DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
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ATLANTIC CITY, NEW JERSEY 08405
PROPULSION SECTION NA-542

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FLAMMABILITY, SMOKE, AND TOXIC GAS TEST OF AVCO GLASS REINFORCED ARMOR PANELS

PROJECT NO. 184-732-05X
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Purpose

To investigate the flammability characteristics of bullet-resistant armor panels for showing compliance with Federal Aviation Regulation (FAR) Part 25.853, paragraph (a), as amended in the Notice of Proposed Rule Making (NPRM) 69-33. Smoke and toxic gas characteristic tests were also conducted as a part of this investigation.

Background

Flammability tests conducted on a bullet-resistant glass reinforced armor panel installed in the Federal Aviation Administration's DC-9 under Contract FA-71-2500-1, dated 24 March 1971, with the AVCO Corporation, Special Materials Sub-Division, showed that this panel was not self-extinguishing within the required 15 seconds specified in the FAR.

As a result of these tests, a Purchase Request Order No. FA-71-3574-1, dated 28 June 1971, was initiated by RD-732 to the AVCO Corporation to fabricate and supply NA-542 at NAFEC additional samples of armor panels for flammability tests.

The panels specified in the Purchase Request are identified by AVCO Corporation as:

1. Flightweight II - samples identical to the armor installed in the FAA DC-9 under the original contract.

2. Flightweight IIF - samples fabricated of the same material but treated with a fire retardant of the contractor's choice.

Test Procedure

Flammability tests included:

1. Vertical tests for showing compliance with FAR Part 25.853a as amended in NPRM 69-33.

2. Radiant panel tests to obtain a flame-spread index (I_s) as described in ASTM E-162.

Smoke generation tests were accomplished by utilizing the test apparatus and procedures developed by the National Bureau of Standards and described in the Special Technical Publication, STP No. 422, published in 1967 by the American Society for Testing and Materials (ASTM).

Toxic gas concentration measurements were made by drawing samples of gas from the smoke chamber through colorimetric gas detection tubes from special ports provided for this purpose.

Discussion

Vertical test results show that both panels have a burn length of 1 inch or less. However, the flightweight II panel continued to flame for 2.15 minutes after removal of the Bunsen burner, and the flightweight IIF panel was self-extinguishing immediately after removal of the Bunsen burner. Therefore, the flightweight II panel will not qualify for acceptance in transport category aircraft in accordance with FAR Part 25.853 when amended by NPRM 69-33.

Radiant panel flame-spread tests show that the flightweight II panel has an average flame-front travel reaching the 12-inch mark in 8.15 minutes, and a net stack temperature rise of 56°C resulting in an I_s value equal to 24, and that the fightweight IIF panel has an average flame-front travel reaching the 9-inch mark in 6.24 minutes and a net stack temperature rise of 45°C resulting in an I_s value equal to 16.

Smoke generation measurements were made on the panels when exposed to flaming combustion and nonflaming pyrolytic decomposition. The results of these measurements are expressed in terms of specific optical density (D_s) at time intervals of 1.5, 4, and 20 minutes after the start of the test. Average D_s values for the flightweight II panel were 8, 56, and 303 when tested using the flaming combustion condition and 0, 2, and 378 when tested under the nonflaming condition. Average D_s values for the flightweight IIF panel were 10, 128, and 549 when tested under the flaming combustion condition and 0, 2, and 316 when tested under the nonflaming condition.

Toxic gas concentration measurements for carbon monoxide (CO), hydrogen chloride (HCl), and hydrogen cyanide (HC_n) were made concurrently with the smoke generation measurements under the flaming combustion conditions. Commercial colorimeteric gas detector tubes were utilized for making these measurements. Gas samples were taken from the test chamber during the time periods between 1.5 and 4 minutes and again between 15 and 20 minutes after the start of the smoke generation tests. Flightweight II panel concentrations were CO = 10ppm, HCl = 1 ppm, and HC_n = less than 1 for the first time period and CO = 1000 ppm, HCl = 4 ppm, and HC_n = less than 1 for the later time period. Flightweight IIF panel concentrations were CO = 200 ppm, HCl = approximately 90 ppm, and HC_n = less than 1 for the first time period and CO = 3500 ppm, HCl = 10 ppm, and HC_n = 1 ppm for the later time period. Threshold limit values for these gases, as established by the American Conference of Governmental Industrial Hygienists are CO = 50 ppm, HCl = 5 ppm, and HC_n = 10 ppm based on an 8-hour exposure time.

Summary of Test Results

A review of the test results of the flightweight II and IIF panels show that the addition of the fire retardant in the flightweight IIF panel qualifies this panel for use in the transport category aircraft as specified in FAR 25.853, NPRM 69-33 by reducing the flaming time from 2.15 to 0 minute after removal of the Bunsen burner. The flame-spread index (I_s) was also decreased from 24 for the flightweight II panel to 16 for the flightweight IIF panel. However, the smoke and toxic gas concentrations were raised appreciably for the flightweight IIF panel, especially in the case of toxic gas concentrations during the first 5 minutes of burning.