MINIMUM PERFORMANCE STANDARDS FOR HANDHELD FIRE EXTINGUISHERS AS A REPLACEMENT FOR HALON 1211 ON CIVILIAN TRANSPORT AIRCRAFT.

FAA Draft

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1. INTRODUCTION.

Federal Aviation Regulations (FAR's) and Joint Aviation Regulations (JAR's) require that one or more Halon 1211 fire extinguishers be carried in the passenger cabin of transport aircraft. Because of the ban on production of Halon 1211, mandated by the Montreal Protocol and effective January 1994, new fire extinguishing agents will need to be certified when the use of Halon 1211 is no longer viable. The tests described in this standard are one part of the total FAA/JAA certification process for hand held fire extinguishers. Compliance with other applicable regulations, some of which are listed below, is also required. Applicants attempting to certify replacement agents are encouraged to discuss the required process with regulatory agencies prior to conducting testing.

1.1 APPLICABLE REGULATIONS.

The following existing FAR's/JAR's pertain to hand held fire extinguishers:

25.851. "(a) Hand fire extinguishers.

(1) The following minimum number of hand fire extinguishers must be conveniently located and evenly distributed in passenger compartments:

Passenger Capacity	Number of Extinguishers
7 through 30	1
31 through 60	2
61 through 200	3
201 through 300	4
301 through 400	5
401 through 500	6
501 through 600	7
601 through 700	8

(2) At least one hand fire extinguisher must be conveniently located in the pilot compartment.

(3) At least one readily accessible hand fire extinguisher must be available for use in each Class A or Class B cargo or baggage

compartment and in each Class E cargo or baggage compartment that is accessible o crewmembers in flight.

(4) At least one hand fire extinguisher must be located in, or readily accessible for use in, each galley located above or below the passenger compartment.

(5) Each hand fire extinguisher must be approved.

(6) At least one of the required fire extinguishers located in the passenger compartment of an airplane with a passenger capacity of at least 31 and not more than 60, and least two of the fire extinguishers located in the passenger compartment of an airplane with a passenger capacity of 61 or more must contain Halon 1211 (bromochlorodifluoromethane $CBRC_1F_2$), or equivalent, as the extinguishing agent. The type of extinguishing agent used in any other extinguisher required by this section must be appropriate for the kinds of fire likely to occur where used.

(7) The quantity of extinguishing agent used in each extinguisher required by this section must be appropriate for the kinds of fires likely to occur where used.

(8) Each extinguisher intended for use in a personnel compartment must be designed to minimize the hazard of toxic gas concentration."

23.851 "Fire extinguishers.

(a) There must be at least on hand fire extinguisher for use in the pilot compartment that is located within easy access of the pilot while seated.

(b) There must be at least one hand fire extinguisher located conveniently in the passenger compartment.-

(1) Of each airplane accommodating more than 6 passengers; and

(2) Of each commuter category airplane.

(c) For hand fire extinguishers, the following apply:

(1) The type and quantity of each extinguishing agent used must be appropriate to the kinds of fire likely to occur where the agent is used.

(2) Each extinguisher for use in a personnel compartment must be designed to minimize the hazard of toxic gas concentrations."

29.851 "Fire extinguishers.

(a) *Hand fire extinguishers.* For hand fire extinguishers the following apply:

(1) Each hand fire extinguisher must be approved.

(2) The kinds and quantities of each extinguishing agent must be appropriate to the kinds of fires likely to occur where the agent is used.
(3) Each extinguisher for use in a personnel compartment must be designed to minimize the hazard of toxic gas concentrations."

135.155 "Fire extinguishers: Passenger carrying aircraft.

No person may operate an aircraft carrying passengers unless it is equipped with hand fire extinguishers of an approved type for use in crew and passenger compartments as follows-

(a) The type and quantity of extinguishing agent must be suitable for all the kinds of fires likely to occur;
(b) At least one hand fire extinguisher must be provided and conveniently located in the passenger compartment of each aircraft having a passenger configuration, excluding any pilot seat, of at least 10 seats but less than 31 seats."

2. SCOPE.

This document establishes the minimum performance standards (MPS) that a hand fire extinguisher must meet to replace Halon 1211. It describes the tests that should be performed to demonstrate that the performance of the replacement agent equals or exceeds the performance of the currently approved Halon 1211 fire extinguishers.

3. AGENT SELECTION GUIDANCE.

3.1 ENVIRONMENTAL.

The replacement agent must be approved under the Environmental Protection Agency (EPA), Clean Air Act, Significant New Alternatives Policy (SNAP) program, or other international governmental approving program. The agent selected should have environmental characteristics in harmony with international laws and agreements, as well as applicable local laws. This MPS sets out the means of assessing the technical performance of potential alternatives..

3.2 TOXICOLOGY.

The selected agent must be designed to minimize the hazard of toxic gas concentration when discharged in an aircraft cabin. The agent must not pose an unacceptable health hazard for either the cabin crew or the passengers. Following the discharge of the agent during fire extinguishment, the cumulative effect of the agent, its pyrolytic breakdown products, and the byproducts of combustion must not pose an unacceptable health hazard.

The specific toxicology associated with an agent in a ventilated aircraft cabin is to be determined in the Seat Fire / Toxicology Test performed at the FAA Technical Center.

4. TEST REQUIREMENTS.

The candidate replacement agents are required to pass two aircraft specific tests. They are the Hidden Fire Test and the Seat Fire / Toxicology Test. The Hidden Fire Test will establish the flooding capability of an agent / extinguisher combination. The Seat Fire / Toxicology Test will determine the health hazard associated with the discharge of an agent during fire extinguishment.

4.1 HIDDEN FIRE TEST.

4.1.1 PURPOSE

The purpose of this test is to evaluate the effectiveness of candidate replacement hand held streaming agents in a flooding situation. Halon 1211, a streaming agent, has been shown to be an effective flooding agent, both in this test and in the field. This test will ensure that there is no loss of safety when newer, more environmentally friendly agents replace Halon 1211 in service.

4.1.2 BACKGROUND

Halon 1211 was initially selected for use in aircraft cabins in response to the Arsonist / Hijacking scenario. This scenario, consisting of gasoline splashed on a seat cushion and ignited, is still a concern and the basis for the second performance test, the Seat Fire / Toxicology Test. Later, it was determined that Halon 1211 in hand held extinguishers, while primarily a streaming agent, provided the capacity to act as a flooding agent. This was demonstrated during an in flight cheek area fire in a large transport aircraft, possibly preventing the loss of the aircraft. KIDDE International –UK, developed the test described in this section by Mr. A Chattaway. The operating procedure has been refined and standardized at the FAA William J. Hughes Technical Center, USA.

4.1.3 TEST DESCRIPTION

A candidate fire extinguisher is discharged into the left side of a rectangular box. Inside the box are twenty small cup fires arranged in five arrays of four. The arrays are separated by solid and perforated baffles. The baffles require the agent to extinguish the fire by indirect means. The extinguisher is discharged fully and the total number of fires extinguished are counted. Baseline testing with Halon 1211 extinguished nine fires.

4.1.4 TEST APPARATUS

The test is conducted in a rectangular box two meters high, 2 meters long and one half meter wide. One long side of the box is fitted with clear Plexiglas to allow an unobstructed view of the interior. The interior of the box is fitted with 20 metal cups, 35mm in diameter, arranged in three vertical arrays of four cups and one vertical array of eight cups. Baffles perforated to allow thirty-three percent hole area separate the arrays. The lower end of each baffle is fitted with solid stop plates, in line with the extinguisher injection port. The first three arrays and the top four cups of the fourth array are installed in the upper half of the test fixture. The lower four cups of the fourth array are installed in the lower half of the fixture. Two ventilation ports are cut into the left side of the box, at the top and bottom of the fixture. A two-inch hole is cut into the same side, through which the extinguisher agent is introduced. [need drawings]

4.1.5 Fire Loading

The twenty cups in the four arrays are loaded with 10 ml of water and 5 ml of n-heptane, floated on top of the water.

4.1.6 Extinguisher Rating

The candidate extinguisher must be approved by a recognized fire testing laboratory and have a minimum rating of UL 5BC, or an equivalent rating to 2.5 pounds of Halon 1211.

4.1.7 Instrumentation

The interior temperature of the box is measured in a central location near the top of the fixture. The temperature is to be recorded prior to each test. The test is recorded on videotape.

4.1.8 TEST PROCEDURE

This test is to be performed five times for each extinguisher / agent combination to be certified. The results from the five tests are to be averaged. Subsequent changes in hardware that affect the spray pattern or discharge time, or quantity and formulation of agent, require that the extinguisher be recertified.

1. Operating Temperature: The test fixture and the extinguishers are to be equilibrated at a temperature of 70-90 degrees Fahrenheit. If successive tests are to be run, the test fixture must be allowed to cool to the prescribed temperature.
2. Agent Weight: The extinguisher is to be weighed before and after discharging to determine the weight of the agent discharged.

3. Extinguisher Mounting: The loaded extinguisher is mounted on the side of the fixture such that the nozzle is directed through the two inch hole in the left side of the fixture. Care must be taken with the nozzle orientation to insure that the discharge nozzle is level and centered left to right through the discharge port.
4. Fire Loading: The cups are loaded with 10-ml water and 5 ml n-heptane and ignited. The access doors are closed at this time. A preburn of 30 seconds is timed from the closing of the access doors.
5. Extinguisher Discharge: The extinguisher is discharged fully at the end of the 30 second preburn. A stopwatch is used to measure the discharge time.
6. Test Results: The number of fires extinguished up to 60 seconds after discharge is noted.

At the conclusion of the test, the access doors are to be opened to vent the fixture and any remaining fires are extinguished. The temperature in the box is allowed to return to 70 to 90 degrees F. The remaining contents of the cups are emptied and the cups are cleaned to remove any residue to insure that subsequent tests are not compromised.

7. Test Report. A report is generated at the end of each series containing the following information:

Agent, extinguisher manufacturer, extinguisher rating, extinguisher model and serial numbers, weight of agent, fixture temperature at the start of the test, number of fires extinguished for each test, average number of fires extinguished for the series of five tests.

4.1.9 Minimum Performance

The candidate replacement agent must extinguish a minimum of nine fires when averaged over the five tests.

4.2 SEAT FIRE / TOXICOLOGY TEST

4.2.1 PURPOSE

The objectives of this test are to evaluate the performance of a candidate replacement handheld agent under in flight conditions to insure that there is no loss of safety in terms of agent fire fighting performance and occupant exposure to toxic decomposition byproducts. Unlike the Hidden Fire Test, this test will certify an agent, not an agent / extinguisher combination.

4.2.2 BACKGROUND

The basic parameters for this test were developed at the FAA Technical Center as described in the 1982 report “In-Flight Aircraft Seat Fire Extinguishing Tests (Cabin Hazard Measurements) by Richard G. Hill and Louise C. Speitel. The test

was designed to (1) determine the amount of toxic decomposition byproducts from the use of Halon 1211 on large seat fires in an aircraft cabin while in flight, (2) compare the relative hazard levels from the use of common aircraft handheld extinguishers (Halon 1211, monoammonium phosphate, carbon dioxide, water); and (3) compare the hazards from the handheld extinguishers extinguishing a large aircraft seat fire to the hazards of an uncontrolled fire.

The current test has essentially the same goals applied to replacement agents for Halon 1211. The test has been modified to include the use of fire-blocked seats and an extended (thirty-second) preburn. The use of the remote controlled fire extinguishing unit was discontinued due to the slow reaction time and replaced by an experienced fire fighter in full turnout gear and self contained breathing unit.

4.2.3 TEST DESCRIPTION

A fire blocked triple seat is installed in the cabin of the TC-10 test article. Airflow conditions in the test article are set to simulate in-flight conditions at one air exchange every four minutes. The seat is primed with one quart of automotive gasoline on top of the base cushions. The seat is ignited and allowed to burn for thirty seconds. Gas and temperature data collection is initiated at the moment the seat is ignited. A fire fighter is positioned six feet forward of the seat with the extinguisher ready. The fire fighter extinguishes the fire thirty seconds after ignition as efficiently as possible. Data collection continues for 9.5 minutes after discharging the extinguisher, for a total of 10 minutes of data.

4.2.4 TEST ARTICLE

The TC-10 full-scale wide body test article is used for this test program. The cabin is equipped to simulate in flight air ventilation conditions at the rate of one air exchange every four minutes. The cabin is fitted with a single triple seat stand. The six cushions that make up the three seats are made up of fire retardant foam, Norfelt fire blocking layer, and covered with a 90/10 wool decorative material.

4.2.5 INSTRUMENTATION

The type and location of all instrumentation is shown in figure 1. Cabin temperature profiles were measured using 24-gauge chromel-alumel type K thermocouples. A calorimeter, calibrated in the 0-5 BTU/ft2-sec range was installed at the discharge point to measure the intensity of the fire. Carbon dioxide (CO2), carbon monoxide (CO), oxygen (O2), and the neat agent concentrations (where possible) were measured using Beckman continuous infrared analyzers. The acid gases were collected and analyzed as follows:

Acid Gas Collection. Absorption tubes were used to collect acid gas samples during the tests. Each tube is made up of a glass lined stainless steel, 16 ½ centimeters long with a 4 millimeter inside diameter, attached to a 4 inch long glass tube with a 2mm internal diameter. It is packed to a depth of 14 centimeters with 3-millimeter diameter glass beads, which are held into place by a slice of Teflon pressed into the tube at each end. The beads are rinse coated with 0.25Molar (M) Sodium Hydroxide (NaOH) just prior to use, excess solution being blown from the tube by syringe. The absorption tubes are housed in an ice-water solution in an aluminum box, which is insulated with Kaowool™ ceramic board. The horizontally mounted tubes are held in place by drilled through watertight bulkhead fittings. The outside glass ends extend one inch beyond the insulation. The interior ends are attached to separate vacuum lines, which pass through the bottom of the box and lead to the solenoid valve assembly. A flow rate of 0.78 liters per minute is drawn during the test. The solenoid valves are programmed to open sequentially as shown in the following table:

Solenoid Valve	Time open*	Time close	Duration
1	0:00	0:30	0:30
2	0:30	1:00	0:30
3	1:00	1:30	0:30
4	1:30	2:00	0:30
5	2:00	2:30	0:30
6	2:30	5:00	2:30
7	5:00	10:00	5:00

* All times are in minutes and seconds.

The anion samples are recovered for analysis by rinsing the absorption tubes with a 0.025M NaOH solution dispensed by syringe. The filtered washings are collected in autosampler plastic cuvettes for subsequent analysis.

Acid Gas Analysis. Hydrogen fluoride, hydrogen chloride, and hydrogen bromide were identified and quantified by ion chromatography (IC). The method and instrumentation used for the anion analysis are described in table1.

Table 1 Acid Gas Method of Collection and Analysis

Gases	**Sampling System**	**Instrument**	**Method**	**Comments**
HF, HCl, HBr	Time sequenced batch sampling: 10 time sequenced sampling tubes and 2 control tubes: all are 4 mm id, filled with 3 mm glass beads coated with a 0.25M NaOH solution, with a glass extension tube of 2mm id. Flowmeter, filter, and vacuum pump downstream. Tubes housed in an ice-water bath at point of sampling.	Dionex DX 500 Chromatography System with GP40 Gradient Pump w/Degas, LC30 Chromatography Oven, ED40 Electrochemical Detector with ***conductivity cell***, DS3 Detection Stabilizer (temperature control chamber for conductivity cell), AS3500 programmable Autosampler with sample prep, Peaknet Chromatography Data Acquisition System on IBM compatible PC.	Ion Chromatography Gradient Elution. Ionpac AS10 Analytical Column (4x250mm), Ionpac AG10 Guard Column Eluent A: 200mMNaOH Eluent C:Water Total flow: 1.0ml/min time %A %C (min) 0.00 10 90 5.00 10 90 20.00 75 25 35.00 75 25 35.10 10 90 45.00 10 90	IC method provides a good separation of light organics from Fluoride peak. IC Method developed by Dionex for FAA combustion gas samples:

SEAT FIRE / TOXICOLOGY TEST INSTRUMENTATION
TC-10 TEST ARTICLE

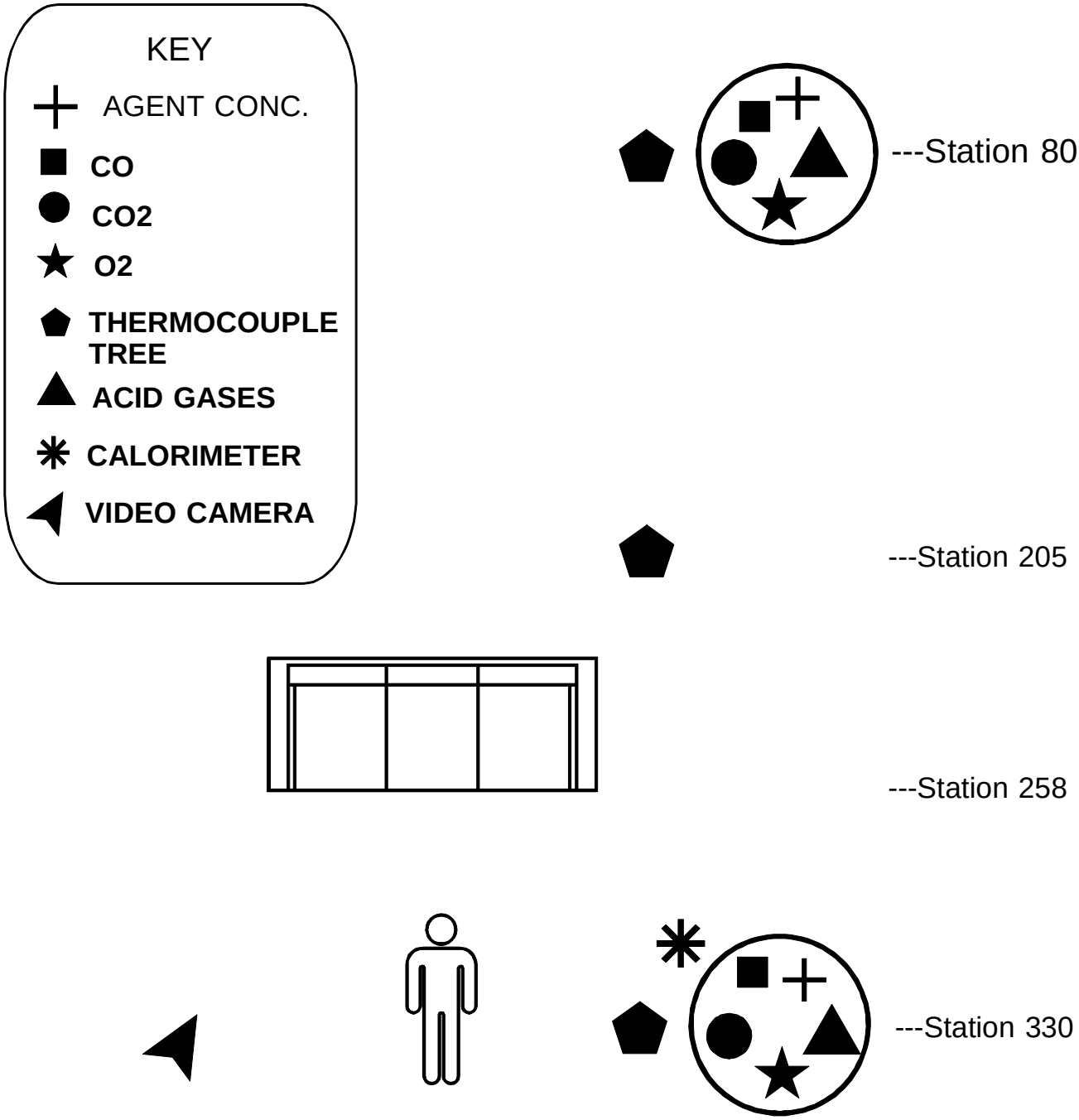

Fig. 1

4.2.6 Extinguisher Rating.

The candidate extinguisher must be approved by a recognized fire testing laboratory and have a minimum rating of UL 5BC, or an equivalent rating to 2.5 pounds of Halon 1211.

4.2.7 Seat Cushions.

The seat cushions are to be identical for all tests. The cushion is made up of fire retardant foam, Norfelt seat blocking layer, and 90/10 wool decorative covering. The seat base foam dimensions are 18”x20”x4”. The seat back dimensions are 18”x25”x2”.

4.2.8 Practice Fires.

The fire fighter will extinguish a minimum of two seat fires to familiarize him with the characteristics of the candidate extinguisher. These fires will utilize the same seat cushion / fire blocking / coverings as will be utilized in the data tests. Instruction for any special techniques required for the efficient extinguishment of the fire will be supplied by manufacturer.

4.2.9 Number of Data Tests:

The Seat Fire / Toxicology Test shall be performed three times for a candidate agent.

4.2.10 TEST PROCEDURE

1. The extinguisher is equilibrated at normal room temperature and weighed before and after discharge to determine the amount of agent used. The extinguisher is fitted with a mechanism to record the discharge time.
2. The seat cushions are equilibrated at room temperature prior to installation on the seat frames.
3. The center seat base is fitted with a length of nichrome wire stretched across the top of the cushion. When energized with 110 volt AC current, this will supply the ignition source.
4. Cabin ventilation is turned on.
5. The fire fighter, with the extinguisher, is positioned in the cabin, well back from the seat.
6. The seat is primed with one quart of automotive gasoline poured across the forward one third of the three seat bases.
7. The cabin is sealed.
8. The data systems are started and verified.
9. The seat is ignited, gas collection begins.
10. The fire fighter advances to the burning seat and stands at a mark six feet from the forward edge of the lower cushion

11. At thirty seconds after ignition, the fire fighter begins to extinguish the seat, using only as much agent as is necessary to extinguish the fire.
12. Data and gas collection continue until ten minutes from the ignition point.
13. The test is terminated at this time and the cabin is ventilated and the gas collection cylinders are retrieved for analysis.
14. Test report. A report is generated at the end of the series with the following information:

Agent, extinguisher manufacturer, extinguisher rating, extinguisher model and serial numbers, weight of agent used, extinguisher discharge time, graphs for cabin temperature, carbon dioxide, carbon monoxide, oxygen, agent concentration, toxic gases.

4.2.11 Minimum Performance.

The candidate replacement agent must be capable of extinguishing the seat fire. The levels of hazardous gases generated by the interaction of the agent and the fire as well as the neat agent must not exceed dangerous levels.

5. ACCEPTANCE CRITERIA

The acceptance criteria for a replacement agent in a hand held fire extinguisher is as follows:

1. Extinguish a minimum of nine cup fires in the Hidden Fire Test.
2. The agent must be capable of extinguishing the seat fire in the Seat Fire Toxicology Test.
3. The toxic gases resulting from discharging the agent during fire extinguishment of the seat fire must not exceed the following (proposed) limits:

Analysis of the data indicate that Hydrogen Flouride is the primary hazardous decomposition product. The proposed limits for HF are as follows:

1. The average concentration of HF shall not exceed 200ppm for any one minute period.
2. The average concentration of HF shall not exceed 100 ppm for any five minute period.