

Flame Propagation Evaluation of Composites Materials

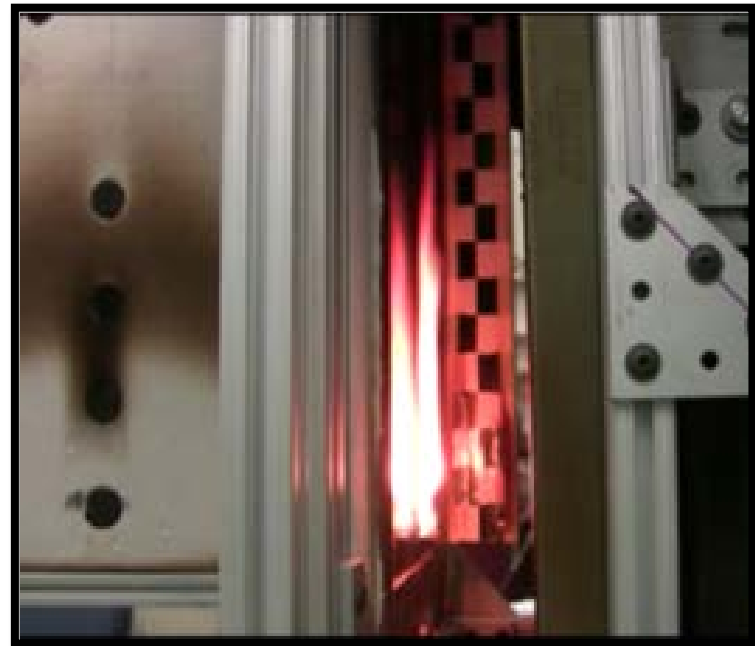


**International Aircraft Materials & Fire Test Working Group
Seattle, WA March 6, 2013**

Presenter: Ricardo Andrade Aguilar / Dan Slaton
Role/Title: Flammability Safety and Airworthiness
Organization/Affiliation: Boeing Commercial, Payloads

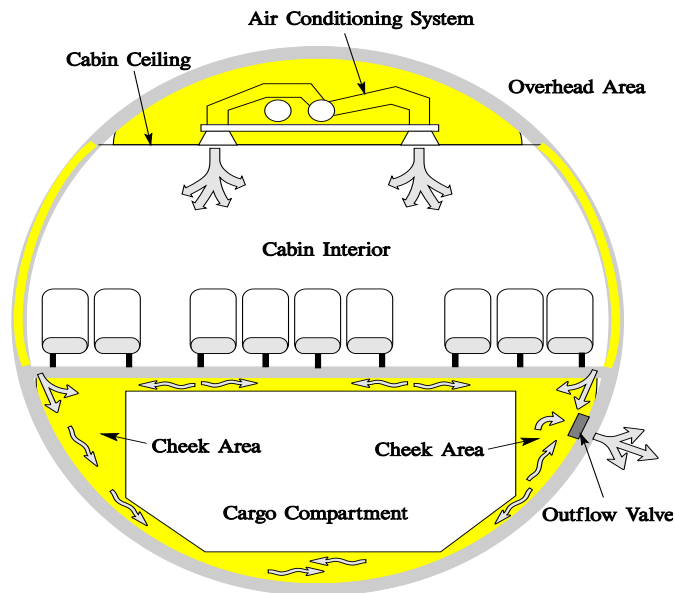
Agenda

- 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

Test Method Development Overview



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	12 Sec Bunsen Burner	Foam Block	New 60 sec Bunsen Burner	Meeker Burner	Horiz./30deg Radiant Panel	Vertical Radiant Panel
Enhance Safety: * Greater Application * Larger Ignition/Fuel Source	☑	☑	☑	☑	☑	☑
Simple Test Method	☑ 1	☑ 2a	☑ 1	☑ 1	☑ 3	☑ 5
Fire Threat Correlation * Method & requirements define correlation potential	☑	☑	☑ On-hold	☑	☑ 4	☑ 5

- 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)

	highly
	somewhat
	no

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"

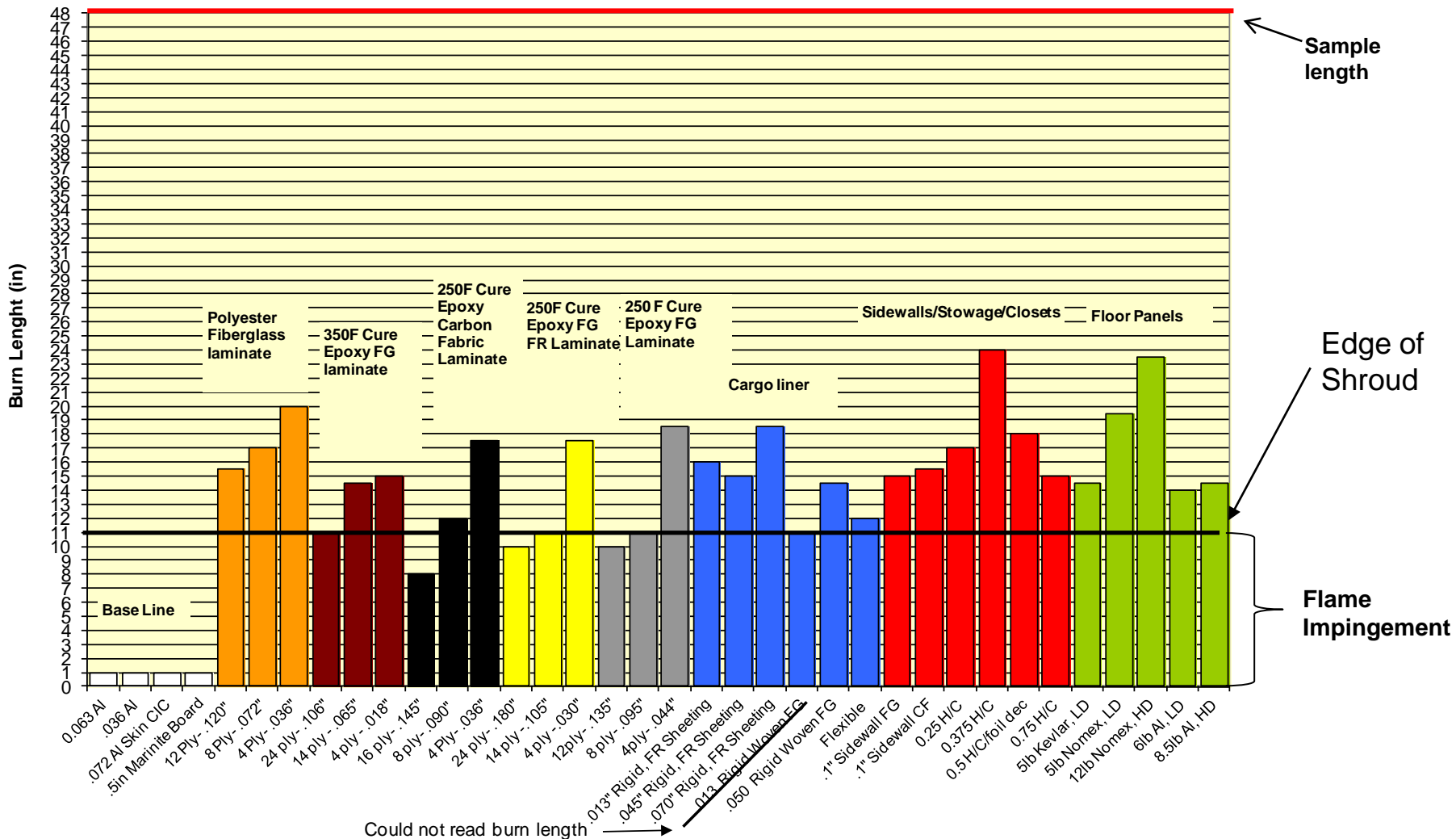
Pass/Fail Criteria: Not currently Defined



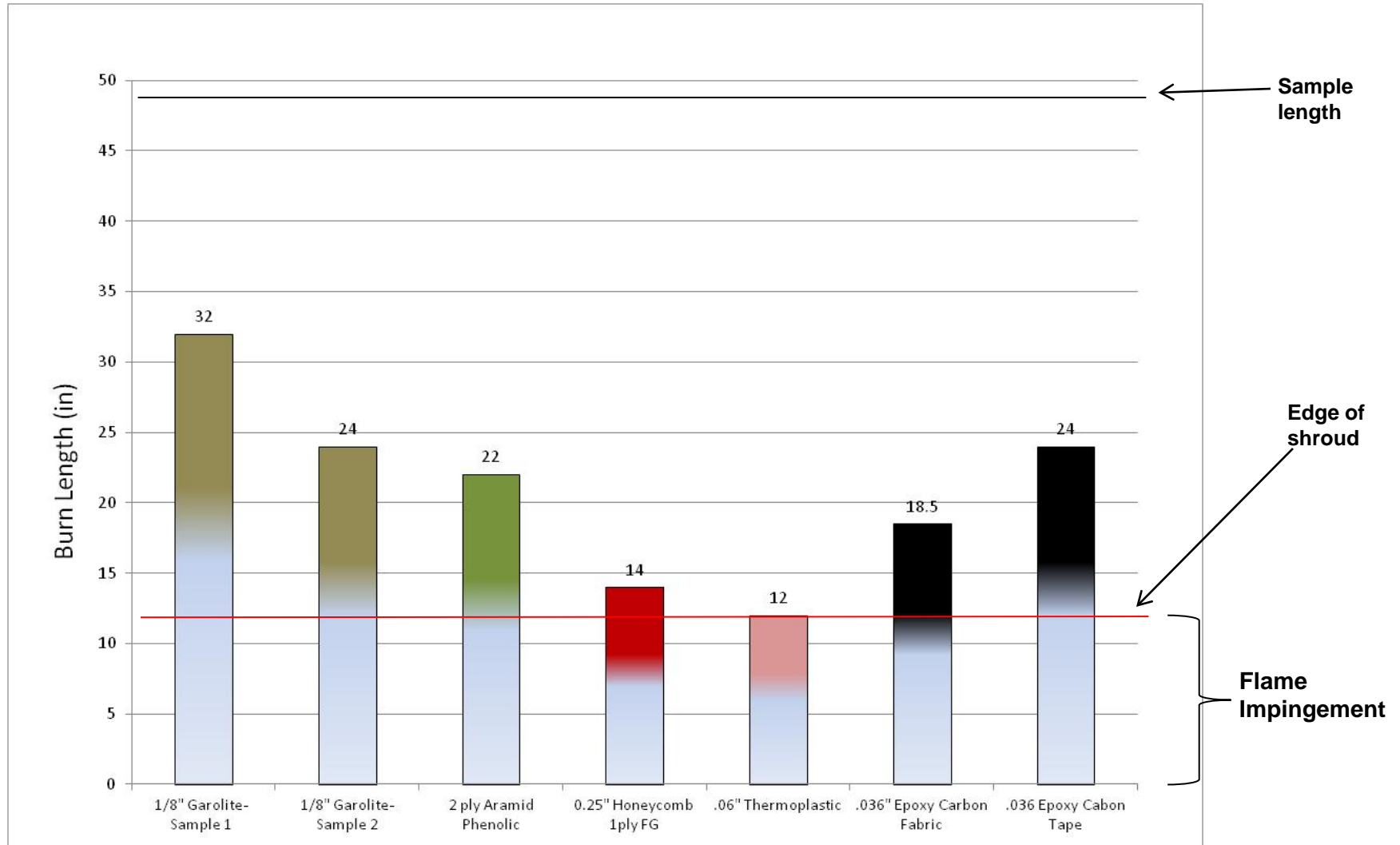
Front edge of shroud
-Flame impingement
area: 11"X 17.5"



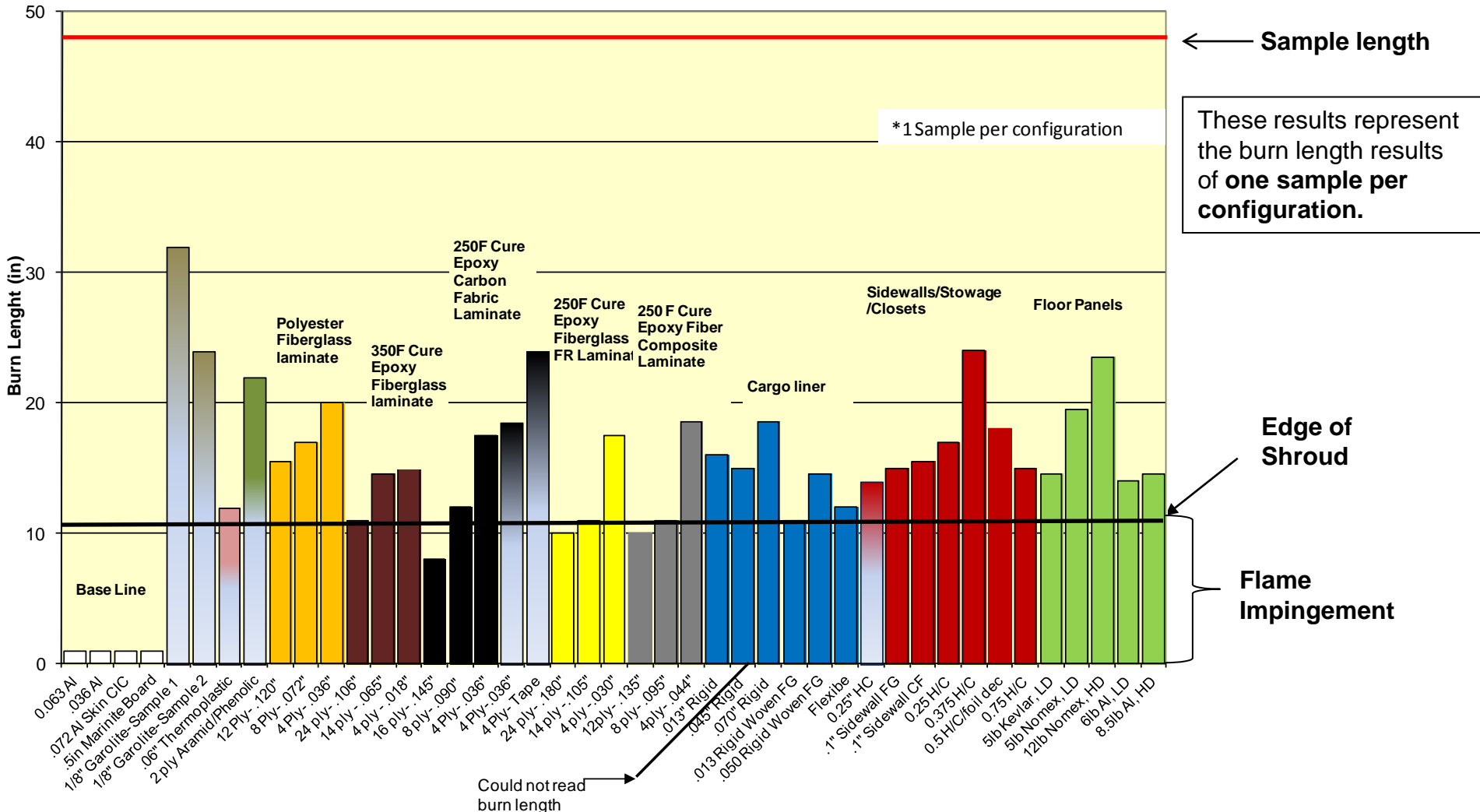
June 2012 FTWG Foam Block Results



New Foam Block Testing



Foam Block Results: Burn Length



Observations New Materials

Garolite (Phenolic Cotton)



Back



Front

Carbon Epoxy Laminate



Back



Front

Observations Continue

.06" Thermoplastic)



Back

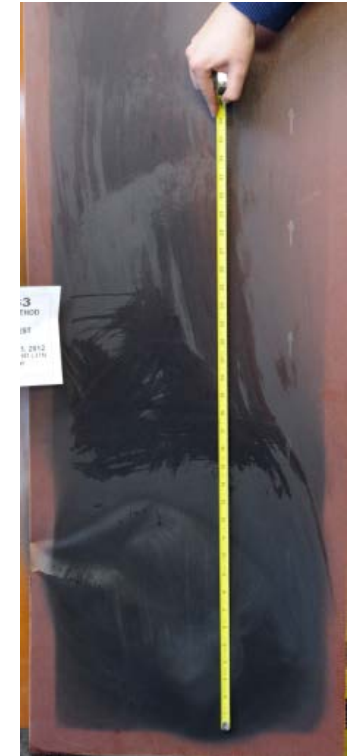


Front

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



Back



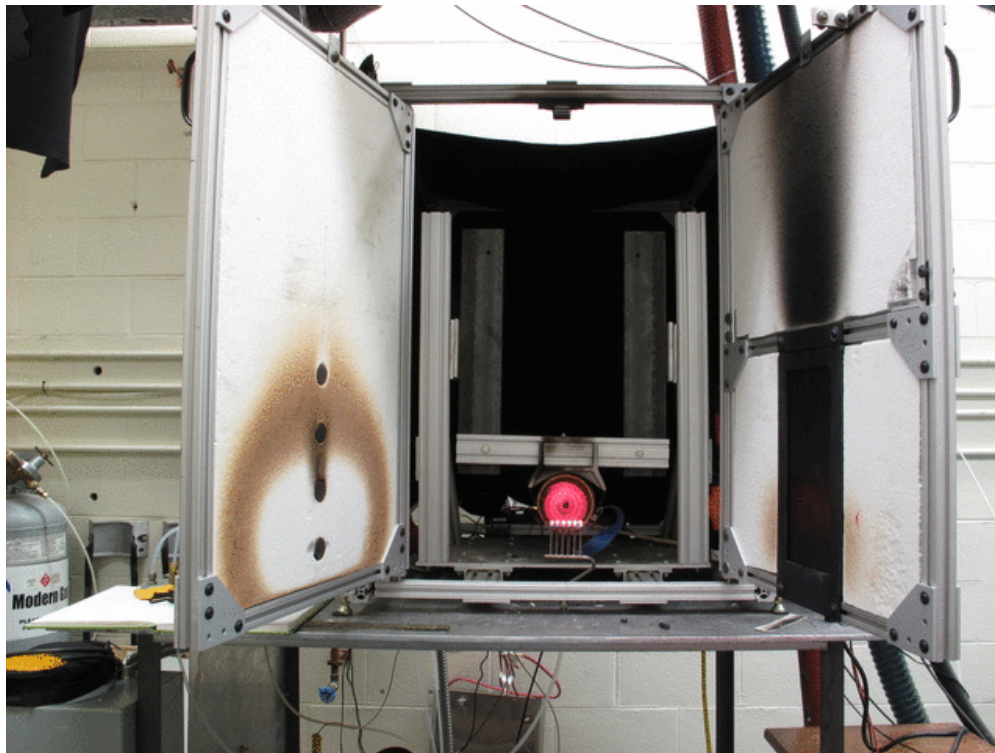
Front

Foam Block Observations

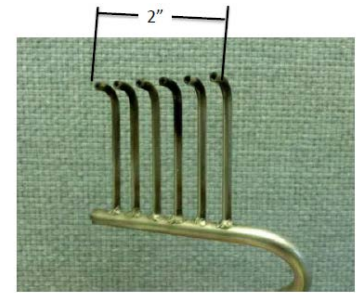
- **Cannot observe flame propagation during test (enclosed test) - No exact way to evaluate extinguishing time.**
 - How to extrapolate extinguishing time to a lab scale test?
- **Difficult to determine burn lengths post test**

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

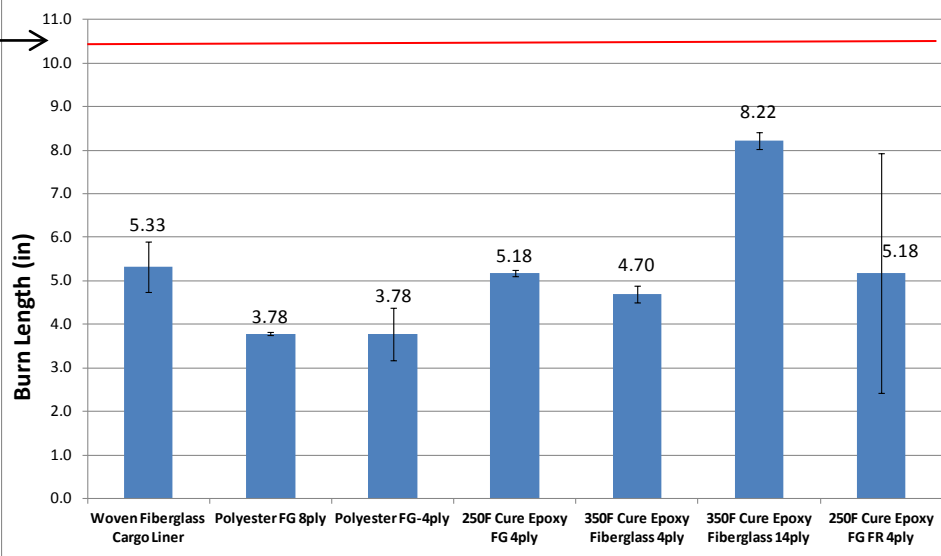
Selected worse case materials/configurations to evaluated in the new VRP.

Material	Quantity Tested
Woven Fiberglass Cargo Liner	3
Polyester FG Fabric 8 ply	3
Polyester FG Fabric 4 ply	3
250 cure epoxy FG 4 ply	3
250 cure epoxy FG, FR 4ply	3
350 Cure epoxy FG 4ply	3
350 Cure epoxy FG 14ply	3

VRP Test Results:

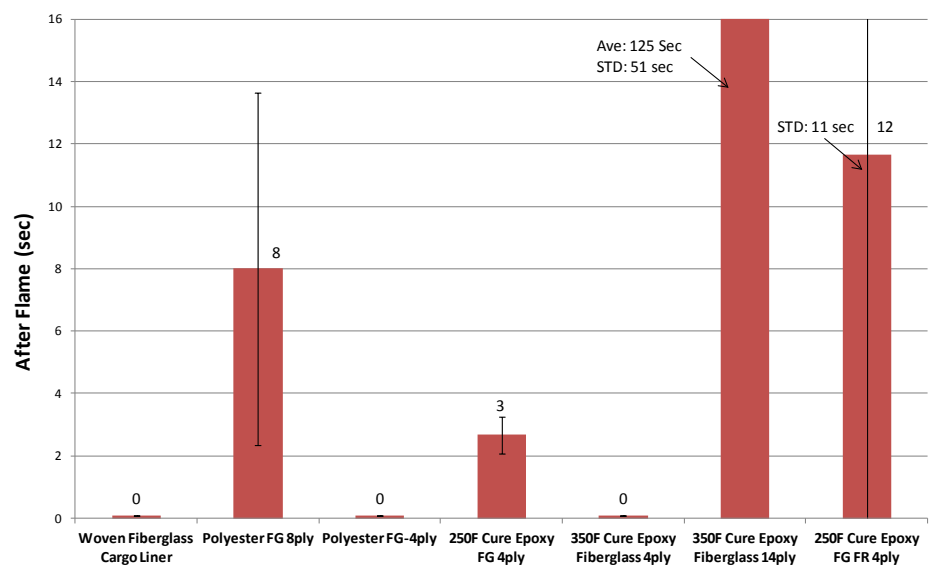
Vertical Radiant Panel Results- Burn Length

Sample Length →



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

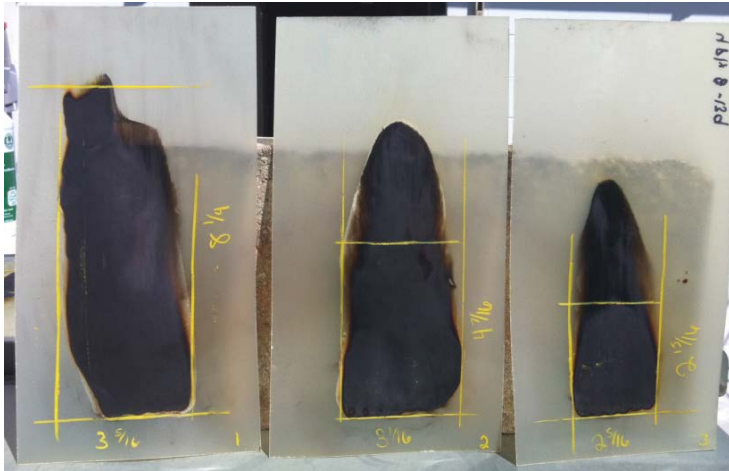
Vertical Radiant Panel- After Flame



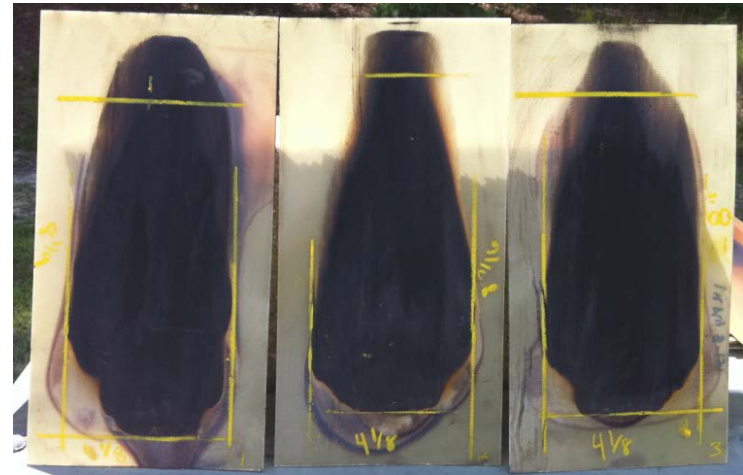
Error bars represent one standard deviation
Each bar represents the average of three coupons

Photos Continue..

350F Cure Epoxy Fiberglass 4 ply



350 F Cure Epoxy Fiberglass 14 ply



250F Cure Epoxy Fiber Glass FR 4 ply

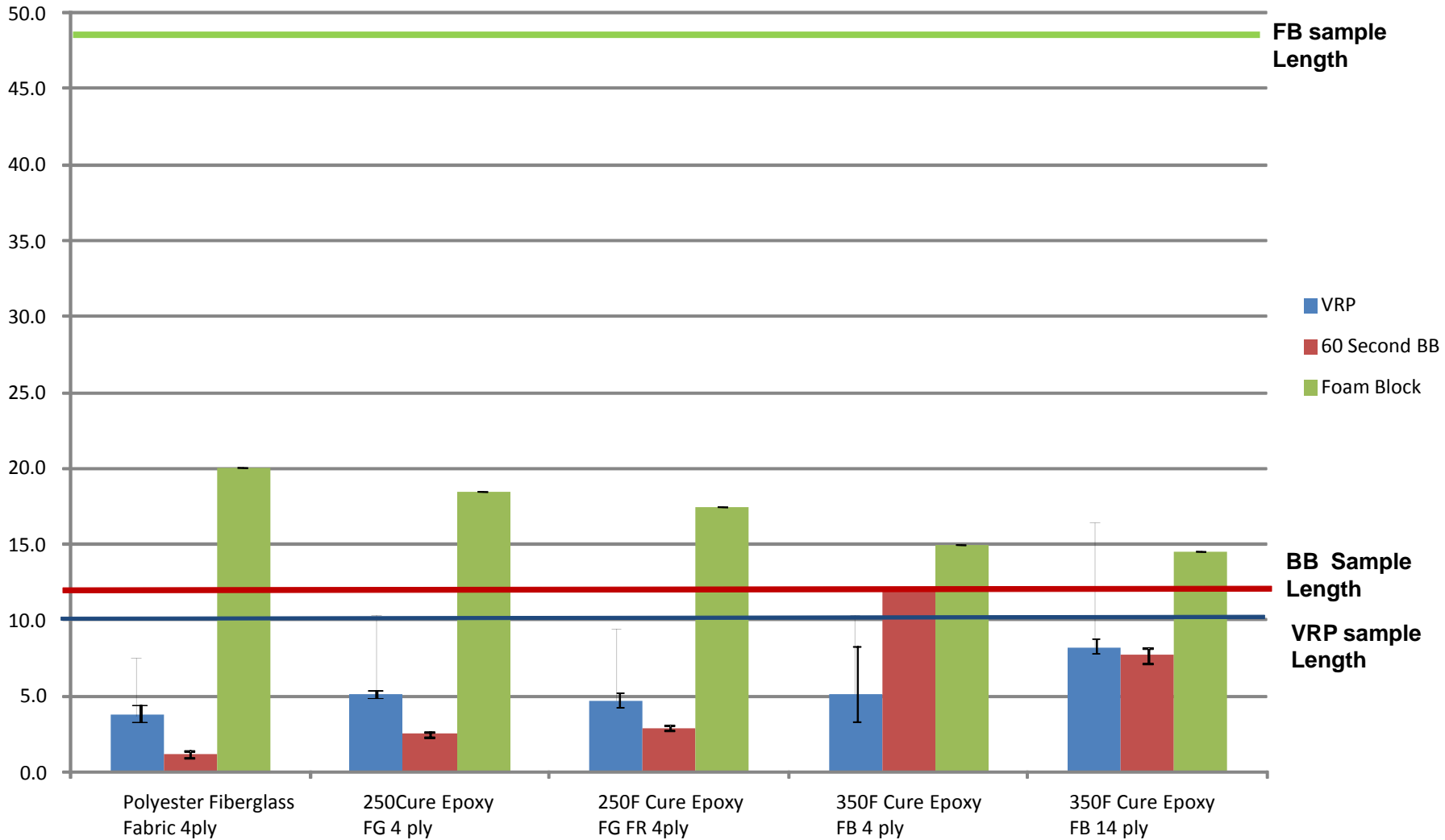


Key Variables That Need Further Validation

- **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



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!