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Aircraft Fire Safety

(la Sécurité incendie des aéronefs)

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North Atlantic Treaty Organization
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HALON REPLACEMENT - AVIATION TEST CRITERIA

Nick J Povey
Safety Regulation Group
Civil Aviation Authority
Gatwick Airport South
West Sussex RH6 0YR
United Kingdom

INTRODUCTION

Halon is widely used in civil aircraft. In a typical wide body jet aircraft passengers will be protected by both Halon 1301 and Halon 1211. Over the past 30 years, because of its exceptional fire fighting performance, relative low cost, ready availability and low weight and volume to effectiveness, Halon 1301 has evolved as the agent of choice. A vast amount of testing has been done during that period to certificate Halon fire suppression systems in engine nacelles, auxiliary power unit compartments, trash containers, and cargo compartments of various size and shape. In addition, Halon 1211 in hand held extinguishers has been found to be very effective in fighting the most hazardous of in-flight fires.

Cargo compartment fire suppression.

In modern large passenger aircraft in which cargo compartments have a volume greater than 1000 cubic feet these areas are protected with fixed fire extinguishing systems. An uncontrolled fire in a cargo area may cause fumes and smoke to penetrate into the cabin and heat from the fire could disable vital functions of the aircraft controls. To protect against this possibility both passive and active defences are utilised. The cargo compartment is lined with fire resistant panels that will help to prevent the spread of fire outside of the compartment and the airflow into and out of the compartment is controlled. In addition the compartment will have smoke detectors fitted which in the event of a fire will alert the crew and enable them to activate the fire suppression system.

The extinguishing agent must be compatible with aircraft materials and electrical systems, it should not be dangerously toxic, nor should it settle or stratify when released. The extinguishing agent must have a rapid knockdown capability and then maintain continued protection for a period of time until the aircraft can safely land, this could be three hours. Halon 1301 meets all of these requirements, a typical wide body aircraft will carry 60 kg. The rapid knockdown and continued protection can be achieved with an initial concentration of 5% and thereafter 3%.

Engine power plant fire extinguishment

Halon 1301 is also used for fire extinguishing systems in aircraft power plants (the area around the core of the engine in which electrical generators, igniters, hydraulic pumps, oil and fuel systems may be found) Fires may occur during any phase of operation, the physical properties of Halon 1301 are therefore very important in this application. The agent must discharge extremely rapidly and expand within the engine nacelle over the full range of ambient pressures and temperatures that an aircraft may experience. Fires occurring at flight speeds can rapidly become very intense, engines are necessarily located close to, and supplied with, large quantities of fuel. A fire needs to be quickly controlled. A typical wide body twin engined aircraft would have 15 kg of Halon 1301 installed to protect the engine installation.

Hand held fire extinguishers

Halon 1211 is used for the protection of aircraft and passengers from fires arising in the cabin or cockpit. Hand held portable extinguishers, usually with 1.5 kg of agent, will be strategically positioned throughout the cabin and flight deck for use by the flight crew and cabin staff. Fires arise from many sources, typically; cigarettes, ovens, non safety matches and electrical fires. There are documented incidents where, if it were not for the capability of Halon 1211 to extinguish fire in inaccessible locations, the aircraft and passengers would most probably have perished. The extinguishing agent must be non toxic to occupants. The agent must be safe to use in the flight deck of an aircraft whilst in flight with no risk of causing instruments and controls to fail due to electrical or material incompatibility. It must not generate dust or smoke which may obscure instruments or vision out of the aircraft. Minor in flight fires occur relatively frequently, typically there have been 20 per year reported in UK passenger aircraft during recent years. Whilst the flight and cabin crews have to undertake training in the use of the portable fire extinguishers aboard their aircraft they cannot be considered to be "trained fire fighters". Therefore an agent is required that will be effective even if the method of application may be less than optimum. A typical wide body aircraft would require twelve 1.5 kg Halon extinguishers. (Sometimes water extinguishers are also carried, these have particular capabilities such as the cooling and dampening down of potential fuel sources following a fire incident.).

The aviation authorities have two key roles to play in the transition away from Halon. Firstly they must use their influence to ensure that the Aviation Industry is fully informed of all the issues concerning the continued use of Halon, and that the environmental legislators understand the needs of aviation and the potential serious safety implications if Halon were withdrawn from use without alternatives having been developed. Secondly they must assist the Industry in the search for acceptable alternatives by ensuring that practicable methods of certificating alternatives agents and systems have been developed.

The CAA has played a lead role in ensuring that the interests of the UK aviation industry have been presented to the Department of Transport and Department of Environment. The CAA assisted in the formation of the Halon Users National Consortium (HUNC), the organisation which enables trade in recycled Halon. It was recognised that recycling and the trading of existing agent would form an essential element in a well managed and safe transition away from Halon. Additionally by reviewing its own requirements the CAA has helped prevent unnecessary use of Halon. By initiating the production of a video detailing the use of Halon 1211 extinguishers the CAA has been able to make changes to the training syllabus for cabin and flight crews so that it is no longer necessary for them to discharge Halon when training.

The aviation authorities in their design requirements strive to define safety objectives and performance standards rather than prescribe specific solutions. In this manner Industry is then able to develop the optimum solution for any particular application taking full advantage of new technologies. Apart from an operational requirement that stipulates the quantity of Halon 1211 extinguishers to be carried in passenger aircraft, there is no requirement that states Halons must be used. However, due to the nature of the Halon agents and their very high performance these agents became the natural choice and it was never necessary to develop detailed acceptance criteria to cater for alternative agents and systems. Now, with the production ban on both 1301 and 1211, it is necessary to define the performance of current Halon systems and set minimum performance requirements for alternative systems. This is not a simple task, for Halon will not necessarily be replaced by similar agents. An entirely different approach to achieving the current safety standards may be adopted. As an example, it has been suggested that future engine installations could be designed with fireproof barriers so that in the event of fire all fuel and oil supplies would be isolated and the fire allowed to burn out without risk to the airframe.

The aviation authorities must decide whether to accept the performance of Halon as the minimum level of safety (that is any replacement must perform as good in all parameters as the Halon it is replacing) or whether to accept a level independently derived from a determinate of tolerance limits for both passengers and airframe, or a combination of the two.

As an example the following is a list of some of the questions concerning cargo compartments which need consideration :

1. Toxicity. Is the killing of humans or animals by an accidental discharge acceptable? A CO_2 or Nitrogen inerting system could do this.
2. If the agent were corrosive would it be acceptable?
3. Would damage to cargo be a major concern?
4. Is volume of agent a problem? The greater the volume of agent pumped into the cargo compartment the more combustion by-products will be pushed out of the compartment and possibly forced into the passenger cabin.
5. Maximum temperature in a compartment. Halon 1301 and anticipated replacements will suppress most Class A fires. They do not necessarily extinguish them. Should the allowable smouldering rate (this would equate to temperature in the compartment) be equal to or less than when 1301 is used?
6. It has been shown that Halon 1301 will suppress the explosive combustion of an aerosol can (which now typically use butane or propane as the propellant instead of CFCs) Must a replacement agent also protect against the possibility of aerosols exploding if they were near to a fire?

Questions such as these are very difficult to answer without knowledge of possible alternative agents and systems and an indication from the airlines and aircraft manufacturers as to what they consider to be acceptable. As a result of discussions between the aviation authorities the US Federal Aviation Administration in their Public Notice 93-1 published in the Federal Register 17 June 1993, announced a proposed research programme to develop performance test methodologies which would lead to recommended airworthiness criteria for the evaluation of non-Halon fire suppression agents and systems to be used aboard aeroplanes and rotorcraft.

To support this activity the FAA invited any interested organisation to join an International Halon Replacement Working Group (IHRWG) The purpose of the working group is to assist the aviation authorities in the development of certification criteria for future non-Halon fire protection systems on aircraft

The IHRWG is an informal group composed of chemical companies, fire protection system manufacturers, airframe manufacturers engine manufacturers, researchers, operators and regulators. In this forum issues can be openly discussed and quickly resolved to enable the necessary information to be available to guide research and regulatory decisions that will be made by the Authorities.

AN EXAMPLE OF THE DEVELOPMENT OF HALON REPLACEMENT - AVIATION TEST CRITERIA

I would like to take one area of fire protection on an aircraft and use that as an example to illustrate how the selection criteria for non halon fire protection have been derived. The UK Civil Aviation Authority was responsible for research in the area of handheld extinguishers and I will therefore use this specific use of halon as my example.

Three questions were key to the identification of the important criteria.

1 Why carry handheld extinguishers on aircraft?
2 Why use Halon 1211 as an extinguishing agent?
3. How do we ensure no loss in safety?

Why carry handheld extinguishers on aircraft?

The design philosophy adopted by all manufacturers and reinforced by the airworthiness requirements is to minimise the likelihood of a fire occurring This aim is achieved by a number of different means; only materials which are heat and fire resistant or fireproof are used in areas considered to be vulnerable, the location of potential ignition sources is carefully controlled. Flammable fluids are similarly kept well away from heat and electricity In addition to these physical measures there are also procedures adopted by the operators of the aircraft, these range from ensuring the integrity of systems during routine maintenance, the cleaning of dust and rubbish from the cabin and air return grilles, to the purposeful checking of lavatories regularly during flight for any signs of smoke or fire. Further restrictions are placed on passengers to ensure that they do not bring hazardous materials onto the aircraft and to control smoking to only those occasions when they are seated.

However as we all know things can and do go wrong and the unexpected happens, it is on these occasions that the adaptable and resourceful human being can be invaluable, provided they have a capable fire extinguisher available to them. This is the reason that handheld extinguishers are carried on aircraft.

There are incidents recorded which demonstrate the need to cater for the unexpected:

> "Passenger dropped cigarette into bag of passenger seated behind. Bag immediately caught fire and set the surrounding carpet alight".

> "Passenger stowed a bag containing a chainsaw in overhead locker, gasoline seen dripping from locker"

Why use Halon 1211 as an extinguishing agent?

To effectively answer this question it is necessary to consider the alternative agents. Across all applications water is the most commonly used fire fighting agent, it also has a role in aviation and is used in aircraft cabins. It cannot be used on electrical or fuel fires but is very good in extinguishing class A fires such as trash container fires consisting of burning paper. It is excellent at cooling materials and preventing re-ignition.

Carbon Dioxide (CO_2) extinguishers have been used on aircraft in the past but have very limited class A fire fighting capability in relationship to the size and weight of the required extinguisher. They cannot be used safely on electrical equipment because of the risk of thermal shock from the dry ice expelled by the extinguisher.

Chemical Powder extinguishers suffer from many disadvantages. The powder when discharged forms a cloud restricting visibility, thus they cannot be used in the cockpit of an aircraft, in addition the powder when it settles would cover instrument faces making the instruments unreadable. The powder can cause electrical failure of switches (usually by insulation of the contacts) and finally the residue is corrosive to an aircraft structure and components, and therefore requires very careful cleanup after a discharge.

Halon 1211 is very effective on fuel fires (class B), has quite good class A fire fighting ability and can be used on fires involving electrical energization (class C). It is not very critical with respect to operator technique and the agent is relatively efficient which enables the extinguisher to be physically quite small. The use of water to dampen a fire after extinguishment with Halon 1211 is recommended. As noted by Krasner[1] there are many sources of water available in an aircraft cabin, including coffee and soft drinks.

In August 1980 a new FAA Advisory Circular 20-42A was issued entitled "Hand Fire Extinguishers for Use in Aircraft" this indicated the acceptability of an Underwriters Laboratory (UL) toxicity rating of 5 or higher and for the first time allowed for the use of Halon 1211. At approximately the same time a series of hijackings took place, all using volatile liquid as the threat. The FAA Technical Centre in Atlantic City conducted a series of tests and in November 1980 a general notice was issued which encouraged operators to carry at least two Halon 1211 extinguishers. The tests conducted at this time demonstrated that Halon 1211 was the best available agent[2] and that potential toxic breakdown products were not an additional hazard[3].

Halon 1211's full chemical name is Bromochlorodifluoromethane or BCF for short. It is a liquid when stored at pressure, which is typically 130 psi for an extinguisher, but has a boiling point of -4 degrees centigrade. It is thus a gas at room temperature. In practice the agent leaves the extinguisher primarily as a liquid which enables it to be directed towards the fire, it then rapidly evaporates to become a gas. It acts chemically to prevent combustion and requires only 3.5% concentration to achieve this. It is thus easy to use and forgiving of poor fire fighting technique.

In ground based applications Halon 1211 is acceptable for use as a hand held extinguishant but not for fixed systems in occupied spaces due to its toxicity. However the tests previously mentioned[3] demonstrated that a more toxic agent that puts the fire out very quickly with the use of only a small quantity of agent could be safer for passengers in the cabin than a less toxic but less effective agent. This is because the hazard that the passenger has to endure is the combination of the toxic threat of the agent and its breakdown products together with the toxic threat of the combustion products from the fire, and it is the fire which rapidly becomes the most extreme hazard.

Toxic threat of the agent + Toxic threat of thermal breakdown products of the agent + Toxic threat of fire products = Gross toxic threat to passenger.

Past experience of fires in aircraft cabins confirm that it is rare for a fire to occur. The statistics also confirm that the vast majority of incidents are readily resolved by the flight attendants. Table 1 records the percentage of reports of smoke or fire by location within the cabin. Table 2 records the percentage of actual discharge of extinguishers by location within the cabin. By comparison of the number of incidents recorded for each of the two tables it can be surmised that many incidents, particularly those related to the galley, are resolved without the need for an extinguisher.

Location in Cabin	Percentage
Galley	67%
Passenger Cabin	16%
Lavatory	10%
Flight Deck	5%
Overhead Area	1%
Cargo	1%

Table 1 Reports of Fire or Smoke

Location in Cabin	Percentage
Passenger Cabin	32%
Galley	27%
Lavatory	27%
Flight Deck	9%
Other	6%

Table 2 Location of Fire or Smoke

Ignition Source	Percentage
Electrical	38%
Cigarette	28%
Not recorded	15%
Oven	7%
Other	11%

Table 3 Reports of Ignition Source

From reading the description of the events it is clear that in only a very small percentage of the incidents is the location of the fire not immediately evident. The majority of the data above was recorded prior to the more widespread restrictions on smoking. There is now some evidence developing which suggests that incidents in the passenger cabin are diminishing whilst reports of illicit smoking in lavatories is increasing.

The Cincinnati DC9 accident of 2 June 1983 clearly demonstrates that the most dangerous fire is one that is hidden from the cabin. Figure 1 illustrates what is meant by "hidden" areas, these are the cheek areas, the overhead and underfloor voids and the area behind sidewalls. In this accident an in-flight fire in a lavatory developed behind the sidewall. One CO_2 extinguisher was discharged into the lavatory from the cabin. The fire continued to increase in size and the cabin progressively filled with smoke. The aircraft landed safely, however there were 23 fatalities during the evacuation as the fire "flashed" in the cabin.

More recently in March 1991 an L1011 aircraft flying from Frankfurt to Atlanta whilst carrying 226 people experienced an in-flight fire at 33,000 ft and 200 miles from the nearest place to land. A fire in the cheek area was started by an overheating electrical cable but fuelled by dust, dirt and debris below the floor, flames 2 feet high entered the cabin. This fire was extinguished by injecting three Halon 1211 extinguishers through return air grilles at floor level. The aircraft made a safe landing at Goose Bay, Newfoundland. It is incidents such as this which re-affirm the need to carry Halon 1211 extinguishers on public transport aircraft

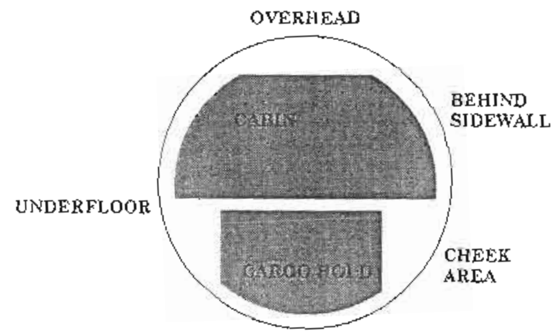

Figure 1 Cross Section of Fuselage Illustrating Hidden Areas

How do we ensure no loss in safety?

If the change from halon is to be made without incurring any drop in safety then it is necessary to define the capability of the current extinguishers and ensure that replacements have equal or better performance. In part this can be achieved by ensuring that the extinguisher is approved by an organisation such as Underwriters Laboratories or Factory Mutual, or meets a defined standard, for example British Standards Institute or EN - Euro-Norm. This will ensure that the extinguisher has a basic defined fire fighting performance. In addition it will be necessary that the extinguisher must demonstrate the capability to deal with the specific threats peculiar to aviation. These threats could be a large fires that results when flammable fluid is splashed on a passenger seat and ignited or when a fire develops in a hidden area. Further considerations will be; ease of use and training, and the assurance that no additional hazards are introduced as a result of the new agent.

To ensure that the objectives outlined above could be defined in detail the Aviation Authorities agreed that both research effort and industry involvement was required. As part of this International effort the UK Civil Aviation Authority agreed to pursue the development of a representative hidden fire test method as none existed previously.

Following an invitation for competitive tenders to develop a standard hidden fire test protocol, the Civil Aviation Authority awarded a contract to Kidde International Research.

The basic methodology was to replicate the volumes, airflow rates and physical restrictions found in the hidden areas of a fuselage. Comparison of figures 2 and 3 will illustrate how this has been achieved.

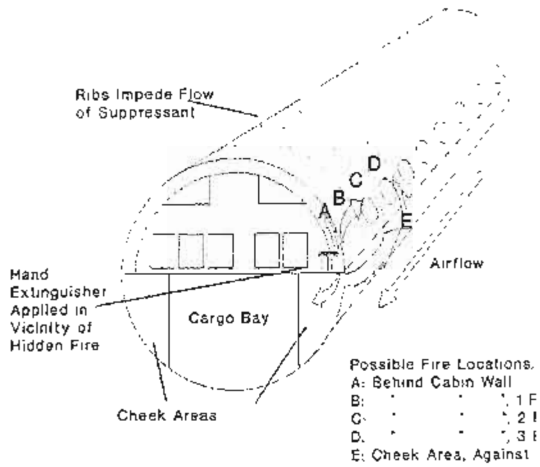

Figure 2 Hidden Areas within the Fuselage

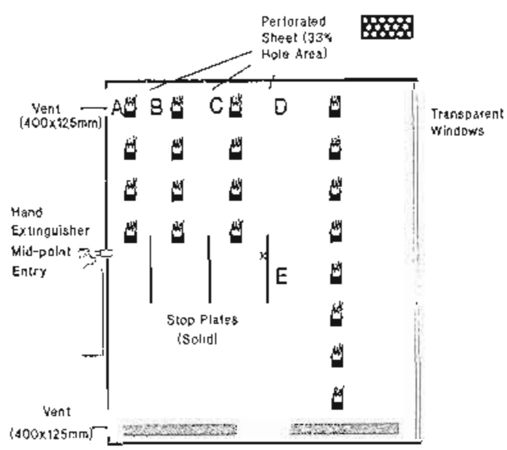

Figure 3 Illustration of Hidden Fire Test Chamber. Measuring 2m x 2m x 0.5m

Figure 4 illustrates how the test method can then be used to "map" the effectiveness of an extinguisher and agent by observing extinguishment of the test fires.

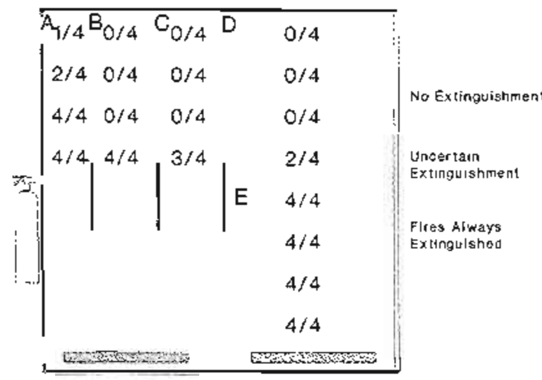

Figure 4 Test Results for 2 1/2 lb. Halon 1211 Extinguisher

Tests have been carried out with hand extinguishers from Walter Kidde, Kidde Thorn, First Technology and Chubb. Results varied from 45% extinguishment to 60%, depending on the quantity of Halon contained in the extinguisher, and the discharge rate (a faster discharge rate creates more turbulence, aiding mixing and dispersion). In addition, tests were carried out using under- and over-filled extinguishers to examine the sensitivity of the test method. With the exception of the First Technology hand extinguisher, all results could be correlated to the mass and mass of agent flow rate used. This device extinguished a significantly higher percentage of fires than would be expected, based on its mass/mass flow rate characteristics.

Limited testing was carried out with six Halon replacements: FM-200, FE-25, CEA-4.10, CEA-6.14, FE-36 and CF_3I, using apparatus designed to give a constant discharge time (10±1 s). The results obtained appeared to be similar to Halon 1211 (50±5% extinguishment), provided the quantity of agent is scaled according to its n-heptane cupburner concentration. The two exceptions are agents with markedly different volatilities to Halon 1211 (b.p. -4°C): FE-25, b.p. -49°C, (65% extinguishment) and CEA-6.14, b.p. +58°C (35% extinguishment).

Implications for the size and weight of a hand extinguisher, based on the results of these tests, are for the physically acting agents, a weight penalty of 1.4 to 2.6, and a volume penalty of 1.9 to 2.9. If CF_3I is considered, there is a weight penalty of 1.06, and no volume penalty. However, it should be borne in mind that any hand extinguisher, before it is evaluated against hidden fires, will have had to have passed the traditional ratings (currently UL 5B:C, BS 3A:34B) to be approved for aviation use. This work is detailed in reference 4.

The International Halon Replacement Working Group has a number of sub groups each addressing a particular task. One sub group has been developing the Minimum Performance Criteria for hand held portable extinguishers. The most recent draft of this document follows.

DRAFT MINIMUM PERFORMANCE CRITERIA FOR REPLACEMENT HAND HELD PORTABLE EXTINGUISHERS 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 require 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 enhancing in-flight fire fighting capability including the need to deal with the arsonist/high-jacking threat which was prevalent in the 1970s. The FAA Technical Centre identified that Halon 1211 was vastly superior to the previously used CO_2 and dry chemical extinguishers, and in particular for protecting against flammable fluid fires on typical seat materials (DOT/FAA/CT-87/111). Later it was determined that Halon 1211 in handheld extinguishers, while primarily a streaming agent provided an additional benefit by having capacity to fight "hidden" fires through total flood effect. This was demonstrated on an in flight cheek space fire in a large cabin aircraft which might otherwise have resulted in a major catastrophe.

It is agreed that any replacement extinguisher must offer at least an equivalent level of fire fighting capability to the hand held fire extinguishers currently in service.

Agent Selection Guidelines

Types of Fire

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

Environmental Effect

Airworthiness Requirements specifically call for the provision of halon based portable fire extinguishers for in-flight fire fighting 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.

Toxicology

As a general rule the agent must not pose an unacceptable health hazard for those likely to be exposed to the agent repeatedly such as workers during installation and maintenance of the extinguishing system. In confined areas such as the cockpit or galley at no time should the agent concentration present an unacceptable health hazard whether as a result of deliberate discharge or leakage. 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 for Fire Extinguishers and Agent

General

The extinguisher must be approved by a recognised fire testing laboratory which is acceptable to the Regulatory Authorities. Extinguishers with overall mass 6 kg or less shall be intended to be carried and used with one hand. The extinguishing agent must not present an unacceptable hazard such as serious impairment to visibility

Minimum Rating

Each extinguisher employed must contain an agent with Class A fire extinguishing capability and meet the minimum rating.
UL 5B C or,
BS 5423 3A.34B or,
equivalent.

Hidden Fire Demonstration: (see Appendix I)

The extinguisher must meet the minimum performance standard of the hidden/remote fire challenge test.

Arson / High-jacking Threat Protection Demonstration: (see Appendix II)

The extinguisher must meet the minimum performance standard of the aircraft Arson/High-jacking Threat fire challenge test.

Compatibility with Aircraft Operating Environment

Each extinguisher utilised on the aircraft must satisfactorily demonstrate compatibility with the appropriate aircraft operational environments.

The extinguisher including its method of attachment in the aircraft must meet the following paragraphs of RTCA / DO 160C:

Section 4:	Temperature and Altitude
Section 6:	Humidity
Section 7:	Operational Shocks and Crash Safety
Section 8:	Vibration
Section 15:	Magnetic Effect

Appendix I: Proposed Hidden Fire Demonstration

A1.1 Test Fixture

The test fixture shall be 2 ± 0.050 m high, 2 ± 0.050 m long and 0.5 ± 0.025 m wide, fabricated from 0.9 ± 0.1 mm sheet steel, as shown in Figure 5. The temperature within the test fixture shall be maintained at 21 ± 1°C (70 ± 2°F). The agent shall be introduced through a hole positioned centrally in one of the end walls of the test chamber. The internal baffles shall comprise 33% hole area, and shall occupy the upper half of the test fixture, adjacent to the end wall through which the agent is injected. The baffle plates shall extend to the side walls and the roof. The spacing between the baffle plates shall be not less than 0.300 mm and not more than 0.350 m (refer to Figure 5). The solid 'stop' plates shall be 0.300 ± 0.025 m, centrally aligned with the agent injection point. Transparent plastic windows will be placed either at one end, or along one side of the test fixture to allow observation (or preferably video recording) of fire extinction times.

A1.2 Fire Threats

The *n*-heptane fire cups shall be 35 ± 2 mm in diameter, and are positioned in two arrays of four as shown in Figure 5. The fire cups shall be charged with 5 ± 1 mL *n*-heptane, floated on 10 ± 2 mL water so that the depth of the liquid surface below the rim of the cup is xxx mm. The trays for the paper fires shall be made from the same perforated material as the baffle plates, and shall be 80 ± 5 mm in diameter, 60 ± 5 mm deep. The fire load shall be 8 ± 0.1 g shredded white 80 g.s.m. copier paper, dosed with 1 ± 0.1 mL *n*-heptane to aid ignition.

A1.3 Test Procedure

The extinguisher is charged with the agent then equilibrated at 25 °C for a minimum of 15 minutes in a temperature controlled water bath. The fires are positioned in the correct zones, charged with water and *n*-heptane and ignited. Any access doors or windows are closed at this time. A pre-burn of 60 seconds is allowed, after which the agent is discharged. The discharge time and the fire extinction times shall be noted. Any fires remaining alight 60 seconds after discharge are classed as failed suppressions, and are to be extinguished manually. The chamber should then be thoroughly vented to remove both the acrid decomposition products and traces of agent which might otherwise affect the outcome of the following test. A suggested test matrix is outlined below

Test No	Fires in Locations
1	A & B
2	A & B
3	B & C
4	B & C
5	A & D
6	A & D
7	C & E
8	C & E
9	D & E
10	D & E

Thus each location is tested four times, in two different configurations.

A1.4 Presentation of Results

For each fire location the aggregate number of successful and failed suppressions shall be plotted in a figure similar to 3.2. The overall percentage extinguishment for *n*-heptane fires shall be calculated and compared to the minimum performance standard, which is yet to be defined.

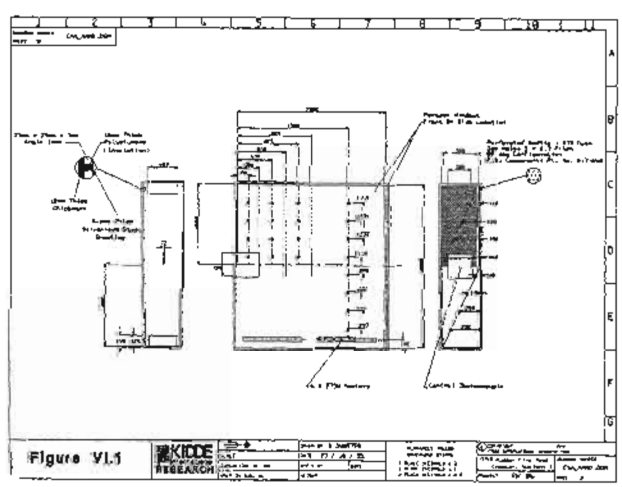

Figure 5 Construction Details of the Test Fixture

Appendix II: Proposed Arson/Hijacking Threat Protection Demonstration

Input from FAA Technical Center required.

Suggest 1 litre of gasoline spread on a triple seat, 1/3 seat backs, 1/3 top of seat cushions. 1/3 under the seat on the floor. The idea being to generate a 3 dimensional fire in a manner that could readily occur.

SUMMARY

This example of handheld extinguishers demonstrates the process of identification of key performance criteria and the development of aviation specific tests to ensure the continued high level of safety that we enjoy with the use of halon. A similar process is underway for uses such as the protection of engines and cargo compartments where Halon 1301 is the preferred agent.

The aviation business is truly international and the Aviation Authorities are striving to achieve common requirements for the design, build, operation and maintenance of aircraft. A manufacturer producing a new design can expect that decisions made in the design stage of a new aircraft type will affect the day to day operation of that aircraft type in 40 or more years time. Clearly the manufacturer will want to be absolutely sure before they commit to a new fire control system. They need to know what environmental legislation controlling CFCs, HCFCs and other alternative agents is proposed. The current differences that are emerging between the US and European environmental legislation do not help the aviation industry achieve common international safety standards Newer concerns, beyond ozone depletion, such as global warming potential or atmospheric lifetime may be the subject of future environmental legislation which would affect agent choice.

It should be remembered that whilst the aviation industry relies heavily on halon it is not a major consumer, on average ½ kg per aircraft per year is released. The Aviation Authorities have commenced a major research effort so that they will be able to approve alternative fire suppression systems as they are developed by Industry and ensure that they are at least of equal safety to current systems which use halon

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DISCUSSION - PAPER NO. 15

C.A. Kirk (Question)

Will the use of CF_3I handheld extinguishers be allowable in the cabin, from a toxicity point of view in the case of accidental discharge?

N.J. Povey - Author/Speaker (Response)

Both the airworthiness requirements and the draft minimum performance standard for handheld extinguishers, being developed by the International Halon Replacement Working Group, require the applicant to minimise the hazard to occupants from accidental discharge. This will apply equally to all agents considered. To make judgement, the toxicity, size of extinguisher and volume of the compartment will, at least, all need to be known.