Appendix 2: Seat Fire / Toxicology Test (Arson / Hijacking Scenario)

DRAFT

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.

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) to 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 (ref1).

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.

TEST DESCRIPTION

A triple fire blocked 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 three minutes after the ignition point.

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.

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 and organic 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 (min) %A %C 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

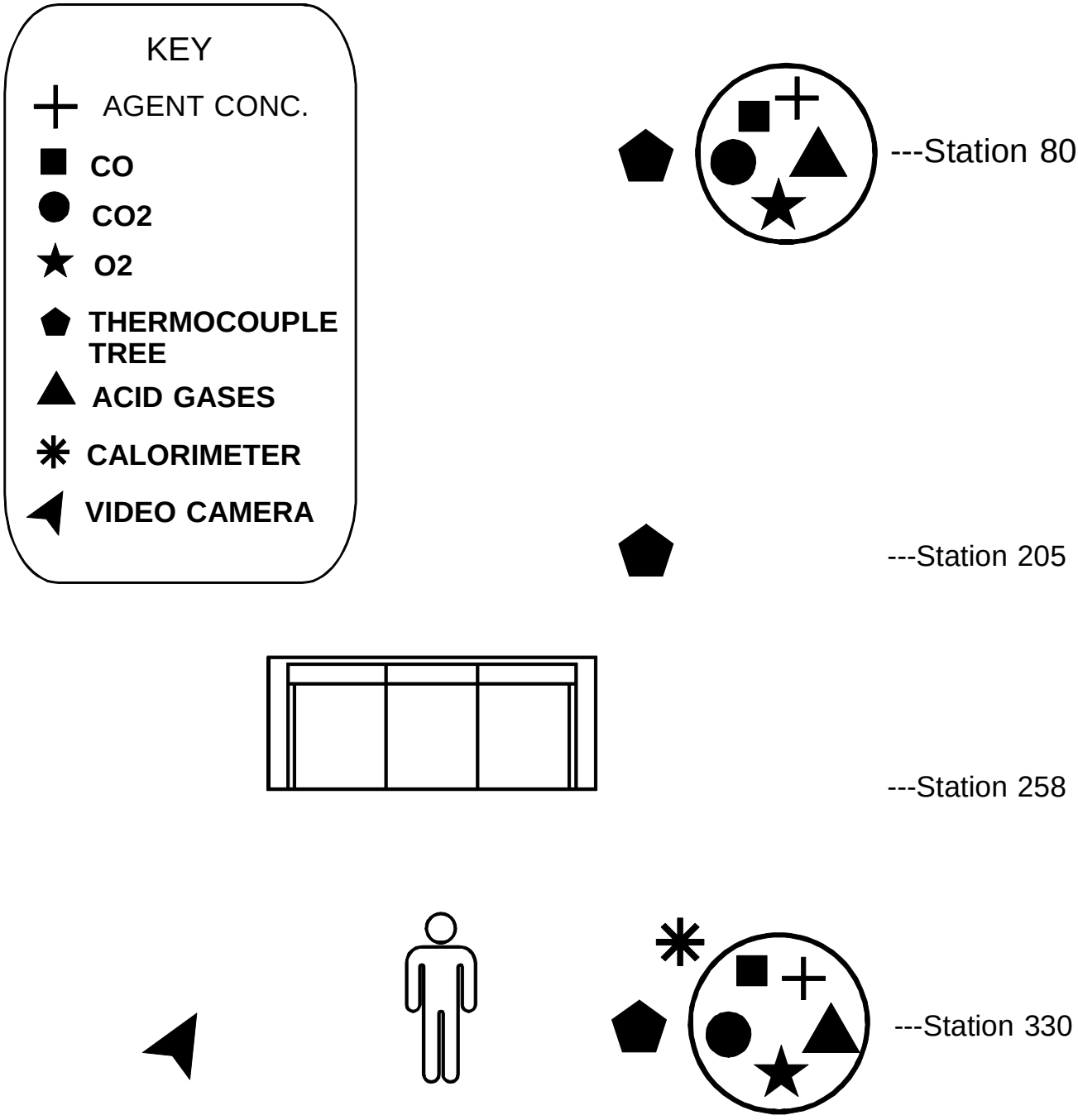

Fig. 1

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.

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 17”x25”x2”.

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.

Number of Data Tests:

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

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.

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.

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.

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.

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