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EVALUATION OF FLUOREL COATING FOR AIRCRAFT FIRE BARRIER APPLICATION

PROJECT NO. 510-001-11X

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INTRODUCTION

Purpose

The test program was conducted to evaluate the effectiveness of Fluorel as a coating for increasing the fire resistance of aluminum skin to a kerosene fuel fire.

Background

During the past two years, a number of materials supplied by various manufacturers were evaluated as possible suitable candidate materials to improve the fire resistance of the aluminum fuselage structure of aircraft. This included materials as follows: (1) Nomex/Mica paper (0.030 inches thick), (2) sodium silicate intumescent sheet, (3) Microquartz batt (3/16 inches thick), (4) high-temperature glass fabric treated with chromium salts (several plies), and (5) AVCO/NASA rigid foams (1 3/4 and 3 3/4 inches thick). Although considerable fire protection as well as heat insulation was provided by some of these materials, none were considered entirely satisfactory. Reasons for this were, (1) difficulty of attaching material to aircraft structure, (2) weight penalty, and (3) lack of structural strength during and after exposure to fire.

The need for greater fire endurance of air transport fuselages to allow more time to control an external fuel fire and allow more time for passenger evacuation has been demonstrated by the results of full-scale tests at NAFEC involving aircraft (References (1) Report No. RD 65-50, May 1965 and (2) Report No. NA 69-37, December 1969). Tests by George Geyer, at NAFEC, have shown that structural integrity to fire of the aluminum skin covering, the fuselage may be insufficient to allow 90 seconds time for passenger evacuation to be completed. Instead, "burn-thru times" of 15 to 50 seconds were obtained in the above tests for different thicknesses of the sheet metal skin. The above situation has focused increasing attention to possible means of improving the fire endurance of the fuselage without imposing too severe a weight penalty which is the main hurdle to overcome in solving the problem.

DISCUSSION

Materials Description

Aircraft aluminum sheets,2 foot square, were coated with Fluorel for tests by the Raybestos-Manhattan Co. This company has been one of the principal NASA developers of this material. A more complete description of the construction of the sheets fire tested is contained in Table 1.

TABLE 1

MATERIALS DESCRIPTION

Test No.	ALCLAD Sheet Type	ALCLAD Sheet Thickness (in.)	Fluorel Coating Type	Fluorel Coating Thickness (in.)
1	7075-T6	.032	Blank	None
2	7075-T6	.032	L-3893-1	.010 - .016
3	7075-T6	.032	L-3893-1	.016 - .026
4	2024-T3	.090	Blank	None
5	2024-T3	.090	RL-3550	.078 - .100
6	2024-T3	.090	L-3929-1	.105 - .115

No information regarding the formulation of the Fluorel compounds was furnished by the company. The basic material developed by the Minnesota Mining and Manufacturing Company (3M), consists of a polymer of hexafluoropropene and vinylidene fluoride. The material owes its unusual flame resistance to its high fluorine content (over 50 percent). According to NASA Program Apollo Working Paper No. 1337, April 1968, which lists the RL 3550 compound, the formulation also contains 25-percent asbestos by weight.

Test Procedure

The 2-foot-square panels were bolted to the open end of a rectangular steel box and subjected to flames (2000°F) of a 2-gal/hr kerosene torch with a 6 1/2- by 11-inches elliptical outlet. Four thermocouples were used to record temperatures of (1) burner flames, (2) exposed surface of the test panel, and (3) backside surface of the panel. "Burn-thru times" were obtained by viewing the backside of the panel through the opposite end of the box and noting the first appearance of flames.

Total heat flux at the center of the test panel was measured as being 16.3 Btu/ft^2/sec (11.7-Btu/ft^2/sec radiant). This is somewhat higher than the figures quoted for a free-burning kerosene spill fire. However, the "burn-thru times" for aluminum panels exposed to the laboratory kerosene are considered close enough to those obtained in the large-scale kerosene fire tests from published data to show comparable fire severity for purposes of simulation.

TEST RESULTS

Kerosene Burner Tests

The results of the tests on six aluminum sheets, four of which were Fluorel coated, are presented in Table 2. Increase in "burn-thru times" provided by the coatings is shown in the data. All the coated aluminum sheets, except for the .090 sheet coated with Fluorel containing asbestos, showed flame penetration. Except for cracks, the charred coating continued during the fire to adhere to the metal surface. The thickest and most durable coating (3/32 inches) was that formed by asbestos (RL3550). Buckling of the sheet causing separation from the asbestos layer was credited with keeping the temperature of the metal sheet below its meeting point. In general, the Fluorel coating, depending on its thickness, provided some protection. For the most typical case of .032-inch aluminum skin and a .010- to .020-inch coating, "burn-thru time" was about doubled. Using Fluorel as an inside coating showed that this would produce a serious smoke hazard.

Of particular interest to the test program were observations that the aluminum sheet did not completely melt within the 12-by 16-inch area of flame impingement and thereby expose a large hole in the panel for flame entry. Instead, a very thin metallic foil, believed to be aluminum oxide, formed across the opening, thus providing an obstruction to flame penetration except in places where the foil had cracked. This experience suggested the possible use in future evaluation of aluminum-clad (with stainless steel and/or titanium) sheets.

Another unexpected occurrence in Test No. 5 was the appearance of a small bluish flame between the asbestos layer and aluminum sheet which persisted for about 30 seconds after the burner was shut off.

It was concluded from the tests on Fluorel coated aluminum panels that the gain in additional fire resistance was unsufficient to warrant further and more extensive testing. As a fire-barrier material, Fluorel suffers the disadvantages of poor adhesion and abrasion resistance as shown by the ease by which the coating may be scratched off the metal surface by fingernail. Also, the material generates dense smoke and very noxious fumes in a closed housing when exposed to heat as in Test No. 3.

TABLE 2

FLAME PENETRATION TEST DATA

Test No.	Coating Thickness (in.)	Burn-Thru Time (sec.)	Backside Temp. (°F)	Backside Time (sec.)	Remarks
1	None	19	1000	50	Burn-thru (.032 sheet)
2	.010 - .016	41	1000	50	Burn-thru (.032 sheet)
3	.016 - .026 (1)	87	1000	110	Burn-thru (.032 sheet) Heavy smoke developed in box.
4	None	50	1000	90	Burn-thru (.090 sheet)
5	.078 - .100	1200 +	150 800	210 300	No Burn-thru (.090 sheet) Cracks in coating in 95 seconds.
6	.105 - .115	124	700 900	120 285	Burn-thru (.090 sheet) Cracks in coating in 59 seconds.

NOTE: (1) Coated sheet reversed in this test so that coating was not exposed to burner flames.