

Title: Insulation Materials for Burnthrough Protection

Authors: Becky Wulliman, Product Development Engineer
Aerospace Insulations
Johns Manville Corporation, Denver, Colorado

Jeff Townsend, Sales and Marketing Specialist
Aerospace Insulations
Johns Manville Corporation, Denver, Colorado

Michael Fay, Research Manager
Corporate Research and Development
Johns Manville Corporation, Denver, Colorado

Abstract:

Johns Manville has developed a medium-scale test method to evaluate candidate materials for burnthrough resistance. The test method, presented at the March FAA Conference in Oakland, California, showed good relative ranking correlation with the full scale FAA burnthrough test. This test method is currently being used to evaluate a variety of insulation systems for relative burnthrough protection. Test results from a number of these systems will be presented in this paper.

At the March 1998 FAA Conference in Oakland, California, Jeff Townsend of Johns Manville presented details on the development of a smaller scale test method that showed good relative ranking correlation with the full scale FAA burnthrough test. Since that time, efforts have been focused on evaluating a wide variety of insulation systems and materials using this test method to help determine a path forward in providing a significant increase in the burn through resistance of an aircraft fuselage.

History

To review, the test method developed at the Johns Manville Technical Center is based on an ASTM E-119 test rig. This ASTM test method is a standard one for fire tests of building construction and materials. The test sample is 73.7 cm x 73.7 cm square and is tested in a vertical configuration. The sample itself is made up of a “system” consisting of a 1.6mm aluminum skin to the fire side and the insulation batting enclosed in covering films of various types. The sample is subjected to a furnace with a heat flux of 12 to 15 W/cm² and a temperature of 1093°C.

The test begins when the sliding door separating the furnace from the test sample is removed. The time of failure (defined as initial melting of the film) of the back or cold side covering film is recorded, and burn through time is deemed to be when the flame reaches the cold side.

Initial test results from this method showed that aluminum skin on its own achieved an approximate failure time of one minute. The standard configuration of three layers of 0.42pcf Microlite AA[®] encased in a Mylar[®] film yielded a result of 2.67 minutes to burnthrough. A system consisting of a layer of carbon fiber batting and two layers of fiber glass encapsulated in polyimide film yielded a burnthrough time of 8.55 minutes in the JM medium scale test apparatus. These results show good relative ranking with the full scale FAA results for burnthrough system resistance.

Results

Many different materials were tested to determine their benefit to the burnthrough resistance of an insulation system. Systems have been tested using standard JM 0.42 pcf AA fiber glass, 0.34 Premium NR[®] fiber glass, Johns Manville Q-Felt[®] (quartz fiber felt), and polyimide foam insulation as the core materials. Along with these, a variety of interleaf materials were also considered, including different high temperature organic fiber mats, coated glass mats, 3M Nextel[®] and a JM intumescent spray coating, Fire-Temp[™].

Additional materials, such as fire retardant interleafs, or increasing the density of the core material will, of course, add significant weight to an aircraft. Our goal in developing an improved burnthrough resistant system was to keep the square foot weight of the system below the weight of a 3-layer 0.6pcf AA fiber system (approximately 68 g/ft²), while obtaining at least seven minutes to burnthrough using our test method. Over twenty tests have been conducted; the balance of this paper will provide an update of the results and the direction of future evaluations.

Table 1 shows an abbreviated list of some of the systems tested. The weights per square foot noted do not include the weight of the aluminum skin.

Table 1. Burnthrough Systems—Times to Failure and Weights

System Configuration	Film failure, minutes	Burnthrough, minutes	Weight per square foot, grams
Aluminum alone	N/A	1.0	N/A
0.42AA/0.42AA/0.42AA – mylar film	--	2.67	53.1
0.42AA/0.42AA/0.42AA – p/i film	--	3.28	57.0
carbfib/0.42AA/0.42AA - mylar film	--	4.33	48.8
carbfib/0.42AA/0.42AA – p/i film	--	8.55	52.7
0.42AA/0.3pifoam/0.42AA – mylar film	5.00	5.42	43.3
0.6pifoam/0.6pifoam/0.6pifoam-mylar film	3.00	4.67	73.9
0.3pifoam/0.3pifoam/0.3pifoam-mylar film	3.46	4.00	43.3
0.42AA/mat2/0.42AA/mat2/0.42AA-mylar	5.00	10.00	86.1
0.42AA/of1/0.42AA/of1/0.42AA-mylar	7.67	10.00	90.7
0.42AA/of2/0.42AA/of2/0.42AA-mylar	6.45	8.87	68.3
0.42AA/mat1/0.42AA/mat1/0.42AA-mylar	3.90	10.00	81.1
0.42AA/fs/0.42AA/0.42AA - mylar	6.50	7.00	65.5
0.34NR/of2/0.34NR/of2/0.34NR-mylar	8.08	9.75	59.3
Fs/0.42AA/0.42AA/0.42AA – mylar	3.42	4.33	65.5
4#Q/0.34NR/0.34NR –mylar	5.33	10.00	88.3
0.34NR/fs/0.34NR/fs/0.34NR – mylar	10.00	10.00	68.5

The following abbreviations were used above:

- 0.42AA is 0.42pcf x 1-inch Microlite AA
- mylar film is either Orcon AN47R[®] or Insulfab 240[®]
- p/i film is polyimide film covering
- carbfib is a 1-inch proprietary carbon fiber blanket
- 0.3pifoam is 0.3pcf x 1-inch polyimide foam
- 0.6pifoam is 0.6pcf x 1-inch polyimide foam
- mat2 is a glass mat treated on both sides with a proprietary burnthrough resistant coating
- of1 is an proprietary organic fiber mat with a burnthrough treatment
- of2 is a version of of1 without the treatment
- mat1 is a glass mat treated on only one side with a proprietary burnthrough resistant coating
- fs refers to sprayed intumescent coating, JM Fire-Temp
- 4#Q is 4pcf x 3/8-inch Johns Manville Q-Felt

Analysis of Results

The test results yielded some interesting system comparisons. Two of the systems were tested using the same core materials but with different film coverings. A three layer system of 0.42 Microlite AA was tested with a mylar covering and again with a polyimide covering. The same two tests were conducted on a three layer system consisting of carbon fiber blanket with two layers of 0.42AA. Results in both cases, shown below in Figure 1, show the polyimide film adds to the burnthrough resistance of the system.

Figure 1. Effect of Polyimide Film on Burnthrough Resistance

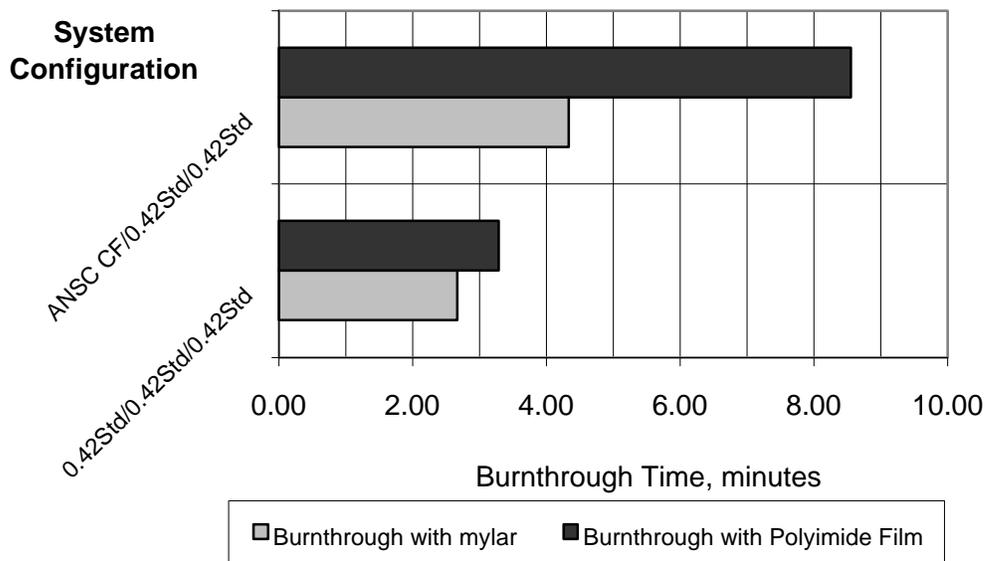


Figure 2 is a bar chart of all the results that yielded a burnthrough time greater than seven minutes. Figure 3 is a bar chart of the systems that yielded a burnthrough time greater than seven minutes and a system weight less than 70 g/ft². Although several of the most promising systems were heavier than the “cut-off” weight, they have not been entirely eliminated. Investigation is underway to determine whether the organic fiber mat can be produced in an even lighter version. Also, Q-felt products of lower density and thickness will be tested to see whether they will yield the same excellent burnthrough resistances.

Another interesting comparison that came to light in the testing was the effect on burnthrough resistance of the placement of the intumescent coating, Fire-Temp. Figure 4 demonstrates the differences. The coating seemed to lose its effectiveness when it was placed on the core material closest to the aluminum skin. Additionally, a second layer of Fire-Temp to the system appeared to add significantly to the burnthrough resistance. It should be noted, however, that in the two-layer test, the Fire-Temp was sprayed onto the fiber glass core blankets with an open-weave scrim laid on top of the blanket. This was done to provide more structural integrity

for the system in anticipation of the positive pressures that would be introduced in full scale future testing. Perhaps the scrim also added something to the burnthrough resistance in our medium scale test.

Figure 2. Burnthrough Times Greater Than 7 Minutes

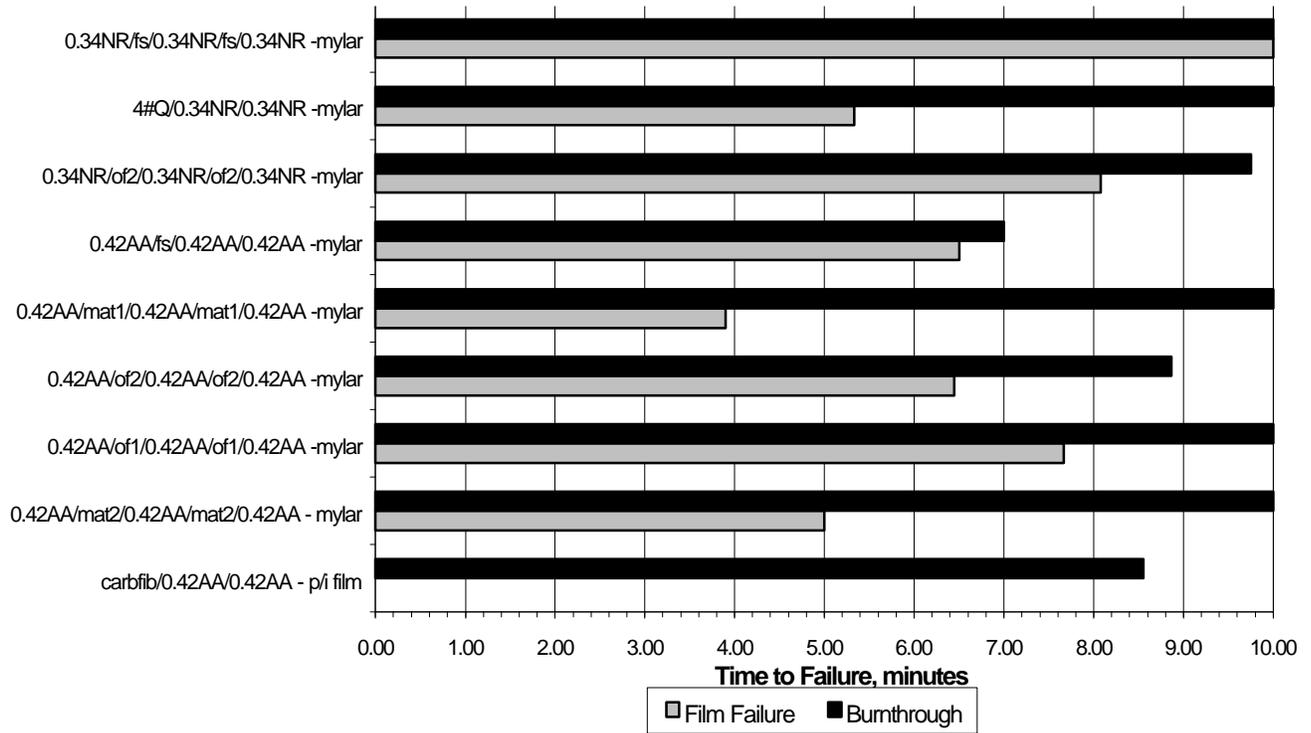


Figure 3. Burnthrough > 7 Minutes; Weight < 70 g/ft²

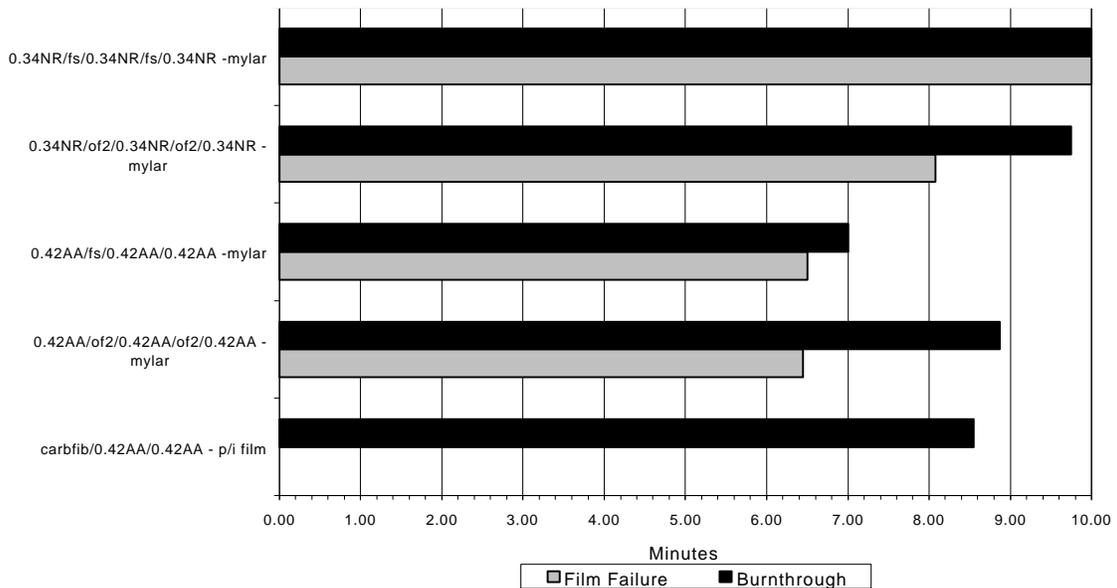
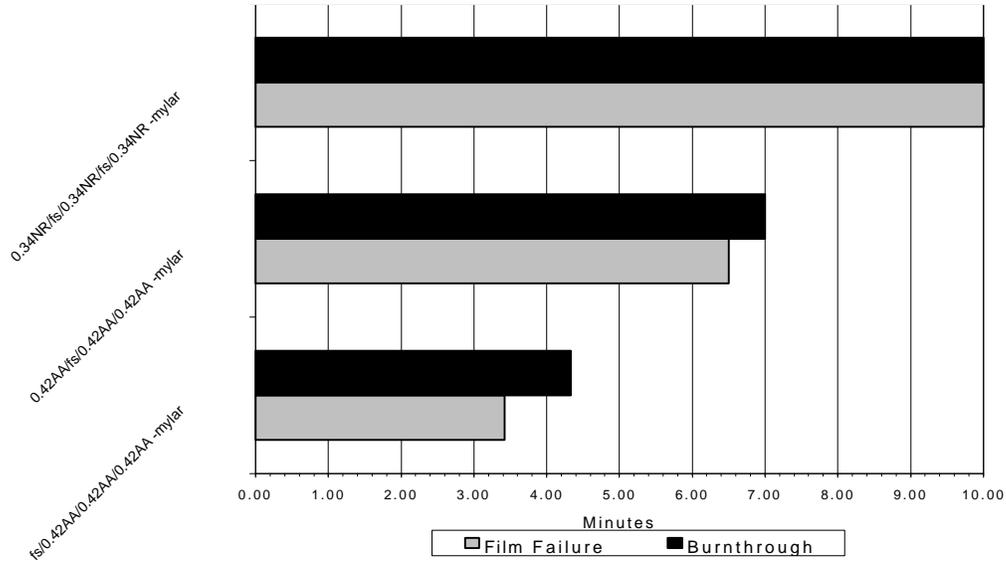


Figure 4. Fire-Temp™ Results



Future Testing

Based on the results presented, investigation into several areas is planned in the future. Optimization efforts will continue on the surface weights of the Fire-Temp coating, the organic mat interleaf, and the coated glass mat interleaf that are able to yield acceptable burnthrough resistances. System configurations using Q-Felt will also be investigated in further detail, especially lower density felts. Before a system is chosen to be subjected to the rigorous FAA full-scale test, evaluation of the structural integrities of the “best” systems will be done.

In recognition that burnthrough is very important, yet is not the only property for which insulation systems are chosen, acoustical testing is currently underway of several of the systems. Simulated Aircraft Fuselage transmission loss testing of a variety of the interleaf and the coating systems is being performed.