

Composite Structure Flame Propagation Test Method Development

Presented to: IAMFTWG, Singapore

By: Robert I. Ochs

Date: February 8, 2012



Federal Aviation
Administration

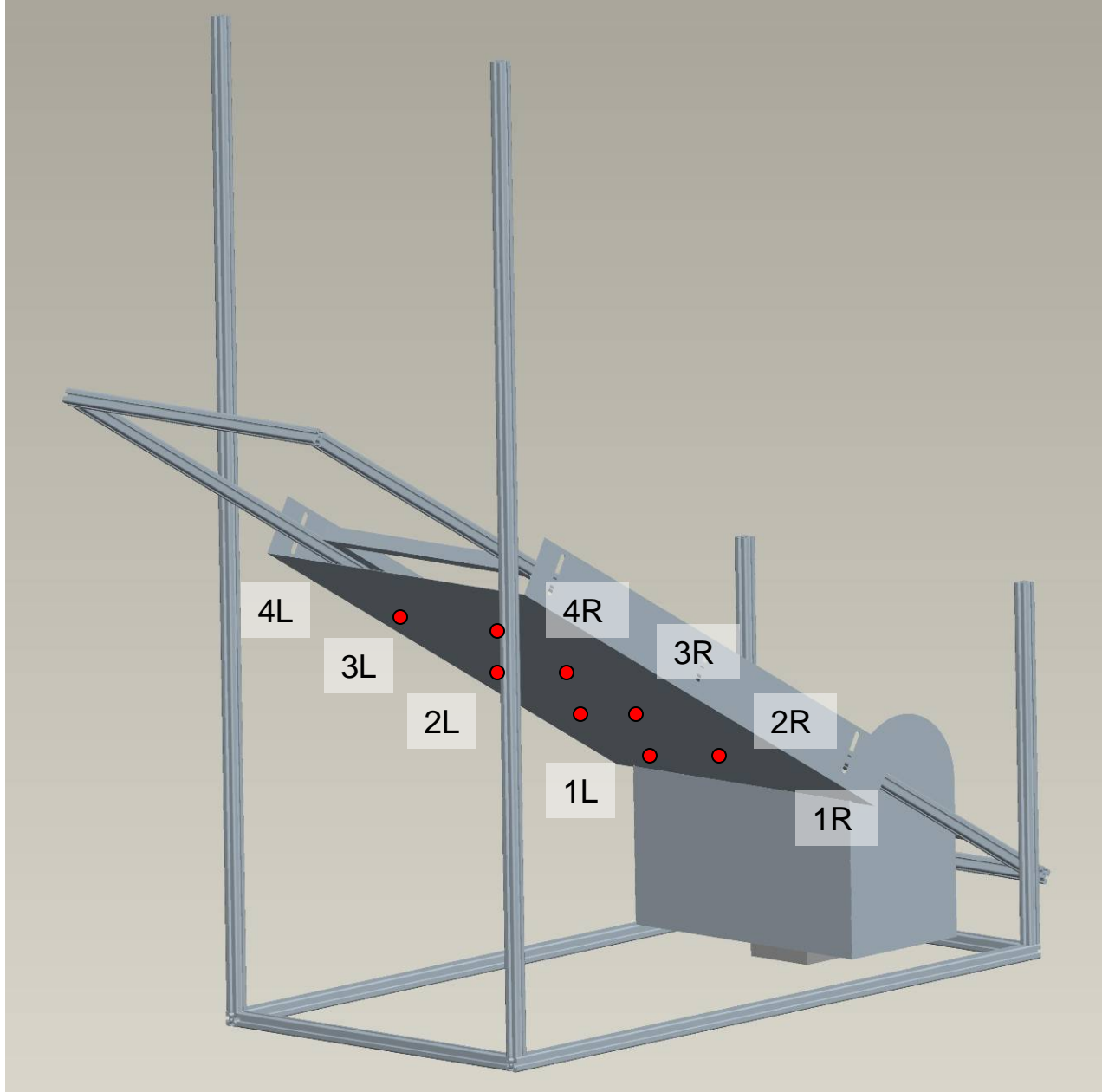


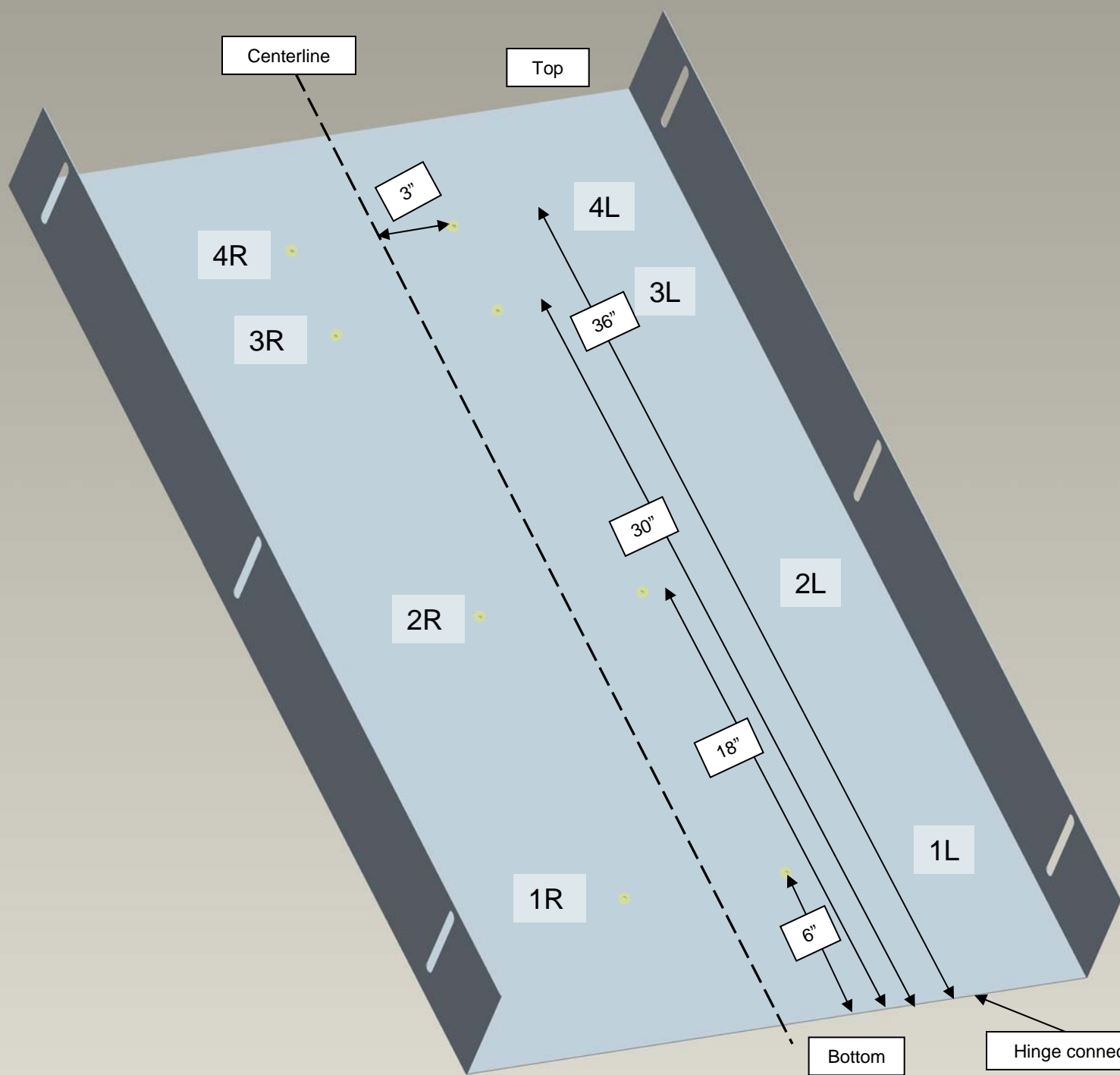
Part 1: Objective

- To determine the effect of the foam block fire source on aerospace-grade carbon epoxy panels of varying thicknesses
- Material is *similar* to the ACF1 tested in previous trials
 - Toughened epoxy resin system
 - 350°F cure
 - Unidirectional carbon fiber tape

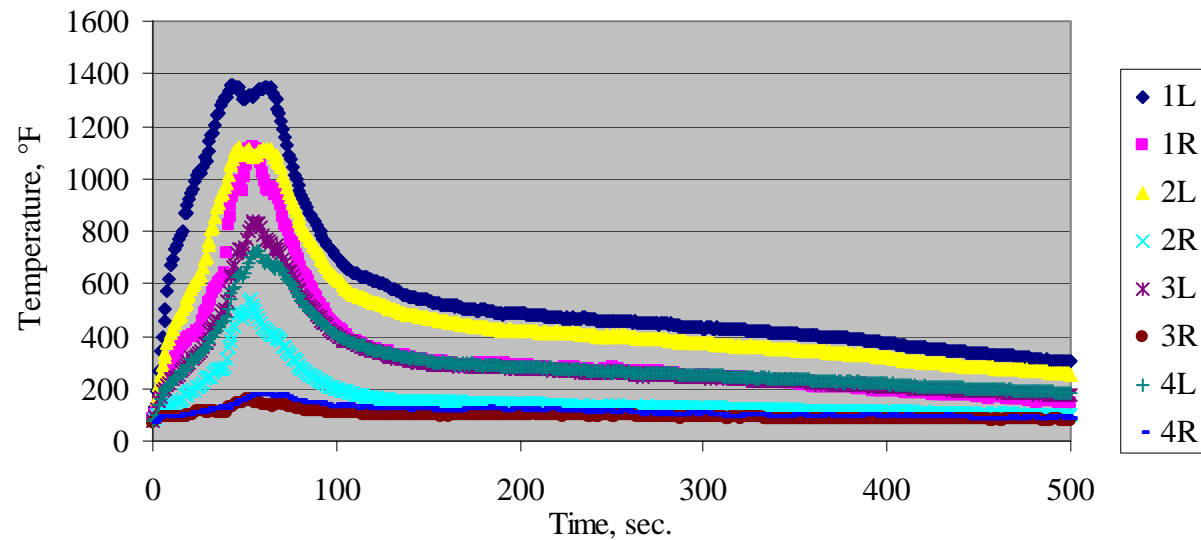


# Plies	Thickness (in.)	Thickness (mm)	Layup
4	0.044	1.1176	(0,90,90,0)
8	0.1005	2.5527	(0,45,-45,90)s
16	0.1325	3.3655	(0,45,-45,90)2s
24	0.2775	7.0485	(0,45,90,-45,90,0)2s
32	0.3675	9.3345	(0,45,-45,90)4s





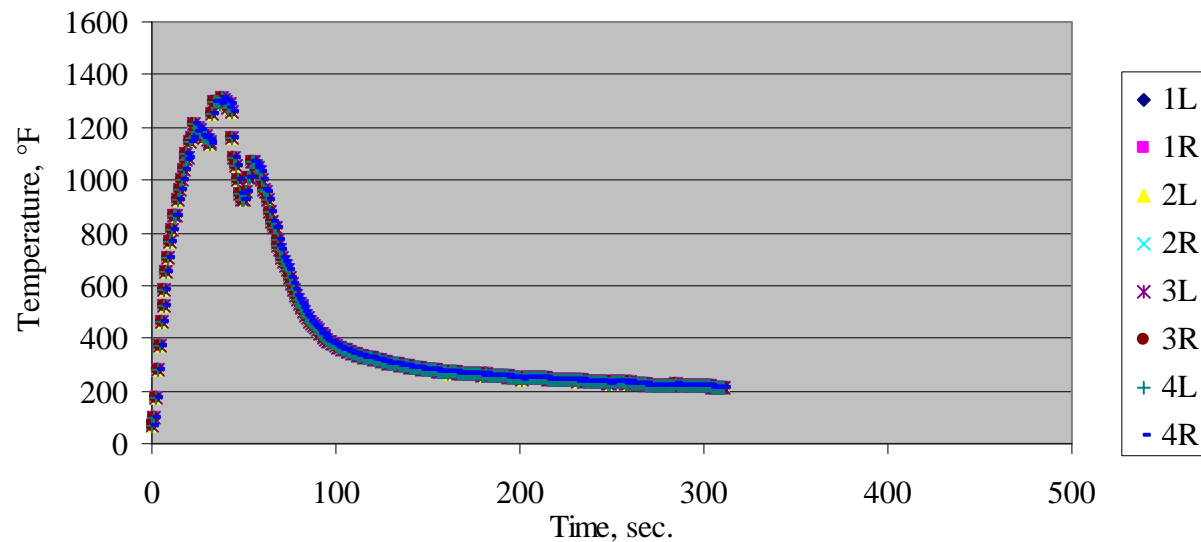
Kaowool Board Baseline 11/22/11



4 ply Carbon Epoxy

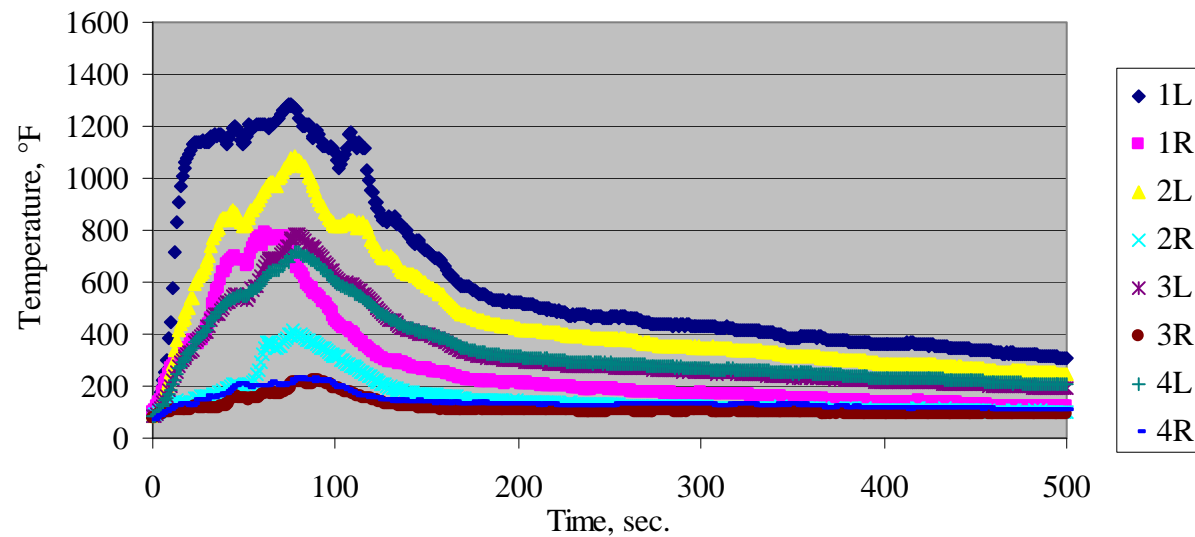


4 ply Carbon Epoxy

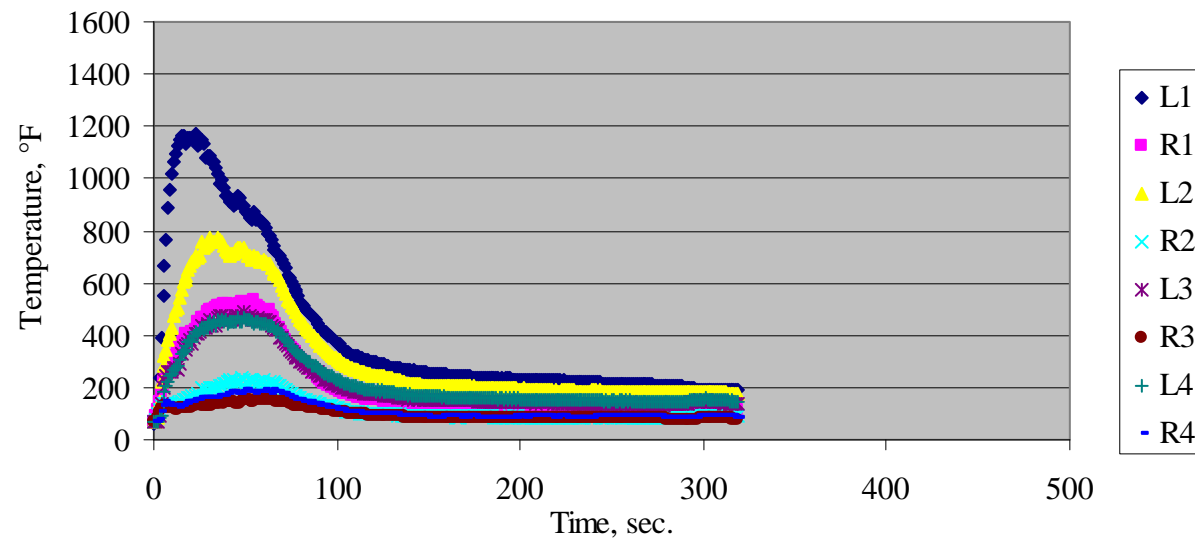


**Note: only channel 1L
recorded during this test*

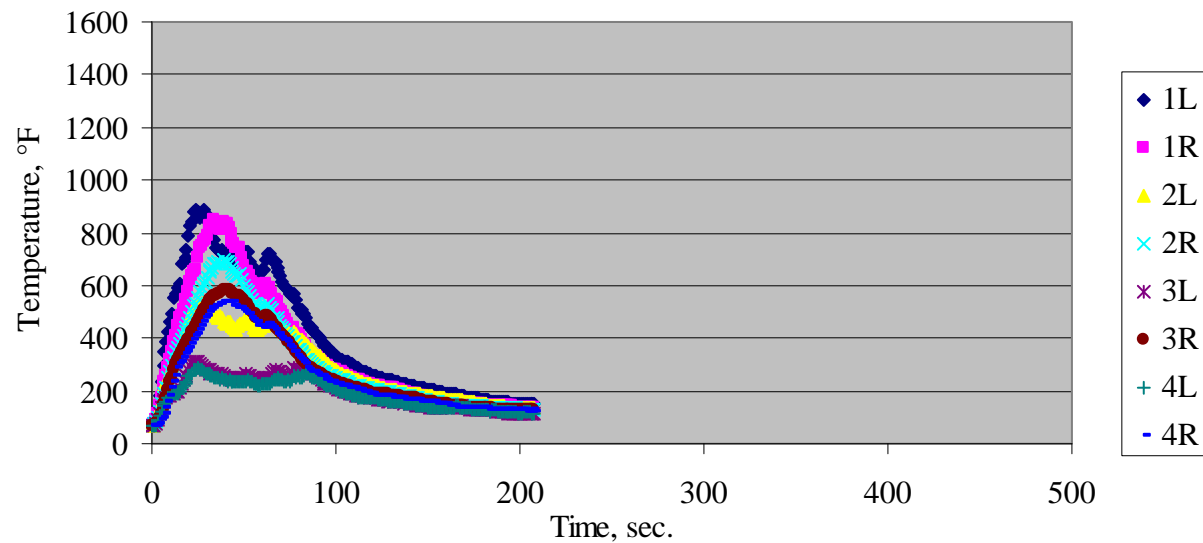
8 Ply Carbon Epoxy, 11/22/2011



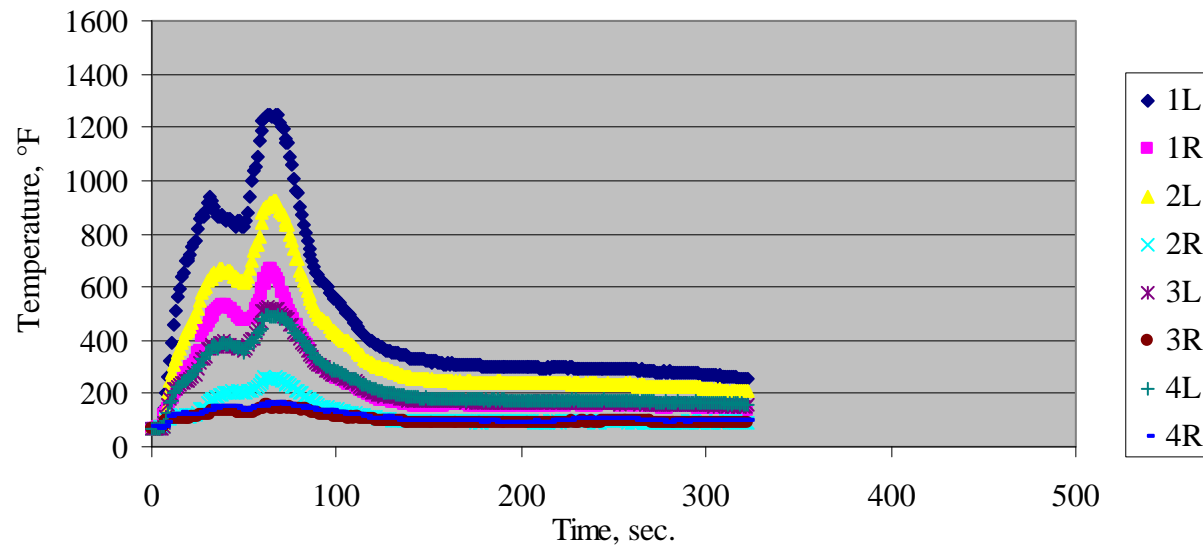
16 Ply Carbon Epoxy



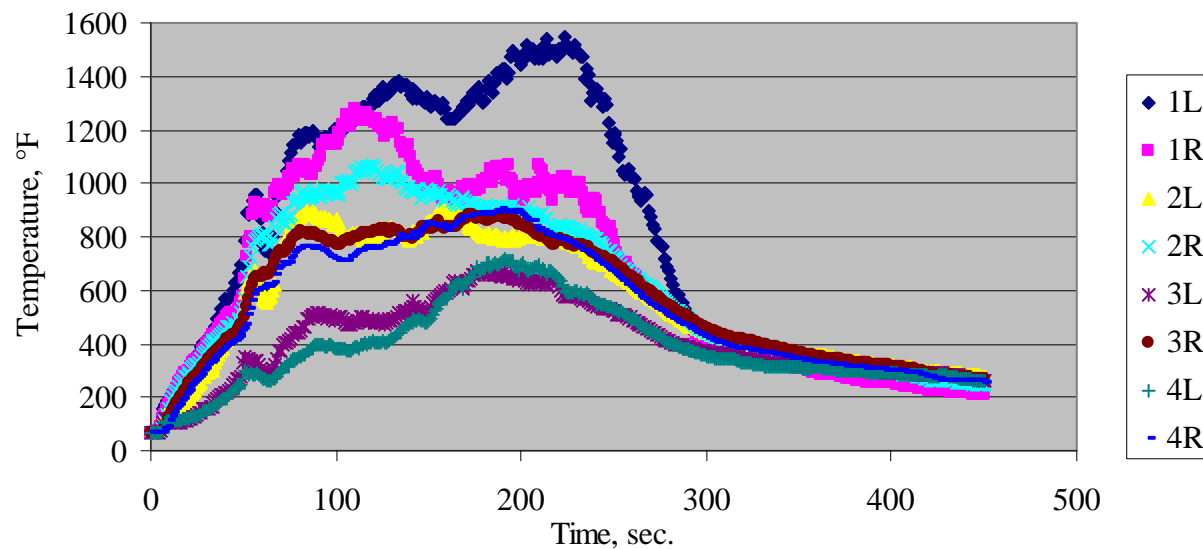
24 Ply Carbon Epoxy



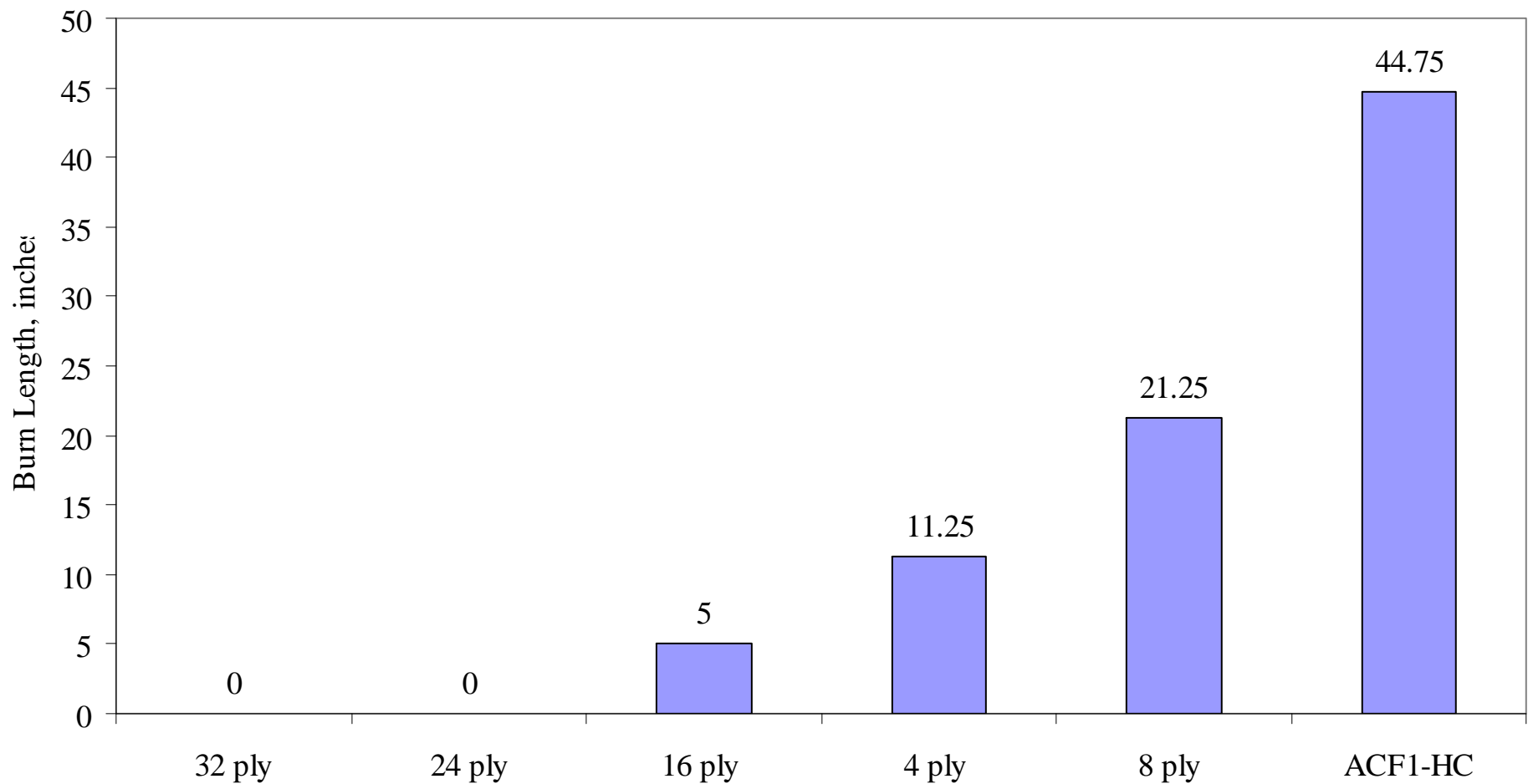
32 Ply Carbon Epoxy



ACF1-HC 4 Ply/1" HC Core/4 Ply



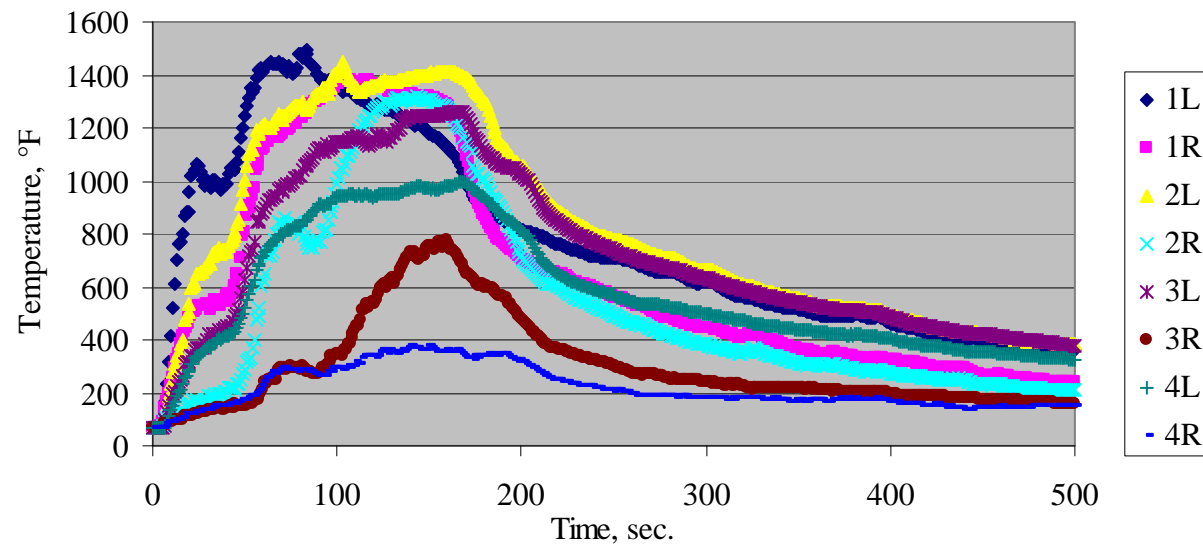
Results – Various Thicknesses



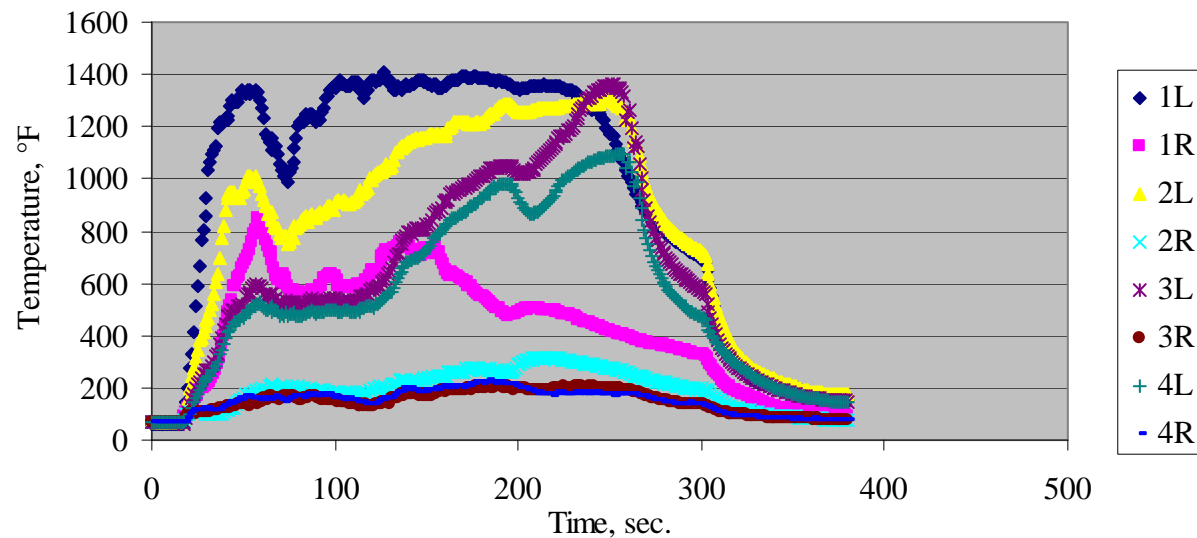
4 Ply Carbon Epoxy w/ Kaowool on Back



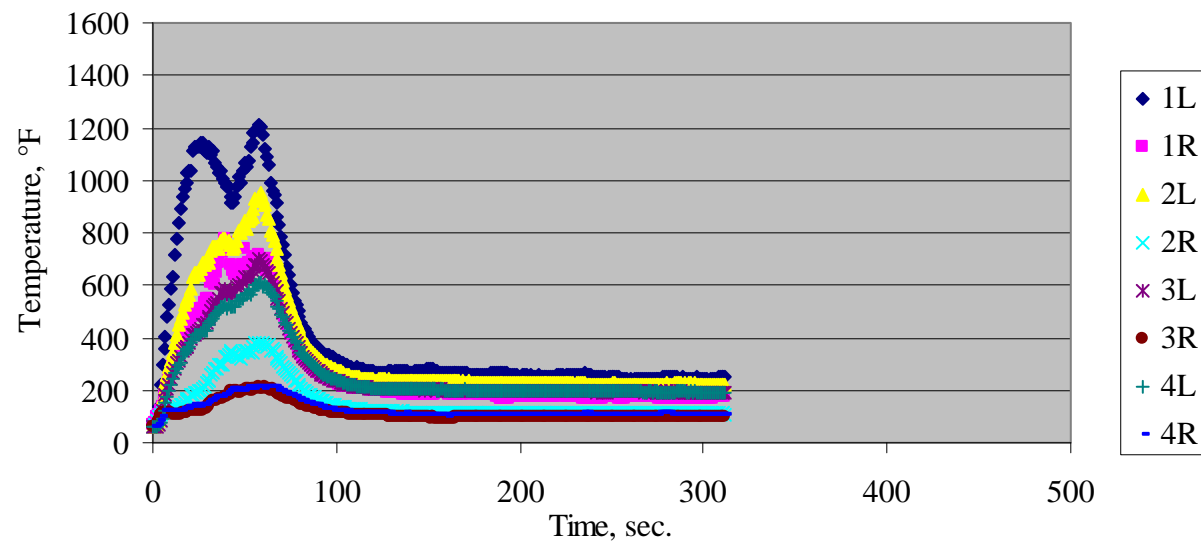
4 Ply Carbon Epoxy w/ Kaowool on Back



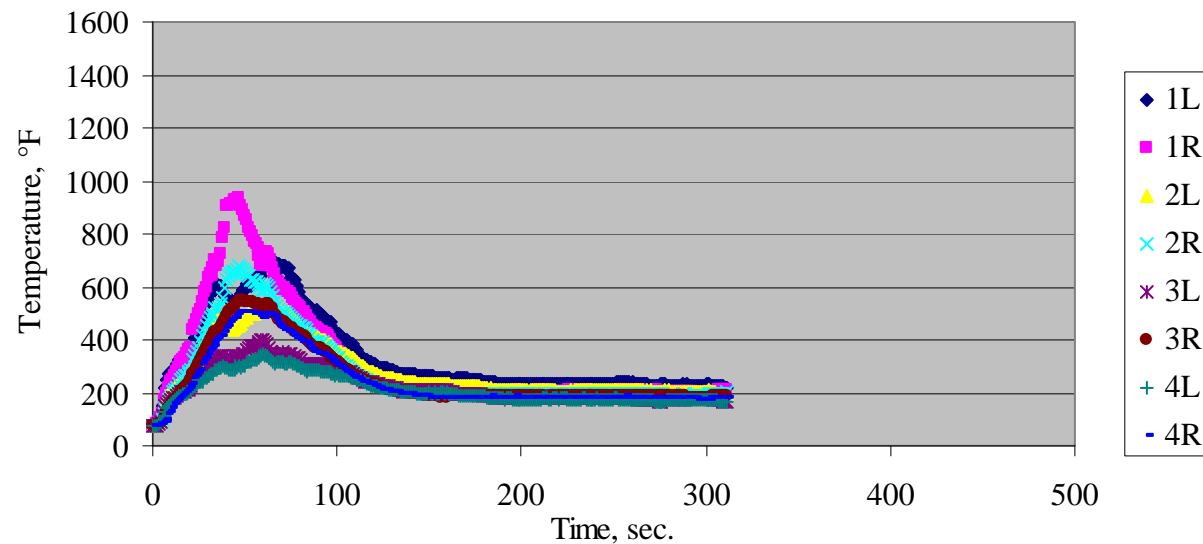
8 Ply Carbon Epoxy w/ Kaowool on Back, 11/29/2011



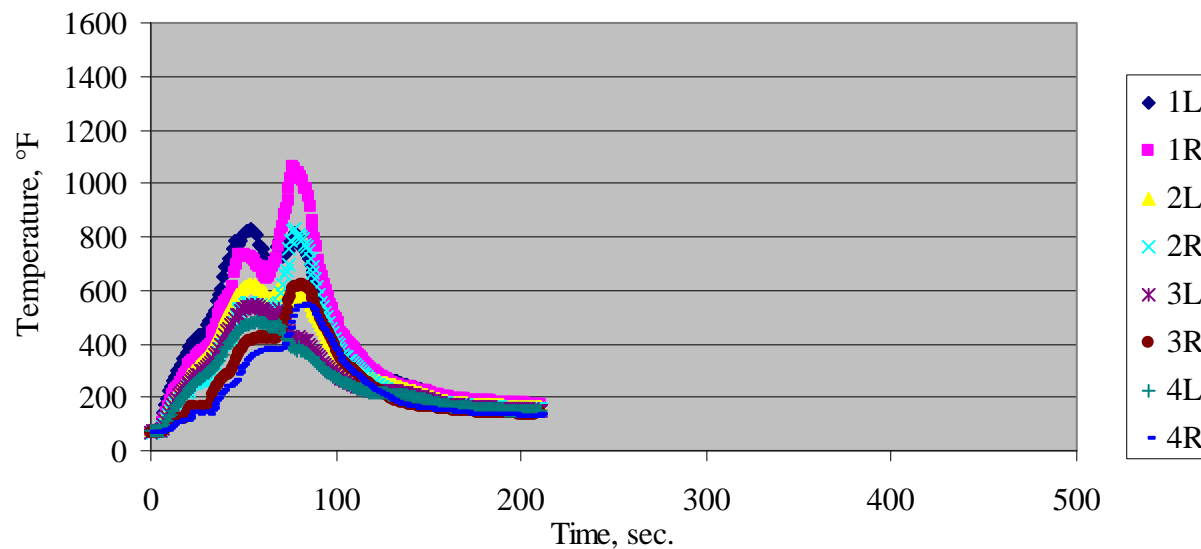
16 Ply Carbon Epoxy w/ Kaowool on Back



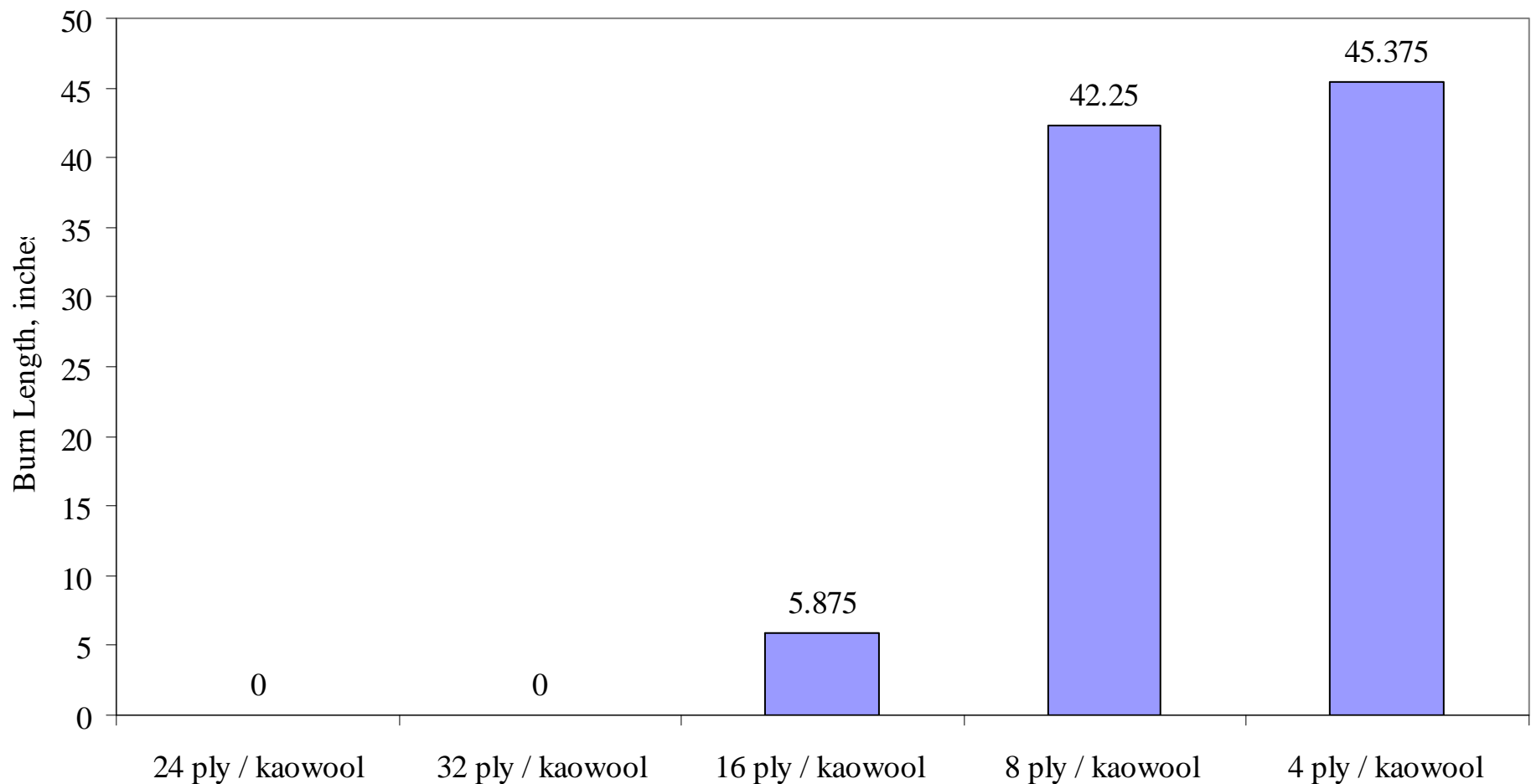
24 Ply Carbon Epoxy w/ Kaowool on Backside



32 Ply Carbon Epoxy w/ Kaowool on Backside



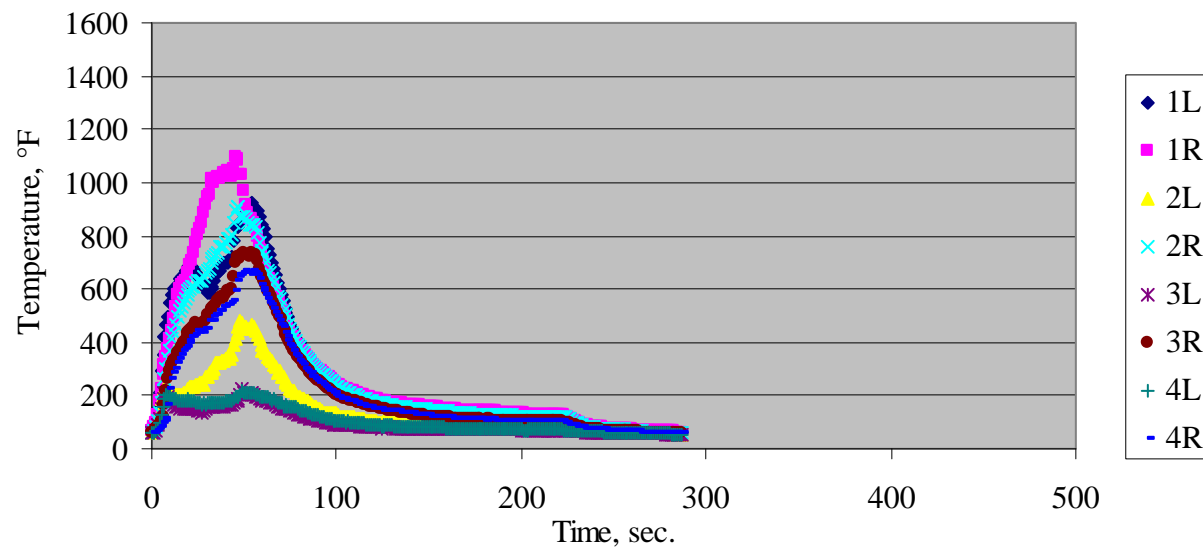
Results – Insulated Backside



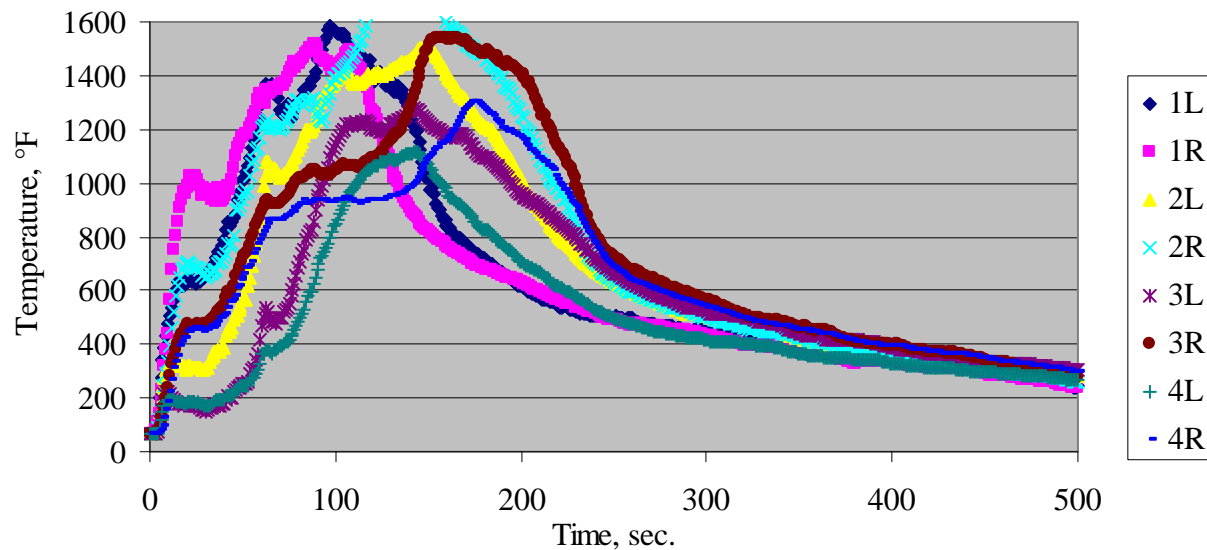
4 Ply Carbon Epoxy w/ water on Back



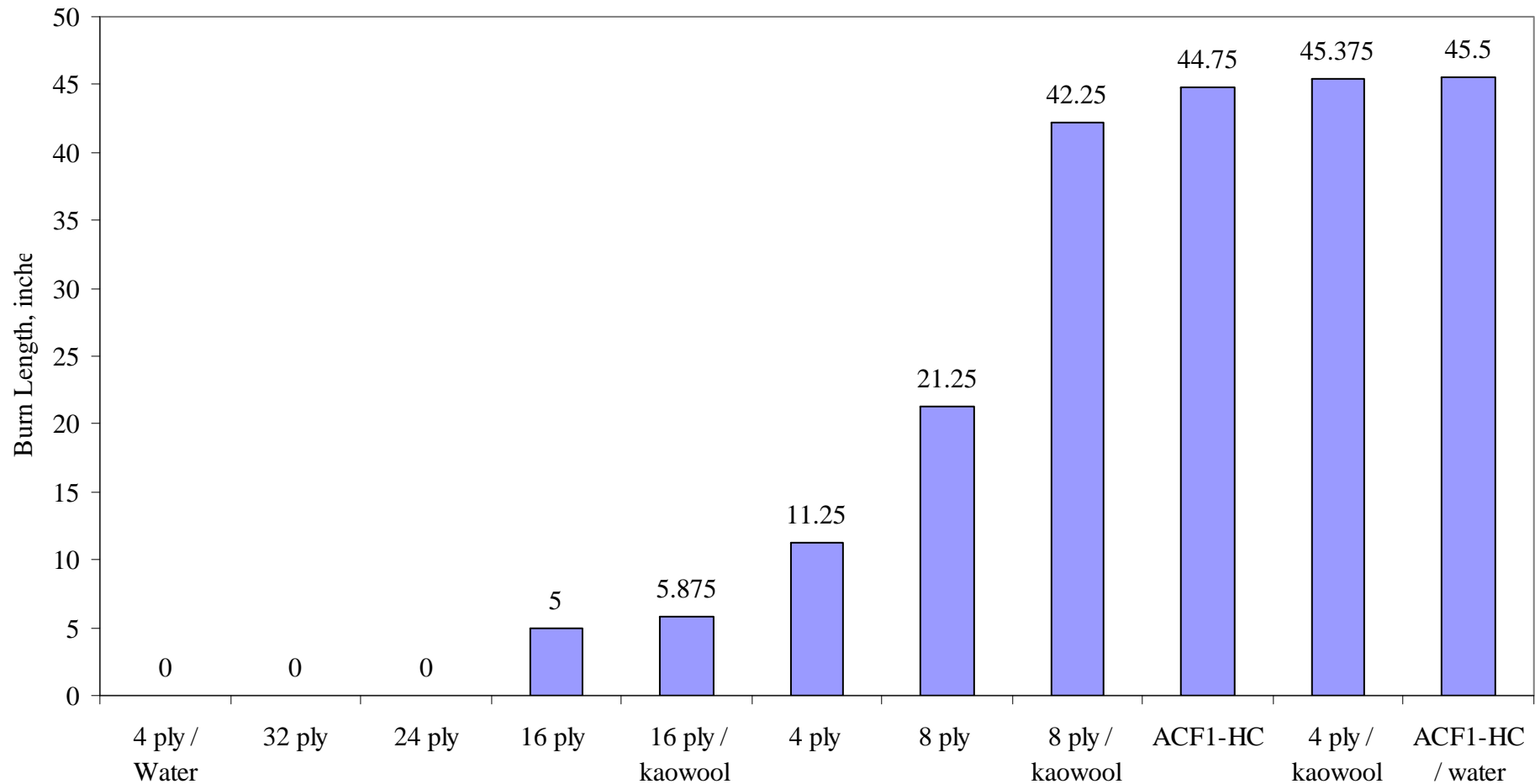
4 Ply Carbon Epoxy w/ water on Back



ACF1-HC 4 Ply/1" HC Core/4 Ply w/ Water on Backside



Overall Results



Part 1 - Summary

- **Several aerospace grade carbon epoxy samples of different thicknesses were tested on the foam block test rig**
 - Results indicate thickness (conductivity) of panel has big impact on flame propagation ability
- **Sample back side has large impact on flame propagation ability**
 - Backside “extremes” were tested simulating
 - Minimal heat loss (kaowool)
 - Normal conditions (ambient)
 - High heat loss (water)
 - These results can be used to correlate with lab scale test

Part 2

Foam Block Characterization and Simulation

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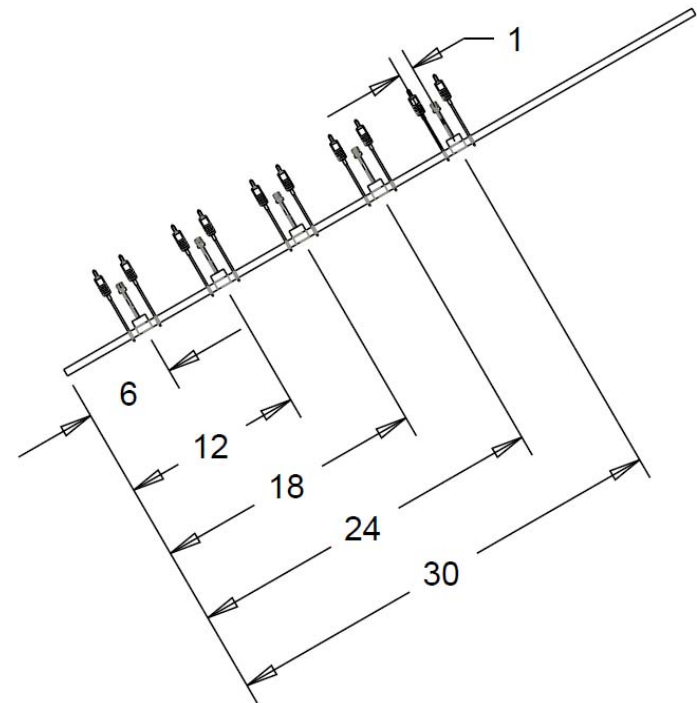
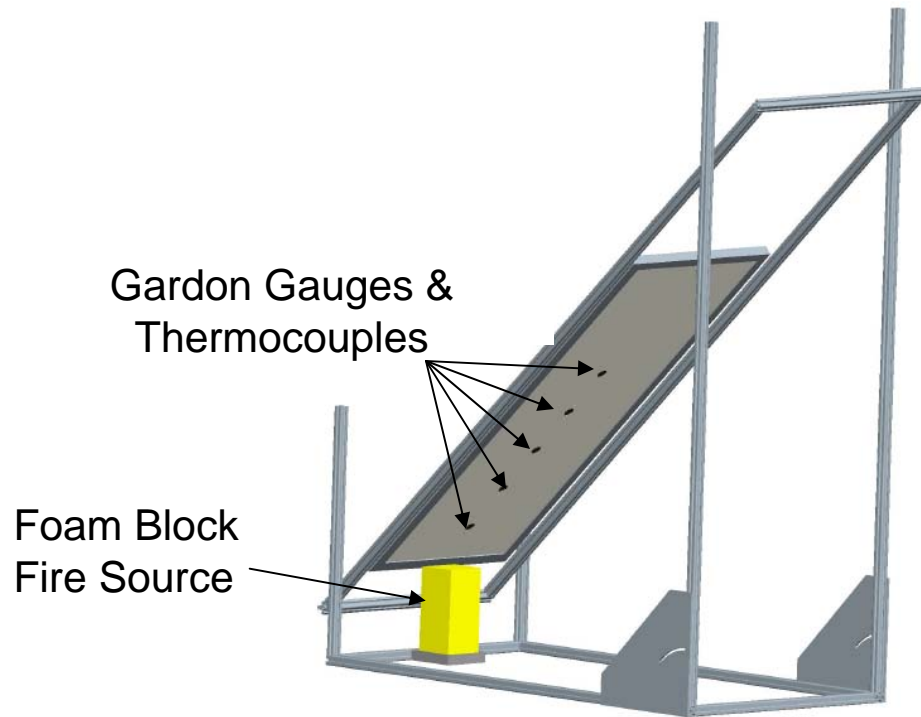


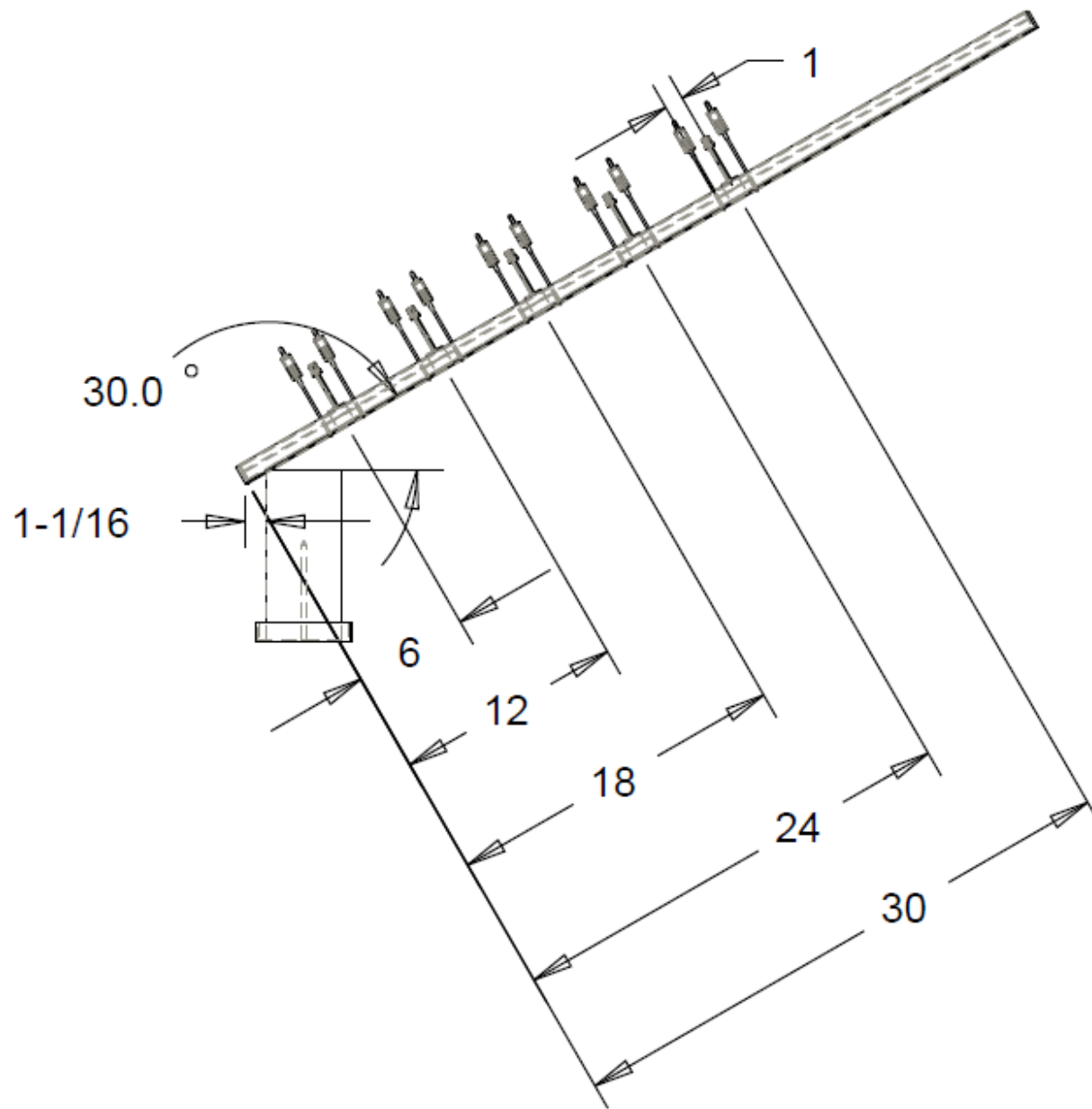
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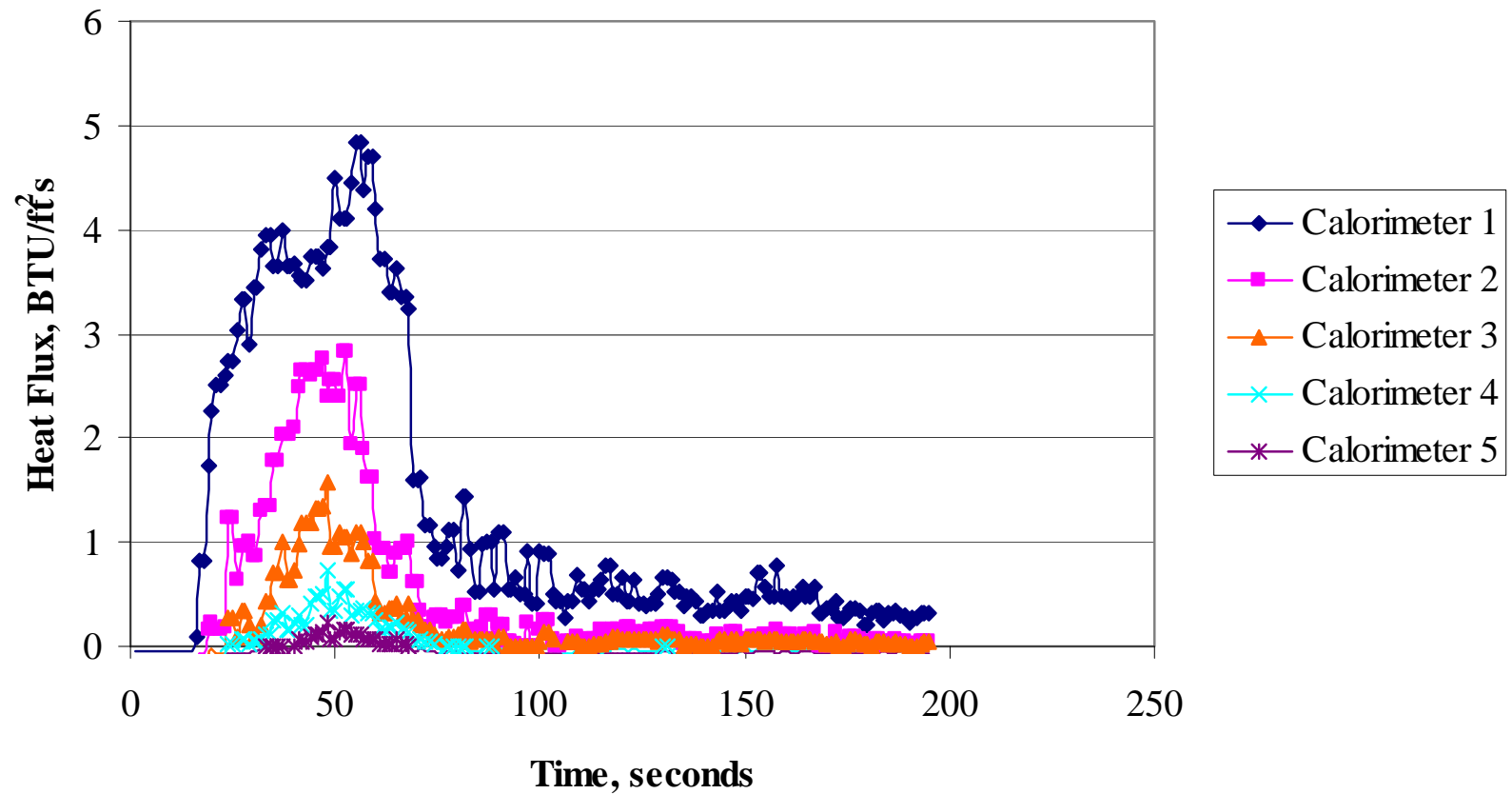
Experimental Setup

- Intermediate scale flame propagation test rig
- Three foam block-panel angles tested
 - 30°
 - 45°
 - 60°

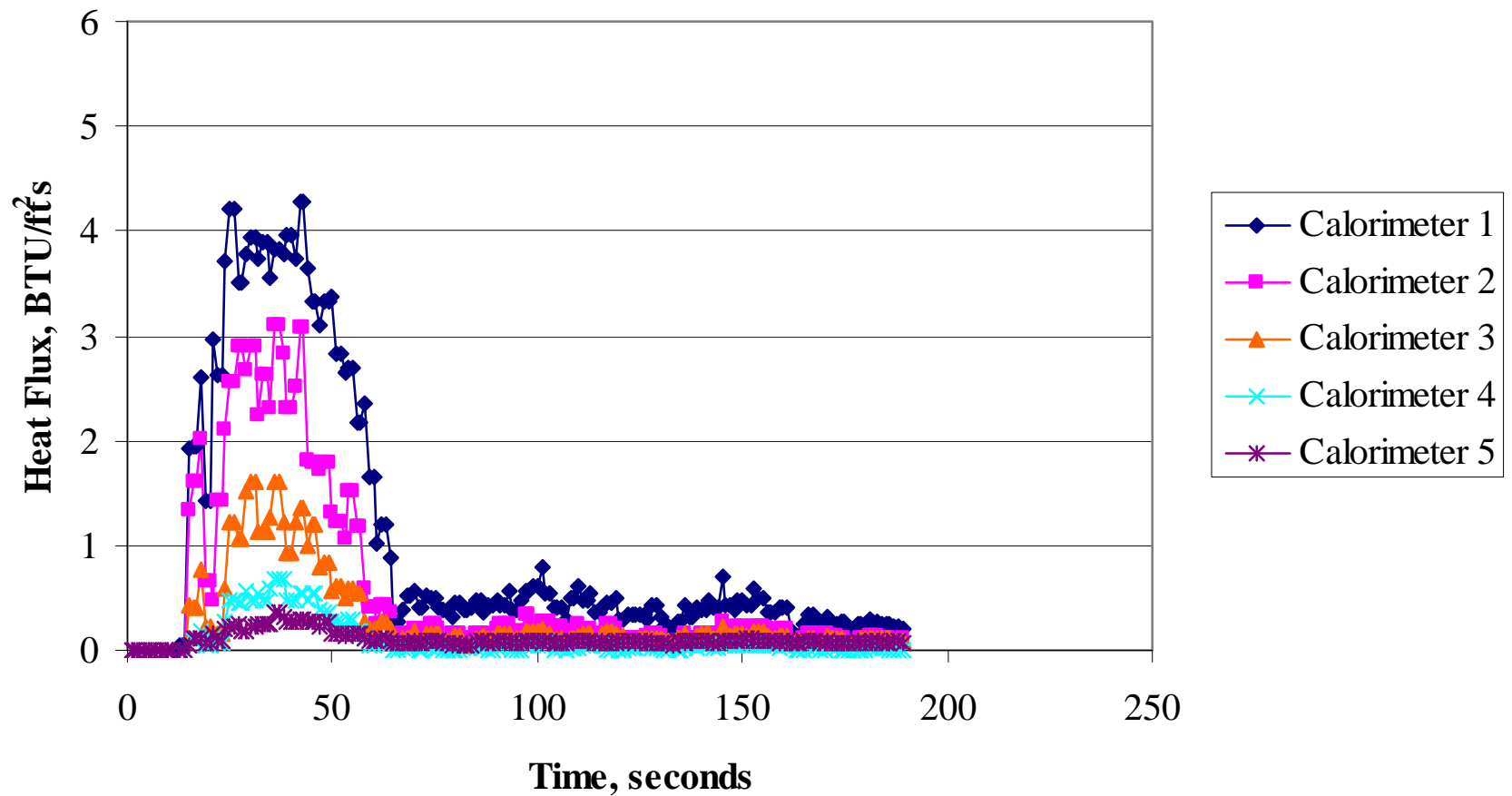




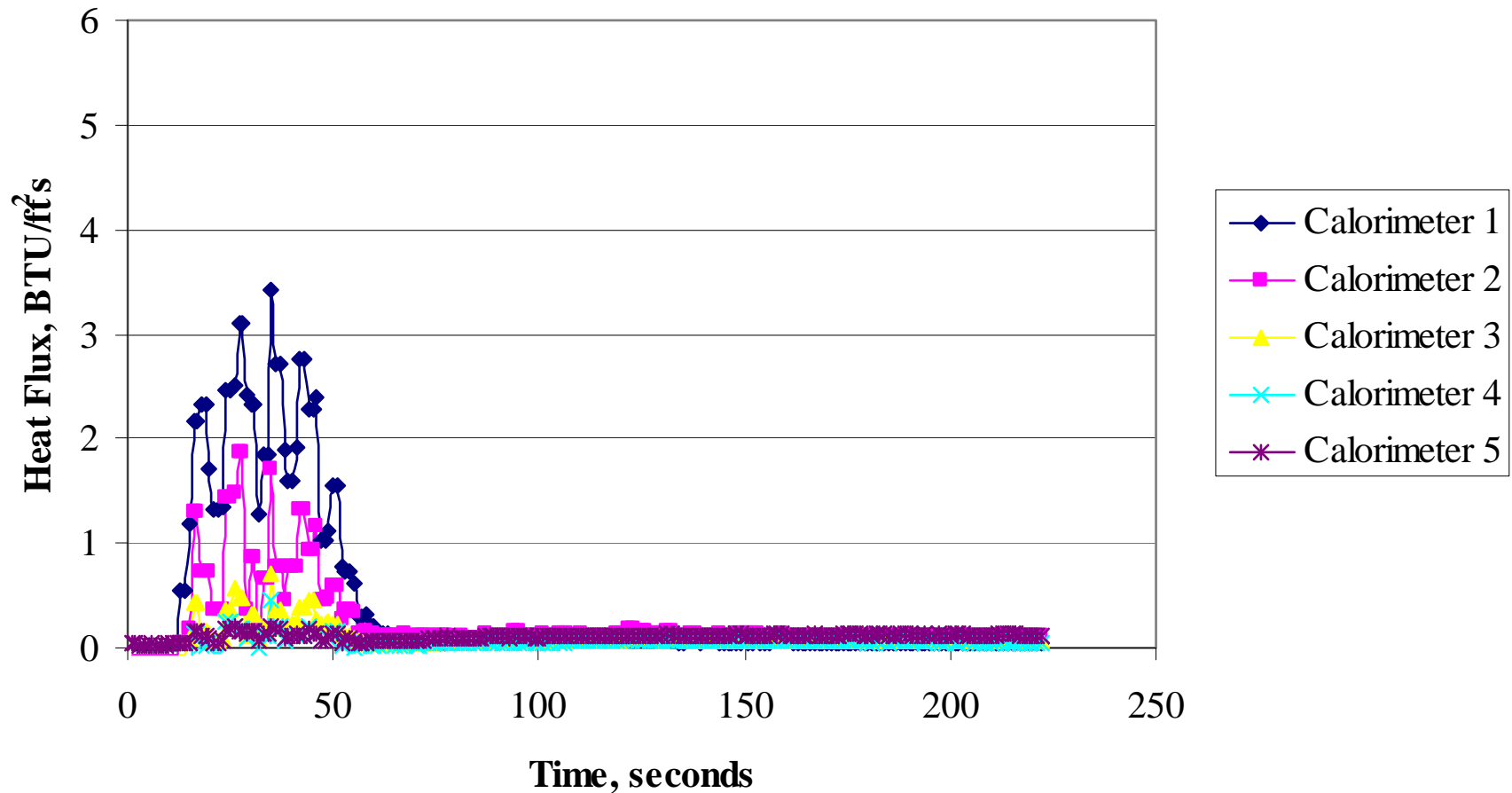
Heat Flux - 30°



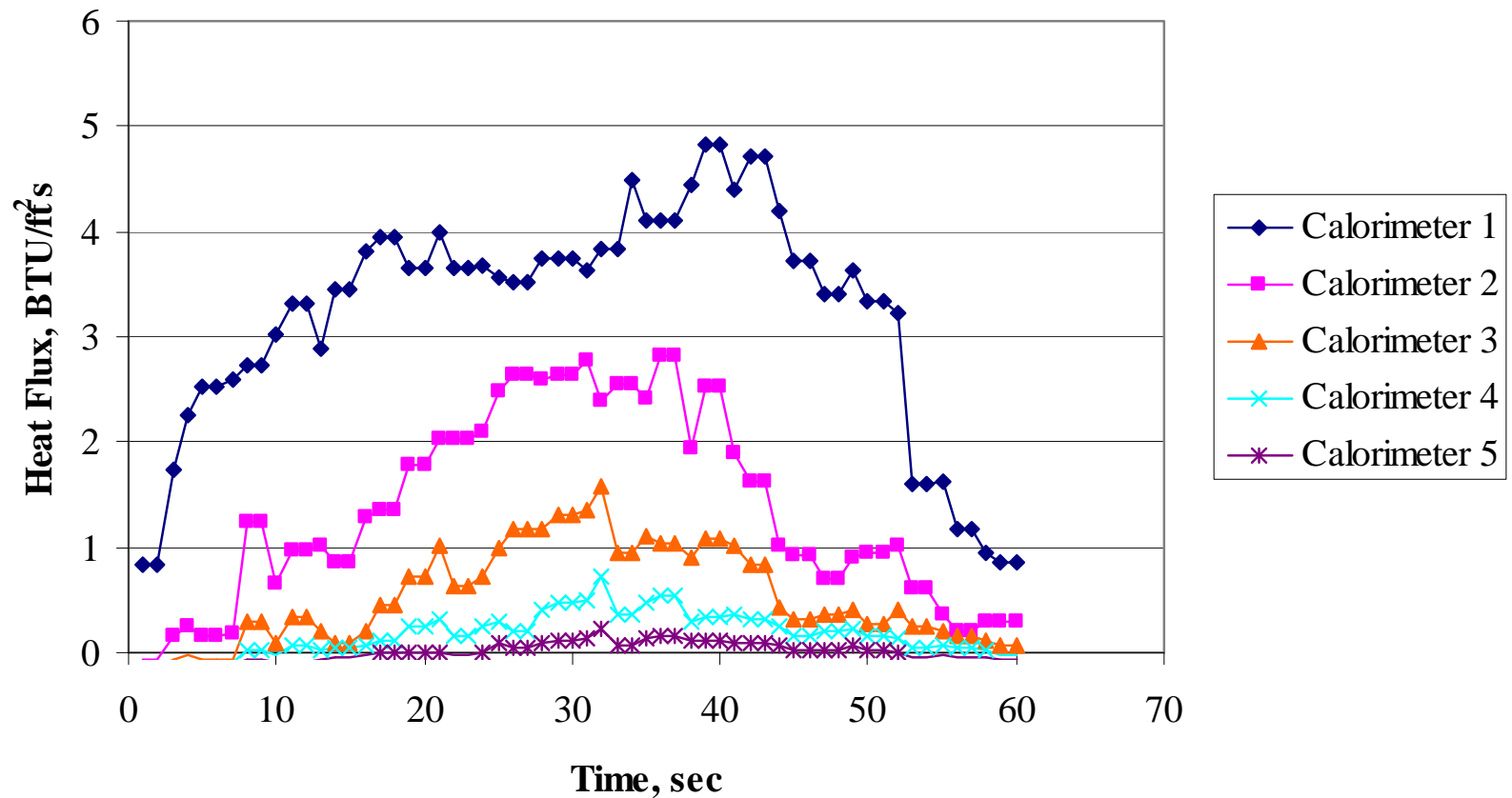
Heat Flux - 45°



Heat Flux - 60°



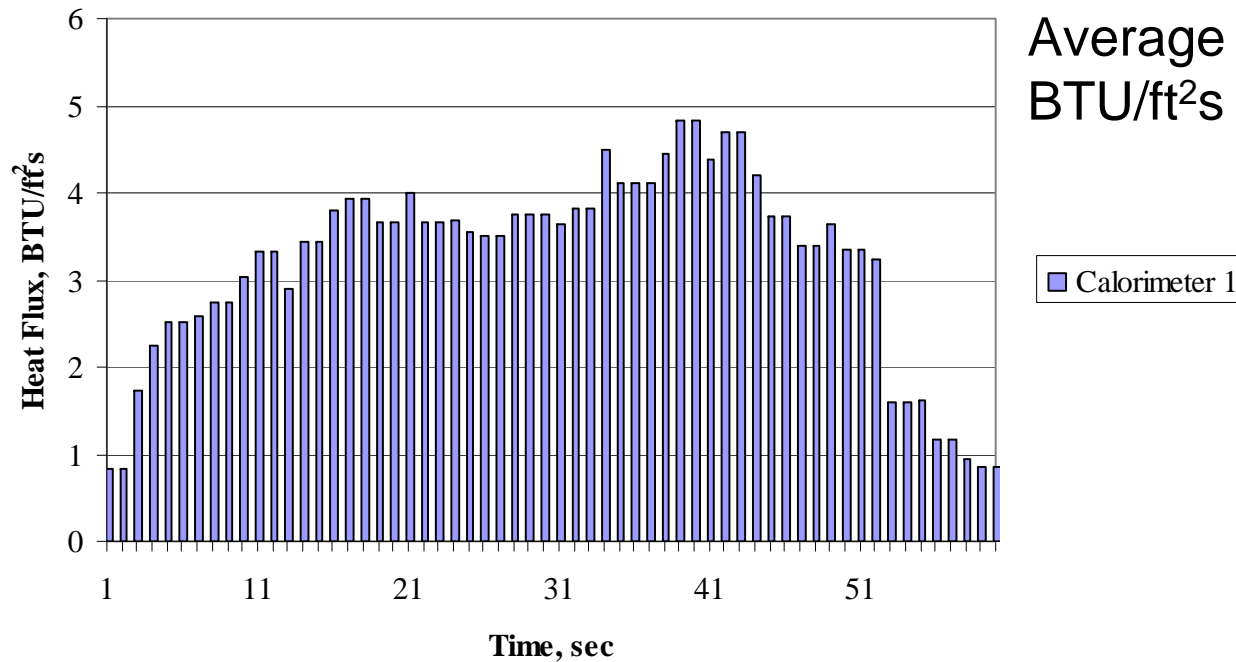
Heat Flux 30°– 60 sec. Period



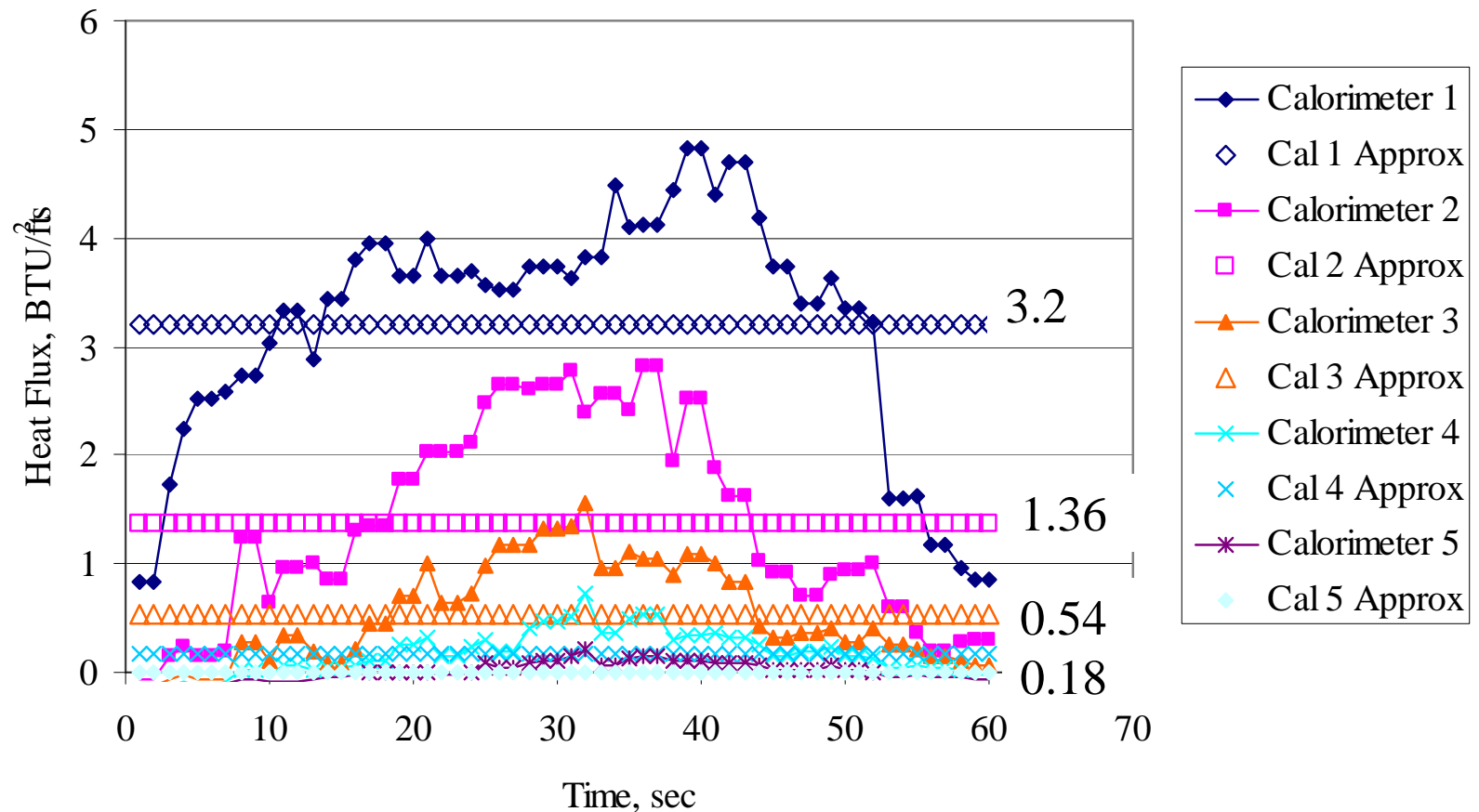
Calorimeter 1

Total Heat = area under curve
= 191.85 BTU/ft²

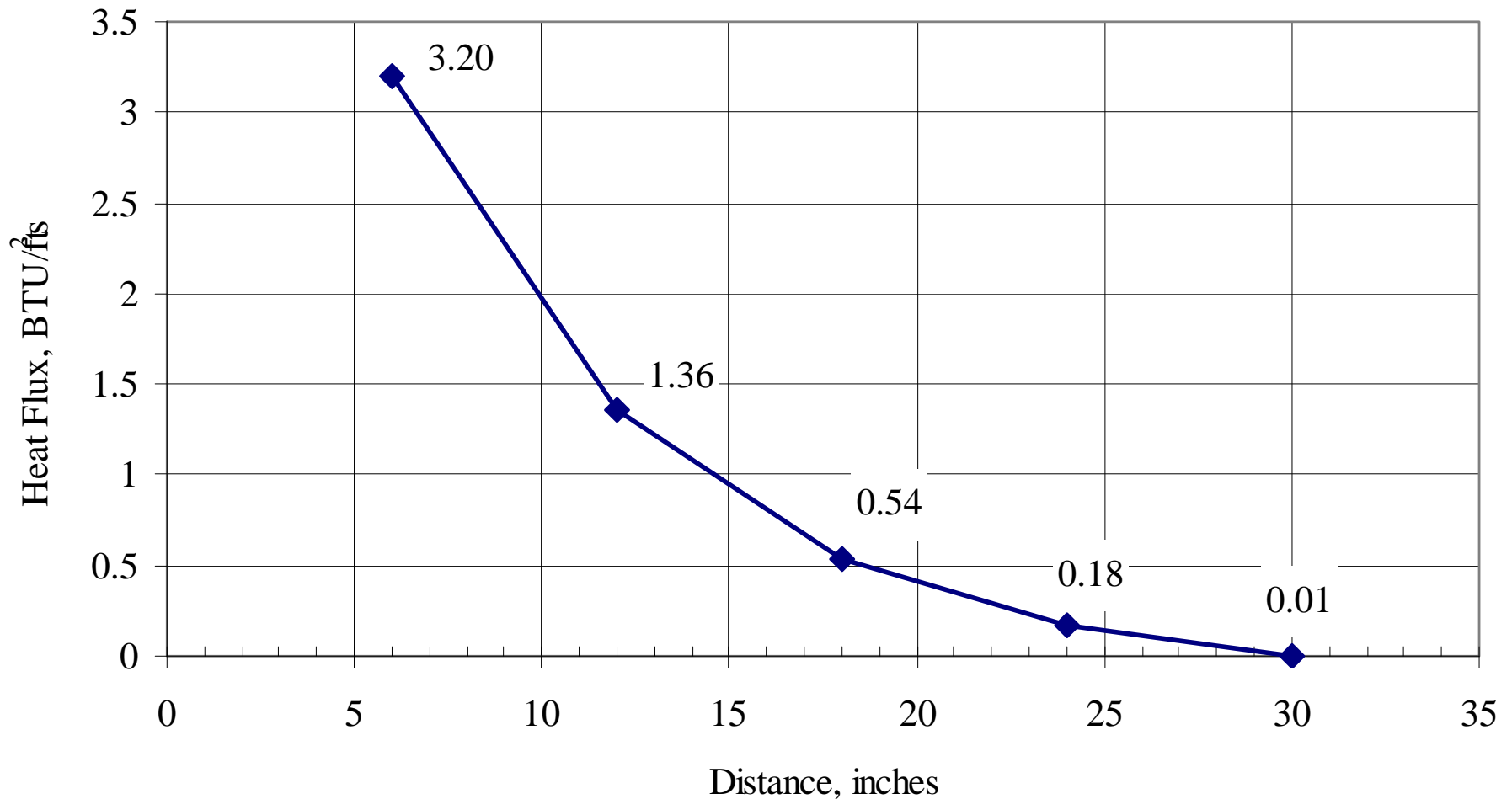
Average Heat Flux = 3.20
BTU/ft²s



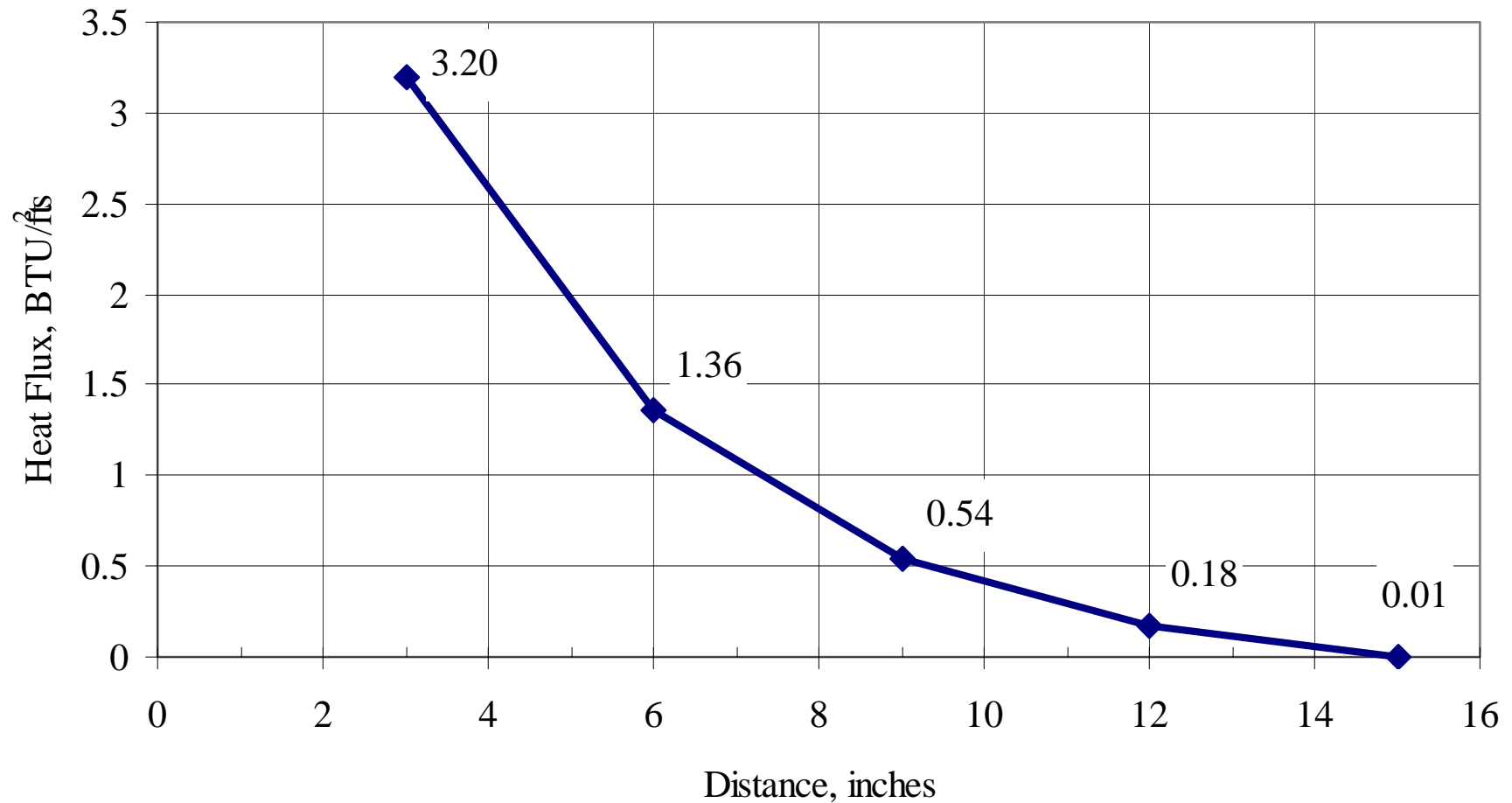
Estimated Heat Flux – 60 sec. Period



Heat Flux Gradient – Intermediate Scale

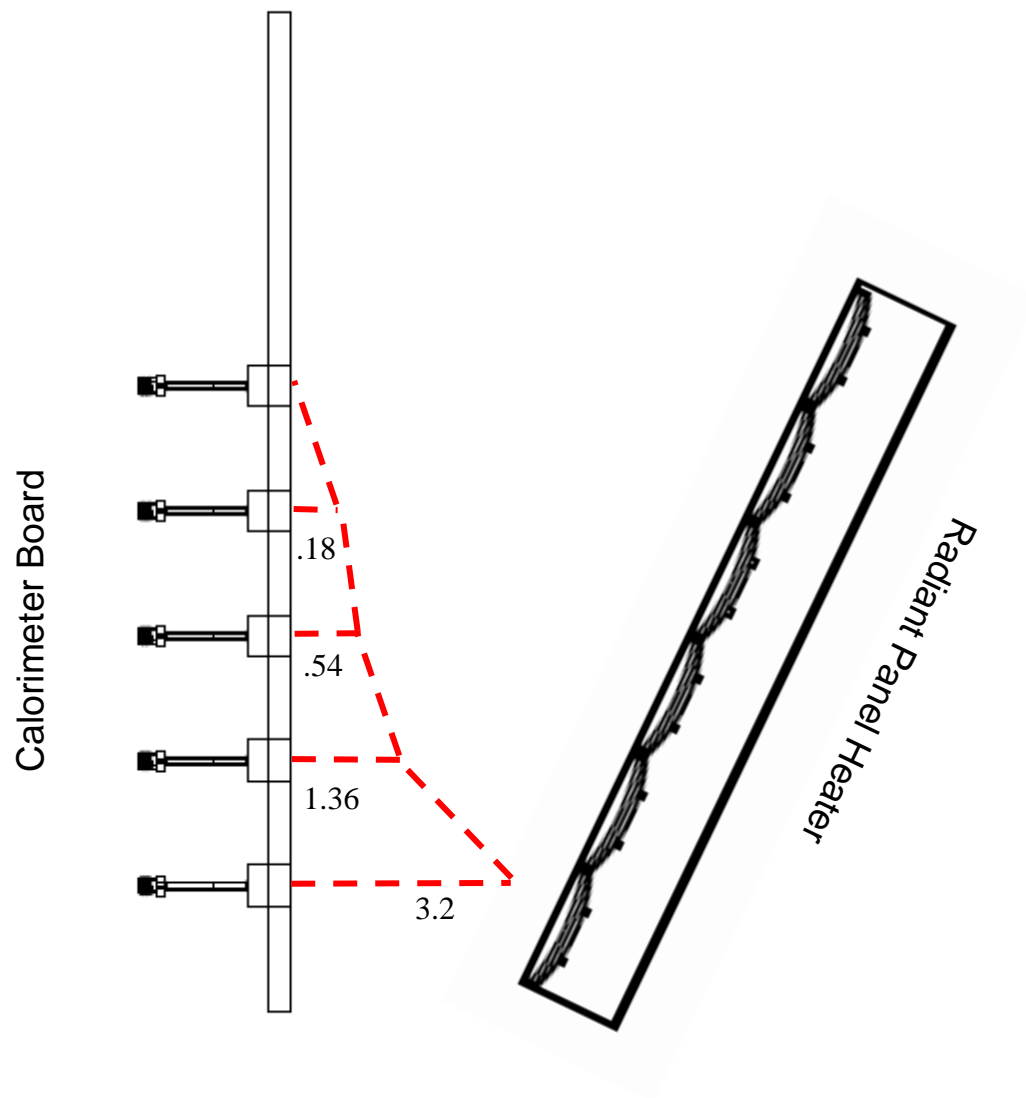


Heat Flux Gradient – Lab Scale

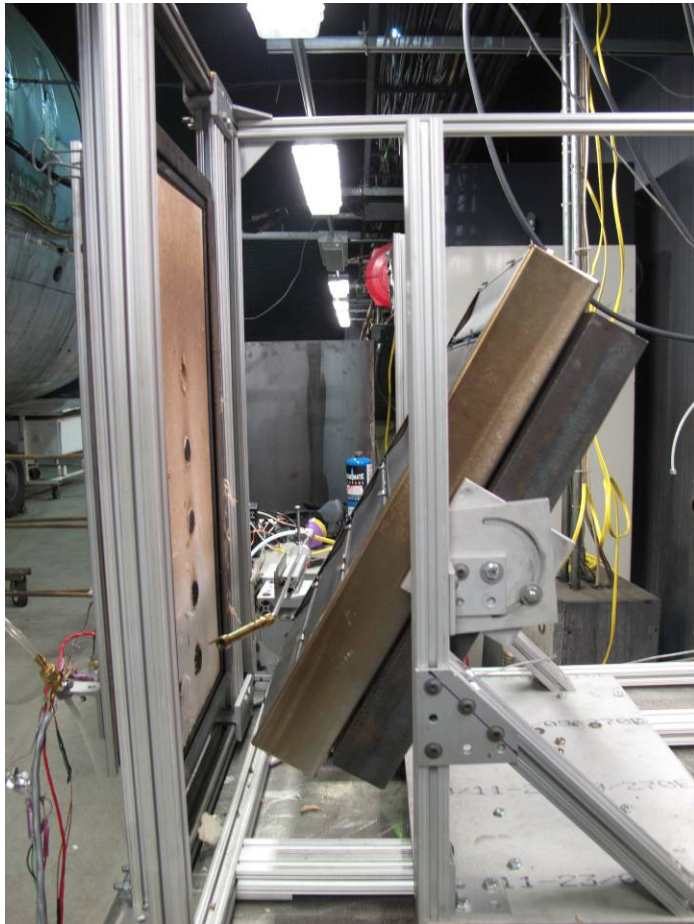


Vertical Radiant Panel (VRP) Development

- **Objective: to develop a “new” radiant panel type test that will:**
 - Simulate conditions of a foam block test
 - Incident heat flux on sample
 - Duration
 - Geometry
 - Correlate results from foam block test
 - Use current database of materials already tested
 - Aerospace/non-aerospace grade composites (1/8” thick)
 - Aerospace grade carbon epoxy, varying thicknesses
 - Cargo liners and floor panels, varying thicknesses



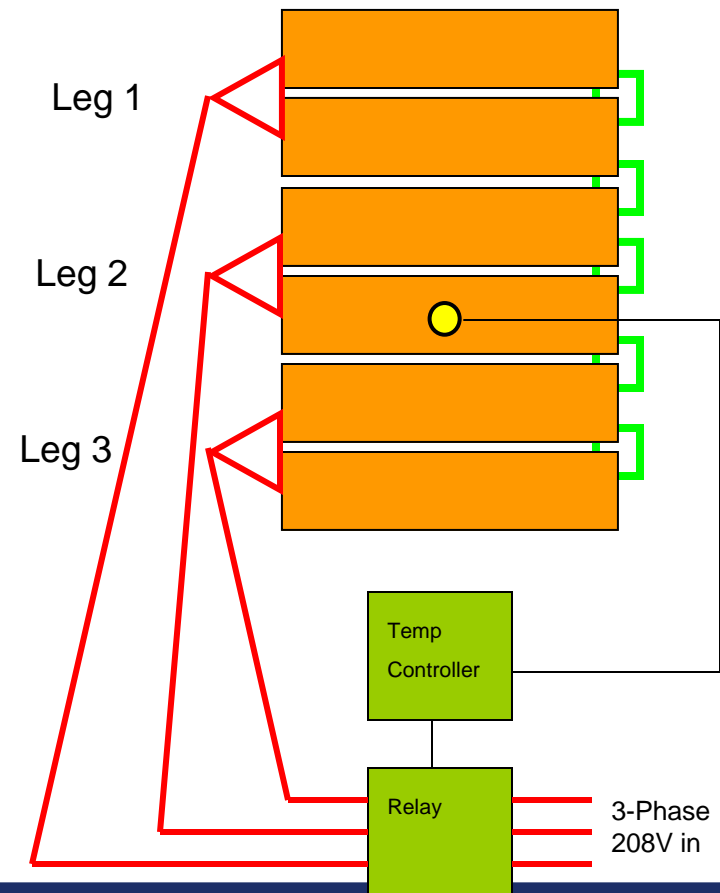
VRP Configuration



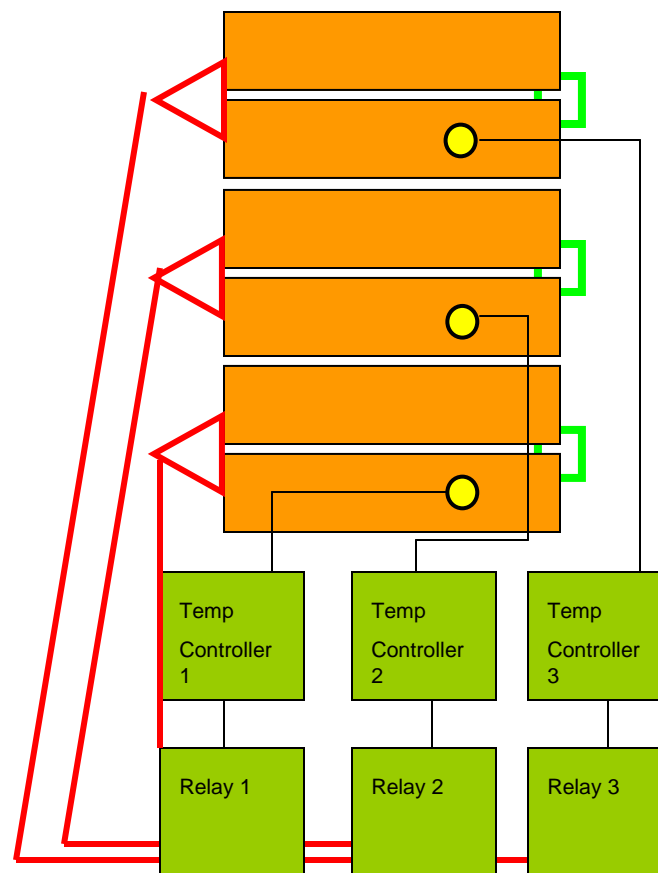
- **Heat flux gradient**
 - A tilted panel was used to attempt to achieve the same measured gradient as the foam block test
 - Furthest backward tilt (70°) could not achieve steep enough gradient
 - Zero position heat flux too low
- **Next attempt:**
 - Separate emitter strips into 3 individually controlled pairs to control the heat flux gradient

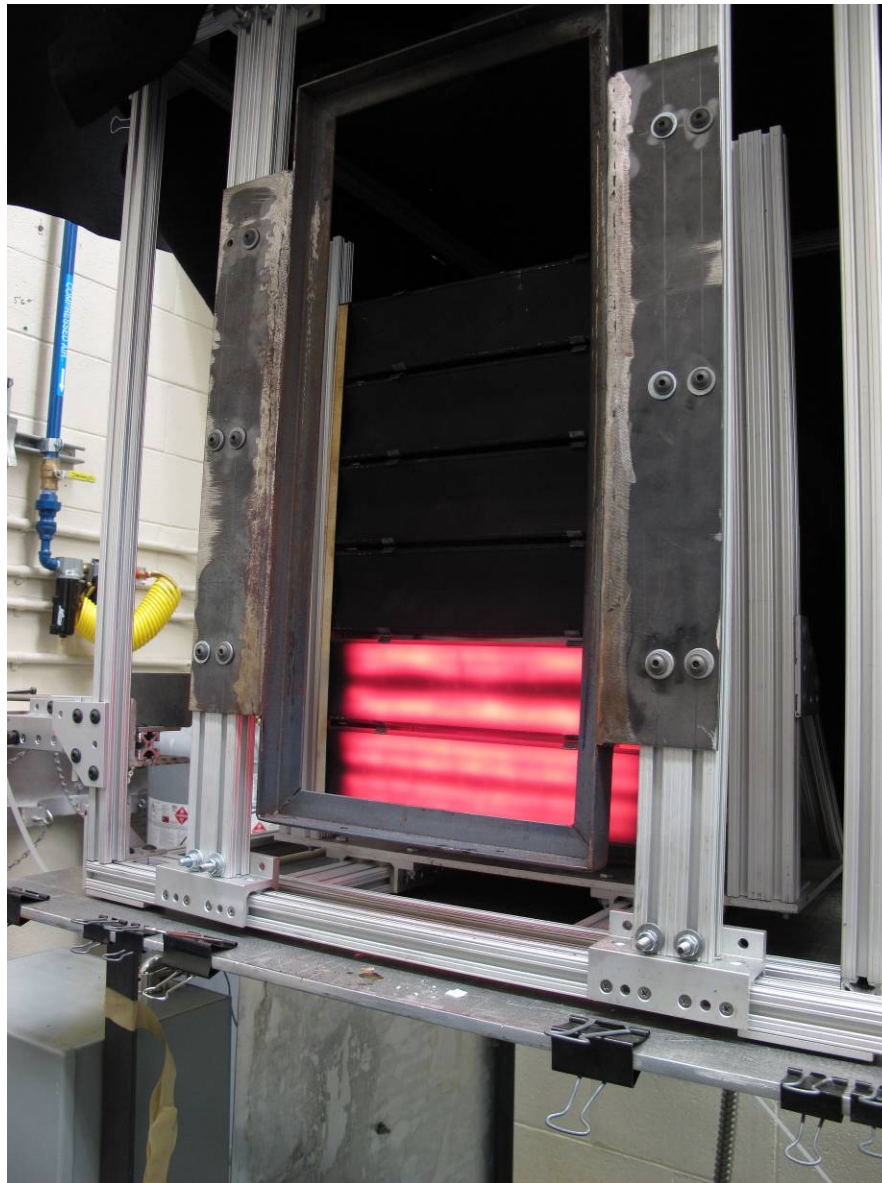


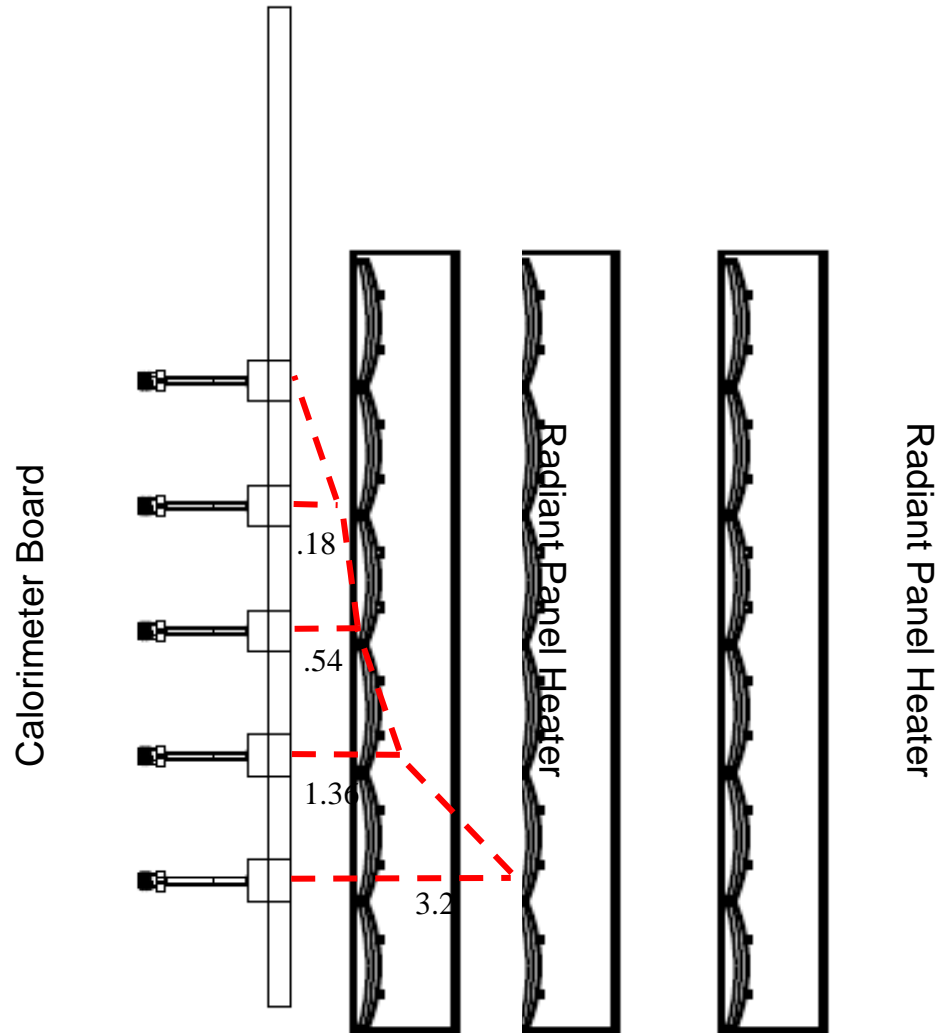
Current Configuration



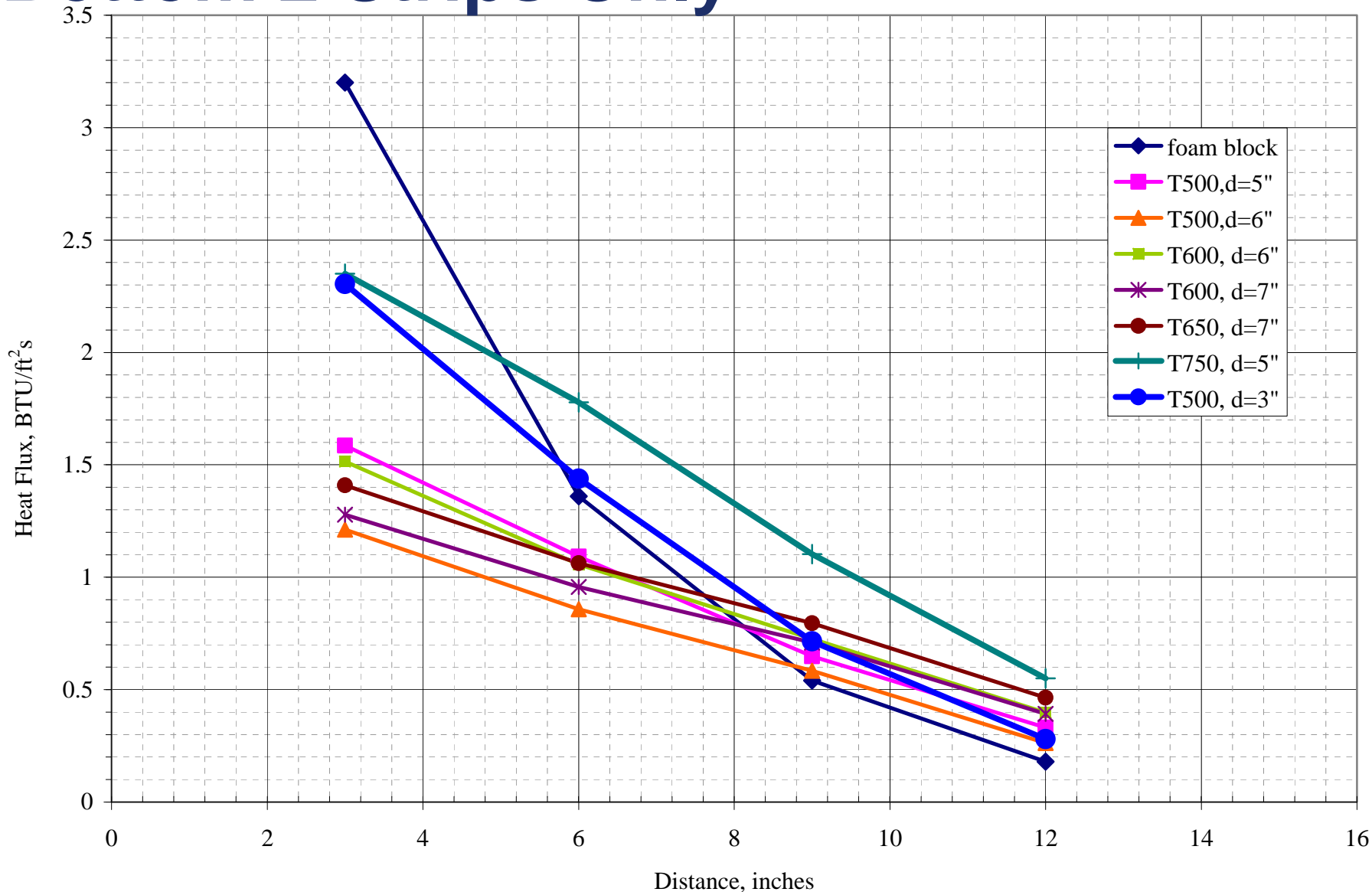
New Configuration







Bottom 2 Strips Only





Part 2 - Summary

- **The VRP was constructed to simulate the foam block heat flux gradient on a test sample from the intermediate scale composites test rig**
- **A similar heat flux gradient was achieved by separating the radiant heater into 3 zones and using only the bottom 2 strips**
- **The configuration tested indicates that the VRP can show flame propagation similar to the intermediate scale test rig**
- **More testing needs to be performed with other materials from the database**
 - Aerospace/non-aerospace grade composites (1/8" thick)
 - Cargo liners and floor panels, varying thicknesses
 - Aerospace grade carbon epoxy, varying thicknesses
 - Perhaps reduce sample size to 6" x 12"