



**UPDATE ON THE DEVELOPMENT OF  
HALON ALTERNATIVES  
FOR FIRE SUPPRESSION SYSTEMS<sup>1</sup>  
(INFORMATION RELATED TO A39-WP/36)**

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<sup>1</sup> This material is available in English only.

## **UPDATE ON THE DEVELOPMENT OF HALON ALTERNATIVES FOR FIRE SUPPRESSION SYSTEMS**

### **1. Lavatory Systems**

1.1 Halon replacement agents for aircraft lavatory fire protection systems that meet the criteria for space and weight are now available and cost the same or less than the halon extinguishers being replaced. Aircraft manufacturers have begun installing halon replacement agents in aircraft lavatories; these installations are considered to be a “drop in” replacement. The International Coordinating Council of Aerospace Industries Associations (ICCAIA) reported that the 2011 halon replacement timeframe called for in Assembly Resolution A37-9 have been met in new type design. For additional information on halon alternatives for use in lavatory extinguishing systems, please refer to Table 1 below.

### **1.2 Handheld fire extinguishers**

1.2.1 Three halon alternatives (HFC-227ea, HFC-236fa, and HCFC Blend B) are currently available for use in aviation. However, they have weight and volume penalties that present installation and operation challenges. Two of the alternatives are hydrofluorocarbons (HFC-236fa and HFC-227ea) and have global warming potential (GWP) greater than Halon 1211 and are designated greenhouse gases under the Kyoto Protocol. The third alternative agent for handhelds, HCFC Blend B-123, has a lower ozone depleting potential (ODP) than Halon 1211, but national regulations may limit its use. Based on these issues, airframe manufacturers may choose not to pursue further testing and certification for installation of these alternatives. A fourth promising halon replacement agent known as 2-bromotrifluoropropene (2BTP) is awaiting final approval for manufacture in the United States. ICCAIA reported that there is likely to be a 2-year slippage in meeting the 2016 halon replacement timeframe called for in Assembly Resolution A37-9. For additional information on halon alternatives for use in handheld fire extinguishing systems, please refer to Table 2 below.

### **1.3 Engine nacelle/auxiliary power unit (APU) extinguishers**

1.3.1 Four potential halon alternatives, HFC-125, Novec 1230 (FK-5-1-12), FIC-131I and Powdered Aerosol F have been tested to the draft version of the Minimum Performance Standards (MPS) for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems (MPSe)<sup>5</sup> and Halon 1301 equivalent minimum extinguishing concentrations were determined. However, further research and development is needed with Novec 1230 and FIC-131I. An engine nacelle/APU system using FK-5-1-12 was developed but it failed an FAA required live fire test using a cold soaked fire protection agent to simulate low temperature use. Also, an engine nacelle/APU system based on the use of Powdered Aerosol F failed an Federal Aviation Administration (FAA)-required full-scale engine fire test that was a supplemental requirement to the MPSe. Further work continues on both of these systems. Despite the fact that HFC-125 has a relatively high global warming potential (GWP) and has increased space and weight requirements that present installation and operational considerations, it is still successfully used by the United State military and there is currently no prohibition on its use in aviation.

1.3.2 Concerns have been expressed as to the ability of industry to meet the requirements of Annex 8 — *Airworthiness of Aircraft* for halon replacements in new aircraft design by 31 December 2014 due to setbacks in the development of Novec 1230 and Powdered Aerosol F systems.

1.3.3 To address these concerns and challenges based on the delays experienced with Novec 1230 and Powdered Aerosol F systems which have been under research and development for several years, an Engine Nacelle/APU Halon Alternatives for Aircraft Propulsion Systems (HAAPS) Consortium is in the process of finalizing a collaboration agreement to coordinate the efforts of industry in developing a suitable replacement agent or agents. The consortium is expected to complete its work in 2018. The only alternative agent available today which have passed the MPS<sup>1</sup> testing and the SNAP<sup>3</sup> assessment is HFC-125. For additional information on halon alternatives for use in engine nacelle/APU extinguishing systems, please refer to Table 3 below.

#### **1.4 Cargo compartment**

1.4.1 Research and development for halon replacement in cargo compartment fire suppression systems is on-going. To date, there are no agents identified that could be used in cargo compartment fire suppression systems. Two promising concepts using the mixture of CO<sub>2</sub>/nitrogen and water mist/nitrogen that are able to meet the updated MPS<sup>1</sup> requirements are being developed. However, the concepts require significant development and acceptance due to their weight and volume penalties. In conclusion, more research is needed in the development of halon alternatives for cargo compartments. For additional information on halon alternatives for use in cargo compartment fire suppression systems, please refer to Table 4 below.

1.4.2 The establishment of a timeframe for the replacement of halon in cargo compartment fire suppression systems has been achieved. During the last ICAO International Halon Replacement Coordinating Meeting (IHRCM/3), an approach was agreed upon to establish the Cargo Compartment Halon Replacement Working Group (CCHRWG) under the umbrella of ICCAIA involving the major aircraft OEMs. ICCAIA accepted the CCHRWG's terms of reference and work commenced on the implementation of the mandate. CCHRWG coordinated a collaborative approach involving all stakeholders and developed an industry recommendation for a halon replacement timeframe for cargo compartment fire suppression systems.

1.4.3 The CCHRWG started looking at technology-readiness timeline and following definite steps, ICCAIA proposed in its working paper a timeframe for "the replacement of halon in cargo compartment fire suppression systems". ICCAIA reported that the recommendation to ICAO was based on industry expectations that a non-halon cargo compartment fire suppression system will be available for new aircraft designs in approximately nine years. Therefore, a deadline for new Type Certification application submittal on or after 31 December 2024 was recommended by the CCHRWG with no retrofit of existing halon systems.

**TABLE 1 – EXAMPLES OF POTENTIAL HALON ALTERNATIVES FOR USE IN LAVATORY EXTINGUISHING SYSTEMS APPLICATION**

<b>Lavatory (Halon 1301)</b>				
<b>Annex Date requirements</b>				<b>Industry Acceptance</b>
Currently produced aircraft after 31 December 2011				✓
<b>Chemicals</b>	<b>MPS<sup>1</sup></b>	<b>EU ECHA/ REACH registered<sup>2</sup></b>	<b>US EPA SNAP/TSCA approved<sup>3</sup></b>	<b>Concern / comments</b>
Halon 1301	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>- According to the estimation of UNEP, halon 1301 will run out between 2034-2045. [d]</li> <li>- This application has the smallest use of halon estimated to be less than 0.5% of its total installed base on aircraft. [d]</li> </ul>
(HFC-227ea)	✓		✓	<ul style="list-style-type: none"> <li>- Cost the same or less than the halon extinguisher being replaced. [e]</li> <li>- New production aircraft (Boeing) are installed with non-halon lavatory systems that contain HFC-227ea. [e]</li> <li>- Bombardier and Embraer are replacing halon from the lavatory fire extinguishers on newly produced aircraft, as of January 2013. [b]</li> <li>- Some airlines (Lufthansa) are replacing existing Halon 1301 lavatory systems with these alternative systems during scheduled maintenance operations after ensuring that installation certification has been approved. [e]</li> <li>- ICAO Resolution A37-9 and amendments to Annexes 6 and 8 of the Chicago Convention requiring the use of halon replacements in lavatories for new production aircraft by December 31, 2011 and for new designs by December 31, 2014 have largely been met. [e]</li> </ul>
(HFC-236fa)	✓		✓	<ul style="list-style-type: none"> <li>- Cost the same or less than the halon extinguisher being replaced. [e]</li> <li>- New production aircraft / in service (Airbus) are installed with non-halon lavatory systems that contain HFC-236fa. [e]</li> <li>- Bombardier and Embraer are replacing halon from the lavatory fire extinguishers on newly produced aircraft, as of January 2013. [b]</li> <li>- Some airlines are replacing existing Halon 1301 lavatory systems with these alternative systems during scheduled maintenance operations after ensuring that installation certification has been approved. [e]</li> </ul>

**TABLE 2 – EXAMPLES OF POTENTIAL HALON ALTERNATIVES FOR USE IN HANDHELD EXTINGUISHING SYSTEMS APPLICATION**

<b>Handheld (Halon 1211)</b>				
<b>Annex Date requirements</b>				<b>Industry Acceptance</b>
New aircraft type designs after 31 December 2016				✓
<b>Chemicals</b>	<b>MPS<sup>1</sup></b>	<b>EU ECHA/ REACH registered<sup>2</sup></b>	<b>US EPA SNAP/TSCA approved<sup>3</sup></b>	<b>Concern / comments</b>
Halon 1211	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>- According to United Nation Environmental Programme (UNEP), no shortage of Halon 1211 has been reported and thus, shortage will not be an issue for a short term.</li> </ul>
Halotron 1 (HCFC Blend B)	✓	✓	✓	<ul style="list-style-type: none"> <li>- Meet the MPS for UL 5BC rating<sup>4</sup>. [f]</li> <li>- Already available on the market, there are already larger fire extinguishers for ratings higher than 5BC. [f]</li> <li>- Subject to future Ozone Depleting Substance (ODS) restrictions. [b] [e]</li> <li>- Has increased space and weight characteristics that present installation and operational considerations. [e]</li> <li>- Has environmental and toxicity concerns. [e]</li> </ul>
(HFC-236fa)	✓	✓	✓	<ul style="list-style-type: none"> <li>- Meet the MPS for UL 5BC rating. [f]</li> <li>- Already available on the market, there are already larger fire extinguishers for ratings higher than 5BC. [f]</li> <li>- One aircraft manufacturer having applied for approval of a HCF-236fa (= DuPont FE-36) fire extinguisher. [f]</li> <li>- Considerable GWP. [f]</li> <li>- Subject to future production phase-down of HFCs. [b] [e]</li> <li>- Has increased space and weight characteristics that present installation and operational considerations. [e]</li> <li>- Has environmental and toxicity concerns. [e]</li> </ul>
(HFC-227ea)	✓	✓	✓	<ul style="list-style-type: none"> <li>- Meet the MPS for UL 5BC rating</li> <li>- Already available on the market, there are already larger fire extinguishers for ratings higher than 5BC. [f]</li> <li>- Considerable GWP. [f]</li> <li>- Subject to a production phase-down of HFCs. [b] [e]</li> <li>- Has increased space and weight characteristics that present installation and operational considerations. [e]</li> <li>- Has environmental and toxicity concerns. [e]</li> </ul>

2-BTP	✓	✓	*	<ul style="list-style-type: none"> <li>- Not currently listed as a greenhouse gas or an ozone depleting substance. [e]]</li> <li>- Potential to be a near “drop-in” replacement with minimal space and weight impact for some aircraft. [e]]</li> <li>- Limited supply chain (Status 2014). [b]]</li> <li>- Uncertainties in agent and equipment availability. [f]]</li> <li>- It is European Union (EU) <b>Registration</b>, Evaluation, Authorisation and Restriction of Chemicals (REACH) registered and proving to be a promising agent without GWP impact and minor weight and volume penalty. [f]]</li> <li>- U.S EPA review of the applications under the Toxic Substances Control Act and the Significant New Alternatives Policy (SNAP) is not yet completed. [e]]</li> <li>- The industry is already working on supply chain coordination and aircraft manufacturer implementation. [e]]</li> </ul>
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**TABLE 3 – EXAMPLES OF POTENTIAL HALON ALTERNATIVES  
FOR USE IN ENGINE NACELLE /APU EXTINGUISHING SYSTEMS APPLICATION**

Engine nacelle /APU (Halon 1301)				
Annex date requirements				Industry Acceptance
New type designs submitted after 31 December 2014				✓
Chemicals	MPSe <sup>5</sup>	EU ECHA/ REACH registered <sup>2</sup>	US EPA SNAP/TSCA approved <sup>3</sup>	Concern / comments
Halon 1301	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>- According to the estimation of UNEP, halon 1301 will run out between 2034-2045.</li> <li>- Rise in price due to decreasing supply. [e]]</li> </ul>
HFC-125	✓	✓	✓	<ul style="list-style-type: none"> <li>- Already used by military. [c]] [e]]</li> <li>- Significant weight and volume penalty. [c]]</li> <li>- Considerable GWP. [b]]</li> <li>- Subject to a production phase-down of HFCs. [d]]</li> <li>- Currently being developed for use on a military derivative of a large commercial aircraft (Boeing 767; military derivative KC-46). [e]]</li> </ul>
Novec 1230 (FK-5-1-12)	✓	✓	✓	<ul style="list-style-type: none"> <li>- Failed an FAA required live fire test using a cold soaked agent and distribution system. [c]] [e]]</li> <li>- The system needs further development. [e]]</li> </ul>
FIC-1311(CF3I)	✓	✓	✓	<ul style="list-style-type: none"> <li>- Toxicity concerns. [c]]</li> </ul>
Powdered Aerosol F	✓	<b>In progress</b>	✓	<ul style="list-style-type: none"> <li>- Failed an FAA required full-scale engine fire test that was a supplemental requirement to the MPSe. [e]]</li> <li>- The system needs further development. [e]]</li> </ul>

**TABLE 4 – EXAMPLES OF POTENTIAL HALON ALTERNATIVES  
FOR USE IN CARGO COMPARTMENT FIRE SUPPRESSION SYSTEMS APPLICATION**

Cargo (Halon 1301)				
Annex date requirements				Industry Acceptance
No standard developed for the replacement of halon in cargo compartment fire suppression systems				
Chemicals	MPS <sup>1</sup>	EU ECHA/ REACH registered <sup>2</sup>	US EPA SNAP/TSCA approved <sup>3</sup>	Concern / comments
Halon 1301				<ul style="list-style-type: none"> <li>- According to the estimation of UNEP, halon 1301 will run out between 2034-2045. [d)]</li> <li>- Rise in price due to decreasing supply. [e)]</li> </ul>
CO <sub>2</sub> /nitrogen	✘	✘	✘	- Requires significant development and acceptance. Still a concept. [c)]
Water Mist/Nitrogen gas hybrid System concept	✓	✘	✘	<ul style="list-style-type: none"> <li>- This hybrid system represents significant installation and operational challenges. [e)]</li> <li>- Design changes within the cargo compartment may be necessary to prevent water damage to aircraft systems and structures. [e)]</li> <li>- Certification of non- gaseous systems is still an open issue</li> </ul>
Water Mist	✘	✘	✘	- Cannot prevent an aerosol can explosion

**Notes**

<sup>1</sup> Minimum performance standards (**MPS**) define full-scale fire tests to demonstrate that a replacement agent is equivalent to halon in terms of fire extinguishment/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. MPS are developed by the International Aircraft System Fire Protection Working Group (IASFPWG) formerly known as the International Halon Replacement Working Group (IHRWG), along with certification requirements from airworthiness authorities. The working group is tasked to develop MPS for fire-extinguishing applications regarding non-halon aircraft fire suppression agents/systems in cargo compartments, engine nacelles, handheld (portable) extinguishers, and lavatory waste receptacles. The IASFPWG is international in scope, with active participation by the aviation industry, agent suppliers, extinguishing system companies, the international regulatory authorities and other interested parties.

<sup>2</sup> Registration, Evaluation, Authorisation and Restriction of Chemicals (**REACH**) is a European Union regulation adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals.

<sup>3</sup> Significant New Alternatives Policy (**SNAP**) programme is established by the United States Environmental Protection Agency (EPA) to identify and evaluate substitutes in end-uses that have historically used ozone-depleting substances (ODS).

<sup>4</sup> Underwriters Laboratory (UL) All Fire Extinguishers are tested by the Underwriters Laboratory for safety and performance and rated. The rating itself have a reference to the type of fire in which they can be used and a numerical evaluation on the effectiveness against that type of fire. The combination of the letters and numbers associated with those letters are the indicator of the size/intensity of the fire it can be effective against.

<sup>5</sup> Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems (MPSe) describes the conditions an aviation entity must satisfy to acceptably use an alternate material to replace Halon 1301. MPS are developed by the International Aircraft System Fire Protection Working Group (IASFPWG) formerly known as the International Halon Replacement Working Group (IHRWG) along with certification requirements from airworthiness authorities. The working group is tasked to develop MPS for fire-extinguishing applications regarding non-halon aircraft fire suppression agents/systems in cargo compartments, engine nacelles, handheld (portable) extinguishers, and lavatory waste receptacles. The IASFPWG is international in scope, with active participation by the aviation industry, agent suppliers, extinguishing system companies, the international regulatory authorities and other interested parties.

## **References**

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- [f)] **STATUS OF RESEARCH & TESTING TO REPLACE HALON EXTINGUISHING AGENTS IN CIVIL AVIATION.**  
<http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwjLpcCGpv3KAhUCdz4KHQzhC28QFggsMAE&url=http%3A%2F%2Fwww.nfpa.org%2F~%2Fmedia%2Ffiles%2Fresearch%2Fresearch-foundation%2Ffoundation-proceedings%2Fingerson.pdf%3Fla%3Den&usg=AFQjCNFbAIQ8Aj2xYCI1MW0eZK1iEYV9g&sig2=d4m6zA7BT8-zgZqQbzCjXw>
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