MSA 094
FSS 594 R

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, NEW JERSEY 08405
PROPULSION & FIRE PROTECTION BRANCH NA-420

11 May 1972

DATA REPORT NO. 93

EVALUATION OF FIRE TECT COATING ON URETHANE SEAT FOAM IN AIRCRAFT

PROJECT NO. 184-732-05X

Prepared by: John F. Marcy
Eldon B. Nicholas

Purpose

Conduct studies and tests on Fire Tect, a plastic spray product, to determine its effectiveness in reducing flame propagation when used as a coating on urethane seat foam. The manufacturer of the material had claimed in his advertisement, "Fire Tect PC-210 enables current sub-standard seat cushions to meet the new FAA fire retardant standards, Part 25, Section 25-853."

Background

Mr. G. B. Warsaw, Sales Manager of the Consolidated General Corporation of Hollywood, California, in March of 1971, sent letters to various regional and Washington offices of the FAA describing a product sold by this company under the trandmark of Fire Tect PC-210. According to the letters, "Our newly developed product provides a dramatic break-through in the fire-retardancy of aircraft interiors." These letters with descriptive literature and coated urethane foam samples of about 3 inches square in size were referred to NAFEC for followup. First telephone contact with Mr. Warsaw was on 16 April 1971 at which time he promised that he would send standard-size foam specimens coated with Fire Tect. After completion of the tests on the coated samples furnished, the results were telephoned to Mr. Warsaw, and Mr. Marks, technical representative of Fire Tect.

It was pointed out, by the writer, that the availability of improved flame-retardant (FR) foams presently in use in the wide-bodied jet transports that are capable of meeting the self-extinguishing requirements would appear to make Fire Tect superfluous. Besides, the method of preparing the test specimen specified in Appendix F, paragraph (b), titled "Specimen Configuration of FAR 25," makes impractical the use of Fire Tect for foam. This is because the half-inch test specimen can be cut from any portion of the seat cushion foam pad. Only the outside layers of the foam pad would include the surface coating. It would make no sense to coat test specimens cut from the inside of the pad. In answer, Mr. Warsaw proposed a change in the test method to eliminate this contradiction. Instead, tests would be conducted on the entire foam pad rather than on a cut specimen. Mr. Warsaw further recommended that the test method also include the upholstery fabric in combination with the foam as a

complete cushion. For justification of this position, Mr. Warsaw cited demonstrations he performed at the Western office and elsewhere. He cited tests where FR foams that had passed the 8-inch burn length requirement failed when tested in intimate contact with an upholstery fabric. A Fire Tect coating on the foam eliminated this type of failure. Also, according to Mr. Warsaw, the Fire Tect coating was equally effective on the non-FR foams in meeting the new requirements. Thus, Fire Tect coating would make possible the continued use of regular highly flammable foam in the place of the new FR foams which would be more desirable on the basis of presumably improved service life and comfort of the older untreated foams. In reply, recent experience at NAFEC was cited to show that in a similar test, using a wool fabric in current use in an airline, both the fabric and foam in combination passed the 8-inch burn length requirements by a wide margin. It is not known what type of fabric material was used by Mr. Warsaw to cause the foam to fail. However, the mechanism that was responsible for this type of failure is known and referred to as either "ladder or wicking effects." It represents a limitation in the vertical test method for materials like foam which melt and drip and thus interfere with the free dripping action, since some of the molten foam will adhere to the fabric thereby maintaining the fire for continued upward flame spread. Whether these effects would cause failure, as reported by Mr. Warsaw, would depend on the flammability of both the fabric and foam. Presumably, in the NAFEC test the materials were much less flammable.

After receipt of 1 gallon of Fire Tect solution, a test program was organized to evaluate more completely the use of Fire Tect. During this time, contact was maintained with both Flight Standards Service (FS-120) and with Fred Jenkins of the Western Region.

Introduction

Because of the large quantities of urethane foam used in the seating of passenger air transports and the extreme flammability of this material, much more attention has been devoted to the study of the fire hazards involving this material than that of any other aircraft interior materials. This is reflected by the fire tests on foam pads and complete seat assemblies covered in Report No. RD-70-81, titled "Air Transport Cabin Mockup Fire Experiments," which showed that the fire hazard could be greatly reduced by the use of FR foam. Considerable testing on the seat foams has continued during the past two years and a report of the test results is planned for the end of FY 1972. The need for the extensive effort on flexible foam is due to the problems associated with the replacement of the rapidly flaming urethane foam, designated as flash resistant (maximum horizontal burn rate of 20 inches/minute), by a variety of FR self-extinguishing foams as required by NPRM 69-33, July 1968, which was adopted for certification of materials in the wide-bodied jet transports. Problems investigated pertaining to the use of FR foams resulted from statements that after extended use of the seats, much of the original flame retardancy of the foam would be lost because of the fugitive nature of the chemical additives. Also, that the additives had a deleterious effect on the flexibility of the foam causing the seat to bottom out. Since Pan Am replaced the seats on

their B-747 fleet as part of a complete refurbishing of the interior of this airplane after about one year, some credence was given to the charges. However, fire tests on a Pan Am seat cushion that had been removed from a B-747 after 6 months or more of continuous use, plus information obtained from the seat manufacturer, tended to prove that the problems resulting from the use of FR foams was not as serious as first reported. The recent developments in foam technology give promise of foams that are inherently self-extinguishing without need for chemical additives which impair the comfort characteristics (Modern Plastics, pages 68-71, October 1970, titled "Flame-retardant Urethanes: It's the Coming Thing"). Much effort has been expended to promote the use of FR foams for aircraft seating in order to meet the more severe flammability requirements of FAR 25.853. Proposals recommending the use of coatings, such as NASA's Fluorel, have been investigated (Data Report No. 69, April 1970). These have with Fire Tect, more recently, created additional controversy over the proper test standards needed to evaluate the fire hazards of the material.

Test Procedures

Fire Tect is supplied as a liquid with the active ingredients dissolved in a flammable thinner. It is pinkish in color and is air-sprayed onto the surface to be protected as with ordinary paint. The manufacturer claims that the coating does not affect the resiliency of the foam and that the treatment is permanent. However, experience at NAFEC shows that the coating abrades very easily when rubbed by the thumb. The coatings on the foam specimens showed a strong tendency to stick to paper, fabric, and other foam specimens. Specimens stored in the conditioning chambers at 70°F and 50-percent R.H. became moist due to absorption of water moisture. It was also noted that the coated sample sent out with the descriptive literature was found to have flattened out to half of its original thickness of one-half inch from being compressed in a folder.

All the foam specimens prepared for the vertical burn test in accordance with Test Method 5903, as specified in FAR 25.853, were cut to standard size from a large pad in strips of one-half inch thickness. The foam strips were sprayed only on the top and bottom surfaces but not along the cut edges and then conditioned at 70°F and 50-percent R.H. prior to test. A few specimens already coated by the manufacturer were also tested. Tests were also conducted with two pieces of coated 1/4-inch-thick foam bonded together with an adhesive film to determine the effect of the Fire Tect coating on the sandwich construction. Both adhesive seams and Velcro pads appear in the construction of some seat cushions. Additional tests were also conducted on FR foam in contact with an upholstery fabric and also with the FR foam bonded by an adhesive film to an FR cotton ticking fabric.

In addition to the standard laboratory tests described above, two large Fire-Tect-coated pads measuring 3 feet square and 4 inches thick and weighing about 11 pounds were subjected to a flame-ignition source. These pads after a spray application of Fire Tect over all surfaces of the two foam pads at a rate of 0.9 ounce/ft^2 were placed atop of one another on an open mesh iron grill for support. A propane-fed Bunsen burner flame of about 3 to 6 inches in height was placed below, at the center, and in contact with the bottom pad. The test was conducted inside a 640-ft^3 enclosure which

had been used in previous tests to study the burning characteristics of different types of foam padding on a larger scale, including tests on complete assemblies. Results of these tests are contained in Report RD-81, "Air Transport Cabin Mockup Fire Experiments," dated December 1970. The advantage of the FR foams over the non treated foams to significantly reduce the cabin fire hazard had already been demonstrated in the previous tests. The test was conducted to determine the effectiveness of Fire Tect coating on a much larger scale than that represented in the laboratory tests both in regard to size of the foam specimen and severity of the ignition source.

Summary of Test Results and Analysis

1. Laboratory Tests

Results of standard laboratory tests conducted on 26 different combinations of materials consisting of five various types of urethane foa both coated and uncoated with Fire Tect and with and without adhesive joints, slip coatings, and upholstery fabrics are presented in Table 1.

The first group of tests, Nos. 1 through 4, were conducted on the most flammable type of foam. The effectiveness of the Fire Tect coating in arresting the upward propagation of the flame is shown by the reduction of the burn length. The coating is most effective when applied to both sides of the 1/2-inch standard foam specimen which is, of course, of no practical importance. Of particular interest is the failure of Fire Tect Test No. 4 to protect the foam when it is tested in contact with fabric along the protected surface of the foam. Although the fabric burn length was only 1.7 inches, the back side of the foam specimen burned completely constituting a failure for the combination.

Four types of FR foams were used to evaluate the effect of Fire Tect coatings on the burn, char and/or melt length and flameout time in comparison with the maximum allowable 8-inch length and 15-second time limit specified in FAR 25. The best of the foams as shown by Test No. 20 was the E. R. Carpenter FR foam based on its short burn length indicating the least amount of melting of any of the foams. The worst of the foams in terms of maximum melting was the Upjohn foam supplied by the Fire Tect Company as shown by Test No. 16. It is important to note that the Upjohn foam in Test No. 15 when burned in contact with the wool fabric of Test No. 12 failed as it burned in excess of the 8-inch requirements. This proves the contention of Mr. Warsaw that an upholstery fabric in contact with foam can reinforce the burning of the foam to the extent that it may fail in a situation as presented in a seat cushion configuration. This is especially true if a slip coating as supplied with the Fire Tect Company's test specimens is used in the place of a cotton ticking. However with the latest techniques of molding seats, this coating as well as the ticking would not be needed. The use of Fire Tect coatings was successful in limiting the burn length to less than 6 inches when tested with both the slip coating of Test No. 17 and wool fabric of Test No. 16 as shown in Test No. 19.

The tests with specimens prepared at NAFEC with FR foams that were superior to the FR Upjohn foam in resisting burning did not fail when tested in combination with the wool fabric as shown in Test No. 14.

Tests were also conducted to investigate the problem of increased flammability of 1/2-inch-thick specimens cut from any selected section of the seat cushion pad such as when an adhesive joint is present as in Test No. 8. Although both the foam and adhesive film each met the 8-inch burn length requirement when burned separately, these failed when tested in combination with the fabric as shown in Tests Nos. 8 and 9. A coating of Fire Tect under the adhesive film in contact with the foam was effective in limiting the burn length to 3.5 inches as shown by Test No. 10. However, with the best type of foam tested as with the FR Carpenter H 45C foam exhibiting low melting, the adhesive joint will not cause failure of this foam as shown in Tests Nos. 21 and 25.

In summary, test results confirm that fabrics in contact with the foam specimen can fail in combination even though the materials separately meet the 8-inch burn length self-extinguishing requirement. An adhesive film bonding two pieces of foam can likewise cause the foam to fail. However, the more flame-resistant foams currently available are capable of meeting the FAR 25 requirements under all conditions of use investigated without recourse to any protective coating such as Fire Tect. The advantage of Fire Tect would be to allow the use of marginal foams to meet the flammability requirements. Such foams may be more desirable on the basis of their superior physical characteristics.

2. Cabin Mockup Test

Results of the test on urethane foam pads coated with Fire Tect are presented in Figure 1. The test was conducted to compare the burning characteristics of a coated sample of conventional urethane foam with that of an uncoated FR foam previously tested under identical conditions for direct comparison.

The foam pads were burned at one end of an enclosure 16 feet 9 inches in length, 6 feet 3 inches high, at a location about 2 feet from the longitudinal wall. Thermocouples were used to record the air temperatures at four locations; namely, (1) 1 foot directly above the foam pads, (2) 6 inches below the ceiling directly above the foam pads, (3) 6 inches below the ceiling at the center of the enclosure, and (4) 6 inches below the far end of the ceiling. Temperature increase at the four locations with the time after exposure to the burner flame of the bottom Fire Tect coated surface of the foam pads is shown by the curves.

These show that for almost 4 minutes the burning of the foam was slight, since temperatures in the mockup were still below 100°F. At 4.8 minutes, flames apparently broke through the two 4-inch-thick foam pads and contacted Thermocouple No. 1 located 1 foot above the foam pads. At 5.0 minutes, a flash fire developed as demonstrated by the rapid rise in temperatures along the ceiling with air temperatures decreasing with increase in distance from the fire.

Observations and photographs were made by viewing through a window in the enclosure about 2 feet from the foam pads. It was noted that the foam started to drip after 1.5 minutes. At 2.0 minutes, flaming on the bottom cushion was limited to an 8-inch circle. It was apparent from previous tests that the Fire Tect coating prevented the rapid flame spread to cover most of the bottom surface area of the foam pad within about 1 minute as experienced before. At 3.0 minutes, the burner was shut off as the foam was flaming of its own accord. At 3.5 minutes, flames were seen flashing across the bottom of the foam pads. At 5.0 minutes, flames were seen emerging from the top surface of the foam pads after burning a large hole through the two pads. At this time, the pads were beginning to burn vigorously with heavy dripping of the foam which burned with flames on the floor. At 6.0 minutes, photographs of the burning pads were taken which confirmed earlier visual observations. At 7.0 minutes, popping sounds were heard which continued for about 2 minutes. At 10.5 minutes, all flaming of the foam was extinguished for lack of oxygen and the door was open. No reignition occurred with admittance of fresh air to the mockup.

A recapitulation of the test results shows that:

1. Some FR foams which meet the 8-inch burn length self-extinguishing requirement of the latest regulations can fail when tested in combination with other materials such as an upholstery fabric simulating a 1/2-inch-thick section cut from a seat cushion. However, this problem exists only with the marginal types of materials.

2. Although Fire Tect coating provides some fire protection to the regular type (nonflame treated) urethane foam pads, it will not prevent a flash fire from occurring when the pads are burned in a closed area. In previous tests, it was demonstrated that FR foam pads did not flash even when subjected to an 8-ounce kerosene pan fire. In these tests, the amount of foam consumed by the fire was limited to the immediate radius of the ignition flames, unlike the Fire Tect coated foam which continued to flame resulting in the flash fire.

TABLE 1

FLAMMABILITY DATA BY VERTICAL BURN TEST - FEDERAL STANDARD 191, TEST METHOD 5903

Test No.	Fire Tect Coated (1)	Description of Test Specimens	Burn (2) Length (in.)	Char/ Melt (3) Length (in.)	Flameout Time (4) (sec)
1	No	Non FR Foam (1.5 pcf) - Tested alone.	Complete (5)	Complete	12
2	Yes	Non FR Foam (1.5 pcf) - Coated one side only.	5.7	1.0	0
3	Yes	Non FR Foam (1.5 pcf) - Coated both sides.	0.9	0.9	10
4	Yes	Non FR Foam (1.5 pcf) - Coated one side only and coated side covered with FR Wool Fabric.	Complete (6)	Complete (7)	32
5	No	FR Cold Cure Union Carbide Foam (2.5 pcf) - Tested alone.	3.1	1.3	0
6	Yes	FR Cold Cure Union Carbide Foam (2.5 pcf) - Coated one side only.	1.8	0.8	0
7	Yes	FR Cold Cure Union Carbide Foam (2.5 pcf) - Coated both sides.	0.7	0.7	0
8	No	FR Cold Cure Union Carbide Foam (2.5 pcf) - Two 1/4-inch-thick pieces bonded together by U.S.M. Corp. Adhesive Film (8).	Complete	Complete	96
9	No	FR Cold Cure Union Carbide Foam (2.5 pcf) - Bonded to FR Cotton Ticking (9) cover by U.S.M. Corp. Adhesive Film.	Complete	Complete	100
10	Yes	FR Cold Cure Union Carbide Foam (2.5 pcf) - Coated one side with Fire Tect and bonded to FR Cotton Ticking cover by U.S.M. Corp. Adhesive Film.	3.5	0.6	0
11	No	FR Cotton Ticking - Tested alone.	2.0	1.2	0
12	No	FR Timme & Sons Wool Fabric (10) - Tested alone.	2.2 W (11) 1.6 F	0.3 W 0.8 F	0

TABLE 1 (Continued)

FLAMMABILITY DATA BY VERTICAL BURN TEST - FEDERAL STANDARD 191, TEST METHOD 5903

Test No.	Fire Tect (1) Coated	Description of Test Specimens	Burn Length (2) (in.)	Char/Melt Length (3) (in.)	Flameout Time (4) (sec)
13	No	FR Goodrich U 44 Foam (12) (2.0 pcf) - Tested alone.	5.7	2.0	0
14	No	FR Goodrich U 44 Foam (2.0 pcf) - Covered one side by FR Wool Fabric	5.4 (13)	1.1	0
15	No	FR CPR Upjohn Foam (2.5 pcf) supplied by Fire Tect - Tested alone (14)	5.5	2.7	0
16	No	FR CPR Upjohn Foam (2.5 pcf) - Covered on one side as in Test No. 14 by FR Wool Fabric.	10.0 (15)	6.0	95
17	No	FR CPR Upjohn Foam (2.5 pcf) - Coated both sides with Slip Coat.	Complete	Complete	60
18	Yes	FR CPR Upjohn Foam (2.5 pcf) - Coated both sides with Fire Tect first and then coated with Slip Coat.	3.9	0.6	0
19	Yes	FR CPR Upjohn Foam (2.5 pcf) - Coated both sides with Fire Tect and Slip Coat as in Test No. 18, then one side covered with FR Wool Fabric.	4.3 (11)	0.6	0
20	No	FR E. R. Carpenter H 45C Foam (2.0 pcf) - Tested alone.	2.7	1.2	0
21	No	FR E. R. Carpenter H 45C Foam (2.0 pcf) - Two 1/4-inch-thick foam pieces as in Test No. 7 bonded together by U.S.M. Corp. Adhesive Film.	4.3	0.7	0
22	Yes	FR E. R. Carpenter H 45C Foam (2.0 pcf) -- Coated one side only.	1.8	0.6	0
23	Yes	FR E. R. Carpenter H 45C Foam (2.0 pcf) - Two 1/4-inch-thick foam pieces as in Test No. 21 bonded together by Adhesive Film. Only one side of external surface was coated.	3.6	0.8	0

TABLE 1 (Continued)

FLAMMABILITY DATA BY VERTICAL BURN TEST - FEDERAL STANDARD 191, TEST METHOD 5903

Test No.	Fire Tect (1) Coated	Description of Test Specimens	Burn (2) Length (in.)	Char/ Melt (3) Length (in.)	Flameout Time (4) (sec)
24	Yes	FR E. R. Carpenter H 45C Foam (2.0 pcf) - Two 1/4-inch-thick foam pieces first coated with Fire Tect and then bonded together by Adhesive Film. No Fire Tect coated surfaces.	2.8	0.4	0
25	No	FR E. R. Carpenter H 45C Foam (2.0 pcf) - External surface of foam bonded to FR Cotton Ticking by U.S.M. Corp. Adhesive Film.	3.8 (13)	0.7	0
26	No	U.S.M. Corp. Adhesive Film - Tested alone.	5.5	5.5	5

Notes:

(1) Fire Tect Application Rate - 0.9 oz/ft^2
(2) Burn Length - Complete plus partial destruction of specimen by fire
(3) Char and/or Melt Length - Complete destruction by charring (fabric) and melting (foam)
(4) Flameout Time - Extinction of flaming combustion after removal of the burner
(5) Complete Burning - Entire 12-inch specimen burned. Not self-extinguishing. Failed test.
(6) FR Wool Fabric burned 1.7 inches
(7) FR Wool Fabric charred 0.5 inches
(8) U.S.M. Corp. Adhesive - 0.020-inch-thick film
(9) FR Cotton Ticking - 12 oz/yd^2
(10) FR Wool Fabric - 16 oz/yd^2
(11) W and F - Refers to Warp and Fill direction of weave
(12) FR Goodrich Foam - Same as in FAA Reports NA-68-30 and RD-70-81.
(13) This is burn length for foam, that of fabric is much less
(14) All FR Upjohn foam coated specimens were prepared by the Fire Tect Company
(15) Exceeded the 8-inch burn length and failed requirements of FAR 25

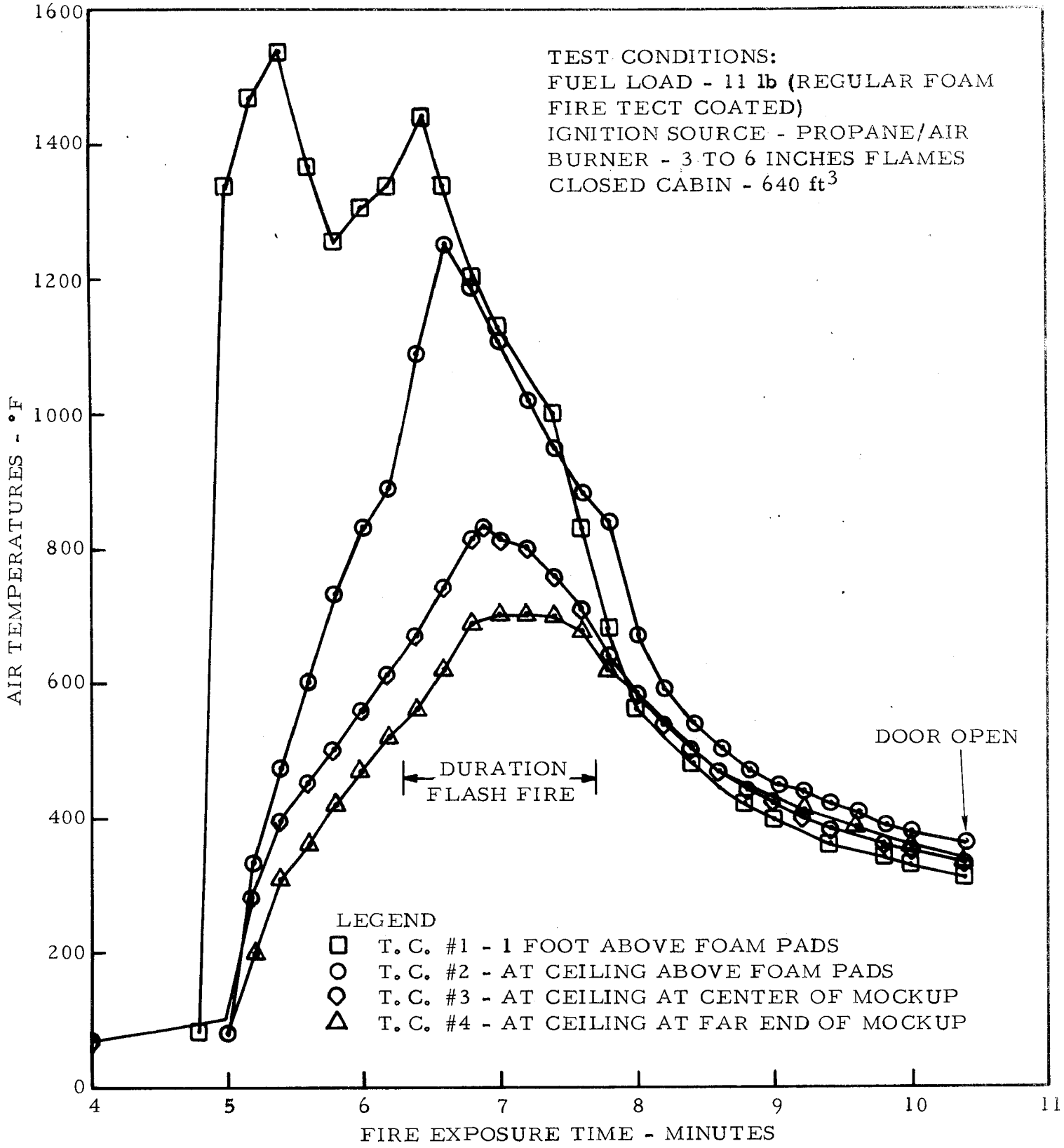

FIGURE 1 - CABIN TEMPERATURES FROM BURNING FIRE TECT COATED URETHANE SEAT FOAM