLATTEN ATTACHED TO A LOAD CELL. PRE-BURN IS TAKEN TO CONSTANT WEIGHT LOSS ESTIMATED AT 20% OF FUEL LOADING. FUEL DEPTH IS TO BE 1" IN EACH TEST PAN. PAN DIMENSIONS ARE:
.0077 SQ.FT.
.077 SQ.FT.
.77 SQ.FT.
THE FUEL FOR EACH FIRE WILL BE HEPTANE OF COMMERCIAL QUALITY.
AFTER EACH TEST THE CONTAINER WILL BE VENTED TO ATMOSPHERE TO REMOVE CONTAMINATION FROM THE PRECEDING FIRE.

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LINEAR DIMENSIONS IN INCHES, WHEN TOLERANCES ARE NOT GIVEN, THEY ARE:

	MM	IN.
2 PLACE	±0.5	±0.02
3 PLACE	±0.13	±0.005
ANGLES	±1/2°	

MATERIAL

THIRD ANGLE PROJECTION

A.Q.L. DEFECT CLASSIFICATION
Ⓒ CRITICAL Ⓜ MAJOR

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EXPERIMENTAL DATA

The data collected during the investigation is summarized in Tables 1 and 2. Table 1 contains the data for several candidate replacements using Halon 1301 as **a** control with a fixed 10 second discharge time and using a .077 ft^2 pan fire with heptane as the fuel.

Table **2** displays the data collected with several candidate replacements using Halon 1301 as a control. In this case both fire size and discharge times were used to determine what effect these variables would have on the concentration of halogen acids generated.

TABLE 1

SUMMARY OF HALON CHAMBER FIRE TESTS OF
SAMPLE 1508, SAMPLE 1773, SAMPLE 1742, AND HALON 1301

		AVERAGE		PEAK (077 ft^2 pan)		
		TOP	BOTTOM	TOP	BOTTOM	HBr
1301	10 sec ave	11	-2	12.7	.2	25.6
1508	10 sec ave	8.2	3.3	9.5	4.3	<4
1773	10 sec ave	18.2	13.8	25.3	21.9	N/A
1742	10 sec ave	off scale		off scale		N/A
1742	10 sec ave (.0077 ft^2)	17.8	17.0	19 6	21.6	N/A

TABLE 2

"Total Flooding Evaluation of Candidate Halon Replacements"

RUN #	AGENT	FIRE SIZE	WEIGHT	NOZZLE	HF (by scrub)
10	1301	0.2	2.44	s	18
9	1301	0.5	2.44	s	384
15	1301	0.2	2.125 (4.0%)	l	43.4
17	1301	0.5	2.1 (3.96%)	l	87.9
12	1301	0.2	2.2 (4.2%)	s	28
20	1301	0.5	2.2	l	52.1
11	125	0.2	4.5	s	115
8	125	0.5	4.5	s	481
19	125	0.5	4.5	l	345.8
14	125	0.2	4.5	l	389.4
6	23/134a	0.2	4.0	s	414
7	23/134a	0.5	4.0	s	760
13	23/134a	0.2	4.0	l	47
18	23/134a	0.5	4.0	l	690
16	23/134a	0.2	4.0	l	560.2

(s) small nozzle ¼" total effective area
(l) large nozzle ½" total effective area

CONCLUSIONS

- The results of this investigation indicate that both fire size and discharge time have an effect on concentration of decomposition product.

- Required extinguishing concentrations may not be consistent with those obtained using the Cup Burner Method.

- It is necessary to maintain certain fuels and *to* enclosure volume rates to obtain consistent results.

- As the fuel area is increased for a given enclosure volume, the concentration of halogen acids increases.

- As the discharge time is increased for a fixed enclosure volume and fire area size the concentration of halogen acids increases.

- 1508 and Halon 1301 produce about the same amount of HF.

- 1773 produces larger quantities of HF than 1508 or Halon 1301.

- 1742 produces substantially more HF than does 1508, 1773 or Halon 1301. Decreasing the fire size by a factor of 10 reduces the HF concentration to that equivalent to 1773.

- The amount of HF produced by decomposition of FE 125 is about 2 times that produced by Halon 1301.

- The amount of HF produced by decomposition of F-12/HCFC134a is 2 times that produced by Fe-128 or *4* times that produced by Halon 1301.

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