The Critical Radiant Flux Test

-1- Development and description

FAA is examining a number of small-scale flammability tests to evaluate the behavior of aircraft thermal acoustic insulation under in-flight fire conditions. Recently, the FAA has employed the flooring radiant panel test and, on a preliminary basis, found the fire performance of insulation films to be similar to that measured during full and intermediate-scale fire tests.

For a description of the test method refer to Standard Test Method ASTM E 648 for Critical Radiant Flux of Floor-Covering Systems using a Radiant Heat Energy Source.

Fig: Radiant Panel Test Showing Sample Emplacement and Fueled Panel.

This test was developed over 20 years ago for measuring the critical radiant flux of horizontally mounted floor-covering systems exposed to a **flaming ignition** source in a **graded radiant heat energy environment** inside a test chamber.

Since April 1999 the FAA has employed this test to examine the fire behavior of thermal acoustical insulation covering films for the following reasons:

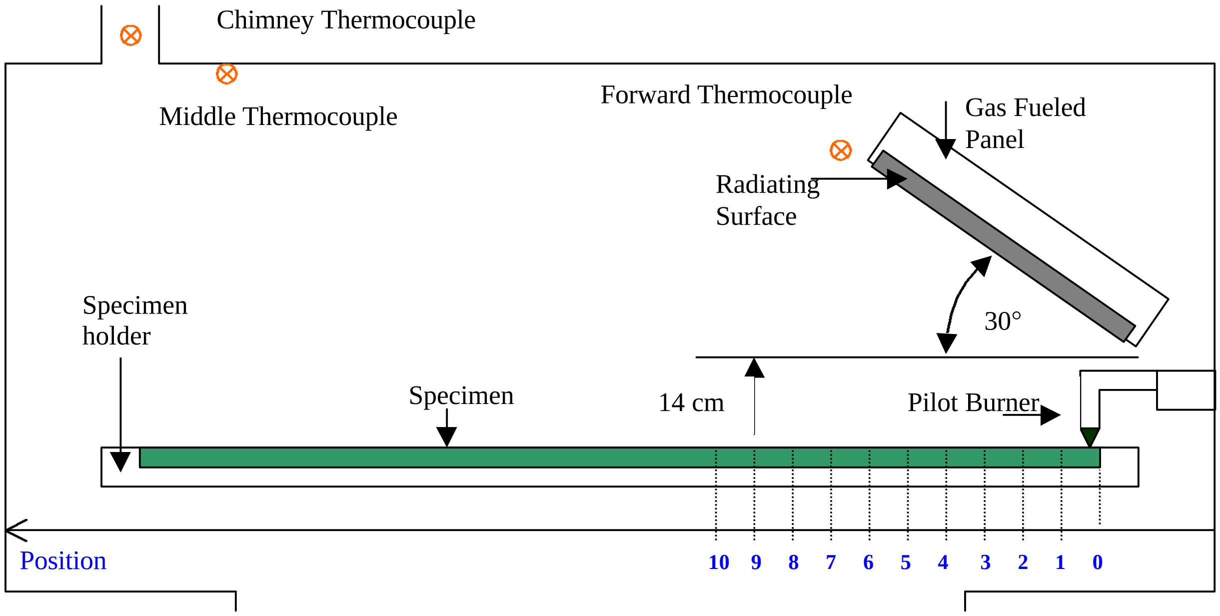
- The need for a more realistic small-scale flame propagation test correlating with the intermediate and full-scale fire tests.

- The test offers the possibility of recording flame propagation velocity, the time of ignition and the burn length at different heat fluxes.

- The test allows the recording of critical heat flux: the level of incident radiant heat energy on the covering film at the most distant flameout point. It is reported as kW/m^2 (or BTU/ft^2*s).

- The test allows important physical effects to take place and be observed including melting and shrinking of film, and the behavior of the scrim and adhesive relative to the film.

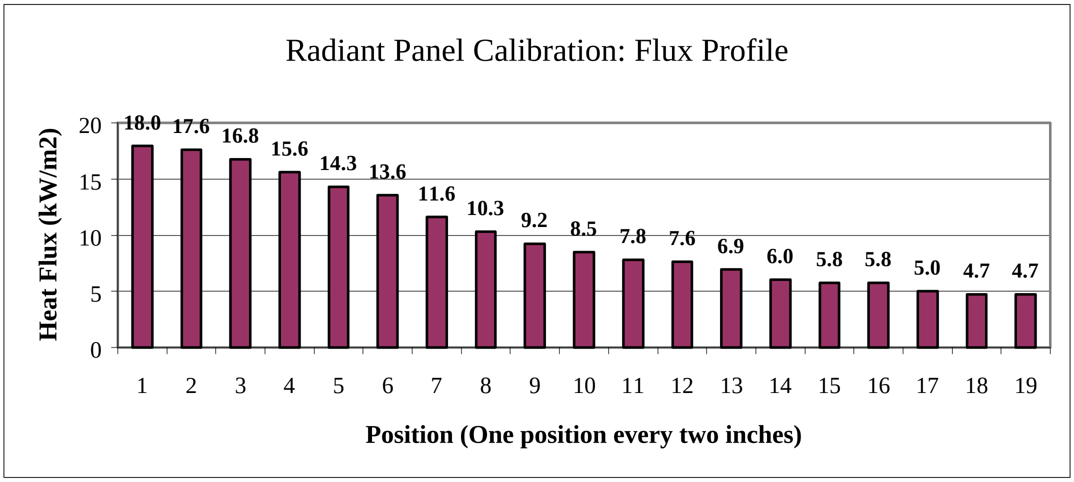
The radiant heat energy source is a panel of porous refractory material mounted in a cast iron frame, with a radiation surface of 12 by 18 inches (305 by 457-mm). The radiant panel fuel is propane. The panel fuel system consists of a venturi-type aspirator for mixing gas and air at approximately atmospheric pressure.



Radiant Panel Tester

The intensity of the radiating surface can be varied by changing the gas-fueled mixture. An incident heat flux near the leading edge of the specimen of 18 kW/m^2 appears to give results similar to large and intermediate scale data. The variation in heat flux along the sample was measured and is shown below.

The distance between each position is two inches or five centimeters. At each position a 0 to 10-mV range calorimeter recorded the heat flux. In a continuing program of tests, the flux profile shall be determined not less than once a week.



Flux Profile: curve of incident radiant heat energy on the specimen plane to distance from the point of initiation of flaming ignition that is 0 cm.

-2- Summary of Test

The specimens tested are 40 inches (100cm) long by at least 10 inches (25cm) wide to assure clamping in the mounting frame. A specimen usually consists of 2 inches (5cm) of fiberglass (Johns Manville Microlite AA 0.34pcf or 0.42pcf) and insulation film covering. A minimum of three specimens per sample is tested. Other types of foam or insulation materials can be tested on the radiant panel.

The radiant panel is ignited with the sliding platform out of the chamber. A piece of Kaowool board is inserted between the chamber and the platform to prevent preheating of the sample. As soon as the temperatures recorded by the three thermocouples (one on the ceiling, one on the chamber and one in the chimney) are in agreement to within 20°C with those values determined during the calibration (that is to say 870°F or 465°C Forward, 430°F or 221°C in the middle and 300°F or 149°C in the chimney), the chamber is ready for use.

The sample and the specimen holder are inserted in the sliding platform, the pilot burner ignited, and the piece of Kaowool board removed.

The specimen is inserted into the chamber and the access door closed. The pilot burner flame (on and set so that the flame is horizontal and 2 inches (50 mm) above the specimen) is immediately brought into contact with the center of the specimen at the position 0. It is left in contact with the specimen for about 10 seconds.

For specimens that do ignite the test is over when the flame goes out.

Significant phenomena such as melting, shrinkage and flame propagation are recorded. The distance burned is measured and converted from the flux profile curve into kW/m^2 critical radiant heat flux at flame out.

The test assembly should be at room temperature prior to start up.

-3- Material Ignition and Flame Spread Properties

A number of aircraft films have been tested with the identical 0.34pcf fiberglass or 0.42pcf fiberglass for materials used only with the 0.42pcf fiberglass. The preliminary results are shown bellow in terms of burn length or critical heat flux.

Films tested with 0.34pcf Fiberglass	Supplier Product Designation	Mass per Area g/m2	Burn length (inches)	Burn length (inches)	Burn length (inches)	Burn length Average (inches)	Critical Heat Flux kW/m2
Mylars							
PET00_L	8273	18	13	15	11	13	12
PET00_O	Orcofilm AN 36W	17.8	15	12	16	14.3	10.5
PET1_L	8234	29.6	24.5	25	24.5	24.67	7.5
PET1_F	Insulfab 240	30.1	21	20	22	21	7.5
PET1_O(R)	Orcofilm AN 47R	27.2	TC	TC	TC	TC	<4
PET1_O(W)	Orcofilm AN 47W	30.4	19	17	21	19	8.5
PET2_L	8271	43.1	27.5	26.5	24.5	26.2	7
PET3_L	8272	57.5	28	22.5	19.5	23.3	7.3
PET3_F	Insulfab 260	54.6	30.5	34.5	35	33.3	5.2
MPET1_F	Insulfab 350	32.8	TC	TC	TC	TC	<4
Tedlars							
MPVF1_O	Orcofilm AN 18R	32.8	14.5	17	15.5	15.7	10
MPVF2_F	Insulfab 330	44.1	NFP	NFP	NFP	NFP	>18
PVF2_J	Terul 14	47.6	19	22	24	21.7	8.5
PVF2_J	Terul 9 Lab13H	45.5	NFP	NFP	NFP	NFP	>18
Polyimides							
PI_F	Apical 100JL	65.5	NFP	NFP	NFP	NFP	>18
PI_O	Orcofilm KN80	52.2	NFP	NFP	NFP	NFP	>18
PI_L	10313	49.5	NFP	NFP	NFP	NFP	>18
PI_J	Terimide9 Lab06E	52.5	NFP	NFP	NFP	NFP	>18
Others							
INS2000_F	Insulfab 2000	103.8	NFP	NFP	NFP	NFP	>18
FPC3_C	Chemfilm	61.0	NFP	NFP	NFP	NFP	>18

FPC= Fluoropolymer Composite
TC= Totally Consumed
NFP= No Flame Propagation

Films tested with 0.42pcf Fiberglass	Supplier Product Designation	Mass per Area g/m2	Burn length (inches)	Burn length (inches)	Burn length (inches)	Burn length Average (inches)	Critical Heat Flux kW/m2
Mylars							
PET00_O	Orcofilm AN 36W	17.8	9	12	13	11.3	13.8
PET00_J	TERIL 34	21	38(TC)	38(TC)	31	35.7	4.9
PET1_F	Insulfab 240	30.1	20.5	17	20	19.2	8.7
PET3_F	Insulfab 260	54.6	32.5	32.5	34.5	33.2	5.3
MPET1_F(K)	Insulfab 350, DMS2072K	32.8	TC	TC	TC	TC	<4
MPET1_F(L)	Insulfab 350, DMS2072L	32.8	5	6	11	7.3	16
Tedlars							
MPVF1_O	Orcofilm AN 18R	32.8	16	16.5	16.5	16.3	10.3
MPVF2_F	Insulfab 330	44.1	NFP	NFP	NFP	NFP	>18
PPVF2_J	TERUL 9 Lab 13 H	45.5	NFP	NFP	NFP	NFP	>18
MPVF3_J	Terul 12	61	TC	TC	TC	TC	<4
Polyimides							
PI_F	Apical 100JL	65.5	NFP	NFP	NFP	NFP	>18
PI_J	Terimide 9 Lab 06 E	52.5	NFP	NFP	NFP	NFP	>18
PI_O	Orcofilm KN80	52.2	NFP	NFP	NFP	NFP	>18
PI_L	10313	49.5	NFP	NFP	NFP	NFP	>18
Others							
FPC3-C	Chemfilm	61	NFP	NFP	NFP	NFP	>18

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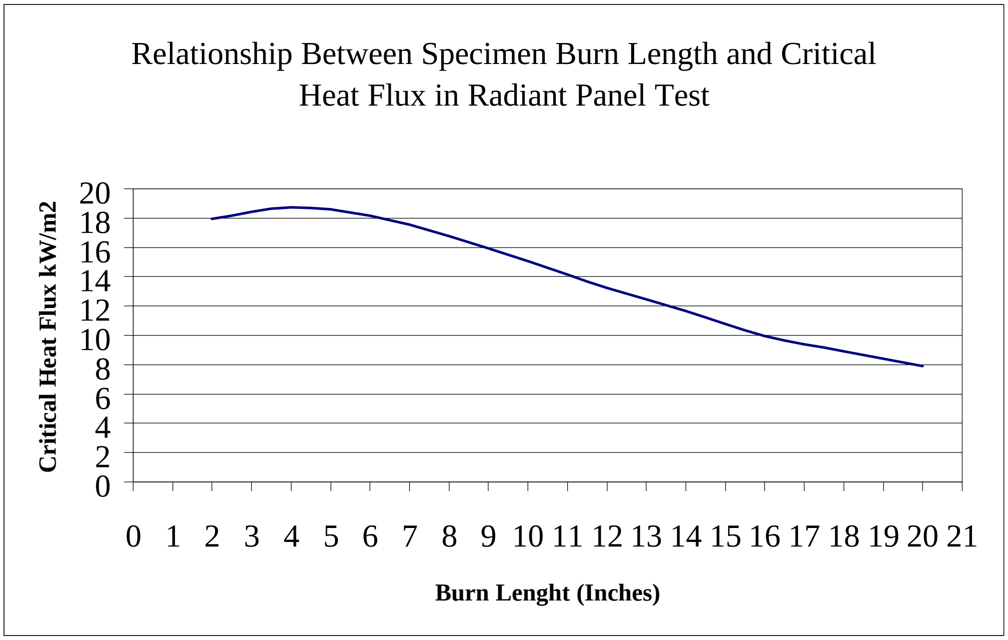
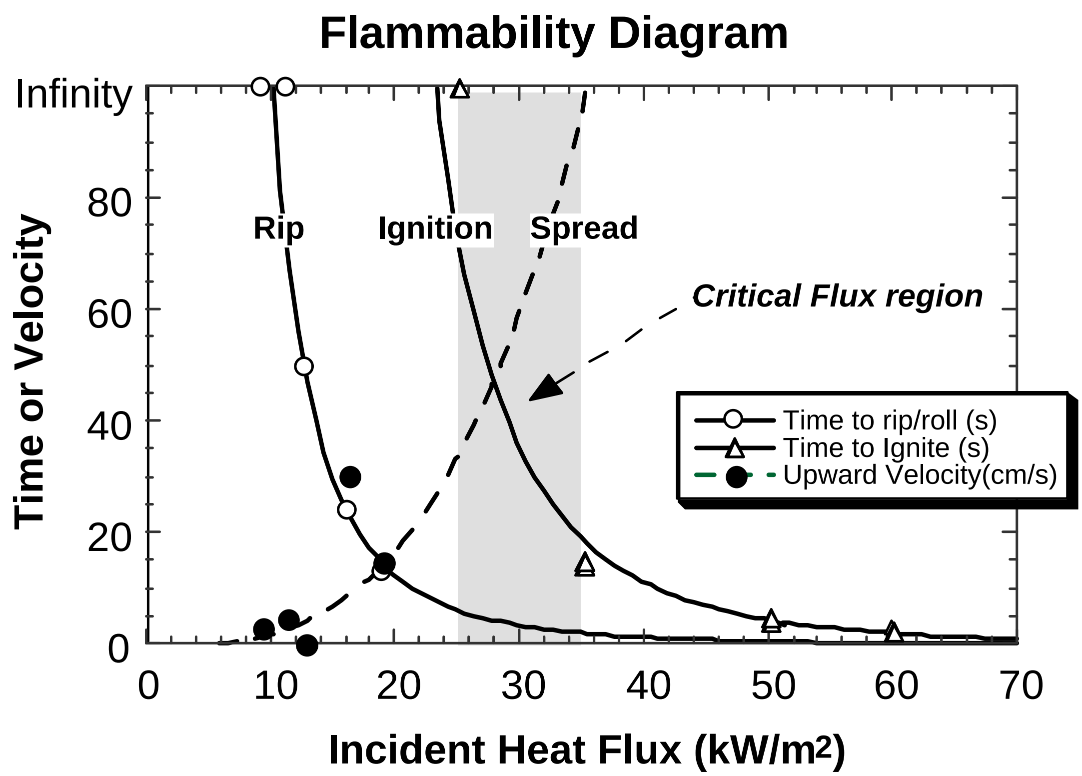
Two trends appear evident. First, the films are more flammable as the area density increases. Second, the Tedlars generally perform better than the Mylars, whereas the Kaptons or Apical (polyimide), as well as the Fluoropolymer Composite are the superior performers.

The relationship between the critical heat flux and burn length is shown below:



The distance of fire propagation is inversely related to critical radiant flux.

An important characteristic of the lightweight thermoplastic is that they rapidly melt and/or contract when subjected to heat. At low heat fluxes, the film will recede (rip/roll) before ignition can occur, as shown below. However, at some higher heat flux, the film will ignite before receding away from the heat ignition source. The practical implication of this finding is that the films will ignite and burn when exposed to a large fire in a confined space.



This diagram shows that when the incident heat flux is below the critical heat flux the material will just rip or spread, over this critical heat flux (which is specific for each material) it will ignite.

-4- Nature of the test

The data are interesting since they show that under the conditions of the experiments the distance of fire propagation is inversely related to critical radiant flux or the heat flux level below which surface flame spread will not occur. In a full-scale test scenario the critical heat flux is dependent upon other variables which include:

- The nature, quantity, and arrangement of the fire load in the compartment where ignition occurs,
- Ventilation conditions,
- Heat release rate of the fire load and the thermal acoustical insulation-covering system,
- The heat capacity of the enclosure,
- The ignition source.

All these parameters can be important in determining the ultimate spread of fire.

-5- Results

Fig1: Mylar PET1_O (1993)

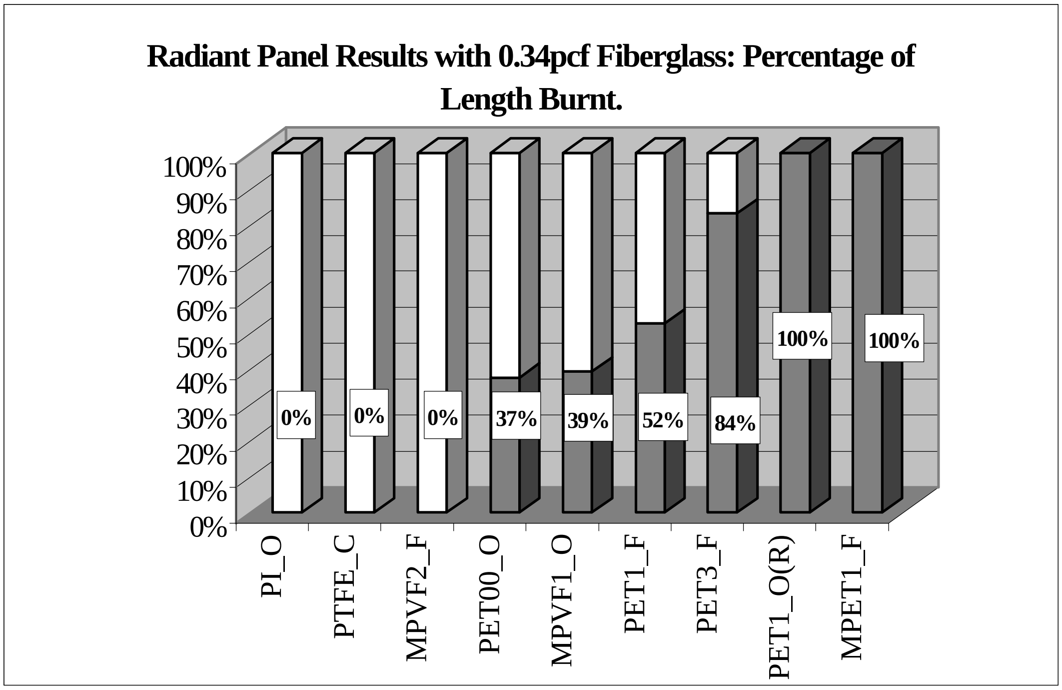
Fig2: Mylar PET1_O (1998)

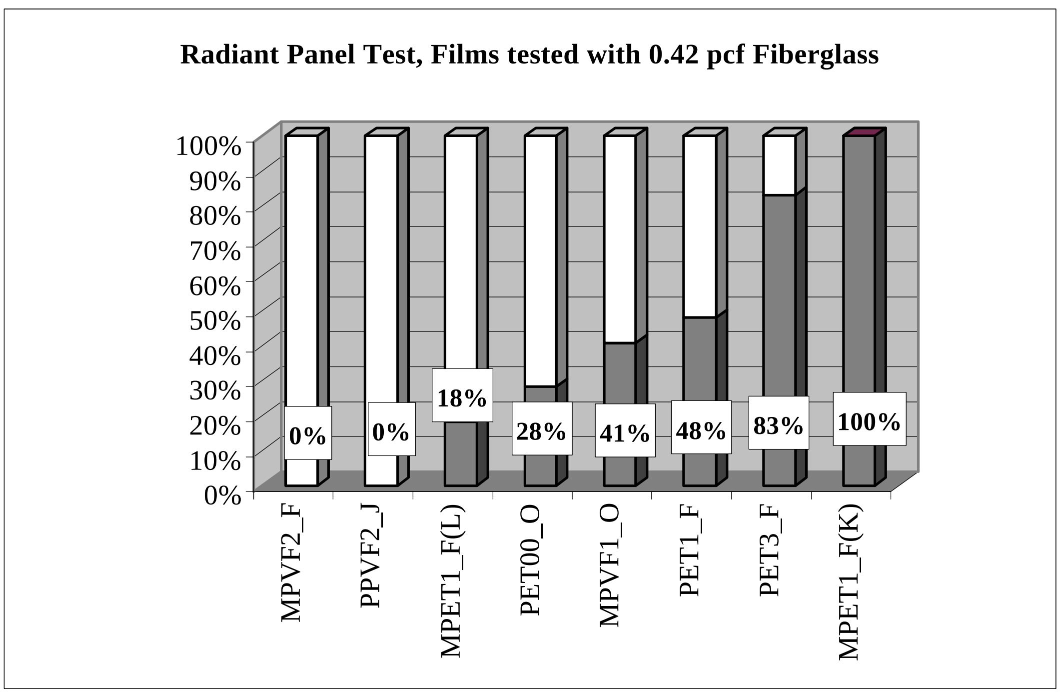
Fig3: Apical (polyimide) PI_F

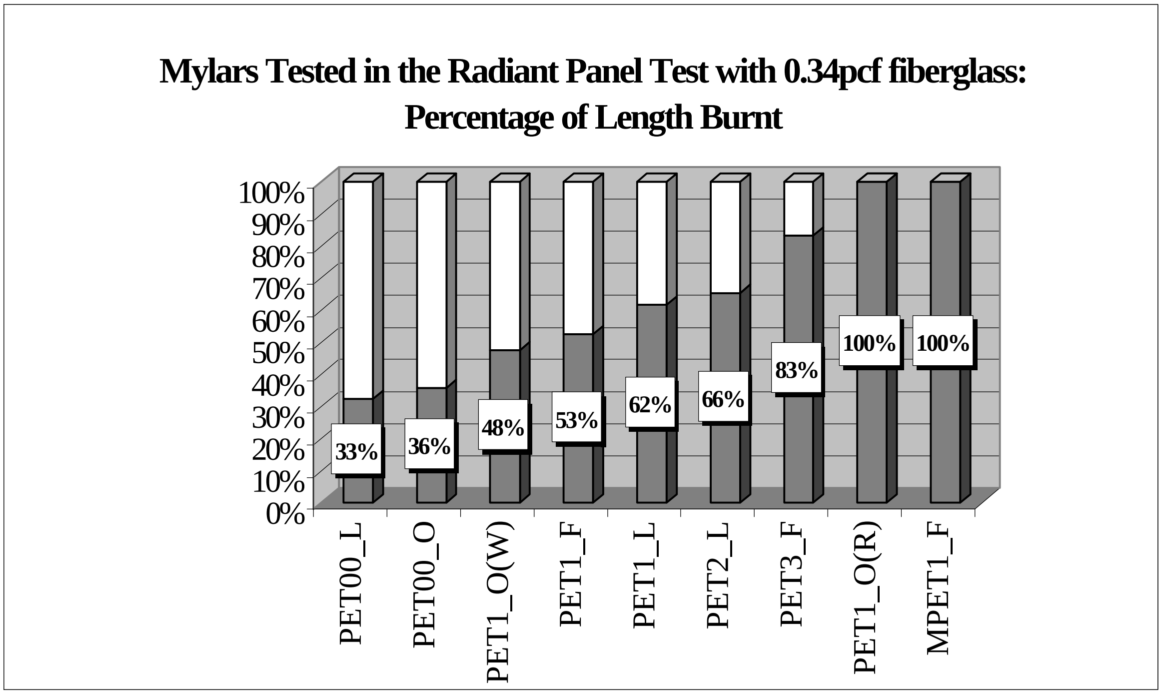
Fig4: Metalized Tedlar MPVF1_O

Fig5: Metalized Tedlar MPVF2_F

Fig6: Metalized Mylar MPET1_F


Radiant Panel Results with 0.34pcf Fiberglass: Percentage of Length Burnt.
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
0%
0%
37%
39%
52%
84%
100%
100%
PI_O
PTFE_C
MPVF2_F
PET00_O
MPVF1_O
PET1_F
PET3_F
PET1_O(R)
MPET1_F


Radiant Panel Test, Films tested with 0.42 pcf Fiberglass
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
0%
18%
28%
41%
48%
83%
100%
MPVF2_F
PPVF2_J
MPET1_F(L)
PET00_O
MPVF1_O
PET1_F
PET3_F
MPET1_F(K)



Mylars Tested in the Radiant Panel Test with 0.34pcf fiberglass:
Percentage of Length Burnt
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
33%
36%
48%
53%
62%
66%
83%
100%
100%
PET00_L
PET00_O
PET1_O(W)
PET1_F
PET1_L
PET2_L
PET3_F
PET1_O(R)
MPET1_F