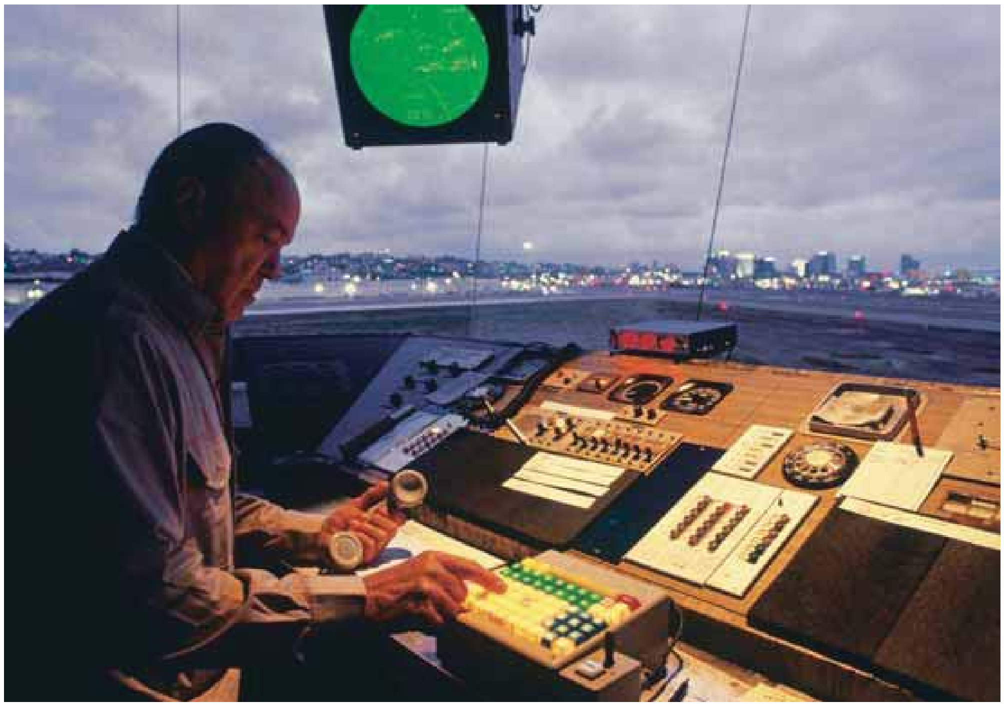
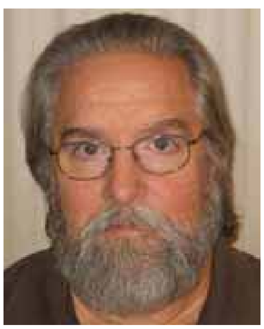
Clean Agents in Av Protection





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For more than three decades, Halon 1301 and Halon 1211 played a key role in the fire protection of airport facilities and aircraft, and they continue to provide fire protection in critical applications such as cargo bay protection. However, clean agent Halon replacements are gradually finding their way into on-board aircraft applications including engine nacelle and lavatory trash receptacle protection systems, and are ideally suited for the protection of ground-based mission critical assets.

For more than three decades, Halon 1301 (CF_3Br) and Halon 1211 (CF_2BrCl) have been widely employed for the protection of airport facilities and aircraft. The Halons are "clean" agents, leaving no corrosive or abrasive residues after their use, thus eliminating the secondary (non-fire) damage associated with extinguishing agents such as water, dry chemicals or foams. In addition, the Halons are non-conductors of electricity; hence they are applicable for the protection of electronic equipment. Halon 1211, characterised by a low vapour pressure, is most suitable as a streaming agent in flight-line applications and in portable extinguishers, whereas the more volatile Halon 1301 is best suited as a total flooding suppression agent for the protection of engine nacelles, auxiliary power units (APUs), cargo bays, control rooms and facilities housing mission critical equipment.

Due to their unique combination of chemical and physical properties, Halon 1301 and Halon 1211 served as nearly ideal fire suppression agents. However, due to their implication in the destruction of stratospheric ozone, the Montreal Protocol of 1987 identified Halon 1301 and Halon 1211 as two of numerous compounds requiring limitations of use and production, and an amendment to the original Protocol resulted in the halting of Halon production on January 1, 1994.

Clean Agent Fire Protection for Airports

Airport fire protection needs include the following:

- Control tower protection.
- Electronic control/computer room protection.
- Records storage facility protection.
- Ground incident protection.
- Flight-line protection.

Clean agents consist of two broad classes of agent: inert gas agents and halocarbon agents. Inert gas agents cannot be compressed to the liquid state, and therefore must be stored as high pressure gases. This in turn necessitates the use of high pressure storage cylinders and high pressure

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piping for inert gas systems, adding significant cost to inert gas suppression systems. The low volumetric efficiency of the inert gas agents and their inability to be stored as liquids leads to the requirement of a large number of system cylinders compared with halocarbon systems. This in turn leads to the requirement for additional storage space and increased system footprint, adding further to the cost of inert gas systems. Due to the inherent weight and volume penalties associated with inert gas systems, their use in aviation applications is limited compared with that of halocarbon clean agent systems such as hydrofluorocarbon (HFC) systems.

The halogenated agents can be stored as liquids, allowing for a much larger mass of agent to be stored in the same volume compared with inert gases, significantly reducing the number of cylinders required with these systems compared to inert gas systems. In addition, the halocarbon agents can be stored in standard low pressure cylinders and employ standard piping.

The most widely employed clean agents in aviation applications, due to their high volumetric efficiency and low weight and volume requirements, are the HFC-based clean agents HFC-227ea (FM-200) and HFC-125 (FE-25).

Control Tower Protection

Critical to the operation of any airport is the air control tower.

In the United States alone there are approximately 7,000 aircraft in the sky at any given time. Air traffic controllers are tasked to ensure the safe operation of commercial and private aircraft, and must coordinate the movements of thousands of aircraft during take-off, flight and landing, directing them around bad weather and ensuring that air traffic flows smoothly. The mission critical nature of control tower operation demands a fire protection system that provides rapid fire extinguishment and results in a minimum amount of downtime following a fire incident – clean agents are hence an ideal fire protection option.

The most widely employed clean agents for air control tower protection are FM-200 (HFC-227ea) and Inergen (blend of N_2, Ar, and CO_2). For example, the world's tallest air control tower, located at the Kuala Lumpur Airport's new terminal (KLIA2) in Malaysia, employs FM-200 systems for the protection of numerous rooms within the air control tower structure.

Electronic Control, Computer & Records Storage Room Protection

In addition to the air control tower, mission critical facilities within airports also include control rooms, computer rooms and record storage rooms. FM-200 and Inergen clean agent systems are widely employed in these facilities, providing both rapid fire extinguishment and minimum downtime in the event of a fire. Table 1 indicates a selection of the numerous airports worldwide employing FM-200 clean agent systems for the protection of control, computer and record storage rooms.

Table 1. FM-200 Clean Agent Airport Installations

Kuala Lumpur KLIA2 (Malaysia)	Barcelona Airport (Spain)
Dubai Int'l Airport (UAE)	Budget Terminal, Changi Airport
Dusseldorf Int'l Airport (Germany)	Changi Airport (Singapore)
Hanoi Int'l Airport (Vietnam)	Charles DeGaulle Airport (France)
Hong Kong Int'l Airport	Doha Int'l Airport (Qatar)
New Bangkok Int'l Airport (Thailand)	Philadelphia Int'l Airport (USA)
Phuket Airport (Thailand)	Newark Int'l Airport (USA)
Bahrain Airport (Bahrain)	San Francisco Int'l Airport (USA)

Ground Incident Protection

Ground-level fire threats include high-speed and/or high-angle ground impact incidents, low-speed and/or shallow ground impact angles, and fire incidents involving aircraft in a landing, take-off, or taxi mode. Aircraft Rescue and Firefighting (ARFF) services employ specialised vehicles to transport rescue and firefighting personnel, equipment and extinguishing agents to the scene of aircraft accidents. NFPA 403 *Standard for Aircraft Rescue and Fire Fighting Services at Airports* contains the minimum requirements for ARFF services. NFPA 403 requires ARFF vehicles to carry one or more of AFFF, fluoroprotein foam, protein foam or fluorine-free synthetic foam as a primary agent, and to carry as a complimentary agent one or both of a potassium-based agent or a halogenated agent. In most cases the halogenated agent employed is either Halon 1301 or Halon 1211.

Flight-line Protection

The parking area and maintenance hangars, where aircraft are on-loaded, off-loaded, and serviced, present significant fire protection challenges. In addition to foam-based systems, 68kg wheeled units of clean agents Halon 1211 or Halotron I (HCFC Blend B) are commonly employed in flight-line fire protection.

Minimum fire requirements for aircraft hangars are contained in NFPA 409 *Standard on Aircraft Hangars.* Although water-based systems such as deluge systems were employed in the past, NFPA 409 does not recognise these as viable systems. Foam-water deluge systems are now the norm for hangar protection.

Fire Protection for Commercial Aircraft

Typical commercial aircraft fire zones equipped with fire extinguishing systems include:

- Engine nacelle and APU.
- Lavatories.
- Crew and passenger cabins.
- Cargo and baggage compartments.

Engine Nacelle/APU

Despite the successful employment of HFC-125 by the US military in engine nacelle/APU fire protection, to date there have been no examples of the replacement of Halon 1301 in the engine nacelle or APUs of commercial aircraft, and Federal Aviation Administration (FAA) research in this area is ongoing. A minimum performance standard (MPS) for engines and auxiliary power unit compartments has been established by the FAA in cooperation with international airworthiness authorities that seeks the current level of safety provided by Halon 1301 at 6 percent volumetric concentration throughout the protected zone for a duration of one-half second.

Past FAA testing of agents including HFC-125, CF_3I, and 2-bromo-1,1,1-trifluoro-propene (2-BTP) failed to identify a suitable Halon 1301 replacement. Recent FAA engine nacelle fire testing of a solid aerosol agent failed due to agent distribution problems, and FAA testing of a perfluoroketone agent (FK-5-1-12, Novec 1230) failed due to insufficient volatilisation of the agent at low temperatures; this same low temperature behaviour led Airbus to abandon its initial plans to replace Halon 1301 in engine nacelles/APUs with FK-5-1-12.

The inability of the commercial aircraft industry to identify a Halon 1301 replacement for engine nacelle/APU protection has led to the formation of the Engine/APU Halon Replacement Industry Consortium (IC), whose goal is to define a common non-Halon fire extinguishing solution for use in engine/APU fire zones. The IC includes airframe manufacturers, system manufacturers, airworthiness authorities and agent producers. The current IC goal is to down-select to a single agent by the end of 2015.

Table 2. Military Aircraft: Clean Agent Protection

Aircraft	Fire Extinguishing System	Area Protected
F/A-18E/F Super Hornet	HFC-125	Engine nacelle/APU
	OBIGG	Dry bay; Fuel tank
F-22 Raptor	HFC-125	Engine nacelle/APU
V-22 Osprey tilt-rotor aircraft	HFC-125	Engine nacelle/APU)
	OBIGG	Dry bay; Fuel tank
H-92 helicopters	HFC-125	Engine nacelle/APU
UH-1Y helicopters	HFC-125	Engine nacelle/APU
AH-1Z helicopters	HFC-125	Engine nacelle/APU
F/A-35 Lightning II	OBIGG	Fuel tank

Lavatories

The requirement for an automatic fire extinguishing system in aircraft lavatory trash receptacles was proposed in FAA Notice 84-5 as a consequence of two incidents. The first involved a cabin fire aboard an Air Canada flight in 1983, in which 23 people perished. The second occurred in the same year at Tampa International Airport, without injuries or loss of life.

Technically feasible alternatives for Halon 1301 have been identified and tested to the FAA's Lavatory Extinguishing Unit MPS. New production aircraft are being installed with lavatory extinguishing (lavex) systems that contain either HFC-227ea or HFC-236fa. In addition, several airlines are replacing existing Halon 1301 lavex systems with HFC-227ea or HFC-236fa systems during scheduled maintenance operations.

Cabin Protection

FAA and international airworthiness regulations mandate that hand-held fire extinguishers be located in crew and passenger compartments. An MPS for handheld extinguishers has been established; the purpose of the MPS is to ensure that extinguishers using Halon replacement agents pose no reduction in safety, both in terms of effectiveness in fighting on-board fires and decomposition product toxicity. The MPS specifies Halon 1211 equivalency testing, a hidden fire test and a gasoline-drenched seat fire toxicity test.

Currently, no technical barriers exist to the replacement of Halon 1211 in this application, as HFC-227ea (FM-200), HFC-236fa (FE-36), and HCFC Blend B (Halotron I) systems have passed all of the tests required by the Handheld MPS. Despite this, there has been no replacement of Halon 1211 in handheld extinguishers on-board commercial aircraft.

Cargo & Baggage Compartments

The inability of the commercial aircraft industry to identify a Halon 1301 replacement for cargo/baggage compartment protection has led to the formation of the Cargo Compartment Halon Replacement Working Group, whose goal is to define a common non-Halon fire extinguishing solution for use in cargo/baggage compartment fire zones. The working group includes airframe manufacturers, system manufacturers, airworthiness authorities and agent producers. The current working group goal is to down-select to a single agent by the end of 2015.

Fire Protection for Military Aircraft

In contrast to the situation in the commercial aviation industry, the US military has made significant progress in replacing Halon 1301 in engine nacelle applications. Despite weight, space, and the associated cost penalties, HFC-125 has been adopted in a number of US military engine/APU applications. A Department of Defence (DOD) program has been developed that includes a design model allowing designers to calculate HFC-125 agent mass requirements for a particular engine nacelle or APU compartment. In the case of the U.S. Navy's F/A-18E/F, the mass of HFC-125 shown to meet the design challenge was found to be considerably less than that originally predicted by the DOD model.

On-board inert gas generation (OBIGG) systems have been developed and employed in military aircraft to prevent the build-up of explosive conditions in fuel tanks by generating nitrogen enriched air to lower the oxygen content in the fuel tank ullage.

Table 2 shows a selection of US military aircraft currently employing clean agents. HFC-125 is employed for engine nacelle protection in the F/A-18E/F Super Hornet, the F-22 Raptor, the V-22 Osprey tilt-rotor aircraft, and the H-92, UH-1Y and AH-1Z upgraded helicopters. Inert gas generators protect the dry bays on the V-22 Osprey and the F/A-18E/F Super Hornet. On-board inert gas generating (OBIGG) systems are employed to inert the fuel tanks of the V-22 Osprey, F/A-18E/F Super Hornet, and the F/A-35 Lightning II Joint Strike Fighter.

Conclusion

For more than three decades, the clean agents Halon 1301 and Halon 1211 have played a key role in the fire protection of airport facilities and aircraft, and the Halons continue to provide fire protection in critical applications such as cargo bay protection where no suitable replacements have been developed. Clean agent Halon replacements, especially the HFC-based agents, are gradually finding their way into on-board aircraft applications including engine nacelle and lavatory trash receptacle protection systems, and are ideally suited for the protection of ground-based mission critical electronics in airport control towers, computer rooms and control rooms. Halon 1301 and Halon 1211 are no longer produced, and as the current Halon bank continues to shrink, the use of the clean agent Halon replacements in these demanding applications is expected to increase. IFP

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