U.S. Department
of Transportation
**Federal Aviation
Administration**

Technical Center

Atlantic City Int'l Airport
New Jersey 08405

December 4, 1995

Dear International Halon Replacement Working Group Member:

Enclosed please find a copy of the Minutes/Information Package from the meeting held in Atlantic City, New Jersey, November 17, 1995.

Copies of the Task Group Leader Presentations are included, however, if you would like a copy of any of the following presentations, please contact April Horner at 609-485-4471, or by fax at 609-646-5229:

1) "Results of Halon 1301 and HFC-125 Concentration Tests on a Large Commercial Aircraft Engine Installation", By K. Kaufmann, The Boeing Company; M. Miller, The Boeing Company; G. Wozniak, The Boeing Company; and M. Mitchell, Walter Kidde Aerospace.

2) "Engine Fire Extinguisher Agent Concentration Testing: Comparison of HFC-125 and Halon 1301", By D. Riordan, Shorts Brothers Plc.

3) "U.S. Navy Inert Gas Generator Program", By B. Leach, Naval Air Warfare Center.

4) "FE-36 - A New Clean Agent for Streaming Applications", By D. Moore, DuPont Fluoroproducts.

The next meeting will be hosted by Airbus Industries and Lufthansa Technik in Hamburg, Germany, on March 26-27, 1996. Tours of DASA and Lufthansa Technik will be given on March 28, 1996. Details on the meeting and tours are included in this package. A Meeting Return Form is included in this package. It must be returned by February 15, 1996, if you plan to attend the next meeting.

We look forward to seeing you in March.

Sincerely yours,

Richard G. Hill
Program Manager

Enclosure

First	Last	Company	Country	Phone	Fax
Dale	Atkinson	Consultant		703-451-3011	703-451-4278
Stephen	Berg	H3R, Inc.		415-621-3588	415-621-3479
Hanns-Joerg	Betz	Lufthansa Technik	Germany	49 69 696 4612	49 69 696 4604
Dave	Blake	FAA Technical Center		609-485-4525	609-485-4810
Michael	Bucke	American Airlines		918-292-2388	918-292-3040
Nick	Butcher	United Kingdom Civil Aviation Authority	England	44 1 293 573 341	44 1 293 573 991
Dave	Catchpole	BP Exploration		907-564-5038	907-564-5020
Adam	Chattaway	Kidde International	United Kingdom	44 1753 683245	44 1753 683810
Tom	Cortina	HARC		202-223-6166	202-223-5979
Doug	Dierdorf	Pacific Scientific		505-291-1109	505-291-1141
Dung	Do	FAA Technical Center		609-485-4530	609-485-5580
Larry	Dvorak	Raytheon Aircraft Corporation		316-676-8991	316-676-7440
Bob	Filipczak	FAA Technical Center		609-485-4529	609-646-5229
Ron	Fisher	Defense Fire Protection		703-379-6382	703-379-9256
Bob	Glaser	Walter Kidde Aerospace		919-237-7004	919-237-4717
Jim	Gourley	Amtrak - Fire Protection Safety		215-349-2786	215-349-2767
Gregory	Grimstad	Boeing Commercial Airplane Company		206-234-1366	206-237-4831
Alankar	Gupta	Boeing Commercial Airplane Company		206-237-7515	206-237-5444
Sham	Hariram	McDonnell Douglas Corp.		310-593-4305	310-593-7104
Carlos	Hilado	Product Safety Corporation		304-984-2994	
Richard	Hill	FAA Technical Center		609-485-5997	609-646-5229
_April	Homer	FAA Technical Center		609-485-4471	609-646-5229
Frank	Hughes	British Airways	England	44 1 81 562 3944	44 1 81 562 2026
Paul	Huston	Paul O. Huston & Associates		205-655-2961	
Doug	Ingerson	FAA Technical Center		609-485-4945	609-646-5229
Konstantin	Kallergis	German Aerospace Research Establishment	Germany	49 5055 596 0	49 5055 596 17
Dale	Kent	3M		612-631-0629	612-636-1977
Bill	Leach	Naval Air Warfare Center		908-323-1184	903-323-1989
Claude	Lewis	Transport Canada Aviation(AARDH)	Canada	613-990-5906	613-996-9178
David	Liddy	Ministry of Defense	England	44 171 218 4908	44 171 218 4609
Jim	Lonergan	Halotron		702-735-2200	
Virgil	Lovett	IAM/Continental Airlines		201-824-1400	201-824-3025
Donald	MacElwee	Powsus Inc.		610-296-2237	610-695-0230
Tim	Marker	FAA Technical Center		609-485-6469	609-485-5580
Marion	McQuaide	Ministry of Defence	England	44 71 218 4926	44 71 218 4609
Harry	Mehta	The Boeing Company		206-234-3650	206-234-8539
Daniel	Moore	DuPont Fluorochemicals		302-992-2177	302-992-6664
John	Oberst	Lifetech Systems, Inc.		703-273-2009	703-273-9516

First	Last	Company	Country	Phone	Fax
A.T.	Peacock			206-294-4642	206-294-4709
Neil	Percival	Percival Associates Ltd.	England	329 833 814	329 834 013
Jim	Petek	ADI Technologies Inc.		703-734-9626	703-448-8591
James	Peterson	Boeing Commercial Airplane Group		206-237-8243	206-237-0052
Jean-Francoi	Petit	CEAT Toulouse	France	33 61 58 74 10	33 61 58 74 78
John	Petrakis	FAA Aircraft Certification		202-267-9274	202-267-5340
Marco	Potschkat	Airbus Industrie	France	33 61933759	33 61934908
Nick	Povey	U.K. Civil Aviation Authority	England	44 1 293 573 347	44 1 293 573 554 or 981
Glynn	Rountree	Aerospace Industries Association		202-371-8401	202-371-8470
Gus	Sarkos	FAA Technical Center		609-485-5620	609-485-4004
Richard	Sears	Walter Kidde Aerospace		919-237-3787 ext. 287	919-237-4717
Louise	Speitel	FAA Technical Center		609-485-4528	609-646-5229
Bob	Stacho	FAA Los Angeles ACO		310-627-5334	310-627-5210
Russell	Stark	Autronics Corporation		818-445-5470	818-446-0014
Felix	Stossel	Swissair Engineering	Switzerland	41 1 812 6930	41 1 812 9098
Lionel	Virr	Civil Aviation Authority	England	44 0 293 573 129	44 0 293 573 975
Carole	Womeldorf	NIST		301-975-4415	301-975-4052
Brain	Wozniak	IAM/Continental Airlines		201-824-1400	201-824-3025

INTERNATIONAL HALON REPLACEMENT WORKING GROUP MEETING

Held at Harrah's Casino-Hotel

November 17, 1995

INTRODUCTION/BACKGROUND - R. Hill (FAA Technical Center)

Explanation of Working Group Activities

REVIEW OF JULY 1995 MINUTES

Minutes approved.
**Send meeting announcement and return form to all WG members.

SUBGROUP LEADER REVIEWS/PRESENTATIONS

Cargo - D. Blake

Reviewed work done to try to establish a baseline data from a fire controlled but not extinguished by Halon and minimally affected by oxygen depletion. The test apparatus is being reworked to correct higher than expected leakage rates of halon.

Small-Scale Screening Test for Halon Replacement Agents - B. Filipczak

Reviewed work done to date. Described test apparatus set-up. Reviewed preliminary results of early tests. Oxygen concentrations are up around 18%. This will not be a regulatory test. It is designed to establish a baseline for the Cargo tests. Member question: How is the fire exposed to the agent? The halon is gravity-fed into the center of an adjacent compartment and introduced into the fire compartment after agent discharge and attainment of a uniform concentration. Some additional discussion whether reduced oxygen concentration was affecting the agent extinguishment

Engines - D. Ingerson

Reviewed status of this project. Outlined plans for FAATC Nacelle Simulator set-up including the areas of core heating, fire threat, fire suppression delivery system, fire detection system, instrumentation/data gathering, and software and unit control. Informed group of planned concentration measurements work at Wright Patterson AFB in December. The core heating is about to be put into place. The gaseous agents will be the primary focus followed by the gas generator, water spray/mist, and other types of systems. S suggestion was made to test CF3I initially, followed by gas generator since the latter may be a drop-in replacement.

Handheld - N. Povey

Gave status of handheld fire extinguisher work. Our completed work on the development of a hidden fire test will be published as a CAA paper #9513.

Handheld Extinguisher Tests - K. Kallergis (DLR)

Reviewed work done at DLR. Data on extinguishing time and mass for aircraft carpet, and toxic gas data results were also presented for these tests. Presented data on extinguishing

time and mass $4m^2$ pool fires. A. Gupta: How do you establish equivalency? K. Kallergis: In my opinion, extinguishing time is most important. There are others that believe extinguishing mass is most important. All tests were conducted with 6 Kilogram extinguishers, charged and fitted with a new nozzle in some cases, to discharge the particular agent being tested. Paul Huston pointed out that hand-held extinguishers are designed to expell the agent in 8 seconds minimum (to avoid loss of agent during ineffective rapid discharge). This should be a design constraint on the experiment.

Handheld Extinguisher Toxicity Work - J. Petit (CEAT)

Reviewed work done to date and plans for future. Described early tests conducted and presented their preliminary results.

Handheld Test Method - A. Chattaway (Kidde-Gravner)

Presented update on hidden fire work done. Described hidden fire test appartus and set-up. Presented results of tests previously conducted with Halon 1211. Described experimental design to evaluate halon replacement agents and presented results. As expected, there was a direct relationship between agent volatility and hidden fire extinguishment effectiveness. There is a need to derive pass/fail criteria. Presented results using newly design apparatus with halon 1211 and replacement agents.

R. Hill - We (at FAATC) are building the hidden fire handheld test apparatus for use in the United States and will evaluate replacement agents at no cost.

TASK GROUP LEADERS PRESENTATIONS

Advanced Alternative Agents - R. Hill (B. Tapscott unable to attend)

Final Report entitled "Chemical Options to Halons for Aircraft Use" published (February 1995, Report #DOT/FAA/CT-95/9). This task group is working to update this report for next generation agents.

Halon Restrictions Update - F. Hughes/D. Catchpole (J. O'Sullivan unable to attend)

Update given.

Potty Bottles Final Report - B. Glaser

November 9, 1995: Final Draft sent to Task Group members for review. Comments should be sent to April Horner for incorporation into final report. Once comments from task group members are incorporated, the report will go to the authorities for review and comments prior to publication. A new requirement based on user input (Northern European operators) is that the potty bottle should be effective at $0^{\circ}F$.

Cargo Agent Preference - A. Gupta

A report was submitted to the FAA in September 1995 for review. The response to the survey was poor--only about 50 percent of those questionned responded. Recommended that after FAA establishes replacement agent quantities, for cargo fire extinguishment, the survey should be updated and resubmitted with the hope of achieving a higher response rate.

R. Hill: Our plan is to publish this report as a Working Group report through the FAA as we did with the Chemical Options to Halon published last year.

Potty Bottle Agent Preference - G. Grimstad

He will forward a copy of the draft of his findings to the task group members for comments. It will be included as an Appendix to the Potty Bottles Final Report (B. Glaser's Task Group) if time allows. If not, it will be published separately.

Engine Agent Preference - H. Mehta

Explained survey sent out to airlines, engine and APU manufacturers, airframe manufacturers, and other respondents on "User Preferred Agent for Engine and APU Compartment Fire Extinguishing Systems". Reviewed responses received to this survey. Summary results are available. A final report is currenlty being written. We hope to have the report prepared by the March 1996 meeting.

Simulants - B. Leach/C. Womeldorf

B. Leach: Presented plans/objectives for this task group.

C. Womeldorf: Reviewed information currently available in report format. D. Blake: Are you aware of any work going on for cargo compartment simulants? C. Womeldorf: No, not at this time, but possibly some of our findings could be applied to the cargo compartment area. The four references listed below are those that will be most useful to those looking for information on CF3Br simulants (this information has been provided by C. Womeldorf):

1) Womeldorf, C.A., Grosshandler, W.L., "Chapter 12: Selection of a CF3Br Simulant for Use in Engine Nacelle Certification Tests", Fire Suppression System Performance of Alternative Agents in Aircraft Dry Bay Laboratory Simulations, NIST SP 890: Vol. II; R.G. Gann, ed., November 1995.

2) Kaufmann, K.J., Miller N.P., Wozniak, G., Mitchell, M., "Results of Halon 1301, HFC-125, and SF6 Concentration Tests in a Large Commercial Aircraft Engine", Proceedings of the Halon Options Technical Working Conference, Albuquerque, New Mexico, May 3-5, 1995.

3) Leach, W., Homan J., "U.S. Navy Halon Simulant Identification Program," Proceedings of the Halon Options Technical Working Conference, Albuquerque, New Mexico, May 3-5, 1995.

4) Womeldorf, C.A., Mitchell, M., Grosshandler, W.L., "Selection of a Simulant of CF3Br for Use in Engine Nacelle Certification Tests", Proceedings of the Halon Options Technical Working Conference, Albuquerque, New Mexico, May 3-5, 1995.

Agent Concentration - D. Dierdorf

He sent out a questionnaire to those who initially indicated an interest in this task to see how much interest there is in this group. Direction of group needs some clarification. Looking for additional members for this task group.

Detection Systems Analysis - F. Stossel

Explained background on creation of task group. We will prepare a questionnaire concerning the cargo compartment false alarm problem and send it out to airlines. Based on the responses we receive from the airlines, we will determine if we should establish a task group on this subject.

DISCUSSION ON TASK GROUP PRESENTATIONS

R. Hill: Is there a need for any new task groups?

N. Povey: One of the objectives of the Simulants Task Group should be to write up proposed amendments to the A/C 20-100. B. Leach: How immediate of a need is this document? R. Hill: There is a need right now. We need to combine all the information available together into one document. B. Leach: We need an FAA representative on this task group. R. Hill: John Petrakis will contact Bernie Gonzalez at FAA NWM Region to request his participation in this task group.

QUESTIONS OR COMMENTS ON SUBGROUP LEADER REVIEWS

Handheld Work - N. Povey: Where should the handheld test be set up and how can people get access to it? Right now there is only one location in Europe where this test is set up (near Heathrow Airport in England). S. Hariram: Put it in the A/C, then someone will come up with a location set-up to meet the requirement. N. Povey: The contract at Kidde-Gravner is completed. We would like to find someone to possibly set up the handheld test apparatus at their location. We are looking for other companies to set up the existing test apparatus and run tests.

DLR Handheld Work - N. Povey: Suggestion that DLR measure discharge times in their work. G. Sarkos: Suggested sizing the fire for a 2.5 lb. Halon 1211 extinguisher. It will require some thought.

MINIMUM PERFORMANCE STANDARDS

HANDHELD EXTINGUISHERS: N. Povey gave update on development of Minimum Performance Standard for Handheld Extinguishers. We seek some regulatory input on this standard.

CARGO COMPARTMENT: We are presently waiting for some data before we can continue work on this standard.

ENGINES: H. Mehta reviewed a paragraph which could possibly be included in the standard. He asked for group input into whether or not this information should be included.
S. Hariram: This reference to halon 1301 should not be included in the standard. R. Hill: It is not necessary to include it in the standard as long as you make it clear that the fire threats are sized to that which halon 1301 can handle.

POTTY BOTTLE: This standard has been distributed in the draft Bob Glaser sent out for review to task group members.

WORKING GROUP MEMBER PRESENTATIONS

Bill Leach - Naval Air Warfare Center - gas generator work
Dan Moore - Du Pont - handheld extinguishers testing of FE 36

MARCH 26-27, 1996
MEETING RETURN FORM

INTERNATIONAL HALON REPLACEMENT WORKING GROUP

NOTE: YOU WILL NOT RECEIVE MINUTES OF THIS MEETING UNLESS THIS FORM IS RETURNED BY FEBRUARY 15, 1996.

☐ I will not be able to attend, but please send me the meeting minutes.

TOUR PARTICIPATION:

☐ I will participate in the DASA and Lufthansa Tours.

The next meeting will be hosted by Airbus Industries and Lufthansa Technik at the Radisson Hotel in Hamburg, Germany, on March 26-27, 1996. Please see letter and other enclosures for complete details.

PLEASE COMPLETE THE FOLLOWING INFORMATION IF YOU PLAN TO ATTEND:

NAME: _____

COMPANY: _____

PHONE: _____ FAX: _____

ADDRESS: _____

CITY, STATE, ZIP: _____

COUNTRY: _____

RETURN THIS FORM BY FAX BY THURSDAY, FEBRUARY 15, 1996, TO:

PLEASE NOTE MY NEW FAX NUMBER:

APRIL HORNER
FAX: 609-646-5229

OR CALL:

PHONE: 609-485-4471

U.S. Department of Transportation
Federal Aviation Administration

Ron Fisher - Defense Fire Protection Association

FINAL DISCUSSION

A. Gupta: Need a schedule for halon replacement program. We are behind the goals set by AIA. R. Hill: The problem may be that the AIA schedule was made without defining a program. FAA will propose a schedule for presentation at the next meeting.

NEXT MEETING/CLOSING

The next meeting will be held March 26-27, 1996, in Hamburg, Germany. The meeting will be hosted by Airbus Industries and Lufthansa Technik.

It will be held at the Radisson SAS Hotel Hamburg. The hotel address, telephone and fax numbers are as follows:

Radisson SAS Hotel Hamburg
Marseiller Strasse 2
D-20355 Hamburg, Germany
Phone: 49 40 3502 3410 Fax: 49 40 3502 3250

The special room rate for meeting participants will be DM 190,00 (U.S. $135.00). This includes 15% tax. Breakfast is not included. To receive the special meeting rate be sure to use the reservation code: "**LH-HALON**". Hotel reservations may be made through the Radisson Reservation Centers (see list at bottom of page) or directly with the hotel.

Special arrangements have been made for tours of the Airbus Production Line (A319, A321) in Hamburg Finkenwerder and the Lufthansa Overhaul Base, HAM Airport on March 28, 1996. Bus transportation will be provided.

The tour schedule for March 28, is as follows:

9:00 AM	Depart from Hotel
9:30 AM	Arrival at DASA Finkenwerder
9:45 AM	Guided tour through DASA Production Lines
12:00 noon	Depart DASA
12:45 PM	Arrival at Lufthansa Technik Base
1:00 PM	Lunch in Lufthansa Technik Canteen
1:30 PM	Guided tour through Lufthansa Technik Overhaul Base
3:30 PM	Depart for hotel or Airport Terminal
3:45 PM	Arrival at Airport Terminal
4:00 PM	Arrival at Hotel

A Meeting Return Form is included in this package. If you plan to participate in the tour, you must indicate that on the Meeting Return Form. The deadline to sign up for the tour is February 15, 1996.

PROJECT STATUS

- **NACELLE SIMULATOR (status and design goal breakdown)**
  - a) Core heating (surface temperature 400°-600°F)
  - b) Fire threat
    - i) scenarios (with flame holder)
      - a) Pool
      - b) Spray
      - c) Flowing fuel over hot surface
    - ii) fuel types
      - a) Lubrication oil (Mobil Jet oil II)
      - b) Hydraulic fluid (Skydrol LD4)
      - c) Aviation fuel (JP8, Jet A)
  - c) Fire suppression delivery system
    - i) Gaseous - PRIMARY FOCUS
      - a) HFC-227ea
      - b) CF_3I
      - c) HFC-125
      - d) HFC-236fa (??)
    - ii) Gas generator
    - iii) Water spray/mist
    - iv) ??? (any suggestions...)
  - d) Fire detection system (thermistor wire)
  - e) Instrumentation/data gathering (measurements)
    - i) Simulator temperatures
      - core surface
      - air flow profile within simulator
      - fire zone
      - fuel
      - agent
    - ii) Suppressant concentrations
      - gaseous
      - ??? (fine particulate aerosols, solid and/or liquid...)
    - iii) Time record for fire detection
  - f) Software and unit control

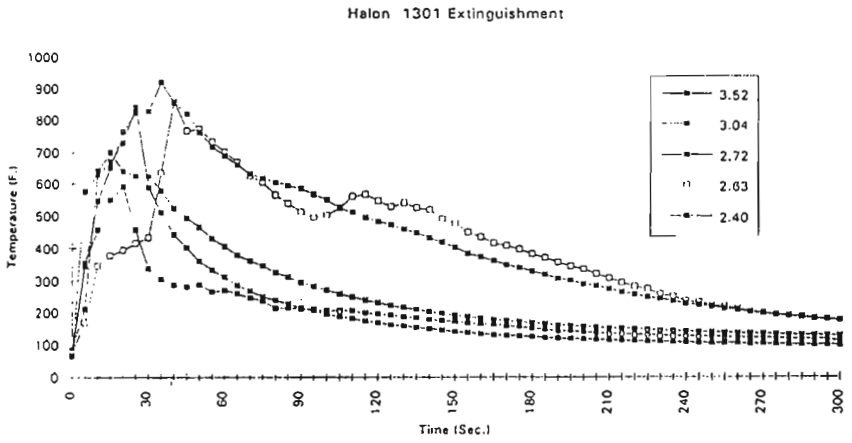
- **MISCELLANEOUS INFORMATION**
  - a) Wright-Patterson AFB
    - Concentration measurements set for weeks of 11 and 18 December
      - a) Main agent to be worked with will be HFC125
      - b) Trying to make arrangements to work with some CF_3I

Presentation overhead view graph - Doug Ingerson
FAA Nacelle Simulator update and design goal outline
International Halon Replacement Working Group meeting
Harrah's Casino/Hotel, Atlantic City, NJ, November 17, 1995

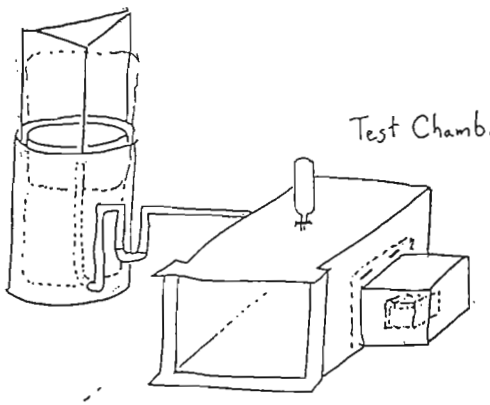
A Small-Scale Screening Test for Halon Replacement Agents

Robert Filipczak AAR-422
FAA Technical Center
Atlantic City, NJ 08405

H1301.XLC



Small Scale Cargo Test



Test Chamber - 3.75 × 3.75 × 6.55
- 92 cu.ft.

Fire Box - 2 × 2 × 2
8 cu. ft.

Fire Load - 1 cu.ft.

Halon Replacement Research

Handheld Extinguisher Tests

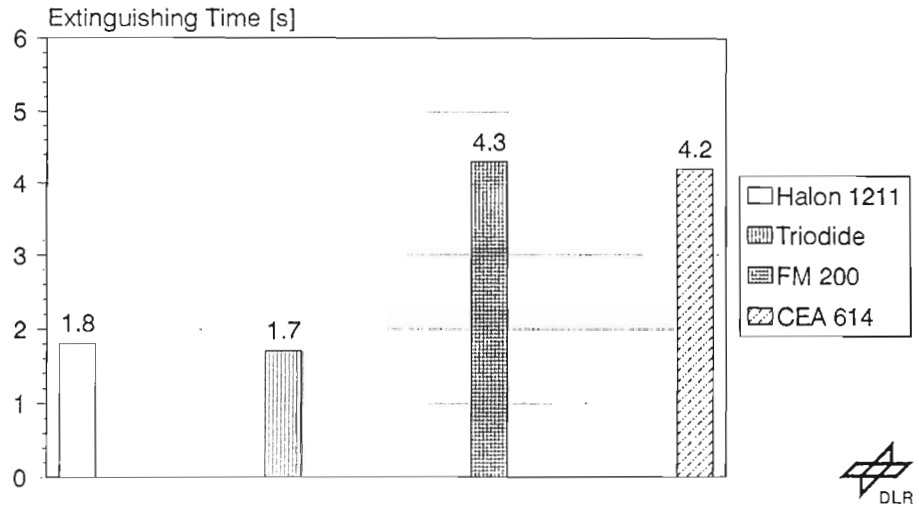
- Object:
  - Aircraft Carpet, 2m x 2m
  - Soaked with 4 l Gasoline
  - Preburn Time: 30 s

- Measuring Parameters:
  - Extinguishing Time
  - Extinguishing Mass
  - Gas Analysis: O2, CO
  - Toxicity: HBr, HCN, HCl, HF
  - Temperatures

Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

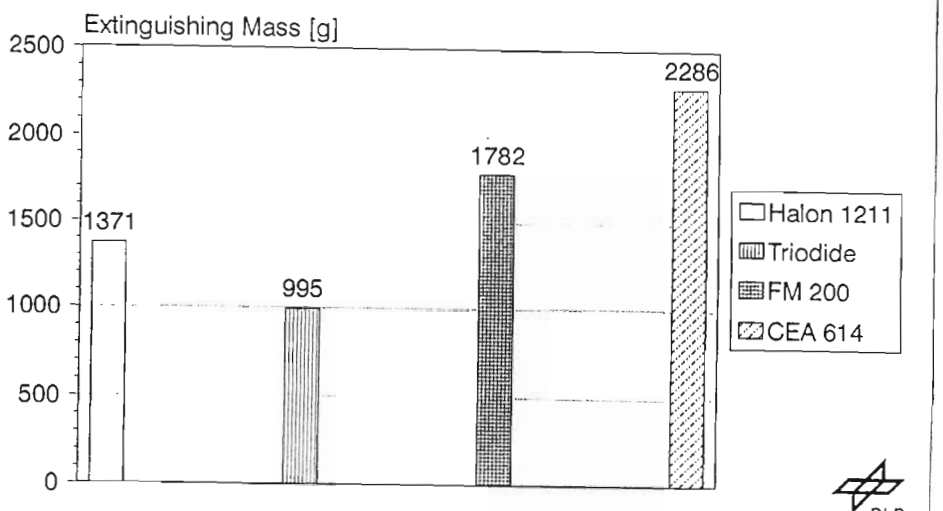
Extinguishing Time, Aircraft Carpet Fire



Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

Extinguishing Mass, Aircraft Carpet Fire



(2)

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Handheld Extinguisher Tests

Toxicity, Aircraft Carpet Fire

	Halon 1211	Triodide	FM 200	CEA 614
F [Vol.ppm]	*	60	10	60
Cl [Vol.ppm]	*	*	*	*
Br [Vol.ppm]	*	*	*	*
CN [Vol.ppm]	*	*	*	*

* : Under value of pure carpet fire

DLR

Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

CO and O2, Aircraft Carpet Fire

	Halon 1211	Triodide	FM 200	CEA 614
CO max. [ppm]	3100	5700	3300	2800
O2 min. [Vol.%]	12.3	13.4	11.4	12.8

DLR

Halon Replacement Research

(3)

Handheld Extinguisher Tests

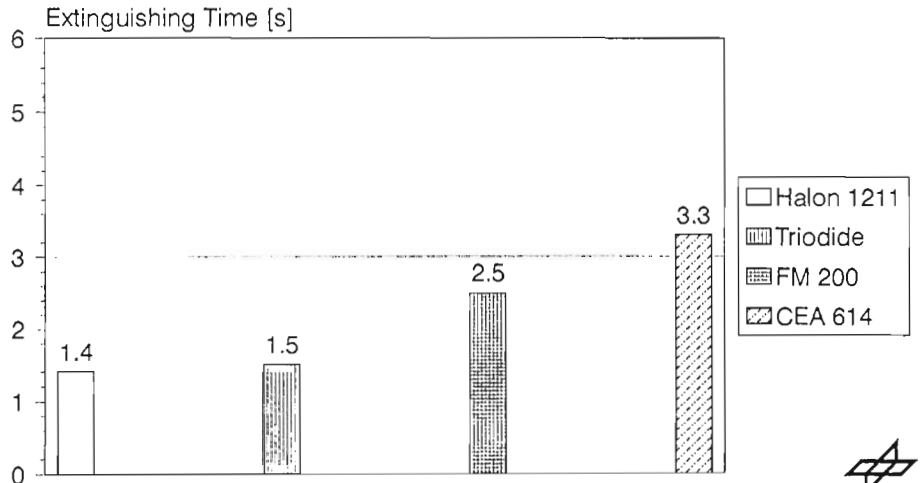
- Object:
  - Aircraft Seat
  - Soaked with 1 l Gasoline
  - Preburn Time: 60 s

- Measuring Parameters:
  - Extinguishing Time
  - Extinguishing Mass
  - Gas Analysis: O2, CO
  - Toxicity: HF
  - Temperatures

Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

Extinguishing Time, Aircraft Seat Fire



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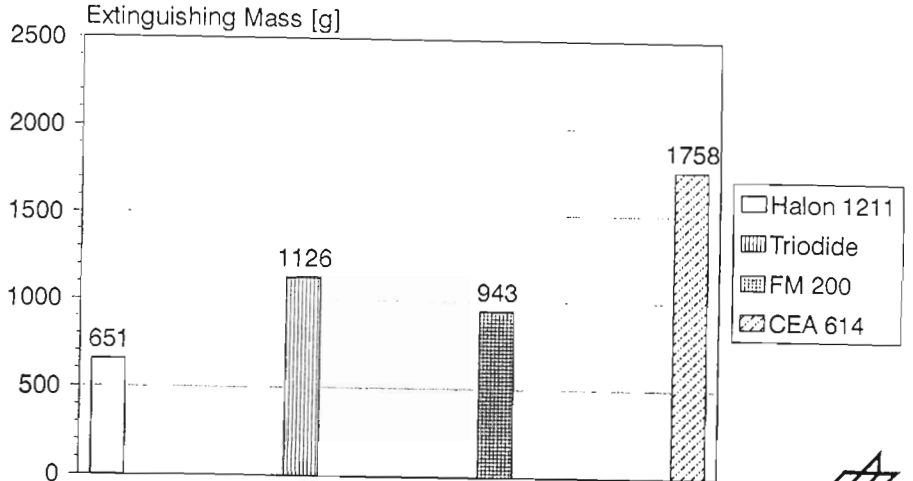
Handheld Extinguisher Tests

Extinguishing Mass, Aircraft Seat Fire



(4)

Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

Toxicity, Aircraft Seat Fire

	Halon 1211	Triodide	FM 200	CEA 614
F [Vol.ppm]	< 2	17	21	22

DLR

Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

CO and O2, Aircraft Seat Fire

	Halon 1211	Triodide	FM 200	CEA 614
CO max. [ppm]	175	118	202	235
O2 min. [Vol.%]	20	20.1	20	20.2

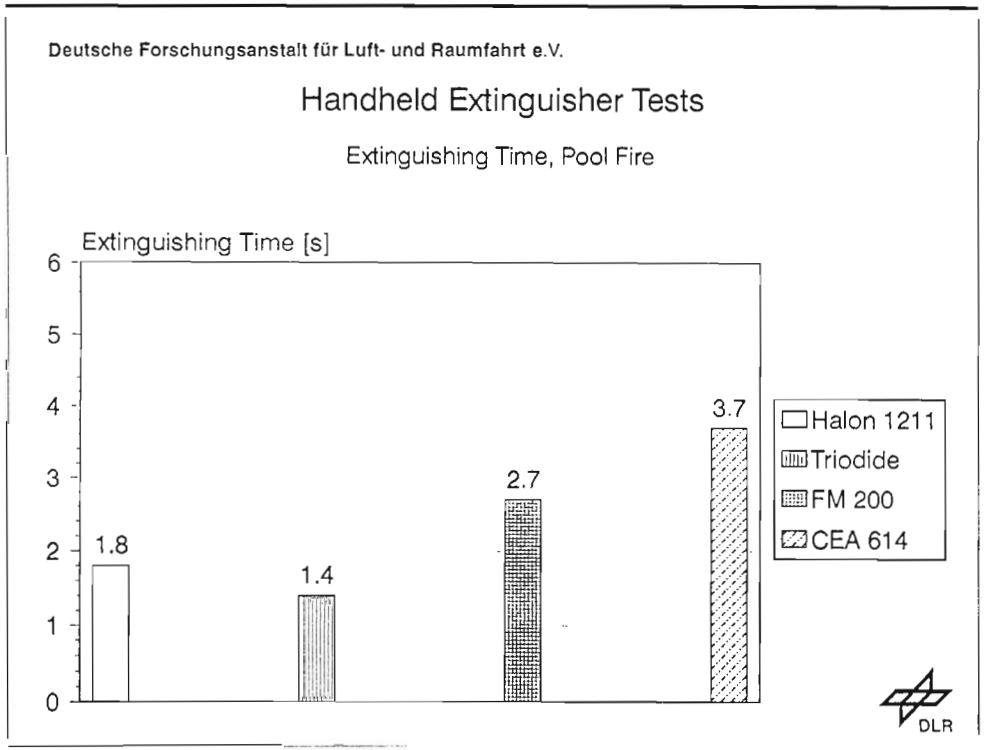
DLR

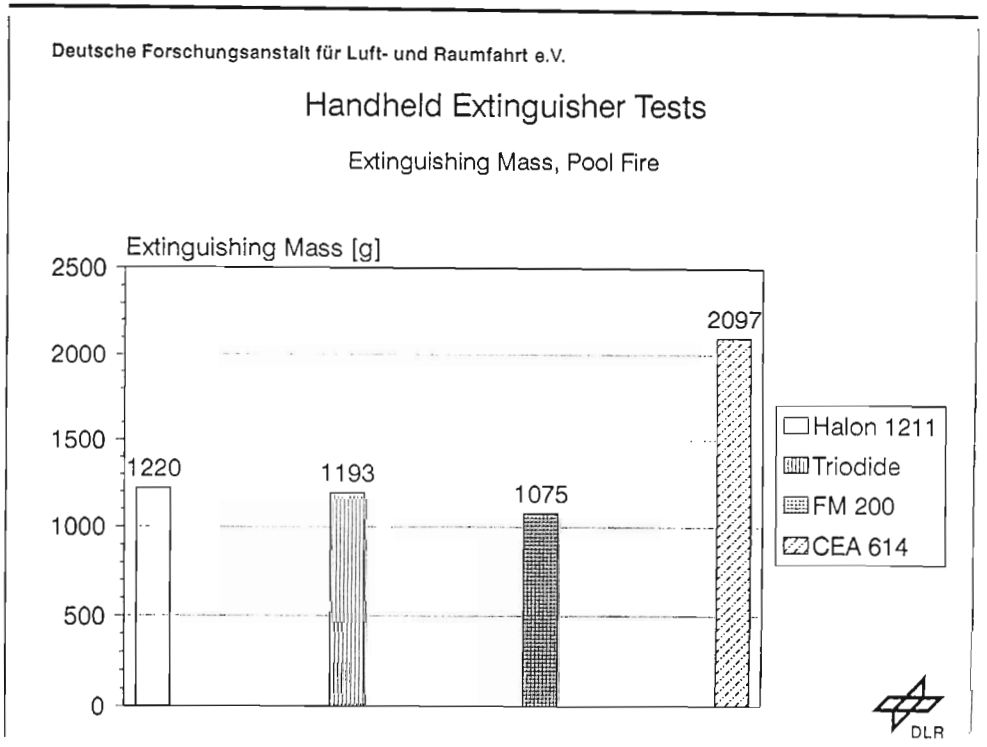
(5)

Halon Replacement Research

Handheld Extinguisher Tests

- Object:
  - Pool Fire, 4 m2, round, only burning surface
  - Preburn Time: 60 s
- Measuring Parameters:
  - Extinguishing Time
  - Extinguishing Mass





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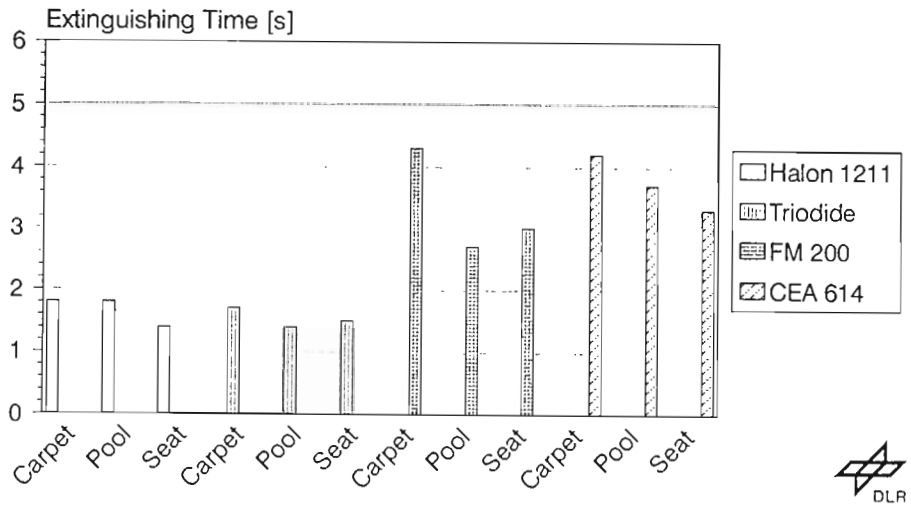
Handheld Extinguisher Tests

Extinguishing Time

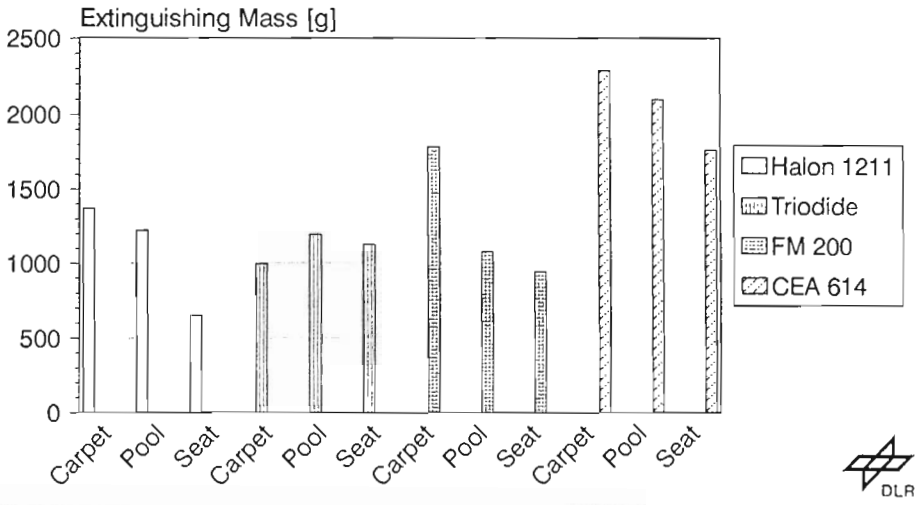


DLR

Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

Handheld Extinguisher Tests

Extinguishing Mass



DLR

HALON REPLACEMENT PROGRAM

TOXICITY MEASUREMENT

PRELIMINARY TESTS ON HALON 1301

This presentation follows the Rome meeting presentation of a proposed test method using a modified NBS smoke chamber for the measurement of toxic gases released by the discharge of an extinguishing agent on a fire.

Several preliminary tests have been conducted on HALON 1301 :

First of all, research and identification of major decomposition products : a tubular furnace is used as shown on this photograph (sampling scrubbers are connected at the outlet of the tube)

As expected, decomposition occurs over 500°C, identified decomposition products are HF & HBr, the decomposition ratio increases with temperature.

In a second time, the existing smoke chamber is modified as shown on this photograph

- a new door is mounted, equipped with a small circular window and a hole for the extinguisher extension tube ended by a diffuser,

- the furnace and specimen holder are replaced by a heat source (here its 10x10 cm2 pan containing alcohol)

Test equipment consists in :

- sampling impingers with 20 cm3 water connected to pumps are installed on the flour of the chamber, 2 l of gas pass through the scrubbers in 48 s

- pressure controlled valve mounted at the outlet of the extinguisher to control the discharge on the heat source (during prliminary tests the diffuser was not in place) 300 cm3 of agent is discharged at a pressure of 0,5 bars.

Several tests have been conducted in the modified test chamber, on different types of heat sources :

- on a hot metal sheet at T°C 600 no decomposition products are measured, due to a low decomposition ratio at this temperature and dilution in the chamber atmosphere.

- on smoldering ashes : no decomposition products measured, immediate extinction and difficulties in setting up the scenario

- on flaming fire, 25cm3 of alcohol

No extinction of the fire : high level of decomposition, extinction of the fire (higher pressure) lower level of decomposition

This scenario seems to be the most efficient, the next series of tests will be conducted on this basis, to finalize the test parameters e.g.

- type of fuel and volume of fuel

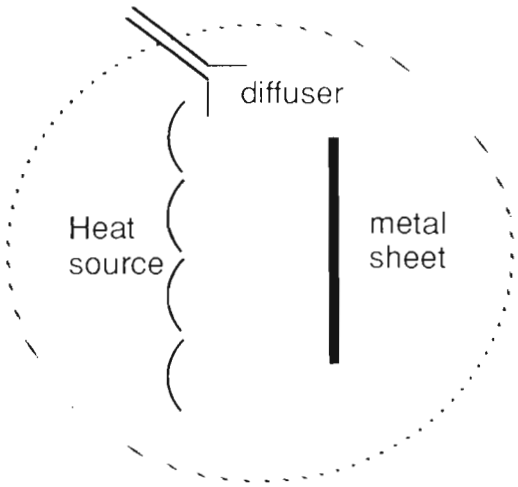
- volume of agent to be discharged, pressure of discharge

- sampling conditions

3 FIRE SCENARIOS

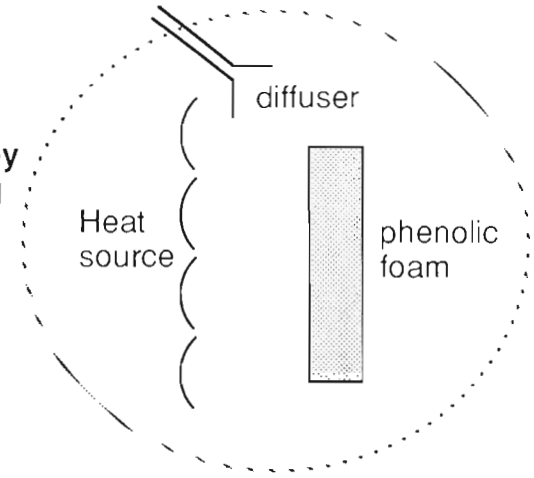
1

Hot metal sheet
Temperature about 800°C



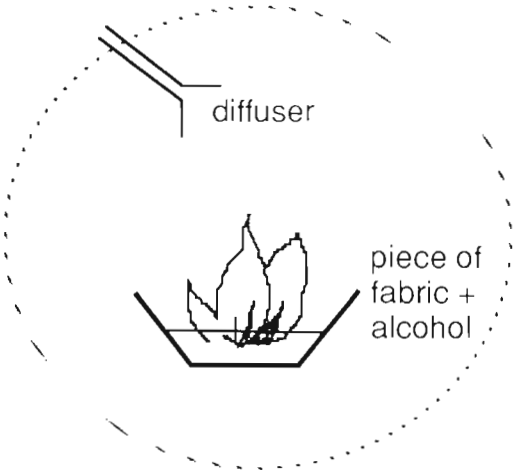
2

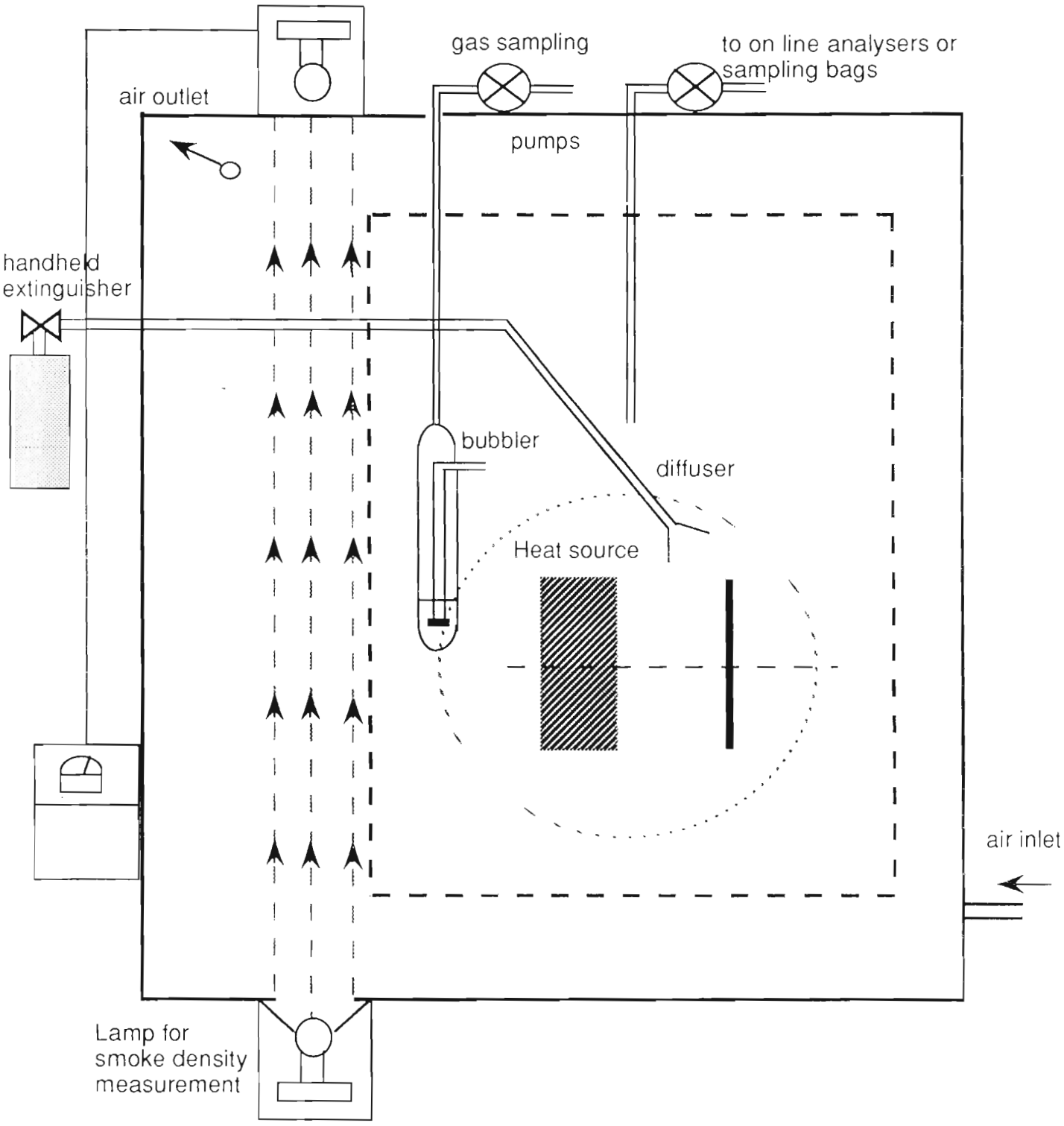
Smoldering fire : phenolic foam heated by a radiant heat source to form smoldering ashes



3

Flaming fire : piece of fabric with alcohol





MODIFIED NBS SMOKE CHAMBER

HALON REPLACEMENT PROGRAM TOXICITY MEASUREMENTS

PRELIMINARY TESTS: Research of decomposition products

- Decomposition over 500°C
- Decomposition products: HF & Hbr
- Decomposition reatio increases with T°C

NEXT INVESTIGATIONS: DEFINITION OF TEST PARAMETERS

BASIC HEAT SOURCE: Flaming Fire

- Type of Fuel and volume of Fuel
- Volume of agent to be discharged
- Pressure of discharge
- Sampling conditions

PRELIMINARY TESTS: Modified Smoke Chamber

- Modified door
- Sampling impingers
- Heat source: 25 cm3 alcohol fire
- Diffuser in position

Hidden Fire Challenge Update

17 November 1995

Phase II: Testing of Halon Replacement Agents

Adam Chattaway

KIDDE International RESEARCH

Principal Research Scientist

Background

1. March 1992 - Delta Airlines L1011 suffered a hidden fire in the cheek area which was successfully extinguished using a number of Halon 1211 hand extinguishers
2. Following Montreal Protocol & subsequent ammendments, Halon production ceased 1.1.94.
3. There is a need to quantify how effective Halon is for the suppression of hidden fires before any replacements are tested

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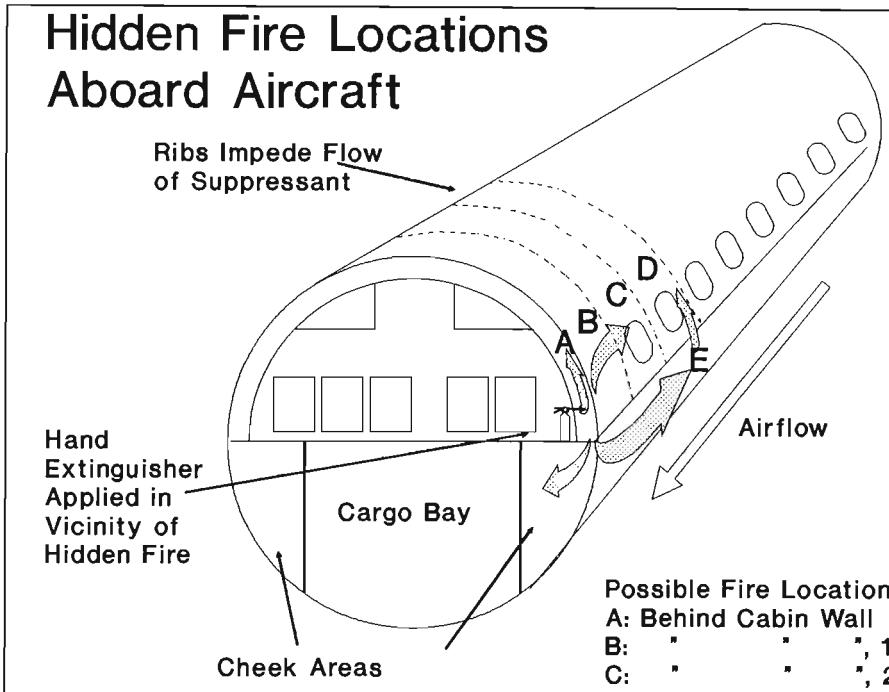
Hidden Fire Locations Aboard Aircraft



Possible Fire Locations:
A: Behind Cabin Wall
B: " " ", 1 Rib away
C: " " ", 2 Ribs away
D: " " ", 3 Ribs away
E: Cheek Area, Against Airflow

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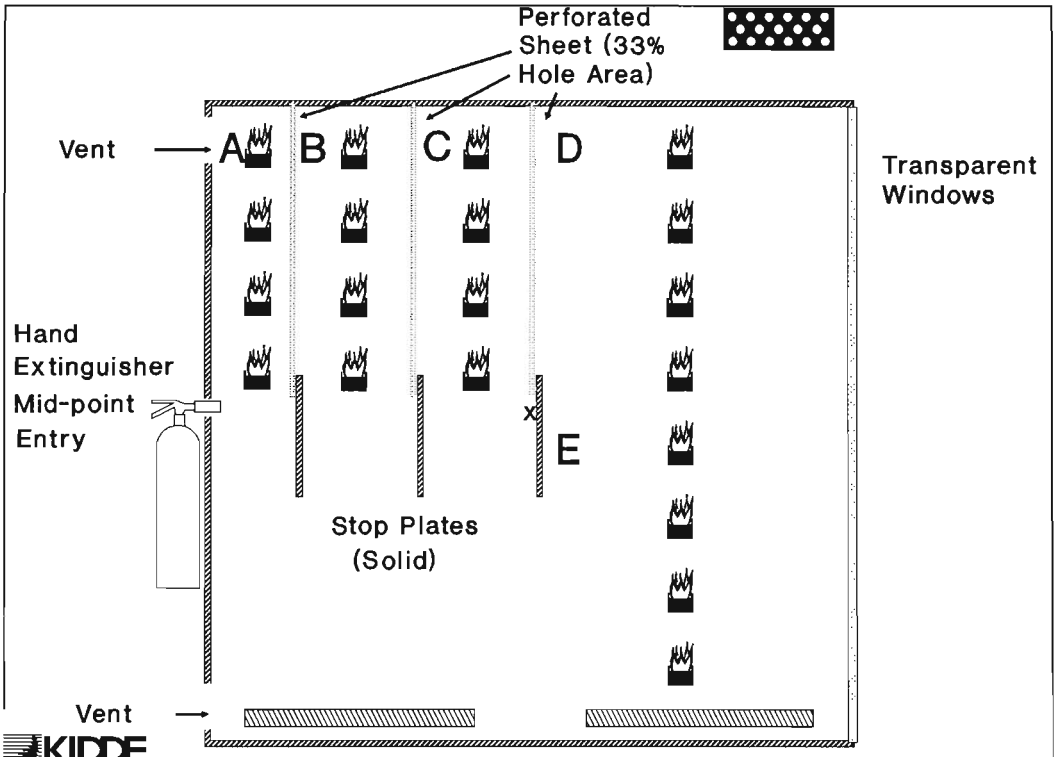

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Hidden Fire Test Chamber

Test Procedure/ Reduction of Results

Five fire zones (A-E); two used per test
A/B, B/C, C/D, D/E, A/E gives 5 combinations.
Each combination tested twice, 10 tests in all
Four fires per location, ie 8 fires per test
making a grand total of 80 fires

In addition, Halon concentration could be measured in three locations, and
O_2, CO & CO_2 were measured in some tests
NB: This was not included in the Contract, but the information obtained was very useful in understanding the results

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Summary of Halon 1211 Results

Extinguisher	Mean Agent Mass (kg)	Mean Discharge Time (s)	Mass Flow Rate ($kg\ s^{-1}$)	Normalised Mass	Normalised Mass Flow Rate	Total Percentage of Fires Extinguished
WK 2lb, 130psi	0.91	6.4	0.142	0.8	1.15	40
WK "Standard"	1.14	9.2	0.123	1	1	45
WK 3lb, 130psi	1.36	13.0	0.105	1.2	0.85	50
WK 2.5lb, 100psi	1.14	11.4	0.100	1	0.81	40
WK 2.5lb, 220psi	1.14	7.0	0.162	1	1.32	51
First Technology	1.07	9.4	0.114	0.95	0.93	59
Chubb	1.47	17.2	0.085	1.29	0.69	50
Kidde Thorn	1.44	9.8	0.147	1.26	1.2	60

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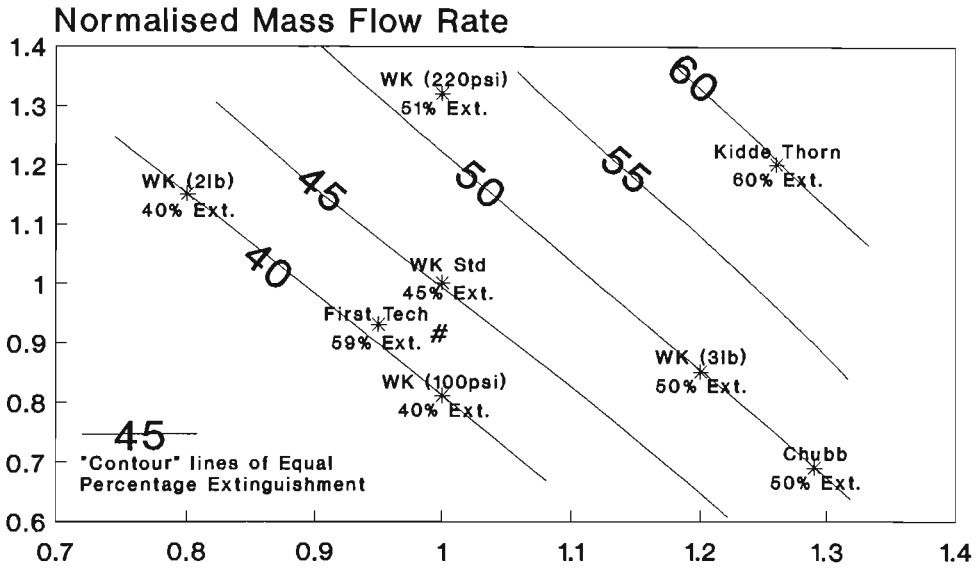
Summary of Hand Extinguisher Results Effect of Mass & Mass Flow Rate



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Note High Efficiency of First Technology Extinguisher

Testing of Halon Replacements

- No extinguishers commercialised to sufficient extent, CAA/KIR wished to finish contract a.s.a.p.
- KIR designed special apparatus to allow discharging of "appropriate" quantities of replacement agents at constant pressure, temperature, and discharge time
- Appropriate quantity obtained by ratioing *n*-heptane cupburner concentration to that of Halon 1211, then multiplying by quantity of Halon 1211 used

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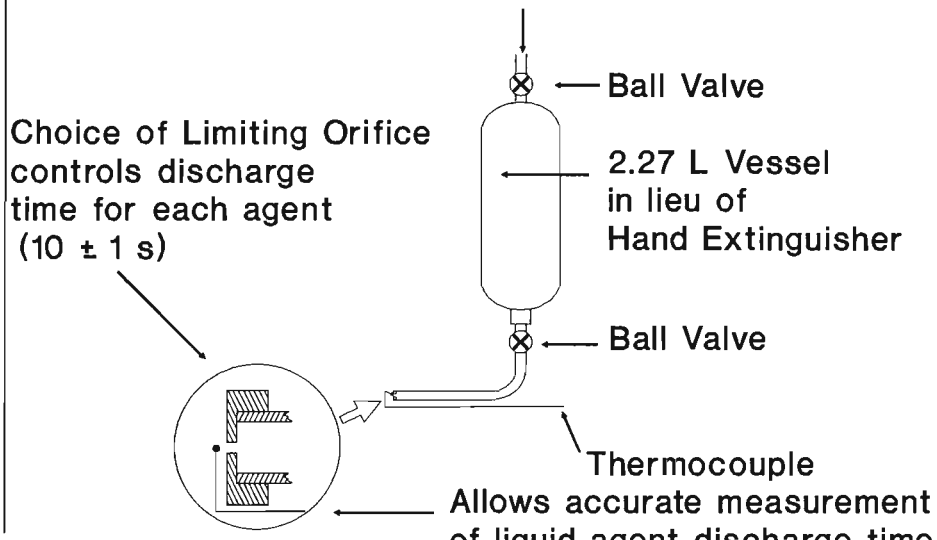
Apparatus for Discharging Halon Replacement Agents



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Halon Replacement Agent Requirements

Agent	n-Heptane Cupburner (Vol%)	Required Concentration (Vol%)	Mass Required (kg)
Halon 1211	3.5	8.4	1.14
FM-200	5.8	13.9	1.94
FE-25	9.1	21.8	2.14
FE-36	5.3	12.7	1.58
CEA-4.10	5.5	13.2	2.57
CEA-6.14	4.4	10.6	2.92
Triodide	3.1	7.5	1.21

Required Concentration =
2.4 x n-Heptane Cupburner Concentration

Mass Required ∝ Required Concentration x (Volume of Chamber/Molar Volume) x Mol. Wt

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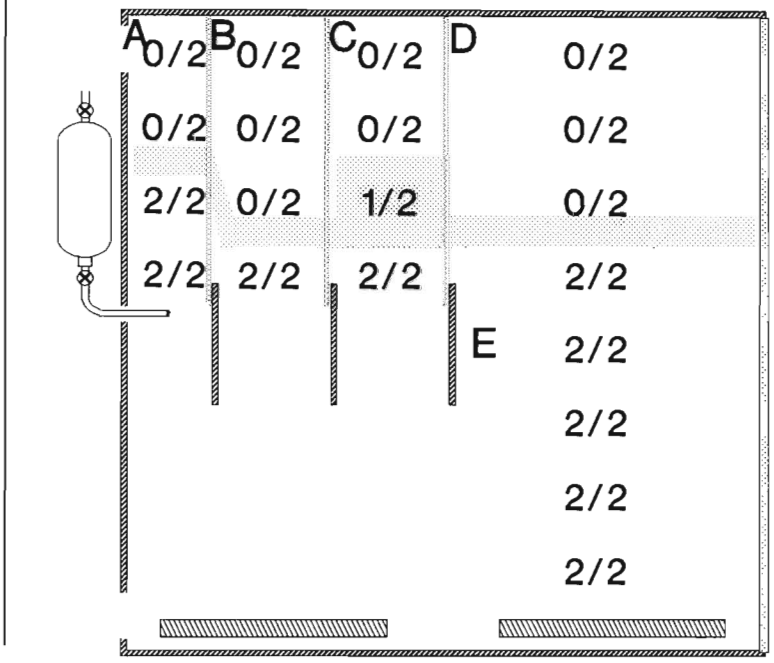
Halon 1211 Results Using KIR Apparatus



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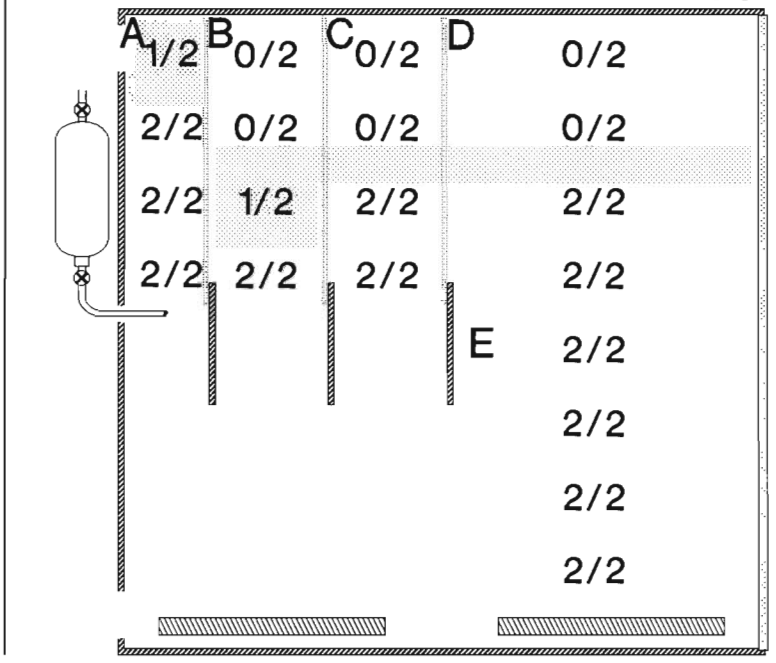
Total Number of Fires Extinguished: 19/40 (48%)

FE-25 Results with KIR Apparatus



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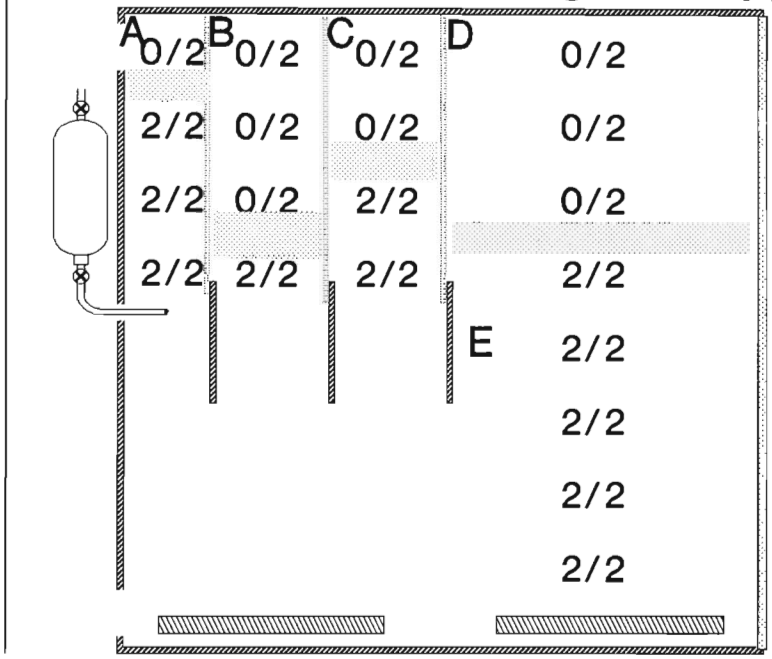
Total Number of Fires Extinguished: 26/40 (65%)

FM-200 Results Using KIR Apparatus



No Extinguishment

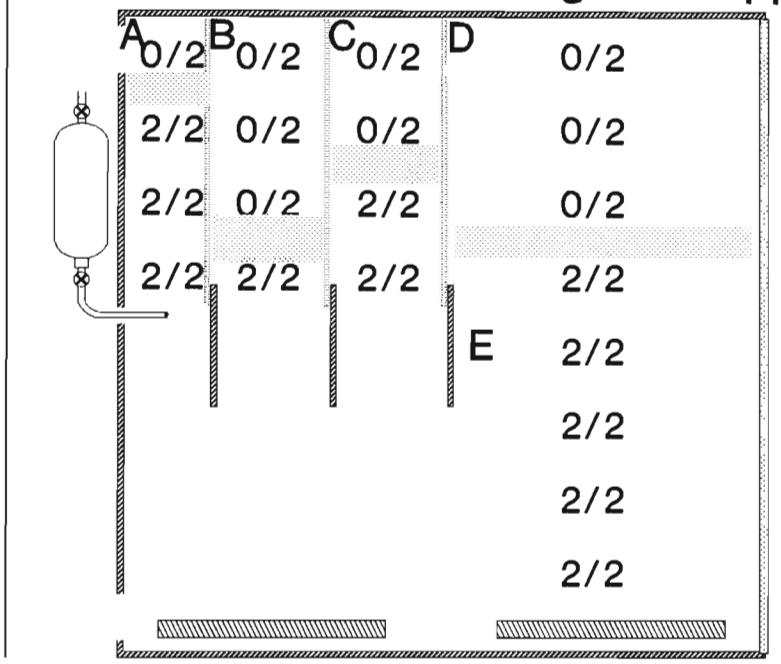
Uncertain Extinguishment

Fires Always Extinguished

KIDDE International RESEARCH

Total Number of Fires Extinguished: 22/40 (55%)

FM-200 Results Using KIR Apparatus



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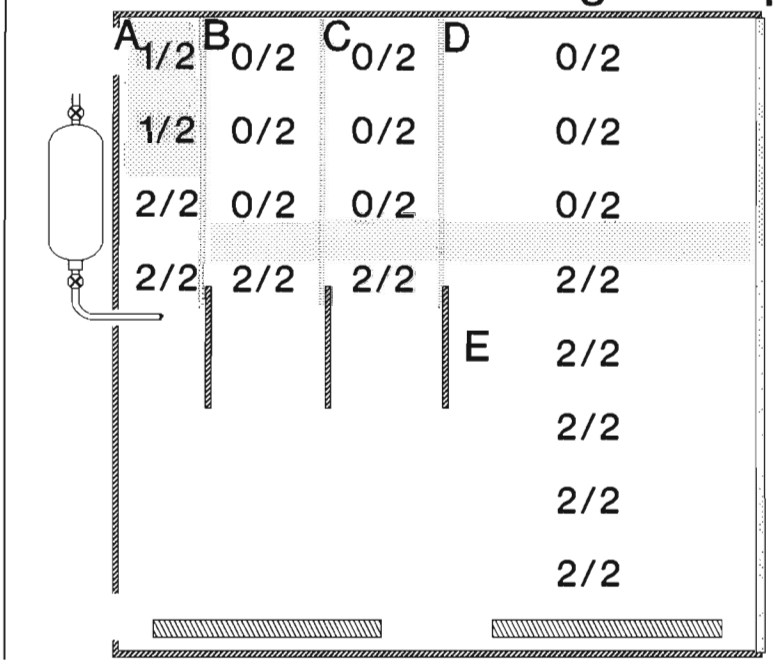
Total Number of Fires Extinguished: 22/40 (55%)

CEA-4.10 Results Using KIR Apparatus



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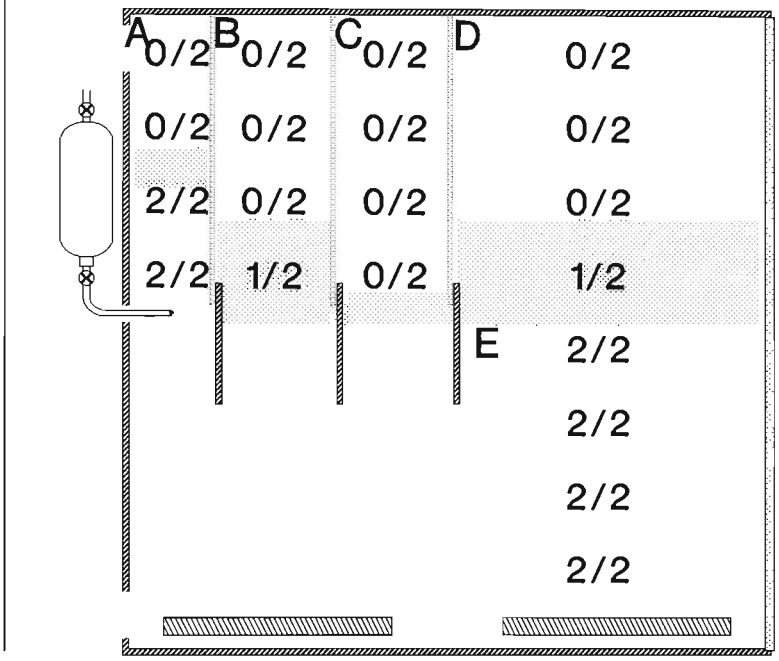
Total Number of Fires Extinguished: 20/40 (50%)

CEA-6.14 Results Using KIR Apparatus



No Extinguishment

Uncertain Extinguishment

Fires Always Extinguished

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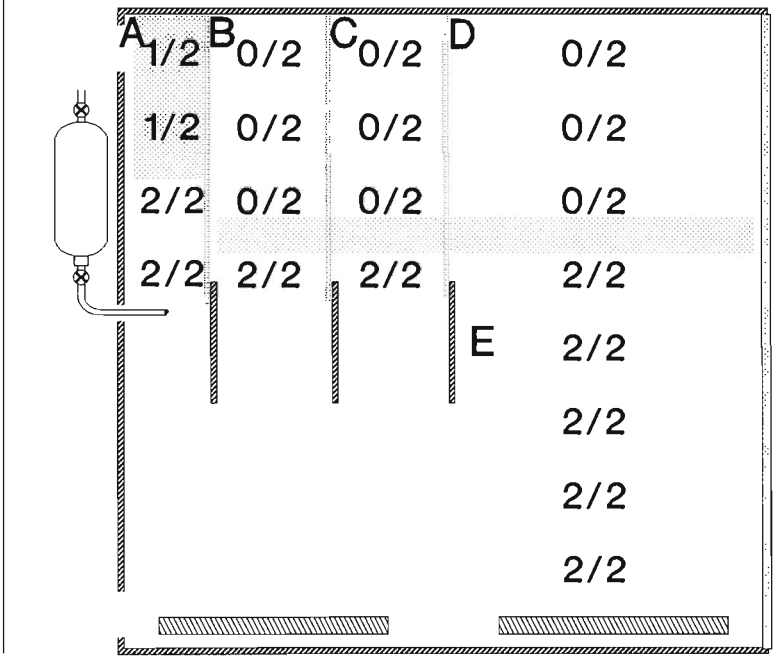
Total Number of Fires Extinguished: 14/40 (35%)

FE-36 Results Using KIR Apparatus



No Extinguishment

Uncertain Extinguishment

Fires Always Extinguished

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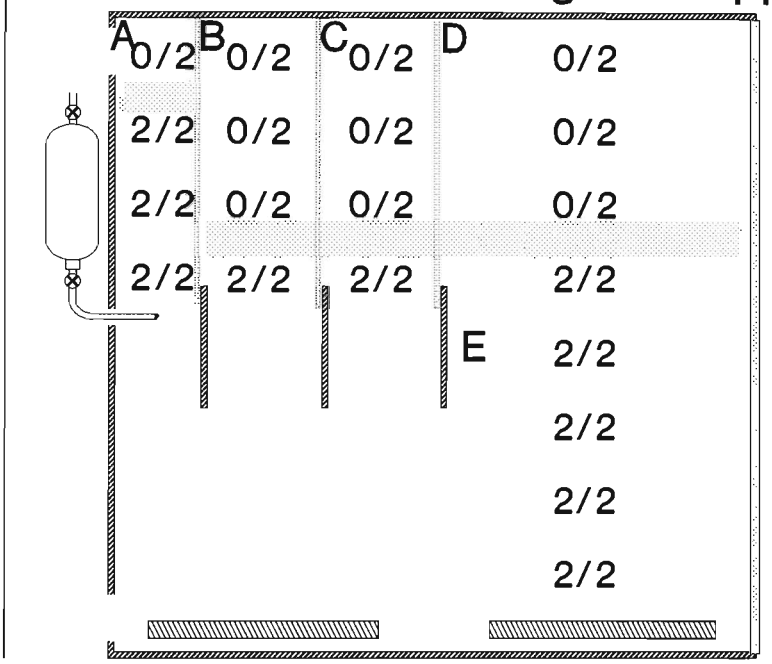
Total Number of Fires Extinguished: 20/40 (50%)

Triodide Results Using KIR Apparatus



No Extinguishment

Fires Always Extinguished

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Total Number of Fires Extinguished: 20/40 (50%)

Halon Replacement Agent Results

Agent	Required Concentration (Vol%)	Mass Used (kg)	Percentage Of Fires Extinguished
Halon 1211	8.4	1.14	48
FM-200	13.9	1.94	50
FE-25	21.8	2.14	65
FE-36	12.7	1.58	50
CEA-4.10	13.2	2.57	50
CEA-6.14	10.6	2.92	35
Triodide	7.5	1.21	50

All agents extinguished 50±5% of the fires, apart from the two agents of markedly different volatility, FE-25 & CEA-6.14

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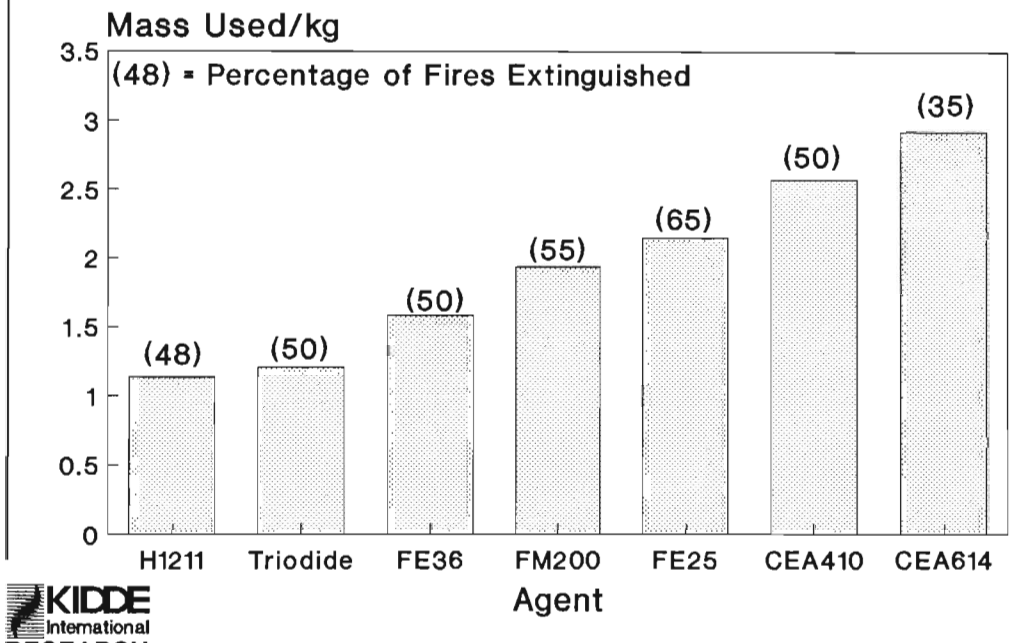
Halon Replacement Agent Results (2): Agent Ranking By Weight



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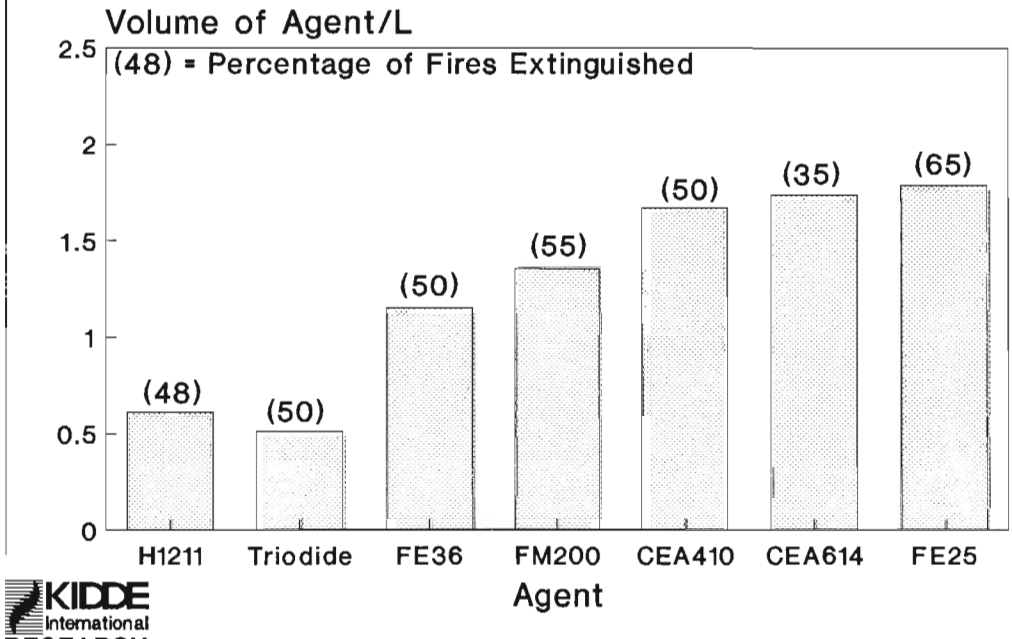
Halon Replacement Agent Results (3): Agent Ranking By Volume



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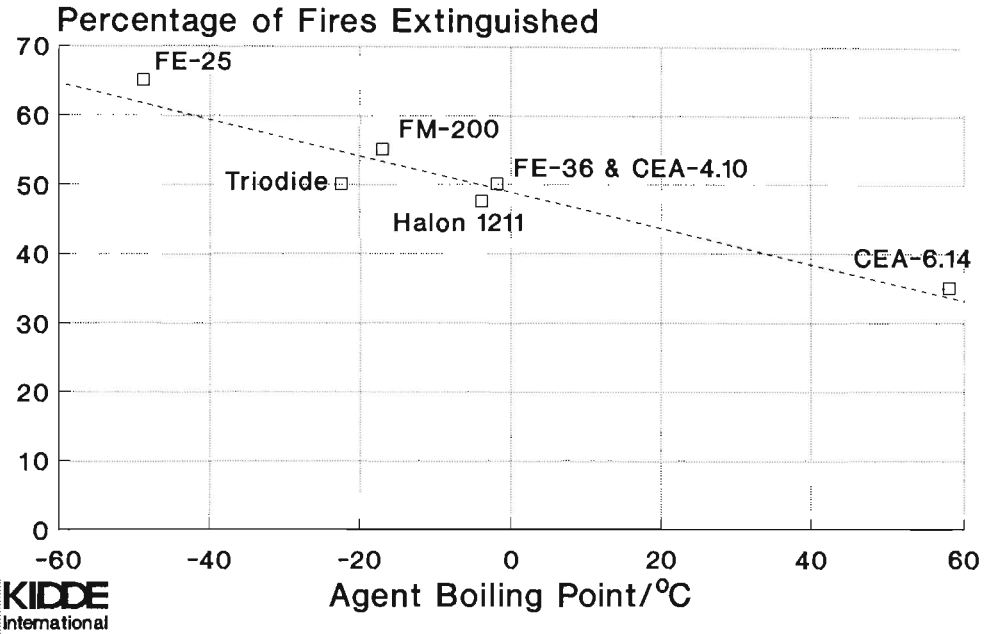
Halon Replacement Results (4): Effect of Agent Volatility



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Summary & Conclusions

- Performance of Halon 1211 has been defined as 45-60% extinguishment, mean 53.5%, based on results from 4 hand extinguishers. Also dependence on fill characteristics has been determined.
- 6 replacement agents tested, at one concentration each
  - results appear consistent, a similar percentage of fires are extinguished, unless agent is of very different volatility
- As with Halon results, there is scope for hardware optimisation, weight/volume penalties may be lessened
- Final report handed over to the CAA for publication
  - All test results
  - Draft Standard for hidden fire challenge
    - Within 1 year timescale required by IHRWG

KIDDE International RESEARCH

SIMULANT TASK GROUP

Presented to: FAA International
Halon Replacement Working Group
17 November 1995

CO-CHAIR: Bill Leach
Naval Air Warfare Center
Lakehurst, NJ

CO-CHAIR: Carole Womeldorf
National Institute of Standards and Technologies
Gaithersburg, MD

SIMULANT TASK GROUP

- NOW ACCEPTING RESUMES!!!

POTENTIAL ISSUES

- CARGO SYSTEM SIMULANT
- FM-200 SIMULANT
- HALON 1211 SIMULANT

OBJECTIVES

- EVALUATE QUALIFICATION REQUIREMENT
  - NATIONAL AND INTERNATIONAL RESTRICTIONS
  - HALON REPLACEMENT RETROFIT
- CREATE/REVISE SIMULANT SPECIFICATION
  - FAA
    - ADVISORY CIRCULAR
  - DOD
    - MIL-E-22285
  - CAA
    - AC 20-100

OBJECTIVES (CONT.)

- PROVIDE TECHNICAL SUPPORT
  - INTERPRETATION OF DATA
    - EQUIVALENT LIQUID FILL VS EQUIVALENT WEIGHT
    - STATHAM VS HALONIZER
    - LOW TEMPERATURE REQUIREMENT
  - EVALUATION OF OTHER PROPOSED SIMULANTS

TASK GROUP OBJECTIVES

- COMPILE EXISTING SIMULANT DATA
  - U.S. NAVY
  - FAA (BOEING)
  - CAA

INTERNATIONAL HALON REPLACEMENT WORKING GROUP

TASK GROUP #7

"POTTY BOTTLES"

FINAL, FINAL, FINAL REPORT !!

REPORTED ON NOVEMBER 17, 1995
HARRAH'S
ATLANTIC CITY, N.J.

BY
R. E. GLASER

IHRWG
TASK GROUP #7

- Action item to document group proceedings & final recommendations. (Rome meeting April, 1995)
- Status - Complete: Draft submitted to group for comment November 9, 1995.
- Comments should be sent thru April Horner for incorporation into final report.

IHRWG
TASK GROUP # 7

- Feedback on agent preference highlighted significant concern with original low temperature recommendation of 33° F. (Minimum requirement.)
- Informal meeting yesterday revised this recommendation, new suggested limit ~~5° F/-15° C.~~ 0°F/-18°C
- These revised criteria will be included in group final recommendations.

Historically, halon 1301 has proven to be an extremely effective total flooding type of agent for extinguishing fires. A comparison of the performance of candidate replacement agents to date with halon 1301, shows higher agent concentration and/or total quantity necessary to extinguish fires. In evaluating the performance of any candidate agent using the following performance standards, fires that can be extinguished by halon 1301 (with presently defined concentration levels) must be extinguished by the candidate agent and the agent concentration/quantity required to accomplish this will provide a basis for performance criteria. The candidate replacement agent should not be expected to extinguish fires which halon 1301 cannot extinguish (with presently defined concentration levels). When the replacement agent(s) has been identified, approved and introduced in aircraft systems, the performance standards leading to its acceptance will be recognized as the new reference, eliminating the need to rely on the performance of halon 1301 as the reference.

CF_3I, Iodotrifluoromethane, Stability and Materials Compatibility Study

Edward A. Walters, Robert Loomis, Michael Williams

Department of Chemistry
University of New Mexico
Albuquerque, NM 87131

Summary

prepared for Boeing Corporation
11/10/95

The purpose of this project is to examine the stability and materials compatibility of CF_3I, potential drop-in under somewhat elevated temperatures.

In order to predict the final product distribution of thermal decomposition of neat CF_3I with added H_2O and/or HF a program entitled "Chemical Equilibrium System" was used. The experiments performed never approached equilibrium, but the calculations were useful predictions of which products to expect and their proportions.

The experimental findings are summarized as follows:

1). The vapor pressure was determined over the range of 20-140°C. The critical point was P_c=245 psia and T_c=353K.

2). The heat of vaporization was measured as ΔH_{vap} = -19.2+/- 1.3 kcal mol^{-1}.

3). In a clean stainless steel bomb at P=324 psia and T=200°C the unimolecular rate of decomposition of CF_3I was measured, k(473 K) = 4.5 x 10^{-11} s^{-1}. This corresponds to $t_{1/2}$ = 480 years. The only solid residue was I_2. No evidence of metal erosion from the bomb was detected.

4). Cleaned coupons of round and stressed Ti cut from a sheet were exposed to CF_3I at 200° C for 1 week. The coupons were examined under a microscope for craters and cracks after adding a fluorescent dye to highlight flaws. None were observed.

5). Lexan coupons were exposed to 18 psia of CF_3I at 25°C for 3 days. No evidence of Lexan degradation was seen.

6). Cleaned coupons of Ni 625 were held at 200°C and 555 psia of CF_3I for 23 days. I_2 crystals were washed from the coupons with CCl_4 and the coupons were examined for defects. None were found.

7). Decomposition rates of CF_3I in the presence of H_2O were determined. The results are:

0.5mol CF_3I, T=473 K

mol H_20	k, s^{-1}	exposure time
0.0	4.5×10^{-11}	23 days
0.018	2.1×10^{-10}	2 weeks
0.055	6.9×10^{-10}	1 week

We conclude that CF_3I reacts with H_2O in a bimolecular reaction that obeys the rate law

$$-\frac{d\{CF_3I\}}{dt} = k_{bi}\,[CF_3I]\,[H_2O]$$

FTIR spectra of the product vapor showed the presence of CF_4, CF_2O, CF_3H, and CO_2. In addition, mass spectrometry analysis confirmed the presence of small amounts of m/z 354 ($C_2F_4I_2$) and m/z 749 (no structure assigned).

No evidence of metal-containing reaction products was found.

8). A Parr bomb was fitted with cleaned stainless steel (CRES 21-6-9); aluminum 2024 and titanium coupons on a glass tree and loaded with 0.5 mol CF_3I, 0.53 g H_2O, 0.59 g HF and 2.9 g C_2F_4. The system was heated at 200°C, 525 psia, for 18 days. Product analysis of the vapor showed presence of numerous C_2 and C_3 compounds containing both H and F. After dissolving I_2 in CCl_4 50 mg of a brownish solid remained that contained metals. The coupons all exhibited surface corrosion, probably from reaction with HF at the elevated temperature.

9) Teflon coupons were exposed to CF_3I at 150°C and 238 psi for 3 days. The coupons were inspected visually for damage and swelling. None was observed. Scanning tunneling microscopy survey of one coupon revealed no surface deterioration.

10) The silicone sealants GE-RTV-106, Locktite, Dow Corning 97-006, and Dapco 18-4 were applied to coupons, cured, and exposed to CF_3I, T=25°C, P= 78 psia for 3 days and examined visually for damage. No swelling or decomposition was observed.

International Halon Replacement Working Group

RESULTS OF THE SURVEY "User Preferred Agent for Engine and APU Compartment Fire Extinguishing Systems"

Airlines RESPONDENT	Agree?	Concern?	Gas gen?	Different?	Name & Phone
Hawaiian Airlines	Yes	No	Yes	No	Richard Bonnardel 808–835–3378
Cost effectiveness			Yes		Richard Hosokawa 808–835–3457
Quantas Airways Drop in, not toxic	Yes	Yes	Yes	No	R. W. Alcorn 61–2–691–7658
British Airways Include other agents, water mist	Yes	Yes	Yes	Yes	John J O'Sullivan 44–181–502–5460
Aloha Airlines	Yes	No	No	No	Scott Fung 808–836–4235
Lufthansa Technik AG ODP=GWP=0 for new aircraft	Yes	No	Yes	Yes	Hans Humfeldt 49–40–5070–2406
Japan Airlines *No answers, general priorities: safe, easy cleanup, availability*					Toru Kawano 81–3–3747–3721
KLM	Yes	No	Yes	No	Theo Bloemendal 31–20–6499128
Air France W,V< W,V 1301	Yes	Yes	Yes	No	Maurice Kindel 33–1–48649977
Philippine Airlines Include FC 3110, safe to env, humans	Yes	Yes	Yes	Yes	Francisco R. Ramiro 632–832–3351
American Trans Air	Yes	No	Yes		Luis A. Camacho 317–240–7663

International Halon Replacement Working Group

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Lufthansa Technik AG ODP=GWP=0 for new aircraft	Yes	No	Yes	Yes	Hans Humfeldt 49–40–5070–2406
Japan Airlines *No answers, general priorities: safe, easy cleanup, availability*					Toru Kawano 81–3–3747–3721
KLM	Yes	No	Yes	No	Theo Bloemendal 31–20–6499128
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International Halon Replacement Working Group

RESULTS OF THE SURVEY "User Preferred Agent for Engine and APU Compartment Fire Extinguishing Systems"

Engine/APU Manufacturers RESPONDENT	Agree?	Concern?	Gas gen?	Different?	Name & Phone
BFGoodrich Aerospace	*Products not affected*				Lamont F. Jones 607–335–5475
International Aero Engines	Yes	Yes		Yes	William A. Raabe 203–652–1674
Pratt & Whitney Must perform material compatibility tests, 2–3 month needed	Yes	Yes		No	John Zavodjancik 203–565–5030
G. E. Aircraft Engines Evaluate corrosiveness on materials	Yes	No	Yes		Wallace M. Schulze 513–552–5671
Allied Signal Engines Concern due to cabin bleed air	Yes	Yes	No		Jim Laird 602–231–1613
Mitsubishi Heavy Industries	Yes	Yes	Yes	No	Masaji Mita 81 568 79 0324

International Halon Replacement Working Group

RESULTS OF THE SURVEY "User Preferred Agent for Engine and APU Compartment Fire Extinguishing Systems"

Airframe Manufacturers RESPONDENT	Agree?	Concern?	Gas gen?	Different?	Name & Phone
Aerospatiale Potential use of FIC–13I1 in cargo compt., favor same as it could be drop–in	Yes	No	Yes	No	Jean Paillet 33 61 93 71 65
Airbus Industrie Why HFC–125 not on the list?,	Yes	No	Yes	No	Marco Potschkat 33 61 93 33 33
Daimler Benz Aerospace Include HFC–125, * if toxic effects are not negligible	Yes	Yes*	Yes	No	Bernd Dunker 49 40 7437 5309

Other RESPONDENT	Agree?	Concern?	Gas gen?	Different?	Name & Phone
Ministry of Defense, UK * Agree if other agents included, water mist,	No*	No	Yes		A. J. Killingray 0171 3050 360
Short Brothers Plc Atmospheric life, toxicity, corrosive Eval. other halocarbons, water	No	Yes		Yes	John H. Miller D. Riordan 44 1232 733604

RESULTS OF THE SURVEY "User Preferred Agent for Engine and APU Compartment Fire Extinguishing Systems":

IN ALL 27 RESPONSES WERE RECEIVED. AGREEMENT WITH THE SURVEY PROPOSALS BY BOEING AND MD REPRESENTATIVES IS IMPLIED.

THERE IS ALMOST UNANIMOUS SUPPORT FOR THE PREFERRED AGENTS PROPOSED BY THE TASK SUBGROUP IN THE ALBUQUERQUE MEETING.

THOSE WHO OPPOSED THE PROPOSAL DID IT BECAUSE OTHER AGENTS WERE NOT INCLUDED.

COMMENTS EMPHASIZED NEED FOR A DROP–IN AGENT, COMPATIBLE WITH EXISTING SYSTEMS (EASY TO RETROFIT), SAFE TO ENVIRONMENT AND HUMANS.

ONLY A FEW RESPONDENTS SUGGESTED TO CONSIDER WATER BASED SYSTEM

CONCLUSIONS:

THE TASK SUBGROUP RECOMMENDS CF_3I AND FM–200 AS THE FIRST CHOICE REPLACEMENT AGENTS FOR ENGINE NACELLE/APU FIRE PROTECTION FOR DETAILED EVALUATION BY THE FAA.

THE TASK SUBGROUP ALSO RECOMMENDS GAS GENERATOR AND FE–36 (A RELATIVELY RECENT CANDIDATE) AS THE SECOND CHOICE OF AGENTS FOR EVALUATION BY THE FAA.

IF RESOURCES PERMIT, OTHER PROMISING AGENTS SHOULD BE ADDED TO THE LIST FOR FURTHER STUDY.

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PRELIMINARY AGENDA

INTERNATIONAL HALON REPLACEMENT WORKING GROUP MEETING

Friday, November 17, 1995

To be held at Harrah's Casino-Hotel

Atlantic City, New Jersey

THURSDAY, NOVEMBER 16, 1995

Task Group Leaders ***may make their own arrangements*** to hold Individual Task Group Meetings.

FRIDAY, NOVEMBER 17, 1995

8:00-8:15	Introduction/Background/General Information - R. Hill (FAA Technical Center)
8:15-8:30	Review of Minutes of July 1995 Meeting
8:30-9:30	FAA Subgroup Leader Reviews/Presentations
	8:30-8:50 Cargo - D. Blake
	8:50-9:10 Engines - D. Ingerson
	9:10-9:30 Handheld Presentations - N. Povey
	K. Kallergis - DLR
9:30-10:00	*BREAK*
10:00-11:30	Task Group Leader Presentations

Each Presentation will be approximately 10 minutes in length:

Advanced Alternative Agents - B. Tapscott
Halon Restrictions Update - J. O'Sullivan
Potty Bottles Final Report - B. Glaser
Cargo Agent Preference - A. Gupta
Potty Bottle Agent Preference - G. Grimstad
Engine Agent Preference - H. Mehta
Simulants - B. Leach/C. Womeldorf
Agent Concentration - D. Dierdorf
Detection Systems Analysis -

11:30-1:00	*LUNCH*
1:00-3:00	Discussion on Minimum Performance Standards for:

Cargo
Engines
Handheld
Potty Bottle

3:00-3:30	*BREAK*
3:30-4:30	Working Group Member Presentations

B. Leach - Naval Air Warfare Center (10 minutes) NAWC Work
A. Richardson - Control Fire Systems (10 minutes) Halon Banking

(Anyone interested in giving a brief presentation MUST CALL April Horner at 609-485-4471 prior to the meeting.)

4:30-5:00 Final Discussion/Next Meeting/Closing - R. Hill

LIST OF ATTENDEES
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November 17, 1995

NAME	ORGANIZATION/ AFFILIATION	ADDRESS	PHONE/FAX
Dave Blake	FAA Tech Ctr		PHONE: 609-485-4525 FAX: 609-485-4810
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CLAUDE LEWIS	TRANSPORT CANADA AVIATION	(NO CHANGE)	PHONE: (NO CHANGE) FAX:
John Patrakis	FAA Wash DC	800 Independence Ave. SW Washington DC 20591	PHONE: 202 267-9274 FAX: 202 267-5340
Bob GLASER	Walter Kidde Aerospace	4200 Airport Dr WILSON NC 27896-9643	PHONE: 919 237-7004 FAX: 919 237-4717
JOHN OBERST	LIFETECH SYSTEMS INC,	11350 RANDOM HILLS RD FAIRFAX, VA 22030	PHONE: 703 273 2009 FAX: 703 273 9516
* Nick BUTCHER	UK CAA FLIGHT OPERATIONS	AVIATION HOUSE GATWICK AIRPORT SOUTH WEST SUSSEX RH6 0YR ENGLAND	PHONE: 1293-573541 FAX: 1293-573991.
LIONEL VIRR	JAA (CAA) DESIGN & MANUFACTURING STDS	AVIATION HOUSE GATWICK AIRPORT SOUTH WEST SUSSEX RH6 0YR ENGLAND	PHONE: 44.1293 573129 FAX: " " 573975
NICK POVEY	UK CAA RESEARCH	AVIATION HOUSE — " —	PHONE: 44 1293 573347 FAX: 44 1293 573554
Jim LONERGAN	HALOTRON, INC.	LAS VEGAS, NV.	PHONE: 702-735-2200 FAX:
Felix Stössel	SWISSAIR	TEPS CH 8058 ZURICH AIRPORT SWITZERLAND	PHONE: 41-1-812 6930 FAX: 41-1-812 9098

* FIRST MORNING SESSION ONLY.

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HARENDRA MEHTA	THE BOEING CO.	M.S. 67-MH (WILL CHANGE IN 2/96) P.O. BOX 3707 SEATTLE, WA 98124-220	PHONE: 206-234-3650 (WILL CHANGE 2/96) FAX: 206-234-8539
HANNS-JÖRG BETZ	LUFTHANSA TECHNIK	AIRPORT AREA WEST DEPT. FRA WF 22 D60546 FRANKFURT	PHONE: 49-69-696-4612 FAX: 49-69-696-4604/4555

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LARRY E. DVORAK	RAYTHEON AIRCRAFT CO. (BEECHCRAFT/HAWKER)	P.O. BOX 85 WICHITA, KS 67206-0085	PHONE: 316-676-8991 FAX: 316-676-7440
Dale Kent	3M	3M 223-6S-04 St. Paul, MN 55112	PHONE: 612-733-4931 FAX: 612-636-1977
BILL LEACH	NAVY - LAKEHURST, NJ	CODE 4.3.5.2A LAKEHURST, NJ 08733 -5100	PHONE: (908) 323-1184 FAX: (908) 323-1989
Carole Womeldorf	NIST - Building & Fire Research Labs	Bldg 224, Rm B356 NIST Gaithersburg MD 20899	PHONE: 301/975-4415 FAX: 301/975-4052

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Dan Moore	DuPont Fluoroproducts	Barley Mill Plaza 21-2154 PO Box 80021 Wilmington DE 19880-0021	PHONE: 302 992 2177 FAX: 302 992 6664
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Jean-François PETIT	CEAT / DGA	23 avenue H. Guillaumet 31056 TOULOUSE France	PHONE: 33 61 53 74 10 FAX: 33 61 53 74 78
DONALD B. MACGIVREE	POWDER INC	14 WOODSTREAM DRIVE WAYNE, PA 19087	PHONE: (610) 296-2237 FAX: 610 695-0230
Jim Gourley	Amtrak	Fire Protection Safety 5TH FLOOR SOUTH 30TH Street Station Phila, PA 19104	PHONE: 215-349-2786 FAX: 215-349-2767
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Tom Cortina	HARC	2111 Wilson Blvd. Suite 850 Arlington, VA 22201	PHONE: 703-524-6636 FAX: 703-243-2874
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Tom Peacock	Consultant.	1625 Edgemoor Ln Everett, WA 98203	PHONE: 206/348-5919 FAX: SAME (7am-5pm Pacific)
James M. Peterson	BOEING	M/S 73-48 Boeing Company Seattle WA 98124	PHONE: 206-237-8243 FAX: 206-237-0052
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