DANGEROUS GOODS PANEL (DGP)

TWENTY FIRST MEETING

Montréal, 5 to 16 November 2007

WORKING PAPER PRESENTED AT THE 36TH SESSION OF THE ASSEMBLY ON HALON REPLACEMENT IN CIVIL AVIATION AIRCRAFT

ASSEMBLY — 36TH SESSION

TECHNICAL COMMISSION

Agenda Item 30: Other safety matters

HALON REPLACEMENT IN CIVIL AVIATION AIRCRAFT

(Presented by the United States and the
United Nations Environment Programme's Ozone Secretariat)

EXECUTIVE SUMMARY	
This paper provides background information on progress that has been made related to the development and approval of non-halon agents for use in civil aircraft. This paper supplements the proposal in Working Paper A36-WP/206-TE/63.	
Strategic Objectives:	This working paper relates to Strategic Objective A.
Financial implications:	
References:	

1. INTRODUCTION

1.1 As noted in A36-WP/206-TE/63, for over 45 years halogenated hydrocarbons (halons) have been practically the only fire-extinguishing agents used in civil transport aircraft. However, halon is an ozone-depleting and global warming chemical and its production has been banned by international agreement. Although halon usage has also been banned in some parts of the world, aviation has been granted an exemption because of its unique operational and fire safety requirements.

1.2 At the meeting of the parties to the Montreal Protocol in 2003, the parties tasked the United Nations Environment Programme's (UNEP) Ozone Secretariat to work with ICAO to develop a timely plan of action for the replacement of halons in civil aviation.

1.3 Additionally, knowing that supplies of halon are diminishing, industry and the United States Federal Aviation Administration (FAA), together with authorities from Australia, Brazil, Canada, France, and the United Kingdom, formed an International Aircraft Systems Fire Protection Working Group (IASFPWG) to develop Minimum Performance Standards (MPS) for alternative chemicals. These MPS (see Appendix A) describe acceptable full-scale fire tests to demonstrate that an environmentally acceptable replacement agent is equivalent to halon in fire-extinguishing effectiveness. However, although the standards are available, there has been little success in developing and installing alternatives to halon in civil transport aircraft.

2. BACKGROUND

2.1 Halon has been the fire-extinguishing agent of choice in civil aviation because it is: a) extremely effective on a per unit-weight basis over a wide range of aircraft environmental conditions; b) a clean agent (no residue); c) electrically non-conducting; and d) of relatively low toxicity. Two types of halons are employed in aviation: Halon 1301 ($CBrF_3$) a total flooding agent and Halon 1211 ($CBrClF_2$) a streaming agent.

2.2 Halon 1211 is used in hand-held extinguishers, while Halon 1301 is used in fixed extinguishing systems for protection of lavatories, engine nacelles/auxiliary power-units (APUs), and cargo compartments. On a weight basis, the largest application by far is in cargo compartments, followed by engines/APUs, hand-held extinguishers and lavatories (minimal quantity). As an example for a recent transport airplane, the relative quantities of halon are: lavatories, 0.7 - 1.4 kg; hand-held extinguishers, 4.5 - 8 kg; engines/APUs, 26 kg; and cargo compartments, 171 kg.

2.3 With the signing of the Montreal Protocol on Substances that Deplete the Ozone Layer, the production of halons ceased in the developed countries on January 1, 1994, although the use of halons was not prohibited. At about this time the FAA, with the support of other aviation authorities and members of industry, convened an informal working group, the International Halon Replacement Working Group (now called the International Aircraft Systems Fire Protection Working Group or IASFPWG) to develop MPS's for each of halon's four uses on aircraft.

2.4 The IASFPWG is international in scope, with active participation by the aviation industry, agent suppliers, extinguishing system companies, international regulatory authorities and other interested parties (see Appendix B). The main purpose of each MPS is to define full-scale fire tests to demonstrate that a replacement agent is equivalent to halon in terms of fire-extinguishing/suppression effectiveness. Moreover, the full-scale fire tests can be used to derive certification criteria to allow for the approval of new agents/extinguishers/systems by the regulatory authorities. All of the fire tests defined in the four MPS's are set up at the FAA Technical Center in Atlantic City, New Jersey and have been made available to the aircraft manufacturers and others for cooperative testing with FAA.

2.5 It must be recognized that any fire-extinguishing agent and delivery system that meet the MPS must meet additional requirements for installation on aircraft. Issues that need to be addressed include compatibility with the aircraft materials and equipment, acceptable performance across the airplane operating conditions, low toxicity, and acceptable environmental impact. These requirements must be demonstrated by the fire protection system manufacturer in order to qualify the agent and the system to the airframe manufacturer's requirements. Then the airframe manufacturers must demonstrate compliance to the applicable safety and performance requirements before the agent/system installation can be certified by the appropriate authorities.

2.6 **Protection of lavatories**. The MPS for lavatory trash receptacles was the first completed and published because of the relative simplicity of this application. In late 2000, an FAA/industry team conducted tests in accordance with the MPS at the Technical Center. Two halon-replacement agents, HFC-236fa and HFC-227ea, passed the MPS tests. Two major airplane manufacturers are currently offering their customers lavatory extinguishers containing these agents to its customers.

2.7 **Hand-held extinguishers**. The published MPS for hand-held extinguishers describes the required extinguishment of two important in-flight fires, a hidden fire and a gasoline-drenched seat fire. Under the auspices of the IASFPWG, a hidden fire-extinguishment test method was developed and standardized. Underwriters Laboratories (UL) provides testing services to demonstrate that a hand-held extinguisher complies with the hidden fire-extinguishment criteria contained in the MPS. UL has listed the following commercially available extinguishers as being MPS-compliant: HCFC Blend B, HFC-227ea and HFC-236fa. In addition, FAA full-scale fire tests showed that gasoline-drenched seat fires were extinguished by these UL-listed extinguishers without creating hazardous levels of agent decomposition gases, which is also an MPS requirement.

2.8 A concern with the introduction of new hand-held extinguishers in aircraft is the potential build-up of harmful concentrations of the extinguishing agent during discharge in a small compartment. Working with experts in the IASFPWG, FAA is significantly revising its Advisory Circular (AC) on hand-held extinguishers to contain guidance for the safe discharge of halon-replacement extinguishers inside a wide range of aircraft compartments, including small general aviation aircraft. Additionally, the existing alternative extinguishers for hand-helds are larger and heavier than the current halon extinguishers which will trigger additional requirements for airframe manufacturers (i.e., design change approvals) and airlines (e.g., crew training) prior to incorporation into existing designs.

2.9 **Engine protection**. The MPS for engines describes a series of full-scale fire tests under different fire scenarios and engine operating conditions to demonstrate halon equivalency. Three halon-replacement agents, HFC-125, CF3I, and FK-5-1-12, were tested by the FAA using its full-scale engine nacelle fire simulator and were shown to meet the requirements of the MPS. Another agent is currently undergoing testing. It is likely that any known alternative agents for engines/APUs will require more agent and system weight and will require significant design approval activity prior to incorporation into existing designs.

2.10 **Cargo protection**. The published MPS for cargo compartments describes full-scale fire tests and criteria to demonstrate equivalent performance to halon 1301 for four separate fire scenarios: bulk-loaded cargo, containerized cargo, surface burning fire and exploding aerosol scenario. FAA has teamed with airframe manufacturers, extinguisher companies, and agent suppliers to evaluate a number of halon-replacement agents, including commercially available agents as well as developmental systems and concepts. Generally, each approach had one or more shortcomings compared to halon 1301. With two of the agents, tests have produced excessively high levels of hydrogen fluoride and a significant weight penalty. During the fire suppression phase, the smoke layer ignited unexpectedly, producing a "rollover" and temperature spikes, phenomena never seen with Halon 1301. Unrealistic quantities of agent would be required to meet the MPS criteria without the "rollover" effect. Some cargo fire-extinguishing tests were conducted with CF3I – once touted as a drop-in replacement for halon 1301 – but these tests were discontinued because of toxicity concerns. Two other agents that seemed promising produced unexpected over-pressurization during the suppression of a fire involving aerosol cans. Another promising EPA-approved agent also experienced two major failure modes – enhanced overpressures during aerosol can tests and a sudden flare-up during the suppression of a bulk-loaded cargo fire. Finally, although water mist showed some promise, by itself it cannot prevent an aerosol can explosion.

2.11 The only approach that passed the cargo compartment MPS fire test criteria was a water mist/nitrogen gas hybrid system concept. The concept would use water mist to initially extinguish open flames and nitrogen gas, perhaps available from a fuel tank inerting system, to suppress any deep-seated fires for the duration of the flight. Even though the weight of water was comparable to halon, the concept is very different from current systems and would require significant development. There are a number of technical challenges including the scale-up of the demonstrated extinguishing system to provide broader coverage, inclusion of a knockdown gaseous system if it is decided not to use water mist, and adequate nitrogen gas generation technology for maintaining an inert environment. Moreover, inerting systems are currently not used in commercial transport aircraft.

— — — — — — — —

APPENDIX A

MINIMUM PERFORMANCE STANDARDS (MPS) REFERENCE MATERIALS

U.S. Publications:

Lavatory Halon Replacement MPS, FAA Report (DOT/FAA/AR-96/122)

Hand-Held Extinguisher Halon Replacement MPS, FAA Report (DOT/FAA/AR-01/37)

Cargo Compartment Halon Replacement MPS, FAA Report (DOT/FAA/AR-TN05/20)

Engine/APU Halon Replacement MPS, FAA Report (To Be Published)

Review of the Transition Away From Halons in U.S. Civil Aviation Applications, Prepared by Hughes Associates, Inc. and ICF Consulting under contract with the U.S. Environmental Protection Agency (EPA), September 2004.

ICAO Publications:

"Slow transition to halon alternatives in new aircraft raises concern", ICAO Journal, Volume 60, Number 6, 2005.

FAA Technical Center Presentation to International Aircraft Systems Fire Protection Working Group

Engine Nacelle Halon Replacement, Presented by Mr. Richard Hill for Douglas Ingerson, Engineer Federal Aviation Administration, WJ Hughes Technical Center, Fire Safety Branch, April 16-17 2007, London UK.

— — — — — — — —

APPENDIX B

LIST OF MEMBERS OF INTERNATIONAL AIRCRAFT SYSTEMS FIRE PROTECTION WORKING GROUP

INDUSTRY MEMBERS:

Aerojet
Air Liquide
Airline Pilots Association
American Pacific
Ameron Global Inc.
Aviation Safety Facilitators
Boeing Commercial Airplane Group
Bombardier Aerospace
British Airways
Darchem Engineering
DuPont Fluoroproducts
EMBRAER
Fenwal Safety Systems
FR-Hitemp Ltd.
Goodrich Aerospace
Gulfstream Aerospace Corporation
Hamilton Sundstrand
Hughes Associates, Inc.
Inno-Chem GmbH
International Aero Inc.
Kidde Graviner
Life Mist Technologies
Lockheed Martin
Lyontech Engineering
Ocean Optics
Percival Aviation
Pingo Erzeugnisse GmbH
Powsus LLC
Pyroalliance
RemTech International
Rutgers University
Sandia National Laboratories
Siemens
Southwest Sciences
SURVICE Engineering Company
Total Fire Protection
Zin Technologies
3M
AGC Chemicals America
Airbus Industries
Alenia Aeronautica Finmeccanica Group
American-Pacific Halotron Inc.
Autronics Corporation
BAE Systems
Boeing Phantom Works
Booz-Allen & Hamilton, Inc.
Curtiss Wright
Drager Aerospace GmbH
Eaton Aerospace
European Aeronautic Defense and Space Company
Firetrace International
GE Aircraft Engines
Great Lakes Chemical Corporation
Halon Alternatives Research Corporation
Honeywell Engine System & Services
Information Network Systems, Inc.
Institute for Defense Analyses
Kidde Aerospace
Latecoere
Litton Life Support
Lufthansa Technik
Meggitt Safety Systems, Inc.
Parker Aerospace
Phyre Technologies, Inc.
Politecnico Al Italiano
Praxair, Inc.
Redbrooks Laboratory
RGW Cherry and Associates Ltd.
Safety Hi-Tech
Shaw Aero Devices, Inc.
Smiths Aerospace
SR-Technics
The George Washington University
Underwriters Laboratories, Inc.

GOVERNMENT ORGANIZATIONS:

NASA Glenn Research Center
Royal Australian Air Force
United Kingdom Ministry of Defense
United States Air Force
United States Naval Air Systems Command
United States Department of Defense

AUTHORITY MEMBERS:

Direction Generale de l'Aviation Civile - France
National Civil Aviation Agency - Brazil
United Kingdom Civil Aviation Authority
Joint Aviation Authorities of Europe
Transport Canada Civil Aviation
United States Environmental Protection Agency

— END —