ICAO JOURNAL

VOLUME 60 NUMBER 6, 2005

Aircraft Fire Protection

A FUTURE WITHOUT HALONS

Human Factors Research

RESPONDING TO EMERGENCIES

Slow transition to halon alternatives in new aircraft raises concern

Although production of halons has long ceased, the airline industry is still heavily dependent on their use in aircraft fire protection systems. This reliance could be problematic considering that stockpiles of halons will expire before newer aircraft reach their retirement date.

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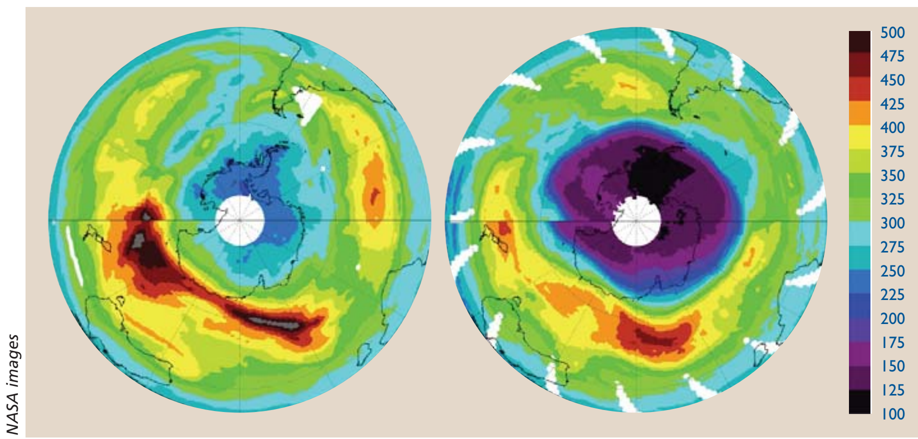
MODERN aircraft fire protection has historically relied on chemicals known as halons, but these substances have been recognized since the 1980s as being particularly destructive to the stratospheric ozone layer. The end of global halon production, uncertainties in the availability and quality of stockpiles, and the lag in adopting available substitutes raise the concern that civil aviation is unprepared for a future without halons.

According to a recent report prepared for the U.S. Environmental Protection Agency (EPA) by ICF Consulting, transition in the United States to the next-generation halon alternatives for aircraft fire protection systems is impeded by technical, regulatory and procedural issues.* The authors of the report conclude, moreover, that this situation is likely mirrored in most member States of ICAO and may pose a significant problem for airlines worldwide. Addressing the potential impacts of the transition away from halons will be most successful through the coordinated action of ICAO member States.



The ozone "hole," visible over Antarctica, in 1979 (left) and 2005.
(Dobson Units: Dark Gray < 100 and > 500 DU)

Need for ozone protection

Over two decades ago, atmospheric scientists warned that the annual appearance of the Antarctic ozone hole and the probability of increasing depletion of the stratospheric ozone layer had serious consequences for all life forms. This came after discoveries in the mid-1970s that some man-made chemicals could destroy ozone, resulting in increased ultraviolet radiation reaching the Earth (see figure on this page).

Although ozone is a small component of the atmosphere, the ozone layer plays a vital role in shielding life on Earth from harmful ultraviolet (UV-B) radiation from the sun. Human exposure to UV-B is known to increase the risk of skin cancer, cataracts, and a suppressed immune system. UV-B exposure can also damage terrestrial plant life, single-cell organisms and aquatic ecosystems.

The evidence that human activities were destroying the stratospheric ozone layer was compelling. Emissions of certain man-made chemicals used in many common products such as refrigerators, air conditioners, cars, fire extinguishers, foams and cleaning solvents were reaching the stratosphere, between 10-16 kilometres and up to 50 kilometres above the Earth's surface, and destroying ozone molecules. With the appearance of the ozone hole, many countries joined efforts for the first time to combat this global environmental threat. Over 180 countries to date have ratified the landmark international environmental treaty, the 1987 *Montreal Protocol on Substances that Deplete the Ozone Layer*. Parties to the Montreal Protocol are committed to eliminating production of ozone-depleting substances by meeting specific phase-out deadlines.

Almost 20 years later, the parties to the Montreal Protocol are now gauging the success of the ozone protection policies and regulations that have been implemented, and are reviewing atmospheric measurements that could indicate the beginnings of a recovery of the ozone layer. In addition, they are identifying sectors that lag in moving away from the use of ozone depleting substances and consequently have the potential to significantly delay or prevent this recovery.

Halon phase-out. Owing to the high ozone depletion potential of halons, the Montreal Protocol called for an end to their production by 1994. Before production ceased, however, halons found extensive use worldwide as clean, safe and very effective gaseous fire suppression agents. In particular, two halons emerged as the agents of choice for many military and commercial fire protection applications: halon 1301, used in fixed total flooding fire extinguishing systems; and halon 1211, used for streaming applications, primarily in handheld fire extinguishers.

Over the last two decades, the availability of many substitutes and alternative technologies has significantly reduced the need for halons in virtually all new installations, and in most applications retrofit has been possible to further reduce the need for halons. In some sectors, however, difficult fire/explosion suppression problems have posed significant technical challenges in making the transition away from halons. This was the case for the military, the merchant marine community, the oil and gas production industry, and the civil aviation industry.

In the military sector today, new facilities or new designs of military equipment no longer require halons (although stockpiles are maintained to service existing equipment that cannot be retrofitted). Military development and testing of halon alternatives have helped in the adoption of alternatives in other sectors. In the merchant shipping sector, halons were banned from use in new ships in 1992 and managed stockpiles service pre-1992 vessels. The oil and gas production sector protects new facilities using available halon alternatives and is managing stockpiles to maintain existing halon equipment.

In contrast with these sectors, the commercial aviation industry has lagged behind in adopting alternatives and new technologies. Existing aircraft and new designs continue to depend on halons for the majority of their fire protection applications.

Halons and aircraft

Halon is used for fire suppression on civil aircraft in lavatory trash receptacle extinguishing systems, handheld extinguishers, engine nacelle/auxiliary power unit (APU) protection systems, and cargo compartment extinguishing systems.

With the exception of lavatory trash receptacles on some Airbus aeroplanes, all new installations of fire extinguishing systems for lavatory trash receptacles, engines and cargo compartments use halon 1301, and all new installations of handheld extinguishers use halon 1211. There has been no retrofit of halon systems or portable extinguishers with available alternatives in the existing worldwide fleet of aircraft. In other words, the airline industry is still heavily dependent on halons; given the anticipated 25-30 year lifespan of commercial aircraft, this dependency is likely to continue well beyond the time when existing recycled halon stocks expire.

Application	Date of Finalized MPS	Status of Testing to MPS		Alternatives installed on aircraft
		Alternatives tested to MPS	Alternatives meeting MPS requirements	
Lavatory Trash Receptacle	February 1997	HFC-125, HFC-227ea HFC-236fa, Envirogel	HFC-227ea HFC-236fa	Airbus A340-600 (HFC-236fa)
Handheld Extinguishers	August 2002	HFC-236fa HFC-236fa/HFC-23 HCFC Blend B HCFC Blend E Envirogel (two versions)	HFC-227ea HFC-236fa HCFC Blend B	None
Cargo Compartment	April 2003	Water mist Water mist/nitrogen HFC-125 Bromotrifluoropropene ("BTP")	Water mist/nitrogen	None
Engine Nacelle/APU	Not available	CF3I, HFC-125	Not available	None

Status of the development of minimum performance standards and the testing of halon alternatives.

With no new halon production allowed, commercial aircraft manufacturers must look either to their own stockpiles of halons or to the limited amounts of recycled halons available on the open market to avoid grounding aircraft because of a lack of appropriate fire protection. This situation is a major cause for concern because even if the parties to the Montreal Protocol were to allow future halon production to service aircraft safety needs, it is estimated that the cost to restart production for a relatively small market would result in halons priced in the U.S. $400 to $600 per kilogram range. (This calculation assumes, of course, that a chemical company would be willing to invest in the manufacture of halon.)

Substitutes for halons include both in-kind gaseous agents and not-in-kind alternatives. In-kind alternatives to halon 1301 used in total flooding fire extinguishing systems include conventional agents such as carbon dioxide and those addressed in the U.S. National Fire Protection Association 2001 standard, *Clean Agent Fire Extinguishing Systems*, which include hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), a fluoroketone and inert gases. Not-in-kind halon alternatives include water sprinklers, fine water mist, foam, dry chemicals and aerosols.

Since 1994, when halon production ended in developed countries, initiatives such as the U.S. Environmental Protection Agency's (EPA) Significant New Alternatives Policy (SNAP) Programme and the U.K. Halon Alternatives Group (HAG) Toxicological *Report on Alternative Agents to Halon* have evaluated many substitutes and alternative technologies for replacing halons. Typically, the programmes assess overall risks to human health and the environment posed by use of the substitutes and consider information such as the substitute chemical's toxicity, ozone depletion potential, global warming potential, environmental fate and transport, occupational and end-use exposure, and commercial availability. The SNAP Programme's evaluations and EPA's determinations of the acceptability or otherwise of substitutes for halon 1301 and halon 1211 are published through formal notices and rules. The listings are posted and updated on its website (http://epa.gov/ozone/snap/fire/halo_10_01_04.pdf), and are legally binding in the United States. The latest HAG report can be found on the website www.hunc.org, and is provided for information only to the general public and regulators.

Minimum performance standards. Key to the acceptance of one or more of the approved substitutes has been their ability to demonstrate a fire extinguishing performance equivalent to halon in specific applications. As such, substitutes for halons in civil aviation fire extinguishing systems are evaluated and approved according to the relevant minimum performance standards and testing scenarios developed by the International Aircraft Systems Fire Protection Working Group (IASFPWG), originally established in 1993 by the U.S. Federal Aviation Administration and cooperating agencies and known then as the International Halon Replacement Working Group.

The recent EPA report on the transition away from halons in the U.S. civil aviation sector examined the current minimum performance standards and test scenarios as part of the process of identifying transition barriers. The 2004 report concluded that the minimum performance standards test protocols for lavatory trash receptacle extinguishing systems, hand-held extinguishers and cargo compartment protection systems have been adequately designed to provide an equivalent level of safety to that provided by halons, and the fire test protocols for the halon alternatives were found to be realistic without being excessively stringent.

The exception to the foregoing is in the case of engine nacelle/APU protection systems, where the lack of finalized minimum performance standards is a barrier to using alternatives to halons in this application. The table on page 7 summarizes the status of the development of each minimum performance standard, and lists the substitutes that have been tested and that meet the requirements of the relevant, finalized standards.

For aircraft fire protection, having an alternative that passes the relevant minimum performance standard is only the first step in the extended process that needs to be completed before installation on board aircraft. There are also regulatory and manufacturing procedures that need to be followed. The 2004 EPA report also describes the procedures that need to be completed in the United States in order for halons to be replaced in the specified applications on new airframes, along with the estimated time for their completion. It highlights the extraordinary length of time that has been spent developing the minimum performance standards, and the slow progress made in installing alternatives that have satisfactorily completed the testing process. However, the report also indicates that there are no obvious immediate incentives for aircraft manufacturers and airlines to begin the change away from the use of halons, even with the looming uncertainty of future halon supplies.

The availability of substitutes and alternative technologies has significantly reduced the need for halon

In addition to the long approval process, the lack of a regulatory requirement to eliminate halon use has often been cited as a reason for the slow transition away from halons in civil aviation. Regulations that allow the continued use of recycled halon have enabled airlines to avoid the costs of early equipment retirement and have not encouraged them to opt for a smooth transition to available alternatives, as in the other sectors. Current halon needs are consequently being met by using existing stockpiles or decommissioned systems reaching the end of useful equipment lifetime. Further, the trend is that new aircraft are continuing to rely on halons. However, as is true for all finite resources, the halon stockpile will diminish and eventually disappear as the number of remaining halon installations dwindles. Some airlines may have taken the necessary steps to ensure a secure supply, but most probably rely on service companies that simply purchase from the currently available, but increasingly uncertain, market.

Economic barriers to the transition away from halons in civil aviation are the relatively low cost of halons at present and the comparatively higher cost of alternatives — up to 10 times higher in some cases. Therefore, until supplies of recycled halon become prohibitively expensive to procure or are simply unavailable, the civil aviation industry lacks an economic incentive to move away from halons to the higher-priced alternatives. With a steady or increasing demand and a dwindling supply, however, it is clear that prices of recycled halons will eventually rise significantly. This is a reality that many in the industry must anticipate and plan for now in order to avoid an uncertain and potentially significant economic burden later. Additionally, with the exception of lavatory waste receptacle bottles, the identified alternatives present weight and volume penalties that translate into further economic disincentives. However, this should be considered in the context of overall aircraft operating and equipment lifetime costs.

It is notable that despite similar cost penalties in the other sectors that have difficult problems to overcome, users outside the civil aviation community have successfully made the transition away from halons by maintaining existing systems (thus retaining the initial equipment investment) while adopting halon alternatives in all new installations. This is a model that civil aviation should follow to prepare itself for the future.

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* The 2004 EPA report, *Review of the Transition Away from Halons in U.S. Civil Aviation Applications*, examines in particular the current minimum performance standards developed by the International Aircraft Systems Fire Protection Working Group (IASFPWG) — formerly known as the International Halon Replacement Working Group — for the U.K. Civil Aviation Authority (CAA), the U.S. Federal Aviation Administration (FAA), the European Joint Aviation Authorities (JAA) and Transport Canada, as well as the fire test scenarios employed to evaluate and approve alternatives to ozone-depleting halons in civil aviation. The report, on which this article is based in part, may be obtained at the EPA website (http://www.epa.gov/ozone/snap/fire/index.html).

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and rescue services in African Civil Aviation Commission (AFCAC) member States with more than $844,500 in new funding; a project to carry out European geostationary navigation overlay service (EGNOS) trials in the Caribbean and South American region, with additional funding of $557,000 (with the goal of developing tests and studies to assess the technical and operational benefits that the satellite-based augmentation test system can bring to the region); and a project in Saudi Arabia focused on strengthening the capacity of the Presidency of Civil Aviation that has been extended by one year with an additional $6.7 million in funding. □

ICAO's business plan

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ICAO standards and recommended practices (SARPs), training, performance monitoring, and providing assistance to States. The sharpened focus could come at the expense of other ICAO activities, if necessary — in this case, in all likelihood, the development of new SARPs.

Looking more closely at safety objectives, the business plan puts the accent on results, and not necessarily on conducting traditional activities that can contribute to safety. In distinguishing the more important priorities related to USOAP, for instance, the plan stresses the actual outcome of safety oversight audits and not simply their completion. The goal is to achieve greater compliance with ICAO standards worldwide. This results-oriented approach reflects the unified safety strategy adopted by ICAO at its 35th Assembly. Similarly, the business plan puts the onus on results in terms of ICAO's various other activities.

The business plan is important, from a safety standpoint, if only because it recognizes that it may not be realistic to achieve all objectives, no matter how laudable, but that it is possible to define safety priorities and allocate resources accordingly. This is the framework needed for addressing the issues of greatest concern and for implementing solutions that produce the greatest benefits. Where safety is concerned, the business plan offers the kind of perspective necessary to identify the root causes that underlie safety lapses, rather than their varied symptoms. It places the emphasis on achieving results by addressing these root causes.

As with any business plan, which tends to rely on the availability of good data, ICAO's decisions about safety priorities will be based largely on the safety information at hand. This reliance underscores the need to collect quality data from the world's air transport industry.

In the world of air transport, a business plan serves as the foundation for a safety management system. Similarly, ICAO's business plan contributes to safety by focusing on priorities and responding to changing times, in this case highlighting the need to ensure the effective regulatory oversight of a challenged, but rapidly growing, air transport industry. □

Contingency plan

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primary method of preventing, or delaying, a global outbreak of human influenza is to quickly identify emergence of a virus strain capable of efficient transmission between humans and then rapidly introduce effective containment measures in the affected region.

Proposed measures involve quarantining those affected and anyone who has been in contact with an affected person, while isolating the region where the outbreak occurred. At the same time, the general population in and around the affected region would be provided with antiviral drugs (e.g. "Tamiflu") for a period of some weeks as a preventive measure. By this means, the spread of a local outbreak could be delayed, providing some time to develop a specific vaccine. Such a strategy critically depends on good disease surveillance and rapid deployment of containment measures, both of which might be difficult in many parts of the world where an outbreak is likely.

Where specific aviation measures are concerned, during the SARS outbreak in 2003 airport screening of passengers probably contributed to the successful control of the disease. However, influenza behaves differently from SARS, and it is not certain how effective screening would be. An individual infected with the influenza virus may be contagious 24 hours after being infected, a condition that can last for 48 hours before symptoms, including fever, appear. With SARS, symptoms appear at around the time the patient becomes contagious, so affected individuals can be more effectively identified by use of temperature measurement. ICAO and other concerned organizations continue to work with the WHO to define the most effective response at international airports affected by an influenza outbreak.

The plan developed by ICAO for combating SARS was very useful. For the first time, airports and the wider aviation industry considered how to deal with an outbreak of a contagious disease, and many of the procedures outlined are helpful in defining an approach to future outbreaks. The current threat from highly pathogenic human influenza may not be directly analogous to that of SARS, but the work done in 2003, combined with current efforts, should provide a solid foundation on which to base a generic preparedness plan for aviation for any foreseeable future pandemic. □

Transition to halon alternatives

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Action plan. The current understanding of the status of halon supplies indicates that the time available for making the transition to halon alternatives may be much less than airlines realize. Thus, to avert a situation where aircraft are grounded because halons are unavailable, a plan of action by regulatory authorities is necessary to ensure that the industry can maintain a safe environment for the flying public. To this end, the parties to the Montreal Protocol have requested that their technical advisers cooperate with ICAO on developing an action plan for the aviation sector. The following course of action has been recommended and agreed to by the parties:

- the United Nations Environment Programme (UNEP) Halons Technical Options Committee (HTOC) will use its expertise to make a best estimate of the available halon supply, costs, and current emissions rate. These data will be given to ICAO for distribution to its member States;
- ICAO will issue a State Letter to member States in 2006, inviting them to require the use of proven alternatives in new aircraft designs to the extent practicable;
- the ICAO Secretariat will introduce an ICAO/HTOC working paper on the subject of phasing out halons at the next regular

ICAO Council appointment

D.O. Valente (Argentina)

Daniel Oscar Valente has been appointed Representative of Argentina on the Council of ICAO. Mr. Valente's tenure commenced on 1 August 2005.

A graduate of the Military Aviation School, Mr. Valente holds an air transport pilot licence and flight instructor rating. His flying career encompasses both military and civil activity, including experience as a test pilot. He has also served as an air navigation aids inspector.

Mr. Valente trained in managerial and educational fields at the Advanced School of Air Warfare in Argentina, and also trained at the U.S. Air Force's Air University and the Naval Postgraduate School in the United States. He has attended courses at the National Institute of Air and Space Law in Argentina and studied for a master's degree in international relations at the National University of La Plata. Mr. Valente received a Bachelor's Degree in air and airspace systems from the Aeronautical University Institute.

In the civil aviation field, Mr. Valente served as Head of the Operations Division in the Air Regions Command, a post involving matters related to aviation safety and security. Concurrently, he was involved in the process of awarding airport concessions in Argentina, and also worked as a civil aviation duties inspector and airline inspector.

Mr. Valente played a role in creating the Aircraft Fire Fighting and Rescue Training Centre in Argentina, and in developing and managing the institutional evaluation process for education in the Air Force.

Mr. Valente has been an instructor at military training schools and a professor at the Aeronautical University Institute in his country, where he served on the board that drafted the university's statutes. He has published a number of articles in the Spanish and Portuguese editions of the *Air Power Journal.* □

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session of the ICAO Assembly in 2007; and

- if the ICAO Assembly endorses the working paper's recommendation to use alternatives in new aircraft designs where practicable, States will then be required to use halon alternatives for identified applications in new airframe designs first certificated on or after 1 January 2009.

Conclusions. The airline industry is still heavily dependent on halons for its fire suppression needs. Given the anticipated lifespan of commercial aircraft, this situation is likely to continue well beyond the day when existing recycled halon stocks expire. This is a major cause for concern.

Halon alternatives in almost all civil aviation applications have passed tests based on the relevant minimum performance standards. However, the timing of the inclusion of these halon alternatives in new aircraft designs remains uncertain, and unless the processes of designing, conforming, qualifying and certifying new extinguishing systems on commercial aircraft are made a priority by the approval authorities — and expedited accordingly — they will represent significant barriers to the transition away from halons. Currently, alternatives are used only in the lavatory fire extinguishing systems of certain Airbus aircraft, which is a poor reflection on the extensive research and testing efforts that have been expended on aviation applications to date.

The aviation industry should be encouraged by regulators to follow the lead of other user communities which have had similar difficult problems to overcome, but which, nonetheless, have successfully moved away from halons by maintaining existing halon systems (thus retaining that initial equipment investment) and adopting halon alternatives in all new installations. A commitment to a plan of action that persuades the aviation sector to transition away from halons safely and smoothly would serve the best interests of airlines, the public, and the global environment. □

Essential air services

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by the service, plus a reasonable profit for the employment of capital. In the interests of good governance and transparency, the requested compensation amount and the reimbursement need to be thoroughly assessed. The risks of overcompensation and inefficiency resulting from allocation of common or joint costs to more than one route could be partially mitigated by attracting a sufficient number of potential bidders to an auction.

Sources of financing. Having called for a tender, the State should have prime responsibility for securing the funds needed for paying subsidies. The issue of the kind of taxes that could be levied to help finance subsidies has to be examined carefully, with the goal of minimizing the distortion of the national economy. If the State faces budgetary constraints or other national spending priorities, it would need to arrange for financial support from outside bodies. Among examples are bilateral aid from the other party of the air services agreement and third-party aid from international agencies. A pragmatic way to supplement public financing would be to form a public-private partnership by bringing together national and local governments (with the open participation of other interested States), tourism entities, local businesses, airports and airlines.

Supplementary options. Subsidizing air services may not be sufficient for route development, which might be achieved more effectively if an ESTDR scheme is organized strategically as one part of an integrated package. There are two types of measures for supplementing an ESTDR scheme. One, a supply-side measure, is a way of sharing the financial risk of a new service with an airline by giving various kinds of indirect subsidies and incentives to the air carrier, thereby reducing its operating cost and raising the profile of the destination. The other is a demand-side measure, such as promotional and marketing activities and the provision of incentives for tourism entities, thereby breaking the "chicken-and-egg" dilemma facing aviation and tourism development and generating sufficient inbound traffic for the route's long-term viability. Any supplementary measure, however, should be governed by the same conditions and principles as those applied to an ESTDR scheme because of the potential for distortion of the market.

Interrelated elements. The seven pillars that constitute an ESTDR scheme are interrelated and have a degree of iteration. For example, the specification of adequacy (the second pillar) affects the second stage of the route selection test (the first pil-