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Evaluation of Fire Test Methods for Aircraft Thermal Acoustical Insulation

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16. Abstract

Round robin flammability testing was performed by eight laboratories on thermal acoustical insulation blankets and films used as insulation coverings. Test samples were subjected to vertical Bunsen burner testing and cotton swab testing. The test data indicated that the cotton swab test produced consistent test results, whereas the vertical flammability test did not.

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EXECUTIVE SUMMARY

This report presents the results of laboratory round robin flammability testing performed on thermal acoustical insulation blankets and the films used as insulation coverings. This work was requested by the aircraft industry as a result of actual incidents involving flame propagation on the thermal acoustical blankets. Vertical flammability testing was performed as specified in Federal Aviation Regulation (FAR) 25.853, Appendix F. In addition, a cotton swab test developed by the aircraft manufacturers was also evaluated. These cotton swab tests were performed by placing ignited alcohol saturated cotton swabs on a test-sized blanket and measuring the longest burn length. Test results indicated that the cotton swab tests produced consistent test results, whereas the vertical flammability tests did not. This was especially apparent with one particular film covering which passed the vertical test according to 50% of the participating laboratories while this same film during the cotton swab tests was reported to have been consumed by all but one laboratory which reported that 75% of the sample was destroyed.

INTRODUCTION

PURPOSE.

The purpose of this report is to present the results of round robin flammability testing performed on thermal acoustical insulation blankets and the films used as insulation coverings.

BACKGROUND.

Between 1993 and 1995, a number of incidents involving flame propagation on thermal acoustical insulation blankets have been reported. A description of five of these incidents follows.

1. On November 24, 1993, an MD-87 (McDonnell Douglas) experienced a fire aboard the aircraft while taxiing towards its assigned gate at Copenhagen Airport, Denmark (EKCH). Smoke started to emerge behind and above the service units installed in the aft right-hand side of the cabin. After the aircraft parked and all passengers and crew had disembarked, the smoke intensified drastically. This may have occurred due to the chimney effect when the forward and aft cabin doors were opened. A fierce fire then erupted and spread very quickly. Investigators determined that the thermal acoustical insulation blankets acted as fuel sources which helped to spread the fire. The Aircraft Accident Investigation Board of Denmark concluded that an expanded set of test conditions, which includes additional ignition conditions beyond those previously required, might better determine blanket flammability characteristics [1].

2. On October 10, 1994, a Boeing 737-300 landed in Beijing, China. After landing, the ground crew detected a burning smell. Upon opening the Electronics and Engineering (E/E) bay they found that the insulation blanket under rack 2 was on fire. Upon investigation, it was determined that improper installation of a wire bundle clamp made contact with the associated wires and caused a short circuit. The intense heat from the arcing and sparks ignited the insulation blanket [2].

3. On September 6, 1995, the captain of an MD-11 aircraft was about to start the engines for departure from Capital Airport in China when the flight crew noticed a significant amount of smoke emanating from the E/E bay. Further inspection revealed that areas of the E/E bay were on fire. Investigators found that molten metal from arcing wires had fallen on the fuselage skin insulation blankets under the E/E bay. There was extensive flame propagation from the insulation blankets up into the E/E bay with widespread damage [2].

4. On November 13, 1995, during a “C” inspection of a Boeing 737-300 performed by Yunnan Airlines in China, maintenance personnel found that the floor nut bolt of the left-rear access cargo door was separated. When the nut bolt was removed by an air drill, hot metal chips spewed forth and ignited the insulation blanket film under the floor. Flames propagated on the blanket covering an area of 18 by 40 inches [2].

5. On November 26, 1995, an Alitalia MD-82 aircraft experienced a cabin fire prior to takeoff from Turin Airport in Italy. The cause of the fire was determined to be a ruptured ballast case. The fire spread rapidly. The dust flap, ceiling panels, and wire harnesses showed moderate to extensive fire damage. Although the specific contribution of the film covering of the insulation blankets could not be determined, investigators believed that ignition of the film most probably occurred subsequent to the ignition of either the dust flap or the ceiling panel. There was extensive flame spread on the blankets [3].

Thermal acoustical insulation, insulation covering, and insulation blankets must be tested in accordance with Federal Aviation Regulation (FAR) 25.853. The test method is specified in Appendix F and calls for vertical flammability testing of samples using an approved burner. A minimum of three samples must be tested with a flame exposure of 12 seconds. In order to pass the flammability test, the average burn length should not exceed 8 inches and the average flame time after removal of the flame should not exceed 15 seconds. Drippings on the chamber floor from the test specimen should not continue to flame for more than an average of 5 seconds.

As stated, the Federal Aviation Administration (FAA) requires vertical flammability testing only; however, aircraft manufacturers have developed a cotton swab test that has been shown to be effective in identifying thermal acoustical insulation films that propagate flame in a consistent manner. Vertical testing does not produce consistent results and therefore may not be a suitable indication of the flammability characteristics of these films. In fact, both the Boeing Commercial Airplane Company and Douglas Aircraft Company have added the cotton swab test to their internal material specifications.

MATERIALS

As a result of the incidents discussed above and a request from the aircraft industry, the International Aircraft Materials Fire Test Working Group formed an ad hoc task group for the purpose of conducting vertical flammability round robin testing on thermal acoustical films and blankets and to evaluate the cotton swab test. Eight laboratories participated in this program.

FILMS.

The two principle reasons that films are used as coverings on aircraft blankets are the containment of the fiberglass (keeping the batting in place) and the resistance to moisture permeation. Selection of films is based on durability, fire resistance, weight, and installation considerations. Metalized poly (vinyl fluoride) (PVF) and metalized and nonmetalized polyester poly (ethylene terephthalate) (PET) are currently the most widely used films in the aircraft industry.

In air, PET burns with a smoky flame accompanied by melting, dripping, and little char formation. Therefore, fire retardant (FR) treatments are necessary. The FR treated grades are generally prepared by incorporating halogen or nonhalogen containing materials as part of the polymer molecules or as additives. Metal oxide synergists such as antimony oxide are frequently included. Although fire retarded PET films are resistant to small ignition sources in low heat flux environments, they can burn readily in fully developed fires [4].

In air, biaxially oriented PVF film (Tedlar) has burn characteristics similar to PET film. This particular film contains a flame retardant antimony compound but no brominated or chlorinated ingredients [5].

In air, fully aromatic polyimide is characterized by high char formation on pyrolysis and low flammability and low smoke production when immersed in a flame [4].

The following five films were evaluated in this series of testing:

1. Polyimide film—nylon scrim
2. PVF film—polyester scrim
3. Metalized PVF film—polyester scrim
4. PET film—polyester scrim
5. Metalized PET film—nylon scrim

Polyimide film was included in this program because it is currently being used as a thermal acoustical insulation covering in some business jet aircraft and was used by Lockheed in the L-1011 airplane. While the airplane is no longer being manufactured, there are a number still in service. Furthermore, polyimide film is currently being re-evaluated for future use as an insulation covering due to its excellent flammability resistance and other mechanical properties.

PVF film is not currently used as a thermal acoustical insulation covering on transport category aircraft in America or Europe; however, it is occasionally installed during retrofits of smaller aircraft in the United States.

Metalized PVF film is a commonly used cover material for thermal acoustical insulation on aircraft manufactured both in America and in Europe.

PET film is also a commonly used thermal acoustical insulation cover material in America and in Europe.

Metalized PET film has been used occasionally. One specific metalized PET film that may have been involved in in-service fires has been discontinued. There are, however, airplanes still in service with this film installed. This particular discontinued film was the only metalized PET film included in the round robin.

INSULATION.

The fiberglass insulation was aircraft quality, 3 inches thick, and weighed 0.42 pcf (pounds per cubic foot).

THERMAL ACOUSTICAL INSULATION BLANKETS.

Five test blankets were fabricated using each of the different films to encapsulate the fiberglass. Each blanket measured 16 by 24 inches.

BUNSEN BURNER TEST SAMPLES.

As stated earlier, FAR 25.853 requires that the film (covering), thermal acoustical insulation, and finished blankets be tested in accordance with the test method specified in Appendix F. Since there was sufficient flammability test data available on the 0.42 pcf fiberglass (thermal acoustical insulation), it was not tested in this round robin program.

While not specified in the regulation, the fiberglass/film test specimens were vertically tested in both a compressed and noncompressed (also referred to as lofted) configuration. This was done because of differences in burn length noted by some laboratories when tested both ways.

FLAMMABILITY TESTING

VERTICAL TESTING.

FILMS. The results of vertical flammability testing performed on the films are summarized in tables 1 through 5. Data presented are the averages of the three specimens tested. From table 3, it can be seen that labs C, D, and F failed the metalized PET film since the 8-inch maximum burn length requirement was exceeded. Labs D, F, and H also reported flameout times longer than 15 seconds that also constitutes a failure. Also, note from table 3 the variation in burn lengths and flameout times reported from lab to lab. From tables 1, 2, 4, and 5, it can be seen that all of the other films passed vertical flammability testing (burn length, flameout time, and drip flameout). The polyimide data shown in table 5 also shows a significant variation in burn lengths reported.

FILMS AND FIBERGLASS. The films and fiberglass were cut into 3- by 12-inch samples, sandwiched together, and inserted into the standard specimen holder. The test sample was then clamped in place. This resulted in a compressed (elliptical shaped) configuration when viewed from the bottom. Referring to tables 6, 7, 8, 9, and 10, it can be seen that all samples passed, including the metalized PET samples. This is in sharp contrast to the metalized PET film that failed burn length and/or flameout time as reported by the four labs shown in table 3. Tables 6, 7, 8, and 9 show significant variation in burn lengths. Labs D and H performed testing with the films oriented in both the warp and fill direction. Neither lab observed significant differences when comparing the data of the warp direction with the fill direction.

Additional samples of the films and fiberglass were cut into 3- by 12-inch samples, but this time they were inserted into a special holder that did not compress the samples. The data are presented in tables 11, 12, 13, 14, and 15. All test samples passed with the exception of the metalized PET specimen tested at lab A that failed both flameout time and burn length. (See table 13.) Also, note from this table the significant variations in burn lengths and flameout times reported by all labs. This variation in burn length can also be seen for the PET samples shown in table 14. A comparison of the burn length data of the compressed versus noncompressed samples is discussed below.

1. The majority of the labs reported that metalized PVF samples have longer burn lengths when tested in the compressed configuration versus the noncompressed configuration. See tables 6 and 11.

2. Five labs reported that the compressed PVF samples had burn lengths slightly longer than the noncompressed samples. Two labs reported the opposite. (See tables 7 and 12.)

3. From tables 8 and 13, it can be seen that four labs reported longer burn lengths with the noncompressed metalized PET samples than the compressed samples

4. Referring to tables 9 and 14, it can be seen that the compressed PET samples had longer burn lengths than the noncompressed samples. This was reported by all labs.

5. The compressed and noncompressed polyimide data are shown in tables 10 and 15. A comparison of the burn length data shows minimal difference in values. In fact, labs A, D, E, G, and H reported the same burn length for both compressed and noncompressed samples.

<u>COTTON SWAB TESTING</u>.

As mentioned earlier, the cotton swab test was adopted into both the Boeing and Douglas Aircraft material specifications. The cotton swab test method followed by Boeing is slightly different than the one followed by Douglas Aircraft. Those differences are the test blanket size, the number of cotton swabs used, and the placement of a swab in a seam. A description of the test blanket and procedures followed in this round robin is described below.

Five test blankets, each measuring 16 by 24 inches, were fabricated and sent to each participant. Each blanket was constructed of fiberglass insulation encapsulated with one of the five film materials. Two different means of sealing the blankets were used depending on the manufacturer. This was not a concern since there was no swab placement in a seam in this round robin. The blanket was folded and propped up against a nonflammable supporting surface. The wooden applicator sticks of two cotton swabs were broken off and the cotton ends saturated with isopropyl alcohol and ignited. One of the swabs was placed in the bottom center of the blanket and one in the crease as shown in figure 1. The test blanket was allowed to burn to completion or until it self-extinguished. The burn length measurement, the longest distance of flame travel from the center of the cotton swab, was recorded. Shrinkage and pulling away of the material were not included in the burn length measurement.

<u>COTTON SWAB TEST RESULTS</u>.

Test results are presented in tables 16 through 20. It can be seen that most of the labs reported burn length measurements for both the center and crease positions. One lab reported only the longest burn length (no position specified) and one lab reported results as either pass or fail. Again, bear in mind this is not an FAA mandated test and, therefore, the pass/fail criteria may differ among those who have adopted it. As an example, one lab specifies an 8-inch maximum burn length which is the same value specified for the vertical burn test in FAR 25.853. Burn lengths (both center and crease positions) of less than 8 inches were reported for all test blankets by all labs with the exception of the metalized PET blanket. As shown in table 18, all labs reported that the entire front face (horizontal and vertical components) of the metalized PET blanket was consumed except lab A that reported an 8-inch burn length in the center. Furthermore, flame spread was reported by a number of labs to have propagated to the backside of the metalized PET blanket with extensive fire damage.

BURN LENGTH DISCUSSION

DEFINITION.

Burn length, as defined in FAR 25.853, Appendix F, is defined as the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored, nor areas where material has shrunk or melted away from the heat source.

TESTING AND RESULTS.

Shrinkage appears to be the primary means of PVF, PET, and metalized PVF film degradation when exposed to vertical Bunsen burner testing. To verify this postulation, three samples each of PVF, PET, and metalized PVF were cut and weighed to four decimal places. The samples were then subjected to vertical Bunsen burner testing and reweighed. The data is presented in tables 21 through 23. The areas of the specimens were then measured, but since the reduced areas (voids) were neither perfect triangles nor rectangles the measurements are approximations. From the results, it can be seen that the weight losses for all samples were minimal but the area losses were high. Since the weight/area data supports the phenomenon of shrinkage as the primary mechanism of degradation, it would appear that shrinkage is being interpreted as burn length by some of the round robin participants. This conclusion is based on the burn length data for both film and film/fiberglass assemblies.

CONCLUSIONS

1. The front face of the metalized PET blanket sample was totally consumed when subjected to the cotton swab test. This was reported by all but one lab, which reported that 75% of the front face was consumed. This is in sharp contrast to the vertical flammability test results which indicated that the metalized PET/fiberglass samples (compressed and noncompressed) passed most of the time. Hence, the cotton swab test proved itself to be a more reproducible test than the vertical flammability test for this particular film/fiberglass assembly.

2. The grade of metalized PET film evaluated in this round robin is flammable and possibly could propagate a fire in a realistic situation.

3. Determining the burn length of both the metalized PET and PVF and the clear PET and PVF is not clear, which is apparent from the data. This phenomenon is evident for the

films and the film/fiberglass samples. This may be due to the tendency of the films to shrink quickly away from the heat source, thus creating a void in the sample. The data reported by some labs suggest that shrinkage is being reported as burn length.

4. A comparison of burn length data between compressed and noncompressed test samples does not fully support a conclusion as to which configuration is more severe. An expanded study would be necessary in order to substantiate a definite conclusion.

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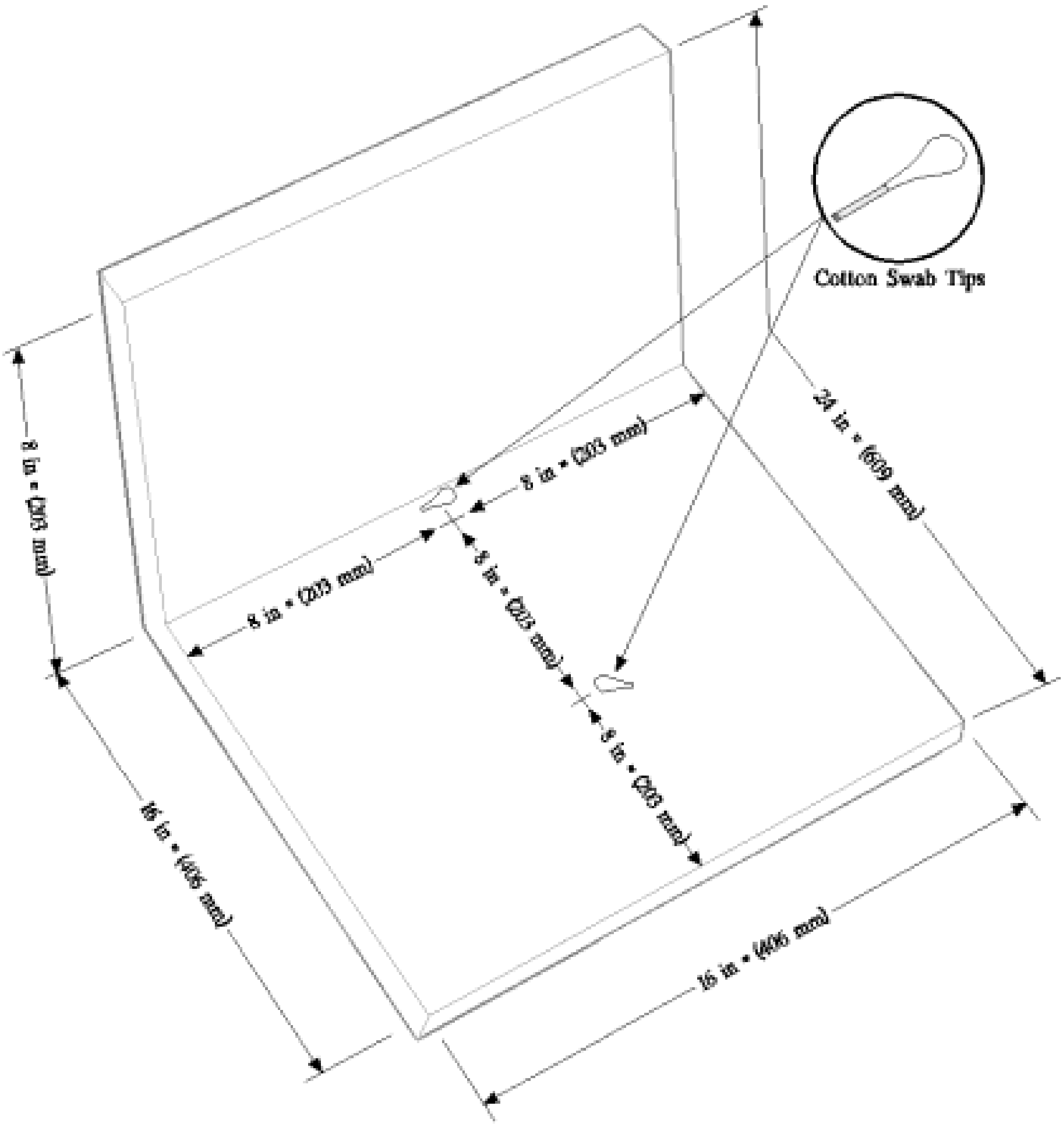

FIGURE 1. COTTON SWAB TEST CONFIGURATION

TABLE 1. VERTICAL BUNSEN BURNER TESTING—METALIZED PVF FILM

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Drippings (seconds)
A	12	0	0	0
B	12	0	1.3	0
C	12	0	0	0
D	12	0	0	0
E	12	0	0.5	0
F	12	0	0.08	0
G	12	0	1.0	0
H	12	0	2.33	0

Data are averages of three tests.

TABLE 2. VERTICAL BUNSEN BURNER TESTING—PVF FILM

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Drippings (seconds)
A	12	0	0	0
B	12	0	0.7	0
C	12	0	0	0
D	12	0	0	0
E	12	0	0.5	0
F	12	0	0	0
G	12	0	1.0	0
H	12	0	1.0	0

Data are averages of three tests.

TABLE 3. VERTICAL BUNSEN BURNER TESTING—METALIZED PET FILM

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Drippings (seconds)
A	12	0	8.0	0
B	12	1.0	3.2	0
C	12	8	8.1	0
D	12	23	>9.6	0
E	12	0.9	4.5	0
F	12	23.8	9.2	0
G	12	0	1.3	0
H	12	33.0	N/A*	0

Data are averages of three tests.
*not applicable

TABLE 4. VERTICAL BUNSEN BURNER TESTING—PET FILM

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Drippings (seconds)
A	12	0	0	0
B	12	0	1.1	0
C	12	0	0	0
D	12	0	0	0
E	12	0	1.0	0
F	12	0	0.36	0
G	12	0	1.0	0
H	12	0	6.67	0

Data are averages of three tests.

TABLE 5. VERTICAL BUNSEN BURNER TESTING—POLYIMIDE FILM

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Drippings (seconds)
A	12	0	0	0
B	12	4	6.3	0
C	12	0	3.4	0
D	12	0	5.7	0
E	12	2.7	5.0	0
F	12	0	4.2	0
G	12	0	2.3	0
H	12	0	3.7	0

Data are averages of three tests.

TABLE 6. VERTICAL BUNSEN BURNER TESTING—COMPRESSED METALIZED PVF FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Drippings (seconds)
A	12	0	0	0
B	12	0	3.4	0
C	12	0	6.6	0
D	12	0	3.1 (warp direction) 3.5 (fill direction)	0
E	12	0	3.1	0
F	12	0	2.8	0
G	12	0	2.7	0
H	12	0	2.5 (warp direction) 3.0 (fill direction)	0

Data are averages of three tests.

TABLE 7. VERTICAL BUNSEN BURNER TESTING—COMPRESSED PVF FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	0	0
B	12	0	2.5	0
C	12	0	5.8	0
D	12	0	3.2 (warp direction) 3.4 (fill direction)	0
E	12	0	1.5	0
F	12	0	0.16	0
G	12	0	2.7	0
H	12	0	3.3	0

Data are averages of three tests.

TABLE 8. VERTICAL BUNSEN BURNER TESTING—COMPRESSED METALIZED PET FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	7.3	2.3	0
B	12	0	3.3	1
C	12	2	5.9	0
D	12	0	4.6 (warp direction) 4.4 (fill direction)	0
E	12	0	3.3	0
F	12	0	5.8	0
G	12	0	3.8	0
H	12	2.1	4.5	0

Data are averages of three tests.

TABLE 9. VERTICAL BUNSEN BURNER TESTING—COMPRESSED PET FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	5.75	0
B	12	0	5.5	0
C	12	0	6.0	0
D	12	0	3.9 (warp direction) 3.5 (fill direction)	0
E	12	0	4.2	0
F	12	0	4.0	0
G	12	1.5	7.8	0
H	12	0	6.6	0

Data are averages of three tests.

TABLE 10. VERTICAL BUNSEN BURNER TESTING—COMPRESSED POLYIMIDE FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	0	0
B	12	0	0.7	0
C	12	0	2.4	0
D	12	0	0 (warp direction) 0 (fill direction)	0
E	12	0	0.5	0
F	12	0	2.2	0
G	12	1.4	1.0	0
H	12	0	<1 (warp direction) <1 (fill direction)	0

Data are averages of three tests.

TABLE 11. VERTICAL BUNSEN BURNER TESTING—NONCOMPRESSED METALIZED PVF FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	0	0
B	12	0	3.0	0
C	12	0	0	0
D	12	0	3.3 (warp direction) 3.1 (fill direction)	0
E	12	0	0.6	0
F	12	0	1.3	0
G	12	0.9	2.9	0
H	12	0	1.4 (warp direction) 1.3 (fill direction)	0

Data are averages of three tests.

TABLE 12. VERTICAL BUNSEN BURNER TESTING—NONCOMPRESSED PVF FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	0	0
B	12	0	3.0	0
C	12	0	0	0
D	12	0	2.5 (warp direction) 2.4 (fill direction)	0
E	12	0	0.9	0
F	12	0	0.7	0
G	12	4.5	2.2	0
H	12	0	1.6	0

Data are averages of three tests.

TABLE 13. VERTICAL BUNSEN BURNER TESTING—NONCOMPRESSED METALIZED PET FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	169.7	12.0	0
B	12	8.0	4.9	1
C	12	8.0	5.8	0
D	12	0	3.0 (warp direction) 3.4 (fill direction)	0
E	12	0	3.6	0
F	12	0	1.5	0
G	12	2.2	3.3	0
H	12	2.2	7.2	0

Data are averages of three tests.

TABLE 14. VERTICAL BUNSEN BURNER TESTING—NONCOMPRESSED PET FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	0	0
B	12	0	3.8	1
C	12	0	5.9	0
D	12	0	3.1 (warp direction) 3.9 (fill direction)	0
E	12	0	0.6	0
F	12	0	1.4	0
G	12	2.3	4.7	0
H	12	0	4.9	0

Data are averages of three tests.

TABLE 15. VERTICAL BUNSEN BURNER TESTING—NONCOMPRESSED POLYIMIDE FILM AND FIBERGLASS

Lab	Ignition Time (seconds)	Flameout Time (seconds)	Burn Length (inches)	Flameout Time Drippings (seconds)
A	12	0	0	0
B	12	0	0.6	0
C	12	0	1.6	0
D	12	0	0 (warp direction) 0 (fill direction)	0
E	12	0	0.5	0
F	12	0	2.0	0
G	12	0.8	1.0	0
H	12	0	<1 (warp direction) <1 (fill direction)	0

Data are averages of three tests.

TABLE 16. COTTON SWAB TEST—METALIZED PVF BLANKET

Lab	Burn Length Crease (inches)	Burn Length Center (inches)	Notes
A	0	0	
B			0.5 in., longest burn length reported
C	4.3	0.78	
D			Blanket passed
E	0.8	0.8	
F	5.0	1.5	
G	1.2	0.8	
H	4.0	1.0	

TABLE 17. COTTON SWAB TEST—PVF BLANKET

Lab	Burn Length Crease (inches)	Burn Length Center (inches)	Notes
A	0	0	
B			2.5 in., longest burn length reported
C	3.9	2.7	
D			Blanket passed
E	2.2	3.3	
F	3.8	1.0	
G	4.2	0.9	
H	5.5	1.5	

TABLE 18. COTTON SWAB TEST—METALIZED PET BLANKET

Lab	Burn Length Crease (inches)	Burn Length Center (inches)	Notes
A	Totally consumed	8	
B	Totally consumed	Totally consumed	
C	Totally consumed	Totally consumed	
D			Failed
E	Totally consumed	Totally consumed	Flame propagated up the vertical back side
F	Totally consumed	Totally consumed	Flame propagated to back face, about 80% consumed
G	About 75% consumed	Totally consumed	Flame totally consumed the back horizontal side and 50% of the vertical back side
H	Totally consumed	Totally consumed	

TABLE 19. COTTON SWAB TEST—PET BLANKET

Lab	Burn Length Crease (inches)	Burn Length Center (inches)	Notes
A	3	0	
B			0.5 in., longest burn length reported
C	3.9	0.5	
D			2.7 in., longest burn length reported
E	2.7	1.5	
F	3.8	1.2	
G	3.1	0.8	
H	2.5	0.5	

TABLE 20. COTTON SWAB TEST—POLYIMIDE BLANKET

Lab	Burn Length Crease (inches)	Burn Length Center (inches)	Notes
A	0	0	
B			0.5 in., longest burn length reported
C	1.96	0.39	
D	0	0	
E	0.5	0.3	
F	0.5	0	
G	1.5	0	
H	1.5	<0.25	

TABLE 21. BUNSEN BURNER TESTS—WEIGHT AND AREA LOSS (METALIZED PVF)

Metalized PVF	Preburn Weight (grams)	Afterburn Weight (grams)	Weight Loss (%)	Area Loss (%) Approximate
Sample 1	1.0032	1.0005	0.26	8.8
Sample 2	1.0216	1.0193	0.23	9.2
Sample 3	1.1412	1.1383	0.29	9.1

TABLE 22. BUNSEN BURNER TESTS—WEIGHT AND AREA LOSS (PET)

PET	Preburn Weight (grams)	Afterburn Weight (grams)	Weight Loss (%)	Area Loss (%) Approximate
Sample 1	0.6071	0.6027	0.72	8.4
Sample 2	0.5877	0.5847	0.51	9.1
Sample 3	0.6012	0.5977	0.58	9.7

TABLE 23. BUNSEN BURNER TESTS—WEIGHT AND AREA LOSS (PVF)

PVF	Preburn Weight (grams)	Afterburn Weight (grams)	Weight Loss (%)	Area Loss (%) Approximate
Sample 1	1.0639	1.0634	0.04	9.0
Sample 2	1.0388	1.0369	0.19	9.2
Sample 3	1.0517	1.0500	0.17	8.9