

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

Introduction

Engine and APU (Auxiliary Power Unit) compartment fire extinguishing systems are required by FAR/JAR 23.1195, 25.1195 including JAR 25A.1195, 27.1195 and 29.1195. The current fire extinguishing systems using Halon 1301 as the extinguishing agent are deemed to satisfy these requirements if the system can produce concentrations of Halon 1301 specified in FAA AC 20-100 (FAA Advisory Circular). This AC was based on the performance of Halon 1301 in developmental testing including large scale fire tests. The standards described herein are intended for use in large scale fire testing for the purpose of developing performance criteria for systems using alternative agents. These standards are also applicable to other FAR/JAR pertaining to fire suppression in aircraft.

These standards are not necessarily the same as for Halon based systems nor are they a complete listing of techniques which may be required for certifying an aircraft engine and APU fire extinguishing system.

There are two major parts to these standards. Section 1 addresses the requirements for alternative agents/systems. Section 2 addresses test apparatus and methods necessary for evaluating agents/systems.

Background

Historically, Halon 1301 has proven to be an extremely effective total flooding agent for extinguishing fires. A comparison of the performance of candidate replacement agents to date, in terms of either the agent concentration or the total mass of an agent required to extinguish fires, has shown that they are not as effective as Halon 1301. The goal of these minimum performance standards is to identify criteria for alternative agents/systems to ensure that the current level of fire safety will be maintained for the engine and APU compartment.

The current level of safety, as recognized by the FAA, is that provided by a volumetric concentration of 6 % Halon 1301 throughout a protected fire zone for a duration of 0.5 second for a given agent discharge scenario. In evaluating the performance of alternative agents using this standard, the test apparatus must have the agent distribution system to demonstrate the current level of fire safety with Halon 1301. A successful application of the standards described herein, including the comparison of performance of Halon 1301 with that of the alternative agent, will allow the definition of an equivalent level of safety in terms of the performance of the alternative agent. At that point, it will be possible to define or evaluate the equivalent level of safety without using Halon 1301 as the standard.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

References

The following references form the basis of current Halon 1301 performance criteria for aircraft engine and APU fire extinguishing systems.

1. Advisory Circular FAA AC 20-100
2. Aircraft Fire Extinguishment, Part I - A Study of Factors Influencing Extinguishing System Design, Technical Development Report No. 184, October, 1952.
3. Aircraft Fire Extinguishment, Part II - The Effect of Air Flow on Extinguishing Requirements of a Jet Power-Plant Fire Zone, Technical Development Report No. 205, June, 1953.
4. Aircraft Fire Extinguishment, Part III - An Instrument for Evaluating Extinguishing Systems, Technical Development Report No. 206, June, 1953.
5. Aircraft Fire Extinguishment, Part IV - Evaluation of a Bromochloromethane Fire Extinguishing System for the XB-45 Airplane, Technical Development Report No. 240, June, 1954.
6. Aircraft Fire Extinguishment, Part V - Preliminary Report on High-Rate Discharge Fire Extinguishing Systems for Aircraft Power Plants, Technical Development Report No. 260, February, 1956.
7. An Investigation of In-Flight Fire Protection with a Turbofan Powerplant Installation, Report No. NA-69-26, April, 1969.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

1.0 Requirements for Agents/Systems

The agent and the fire extinguishing system must comply with the following minimum performance standards.

1.1 Environmental Characteristics

The environmental characteristics of the fire extinguishing agent must comply with international laws and agreements. Agents approved by the regulatory agencies for use in areas not normally occupied by humans are acceptable if they also satisfy the requirements defined in Section 1.3.

1.2 Fire Extinguishing Performance

1.2.1 Fire Threat

The agent (which satisfies requirement 1.1 above) when deployed through a suitable system must be capable of extinguishing any probable fires in the aircraft engine designated fire zone or in the Auxiliary Power Unit (APU) compartment for which the system is intended.

Here a probable fire implies a fire likely to occur in modern aircraft engine installations. Since precise definition of a likely fire in terms of measurable quantities has not been previously developed, the likely fire will be defined for the purpose of these standards by using test parameters such as the fuel type and flow rate. Combined with the simulation of hot engine environment, the simulated fire will adequately represent a real engine fire threat.

A real fire could be large, engulfing most of the protected fire zone in flames or it could be small, localized fire depending on the source and quantity of fuel and other conditions such as the air flow. The requirement for the fire extinguishing system is to defeat the fire anywhere in the zone including the entire zone. For the purpose of evaluating the agents, it is necessary to create a representative fire in a representative fire zone and show that the candidate agent can be distributed effectively in that zone to extinguish the fire; then determine the condition (concentration of the agent in the fire zone) at the location of the fire that resulted in successful extinguishment. It is not necessary to have a fire everywhere in the zone because if it can be shown that a specific real system can produce the required agent distribution throughout the zone which satisfies the condition determined in the fire test then it ensures that a fire will be defeated throughout the zone.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

1.2.1.1 Physical Parameters

A fire in an engine or an APU compartment is probable when a fuel and air mixture comes in contact with an ignition source. Airflow through an engine or APU compartment is normal and a fuel (combustible fluid) source is possible due to leakage of aviation engine fuel, hydraulic fluid or engine oil or due to a failure expelling these fuels. The ignition source could be any surface at a temperature above the hot surface ignition temperature for the fuel in the compartment. Ignition can also occur if the fuel enters an environment in which rapid heating causes it to exceed its autoignition temperature. Three typical combustible fluids for the fire must be considered: aviation engine fuel, hydraulic fluid and engine oil. The consideration of probable fires must cover the range of physical parameters in the fire zone for the operational envelope of the engine or of the APU. These physical parameters include: the zone volume, cross sectional area and shape, the zone air temperature and flow rate, the surface temperatures, the fuel type and flow rate, the amount of clutter within the zone and the temperature of the agent/system (in-service temperatures before a discharge).

For the purpose of this standard, the current level of safety will be determined by tests using 6 % volumetric concentration of Halon 1301 for 0.5 second in the fire zone with probable fires that cover the range of the physical parameters.

To describe simulated fires corresponding to near maximum challenge for Halon 1301 in extinguishing fires at the current level of safety, the term Robust Fire will be used in these standards. This is defined in more detail in Section 2.4.

It is possible that fires in some locations in the fire zone may be more difficult to extinguish than in other locations. The alternative agent/system must be able to extinguish probable fires anywhere in the fire zone. When comparing the performance of the alternative agent with that of Halon 1301, equivalent level of safety implies the same probability of extinguishment with both agents. That is, in five fire tests under similar conditions if Halon 1301 is successful four times, equivalent level of safety would require the alternative agent to be successful in at least four tests.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

1.2.1.2 Fire Extinguishment

A fire will be considered extinguished if there are no visible signs of a flame for eight seconds. In aircraft engine nacelles, fuel (combustible fluid) may still be available after the initial extinguishment of fire. The presence of surfaces which might be cooling down but still hot enough to act as an ignition source could result in a re-ignited fire. To distinguish the original fire from the re-ignited fire, an eight second time interval should be adequate. This is based on test experience and a consensus opinion of fire safety experts.

1.3 Health and Safety

The fire extinguishing agent/system for an engine compartment or an APU configuration must satisfy the following safety and health requirements.

1.3.1 Health and Safety in Handling

The agent/system should be designed to minimize exposure of workers to unsafe conditions during installation and normal maintenance of the system. Safety features incorporated in the equipment and handling procedures for the agent/system which mitigate this hazard should be taken into account while assessing compliance with this provision.

1.3.2 Flight Safety

The use and operation of the agent/system in the aircraft should not result in any additional hazard such as:

- (a) Malfunction of components critical for flight control necessary for continued safety of flight.
- (b) Damage to other critical components and areas within the compartment being protected, which would create a hazard either immediately or remain undetected and be a hazard after a passage of time.
- (c) Corrosion of the aircraft structure.
- (d) Ignition sources in any area of the aircraft not designed for accommodating ignition sources.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

2.0 Test Methods for Agent/System Evaluation

Tests will be necessary to evaluate the fire extinguishing performance of an agent/system and to determine if it will satisfy the requirements stated in 1.2. There are two types of these tests.

The first type of tests will evaluate the effectiveness of candidate agents in extinguishing an actual fire in terms of the “quantity” of the agent required to extinguish the fire within the zone.

It has become the normal practice to specify the performance of a gaseous agent (such as Halon 1301 after a discharge) in terms of the volumetric concentration required to extinguish the fire. A particular replacement agent could be in a solid, liquid or gaseous phase when interacting with the fire and its effectiveness might be dependent on both the state and the quantity of the agent. For example, the particle size of a solid agent or the droplet size of a liquid agent could influence its performance. The standards herein are meant to apply to any type of agent including liquid and solid. However, acceptable methods to specify concentration of solid or liquid agents have not been identified for aircraft applications. Therefore, the generic term “quantity” is used here. For halocarbon agents, which are in gaseous form as they interact with the fire, the practice of specifying extinguishing concentration is acceptable. In the following sections, whenever the term concentration is used for this purpose, it is not meant to exclude the applicability of these standards to other type of agents. It will be necessary to develop suitable methods for specifying the performance of solid or liquid agents prior to their evaluation tests. Any parameters critical to these new methods such as line sizes, line temperatures, nozzle configurations etc. must be controlled during tests. If the effectiveness of the agent is highly dependent upon a certain parameter, it should be investigated through additional testing and documented.

Volumetric concentration of the agent and the time required to extinguish the fire should be recorded. If it is not practical to record the agent concentration in a fire test, back to back tests must be conducted. That is, tests must be conducted with and without the fire with the same fire simulation parameters. The agent would be discharged in both tests in identical manners. The concentration measurement in the test without the fire would correspond to the extinguishing performance in the test with the fire.

As stated in 1.2.1.2, in aircraft engine nacelles, fuel and ignition sources may still be available after the initial extinguishment of fire and a re-ignition of fire is possible. Surface temperature of a strategic location in the vicinity of the fire should be monitored to gain further understanding of the extinguishment process.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

The second type of tests are system validation tests. They will apply to aircraft specific designs in a manner similar to Halon 1301 systems. They will verify the effectiveness of the specific delivery system in transporting the required quantity of the agent at the potential location of the fire. Thus, the agent evaluation tests will provide the basis for: (1) the design and engineering of the system and (2) the system validation tests.

The test methods proposed here address the first type of tests. These tests should be planned and conducted so as to provide complete data for stating the performance criteria for successful fire extinguishing agents/systems.

2.1 Test Apparatus

Aircraft Engine Compartment Simulator

For the purpose of these tests, the engine compartment (nacelle) simulator should have an annular fire zone having a minimum volume of 65 cubic feet and a minimum cross sectional area of the annulus of 5.5 square feet, both before reductions due to clutter simulation. It should be equipped to simulate test parameters described in 2.2.1. The inner cylinder in this configuration will represent the engine case. The test section must be equipped to allow a real time visual indication of fire. A schematic diagram of a simulator is shown in Figure 1. The agent distribution system must be capable of extinguishing fires within the overall zone or in any isolated location within the fire zone. It must be possible to demonstrate the currently acceptable level of safety with Halon 1301. That is, it should be possible to achieve 6 % volumetric concentration of Halon 1301 for 0.5 second in the entire zone. The facility must provide simulation of a flaring fire (leaking fuel stream on fire, also called spray fire) and a residual fire (baffle stabilized pan fire due to ignition of accumulated fuel in some part of the fire zone).

The size of the zone was selected on the basis of the range of fire zone sizes of actual aircraft installations and considerations for a practical simulator where physical parameters can be properly simulated and controlled. If an agent/system is successful with a fire zone of this size, it is highly likely to be successful in both larger and smaller zones with appropriate agent quantities and system designs. The purpose here is to define the minimum performance standards with probable fire scenarios in a typical fire zone.

As stated in 1.2.1, it is not necessary to have a fire everywhere in the zone. However, there may be specific applications which may benefit from these test data but may require additional considerations which are not a part of these minimum performance standards.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

A separate simulator for APU compartments is not necessary because experience in recent testing by the U. S. Air Force has shown that the requirements developed for the engine compartment provide equal or higher level of safety for the APU compartment.

2.2 Test Conditions

2.2.1 Engine Compartment Test Parameters

A number of tests will be necessary to cover the range of conditions. Depending on these conditions, different amounts of agent might be required to establish the extinguishing concentration.

2.2.1.1 Airflow Rate

At least two internal (ventilation) airflow rates should be selected, one each from the following two ranges.

- (a) High 2.5 - 3.0 lbm/sec.
- (b) Low 0.2 - 0.9 lbm/sec.

Section 2.2.1.1 (a) corresponds to about 57 air changes per minute for the fire zone having 65 cubic feet volume and 5.5 square feet cross sectional area. For significantly different volume and cross section, the airflow rates should be adjusted appropriately. These flow rates cover the significant range of air flows in modern engine installations. This information is based on a US Air Force survey. Note that ventilation airflow is a commonly used term for airflow through the engine compartment.

2.2.1.2 Air Temperatures

At least two (ventilation) air temperatures of 100 and 400 °F.

The above temperatures cover a significant range of air temperatures in engine compartments.

Air temperature as low as -40 °F could exist in some cases under extremely cold atmospheric conditions at high altitudes. However, under these conditions an engine fire threat is extremely unlikely due to low power demand from the engine, cold fuel and relatively cooler surfaces in the fire zone. In addition, these conditions could delay the detection of a small fire which could result in an increase in air temperature. These are adequate reasons to conclude that this fire threat could be easily overcome by a system designed for larger fire threats which are likely when the air and surface temperatures are higher. Therefore, it is not necessary to simulate air temperatures below the ambient conditions in the test facility. However, for consistency between tests conducted during different ambient

conditions, a controlled air temperature is preferred. Therefore 100 °F is selected to represent the lower end of the temperature range.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

2.2.1.3 Surface Temperature

At least a portion, about 2 feet long and encompassing a 90° arc, of the surface of the test article simulating the engine core (inner cylindrical surface) must attain temperature in the range 900 - 1300 °F. The tests to establish robust fires (Section 2.4) should begin with the highest surface temperature in this range. Lower temperatures should be used as a last resort parameter to adjust in trying to get successful extinguishment with Halon 1301. The surface temperature must be monitored during the test. After initiating the discharge of the agent, heating of the surface should be discontinued.

In a test, since the fire location would be close to this surface, it could attain higher temperature than the control temperature. As the fire begins to be extinguished, this temperature may decrease. To represent an actual situation in which the engine is shut down prior to the agent discharge and to be able to observe the effect of the agent on the fire, it is appropriate to turn the surface heating off as the agent is discharged in the test.

2.2.1.4 Clutter

The simulated blockage or clutter should have up to 50 % reduction in the local cross sectional area and the resultant volume reduction.

The above estimate is based on visual inspection of clutter in actual engine installations. It is possible that some installations have very high clutter factors. The purpose here is to simulate clutter in a practical manner. For installations with high clutter, the system validation tests will be more important where agent distribution even in such highly cluttered zone must be proven. If the extinguishing concentration can be achieved, the system would have the required level of safety.

2.2.1.5 Fuel Parameters

A fuel (combustible fluid) flow rate of 0.1 to 1 gpm (gallon per minute) at a controlled temperature of 150 °F should be provided. The fuel flow rate should be adjusted to attain a fire threat which is just barely extinguished by Halon 1301. The tests should begin with a high fuel flow rate in the above range to establish robust fires (Section 2.4). Lower fuel flow rates should be successively used if at higher flow rates Halon 1301 cannot extinguish fires.

This method would create a realistic fire threat to evaluate the agents. It is possible that in some aircraft fire scenarios, the flow rate could be higher than 1 gpm which could result in a spread of fire to a larger portion of the zone. However, as it has been stated earlier in this standard, if the extinguishing

concentration is present in the entire zone, the fire should be extinguished everywhere.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

The fuel flow must remain on before and after the discharge of the agent to ensure that the extinguishment is the result of the action of the agent and not due to lack of fuel. As the surfaces might still be hot, this procedure (rather than fuel shut off at the beginning of agent discharge) would increase the chance of a re-ignited fire. Therefore, to address these two concerns in a practical way, **criteria** for fire extinguishment is that mentioned in Section 1.2.1.2, viz. no visible signs of fire for eight seconds.

Proper operation of the fuel delivery system, including nozzles, should be checked to assure that the fire size and intensity are roughly reproducible in tests with similar conditions. A measurement of heat flux density to characterize the fire is not necessary. Undue importance could be attached to this parameter as a means to determine reproducibility of fires while the measurement itself could depend on a variety of different factors.

A baffle stabilized pan fire (residual fuel fire) simulation should be provided with an initial 0.25 gallon of fuel at a controlled temperature of 150 °F at the beginning of the test. The fuel level should be controlled at 1.5 in. below the top of the baffle to ensure repeatable fire conditions. Fuel quantity in the pan should be adjusted if necessary in tests to define robust fires (Section 2.4).

2.2.1.6 Fire Location

Axial location of the flaring fire must be over the surface which is at the controlled, high temperature (900 - 1300 oF) and downstream of the simulated clutter (some clutter could be in the fire). Circumferential location of this fire should be in the upper half of the zone.

Location of the simulated residual fire (baffle stabilized pan fire) can be chosen in the zone where convenient. Locations where the extinguishing agent can directly impinge on **fire** for the given distribution system must be avoided.

2.2.1.7 Preburn

A preburn time is the time elapsed between the initiation of fire (ignition) and the initiation of agent discharge. A minimum preburn time of 5 seconds is required for the spraying fire simulation.

The baffle stabilized pan fire should have a minimum preburn time of 15 seconds.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

In an aircraft installation, when the fire alarm is received an action is initiated resulting in a sequence of events. The engine fuel supply is shut off first. Hot air and electrical sources may also be shut off before activation of the fire extinguishing system. If the alarm occurs during the climb phase of the flight, more than a minute may elapse between the alarm and the discharge of the agent. In other cases, this elapsed time may be shorter than a minute. For the purpose of these standards, a shorter preburn is selected to protect test equipment from exposure to repeated intense fires.

2.2.1.8 Agent Storage Temperature

Three agent storage temperatures will be used in different tests to cover the range of possible operational temperatures. Details of how these temperatures should be used are given in 2.4.

(a) 100 °F.

This condition is chosen to eliminate variations in agent performance attributable to the storage temperature if it was left uncontrolled at the ambient condition.

(b) -65 °F.

This condition is based on the fact that Halon 1301 bottles in some current aircraft models could experience temperatures this low. Halon 1301 does not solidify at this temperature. Actual aircraft installations will be designed for addressing the requirements based on the operational envelope of the aircraft. This may translate into a different low temperature requirement.

The alternative agent in an operating aircraft system must not be stored at temperatures lower than the lowest tested temperature which resulted in a satisfactory fire extinguishing performance.

(c) 200 °F.

This condition is based on some installations for the APU fire extinguishing systems where such high temperatures are possible.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

2.3 Fuels

Perform tests with all the appropriate test conditions specified in 2.2 using the following fuels:

- (a) aviation engine fuel (turbine fuel, Avgas)
- (b) engine lubricating oil
- (c) hydraulic fluid

2.4 Tests

The agent evaluation tests for any given test apparatus will have two parts. In the first part, the current level of safety will be defined in terms of Robust Fires. The second part of tests will be agent evaluation using the robust fires defined in the first part.

A Robust Fire is a diagnostic test fire which establishes the current level of safety provided by Halon 1301 as follows:

- (a) The standard Halon 1301 distribution conditions are 6 % volumetric concentration in all parts of the fire zone for 0.5 seconds.
- (b) The standard distribution conditions must be achieved with the bottle temperature at -65 °F.
- (c) A robust fire will be extinguished in 70-90 % of repeated fire tests with standard distribution of Halon 1301, (a).
- (d) Robust fires will be determined with the agent stored at a temperature of 100 °F.
- (e) At least five tests with identical conditions must be performed to determine the probability of successful fire extinguishment.

A success rate of 70-90 % is chosen to define the robust fire because it assures that the fire threat is sufficiently large for even Halon 1301 to be unsuccessful in some case.

2.4.1 Robust Fire Characterization

This series of tests will establish physical test parameters to characterize robust fires with Halon 1301 as the extinguishing agent.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

2.4.1.1 Halon 1301 Standard Distribution

Develop and implement an agent distribution system for halocarbon agents which will assure Halon 1301 volume concentration of 6 % for a minimum of 0.5 second and a maximum of 1 second throughout the fire zone of the test apparatus. The maximum concentration of Halon 1301 should not exceed 8 % in any location and the minimum concentration should not be greater than 6.6%. Replicate the distribution performance in three consecutive tests. This distribution should be achievable with the Halon 1301 bottle temperature of -65 °F.

After achieving successful distribution with agent bottle at -65 °F, keep the agent mass the same and repeat the concentration measurement tests with the bottle temperature at: (a) 100 °F and (b) 200 °F.

2.4.1.2 Halon 1301 Fire Tests

Select test conditions as specified in Section 2.3 and conduct fire tests to achieve at least two combinations of test conditions resulting in robust fires. Perform these tests with the Halon 1301 bottle at 100 °F. While covering the range of test conditions, begin with the values likely to provide more difficult fires to extinguish. For example, begin with fuel flow rate of 1 gpm, surface temperature of 1300 °F and airflow rate of 2.5 lbm/sec. Modify the values appropriately, if Halon 1301 fails to achieve the required success rate. Lower the surface temperature only as a last resort, after changes in other physical parameters fail to produce required success rate with Halon 1301. Where the prescribed range specifies at least two selections one each from a sub-range, selections from each sub-range should be made. These tests could provide more than just two combinations of test conditions defining robust fires. Identify at least two robust fires with test fuel from two different categories indicated in Section 2.3.

There should be at least one baffle stabilized pan fire which can be defined as a robust fire.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

Procedure:

The tests should be performed using the following general procedure.

1. Select the test conditions and prepare the test equipment.
2. After attaining the desired level of steadiness with the test conditions, initiate the fuel (combustible fluid) flow and ignite the fire.
3. While observing the fire, let the preburn time elapse.
4. Initiate the agent discharge, observing its effect on the fire. Record the time for discharge of the system and extinguishment of the fire.
5. If the fire is extinguished and remains so for eight seconds continuously, the agent is successful in extinguishing the fire.
6. If the fire is not extinguished, the agent has failed.

Perform tests with different conditions until at least the required number of robust fires have been defined.

2.4.1.3 Additional Halon 1301 Fire Tests

Repeat the test conditions for robust fires identified in 2.4.1.2 with bottle temperatures: (a) -65 °F and (b) 200 °F. If the success rate is less than 40 %, repeat tests with different test conditions which satisfy the robust fire definition until a success rate of 40 % or better is achieved with bottle temperatures: (a) -65 °F and (b) 200 °F.

2.4.2 Alternative Agents Evaluation

These tests will be performed in a manner similar to tests described in 2.4.1 but with well defined test conditions (that is the conditions defining robust fires). They will differ in that the quantity of agent required in different tests **will** be subject to estimates and trials.

2.4.2.1 Alternative Agents Fire Tests

Alternative agents shall be evaluated against the robust fires defined in Section 2.4.1.2. Estimated quantities of the agent for different test conditions will be used initially and adjusted subsequently based on the performance of the agent. Test procedure will be similar to 2.4.1.2. Agents must be tested using at least two robust fires in the spray fire category and a robust baffle stabilized pan fire.

The alternative agent evaluated in this manner will be considered to have an equivalent level of safety as Halon 1301 if its probability of success in extinguishing fires is equal or superior to that of Halon 1301.

Minimum Performance Standards for Aircraft Engine and APU Compartment Fire Extinguishing Agents/Systems

In addition, fuels not covered by the robust fires can be qualified if a successful extinguishment of a baffle stabilized pan fire with those fuels is demonstrated.

If the alternative agent cannot perform with storage temperatures of -65 °F or 200 °F, the range of temperature in which it can perform should be established. The agent will then be qualified to be effective within that storage temperature range only.

2.4.2.2 Alternative Agents Distribution

Tests to determine the agent concentration will be necessary to provide a basis for specific system design and the performance criteria for system validation tests. In these tests, the agent concentration profiles and histories **should be determined** while duplicating conditions corresponding to the successful extinguishment of robust fires. These concentration measurements should encompass all conditions necessary to establish the operational range of storage temperatures.

Enough tests should be conducted and results evaluated to develop a consistent correlation between the agent quantity, agent concentration and agent distribution.

Conclusion

The Minimum Performance Standards described herein should lead to an accurate description of fires likely to occur in aircraft engine installations which can be currently extinguished with Halon 1301. **This will define** a currently acceptable level of safety. Evaluation of alternative agents against these standards is expected to lead to the development of performance criteria for aircraft engine and APU fire extinguishing systems based on **the alternative** agents. Subsequently, advisory material for the alternative agents should be developed. This will ensure that the current level of fire safety will continue to be maintained in future for aircraft engine and APU installations.