Flame Propagation Evaluation of Composites Materials

International Aircraft Materials & Fire Test Working Group
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Role/Title: Flammability Safety and Airworthiness
Organization/Affiliation: Boeing Commercial, Payloads
Agenda

- Introduction/Purpose
- Foam Block Testing (New Data)
- Vertical Radiant Panel Testing
- FB, VRP & BB Test Comparison
- Future Work

Ochs, Rob. VRP Side view. June 20, 2012 FTWG Presentation
The FAA is developing new proposed requirements for non-accessible areas. The FAA composite flame propagation task group is developing a new test methods for evaluating flame propagation on composites.

This presentation describes recent research evaluating the behavior of common materials used in the inaccessible areas using three different test methods:

- Foam Block
- Vertical Radiant Panel
- 60-sec Bunsen Burner

The goal of this testing is to support development of a robust laboratory test method.

Summary of test results and recommendations are presented.
# Test Method Comparison

## Supporting ARAC Goals

<table>
<thead>
<tr>
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<th>12 Sec Bunsen Burner</th>
<th>Foam Block</th>
<th>New 60 sec Bunsen Burner</th>
<th>Meeker Burner</th>
<th>Horiz./30deg Radiant Panel</th>
<th>Vertical Radiant Panel</th>
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<td>* Method &amp; requirements define correlation potential</td>
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1. Easy to setup and repeat, accommodates unique sample constructions
2a. COMPOSITE FUSELAGE: Representative test configuration, few part configurations, one time cert (stable type design)
2b. HIDDEN AREA: Large samples, configuration specific, many part configurations, variation in foam
3. Variation from calibration, complex heat flux/pilot flame contribution, non-representative test samples,
4. FAA Conclusions from June 2012 presentation
5. Continue research to achieve ARAC goals (Green)
Foam Block Testing

Ochs, Rob. Foam Block June 20, 2012 FTWG Presentation
Foam Block Testing

FAA Design
• Polyurethane Foam with 10cc of heptane
• Test rig orientation: 30 degrees from horizontal.
• 8 Thermocouples along the base
• Test coupon 47.5”X 17.5”

Test Data Recorded:
• Burn length
• Maximum Temperature
• “Smoke Time”

Pass/Fail Criteria: Not currently Defined

Front edge of shroud
-Flame impingement area: 11”X 17.5”
June 2012 FTWG Foam Block Results

[Bar chart showing burn length for various materials and applications, such as Polyester Fiberglass laminate, 350F Cure Epoxy FG laminate, 250F Cure Epoxy laminate, 250F Cure Epoxy FG FR laminate, and Cargo liner.]

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New Foam Block Testing
Foam Block Results: Burn Length

These results represent the burn length results of one sample per configuration.
Observations New Materials

Garolite (Phenolic Cotton)

Back                                  Front

Carbon Epoxy Laminate

Back                                  Front
Observations Continue

.06” Thermoplastic)

1/4” Honey comb panel/ 1ply Phenolic Fiber Glass

Back                                    Front                                    Back                                    Front
Foam Block Observations

- Cannot observe flame propagation during test (enclosed test) - No exact way to evaluate extinguishing time.
  - How to extrapolate extinguishing time to a lab scale test?

- Difficult to determine burn lengths post test

  Fire Test Handbook, Chapter 1 – Burn Length, Section 1.2.4: “The distance from the original specimen edge to the farthest point showing evidence of damage due to that area’s combustion, including areas of partial 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.”

- Test variability unknown - Not enough testing has been performed
  - Foam block variability (Batch to batch, aging, dimensional tolerance, …)
  - Ventilation (Impact on airflow vs. flame dynamics; test cell, insulation of rig)
  - Inherent material/configuration variability

- No full burn lengths - many current materials evaluated
  - Does it mean that we currently have materials that will not have significant propagation?

- Pass/fail criteria not defined
  - How do we evaluate the results and correlate to a lab scale test?

- How can we be sure that it reasonably represents an actual fire scenario in the hidden area?
VERTICAL RADIANT PANEL TEST

Ochs, Rob. VRP Front View. June 20, 2012 FTWG Presentation

Ochs, Rob. VRP Pilot Flame. June 20, 2012 FTWG Presentation

Ochs, Rob. VRP Heater. June 20, 2012 FTWG Presentation
## Materials Tested at FAA Tech Center

Selected worse case materials/configurations to evaluated in the new VRP.

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity Tested</th>
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<tr>
<td>Woven Fiberglass Cargo Liner</td>
<td>3</td>
</tr>
<tr>
<td>Polyester FG Fabric 8 ply</td>
<td>3</td>
</tr>
<tr>
<td>Polyester FG Fabric 4 ply</td>
<td>3</td>
</tr>
<tr>
<td>250 cure epoxy FG 4 ply</td>
<td>3</td>
</tr>
<tr>
<td>250 cure epoxy FG, FR 4ply</td>
<td>3</td>
</tr>
<tr>
<td>350 Cure epoxy FG 4ply</td>
<td>3</td>
</tr>
<tr>
<td>350 Cure epoxy FG 14ply</td>
<td>3</td>
</tr>
</tbody>
</table>
VRP Test Results:

**Vertical Radiant Panel Results - Burn Length**

Error bars represent one standard deviation. Each bar represents the average of three coupons.

**Vertical Radiant Panel - After Flame**

Error bars represent one standard deviation. Each bar represents the average of three coupons.

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Photos

Woven Fiberglass Cargo Liner

Polyester FG Fabric 4ply

Polyester FG Fabric 8 ply

250F Cure Epoxy Fiber Glass 4 ply
Photos Continue.

350F Cure Epoxy Fiberglass 4 ply

350 F Cure Epoxy Fiberglass 14 ply

250F Cure Epoxy Fiber Glass FR 4 ply
Key Variables That Need Further Validation

- Test sample Size
  - Size (12” X 6”? Other?)

- Sample Orientation
  - Vertical
  - 30,45 degrees?

- Test Chamber
  - Open vs. enclosed
  - Enclosed: What volume? Air flow dynamics?

- Calibration
  - Method
  - Type of Calorimeters

- Pilot Flame
  - NBS vs. RP
  - For NBS flame: Does using 50sccm make sense? Voltage control tolerance?

- Radiant Heat Source
  - What is the proper heat flux?

- Test Method Variability
  - Define testing approach to establish repeatability and define inherent variation
COMPARISON BETWEEN VRP, BB & FB
VRP, 60 second BB & Foam Block Data Comparison

Polyester Fiberglass Fabric 4ply
250 Cure Epoxy FG 4 ply
250F Cure Epoxy FG FR 4ply
350F Cure Epoxy FB 4 ply
350F Cure Epoxy FB 14 ply
FUTURE WORK
Foam Block & Vertical Radiant Panel

Foam Block
• Additional testing to identify main factors of variability

Vertical Radiant Panel
• Standardize test method and equipment
• More testing to understand inherent variability. Validate reliability and repeatability
• Establish plan for robust round robin evaluations
• Set pass fail criteria
• Determine if new test is appropriate – Alignment with ARAC recommendations

Other Test Methods (60-sec BB, Meeker)
• Further discussion, consideration, and evaluation

Validate Test Goals
• enhance safety
• simple test method
• correlates to fire threat
Flame Propagation Evaluation

Thank You!