b. The fire extinguisher bottle containing the simulant is pressurised with nitrogen in an identical manner required by the Halon 1301 charge weight.

c. The simulant is discharged into the test environment, i.e. cargo compartment.

9.1 Pre-Test Considerations:

a. An EASA accepted analyser (for example, Statham-derivative analyser) capable of measuring the simulant distribution profile in the form of volumetric concentration is required.

b. An EASA accepted analyser (for example, Statham-derivative analyser) and associated hardware are configured for the particular application.

c. The fire suppression system should be completely conformed for Halon 1301.

d. The fire extinguisher bottle(s) should be serviced and prepared for the prescribed test(s).

9.2 Test Procedures:

a. Perform the prescribed distribution test in accordance with the EASA approved test plan. See Paragraph 7 for guidance on probe placement.

b. An EASA accepted analyser (for example, Statham-derivative analyser) should record the distribution profile as volumetric concentration for the simulant.

9.3 Test Result Evaluation:

a. Produce the data from the EASA accepted analyser (for example, Statham-derivative analyser) in graphical format. This format should be the volumetric concentration of the simulant versus time. A specific percent volumetric initial concentration and a specific percent volumetric metered concentration for the length of the test duration as determined by previous testing conducted per the established minimum performance standards is required for airworthiness approval of cargo compartment systems.

b. Using the Halon 1301 certification criteria, evaluate the distribution profile of the simulant for acceptable performance. The acceptability of the test data would be dependent upon the distribution profile and duration exhibited by each probe (See above and Paragraph 7 for cargo compartment fire extinguishing systems).

10. ESTABLISHING DURATION FOR THE SUPPRESSION SYSTEM.

The adequacy of the capacity of the “built-in system” is understood to mean, that there is sufficient quantity of agent to combat the fire anywhere where baggage and cargo is placed within the cargo compartment for the time duration required to land and evacuate the aeroplane. Current built-in cargo fire extinguishing systems utilise Halon 1301 as the fire extinguishing agent. Protection is afforded as long as the minimum concentration levels in the cargo compartment do not drop below three percent by volume. The time for which a suppression system will maintain the minimum required concentration levels should be identified as a certificate limitation.

The designer of the product should work with the aircraft owner and the competent authority providing operational approval to ensure that the cargo fire extinguishing system provides the required protection time (i.e., proper sizing of the cargo fire extinguishing system) for the specific route structure. The competent authority may insist on some holding time to allow for weather and other possible delays, and may specify the speeds and altitudes used to calculate aeroplane diversion times based on one-engine-out considerations.

The competent authority providing operational approval for the aeroplane determines the maximum allowable time, following the discovery of a fire or other emergency situation, required to divert the aeroplane to an alternate landing site. In the past, for some cases, the maximum allowable time was calculated by adding a 15 minute allowance for holding and/or approach and landing to the actual time required to reach the alternate landing site under specific operating conditions. With the issuance of this AMC, an allowance of 15 minute for approach and landing must be considered and certification data must include analysis and/or data taken after landing at a time increment which represents the completion of an evacuation of all occupants.

AMC 20-6 "Extended Range Operation with Two-Engine Aeroplanes (ETOPS)," provides acceptable means for obtaining approval under applicable operational rules for two-engine aeroplanes operating over a route that contains a point farther than one hour's flying time at the normal one-engine inoperative cruise speed (in still air) from an adequate airport. It includes specific criteria for deviations of 75 minutes, 120 minutes, and 180 minutes from an adequate airport plus an allowance for 15-minute holding and/or approach and land.

Certification flight tests, supplemented by analysis for cargo load factors and additional metering system bottles as applicable, determines the maximum protection time provided by the cargo fire extinguishing system. This maximum protection time may not be the same as the maximum allowable time required to divert the aeroplane. The certificate limitation for total time, including the 15 minute allowance for holding and/or approach and landing as applicable, should never be greater than the maximum protection time provided by the cargo fire extinguishing system.

The following examples illustrate these issues:

<u>Example 1</u>

Maximum protection time provided

By cargo fire extinguishing system	= 127 minutes
Maximum diversion time	= 112 minutes + 15 minutes

(Note - in this example, the civil aviation authority required an allowance of 15 minutes for holding and/or approach and landing)

Certificate limitation for total time	= 127 minutes

<u>Example 2</u>

Maximum protection time provided

By cargo fire extinguishing system	= 68 minutes
Maximum diversion time	= 60 minutes

(Note - in this example, the civil aviation authority did not require the 15 minutes allowance for holding and/or approach and landing. With the issuance of this AMC, the approach indicated in example 2 above is no longer considered an acceptable means of compliance.)

Certificate limitation for total time	= 60 minutes"

11. MANUAL CONSIDERATIONS.

To ensure fire protection/fire suppression system effectiveness and safe continuation of flight and landing, the applicable aeroplane manuals should contain appropriate directives, for example:

a. Any procedures related to fighting a cargo compartment fire should be clearly defined in the Aeroplane Flight Manual (AFM).

b. Aeroplane Flight Manuals should contain instructions to land at the nearest adequate airport (or suitable airport for ETOPS) following detection of a cargo fire.

c. Cargo loading restrictions (certified type of loading per compartment, limits for loading heights and width, etc.) should be clearly described in the Weight & Balance Manual or any other appropriate aeroplane manual.

d. Where the use of aeroplane manuals is considered to be impractical during cargo loading activities, all necessary information may be introduced into crew operating manuals or part of dedicated instructions for cargo loading personnel.

12. PLACARDS AND MARKINGS IN CARGO COMPARTMENTS

Experience has shown that under certain circumstances and despite clear instructions in the applicable aircraft documentation, cargo loading personnel may not obey loading restrictions. Especially pallets may be loaded higher than certified or bulk cargo may be stowed up to the ceiling, adversely affecting smoke detection and fire protection/fire suppression system effectiveness.

To visually indicate the applicable loading restrictions to each person being responsible for cargo loading activities in a compartment, placards and markings for certified type of cargo, maximum loading height and widths may need to be installed in that compartment.

For the design of these indications (i.e., for shape, size, colour and brightness), illumination conditions in the compartment should be considered. Markings and placards should not be easily erased, disfigured or obscured. Further guidance may be derived from compliance demonstrations for CS paragraphs regulating other internal markings and placards, for example in the cockpit or passenger compartment.

[Amdt 25/4]
[Amdt 25/12]

Appendix 1: Analytical methods for determining Halon 1301 concentration levels

ED Decision 2007/020/R

1. PURPOSE. This appendix contains analytical methods for determining Halon 1301 fire extinguishing agent concentration levels in empty or loaded cargo compartments as a function of time.

2. EXPLANATION OF TERMS AND SYMBOLS.

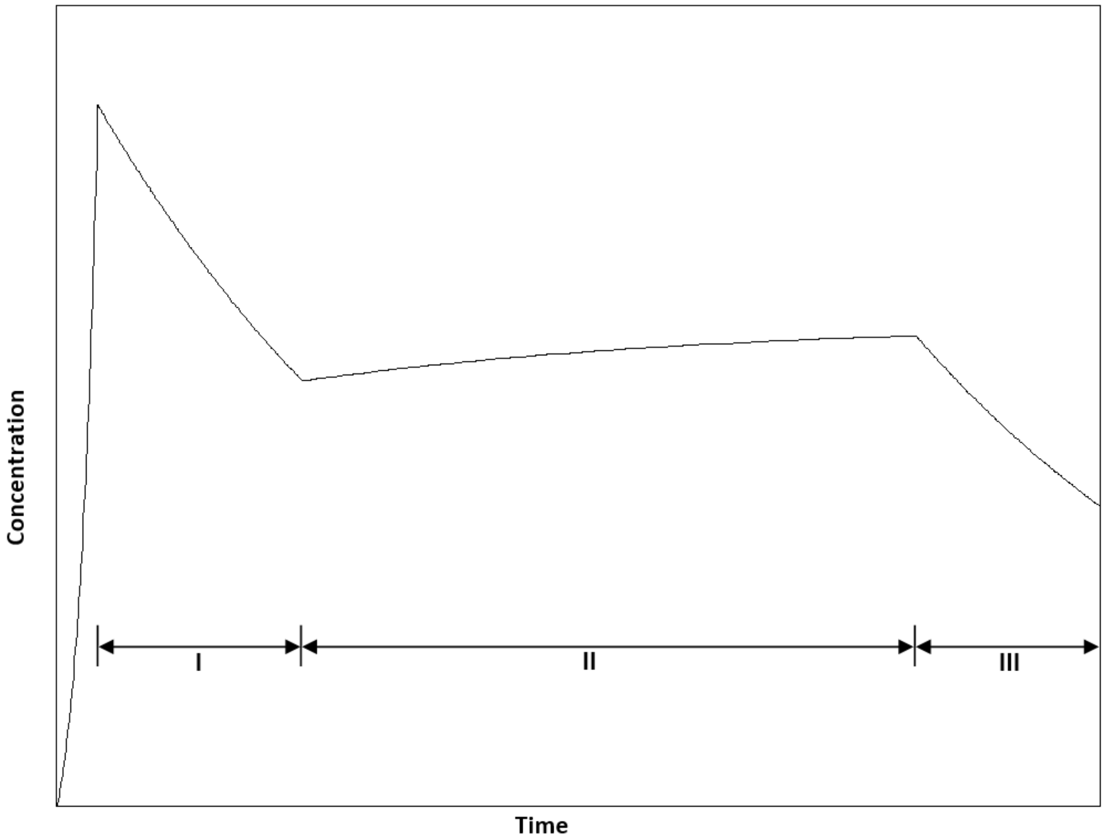
TABLE 2-1. TERMS AND SYMBOLS

SYMBOL	DESCRIPTION	UNITS CONSISTENT WITH EQUATIONS
C(t)	Halon 1301 concentration by volume at time "t." $= V_{Halon\ 1301} / V$	Dimensionless
$V_{Halon\ 1301}$	Volume of Halon 1301 in cargo compartment.	Cubic metre - m^3 (Cubic feet - ft^3)
V	Cargo compartment free volume (i.e., volume not occupied by cargo). $= 1 - (V_{cargo} / V_{empty})$	Cubic metre - m^3 (Cubic feet - ft^3)
V_{cargo}	Cargo volume.	Cubic metre - m^3 (Cubic feet - ft^3)
V_{empty}	Empty cargo compartment volume.	Cubic metre - m^3 (Cubic feet - ft^3)
T	Time.	Minutes – Min
E	Cargo compartment leakage rate.	Cubic metre per minute - m^3/min (Cubic feet per minute - ft^3/min)
S	Specific volume of Halon 1301.	Cubic metre per kilogram m^3/kg (cubic feet per pounds(mass) ft^3/lbm)
R	Halon 1301 flow rate.	Kilogram per minute kg/min (pounds(mass) per minute lbm/min)

3. HALON 1301 CONCENTRATION LEVEL MODEL.

   Cargo compartment fire extinguishing systems generally use a combination of one or two types of Halon 1301 discharge methods. One type rapidly releases all of the fire extinguishing agent from one or more pressurised bottles into the cargo compartment. This type of discharge method is commonly known as a high rate discharge or 'dump' system.

FIGURE 3-1. EXAMPLE - HALON 1301 MODEL



The second type of Halon 1301 discharge method slowly releases the fire extinguishing agent from one or more pressurised bottles into the cargo compartment. This type of discharge method is commonly known as a metering system.

The following list provides some examples, not all-inclusive, of different combinations of these Halon 1301 discharge methods.

a. One high rate discharge.

b. One high rate discharge followed by a second high rate discharge at a specified later time.

c. One high rate discharge followed by a metered discharge at a specified later time.

d. Simultaneous high rate and metered discharges.

The Halon 1301 fire extinguishing system described in paragraph 3.c. above utilises both types of discharge methods and is illustrated in Figure 3-1.

Prior to Phase I - Initial High Rate Discharge of Halon 1301

This portion of the extinguishing process illustrates the high rate discharge method of releasing all of the fire extinguishing agent from one or more pressurised bottles into the cargo compartment.

Phase I - Exponential "Decay" of Halon 1301

The beginning of Phase I represents the initial concentration of Halon 1301 used to knock down a cargo fire. Since no more Halon 1301 is introduced into the cargo compartment during Phase I, the concentration of Halon 1301 undergoes an exponential "decay" versus time.

The governing equation for exponential "decay" during Phase I is the following:

$C(t) = C(0)\, e^{-E\,t/V}$

NOTE - C(0) is the initial concentration of Halon 1301 used to knock down a cargo fire at the beginning of Phase I and t is the time elapsed since the beginning of Phase I.

Phase II - Metered Discharge of Halon 1301

The metered discharge of Halon 1301 starts at the beginning of Phase II. The example in Figure 3-1 shows that the metering rate is set to release Halon 1301 into the cargo compartment at a rate which is slightly greater than the rate Halon 1301 is lost through cargo compartment leakage.

The governing equation for metering during Phase II is the following:

$C(t) = [\, C(0) - \{ R\,S / E \}\,]\, e^{-E\,t/V} + \{ R\,S / E \}$

NOTE - C(0) is the concentration of Halon 1301 at the end of Phase I and t is the time elapsed since the end of Phase I.

Phase III - Exponential "Decay" of Halon 1301

The beginning of Phase III marks the end of Halon 1301 metering. As in Phase I, since no more Halon 1301 is introduced into the cargo compartment, the concentration of Halon 1301 undergoes an exponential "decay" versus time.

The governing equation for exponential "decay" during Phase III is the same as during Phase I with one exception; C(0) is the concentration of Halon 1301 at the end of Phase II and t is the time since the end of Phase II."

[Amdt 25/4]

AMC 25.851(c) Alternative fire-extinguishing agents

ED Decision 2012/008/R

1. General

The Montreal Protocol, in existence since 1987, is an international agreement to phase out production and use of ozone-depleting substances, including halogenated hydrocarbons also known as Halon. The Montreal Protocol prohibits the manufacture or import of new Halon in all developed countries as of 1 January, 1994. The US Environmental Protection Agency (EPA) has released a regulation banning the intentional release of Halons during repair, testing, and disposal of equipment containing Halons and during technician training. However, the EPA has provided the aviation industry an exemption from their ban on the intentional release of Halon in determining compliance with airworthiness standards. A European regulation[1] governing substances that deplete the ozone layer was also published, containing initial provisions for Halon phase-out, but also exemptions for critical uses of Halon, including fire-extinguishing in aviation. It should be noted that the exemptions were predicated on the basis that there were, at that time, no suitable alternate agents or systems available for use on commercial transport category aeroplanes.

[1] Regulation (EC) No 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer.

'Cut-off' dates (i.e. Halon no longer acceptable in new applications for type certification) and 'end' dates (i.e. Halon no longer acceptable for use in aircraft) have been subsequently established by a new regulation in 2010[1], as presented in Table 4.1 below:

Table 4.1: 'Cut-off' and 'end' dates

Aircraft compartment	Type of extinguisher	Type of Halon	Dates	
			Cut-off	End
Inerting of fuel tanks	Fixed	1301 2402	31 December 2011	31 December 2040
Lavatory waste receptacles	Built-in	1301 1211 2402	31 December 2011	31 December 2020
Dry bays	Fixed	1301 1211 2402	31 December 2011	31 December 2040
Cabins and crew compartments	Hand (portable)	1211 2402	31 December 2014	31 December 2025
Propulsion systems and Auxiliary Power Units	Built-in	1301 1211 2402	31 December 2014	31 December 2040
Normally unoccupied cargo compartments	Built-in	1301 1211 2402	31 December 2018	31 December 2040

2 Lavatory extinguishing systems and agents

Historically, Halon 1301 has been the most widespread agent used in lavatory extinguishing (lavex) systems, to be used in the event of a Class A fire. Any alternative acceptable fire-extinguishing agent meeting the Minimum Performance Standards (MPS) laid down in Appendix D to Report DOT/FAA/AR-96/122 of February 1997, which includes the ability to extinguish a Class A fire and, in case of discharge, does not create an environment that exceeds the chemical agent's 'No Observable Adverse Effect Level' (NOAEL) will be acceptable. Research and testing have shown that there are suitable alternatives to Halon for built-in fire extinguishers in aircraft lavatories meeting the MPS for effectiveness, volume, weight and toxicology. Currently HFC-227ea or HFC-236fa are widely used on large aeroplanes and usually considered acceptable by EASA.

3 Hand fire extinguishers and agents

Historically, Halon 1211 has been the most widespread agent in handheld (portable) fire extinguishers to be used in aircraft compartments and cabins. Minimum Performance Standards (MPS) for the agents are laid down in Appendix A to Report DOT/FAA/AR-01/37 of August 2002, while acceptable criteria to select the fire extinguishers containing said agents are laid down in the FAA Advisory Circular AC 20-42C. Version D of the same AC (published in 2011) would be preferred when the needed supporting guidance material has been released. Three agent alternatives to Halon are presently known meeting the MPS: HFC-227ea, HFC-236fa and HFC Blend B. However, these agents are significantly heavier and occupy a greater volume than Halon 1211. This may indirectly (i.e. additional weight of the fire extinguisher and additional weight of the structures supporting it) increase CO2 emissions. Furthermore, some of these

[1] Commission Regulation (EU) No 744/2010 of 18 August 2010 amending Regulation (EC) No 1005/2009 of the European Parliament and of the Council on substances that deplete the ozone layer, with regard to the critical uses of halon (OJ L 218, 19.8.2010, p. 2).

agents have also been identified as having a global warming potential much higher than Halon. Therefore, further research is underway to develop additional alternatives to Halon 1211 for hand fire extinguishers.

Should an applicant wish to propose, even before the end of 2014, any alternative agent for hand fire extinguishers meeting the mentioned MPS, the EASA will initiate a Certification Review Item addressing the use of such an alternate fire-extinguishing agent.

4 Fire protection of propulsion systems and APU

Historically, Halon 1301 has been the most widespread agent used in engine nacelles and APU installations to protect against Class B fires. The MPS for agents to be used in these compartments are particularly demanding because of the presence of fuel and other volatile fluids in close proximity to high temperature surfaces, not to mention the complex air flows and the extremely low temperatures and pressures surrounding the nacelles. Various alternatives are being developed (e.g. FK-5-1-12). The FAA has issued "Minimum Performance Standards (MPS) for Halon replacement in fire-extinguishing agents/systems of civil aircraft engine and APU compartments (MPSHRe rev03)" and intends to issue rev04.

Should an applicant wish to propose, even before the end of 2014, any alternative agent for Class B fire extinction in engine or APU compartments, even in the absence of a published MPS, the EASA will initiate a Certification Review Item addressing the use of such an alternate fire-extinguishing agent.

5 Fire protection of cargo compartments — Gaseous agents

MPS for cargo compartment fire suppression systems have already been published in the Report DOT/FAA/AR-00/28 of September 2000. However, to date there are no known and sufficiently developed alternatives to Halon 1301.

Should the EASA be approached with the intent to utilise for the product an alternate agent or alternate gaseous fire-extinguishing system in lieu of a Halon 1301 system, then the recommended approach would be to perform testing on the product which meets the Minimum Performance Standards for that application as developed by the International Halon Replacement Working Group. The International Halon Replacement Working Group was established in October 1993. This group was tasked to work towards the development of minimum performance standards and test methodologies for non-Halon aircraft fire suppression agents/systems in cargo compartments, engine nacelles, handheld extinguishers, and lavatory waste receptacles. The International Halon Replacement Working Group has been expanded to include all system fire protection R&D for aircraft and now carries the name 'International Aircraft Systems Fire Protection Working Group'.

To ensure acceptable means of compliance, the following must be provided:

a. The test data and gaseous agent distribution profiles which meet the certification criteria as expressed below and in the Minimum Performance Standards as developed by the FAA Technical Center as part of the International Halon Replacement programme. (See paragraph 7 for the listing of the references.)

b. A system description document that includes a description of the distribution of the gaseous agent under test conditions in the cargo compartment.

c. A detailed test plan.

d. Chemical data which describes the agent and any toxicity data.

5.1 Pre-test considerations:

a. An EASA accepted analyser (for example, Statham-derivative analyser) capable of measuring the agent distribution profile in the form of volumetric concentration is required.

b. An EASA accepted analyser (for example, Statham-derivative analyser) and associated hardware are configured for the particular application.

c. The fire suppression system should be completely conformed prior to the test.

d. The fire extinguisher bottle(s) should be serviced and prepared for the prescribed test(s).

5.2 Test procedures:

a. Perform the prescribed distribution test in accordance with the test plan approved by the Agency. (See Paragraph 7 in AMC 25.851(b) for guidance on probe placement.)

b. An EASA accepted analyser (for example, Statham-derivative analyser) should record the distribution profile as volumetric concentration for the agent.

5.3 Test result evaluation:

a. Produce the data from the EASA accepted analyser (for example, Statham-derivative analyser) in graphical format. This format should be the volumetric concentration of the agent versus time. A specific percentage of volumetric initial concentration and a specific percentage of volumetric metered concentration for the length of the test duration as determined by previous testing conducted per the established Minimum Performance Standards are required for airworthiness approval of cargo compartment systems.

b. Using the appropriate MPS evaluation criteria, evaluate the distribution profile of the agent for acceptable performance. The acceptability of the test data would be dependent upon the distribution profile and duration exhibited by each probe per (1) above and Paragraph 7 for cargo compartment fire-extinguishing systems.

6. EVALUATION OF ALTERNATE LIQUID AGENT AND FIRE EXTINGUISHING/SUPPRESSION SYSTEMS

The FAA Technical Center has released a Technical Note (ref. f in paragraph 7 below) that represents the latest Minimum Performance Standards (MPS) for a water spray system. However, as mentioned within the body of the report, additional developmental testing would be needed for the product and the FAA to be approached regarding certification of such a system. Additional testing would be required to demonstrate compliance with an aerosol spray. The Technical Center continues to perform research towards identifying alternate liquid and other fire-extinguishing/suppression systems. Acceptable means of compliance for these immature systems are beyond the scope of this AMC. Future revisions of this AMC will be accomplished as soon as suitable standards are developed for these systems.

If it is proposed to use a liquid fire-extinguishing agent or system for the product, the EASA should be contacted. The EASA will initiate a Certification Review Item addressing the use of an alternate fire-extinguishing agent or system.

7. REFERENCES

a. Report No FAA-RD-71-68, Fire Extinguishing Methods for New Passenger Cargo Aircraft, dated November 1971.

b. UK Civil Aviation Authority (CAA) Paper 91003, Cargo Bay Fire Suppression, dated March 1991.

c. Report No DOT/FAA/AR-96/5, Evaluation of Large Class B Cargo Compartment's Fire Protection, dated June 1996.

d. Report No DOT/FAA/AR-96/122, Development of a Minimum Performance Standard for Lavatory Trash Receptacle Automatic Fire Extinguishers, dated February 1997.

e. Report No DOT/FAA/AR-00-28, Development of a Minimum Performance Standard for Aircraft Cargo Compartment Gaseous Fire Suppression Systems, dated September 2000.

f. Report No DOT/FAA/AR-TN01/1, Water Spray as a Fire Suppression Agent for Aircraft Cargo Compartment Fires, dated March 2001.

g. Report No DOT/FAA/AR-01/37, Development of a Minimum Performance Standard for Hand-Held Fire Extinguishers as a Replacement for Halon 1211 on Civilian Transport Category Aircraft, dated August 2002.

h. 2010 Report of the UN Halons Technical Options Committee – 2010 Assessment

i. FAA Advisory Circular AC 20-42C, Hand Fire Extinguishers for use in Aircraft, dated 07 March 1984.

j. FAA Advisory Circular AC 20-42D, Hand Fire Extinguishers for use in Aircraft, dated 14 January 2011.

[Amdt 25/12]

CS 25.853 Compartment interiors

ED Decision 2019/013/R

(See AMC 25.853)

For each compartment occupied by the crew or passengers, the following apply:

(a) Materials (including finishes or decorative surfaces applied to the materials) must meet the applicable test criteria prescribed in Part I of Appendix F or other approved equivalent methods, regardless of the passenger capacity of the aeroplane.

(b) *Reserved*

(c) In addition to meeting the requirements of sub-paragraph (a) of this paragraph, seat cushions, except those on flight crewmember seats, must meet the test requirements of part II of appendix F, or other equivalent methods, regardless of the passenger capacity of the aeroplane.

(d) Except as provided in sub-paragraph (e) of this paragraph, the following interior components of aeroplanes with passenger capacities of 20 or more must also meet the test requirements of parts IV and V of appendix F, or other approved equivalent method, in addition to the flammability requirements prescribed in sub-paragraph (a) of this paragraph:

(1) Interior ceiling and wall panels, other than lighting lenses and windows;

(2) Partitions, other than transparent panels needed to enhance cabin safety;