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

Technical Center

Atlantic City Int'l Airport
New Jersey 08405

August 8, 1995

Dear International Halon Replacement Working Group Member:

Enclosed please find a copy of the Minutes/Information Package of the July 18-19, 1995, Working Group meeting held in Albuquerque, New Mexico.

There were three new Task Groups formed at this meeting in the areas of engine simulants, agent concentration, and detection systems analysis. If you would like to participate in any of these new Task Groups, please contact April Horner at 609-485-4471, or by fax at 609-646-5229.

The next meeting will be held at Harrah's Casino-Hotel in Atlantic City, New Jersey, on **Friday, November 17, 1995**, following the International Conference on Cabin Safety Research which will be held at Harrah's November 14-16, 1995. A Meeting Return Form is enclosed in this package. If you plan to attend or would like copies of the minutes, please complete this form and return it via fax by *Friday, October 20, 1995*.

I look forward to your continued participation in this Working Group.

Sincerely yours,

Richard G. Hill

Richard G. Hill
Program Manager

Enclosures

## INTERNATIONAL HALON REPLACEMENT WORKING GROUP MEETING MINUTES

**Held at University of New Mexico, Albuquerque, New Mexico**

**JULY 18-19, 1995**

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

Explanation of Working Group Activities

**REVIEW OF APRIL 1995 MINUTES**

No comments.
A. Gupta and P. Huston moved to approve April 1995 Minutes.
End of discussion.
NOTE: In the future, the Meeting Announcement and Meeting Return Forms will be mailed out to all Working Group members prior to meeting date to allow an opportunity to request minutes if unable to attend upcoming meeting.

**TASK GROUP LEADERS PRESENTATIONS**

**Task Group Review - R. Hill**

**Advanced Alternative Agents - B. Tapscott**

A copy of his presentation is included in this package.
Change name of this Task Group to "Chemical Options to Halons".

**Halon Restrictions Update - J. O'Sullivan**

Reviewed notes from May 1995 meeting in Nairobi and the draft response prepared recently. D. Dierdorf: Aviation industry has no special claim to access to Halon was a comment that came out of the recent HARC meeting. Aviation shouldn't expect to pay any less that other industries for Halon.

R. Hill: Is it worthwhile to put together a Task Group to compile a list of companies that supply Halon? D. Dierdorf: The Halon Recycling Corporation functions as a Halon bank in the United States. It is composed of buyers and sellers and operates as a brokerage. Tom Cortina is the executive director of this group. The telephone is 800-258-1283. B. Tapscott: This area is changing so rapidly, it needs to be updated daily. It may not be worthwhile.

**Small Scale Screening for Cargo Agents - D. Blake**

Gave background on this Task Group. Due to lack of response to questionnaires and the suggestion to run full scale tests anyway, I move to dissolve this Task Group. No comments from group. This Task Group is dissolved.

**Potty Bottle Final Report - B. Glaser**

The report is in 80% complete. I am waiting for information from Deutsche Airbus to add to the report on the low temperature. I will have report out for committee and regulatory review by the end of August.

SURVIAC Bulletin Board Update (Engines) - M. Kolleck

The database is done and documentation has been prepared and turned over to WPAFB. SURVIAC is available through the Worldwide Web. We are working on funding to merge these two pieces together and to make it available. The database also contains information on Dry Bays. We will have to go through Public Release to make this information available worldwide. SURVIAC address is: HTTP://SURVIAC.FLIGHT.WPAFB.AF.MIL

Cargo Agent Preference - A. Gupta

A copy of his presentation is included in this package. He presented Preliminary Report based on survey he prepared. Reviewed materials from survey sent out through FAA Technical Center. Presented responses received from world airlines.

B. Glaser: Did your lead-in to this identify performance criteria? Specifically, comparative weights of the various systems. A. Gupta: There were about 13 pages of background information sent out as supporting documentation with the survey. We did not provide any information on the weight of the systems because of the various volumes of the cargo areas. S. Hariram: We should remove those who did not respond and use the majority preference of those who responded. R. Hill: I believe we should take it one step further now, we should have this Task Group put this information into a report and come up with a recommendation on agent preference. We will then have a document to circulate. J. O'Sullivan: I believe clarification is required. The Task Group may need to sit down and review survey results and clarify some of the answers received with some of those who responded. R. Hill: We need a report on your findings. I suggest that others in the Task Group assist with the Task Group work. S. Hariram: I suggest the Task Group meet at the end of the day today to work on this. S. Hariram: Perhaps we should make this a two-phase project. We should consider agents right now and look into agents for future testing since time is an important factor in this issue.

R. Hill: We have to determine which potential agents are the most viable because hundreds of tests are required to come up with a minimum performance standard. We had to run hundreds of tests for Halon 1301. A. Gupta: It seems that foam is the only agent we can eliminate at this time.

Potty Bottle Agent Preference - G. Grimstad

Reviewed survey sent out and responses received. A copy of the information presented is included in this package.

Engine Agent Preference- H. Mehta

A copy of his presentation is included in this package. He explained that this Task Group will prepare a report to recommend agents to be tested based on the work we have done to date. Perhaps the Task Group should also send out a survey similar to those sent out on Cargo Compartment and Potty Bottle agent preference. There are a tremendous number of standards that have already been developed for the aviation industry and many of these agents can be tests using standards that already exist. We should consider test already in existence instead of developing new tests. M. Bennett: If you use another facility, run all three at that facility for a comparison.

N. Povey: Maybe you should address retrofit and new designs in your survey. H. Mehta: Would you provide me with some written suggestions for this?

**Environmental and Toxicity - D. Catchpole**

We were asked to standardize environmental and toxicity information to include in the minimum performance standards. Reviewed proposed advisory statements. A copy of this Task Group's recommendations letter was previously forwarded to all Working Group members. N. Povey: "Existing Fire Protection ..." does this first sentence need to be there? I suggest change to "Existing Fire Suppression measures...". D. Catchpole: I agree with that. D. Moore: Define "existing local laws...". R. Hill: You have to take into consider local laws where you are going to sell the agent. You have to consider all the various laws that are applicable to your situation. R. Hill: In the minimum performance standards we will still need to define toxicity. This statement will not take care of all the toxicity of the agent. You still haven't defined what is acceptable or what is not acceptable. Once you put an agent in the cargo compartment and you are flying with passengers in the plane, you have to define what is toxic and what is not. We still need a definition of what is acceptable and what is not acceptable from a toxicity standpoint up in the cabin. We have to define this in the minimum performance standards.

**SUBGROUP LEADER PRESENTATIONS**

**Cargo - D. Blake**

We are working on establishing good baseline data for Halon 1301. We have Halon 1301 and FM200 and FE25 on order. We are working on coming up with some concentration numbers. A mass spectrometer is being used to measure the concentrations. This will give us the concentration numbers to use in the full-scale tests.

**Engines - D. Ingerson**

Explained status of work to date. Described engine nacelle simulator built at FAA Technical Center. M. Bennett: Will you also be looking at joint agents? D. Ingerson: At this point, I don't know about that. D. Dierdorf: Are you going to use Halon 1301 as a base? D. Ingerson: Ideally, I will probably design the fire toward what is acceptable for 1301 since we are striving for an equivalent level of safety. I would like to incorporate some type of concentration measurement into this set up. I am looking for input from everyone at this point. M. Bennett: Is there any possibility for heating and cooling of the air? D. Ingerson: Not in the present set up, but I have considered it. S. Hariram: Are you using the three agents listed in the performance standard? D. Ingerson: Yes.

**Hand Held Presentations - N. Povey**

He gave an update on progress on hand held work to date.

**Hand Held Hidden Fire Simulation Test - A. Chattaway**

He gave update on work done and adjustments made since April 1995 meeting. A copy of his presentation is included in this package.

**Review of Draft Minimum Performance Criteria for Replacement Hand Held Portable for Aircraft Cabin Fire Protection - B. Glaser**

Review and update on April 1995 meeting presentation. We need feedback from Working Group members in certain areas. D. Dierdorf: What is going on at DLR with their tests? N.

Povey: Their Department of Transport has been doing the work. I will get an update before the next meeting.

JULY 19, 1995

## Discussion on Revised Cargo Compartment Halon Replacement Minimum Performance Standard - R. Hill

The conclusions of the Environmental and Toxicity Task Group (advisory statements) will be incorporated into the minimum performance standard. The work of Al Gupta's Task Group will also be incorporated. Member Question: Has there been any work in the performance standard in the detection of fires in the cargo bays? R. Hill: Talk to Al Gupta, because Boeing is very interested in that. It is beyond the scope of this working group. Possibly, the Working Group will do work in that area in the future. A. Gupta: I get the impression you are waiting for the results from my Task Group, is that correct? You could work on this using Halon so that time is not lost. R. Hill: No, we will be continuing work with other agents. It is of interest to us, but we do not have the manpower or facilities to work on detection systems at this time. Is anyone interested in chairing a Task Group to work on this? F. Stossel: It is important to do some work on detection systems now. C. Womeldorf: NIST has started a group chaired by Bill Grosshandler doing some work in the area of detection. If you are interested in the work of this group, contact Bill Grosshandler. J. O'Sullivan: I think that someone should look into detection systems at this time. D. Dierdorf: Perhaps we should start a Task Group to assess what the 'state-of-the-art' detection system is. R. Hill: If industry wants to chair a Task Group without our input, that is the only way this work will get done at this point. A. Gupta: At Boeing we are doing research on fire detection systems. We have been doing a lot of work in this area and are making progress. At this point, these new systems can only be installed in a new airplane. As a result, the work has very recently been halted in the area of detection systems. N. Povey: In Al's presentation yesterday, he said that there were a number of airlines he had to go back to clarify their answers, possibly we should incorporate false alarm rates. R. Hill: I disagree. The responses Al received are general and probably based on the experience of the person completing the survey. A. Gupta: At Boeing, we have some data on false alarm rates. R. Hill: If Doug Dierdorf and David Ball are interested in forming a Task Group to research 'state-of-the-art' detection systems, let us know.

## Discussion of Minimum Performance Standards for Engines - M. Bennett

He reviewed updates made since April 1995 meeting. D. Dierdorf: Does the standard state that all test fires will be extinguished by Halon. H. Mehta: I don't want to include a statement like that, because the standard may be out there for the next 30 years. I think that we all know that Mike has run enough tests with 1301. In the 1994 FAR, Halon is not mentioned except for hand held extinguishers. R. Hill: Halon 1301 is an acceptable system by the FAA's definition in the FAR. H. Mehta: If we don't mention 1301 but define the fire is that acceptable? R. Hill: Yes, that is preferable. S. Hariram: There is an Advisory Circular that specifically mentions Halon 1301. We should have data to support that the new agent is equivalent to 1301.

## Agent Simulants for Engine Certification - N. Povey

Reviewed new legislations in Europe. A copy of a letter from D. Riordan of Shorts Brothers is included in this package. Nick suggested forming a Task Group to work on this situation.

Task Group Summaries/New Task Groups

1. SIMULANTS: N. Povey, H. Mehta, M. Mitchell (Walter Kidde), D. Dierdorf, there will be an FAA rep, B. Leach (suggested by R. Hill), C. Womeldorf will act as interim chairperson until she contacts B. Leach). Initial Task: compile all information available and establish what should be and should not be allowable. In the future look into cargo simulants.

2. SMALL SCALE SCREENING FOR CARGO COMPARTMENTS. This Task Group has been dissolved.

3. ENGINE SURVEY TASK GROUP. This Task Group has been dissolved. M. Kolleck will keep us updated.

4. POTTY BOTTLE. A final version should be prepared by the Nov. 1995 meeting.

5. ADVANCED AGENTS. Title changed to Chemical Options to Halon. Will work on future agents.

6. HALON RESTRICTIONS: J. O'Sullivan to continue to update the group.

7. CARGO AGENT PREFERENCE: Data will be analyzed. All Task Group members to send their input to A. Gupta by Aug. 15. There are some additional airlines/companies who should received survey. A. Gupta will provide A. Horner with those airlines/companies. A. Horner will send survey to the additional airlines/companies.

8. POTTY BOTTLE PREFERENCE: G. Grimstad will send all responses received from airlines to Task Group members for comments and send their responses to B. Glaser to be added to appendix of report.

9. ENVIRONMENTAL AND TOXICITY: D. Catchpole gave presentation. Advisory material will be incorporated in each minimum performance standard. This Task Group is dissolved.

10. AGENT CONCENTRATION: Look at taking concentration measurements (M. Bennett suggestion): D. Dierdorf suggested title: Future Certification Technologies. Measurement techniques and interpretation for certification. D. Dierdorf, M. Bennett, S. Hariram, M. Robin. D. Dierdorf will chair this Task Group.

11. DETECTION SYSTEMS ANALYSIS: Contact April Horner if you are interested in participating in this Task Group.

Working Group Member Presentations

***NOTE:*** **WORKING GROUP MEMBER PRESENTATIONS ARE TO BE GIVEN WITHIN THE TIME GUIDELINES REQUESTED. THE STANDARD IS 5-10 MINUTES PER PRESENTATION. THE AGENDA DOES NOT ALLOW TIME FOR LONGER PRESENTATIONS.**

Presentations were given by the following Working Group Members:

Ted Moore - (NMERI): A copy of his presentation is included in this package.
Terry Simpson (Walter Kidde Aerospace): Presented work done for Powsus.
Doug Dierdorf (Pacific Scientific): A copy of his presentation is included in this package.
Stephanie Skaggs (Pacific Scientific): Presentation on development of Triodide.
Dale Kent (3M): Presented update on 3M's clean extinguishing agent work.

# LIST OF ATTENDEES
# INTERNATIONAL HALON REPLACEMENT WORKING GROUP MEETING
### Held at University of New Mexico, Albuquerque, New Mexico
### July 18-19, 1995

| NAME | ORGANIZATION/ AFFILIATION | ADDRESS | PHONE/FAX |
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| Bob GLASER | Walter Kidde Aerospace | 4200 Airport Dr<br>Wilson N.C.<br>27896-9643 | PHONE: 919 237-7004<br>FAX: 919 237-4717 |
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| TED MOORE | UNM/NMERI | 901 Univ. Blvd SE<br>Albuquerque, NM<br>87106 | PHONE: 505 272-7261<br>FAX: 505-272-7203 |
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| PAUL HUSTON | PAUL HUSTON P.E AND Associates | 220 SNAKE HILL RD<br>TRUSSVILLE, AL 35173 | PHONE: 205-655-2961<br>FAX: — |
| Dan Moore | DuPont Fluoroproducts | Bmp 21-2154<br>P.O. Box 80021<br>Wilmington, DE 19880-0021 | PHONE: 302 992 2177<br>FAX: 302 992 6667 |

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| Harry Stewart | Pousus Inc | 1178 Wisteria Drive Malvern PA | PHONE: 610 647-2267<br>FAX: 610 648 0793 |
| SIMON CHAER | Cerberus Guinard | I have card | PHONE:<br>FAX: |
| Patrice Fassier | Cerberus Guinard | I have card | PHONE:<br>FAX: |
| Michael J. Clauson | U.S. ARMY TACOM | ATTN: AMSTA-TR-S WARREN, MI 48397-5000 | PHONE: 810-574-5948<br>FAX: 810-574-6674 |
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| | | | PHONE:<br>FAX: |
| | | | PHONE:<br>FAX: |

# NOVEMBER 17, 1995
# MEETING RETURN FORM

## INTERNATIONAL HALON REPLACEMENT WORKING GROUP

***NOTE: YOU WILL NOT RECEIVE MINUTES OF THIS MEETING UNLESS THIS FORM IS RETURNED BY FRIDAY, OCTOBER 20, 1995.***

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

The next meeting will be held at Harrah's Casino-Hotel in Atlantic City, New Jersey on Friday, November 17, 1995.

## PLEASE COMPLETE THE FOLLOWING INFORMATION:

NAME: ______________________________

COMPANY: ______________________________

PHONE: ______________ FAX: ______________

ADDRESS: ______________________________

CITY, STATE, ZIP: ______________________________

COUNTRY: ______________________________

***RETURN THIS FORM BY FAX BY FRIDAY, OCTOBER 20, 1995, 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**

**SHORTS**

*Nacelle Systems*

**Reference :** DR NT 95-212 **Date:** 4 July 1995


**To :** Nick Povey, CAA
**Fax :** 01293 573975

**From :** David Riordan
**Fax :** 01232 462947


Nick,

Herewith find a few notes which you may wish to relate at the next meeting of the International Halon Working Group in Albuquerque, July 18-19, 1995. I am unable to attend this meeting but expect to receive the minutes thereof from April Horner (FAA).

1. Shorts have just completed Fire Suppression tests for the nacelle of the Allied Signal TFE731-40 engine on the IAI Astra SPX aircraft. Both Halon 1301 and HFC-125 were used.

2. Compliance with type approval regulations was accomplished by means of a ground test. During the test, in which the nacelle was subjected to simulated worst case flight conditions, fire extinguishant levels were determined throughout the nacelle using a Statham gas analyser, operated by Steve Lamb, Walter Kidde Aerospace (WKA)

Gaining approval to conduct the tests in Belfast was fraught with difficulties :

3. An initial interpretation of EC Regulation 3093/94, dated 15 December 1994, by the Department of the Environment for Northern Ireland (DOE(NI)), suggested that the use of Halon 1301 was not acceptable. The phrase therein, "All practicable means shall be taken to recapture the gas" was interpretated to mean "physically possible" ; cost not to be an issue.

4. The use of HFC-125 as a simulant was proposed to the CAAI (Israel), but was not deemed acceptable.

5. A compromise position with DOE(NI) was reached whereby both Halon 1301 and HFC-125 were tested "back-to-back". The objective being to:

(a) convince Certification authorities that HFC-125 can be used as a suitable simulant of Halon 1301

(b) convince DOE(NI) that our efforts were directed towards avoidance of Halon 1301 in the future.

6. The position whereby it is 'acceptable' for Halon to be released into the atmosphere in fire suppression tests conducted within Europe, is certainly not a sustainable one

7. Eight tests were conducted as follows :

| Test No. | Agent | Agent Mass, lb | Bottle Temp. | Bottle Press. (psig @ 70°F) | Mass Flow Case | Method |
|---|---|---|---|---|---|---|
| 1 | Halon | 4.0 | -38°C | 600 | (a) | AC20-100 |
| 2 | Halon | 4.0 | -38°C | 600 | (b) | AC20-100 |
| 3 | Halon | 4.0 | ambient | 337 | (a) | AC20-100 |
| 4 | Halon | 4.0 | ambient | 337 | (b) | AC20-100 |
| 5 | HFC-125 | 3.08 | -30°C | 600 | (b) | Boeing |
| 6 | HFC-125 | 3.08 | -30°C | 600 | (b) | NAWC |
| 7 | HFC-125 | 3.08 | ambient | 337 | (b) | Boeing |
| 8 | HFC-125 | 3.08 | ambient | 337 | (b) | NAWC |

Methods for HFC-125 :

Boeing = analyser calibrated for Halon 1301

NAWC = analyser calibrated for HFC-125

8. The above test conditions were determined with helpful advice from :

WKA Steve Lamb
NAWC William Leach
NIST Carole Womeldorf
HTL Mike Diprose

9. Initial results show excellent correlation between HFC-125 and Halon 1301. A full report is due before the end of July.

10. Recognising that this is an international problem, it is the intention that a form of the results will be available (if desired) for presentation at the next meeting of the International Halon Replacement Working Group.

If the brevity of my notes has been at the expense of clarity, please advise and I shall endeavour to elaborate a little.

Yours faithfully,

David Riordan

DAVID RIORDAN
TECHNICAL & SYSTEMS ENGINEERING

| | | |
|---|---|---|
| Copy: | APRIL HORNER (FAA) | 001 609 646 5229 |
| | GEORGE CATHER | |
| | ROY FARREN | |
| | JIM WARNOCK | |

# Report of Task Group on Chemical Options to Halons

International Halon Replacement Working Group Meeting
18-19 July 1995
Albuquerque, New Mexico

- Larry E. Dvorak, Beech Aircraft Corporation
- Estee Jacobson, Spectronix
- Bill Leach, Naval Air Warfare Center Aircraft Division
- Karen Metchis U.S. Environmental Protection Agency
- Terry Simpson, Walter Kidde Aerospace, Inc.
- Louise C. Speitel, DOT/FAA/Technical Center
- Robert E. Tapscott, NMERI/CGET, Chair
- Robert A. Tetla, U.S. Air Force

## Update (Changes in Draft Report 2)

- Environmental Overview

"The agent selected should have environmental characteristics in harmony with international laws and agreements, as well as applicable local laws. It also should be borne in mind that an agent that does not have a zero or near-zero ODP, and the lowest practical GWP and Atmospheric Lifetime, may have problems of international availability and commercial longevity."

## Update (Changes in Draft Report 2)

- Toxicology Overview

"The toxicological acceptability of a chemical option to halons is dependent on its use pattern. As a general rule, the agent must not pose an unacceptable health hazard for workers during installation and maintenance of the extinguishing system. The cumulative toxicological effect of the agent, its pyrolytic breakdown products, and the byproducts of combustion must not pose an unacceptable health hazard."

## Update (Changes in Draft Report 2)

- No HBFCs Now Being Commercialized
- Proposed NFPA 2001 Standard and HTOC Report Require Design Concentrations to be Determined by Cup Burner
- Proposed NFPA 2001 Standard Allows Agent Concentrations for Class B Fires Up to LOAEL With Egress Possible

## Update (Changes in Draft Report 2)

- Removed All References to First- and Second-Generation Agents
- Modified Footnote for HCFC Blend A in Table of Design Concentrations:

  "This value is based on listing/approval tests rather than cup burner testing. Note, however, that proposed changes in the NFPA Standard 2001 may require a higher design concentration based on the cup burner."

# INTERNATIONAL HALON REPLACEMENT WORKING GROUP

JULY 18–19, 1995 • ALBUQUERQUE, NEW MEXICO

H. K. Mehta – Boeing Commercial Airplane Group
MS 67–MH
P. O. Box 3707
Seattle, Washington, 98124–2207
Voice 206–234–3650
Fax 206–234–8539

## TASK (SUB)GROUP – ENGINE & APU FIRE EXTINGUISHING AGENT PREFERENCE

OBJECTIVE:

- RECOMMEND PREFERRED OR THE MOST LIKELY HALON REPLACEMENTS FOR AIRCRAFT ENGINE AND APU FIRE EXTINGUISHING SYSTEMS FOR WHICH THE PERFORMANCE CRITERIA MUST BE DEVELOPED.

APPROACH:

- REVIEW THE FIELD OF ALL POTENTIAL REPLACEMENT AGENTS.
- PROPOSE A FEW AGENTS BASED ON THE CURRENT TECHNICAL INFORMATION.
- INVITE COMMENTS AND SUGGESTIONS FROM THE TASK GROUP AND AIRCRAFT OPERATORS.
- REVIEW THE COMMENTS AND PRESENT THE RESULTS TO THE WORKING GROUP (TARGET DATE NOVEMBER 17, 1995).
- MAKE RECOMMENDATION.

## TASK (SUB)GROUP – ENGINE & APU FIRE EXTINGUISHING AGENT PREFERENCE

POTENTIAL REPLACEMENTS:

- REFER TO THE REPORT DOT/FAA/CT–95/9 BY DR. ROBERT TAPSCOTT, ET AL.
- THE ABOVE REPORT RECOMMENDS HFC–227ea AND HFC–125 AS AGENTS OF FIRST CHOICE FOR ENGINE AND APU FROM THE GROUP HCFCs, HFCs, PFCs, AND BLENDS.
- THE REPORT ALSO MENTIONS FIC–13I1 TO HAVE BEEN FOUND VERY EFFECTIVE IN USAF TESTS.

PROPOSED RECOMMENDATION:

- SELECT HFC–227ea AND FIC–13I1 FOR FURTHER EVALUATIONS AND PERFORMANCE CRITERIA DEVELOPMENT.

ADDITIONAL AGENT:

- RECENT REPORTS ABOUT THE GAS GENERATOR TECHNOLOGY ARE ENCOURAGING.
- RESULTS OF MORE RESEARCH & DEVELOPMENT OF GAS GENERATOR TECHNOLOGY (IN PROGRESS) WILL DETERMINE IF IT SHOULD ALSO BE RECOMMENDED.

# Halonyzer Distribution Testing

Comparision of Triodide™ and Halon 1301

International Halon Replacement Working Group

July 19, 1994

Doug Dierdorf

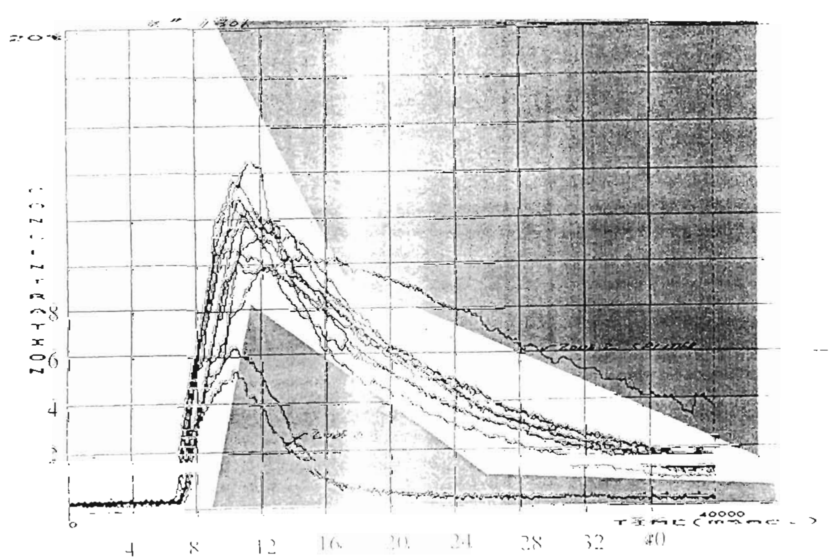
PACIFIC SCIENTIFIC

- Objective
  - Verify distribution of Triodide in Halon 1301 engine nacelle applications
- Experiment
  - Rolls-Royce, Derby, England
  - Engineering Test
  - Simulated Airflows
  - -40 degree bottle/agent temperature
  - Identical agent volume and pressure

PACIFIC SCIENTIFIC

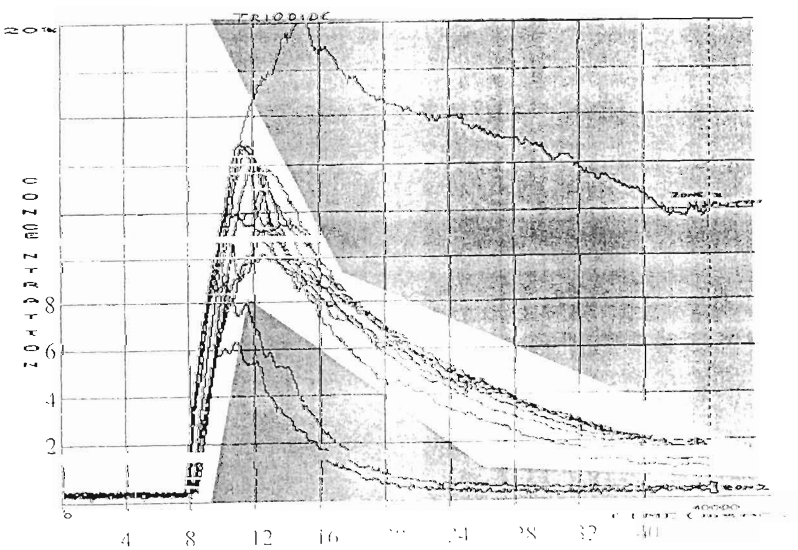
PACIFIC SCIENTIFIC

Halon 1301, 6 lb.




PACIFIC SCIENTIFIC

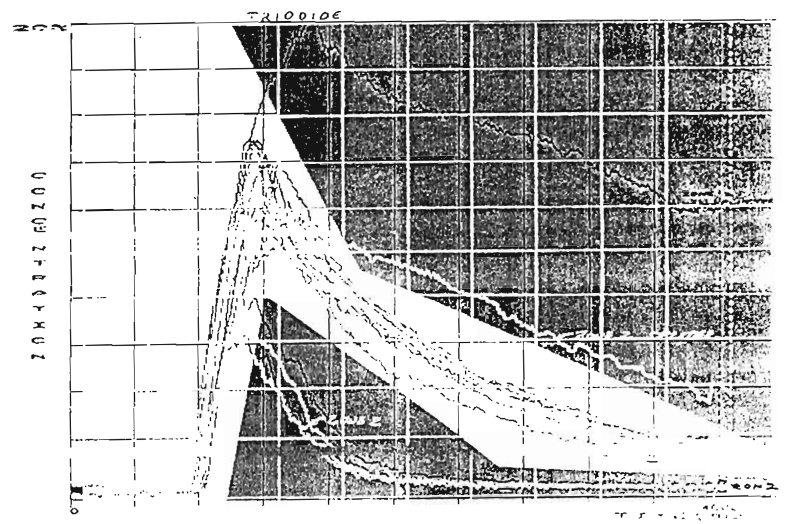
Triodide™, 8.0 lb.



PACIFIC SCIENTIFIC

# Overlay

## Triodide™ -



## Halon Replacement Agents in Aircraft Hand Extinguishers Hidden Fire Simulation Test

## Phase 1B: Sensitivity Tests

CAA Contract No
8D/S/00003

Adam Chattaway

18 July 1995

## Contents

- Recap of Previous Results
  - Initial CAA guidelines
  - Stratification --> Multifire Variant 2
  - FAA/CAA input --> Multilocation Variant 3
  - Preliminary Conclusions
- Extension of contract to include
  - Sensitivity to amount of agent
  - " to disharge time
  - " to hardware used
- Results
- Conclusions

## Extension to Contract
### 2. Hardware Tests

- Investigate effect of different manufacturers hand extinguishers:
- Measure mass agent discharged & time obtain mass flow rate & compare with "standard" Walter Kidde extinguisher
- Suppliers:

First Technology
Chubb Fire
Kidde Thorn

## 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

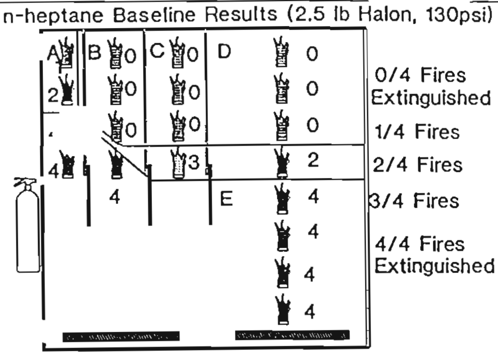
## Recap of Previous Results

- Initial CAA Initiative
  - 2 obscured fires "Variant 1"
  - problems with stratification of agent led to an array of 8 fires "Variant 2"
- CAA/FAA Input, need extinguishing data both on and off the agent flow path led to "Variant 3" with 20 fire positions (8 alight in any one test)
- n-heptane results summarised in one figure

## Extension to Contract
### 1. Sensitivity Tests

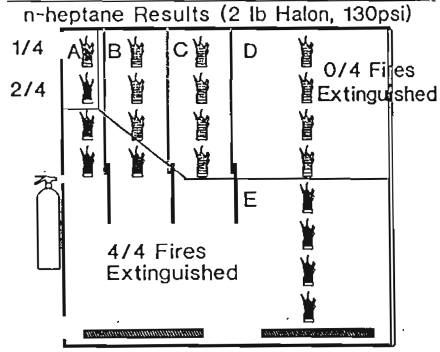
1. Investigate sensitivity to amount of agent: use 2lb & 3lb
2. Investigate sensitivity to pressure, hence discharge time & mass flow rate: use 100psi --> 20% longer discharge time use 220psi --> 20% shorter discharge time
3. Original pressure was 100-130 psi, with corresponding variation in discharge times. As pressure is to be investigated need to repeat baseline results with pressure accurately controlled at 130 psi

### n-heptane Baseline Results (2.5 lb Halon, 130psi)



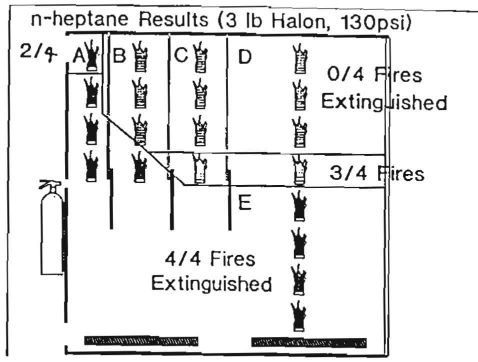

Total no Fires Extinguished: 36/80

### n-heptane Results (2 lb Halon, 130psi)



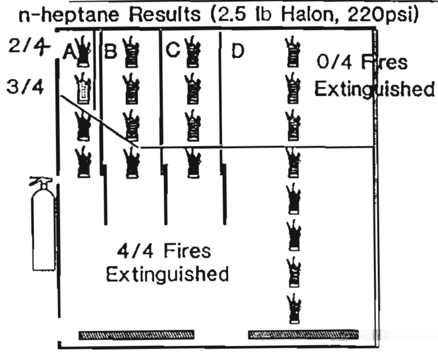

Total no Fires Extinguished: 32/80

### n-heptane Results (3 lb Halon, 130psi)



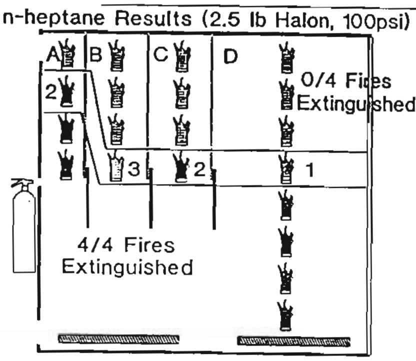

Total no Fires Extinguished: 40/80

### n-heptane Results (2.5 lb Halon, 220psi)



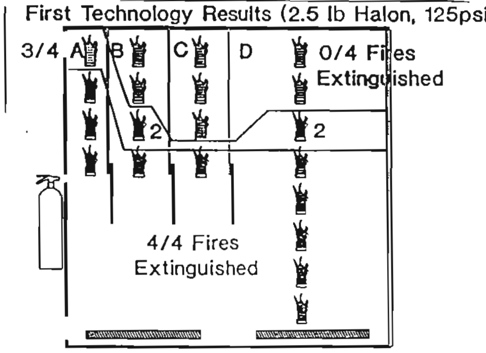

Total no Fires Extinguished: 41/80

### n-heptane Results (2.5 lb Halon, 100psi)



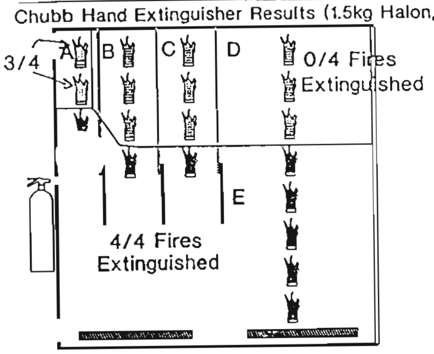

Total no Fires Extinguished: 32/80

### First Technology Results (2.5 lb Halon, 125psi)

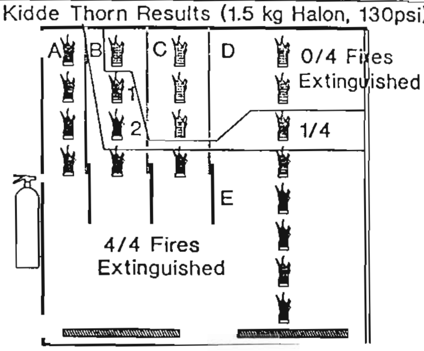



Total no Fires Extinguished: 47/80

### Chubb Hand Extinguisher Results (1.5kg Halon, 130psi)



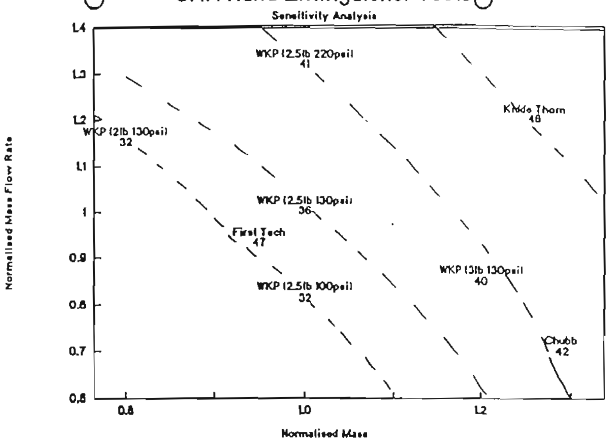

### Kidde Thorn Results (1.5 kg Halon, 130psi)



## Summary of CAA Hand Extinguisher Discharge Characteristics

| Extinguisher Details | Mean Agent Mass (kg) | Mean Discharge Time (s) | Mass Flow Rate (kg $s^{-1}$) | Normalised Mass | Normalised Mass Flow Rate | Total # Fires Out |
|---|---|---|---|---|---|---|
| WK 2lb, 130psi | 0.91 | 6.4 | 0.142 | 0.8 | 1.15 | 32 |
| WK "standard" | 1.14 | 9.2 | 0.123 | 1 | 1 | 36 |
| WK 3lb, [illegible] si | 1.36 | 13.0 | 0.105 | 1.2 | 0.85 | 40 |
| WK 2.5l [illegible] psi | 1.14 | 11.4 | 0.100 | 1 | 0.81 | 32 |
| WK 2.5lb, 220 psi | 1.14 | 7.0 | 0.162 | 1 | 1.32 | 41 |
| First Technology | 1.07 | --9.4-- | 0.114 | 0.95 | 0.93 | 47 |
| Chubb | 1.47 | 17.2 | 0.085 | 1.29 | 0.69 | 42 |
| Kidde Thorn | 1.44 | 9.8 | 0.147 | 1.26 | 1.20 | 48 |

## CAA Hand Extinguisher Tests




"Contour lines" of approximate equivalent extinguishing performance. indicate unusual result for First Technology Hand Extinguisher.

## Summary of CAA Hand Extinguisher Fire Tests

| Extinguisher Details | Normalised Mass | Normalised Mass Flow Rate | Zone A | Zone B | Zone C | Zone D | Zone E | Total # Fires Out |
|---|---|---|---|---|---|---|---|---|
| WK 2lb, 130psi | 0.8 | 1.15 | 12 | 4 | 0 | 0 | 16 | 32 |
| WK"standard" | 1 | 1 | 11 | 4 | 3 | 2 | 16 | 36 |
| WK 3lb, 130psi | 1.2 | 0.85 | 14 | 4 | 3 | 3 | 16 | 40 |
| WK 2.5lb, 100 psi | 1 | 0.81 | 10 | 3 | 2 | 1 | 16 | 32 |
| WK 2.5lb, 220 psi | 1 | 1.32 | 13 | 4 | 4 | 4 | 16 | 41 |
| First Technology | 0.95 | 0.93 | 15 | 6 | 4 | 6 | 16 | 47 |
| Chubb | 1.29 | 0.69 | 14 | 4 | 4 | 4 | 16 | 42 |
| Kidde Thom | 1.26 | 1.20 | 16 | 7 | 4 | 5 | 16 | 48 |

## Conclusions 1
### Sensitivity Analysis

- Using more agent extinguishes more fires
- Using less agent extinguishes fewer fires
- Using higher pressure extinguishes more fires
- Using a lower pressure extinguishes fewer fires
- *i.e.* as expected, but
- magnitude of the two effects appears similar

## Conclusions 2
### Effect of Hardware

- WKP: "Standard" 36 fires extinguished
- Chubb: More agent (but at a lower flow rate) hence more fires out (42)
- Kidde Thorn: More agent (and at a higher flow rate) hence significantly more fires out (48)
- First Technology: Same nominal mass/mass flow rate yet significantly more fires extinguished (47) Why? Nozzle design induces more turbulence -> better dispersion throughout test chamber.

## Discussion
### Points Requiring Clarification

1. Oxygen depletion/fuel supply?
   Measure $O_2$ Concentration during an unsuppressed test, (also see how long fires remain alight)
2. Fate of fires in Zone A:
   Blown out or extinguished?
   Measure Halon 1211 concentration in Zone A
   Try extinguisher filled with air alone
3. How well does test article simulate "infinite" aspect of real cheek area?
   Measure decay of Halon, fit 1st order eqn & obtain ventilation rate.

KIDDE

## Discussion 2
### Results

1. Oxygen depletion/fuel supply
   $O_2$ Concentration essentially unchanged after 4 minutes; all 8 fires still alight
   This implies ventilation more than sufficient
2. Fate of fires in Zone A:
   Cannot be blown out using air alone BUT Halon 1211 concentration at fire A4 is ~1% and fire still goes out in 0.5-1 s.
3. Infinite aspect of real cheek area?
   Ventilation rate is 0.043 $m^3 s^{-1}$ or 0.72 m $s^{-1}$ (typical lab fume cupboard 0.75 m $s^{-1}$!)
   (Halon decays to < 0.5% within 2.5 min)

KIDDE

## Summary & Conclusions 1

1. Sensitivity to amount & flow rate of agent is as expected.
2. Sensitivity has been quantised and appears to be equivalent for mass/mass flow rate.
3. Hardware effects are potentially much greate especially with low volatility agents, such as Halon 1211
4. This is undesirable from the point of view o defining a standard. Choose the lowest?

## Summary & Conclusions 2

5. However, hardware dependance implies scope for improving performance of replacement agents by hardware optimization.
6. [illegible]s suggests the weight penalties may not be as bad as n-heptane cup burner results might suggest.

NB: Any Hand Extinguisher must still obtain UL/FM/BSI Class A & B ratings prior to being tested against hidden fires.

## Future Work

- Contract calls for Replacement Agents to be tested this year
- No extinguishers ready yet
- Determine appropriate quantity of agent scaled by cup-burner
- Use non-specific hardware to discharge agent
- This will provide "agent baseline" so any commercial hand extinguisher should perform equally well

KIDDE

U.S. Department of Transportation
Federal Aviation Administration

Technical Center

Atlantic City Int'l Airport
New Jersey 08405

June 5, 1996

Dear Mr

The enclosed survey has been prepared by a task group representing airlines and airframe manufacturers on the subject of replacement agents for Halon 1301 in cargo compartments

As you are aware, halon is a chlorofluorocarbon and has been banned from production since January 1, 1994. Research is ongoing to find a suitable replacement agent or system for aircraft use. It would be useful for the research efforts if the types of agents/systems that airlines/airframe manufacturers would or would not use were known. Your responses will help research efforts to find a viable replacement for halon.

Please send your responses to Mr. Alankar Gupta of Boeing Commercial Airplane Group by July 12, 1995. His address and fax number are listed below.

Mr. Alankar Gupta
Mail Stop: 6H-TR
Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124
Fax: 206-237-6444

Mr. Gupta will tabulate the responses in order to provide a list of viable options to be researched further.

Sincerely yours,

Richard G. Hill
Program Manager
Fire Safety Section

Enclosure

# QUESTIONNAIRE

## USER PREFERRED AGENT FOR CARGO COMPARTMENTS-

This questionnaire must be returned by July 12, 1995.

Name: ______________________ Company: ______________________
Tel: ______________________ Fax: ______________________

A. Four agent groups (water and water based, halocarbons, particulate aerosols and high expansion foams) have been identified for cargo compartment fire suppression. Please list the groups in order of preference.

* *No preference ---------- (Please skip questions B, C and D)*

Agent Group Preference (0=undesired, 10=most desired)

1. ______________________
2. ______________________
3. ______________________
4. ______________________

B. Please (i) identify the agent (or agents) that you prefer and (ii) tell us your reasons*.

______________________

C. Please (i) list the agent (or agents) that you would not use and (ii) tell us your reasons*.

______________________

D. Will you use an agent not recommended for use in areas normally occupied by humans? (i.e., an agent that may create an inhospitable environment for humans).
YES___ NO___

E. Other comments/suggestions*.

______________________

* Use additional sheets if necessary

F. Please return this questionnaire by 12 July 1995 to A. Gupta, FAX 206-237-5444, or Mailing address: A. Gupta, M/S 6H-TR, Boeing Commercial Airplane Group, P.O. Box 3707, Seattle, WA 98124 (USA)

## USER PREFERRED FIRE EXTINGUISHING AGENT FOR CARGO COMPARTMENTS

ORGANIZATION: International Halon Replacement Working Group
Task Group: User Preferred Agents for Cargo Compartments

SUMMARY: This notice requests information from the user community on fire extinguishing agent(s) that would or would not be considered for use in cargo compartment fire suppression systems. This information is requested to help guide the regulatory authorities (FAA and JAA) develop airworthiness criteria for the evaluation of non halon fire suppression agents/systems.

DATES: Comments must be received by July 12, 1995.

ADDRESSES: Comments on this notice should be sent to:
Alankar Gupta, Chairman
Task Group User Preferred Agents- Cargo Compartments
Mail Stop 6H-TR
Boeing Commercial Airplane Group,
P.O. Box 3707, Seattle, WA 98124 (USA)

Fax 206-237-5444

FOR FURTHER INFORMATION CONTACT:

| | | |
|---|---|---|
| ° Jelle Benedictus | KLM (The Netherlands)<br>Ph. 31 20 64 906 31 | Fax. 31 20 64 881 62 |
| ° John Blackburn | Avro International Aerospace (England)<br>Ph. 061 439 5050x3696 | Fax. 061 767 3180 |
| ° Bernd Dunker | Deutsche Aerospace Airbus (Germany)<br>Ph. 040 7437 5309 | Fax. 040 7437 4742 |
| ° Thomas Grabow | Daimler Benz Aerospace Airbus (Germany)<br>Ph. 49 421 538 4033 | Fax. 49 421 538 4639 |
| ° Alankar Gupta | Boeing Commercial Airplane Group (USA)<br>Ph. 206 237 7515 | Fax. 206 237 5444 |
| ° Hans Humfeldt | Deutsche Lufthansa RG (Germany)<br>Ph. 49 40 5070 2406 | Fax. 49 40 5070 2385 |
| ° Jean Paillet | Aerospatiale (France)<br>Ph. 33 619 371 65 | Fax. 33 619 388 74 |
| ° Krijn Pellen | Fokker Aircraft B.V. (The Netherlands)<br>Ph. 020 605 2069 | Fax. 020 605 2895 |
| °Bud Roduta | United Airlines-SFOCE (USA)<br>Ph. 415-634-4857 | Fax. 415-634-4986 |
| ° Felix Stossel | Swissair (Switzerland)<br>Ph. 41 1 812 6930 | Fax. 41 1 812 9098 |
| ° John Sullivan | British Airways (UK)<br>Ph. 44 81 562 5460 | Fax. 44 81 562 2928 or 2026 |
| ° Sham Hariram | McDonnell Douglas Corporation (USA)<br>Ph. 310-593-4305 | Fax. 310-593-7104 |

SUPPLEMENTARY INFORMATION: At the fifth meeting of the International Halon Replacement Working Group, held 19-20 April 1995 in Rome, Italy, a Task Group was formed to determine the aviation industry's preferred fire extinguishing agent(s) for use in cargo compartments. This information will serve to reduce the list of potential



candidate agents and thus assist the regulatory authorities in planning their research activities to serve the aviation industry in an effective and timely manner.

Membership to this Task Group was limited to representatives from airframe manufacturers and airline operators. Persons identified above (Paragraph "For Further Information Contact") volunteered to serve in the Group. The Group was tasked to:

(i) Contact users (airframe manufacturers and airline operators) and determine fire extinguishing agents they would and would not use for fire suppression in their cargo compartments.

(ii) Prepare a report for presentation at the next IHRWG meeting, scheduled for July 18, 1995.

You are encouraged to submit written data, views, or arguments (see questionnaire attached) on fire extinguishing agent(s) that you would (or would not) use for fire suppression in the cargo compartments. If you have no preference, this information is also of value and we request that you communicate this position. The Task Group shall be obligated to assume that you have no preferred agent if comments are not received by the due date of 12 July 1995.

### Availability of Notice

Any person may obtain a copy of this notice by requesting it from any member of the Task Group. Refer to paragraph "For Further Information Contact" or from Ms. April Horner, IHRWG Coordinator, Phone 609-485-4471, Fax. 609-485-5229. By agreement of the IHRWG only written comments from airframe manufacturers and airline operators shall be considered.

### Background

Given the phase out of halon production, (Montreal Protocol and US Clean Air Act) the Aerospace Industries Association (AIA) held an International Symposium - Halon Replacement in Aviation 9-10 February 1993. The symposium was attended by representatives from the Federal Aviation Authority (FAA). At this meeting it was concluded that:

(i) current regulations do not require the use of halon,
(ii) no regulatory action is necessary, and
(iii) fire hazards, test protocols, and performance criteria all need to be developed.

On June 17, 1993 the FAA published Notice 93-1 in the Federal Register inviting industry to join in a cooperative effort to develop test articles, conduct evaluation tests, develop minimum performance standards, and provide guidance in drafting certification/compliance documents. This invitation resulted in the formation of the International Halon Replacement Working Group (IHRWG). Membership in the Group is open to all interested parties. The first meeting of the IHRWG was held on 13 October 1993, and the most recent, the fifth, was on 19-20 April, 1995.

## Discussion of Cargo Compartment Fire Suppression

Fire protection requirements and characteristics of potential agents/systems (conceptual) is discussed in the next several sections.

### Regulations

Federal Aviation Regulations and Joint Aviation Regulation FAR/JAR 25.857 require that Class C cargo compartments be provided with an approved built-in fire extinguishing system. The regulations do not mandate the use of any particular agent or system type.

FAR/JAR 25.851 applicable to the design of built-in fire extinguishing systems requires that the capacity of each required built-in extinguishing system must be adequate for any fire likely to occur in the compartment where used, considering the volume of the compartment and the ventilation rate.

### Current Practice

Currently all aircraft cargo compartment built-in fire extinguishing systems use halon 1301 as the fire extinguishing agent. All systems are "total flood" type. An initial minimum agent concentration of 5% by volume and subsequent minimum agent concentration of 3% by volume for the remainder of the flight has been accepted to meet the requirements of FAR/JAR 25.851. The concentrations are based on empty cargo compartment volume.

### International Halon Replacement Working Group (IHRWG)

The goal of the IHRWG is to introduce non-halon fire suppression systems into service in a timely, cost effective manner, with no compromise in present level of safety. The Group is working all areas of fire protection on board aircraft: engines and auxiliary power unit, cargo compartment, hand-held fire extinguishers for the occupied area, lavatory trash container, and dry bay (military). The IHRWG has formed several Task Groups to conduct detailed studies. Studies applicable to cargo compartment fire suppression that have been conducted are:

(i) Likely Fire Threats in Class C Cargo Compartments (Task Group 4)

(ii) Chemical Options to Halons for Aircraft Use (Task Group 6). Published by FAA as DOT/FAA/CT-95/9.

The above reports are in public domain and are available from FAA Technical Center, NJ. [Contact Ms. April Horner, Ph 609-485-4471, Fax 609-486-5229]

### Cargo Compartment Fire Suppression System Minimum Performance Standard

FAA/JAA have established that non-halon fire suppression system should provide the same level of protection (safety) as the present halon system. In particular, the systems must be capable of suppressing

(a) exposed or surface Class B (flammable fluids) fire
(b) deep seated Class A (carbon compounds) fire, and
(c) prevent fire hazards of an aerosol can (pressurized flammable gas).



FAA/JAA have neither defined "standard" tests and nor what is implied by equivalent level of protection (safety). FAA/JAA position is that critical tests (fire scenarios) depend on the selected agent/system and equivalent level of protection (safety) can only be established by back-to-back tests using halon 1301. In short, FAA/JAA will conduct the tests and define acceptable design parameters for the selected agent/system. It should be noted that the present halon 1301 system design parameters (acceptable halon concentrations) were previously established by FAA.

### IHRWG Task Group 6 Report "Chemical Options to Halons for Aircraft Use"

At the April 19-20 meeting, Task Group 6 recommended that FAA/JAA develop test protocols for the following classes of fire extinguishing agents for fire suppression in the cargo compartments.

(i) Water and water based agents
(ii) Halocarbon and halocarbon blends
(iii) Particulate aerosols
(iv) High expansion foam

There are several agents in each class and each agent has its pros and cons. Several members of IHRWG commented that they would or would not use certain agents in the cargo compartment. These remarks caused the IHRWG to form this Task Group. The Group has been tasked to determine why some fire extinguishing agent/system would or would not be used by the aviation industry. FAA/JAA believe this intelligence would help reduce potential candidates and help them plan their R&D effort such that they can effectively serve the aviation industry.

### Potential Fire Extinguishing Agents/Systems

Potential fire extinguishing agents and conceptual systems are described. It should be noted that conceptual systems are included to help one understand how a particular agent may be used or the system may be integrated with existing on board systems. The conceptual systems are not recommendations.

### Water And Water Based Agent/System

Several investigators have determined that water in the form of mist or fog is an extremely effective fire suppression agent for Class B (flammable fluid) fires. Some claim its effectiveness is equal to or better than halon 1301. Water and water based agents are highly effective in suppressing Class A fires (wood, cloth, paper, rubber, carbon compounds that form glowing embers, etc.). There are no environmental restrictions on the use of water and it is universally available at a very reasonable cost.

FAA Technical Center conducted several tests using water mist/fog/spray and determined that it provides a level of protection (safety) equivalent to that provided by halon 1301 for a deep seated fire. The critical location of this fire threat, for this class of agent, is in a damaged container located next to the compartment bulkhead. FAA used a zonal fire suppression system in which the suppression process was activated by temperature at the ceiling liner. Activation temperatures used were in the range of 200°F-250°F (93°C-121°C). FAA presented test system (which used solenoid valves to cycle the system) and test results at the last IHRWG meeting. [No formal test report is presently available. Copy of the presentation may be requested from Ms. April Horner Phone 609-485-4471, Fax 609-486-5229].



Figure 1 shows a conceptual system, developed by the Task Group, which can be made to perform the same function as the system tested by the FAA. The system consists of a normally unpressurized tank (1) filled with water or water based agent. The tank is connected to main supply ducts of the forward (2) and aft (3) cargo compartments. At the interface of each main supply duct/tank is located a normally closed pyrotechnically activated (or solenoid controlled) valve (21, 31). The main supply duct is connected to zone supply ducts (A, B, C, D, E, F, G, H). In each zone supply duct is installed a spring loaded or normally open valve (a, b, c, d, e, f, g, h) which is maintained closed by an alloy of low melting temperature (eutectic). The eutectic remains solid for temperatures less than TBD °F (TBD=200-250°F (93-121°C) or lower). Down stream of the valve are located the fire suppression agent delivery nozzles. This conceptual system is similar to industrial sprinkler system.

FAA tested the system in a test cargo compartment, approximately the size of a DC-10 airplane cargo compartment. It is probable that in the optimized system each fire suppression zone may be slightly bigger than the maximum size container or pallet that can be transported in the compartment. Also, it is reasonable to assume that the agent may allow the use of essentially similar size fire suppression zones and mist/fog nozzles in all wide body cargo compartments to maximize commonality of parts. Since, fire suppression in a maximum of two zones (fire at the boundary of two zones) would be required during any flight it is reasonable to conclude that the fire agent weight (or volume) would be independent of the cargo compartment size or volume. It may depend on the flight duration if the initial fire suppression effort is inadequate to suppress the fire below its critical (self sustaining) heat release rate. It has been suggested that one may be able to extend suppression capability by utilizing on-board potable water after the "dedicated" agent has been used.

The agent tank is pressurized by one or more pressurizing sources (4). The pressurizing source may be bleed air, electric motor driven air compressor, compressed inert gas bottle(s) or gas generator(s). The selection of the pressurizing source and the number of sources would depend on a number of factors: system operation (single or multiple discharges), source availability, installation, failure analysis, etc which are presently not known. FAA in their test used multiple discharges (by opening/closing of the solenoid valves in the agent distribution system in response to temperature near the ceiling.)

The fire suppression agent may be potable water, distilled water, ionized water and may (or may not) contain additives. The additives, if added, may be used to (i) depress freezing point (ii) modify surface tension (wetting agent) and/or (iii) enhance fire suppression effectiveness. FAA did not use additives in their tests. Several manufacturers claim that additives (biodegradable, environmentally safe) can enhance fire suppression effectiveness and help reduce agent weight. FAA used approximately 31 gallons (258 pounds or 177 kg) of water to maintain suppressed the test fire for 90 minutes.

The storage tank may be insulated to protect the agent from cold temperatures. Other features such as agent drain/fill, heating blanket, immersion heater, etc may be incorporated to allow extended storage in subfreezing temperatures.

The system may be integrated with existing (smoke, ionization) fire detection systems. The system operating logic is shown on figure 1. When a fire alarm is annunciated in a compartment, the pilot arms the corresponding squib (21 or 31) by pushing the appropriate squib arm switch. This action reconfigures the air-conditioning/ventilation system and illuminates the ARMED legend on the switch plate. (These functions can also be caused to occur automatically on detection of fire). Pressing the discharge switch opens the



appropriate main supply valve and initiates tank pressurization (gas generator, inert gas bottle, compressor or bleed air). On agent discharge (detected by drop in system pressure by a sensor not shown) the legend DISCH illuminates. In summary, it is feasible to design the system with crew actions and flight deck indications identical to the present halon 1301 system.

If the alarm is false or the fire does not produce adequate heat to melt the eutectic, the agent does not discharge. Thus, no clean-up is required in the event of a false alarm or a minor (non hazardous) fire. However, maintenance would be required to depressurize the system and recharge the pressurizing source (if expendable).

On discharge most of the agent will remain concentrated in and around the zone(s) in which it was discharged with some migration to other areas. Wetting of the cargo will occur and water damage (similar to damage one may experience in a heavy mist or drizzle) may occur. The agent will migrate to the bilge area. Migration of the agent to compartments occupied by crew and passengers and to equipment located outside the cargo compartment would depend on the integrity of the compartment liner. Means to exclude hazardous quantities of smoke, flames, or extinguishing agent, from any compartment occupied by the crew or passengers is a FAR/JAR 25.857 requirement and it is reasonable to assume agent migration from a maintained compartment will be a minimum.

Water is non-toxic. Also, It does not substantially reduce oxygen partial pressure when released in an enclosed space. Its discharge would not cause asphyxiation of animals in the cargo compartment.

The agent storage tank(s) would be normally unpressurized. Maintenance of the system may be simple and the required maintenance skill of a low level.

### Halocarbon and Halocarbon Blend Agent/System

The conceptual halocarbon or halocarbon blend agent system would be similar to the present halon 1301 system, figure 2. Halocarbon is independently plumbed from two bottles to each of the cargo compartments. Each bottle is pressurized to a high pressure by an inert (nitrogen) gas. When fire is detected in either the forward or aft compartment, the corresponding squibs are armed by pushing the appropriate squib arm switch. This action arms both extinguisher bottle discharge switches and illuminates the ARMED legend on the switch plate. In addition it configures the air conditioning and ventilation system. (These functions can also be caused to occur automatically on detection of fire). Bottle 1 is discharged by pressing the 1-BTL discharge switch. On successful discharge, the legend DISCH illuminates. The first bottle provides TBD1% concentration of the agent to knock down the fire. The second bottle is discharged after a prescribed time interval (manually or automatically, either as a dump or a metered supply) to prevent the agent concentration from falling below TBD2% by volume. The system would be a total flood system. The extinguishing agent weight (or volume) would depend on cargo compartment size or volume, compartment leakage rate and flight duration.

Commercialized zero Ozone Depletion Potential (ODP) fire extinguishing agents and their characteristics are listed in Table 1. Table 1 data is from IHRWG Task Group 6 report (DOT/FAA/CT-95-9 Chemical Options To Halons for Aircraft Use). Presently, there are no generally accepted standards on Global Warming Potential (GWP) and Atmospheric Life Time (ALT). From environment protection considerations lower value agents are prefered. The Table 1 design concentrations are recommended for extinguishment of Class B fires with n-heptane fuel. These concentrations may be considered as initial dump concentration (TBD1%) required to knock down flames. The subsequent lower suppression concentration (TBD2%) required to maintain a Class A fire suppressed is presently not known. In the case of halon 1301, the ratio of TBD2/TBD1 is 0.6 and this ratio may be assumed for the halocarbons. Test data on the performance of halocarbons for the deep seated Class A fire threat presently does not exist. Weight and volume equivalent data of Table 1 may be used to estimate the agent requirements for equivalent halon 1301 performance. From available data, it is apparent that all SNAP approved and NFPA recognized halocarbons will require increased (60%-100%) agent weight and increased agent (60-120%) storage volume compared to present halon 1301 systems.

Halocarbon systems require pressurized storage bottles. The suggested fill densities and storage pressures are listed in Table 1. The halocarbon have low freezing point and low temperature protection of the agent would not be required. However, at higher temperatures, greater than 70°F, the bottle internal pressures would increase and bottles capable of withstanding pressures substantially greater than storage pressure, indicated in Table 1, would be required. Several investigators have conducted studies on the effect of agent discharge time on fire (Class B) suppression effectiveness and products of combustion. Standard 2001 "Alternative Protection Options to halon" of the National Fire Protection Association (NFPA, 1, Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101), recommends a discharge time of 10 seconds or less or otherwise required by the authority having jurisdiction. It is reasonable to assume that a fast discharge time would be required. This would cause increase in compartment internal pressure and means to prevent cargo compartment over-pressurization may be required.

The conceptual system would lend itself for integration with the existing (smoke, ionization) fire detection systems and operation according to the current crew procedures. Like present halon system, the agent will discharge on crew command. Halocarbons are clean agents and no compartment clean up will be required. However, maintenance (bottle replacement and system checkout) of the fire suppression system would be necessary after each use. Agent discharge will reduce cargo compartment oxygen partial pressure, the decrease will be a function of cargo compartment volumetric loading and the compartment altitude at discharge. Based on past experience with halon 1301 systems, it is reasonable to assume that asphyxiation of animals may occur in a heavily loaded (volumetric) cargo compartment. Since, greater halocarbon agent volume (possible exception Trifluoroiodomethane) will be required for equivalent fire suppression capability it is reasonable to conclude that halocarbons would cause greater reduction in oxygen partial pressure. [Note, there is some concern on the Ozone Depleting Potential (0.0001) and toxicity of Trifluoroiodomethane. It has been proposed acceptable by US EPA for protection of non-occupied areas subject to public comment. At present, it is not recognized by NFPA in Standard 2001 and its acceptability status in other countries is presently not known.]

Halocarbon systems will be a total flood type. Agent will migrate to all parts of the cargo compartment and leak through available leakage paths. Migration of the agent to compartments occupied by crew and passengers and to equipment located outside the cargo compartment would depend on the integrity of the compartment liner. Means to exclude hazardous quantities of smoke, flames, or extinguishing agent, from any compartment occupied by the crew or passengers is a FAR/JAR 25.857 requirement and it is reasonable to assume that agent migration from a maintained compartment will be a minimum.

Halocarbons (exceptions HFC-125 and FIC-13I1) are non-toxic at design concentrations levels, (see LOAEL and NOAEL values Table 1). However, since the systems are designed based on empty cargo compartments, higher concentrations will result when the compartment is loaded. Note, animal asphyxiation referred to above will probably occur



due to the reduction in oxygen partial pressure (Dalton's Law of Partial Pressures) caused by the agent mixing with other gases in the compartment rather than agent toxicity.

The halocarbon system would normally be pressurized. It will be a two phase (halocarbon and inert gas) system. The system maintenance requirements can be reasonably assumed to be the same as the present halon 1301 system and of similar skill level. Periodic pressure test of the bottles would be required.

### Particulate Aerosols

Pyrotechnically Generated Aerosols, PGA, has been approved under SNAP for total flooding of unoccupied areas. [NFPA has no Technical Committee or Standard on this technology. A new project on "Fine Aerosol Technology" was authorized on April 13, 1995 by NFPA Standards Council]. Task Group 6 determined the aerosol technology as proprietary or ill defined.

A Class of agents known as EMAA (Encapsulated Micron Aerosol Agent) on activation ignites and creates an aerosol that contains about 40% solid particles (size less than 1 micron) of salts like Potassium Chloride, Potassium Carbonate, etc. The remaining 60% of the emissions are gaseous combustion products such as carbon dioxide, nitrogen, water vapor, oxygen and traces of hydrocarbons. This class of agents provides total flood capabilities. Some studies indicate that on a weight basis, the agents are five times more efficient than halocarbon extinguishing systems on Class B fires. Little is known of the capability of this agent to suppress Class A (exposed and deep seated) fires.

Figure 3 shows a conceptual particulate aerosol system. The system consists of agent container(s) with means for agent generation/expulsion. It is reasonable to assume that the system would consist of multiple cannisters located along the length of the cargo compartments and with electrical to acitvate agent release. (The agent/cannister/activation means can be reasonably assumed to be similar to chemical oxygen).

The conceptual system would lend itself for integration with the existing (smoke, ionization) fire detection systems and operation according to the present crew procedures. The system operating logic is shown on figure 3. When fire alarm, is annunciated in either the forward or aft compartment, the pilot will arm the corresponding cannister(s) activation system by pushing the appropriate compartment arm switch. This action would reconfigure the the air-conditioning/ventilation system and illuminate the ARMED legend on the switch plate. (These functions can also be caused to occur automatically on detection of fire) Pressing the discharge switch would create agent aerosol. On discharge of agent (detected by canister temperature rise or other means) the legend DISCH will illuminate. Maintenance (cannister replacement and system checkout) of the fire suppression system and clean up of the cargo compartment would be necessary after discharge. Combustion gases generated will reduce cargo compartment oxygen partial pressure. The reduction in oxygen partial pressure will be a function of cargo compartment volumetric loading and the compartment altitude at discharge. Presently, it is not known how much reduction in oxygen partial pressure would typically result with this class of agents. The effect of environment, heavily laden with micron size chemical particles, on the respiratory system of animals is also not known. In all probability it would be deleterious.

Particulate aerosol will be a total flood system. Agent will migrate to all parts of the cargo compartment. Migration of the agent to compartments occupied by crew and passengers and to equipment located outside the cargo compartment would depend on the integrity of the compartment liner. Means to exclude hazardous quantities of smoke, flames, or



extinguishing agent, from any compartment occupied by the crew or passengers is a FAR/JAR 25.857 requirement and it is reasonable to assume migration from a maintained compartment will be a minimum. The agent will settle in various areas of the cargo compartment (bilge area, insulation blankets, etc.).

Little is known about the toxicity of this class of agents. They have been approved under SNAP for total flooding of unoccupied areas. Cargo compartments often have animals and it is reasonable to assume that environment laden with microscopic chemical particles would not be in the best interest of animals.

The particulate system requires no pressurized source. It is similar to a chemical oxygen system and it can be assumed that it will require essentially similar scheduled maintenance. It should be noted that these systems are exothermic.

### High Expansion Foam

According to the Task Group 6 report, high expansion foam systems are uncommon but can be used for total flooding of a protected space, particularly where a Class A fire may be difficult to access for fire fighting. The conceptual high expansion "total flood" system would be similar to the water based system (without eutectic valves). The system would include the foaming agent and foaming equipment. The system would lend itself for integration with the current fire detection systems and operation by current crew procedures.

It is reasonable to assume that this type of system would be relatively more complex than a water based system and would require substantial clean up effort.

### Questionnaire

A questionnaire form consisting of four questions is attached for your use. Please use the form to submit your input. Additional sheets may be used to provide other information. The form should be returned by 12 July 1995 by either fax or mail.



Table 1: Significant characteristics of Commercialized Total Flood Halocarbo Agents. (data extracted from DOT/FAA/CT-95/9 and NFPA Standard 2001)

| Agent | Chemical Name | Trade Name | GWP[a] | Atmospheric Life time, yrs | SNAP[b] approval | NFPA[c] recognized |
|---|---|---|---|---|---|---|
| HFC-23 | Trifluoromethane | DuPont "FE-13" | 9000 | 280 | acceptable | yes |
| HFC-125 | Pentafluoroethane | DuPont "FE-25" | 3400 | 41 | acceptable | yes |
| HFC-227ea | Heptafluoropropane | Great Lakes "FM-200" | 2050 | 31 | acceptable | yes |
| HFC-236fa | Hexafluoropropane | DuPont "FE-36" | + | + | + | |
| FC-218 | Perfluoropropane | 3M "CEA-308" | 6100 | 3200 | acceptable | |
| FC-3-1-10 | Perfluorobutane | 3M "CEA 410" | 5500 | 2600 | acceptable | yes |
| FIC-13I1 | Trifluoroiodomethane | Pacific Scientific Triodide W. Florida Ordnance Iodoguard | <5 | <1 day | acceptable* | |

[a]Based on 100-year horizon, relative to $CO_2$ + Data not available
[b]Significant New Alternatives Policy (SNAP)
[c]National Fire Protection Association (NFPA) Standard 2001, "Alternative Protection Options to Halon"
*Proposed acceptable for protection of non-occupied areas subject to public comment. Aso known by Trade name Iodoguard

| Agent | NOAEL[d] % | LOAEL[e] % | % Design[f] concentr.(%) | Weight[g] equiv. | Volume[g] equiv. | Fill density (lb/ft³) | Storage press (psig) | Freezing Point (°F) |
|---|---|---|---|---|---|---|---|---|
| HFC-23 | 30 | >50 | 16.0 | 1.68(1.7) | 2.10(2.2) | 54.0 | 608.9 | -247.4 |
| HFC-125 | 7.5 | 10 | 10.9 | 1.88(1.9) | 2.44(2.3) | 58.0 | 166.4 | -153.0 |
| HFC-227ea | 9.0 | 10.5 | 7.0 | 1.66(1.7) | 1.61(1.6) | 72.0 | 166.4 | -204.0 |
| HFC-236fa | 10.0 | 15.0 | 6.4 | + | + | + | + | + |
| FC-218 | 30 | 40 | 8.8 | + | + | 80.0 | 360.0 | + |
| FC-3-1-10 | 40 | >40 | 6.0 | 1.91(1.9) | 1.67(1.7) | 80 | 360 | -198.8 |
| FIC-13I1 | 0.2 | 0.4 | 3.6 | + | + | 107 | 360 | + |

[d]No Observed Adverse Effect Level
[e]Lowest Observed Adverse Effect Level
[f]Manufacturer (HFC-236fa, FC-218) and Federal Register (HFC-23, HFC-125, HFC-227ea, FC-3-1-10) data
[g]Calculated from data in NFPA Standard 2001. Values in parentheses taken from SNAP listing.
+ Data not available

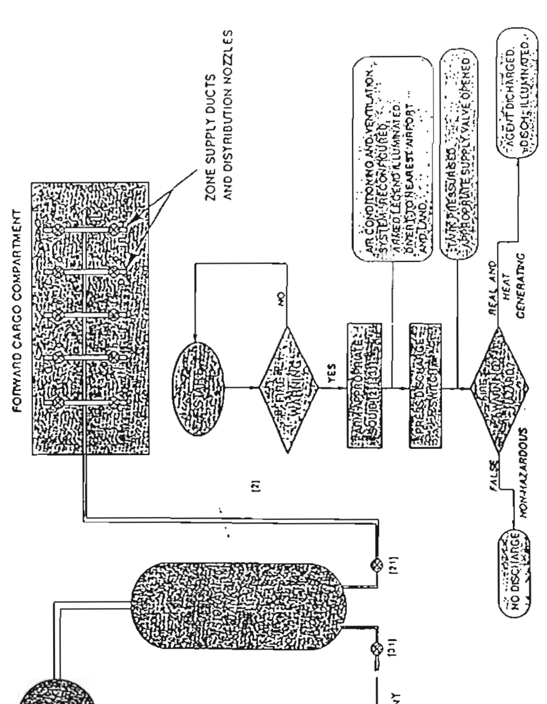



FIGURE 1 : WATER AND WATER BASED FIRE SUPPRESSION SYSTEM (CONCEPTUAL)



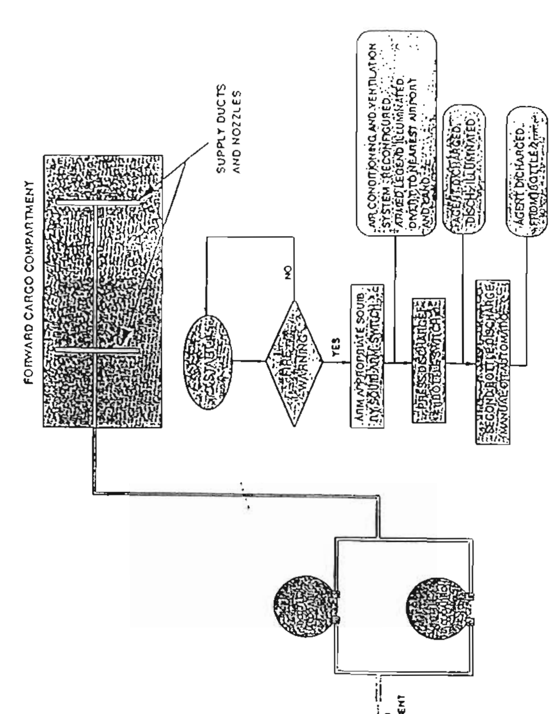



FIGURE 2 : HALOCARBON AND HALOCARBON BLEND SYSTEM (CONCEPTUAL)





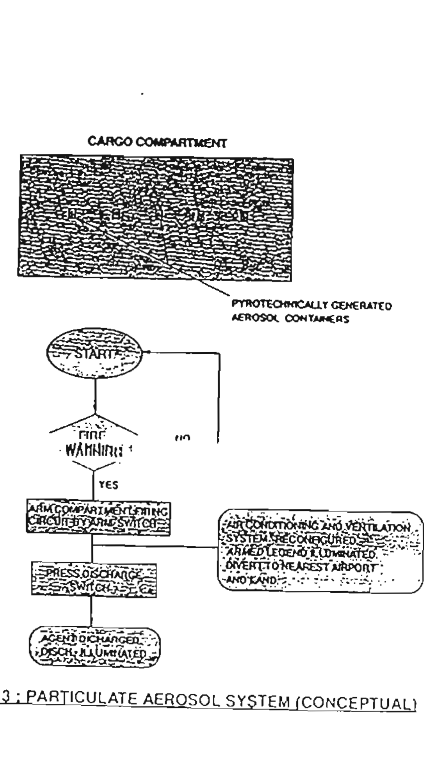



FIGURE 3 : PARTICULATE AEROSOL SYSTEM (CONCEPTUAL)

## ORGANIZATIONS RECEIVING IHRWG SURVEY

| Organization | Name | Title |
|---|---|---|
| Aeroflot Russian International Airlines, RUSSIA | Gennady Anikaev | VP Engineering & Maintenance |
| Aer Lingus PLC, IRELAND | Frank Doyle | General Manager Cargo |
| Air Canada, CANADA | John Dickie | VP Technical Operations |
| Air China, CHINA | Yan Shi An | VP Engineering |
| Air Espana S.A., SPAIN | Juan Jose Hidalgo | Pres. & Dir. General |
| Air France, FRANCE | Sten Grotenfelt | Sr. VP Management |
| Alaska Airlines, USA | Jim Davey* & Larry Sukut# | VP Maint & Engg* and Dir. Maint. & Engg#. |
| Alitalia S.P.A. ITALY | Roberto Schisano | Mng. Dir & Chief Exec. Management |
| All Nippon Airways Co. Ltd., JAPAN | Takaya Sugiura | Chairman |
| ALM Antillean Airlines, NETHERLAND ANTILLES | Kitland Chong | President & CEO |
| Aloha Airlines, USA | Terry Smith | VP Quality assurance & Engg |
| America West Airlines, USA | Everett Murvine | Dir Engineering & Airframe |
| American Airlines, USA | D.L. Kruse* & D.P. Huffmann# | Sr. VP Maint. & Engg* and VP Engg#. |
| American Trans Air, Inc., USA | Randy Marlar | VP Maintenance & Engg. |
| Asiana Airlines, Inc., KOREA | Sam Koo Park | Pres. & CEO Management |
| British Airways, UK | Alistair Cumming | Dir. Engineering |
| Canadian Airlines International Ltd, CANADA | C.W. Nassentein | VP Maintenance & Engg. |
| Cathay Pacific Airways, HONG KONG | Roland Fairfield | Dir. Engineering |
| China Airlines, TAIWAN | Yap Teng-Hsiang | Dir. Cargo Div. |
| China Eastern Airlines, CHINA | Wang Lian | Pres. Management |
| Continental Airlines, USA | Hal Houle | VP Technical Services |
| Delta Airlines, USA | W.E. Doll | VP Engineering |
| Deutsche BA, GERMANY | Richard Heideker | Pres. Management |
| Egyptair, EGYPT | Salah Galal F. Moussa | VP. Engineering |
| Finnair, FINLAND | Juoko malen | VP engineering |
| Hawaiian Airlines, Inc., USA | Bruce Nobles* & Irving S. Fluke# | President* and Sr. Dir, Maint & Engg#. |
| Iberia Airlines, SPAIN | Javier Salas | Chairman & Pres. Management |

## ORGANIZATIONS RECEIVING IHRWG SURVEY

| Organization | Name | Title |
|---|---|---|
| Indian Airlines, INDIA | M. C. Chopra | Dir. Engineering |
| Japan Airlines, JAPAN | Y. Araki*, K. Sakuraba#, Y. Murata+ | Sr. VPs Eng. & Maint*. Operations#. Engg+. |
| KLM-Royal Dutch Airlines, THE NETHERLANDS | R.G. Van Groenewoud | Exec. VP. Engg & Maintenance |
| Korean Airlines, KOREA | Won Lab Loo* & Sei Whan Cho# | Dir. & Sr VP Management*, Dir &VP Flt Op# |
| Lufthansa German Airlines, GERMANY | Dr. Rolf Stuessel | Engineering |
| Northwest Territorial Airways Ltd., CANADA | Dan Murphy | General Manager Management |
| Olympic Airways, S.A., GREECE | Xenofon Stathatos | Dir. Technical Services |
| Philippine Airlines, Inc. PHILIPPINES | Pastor C. Pangilinan | Sr. VP Maintenance & Engineering |
| Qantas Airways Ltd., AUSTRALIA | T. Crabtree* & R. Barkla# | Dir. Engg & Management*, Dir Engg. Support# |
| Scandinavian Airlines System, SWEDEN | Jan Stenberg | Pres. Management |
| Singapore Airlines Ltd., SINGAPORE | Chew Leng Seng | Deputy Managing Dir. Technical |
| South African Airways, SOUTH AFRICA | Mike Myburgh | Pres. Management |
| Southwest Airlines, Co., USA | John A. Vidal | VP Maintenance & Engineering |
| Swissair, SWITZERLAND | Hans Ulrich Beyeler | VP Engg. & Maintenance |
| Trans World Airlines, USA | J.A. Werner | VP Maintenance & Engg |
| United Airlines, USA | Ken Hylander | Genreral Manager Engineering |
| United Arab Emirates, UAE | Iftikhar Mir | Sr. General Manager Engineering |
| USAir, USA | Mark M. Rudo | Dir. Engineering |
| Varig, BRAZIL | Mr. Paulo Lopes Gallindo | Dir. Engg & Maint |
| Virgin Atlantic Airways, Ltd., UK | Roy Gardner | Managing Dir. Technical |
| Aerospace Industries Association of America | | |
| Air Transportation Association of America | | |
| International Air Transportation Association | | |
| International Civil Aviation. Organization | | |

## IHRWG SURVEY : RESPONSES TO QUESTIONS A & B

A. FOUR AGENT GROUPS (WATER AND WATER BASED, HALOCARBONS, PARTICULATE AEROSOLS AND HIGH EXPANSION FOAMS) HAVE BEEN IDENTIFIED FOR CARGO COMPARTMENT FIRE SUPPRESSION. PLEASE LIST THE GROUPS IN ORDER (0 = UNDESIRED, 10 = MOST DESIRED).

B. PLEASE (I) IDENTIFY THE AGENT (OR AGENTS) THAT YOU PREFER AND (II) TELL US YOUR REASONS.

| Organization | Response | Comments |
|---|---|---|
| Cathay Pacific | No preference | Default |
| China Airlines | No preference | |
| China Eastern Airlines | No preference | Default |
| Continental Airlines | No preference | Default |
| Delta Airlines | No preference | Default |
| Deutsche BA | No preference | Default |
| Douglas Aircraft | A-8, F-5, HC-10, W-8 | Halocarbon and Aerosols- Compatability to existing systems. Least design impact |
| Egyptair | No preference | Default |
| El Al Israel Airlines | No preference | |
| Finnair | No preference | Default |
| Fokker Aircraft B.V. | A-6, F-4, HC-10, W-5 | Clean agent advantage inadvertent disch. Weight is lower for small a/p |
| Hawaiian Airlines | A-0, F-0, HC-10, W-6 | No clean up, total flood, less cost |
| Iberia Airlines | No preference | Default |
| Indian Airlines | No preference | Requested resend fax, not legible. |
| Japan Airlines | A-4, F-0, HC-10, W-4 | Weight and similarity to existing system agent. |
| | No preference | Desired Characteristics (in order): safe for human and nature, easy to clean, good availabilty, commonality with other on-board agents. |
| KLM | A-6, F-4, HC-7, W-6 | Effectiveness, clean agent, integration existing fire detection systems. |
| Korean Airlines | No preference | Default |
| Lockheed Martin | A-0, F-0, HC-10, W-5 | Can knock down fire, No clean up |
| Lufthansa | A-5, F-4, HC-10, W-1 | Simple total flood system, no contamination, ETOPS, low mod cost. |
| NW Territorial Airways | No preference | Default |
| Olympic Airways | No preference | Default |
| Philippine Airlines | A-5, F-0, HC-6, W-10 | Environmentally friendly, not hazardous, easy to clean. |

## IHRWG SURVEY : RESPONSES TO QUESTIONS A & B

A. FOUR AGENT GROUPS (WATER AND WATER BASED, HALOCARBONS, PARTICULATE AEROSOLS AND HIGH EXPANSION FOAMS) HAVE BEEN IDENTIFIED FOR CARGO COMPARTMENT FIRE SUPPRESSION. PLEASE LIST THE GROUPS IN ORDER (0 = UNDESIRED, 10 = MOST DESIRED).

B. PLEASE (I) IDENTIFY THE AGENT (OR AGENTS) THAT YOU PREFER AND (II) TELL US YOUR REASONS.

| Organization | Response | Comments |
|---|---|---|
| Aer Lingus PLC | A-5, F-0, HC-10, W-5 | HC option appears to have optimum level of efficiency and ease of integration into existing system at a reasonable cost. |
| Aeroflot Airlines | No preference | |
| Airbus Industrie | A-5, F-3, HC-10, W-5 | Close to a drop in solution; retrofitable with low expense |
| Air Canada | No preference | Default |
| Air China | No preference | Default |
| Air Creebec Inc. | A-5, F-0, HC-3, W-0 | More information needed about aerosol before final decision. |
| Air Espana S.A. | No preference | Default |
| Air Europa | No preference | |
| Air France | A-8, F-3, HC-6, W-5 | High efficiency, low vol & wt, simple design. |
| Air Transat | A-6, F-4, HC-5, W-3 | Particulate aerosol: weight |
| Alaska Airlines | No preference | A drop in would be preferred |
| Alitalia S.P.A. | A-0, F-1, HC-10, W-1 | HFC-227ea is best with zero ODP and lowest weight and volume equivalent. |
| All Nippon Airways | No preference | Default |
| ALM Antillean Airlines | No preference | Default |
| Aloha Airlines | A-0, F-0, HC-10, W-0 | Lessor weight penalty, clean agent, no clean up required. |
| America West Airlines | No preference | Default |
| American Airlines | A-0, F-0, HC-10, W-9 | HC: Less modification/testing. Water-environmental considerations. |
| American Trans Air | A-2, F-0, HC-8, W-10 | Cost; ease of handling; clean up after use (practically negligible). |
| Asiana Airlines | No preference | Default |
| Boeing | A-5, F-1, HC-10, W-2 | HFC-227ea closer to Halon 1301(wt and vol.). FC 3-1-10 low design concentr. HFC236fa-preliminary data looks good. |
| British Airways | A-1, F-0, HC-10, W-0 | Efficient, life, weight, training, costs. |
| Canadian Airlines | A-2, F-*, HC-10, W-8 | Prefer HC of high effcy, low toxicity and residue, e.g., HFC-227ea. *-Insufficient information provided. |

## IHRWG SURVEY : QUESTIONS A & B RESPONSE SUMMARY

Desired agent group - Agent group assigned the highest numerical rating. In the event of equal rating of more than one group all groups were counted.

Agents identified: HFC-227ea, HFC-125 , non-toxic alternative to FIC-I3I1, NAF-SIII for temporary use on old aircraft.

| Desired agent group | No. and (%) of responses | Comments |
|---|---|---|
| Particulate Aerosols | 5 (8.33%) | Air Creebec, Air France, Air Transat, Raytheon Aircraft, United Arab Emirates |
| Foam | 0 (0.00%) | |
| Halocarbon and Blends | 19 (3167%) | Aer lingus, Airbus Industrie, Alitalia, Aloha, Boeing, British Airways, Canadian Airlines, Douglas Aircraft, Fokker, Japan, Hawaiian, KLM, Lockheed Martin, Lufthansa, Qantas(2), South African, Southwest, American Airlines. |
| Water and Water based | 4 (6.67%) | American Trans Air, Philippine, Scandinavian, Southwest |
| No preference | 32 (53.33%) | 27 default responses. |

## IHRWG SURVEY : QUESTIONS A & B RESPONSE SUMMARY

Undesired agent group- Agent group assigned the lowest numerical rating. In the event of equal rating of more than one group all groups were counted.

| Undesired agent group | No. and (%) of responses | Comments |
|---|---|---|
| Particulate Aerosol | 10 (14.28) | Alitalia, Aloha, Canadian Airlines, Hawaiian Lockheed Martin, Qantas, Scandinavian, Southwest, American Airlines |
| Foam | 19 (26.14) | Aer Lingus, Airbus Industrie, Air Creebec, Air France, Aloha, American Trans Air, Boeing, British Airways, Fokker, Japan, Hawaiian, KLM, Lockheed Martin, Philippine, Qantas(2), Southwest, United Arab Emirates, American Airlines |
| Halocarbon and Blends | 0 (0.00%) | |
| Water and Water based | 9 (13.04%) | Air Creebec, Aloha, Air Transat, British Airways, Douglas Aircraft, Lufthansa, Qantas, Raytheon Aircraft, United Arab Emirates |
| None Identified | 32 (45.71%) | 28 default responses |

## IHRWG SURVEY : RESPONSES TO QUESTIONS A & B

A. FOUR AGENT GROUPS (WATER AND WATER BASED, HALOCARBONS, PARTICULATE AEROSOLS AND HIGH EXPANSION FOAMS) HAVE BEEN IDENTIFIED FOR CARGO COMPARTMENT FIRE SUPPRESSION. PLEASE LIST THE GROUPS IN ORDER (0 = UNDESIRED, 10 = MOST DESIRED).

B. PLEASE (I) IDENTIFY THE AGENT (OR AGENTS) THAT YOU PREFER AND (II) TELL US YOUR REASONS.

| Organization | Response | Comments |
|---|---|---|
| Qantas Airways | A-0, F-0, HC-5, W-0 | HC offers the most promise. Non-toxic alternative to FIC-1311 |
| | A-3, F-0, HC-10, W-5 | Similar to halon system. |
| Raytheon Aircraft (Beech) | A-7, F-5, HC-3, W-1 | HFC 125 Close halon simulant |
| Scandinavian Airlines | A-2, F-5, HC-6, W-8 | Harmless, effective |
| Singapore Airlines | No preference | Default |
| South African Airways | A-2, F-4, HC-10, W-8 | HC-Low environment impact, very effective. |
| | | Water- very low environment impact. |
| Southwest Airlines | A-0, F-0, HC-5, W-5 | HC most like current system, least impact on operations. |
| Swissair | No preference | HC, A, F and W in order of preference, no ratings. HFC 227ea or HFC 125. |
| | | No clean up, long suppression, no damage, good survival chance animals. |
| Trans World Airlines | No preference | Default |
| United Airlines | No preference | Default |
| United Arab Emirates | A-9, F-6, HC-7, W-6 | Five times more efficient than HC, easy installation, maintenance. |
| USAir | No preference | Default |
| Varig | No preference | Default |
| Virgin Atlantic Airways | No preference | Default |
| AIA | | |
| ATA | | Little time for response. Airlines rely on systems and airframe designers |
| | | to develop alternatives to the point of removing most of the guess work. |
| ICAO | | |
| IATA | | |

## IHRWG SURVEY : RESPONSES TO QUESTION C

C. Please (i) list the agent (or agents) that you would not use and (ii) tell us your reasons.

| Organization | Agent(s) you would not use and why? |
|---|---|
| Aer Lingus | None Identified |
| Aeroflot | None Identified |
| Airbus Industrie | We will use what is requested by airlines. |
| Air Creebec Inc. | Water and water based- Weight and temperature susceptible. Foam-Weight and temperature susceptible. Halocarbons and halocarbon blends- Asphyxiation of animals. |
| Air Europa | None Identified |
| Air France | Foam: Extensive subsequent clean up required. |
| Air Transat | Water: damage to equipment, corrosion, freezing. |
| Alaska Airlines | None Identified. |
| Alitalia S.P.A | FIC-1311 for high toxicity. Water for the potential damages to the load. |
| Aloha Airlines | Particulate aerosol- not desirable in A/C environment and little is known about it. Foam -requires substantial clean up effort. Water and water based -weight penalty. |
| American Airlines | Aerosol and Foam: do not offer complete and continuous fire suppression deep seated fire. |
| American Trans Air | Foam: high cost and clean up expense after use. |

## IHRWG SURVEY : RESPONSES TO QUESTION C

C. Please (i) list the agent (or agents) that you would not use and **(ii) tell us your reasons.**

| Organization | Agent(s) you would not use and why? |
|---|---|
| Boeing | Water- Potential safety issue |
| British Airways | Foams- weight, efficiency, safety. |
| Canadian Airlines | Aerosol- corrosive inorganic salts and potentially noxious by-products. |
| China Airlines | None Identified |
| Douglas Aircraft | Water and water based- lots of disadvantages, see Boeing's rept submitted to FAA. |
| El Al Israel Airlines | None Identified |
| Fokker | Water and Foam cleaning of cargo and cargo compartment. Installation expected to be heavier relative to Halocarbon |
| Hawaiian Airlines | Foams- Extremely difficult to clean, more complex design and installation.<br>Aerosols: Clean up difficulty, costly system installation. |
| Japan Airlines | Water can't be used against electrical fire. Aerosol clean-up difficulty. Foams lots of uncertain factors<br>Foam- Clean up problems, effectiveness, complexity system. |
| KLM | Clean up problems, effectiveness, system complexity |

## IHRWG SURVEY : RESPONSES TO QUESTION C

C. Please (i) list the agent (or agents) that you would not use and **(ii) tell us your reasons.**

| Organization | Agent(s) you would not use and why? |
|---|---|
| Swissair | Foam- I do not know any foam which is not extremely corrosive. Foam will not stay at fire, will be blown away from hot air. Water may be used but aircraft has to be designed to prevent malfunction (of some systems). Both water and foam will have freezing problems. A/C manufacturers will reject corrosion warranty if water/foam will be used. |
| United Arab Emirates | Water and water based- heavy installation, unsuitable for elect, fires, corrosive properties of water based compounds not defined. Requires protection against low temperatures, expensive installation. |

## IHRWG SURVEY : RESPONSES TO QUESTION C

C. Please (i) list the agent (or agents) that you would not use and (ii) tell us your reasons.

| Organization | Agent(s) you would not use and why? |
|---|---|
| Lockheed Martin | Particulate aerosols and foams- Excessive aircraft clean up required which is costly. Also, the compounds can be corrosive and may not be easily removed from faying surfaces of parts and structure. I have first hand knowledge of the corrosive effects of foam on aircraft structure and would not like to see it repeated. |
| Lufthansa Technik AG | Water and water based-Moisture in electronical systems and cargo, fire fighting in sections only, complicated system with high maintenance cost, excessive tubing and valve system, high mod. costs when changed from halon to water. |
| Philippine Airlines | Halocarbons, particulate aerosols, expansion foams: Maintenance required after use, hazardous, non-environmental friendly, effect of migration of agent to other compartments. |
| Qantas Airways | Water base- secondary damage to systems. Aerosols and Foams- insufficient data available on Class A fires and respiratory problems for livestock carriage. |
| Raytheon Acft Co. | Agents that substantially increase weight and volume and have significantly higher toxicity levels in comparision to halon. |
| Scandinavian Airlines | Exothermic pyrotechnically generated aerosols. It adds to heat generation. |
| South African Airways | Aerosol: clean up required, possibility of corrosion due to trapped material, possibly harmful to animals |
| Southwest Airlines | Particulate aerosols for reasons described. |

## IHRWG SURVEY : QUESTIONS C RESPONSE SUMMARY

| Group will not use | No. and (%) of responses | Comments |
|---|---|---|
| Particulate Aerosol | 10 (14.08%) | Aloha, Canadian Airlines, Hawaiian, Japan, Lockheed Martin, Qantas, Scandinavian, South African, Southwest, American Airlines |
| Foam | 11 (15.49%) | Air Creebec, Air France, Aloha, American Trans Air, British Airways, Hawaiian, Japan, KLM, Qantas, Swissair, American Airlines |
| Halocarbon and Blends | 2 (2.80%) | Air Creebec, Philippine |
| Water and Water based | 10 (14.08%) | Air Creebec, Air Transat, Aloha, Boeing, Douglas Aircraft, Fokker, Japan, Lufthansa, Qantas, United Arab Emirates |
| None Identified | 37 (55.07%) | 28 default responses including Aer Lingus, Alitalia, Raytheon, Scandinavian |

## IHRWG SURVEY : RESPONSES TO QUESTION D

D. Will you use an agent not recommended for use in areas normally occupied by humans? (i.e., an agent that may create an inhospitable environment for humans).

| Organization | Agent that may create an Inhospitable environment for humans |
|---|---|
| | YES/NO |
| Aer Lingus | No |
| Aeroflot | No response |
| Airbus Industrie | No response |
| Air Creebec Inc. | No. Unless it is allowable in limited quantities. Not recommended does not mean unusable |
| Air Europa | No response |
| Air France | Will not use and Will not accept agent not recommended in area normally occupied by humans. |
| Air Transat | Yes |
| Alaska Airlines | No response |
| Alitalia S.P.A. | No |
| Aloha Airlines | No |
| American Airlines | No. |
| American Trans Air | No |
| Boeing | No |
| British Airways | No |
| Canadian Airlines | No |
| China Airlines | No response |
| Douglas Aircraft | No |
| EL AL Israel Airlines | No response |
| Fokker Aircraft B.V. | Yes -as long as the total installation complies with the toxicity requirements. |
| Hawaiian Airlines | Yes-toxicity levels must be minimal |
| Japan Airlines | No |
| KLM | Yes if acceptable to authorities. |
| Lockheed Martin | Yes- but only under strict control to assure people and animals won't be harmed by it. |

## IHRWG SURVEY : RESPONSES TO QUESTION D

D. Will you use an agent not recommended for use in areas normally occupied by humans? (i.e., an agent that may create an inhospitable environment for humans).

| Organization | Agent that may create an Inhospitable environment for humans |
|---|---|
| | YES/NO |
| Lufthansa Technik AG | No |
| Philippine Airlines | No |
| Qantas Airways | No. |
| Ratheon Acft Co. (Beech) | No |
| Scandinavian Airlines | Yes |
| South African Airways | Yes |
| Southwest Airlines | No |
| Swissair | Yes if the aircraft is designed such that no agent can enter the cabin area. Think also about animal transport. We need that business. |
| United Arab Emirates | No. |

## IHRWG SURVEY : QUESTION D RESPONSE SUMMARY

| Yes or No | No. and (%) of responses | Comments |
|---|---|---|
| Yes | 8 (12.90%) | Air Transat, Fokker, KLM, Lockheed Martin & Swissair conditional yes. Hawaiia Scandinavian, South African Airways. |
| No | 18 (29.03%) | Air Creebec, Air France, Air Lingus, Alitalia, Aloha, American Trans Air, Boein British, Canadian Airlines, Douglas Aircraft, Japan, Lufthansa, Philippine, , Qantas, Raytheon, Southwest, United Arab Emirates, American Airlines |
| No response | 36 (58.06%) | 29 default responses |

## IHRWG SURVEY : COMMENTS AND SUGGESTIONS

| Organization | Comments/suggestions |
|---|---|
| Aer Lingus | No comments |
| Aeroflot | No comment |
| Airbus Industrie | No comments |
| Air Creebec | All item referenced address cargo compartments of large aircraft. Nothing appears suitable to Regional cargo aircraft in Combi mode. It appears more R&D is required to a type of extinguishing product. |
| Air Europa | No comments |
| Air France | Combi aircraft are not taken in consideration, approach may be different for full cargo aircraft. |
| Air Transat | R&D Still required. |
| Alaska Airlines | A "drop in" replacement would be preferred. This will minimize any hardware and operational revisions required. Also, any new agent used should not be harmful to aircraft structure or systems, and preferably not harmful to human or animal life. |
| Alitalia S.P.A. | We would like ag agent not requiring major modification on aircraft plants for old aircraft. |
| Aloha Airlines | No comments |
| American Trans Air | Cost of retrofit must be considered. Implementationtime for the new system must be ample for operators. |

## IHRWG SURVEY : COMMENTS AND SUGGESTIONS

| Organization | Comments/suggestions |
|---|---|
| Boeing | Halocarbons best for immediate use. Research for agents to reduce weight and volume. |
| British Airways | No comment |
| China Airlines | No comments |
| Douglas Aircraft | No. |
| EL AL Israel Airlines | No comments |
| Fokker Aircraft B.V. | Yes -as long as the total installation complies with the toxicity requirements. |
| Hawaiian Airlines | The toxicity level in cargo compartments must be minimal. |
| Japan Airlines | Select agent based (i) safe for human and nature (ii) easy to clean (iii) good availability and (iv) consistent with other agents in aircraft. |
| KLM | More detailed information is required with regard to halocarbon & aerosols to express a more motivated preference for the four agent groups. The response is a preliminary indication which agent is preferred. |
| Lockheed Martin Aeronautic | Halon is the best one. |

## IHRWG SURVEY : COMMENTS AND SUGGESTIONS

| Organization | Comments/suggestions |
|---|---|
| Lufthansa Technik AG | We prefer to have one agent Agents in all four systems (Cargo, engine, handheld, and waste bin), but if that is not possible, a slightly toxic agent (like 1211) would be accepted. |
| Philippine Airlines | No comment |
| Qantas Airways | would not use any fire suppressant unless material equals or exceeds existing halon performance criteria and meets non-toxicity requirements. |
| Raytheon Acft Co. (Beech) | No comments |
| Scandinavian Airlines | Clean up after a discharge should be considered a minor problem compared to an uncontained fire. Has the technique suggested for fuel tanks using inert gas or exhaust gas been considered e.g., as a follow up to initial fire suppression with water mist |
| South African Airways | What about the use of carbon dioxide. |
| Southwest Airlines | Keep looking for an acceptable substitute for halon |
| Swissair | No comment |
| United Arab Emirates | Task Force should establish capability of particulate aerosol against Class A fires. Chances of Class A fire originating in cargo compartment is more than Class B. |

Title. Proposed Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

INTRODUCTION

ne and APU compartment fire extinguishing systems are required by FAR/JAR 25.1195 and . 25A.1195. The current fire extinguishing systems using halon 1301 as the extinguishing agent are deemed to satisfy this requirement if the system can produce concentrations of halon 1301 specified on the basis of the system configuration and the operational parameters. Fire extinguishing performance of halon 1301 had been previously established through tests, leading to these specifications (e. g. FAA AC 20–100). The standards being proposed in the following have become necessary to develop specifications for systems using alternative agents for extinguishing fires. These standards are not necessarily the same as for halon based systems nor are they a complete listing of techniques which may be required for certifying an aircraft engine and APU fire extinguishing system.

The agent and the fire extinguishing system must comply with the following minimum performance standards.

1.0 REQUIREMENTS FOR AGENTS/SYSTEMS

1.1 Environmental Characteristics

The environmental characteristics of the fire extinguishing agent must comply with international laws and agreements. Agents approved by the regulatory agencies for use in areas not normally occupied by humans are acceptable.

1.2 Fire Extinguishing Performance

The agent/system (that is the agent which satisfies requirement 1.1 above when deployed through a suitable system) must be capable of extinguishing any probable fires in the aircraft engine designated fire zone or in the Auxiliary Power Unit (APU) compartment for which the agent/system is intended. A fire will be considered extinguished if there are no visible signs of a flame for five seconds. A fire in an engine or an APU compartment is probable when a fuel and air mixture comes in contact with an ignition source. An airflow through an engine or APU compartment is normal and a fuel (usually a combustible fluid) could become available due to a failure expelling aviation turbine fuel, hydraulic fluid or engine oil. The ignition source could be any surface at a temperature above the hot surface ignition temperature for the fuel in the compartment. Ignition can also occur if the fuel enters an environment in which rapid heating causes it to exceed its autoignition temperature. The consideration of probable fires must cover the range of physical parameters in the fire zone for the operational envelope of the engine or of the APU. Three typical combustible fluids for the fire must be considered: aviation turbine fuel, hydraulic fluid and engine oil. The physical parameters must include: the zone volume, cross sectional area and shape, the compartment air temperature and (ventilation) air flow rate, the surface temperatures, the fuel (combustible fluid) flow rate, the amount of clutter within the zone and the temperature of the agent/system (probable inservice temperature before a discharge). It is possible that






fires in some locations in the fire zone may be more difficult to extinguish than in other locations. The agent/system must be able to extinguish probable fires anywhere in the fire zone

1.3 Health and Safety

The fire extinguishing agent/system for an engine compartment or an APU configuration must satisfy the following safety and health requirements

1.3.1 Health and Safety in Handling

The agent/system must not pose a health and safety hazard for workers during installation and maintenance of the system

Safety features incorporated in the equipment and handling procedures for the agent/system which mitigate this hazard should be taken into account while assessing compliance with this requirement.

1.3.2 Flight Safety

The use and operation of the agent/system in aircraft should not cause the following:

(a) Malfunction of components critical for flight control necessary for continued safety of flight.

(b) Damage to other critical components and areas within the compartment being protected, which would create a hazard either immediately or remain undetected and be a hazard after passage of time.

(c) Corrosion of the aircraft structure.

2.0 TEST METHODS FOR AGENT/SYSTEM EVALUATION (SCREENING)

Tests will be necessary to evaluate the fire extinguishing performance of an agent/system and to determine if it will satisfy the requirements stated in 1.2. There are two types of these tests. The first type of tests, agent evaluation tests or screening tests, will provide data which include the effectiveness of an agent in extinguishing an actual fire in terms of the quantity of the agent required at the fire. Volumetric concentration of the agent and the time required to extinguish the fire should be recorded to provide a basis for the system validation tests mentioned in the following. If it is not practical to always record the agent concentration, at least some tests must be conducted without the fire but simulating other parameters of the test which resulted in successful fire extinguishment. The second type of tests, system validation tests, will apply to aircraft specific designs. They will verify the effectiveness of the specific delivery system in transporting the required quantity of the agent at the potential location of the fire. Thus, the agent evaluation tests will provide the basis for the design and engineering of the system and the system validation tests. The test methods proposed here address only the first type of tests.

*In aircraft engine nacelles, fuel (combustible fluid) may still be available after the initial extinguishment of fire. A second bottle of the agent is required for the engine nacelle fire zone (a second bottle is not required for the APU) for discharge in case of a re–ignition indicated by*






*a persistent or a new fire alarm. The objective of the tests described here should be to establish the agent performance in extinguishing the fire through a single discharge.*

*A particular replacement agent could be in a solid, liquid or gaseous phase when interacting with the fire and its effectiveness might be dependent on both the state and the quantity of the agent. For example, the particle size of a solid agent or the droplet size of a liquid agent could influence its performance. These details need to be addressed in tests if they are relevant to the performance of a specific agent/system.*

2.1 Test Apparatus

2.1.1 Aircraft Engine Compartment Simulator

For the purpose of these tests, the engine compartment (nacelle) simulator should have an annular fire zone having a minimum volume of 65 $ft^3$ and a minimum cross sectional area of the annulus of 5.5 $ft^2$, both before reductions due to clutter simulation. It should be equipped to simulate test parameters described in 2.2.1. The inner cylinder in this configuration will represent the engine case. The test section must be equipped to allow a real time visual indication of fire. A schematic diagram of a simulator is shown in Figure 1. The agent distribution system should be capable of extinguishing fires in any location within the fire zone.

*If an agent/system is successful with a fire zone of this size, it is highly likely to be successful in both larger and smaller zones with appropriate agent quantities and system designs. The purpose here is to define the minimum performance standard with probable fire scenarios in a typical fire zone. Specific applications may benefit from these test data but may require additional considerations which are not a part of this minimum performance standard.*

2.1.2 APU Compartment Simulator

The APU compartment simulator should have a minimum volume of 8 $ft^3$ in the shape of a typical aircraft installation. The test section must be equipped to allow a real time visual indication of fire. It should be equipped to simulate test parameters described in 2.2.2.

*The APU compartment simulator could have a conical shape or a rectangular shape. The entire compartment should be treated as a fire zone. Air inlet and outlet positions may be asymmetrical. It differs from the engine compartment simulator in which the annular cavity is the fire zone with air entering from one end of the annulus and exiting from the other end. Actual APU installations have the compartment volume ranging from 2–400 $ft^3$. The minimum volume selected here is closer to the lower end of the range. Results of the engine nacelle fire zone simulations using larger volumes would also be relevant whenever fire characteristics are comparable.*





2.2 Test Conditions

2.2.1 Engine Compartment Test Parameters

2.2.1.1

At least two internal (ventilation) airflow rates:

(a) High 2.5 – 3.0 lbm/sec.

(b) Low 0.2 – 0.7 lbm/sec.

*(a) corresponds to about 57 air changes per minute for the fire zone having 65 $ft^3$ volume and 5.5 $ft^2$ cross sectional area. For significantly different volume and cross section, the airflow rates should be adjusted appropriately.*

2.2.1.2

At least two ventilation air temperatures of 200 and 400 °F.

2.2.1.3

Surface temperature: At least a portion, about 2 ft long and encompassing a 90° arc, of the surface of the test article simulating the engine core (inner cylindrical surface) must be at or above 1100 °F.

2.2.1.4

Two configurations of blockage or clutter:

(a) High: a 30–50 % reduction in the local cross sectional area and a 20–25 % reduction in the compartment volume.

(b) Low: a 10–20 % reduction in the local cross sectional area and a 5–10 % reduction in the compartment volume.

*These numbers are estimates based on visual inspection of clutter in actual engine installations.*

2.2.1.5

A minimum fuel (combustible fluid) flow rate of 1 gpm should be provided.

*Proper operation of the fuel delivery system, including nozzles, should be checked to assure that the fire size and intensity are roughly reproducible in tests with similar conditions. A measurement of heat flux density to characterize the fire is not necessary. Undue importance could be attached to this parameter as a means to determine reproducibility of fires while the measurement itself could depend on a variety of different factors.*

2.2.1.6

The axial location of the fire must be over the surface which is at 1100 °F (or higher) temperature and downstream of the simulated clutter (some clutter could be in the fire).

At least two circumferentially different locations for the fire, determined by the location of the fuel inlet–igniter–flame holder arrangement, should be investigated:

(a) Top dead center

(b) Bottom dead center

If it is evident that the fires at one location are consistently more difficult to extinguish, then further tests may use that location only, eliminating the need to investigate fires at other locations.

2.2.1.7

A preburn time is the time elapsed between the initiation of fire (ignition) and the initiation of agent discharge. A minimum preburn time of 20 seconds is required.

*In an aircraft installation, when the fire alarm is received fuel is shut off. Hot air and electrical sources may also be shut off before activation of the fire extinguishing system. If the alarm occurs during the climb phase of the flight, more than a minute may elapse between the alarm and the discharge of the agent. In other cases, this elapsed time may be shorter than a minute. For the purpose of these tests, a shorter preburn is selected to protect test equipment from exposure to repeated intense fires.*

2.2.1.8

Three agent storage temperatures:

(a) Ambient temperature.

(b) With test parameters representing the two most severe fire conditions observed in the above tests (a), repeat the two tests with a storage temperature of –65 °F.

*This condition is based on the fact that halon 1301 bottles in some current aircraft models could experience temperatures this low. Halon 1301 does not solidify at this temperature. However, it is likely that some replacement agents may solidify and not perform at this storage temperature. This condition may be relaxed to the lowest temperature an agent could withstand while still providing satisfactory fire extinguishing performance. This minimum temperature would then determine the lowest storage temperature at which the agent/system would be qualified to operate.*

(c) With test parameters representing the two most severe fire conditions observed in the above tests (a), repeat the two tests with a storage temperature of 200 °F.





2.2.2 APU Compartment Test Parameters

2.2.2.1

Two internal (ventilation) airflow rates:

(a) High 1.0 – 2.0 lbm/sec

(b) Low 0.2 – 0.5 lbm/sec.

*If the test compartment is small, in the range of 8 – 20 $ft^3$ volume, select (b). For larger compartments, select (a).*

2.2.2.2

At least two ventilation air temperatures of 100 and 200 °F.

2.2.2.3

Surface temperature: At least a portion, about 1 ft long and encompassing a 90° arc, of the surface of the test article must be at or above 800 °F

2.2.2.4

Clutter simulation should be based on visual inspection of clutter in actual APU installations.

2.2.2.5

A minimum fuel (combustible fluid) flow rate of 0.5 gpm should be provided.

2.2.2.6

Same parameters as in 2.2.1.6

2.2.2.7

Same parameters as in 2.2.1.7

2.2.2.8

Same parameters as in 2.2.1.8

2.3 Fuels

2.3.1

Perform tests with all the appropriate test conditions specified in 2.2 using a typical aviation turbine fuel (Jet A–1 or JP 8) as the fuel for the fire.

2.3.2

Using the results from the tests completed with the aviation turbine fuel (2.3.1), determine the two tests in which the fire was most severe. Repeat these two tests, using an engine lubricating oil (Mobil Jet 2) as the fuel for the fire instead of the aviation turbine fuel.

2.3.3

Repeat the two tests identified in 2.3.2 with a hydraulic fluid (Skydrol) as the fuel.





2.4 Test Procedure

2.4.1 Fire Tests

The tests should be performed using the following general procedure.

1. Select the test conditions and prepare the test equipment.
2. After attaining the desired level of steadiness with the test conditions, initiate the fuel (combustible fluid) flow and ignite the fire.
3. While observing the fire, let the preburn time elapse.
4. Initiate the agent discharge, observing its effect on the fire. Record the time for discharge of the system and extinguishment of the fire.
5. If the fire is extinguished and remains so for five seconds continuously, the agent is successful in extinguishing the fire.
   In this case, additional tests with the same test conditions but less agent should be performed to determine the minimum quantity of agent required for success.
6. If the fire is not extinguished, the agent has failed. In this case, additional tests with the same conditions and more agent will be necessary to establish the performance of the agent.

Perform tests to cover the required matrix of test conditions.

The test results should be evaluated to determine the amount of agent required to extinguish any probable fire in the engine or the APU compartment as stated in 1.2.

2.4.2 Agent Concentration Tests

Tests to determine the agent concentration will be necessary to provide a basis for specific system design and validation tests. Agent concentration tests may be run in absence of a fire if the instrumentation must be protected. A suggested approach is described in the following.

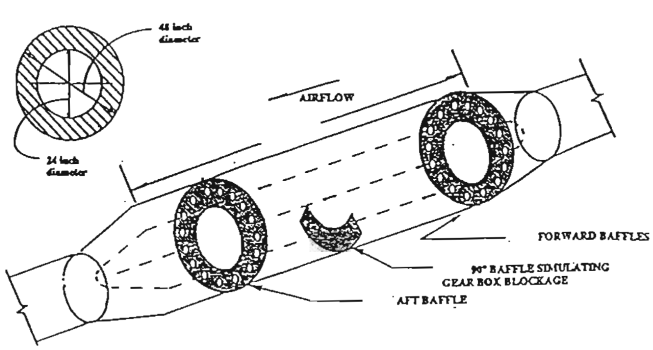
1. Select test runs from the test matrix (2.4.1 tests) which produced successful fire extinguishment and were among the most difficult fires.
2. Activate the concentration measurement instrumentation. It should be capable of determining the agent concentration at several strategic locations throughout the fire zone (the test section) simultaneously and continuously for a period of time extending through the agent discharge initiation and completion plus at least one minute.
3. Simulate test conditions corresponding to the selected test run except for the fuel flow and fire.
4. Discharge the same quantity of agent as was used to extinguish the fire and record the agent concentration history.

Enough tests should be conducted and results evaluated to develop a consistent correlation between the agent quantity and the agent concentration distribution.





(A) Engine Nacelle Simulator




(B) Suggested Additional Clutter Simulation

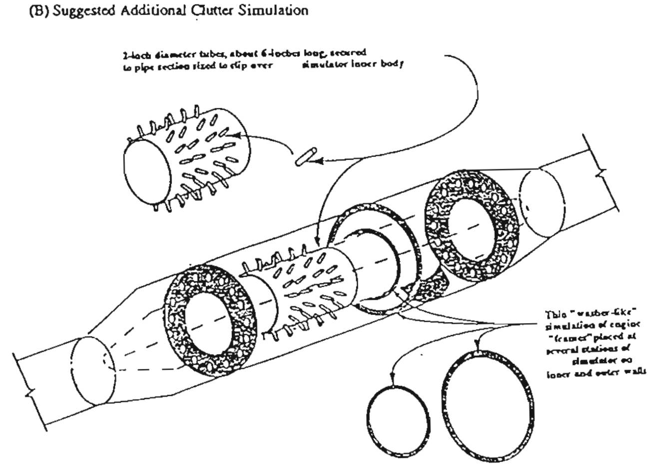



Figure 1. Schematic of the Proposed Aircraft Engine Nacelle Simulator for Fire Tests

## USER PREFERRED FIRE SUPPRESSION AGENT FOR LAVATORY TRASH CONTAINER FIRE PROTECTION

ORGANIZATION: International Halon Replacement Working Group
Task Group: User Preferred Agents for Trash Containers

SUMMARY: This notice requests information from the user community on agent(s) that would or would not be considered for use in lavatory trash containers fire suppression systems. This information is requested to help guide the FAA in development of airworthiness criteria for the evaluation of non-halon fire suppression agents/systems. A questionnaire is provided, page 6, to facilitate a timely response.

DATES: Comments are requested by 14 July 1995.

ADDRESSES: Comments on this notice should be sent to:
Greg Grimstad
Task Group User Preferred Agents
Boeing Commercial Airplane Group,
P.O. Box 3707, M/S 6H-PW
Seattle, WA 98124-2207 (USA)

Phone 206-234-1366
FAX 206-237-4831

FOR FURTHER INFORMATION CONTACT TASK GROUP MEMBERS:

| Name | Company | Country | Phone | Fax |
|---|---|---|---|---|
| Jelle Benedictus | KLM | The Netherlands | 31-20-6494913 | 31-20-6488162 |
| John Blackburn | AVRO | England | 0161 439 5050 ext. 3696 | 0161 955 4112 |
| Bernd Dunker | DASA | Germany | 040 7437 5309 | 040 7437 4742 |
| Thomas Grabow | DASA | Germany | 49 421 538 4033 | 49 421 538 4639 |
| Greg Grimstad | Boeing | USA | 206-234-1366 | 206-237-4831 |
| Sham Hariram | Douglas | USA | 310-593-4305 | 310-593-7104 |
| Hans Humfeldt | Lufthansa | Germany | 49 (40) 5070 2406 | 49 (40) 5070 2385 |
| John O'Sullivan | BA | England | 44 81 562 5460 | 44 81 562 2928 |
| Jean Paillet | Aerospatiale | France | 33 619 371 65 | 33 619 38 874 |
| Krijn Pellen | Fokker | Holland | 020-6052069 | 020-6052895 |
| Bud Roduta | UAL | USA | 415-634-4857 | 415-634-4986 |
| Felix Stossel | Swissair | Switzerland | 41-1-812 6930 | 41-1-812 90 98 |



SUPPLEMENTARY INFORMATION: At the fifth meeting of the International Halon Replacement Working Group (IHRWG), held 19-20 April 1995 in Rome, Italy, a Task Group was formed to determine the aviation industry's preferred fire suppression agent for use in lavatory trash containers. This information will serve to reduce the list of potential candidate agents and thus assist the regulatory authorities in planning their research activities to serve the aviation industry in an effective and timely manner.

Membership to this Task Group was limited to representatives from airframe manufacturers and airline operators. Persons identified above (Paragraph "For Further Information Contact") volunteered to serve in the Group. The Group was tasked to:

(i) Contact users (airframe manufacturers and airline operators) and determine agents they would or would not use for fire suppression in lavatory trash containers.
(ii) Prepare a report for presentation at the next IHRWG meeting, scheduled for 18 July 1995.

You are encouraged to submit the questionnaire provided and any additional data, views, or arguments on agent(s) that you would (or would not) use for fire suppression in lavatory trash containers. If you have no preference, this information is also of value and we request that you communicate this position. The Task Group will be obligated to assume that if no comments are received by the due date of 14 July 1995, then no agent is preferred over another.

### Availability of Notice

Any person may obtain a copy of this notice by requesting it from any member of the Task Group. Refer to paragraph "For Further Information Contact". By agreement of the IHRWG only written comments from airframe manufacturers and airline operators will be considered.

### Background

Given the phase out of halon production, (Montreal Protocol and US Clean Air Act) the Aerospace Industries Association (AIA) held an International Symposium - Halon Replacement in Aviation 9-10 February 1993. The symposium was attended by representatives from the Federal Aviation Authority (FAA). At this meeting it was concluded that:

(i) current regulations do not require the use of halon,
(ii) no regulatory action is necessary, and
(iii) fire hazards, test protocols, and performance criteria all need to be developed.

On 17 June 1993 the FAA published Notice 93-1 in the Federal Register inviting industry to join in a cooperative effort to develop test articles, conduct evaluation tests, develop minimum performance standards, and provide guidance in drafting certification/compliance documents. This invitation resulted in the formation of the International Halon Replacement Working Group (IHRWG). Membership in the Group is open to all interested parties. The first meeting of the IHRWG was held on 13 October 1993, and the most recent, the fifth, was 19-20 April, 1995.

Halon production in the U.S. ceased as of 1 January 1994, due to its identification as an ozone destroying compound.

### Discussion of trash container fire suppression

Fire protection requirements and characteristics of potential replacement agents are discussed in the next several sections.



### Regulations

Federal Aviation Regulation FAR DOT 14CFR 121.308(b) requires that, "After April 29, 1987, no person may operate a passenger carrying transport category airplane unless each lavatory in the airplane is equipped with a built-in fire extinguisher for each disposal receptacle for towels, paper, or waste located within the lavatory. The fire extinguisher must be designed to discharge automatically into each disposal receptacle upon occurrence of a fire in the receptacle."

### Present practice

Currently all aircraft lavatory disposal receptacle fire extinguishers use Halon 1301 as the fire suppression agent. The agent is contained in a pressurized bottle to which is connected a delivery tube and a nozzle. The bottle automatically discharges at a sense temperature in the range of 170°F-175°F. This system is commonly referred to as a potty bottle.

### International Halon Replacement Working Group (IHRWG)

The goal of the International Halon Replacement Working Group, is to introduce non-halon fire suppression systems into service in a timely, cost effective manner, with no compromise in safety. The Group is working all areas of fire protection onboard aircraft: engines and auxiliary power unit, cargo compartments, hand-held fire extinguishers for the occupied area, lavatory trash container, and dry bay (military). The IHRWG has formed several Task Groups to conduct specialized studies. Studies applicable to trash container fire suppression are:

(i) Chemical Options to Halons for Aircraft Use, Published by FAA as DOT/FAA/CT-95/9. (Task Group 6)
(ii) Proposed Methodology for Lavatory Disposal Receptacle Built-in Fire Extinguisher Agent Evaluation. (Task Group 7).

The above two reports are in the public domain and are available from the FAA Technical Center, NJ. [Contact Ms. April Horner, Ph 609-485-4471, Fax 609-485-5796].

At the April meeting it was suggested that the end users be queried as to any preference for the agents recommended by the Task Group 6. These agents are:

(i) water and water based agents, and
(ii) halocarbon and halocarbon blends.

There are several agents in each of these two classes and each agent/class has its pros and cons. Several members of IHRWG commented at the Rome meeting that they would or would not use certain agents. These remarks caused the IHRWG to form this Task Group. The Group has been tasked to determine why some fire extinguishing agent/system would or would not be considered for used by the aviation industry. The FAA believes this activity will reduce the number of potential candidates to be evaluated. Any reduction in the number of candidates at this early stage will assist the industry in arriving at an acceptable replacement agent or agents in a timely manner.

### Trash container fire suppression system minimum performance standard

/JAA have established that non-halon fire suppression system should provide the same level protection (safety) as the present halon systems. In particular, the any system must be capable of suppressing the test fire developed by Task Group 7, and defined in the report "Proposed Methodology for Lavatory Disposal Receptacle Built-in Fire Extinguisher Agent Evaluation."

Lavatories are located in the pressurized shell and the environmental conditions are similar to the conditions in the occupied areas. The likely ignition source is burning material discarded into the trash container; the probability of this occurring is greatest when passengers are on board. The minimum operational temperature has been identified as 33°F by Task Group 7.



### Water and water based agent bottle

Water and water based agents are recognized as effective fire suppression agents for Class A (paper) fires. Water is universally available at very reasonable cost and has no environmental restrictions or toxicity implications. The fire suppression agent could be ordinary water, distilled water, ionized water and may (or may not) contain additives. Additives, if used, could be for depressing the agent freezing point and/or modifying surface tension to enhance the fire suppression effectiveness. Several manufacturers claim biodegradable, environmentally safe additives which enhance fire suppression effectiveness.

A pressurized bottle using water as an agent was tested in some early agent evaluation trials. The water was able to knock-down the flames but re-ignition was found to be a problem. These tests while informative were by no means exhaustive in determining the optimum parameters of water volume, pressure, or nozzle design. An estimate of 1 liter of water does not seem unreasonable, which, if the system was to use a dedicated water supply, would adversely impact system weight. The weight impact could be avoided if wash basin water were to be used.

### Halocarbon and halocarbon blend bottle

A halocarbon or halocarbon blend bottle would be similar to the present Halon 1301 bottle. Depending on agent boiling point, pressurization by an inert gas may be required. Commercialized zero Ozone Depletion Potential (ODP) fire suppressing agents and their characteristics are listed in Table 1. Presently, there are no generally accepted standards, or restrictions, based on Global Warming Potential (GWP) and/or Atmospheric Life Time, however the lower these values the better. All agents listed are acceptable to the U.S. Environmental Protection Agency.

The design concentrations shown in Table 1 are for extinguishment of Class B fires using n-heptane as fuel, rather than the Class A (paper) fire that would be expected in a trash container. Therefore the design concentrations listed are not directly applicable to the expected threat and are provided for information purposes only. Tests have not been performed, for the potential threat, using all the listed halocarbons and relevant data is not available.

[Walter Kidde Aerospace has performed some preliminary tests using FM-200 and have reported fire suppression performance equivalent to that of Halon 1301 with approximately 0.291 pounds (132 grams) of the agent. These test were done using the same size bottle as the current Halon 1301 configuration.]

Halocarbons are non-toxic, see LOAEL and NOAEL values in Table 1. The halocarbon bottle maintenance requirements can be reasonably assumed to be the same as the present Halon 1301 system.

## Us Preferred Agent for Trash Container Fire Suppression

| Company | Name | Preference 1 | 2 | 3 | 4 | Comments |
|---|---|---|---|---|---|---|
| Aer Lingus | Laurence Brayden | Halocarbon | Halocarbon Blends | Water Based | Water | Halocarbon has the optimum combination of efficiency, system compatibility and cost |
| Aerospatiale | Jean Paillet | Halocarbon | Halocarbon Blends | Water Based | Water | Min Op. Temp of 33°F is too high suggest 0°F |
| Airbus Industrie | M. Potschkat<br>G. Theron | Halocarbon | Halocarbon Blends | Water Based | Water | Min Op. Temp of 33°F is too high |
| Alitalia | Francesco Gaspari | Halocarbon | Halocarbon Blends | Water | Water Based | Avoid major modifications to existing a/c |
| Aloha Airlines | Colette Miller<br>Jonathan Goo | Halocarbon & Blends | Water/Water Based | | | |
| American Airlines | Greg Hall | Halocarbon & Blends | Water & Water Based | | | |
| American Trans Air | Louis Camacho | Water & Water Based | Halocarbon & Blends | | | In addition to weight, system retrofit and cost must be considered |
| British Airways | Jack Winell | HFC-227 | HFC-125 | FC-3-1-10 | FC-218 | None are "Desired" these are the least undesirable |
| British Airways | John O'Sullivan | Halocarbon & Blends | Water | Powder Aerosols | Water/Foam | |
| Canadian Airlines International | Steve Mulford | Halocarbons | Water & Water Based | | | FM-200 looks promising Concerns with water and non-paper (plastic) refuse |

## User Preferred Agent for Trash Container Fire Suppression

| Company | Name | Preference 1 | 2 | 3 | 4 | Comments |
|---|---|---|---|---|---|---|
| Fokker (1) | Krijn Pellen | Halocarbon & Blends | Water | | | If FM-200 is able certifiable no additional evaluation is necessary |
| Hawaiian Airlines | Richard Bonnardel | Halocarbon & Blends | Water & Water Based | | | |
| Japan Airlines | Toru Kawano | safe to humans and nature | easy clean up | availability | Consistent w/ other a/c agents | |
| Lufthansa | Hans Humfeldt | Halocarbon (HFC-227ea) | Water | | | Water would be favorite if a simple reliable system were developed |
| Qantas Airways | Mr. R. W. Alcorn | | | | | Any replacement should be drop-in, gaseous preferred |
| SAS | Max Mejer | Water & Water Based | | | | Fluorocarbons have high GWP - not accepted by environmentalists in Scandinavia |
| Southwest Airlines | Ben Harpe | Halocarbon & Blends | Water & Water Based | | | Due to problems inherent to both keep looking |
| Swissair (1) | Felix Stössel | Halocarbon & Blends | Self Extinguishing Container | | | Halocarbons seems to be perfect solution<br>Investigate container technology |
| United Airlines | Bud Roduta | | | | | Are powder/foam agents being tested? |

(1) Receiced when Notice was in the Draft format

Sent out by FAA TC to over 50 interested parties



Table 1: Significant Characteristics of Commercialized Total Flood Halocarbon ts.

(data extracted from DOT/FAA/CT-95/9 and NFPA Standard 2001)

| Agent | Chemical Name | Trade Name | GWP[a] | Atmospheric Life time, yrs | SNAP[b] approval | NFPA[c] recognized |
|---|---|---|---|---|---|---|
| HFC-23 | Trifluoromethane | DuPont "FE-13" | 9000 | 280 | acceptable | yes |
| HFC-125 | Pentafluoroethane | DuPont "FE-25" | 3400 | 41 | acceptable | yes |
| HFC-227ea | Heptafluoropropane | Great Lakes "FM-200" | 2050 | 31 | acceptable | yes |
| HFC-236fa | Hexafluoropropane | DuPont "FE-36" | | | | |
| FC-218 | Perfluoropropane | 3M "CEA-308" | 6100 | 3200 | acceptable | |
| FC-3-1-10 | Perfluorobutane | 3M "CEA 410" | 5500 | 2600 | acceptable | yes |

[a] Based on 100-year horizon, relative to $CO_2$
[b] Significant New Alternatives Policy
[c] National Fire Protection Association Standard 2001, "Alternative Protection Options to Halon"

| Agent | NOAEL[d] % | LOAEL[e] % | % Design[f] Concentr.(%) | Weight[g] Equiv. | Volume[g] Equiv. | Fill Density (lb/ft³) | Storage Press (psig) | Boiling[h] Temp (°F) |
|---|---|---|---|---|---|---|---|---|
| HFC-23 | 30 | >50 | 16.0 | 1.68 (1.7) | 2.10 (2.2) | 54.0 | 608.9 | -247.4 |
| HFC-125 | 7.5 | 10.0 | 10.9 | 1.88 (1.9) | 2.44 (2.3) | 58.0 | 166.4 | -153.0 |
| HFC-227ea | 9.0 | 10.5 | 7.0 | 1.66 (1.7) | 1.61 (1.6) | 72.0 | 166.4 | -204.0 |
| HFC-236fa | 10.0 | 15.0 | 6.4 | | | | | |
| FC-218 | 30 | 40 | 8.8 | | | 80.0 | 360.0 | |
| FC-3-1-10 | 40 | >40 | 6.0 | 1.91 (1.9) | 1.67 (1.7) | 80 | 360 | -198.8 |

[d] No Observed Adverse Effect Level
[e] Lowest Observed Adverse Effect Level
[f] Manufacturer (HFC-236fa, FC-218) and Federal Register (HFC-23, HFC-125, HFC-227ea, FC-3-1-10) data
[g] Calculated from data in NFPA Standard 2001. Values in parentheses taken from SNAP listing.
[h] At 14.7 psia 760 mm Hg) pressure.



## International Halon Replacement Working Group
## User Preferred Agent for Lavatory Trash Container - Questionnaire

Name: ____________ Fax: ____________

Company: ____________ Tel: ____________

A) Two agent categories (water/water based and halocarbon/halocarbon blends) have been identified for lavatory trash container fire suppression.
Please list in order of preference and/or identify an alternative.
1. most desired, 4. least desired
Additional comments are encouraged, attach pages as required.
If you have no preference, skip to B).

1. ____________
2. ____________
3. ____________
4. ____________

B) Comments or suggestions, (attach additional pages as required).

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C) Please return, by mail or fax, on or before 12 July 1995
Mail: Boeing Commercial Airplane Group
P.O. Box 3707 M/S 6H-PW
Seattle, WA USA 98124-2207
Attention: Greg Grimstad

Fax: 206 237 4831

## USER PREFERRED FIRE SUPRESSION AGENT FOR LAVATORY TRASH CONTAINER FIRE PROTECTION

### TASK GROUP MEMBERS

| NAME | COMPANY | COUNTRY |
|---|---|---|
| Jelle Benedictus | KLM | The Netherlands |
| John Blackburn | AVRO | England |
| Bernd Dunker | DASA | Germany |
| Thomas Grabow | DASA | Germany |
| Greg Grimstad | Boeing | USA |
| Sham Hariram | Douglas | USA |
| Hans Humfeldt | Lufthansa | Germany |
| John O'Sullivan | BA | England |
| Jean Paillet | Aerospatiale | France |
| Krijn Pellen | Fokker | Holland |
| Bud Roduta | UAL | USA |
| Felix Stossel | Swissair | Switzerland |

REVISED 07/13/95
R. E. Glaser

# DRAFT MINIMUM PERFORMANCE CRITERIA FOR REPLACEMENT HAND HELD PORTABLE FOR AIRCRAFT CABIN FIRE PROTECTION

## Purpose

To establish minimum performance requirements for an environmentally acceptable replacement for the current halon 1211 hand held fire extinguishers.

## Background

FAR/JAR 25.851 requires that Halon 1211 or equivalent hand held extinguishers to be installed on transport category aircraft. The regulation states that the type and quantity of extinguishing agent (if other than Halon 1211) must be appropriate for the kind of fires likely to occur where used.

These regulations had their origins with the requirement to mitigate the arsonist/hijacking threat which was prevalent in the 1970s. The FAA T.C. (DOT/FAA/CT-82/111) identified that Halon 1211 was vastly superior to the previously used $CO_2$ and dry chemical extinguishers for protecting against flammable fluid fires on typical seat materials.

Later it was determined that Halon 1211 portables provided an additional benefit by having capacity to fight remote fires through total flood effect. This was demonstrated on an in flight check space fire which might otherwise have resulted in a major catastrophe.

It is generally agreed that any replacement extinguisher must offer at least an equivalent level of fire fighting capability to those currently in service.

## Agent Selection Guidelines

A. The agent must be suitable for fire suppression needs typically encountered in transport type aircraft cabins, lavatories and flight decks.

B. Environmental

Existing fire protection measures, required by Airworthiness Regulations, are largely based on the use of halons. For all practical purposes, production of halons has ceased under the provisions of the Montreal Protocol. The primary environmental characteristics to be considered in assessing a new agent are Ozone Depletion Potential (ODP), Global Warming Potential (GWP), and Atmospheric Lifetime. The agent selected should have environmental characteristics in harmony with international laws and agreements, as well as applicable local laws. This Minimum Performance



Specification sets out means of assessing the technical performance of potential alternatives, but in selecting a new agent it should be borne in mind that an agent which does not have a zero or near-zero ODP, and the lowest practical GWP and Atmospheric Lifetime, may have problems of international availability and commercial longevity.

C. Toxicology

The toxicological acceptability of an agent is dependent on its use pattern. As a general rule, the agent must not pose an unacceptable health hazard for workers during installation and maintenance of the extinguishing system. In areas where passengers or workers are present, or where leakage could cause the agent to enter the passenger compartment, at no time should the agent concentration present an unacceptable health hazard. Following release in fire extinguishment, the cumulative toxicological effect of the agent, its pyrolytic breakdown products, and the by-products of combustion must not pose an unacceptable health hazard.

## Performance Criteria

General: The extinguisher must be approved by a recognized fire testing laboratory which is acceptable to the Regulatory Authorities.

Minimum Rating: Each extinguisher employed must meet the minimum ratings
UL - 5BC (AC-20-42C specifies this minimum)
BSI - 34B (Approximate Equivalent of UL-5BC)
USCG - Under Title 46 of the CFR for use in aircraft
Other - (TBD - Need other listing agencies if currently used)

(This criteria is suggested to insure at least an equivalent level of safety with currently deployed extinguishers. We need help from various operators to identify both the agency and applicable minimum ratings. Yet another point to consider is allowing a larger number of units at lower ratings. This could be driven by space considerations with the less efficient agents. However I am concerned that a greater number of lower rated units does not really represent the same level of safety unless they are applied to the fire simultaneously or at least in rapid serial succession which is very unlikely. Comments and help here please!)



Hidden Fire Demonstration:

The extinguisher must successfully pass the aircraft hidden/remote fire challenge test, to the satisfaction of the Regulatory Authorities.

(Nick Povey's CAA organization are developing this criteria which needs to become a part of this standard.)

Arson/Hijacking Threat Protection Demonstration:

The extinguisher must successfully pass an aircraft Arson/Hijacking Threat fire challenge test, to the satisfaction of the FAA or JAR.

(Dick Hill conducted the original work (DOT/FAA/CT-82/111) which documented Halon 1211's superior performance on these gasoline/seat fire scenarios. DLR & CEAT are doing test work. How shall we proceed?)

## Compatibility with Aircraft Operating Environment

In addition to approvals by fire testing laboratories, each extinguisher utilized on the aircraft must satisfactorily demonstrate compatibility with anticipated aircraft operational environments.

(If we decide to include this I suggest we use an existing standard such as RTCA/DO-160C. Appropriate portions of Sections 4.0, 5.0, 7.0 & 8.0 seem most appropriate. However, perhaps AC 20-42C para 7(g)(3)(a) is adequate.

"(a) Due to the weight of hand fire extinguishers, the aircraft structure and extinguisher mounting brackets should be capable of withstanding he inertia forces required in Sections 23.561, 25.561, 27.561, and 29.561 of the Federal Aviation Regulations, with the hand fire extinguisher installed.")

Note: Enclosed parenthesis ( ) are my comments and are not part of the proposed Standard. Any help, comments or suggestions will be gratefully received.

# PROPOSED DRAFT MINIMUM PERFORMANCE CRITERIA FOR REPLACEMENT HAND HELD PORTABLE FOR AIRCRAFT CABIN FIRE PROTECTION

## PURPOSE

TO ESTABLISH MINIMUM PERFORMANCE REQUIREMENTS FOR AN ENVIRONMENTALLY ACCEPTABLE REPLACEMENT FOR THE CURRENT HALON 1211 HAND HELD FIRE EXTINGUISHERS



## AGENT SELECTION GUIDELINES

A. THE AGENT MUST BE SUITABLE FOR FIRE SUPPRESSION NEEDS TYPICALLY ENCOUNTERED IN TRANSPORT TYPE AIRCRAFT CABINS, LAVATORIES AND FLIGHT DECKS.

B. ENVIRONMENTAL

AGENTS SELECTED SHOULD HAVE ENVIRONMENTAL CHARACTERISTICS IN HARMONY WITH INTERNATIONAL AND LOCAL LAWS AND AGREEMENTS.

- ODP
- GWP
- ATMOSPHERIC LIFE



C. TOXICOLOGICAL

AGENTS MUST NOT POSE UNACCEPTABLE HEALTH HAZARD.

- INSTALLATION PERSONNEL
- MAINTENANCE PERSONNEL
- PASSENGERS OR WORKERS IF EXPOSURE IS POSSIBLE
- PYROLYTIC BREAKDOWN PRODUCTS



## PERFORMANCE CRITERIA

GENERAL:

THE EXTINGUISHER MUST BE APPROVED BY A RECOGNIZED FIRE TESTING LABORATORY WHICH IS ACCEPTABLE TO THE REGULATORY AUTHORITIES.

- UL
- FM
- BSI
- OTHERS - TBD NEED OTHER LISTINGS IF APPROPRIATE

## MINIMUM RATING:

EACH EXTINGUISHER EMPLOYED MUST MEET THE MINIMUM RATINGS.

- UL - 5 BC (PER AC 20-42C)
- BSI - 34B (APPROXIMATE EQUIVALENT TO UL-5BC)
- OTHERS - TBD (NEED RATING FOR ANY OTHER LISTING AGENCY)



## HIDDEN FIRE DEMONSTRATION:

THE EXTINGUISHER MUST SUCCESSFULLY PASS THE AIRCRAFT HIDDEN/REMOTE FIRE CHALLENGE TEST, TO THE SATISFACTION OF THE REGULATORY AUTHORITIES.

- CAA ESTABLISHING TEST METHODOLOGY



## ARSON/HIJACKING THREAT PROTECTION DEMONSTRATION:

THE EXTINGUISHER MUST SUCCESSFULLY PASS AN AIRCRAFT ARSON/HIJACKING THREAT FIRE CHALLENGE TEST, TO THE SATISFACTION OF THE REGULATORY AUTHORITIES.

- DOT/FAA/CT-82/111 (DICK HILL)



## COMPATIBILITY WITH AIRCRAFT OPERATING ENVIRONMENT

IN ADDITION TO APPROVALS BY FIRE TESTING LABORATORIES, EACH EXTINGUISHER UTILIZED ON THE AIRCRAFT MUST SATISFACTORILY DEMONSTRATE COMPATIBILITY WITH ANTICIPATED AIRCRAFT OPERATIONAL ENVIRONMENTS.

- RTCA/DO - 160C (APPROPRIATE SECTIONS)
  - SECTIONS 4.0 - TEMPERATURE & ALTITUDE
  - SECTIONS 5.0 - TEMPERATURE VARIATION
  - SECTIONS 7.0 - OPERATIONAL SHOCKS & CRASH SAFETY
  - SECTIONS 8.0 - VIBRATION
- AC 20-42C PARA 7(g)(3)(a)

  SPECIFIES BRACKETS SHOULD WITHSTAND SPECIFIED INERTIA FORCES PER FAR

# HALON RESTRICTIONS UPDATE

Presented by: John O'Sullivan
British Airways

Gary Taylor has just received a fax from Mr Sarma (Co-ordinator, Ozone Secretariat), the text of which is as follows:

"1. Based on the proposal of HTOC and the Ozone Secretariat, the Technical Working Group of the Basel Convention has, at its recent meeting in Geneva, approved the following:

"The controlled substances of the Montreal Protocol which are recovered and purified to usable purity specifications prescribed by appropriate international and/or national organizations including the International Standards Organization (ISO) do not fall under the scope of the Basel Convention."

Dr. Kuijpers and myself assisted this meeting of the Technical Working Group.

2. This proposal will be placed before the Meeting of the Parties to the Basel Convention at their next meeting in September 1995.

3. As proposed by HTOC and Australia at the last Working Group Meeting, the next meeting of the Working Group Meeting of the Montreal Protocol will consider the following decision:

"International transfers of CFCs/halons that cannot meet usable purity specifications should only occur if the recipient country has recycling facilities that can process the received CFCs/halons to these standards."

4. Mr L.E. Baker of United Kingdom has suggested an addition at the end of the sentence above "or destruction facilities in appropriate technologies approved by the Parties". Mr Baker has also suggested a possible additional sentence "international transfers of ODS for destruction should be carried out under the provisions of the Basel Convention for the Control of Transboundary Movements of Hazardous Wastes and Their Disposal".

I shall be grateful for your response to the suggestion of Mr Baker."

## Certification of Engine Fire Extinguishing Systems

- FAR and JAR 25.1195, 1197, 1199, 1201 and similar for Part 23 aircraft
- AC 20-100 details methodology
- Requires the discharge of the extinguishing agent at a range of operating conditions



## Environmental Legislation

- European Community Regulation 3093/94
- "all practical means shall be taken to capture the gas"
- no cost is too great
- similar regulations are being enforced around the world

International Halon Replacement Working Group Albuquerque July 1995
CAA

## Simulants

- Halon will continue to be used for engine fire suppression for some years yet
- Simulants offer the ability to demonstrate compliance without the need to release halon
- The Aviation Authorities need test data to be convinced that the use of simulants is valid

International Halon Replacement Working Group Albuquerque July 1995
CAA

## Propose

- There has been much useful work at Boeing, WKA, NAWC and now Shorts
- Data from this work and future tests should be collated to prove the case for compliance demonstration by simulants
- AC 20-100 could be revised to include the use of simulants
- Industry and Authorities Task Group needed

International Halon Replacement Working Group Albuquerque July 1995
CAA

# ENVIROGEL™ AS A HALON ALTERNATIVE

International FAA Meeting
Albuquerque, NM

18-19 July 1995

Ted A. Moore
Center for Global Environmental Technologies (CGET)
New Mexico Engineering Research Institute (NMERI)
The University of New Mexico

CENTER FOR GLOBAL ENVIRONMENTAL TECHNOLOGIES

## OBJECTIVE

- Evaluation of Envirogel™
- Develop Test Data For Total Flood and Streaming Applications
- Review and Summarize Available Test Data
- Preliminary Corrosion Study
- Analyze Powder Concentrations
- Determine Decomposition Products

CENTER FOR GLOBAL ENVIRONMENTAL TECHNOLOGIES

## METHODOLOGY

- Literature and Toxicity Review
- Laboratory Evaluation
  - Cup Burner, Corrosion Study
- Large-Scale Fire Suppression Tests
  - Total Flooding
  - Streaming
  - Engine Compartment
  - Engine Nacelle
- Decomposition Product Analysis Using FTIR

CENTER FOR GLOBAL ENVIRONMENTAL TECHNOLOGIES

## WHAT IS ENVIROGEL™

- Being Developed by POWSUS, Inc
- Also known as PGA
- Mixture of Fine Grind Powder, Gelling Agent, and Halocarbon
- Halocarbons
  - HFC-125 and HFC-134a
- Powders
  - Ammonium Polyphosphate (APP)
  - Monoammonium Phosphate (MAP)
  - Nomally 7 µm and 35 µm Partical Sizes Have Been Tested

CENTER FOR GLOBAL ENVIRONMENTAL TECHNOLOGIES

## TEST DATA AVAILABLE

- Engine Compartment Testing at NMERI, Aberdeen Proving Ground, and Santa Barbara Research Corp.
- Total Flooding in NMERI 18.3 $m^3$ Chamber
- Streaming Tests at NMERI, Ansul, and Tyndall Air Force Base
- Nacelle Testing At Kiddie Aerospace
- Corrosion Testing (Al, Brass, Carbon Steel, Cu, Mg) 1000 °F Surface Temp
- Preliminary Decomposition Analysis
- Additional Testing in Progress

CENTER FOR GLOBAL ENVIRONMENTAL TECHNOLOGIES

## LITERATURE AND TOXICITY RESULTS

- The Selected Halocarbons Have Least Environmental Impact of Those Currently Available
- Powders are Non-Toxic — Possible Inhalation Effects Still Need To Be Determined
- Halocarbon Concentrations Less Than NOAEL Levels
- Cost per Pound Predicted to be Less Than Other Halon Alternatives — May Be Possible To Use Existing Hardware
- SNAP Listed as Acceptable for Unoccupied Total Flood and Streaming

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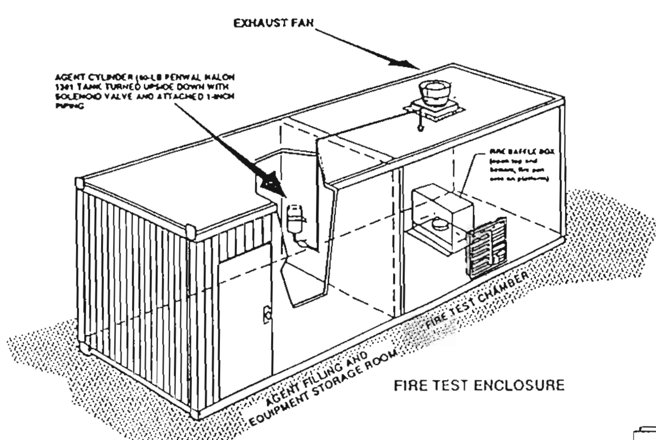
# NMERI TEST CHAMBER

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## RESULTS TO DATE
### (Total Flood)

- Fire Suppression Effectiveness (by Wt.) Similar to Halon 1301 in Total Flood Application
- Flows Through Piping System and Nozzle
- Little to No Decomposition Products
- Able to Prevent Re-ignition of fuel
- Able to Extinguish Semi-Hidden and Tell Tale Fires
- Remains Suspended > 2 min.
- Even Distribution Throughout Chamber
- Cleanup with Vaccum Cleaner and Air Hose
- Suppresses Class A Fires

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## RESULTS TO DATE
### (STREAMING APPLICATION)

- Testing Ongoing At Ansul, Inc
- Similar in Effectiveness to Halon 1211
- Additonal Test Data Will Become Available
- Minimal Decomposition Products
- Cleanup Required When Discharged in An Enclosed Space

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## RESULTS TO DATE
### (ENGINE COMPARTMENT APPLICATION)

- 1.2 to 1.4 Times More Agent by Weight Required Than For Halon 1301
- Effective with Minimal Cleanup Required
- Additional Testing and Optimization Ongoing at APG
- Flows in Existing Distribution System

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## RESULTS TO DATE
### (Corrosion Tests)

| Sample | [illegible] (APT) | [illegible] |
|---|---|---|
| Scenario No. 1<br>- 15 min in 1000 °F oven; sprayed with agent<br>- 15 min in 1000 °F oven; [illegible] 130 °F oven | X | X |
| Scenario No. 2<br>- 15 min in 1000 °F oven, sprayed with agent<br>- [illegible] 130 °F oven | X | X |
| Scenario No. 3<br>- 15 min in 1000 °F oven; sprayed with agent<br>- [illegible] 130 °F oven | X | X |
| Scenario No. 4 - [illegible]<br>- Exposed to agent discharge in [illegible] PSTC<br>- Powder removed; placed in 130 °F oven | X | |
| Scenario No. 5 - [illegible]<br>- Exposed to agent discharge in [illegible] PSTC<br>- Powder not removed; placed in 130 °F oven | X | |

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## RESULTS TO DATE
### (Powder Distribution Tests)

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## CONCLUSIONS

- The agent meets the requirements of a halon substitute. Cleanup of the powder will be required in most cases. However, cleanup after discharge of the agent proved to be minimal and was accomplished using a standard vaccum cleaner and air hose.
- Decomposition Products Were Very Low To None
- Effectiveness Similar to Existing Halons
- Additional Testing and Evaluation Is Ongoing To Meet Requirements for Specific Applications
- SNAP Listed Acceptable for Streaming (Industrial & Residential) and Unoccupied Space Total Flooding
- Preliminary Corrosion Data Available for Review

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## RECOMMENDATIONS

- 0.9 To 1.4 Times More Agent Than Halon 1301 Required for Typical Applications
- Complex Piping Systems Need Testing
- Inhalation Toxicity Needs to be Assessed
- Studies of Long-Term Storage, Handling Requirements, and Tranfering of Product Need to be Completed
- Large-Scale Fire Testing in Specific Applications Required (e.g., Shipboard, aircraft, etc.)
- System Design Standards Need to be Developed
- Need to Determine Effects of Altitude on Ext. Conc.
- Need to Determine Ext. Conc. For Various Fuels
- Investigate Electrical Conductivity

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## Hand Held Extinguisher

- Nick Povey
- Research Project Manager
  - Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick, West Sussex, RH6 OYR, UK.
- JAA Focus for halon issues
- Telephone 44 (0)1293 573347
- Facsimile 44 (0)1293 573554
- E-Mail 100550.3221@Compuserve.com



## Tasks Identified

- **The Aviation Authorities want no loss of safety with new agents - all sectors of the Industry agreed**
- **A single document technical specification was desired**
- **The need for aviation specific fire tests was identified - in particular a hidden fire test**
- **A hand held extinguisher task group was formed**
- **Some urgency was identified - a one year timescale suggested - i.e. by end of 1995**



## Progress of Tasks

- Task group - 19 members
- Data collection - Specifications, Reports, Standards etc
- Incident and accident data collected
- Sub group to address the specification
- Research
  - CAA contract for a hidden fire simulation test
  - Other European research initiatives to be explored
  - DLR Seat and furnishing open fire tests
  - CEAT Toxicology Testing - method proposed, tests to commence late 1995



## Specification

- **Outline of progress reported at the Rome meeting**
- **Consensus that this work had progressed in the desired direction**
- **Very little specific feedback**
- **Need to review the Specification as developed and make decisions now**

## Hidden Fire Test

- Contract placed 21 February 1995
- First meeting with Industry 6 June
- Recommendations made adopted by CAA
- Second meeting with Industry 11 July
- Consensus that the test method is looking good
- Remaining issues include interpretation of the test results



## Hidden Fire Test - Pass/Fail Criteria

- Options
  - a) Minimum standard of any currently approved extinguisher
  - b) Standard based on the average performance of extinguishers currently in service



## Hidden Fire Test - Pass/Fail Criteria

- a) Would lead to drop in safety with time
- b) Would maintain current safety levels