Development of a Laboratory Scale Flame Propagation Test Method for Structural Composites

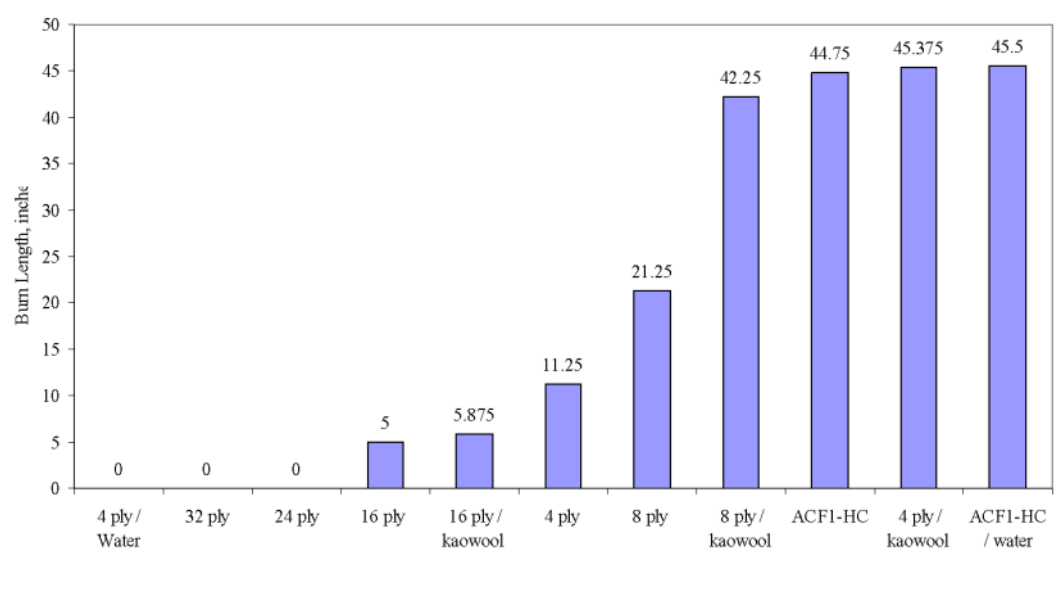
Federal Aviation Administration



Presented to: IAMFTWG, Toulouse, France
By: Robert I. Ochs
Date: June 20-21

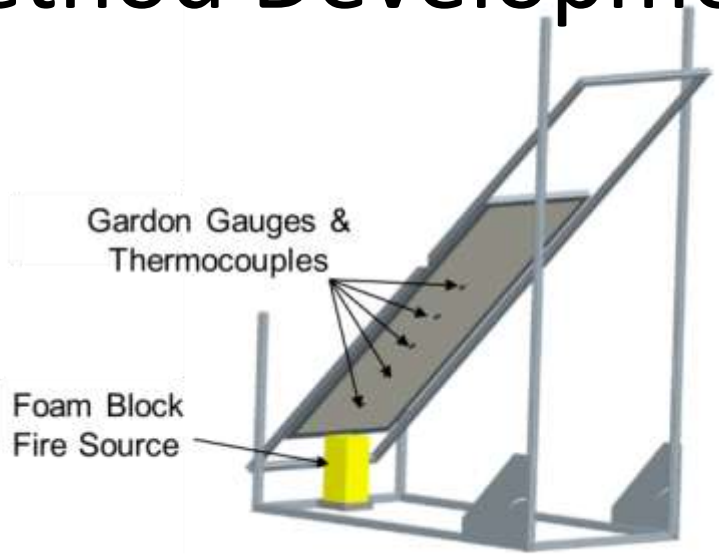
Review from Singapore

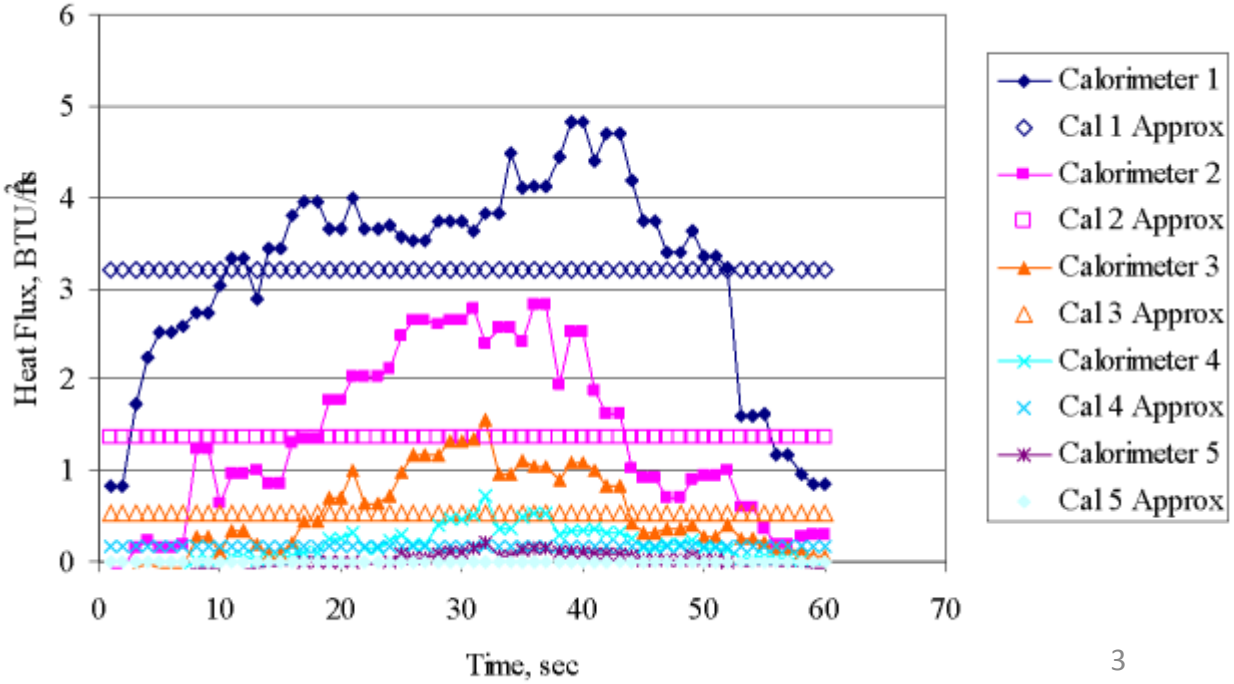
- Intermediate scale tests were performed on aerospace grade structural composite material of varying thickness
  - 4, 8, 16, 24, 32 plies and a honeycomb sandwich panel
  - Various configurations were tested
    - Exposed backside
    - Insulated backside
    - Water-cooled backside
  - Backside heat loss found to have a significant effect on inboard-side burning



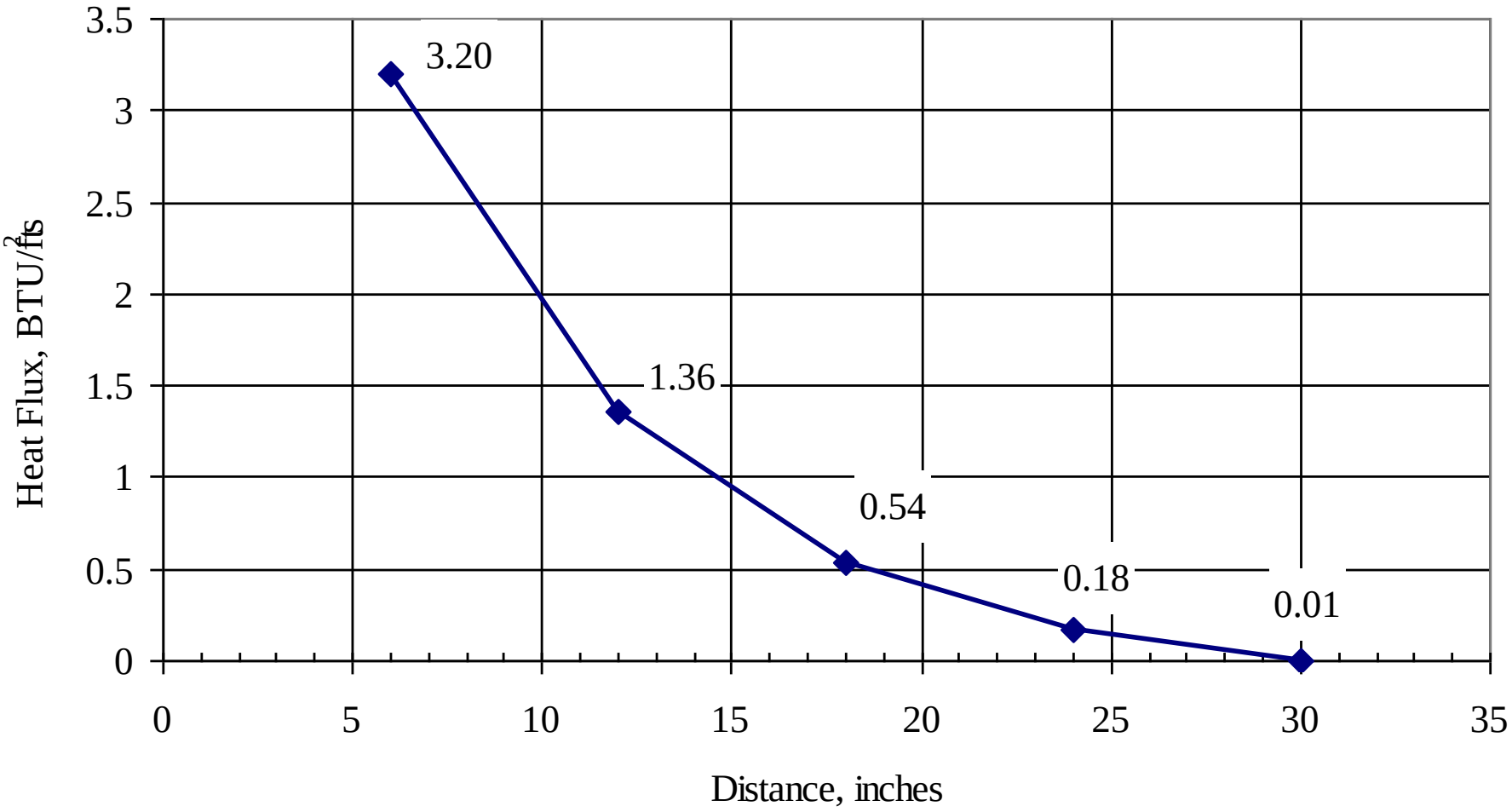
Lab-Scale Test Method Development

- The foam block fire source was characterized by measuring the heat flux gradient along an insulated board for the duration of the foam burning event
- This heat flux gradient will then be used to impose a similar heat flux on a smaller sample in a lab-scale test apparatus



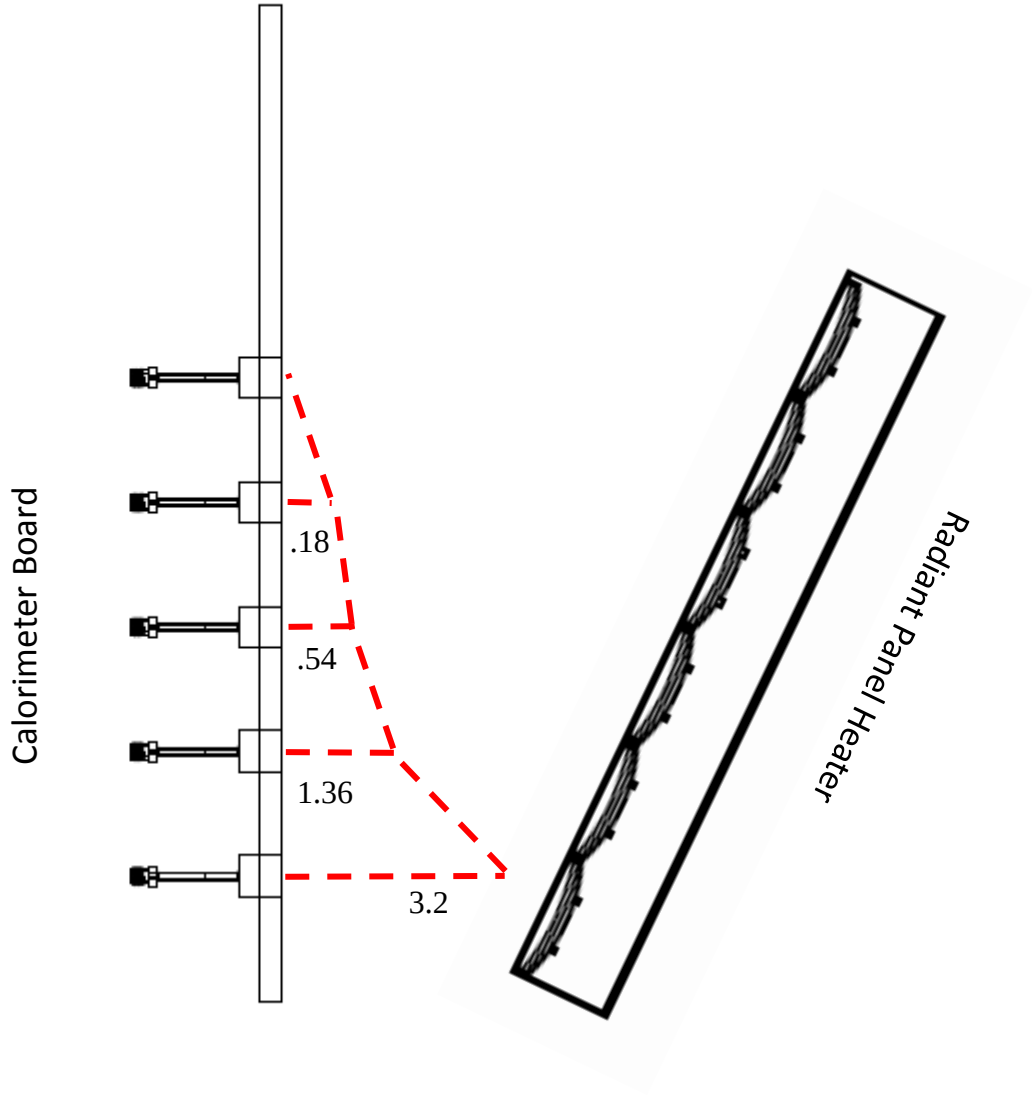


Heat Flux Gradient – Intermediate Scale



Vertical Radiant Panel (VRP) Development

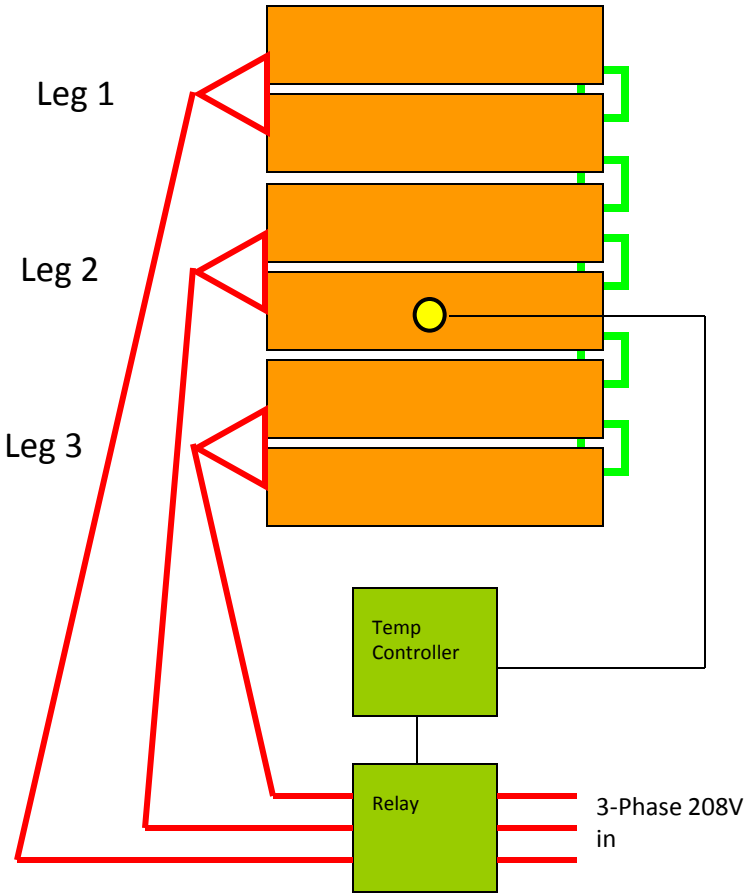
- Objective: to develop a “new” radiant panel type test that will:
  - Simulate conditions of a foam block test
    - Incident heat flux on sample
    - Duration
    - Geometry
  - Correlate results from foam block test
    - Use current database of materials already tested
      - Aerospace/non-aerospace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


Calorimeter Board
.18
.54
1.36
3.2
Radiant Panel Heater

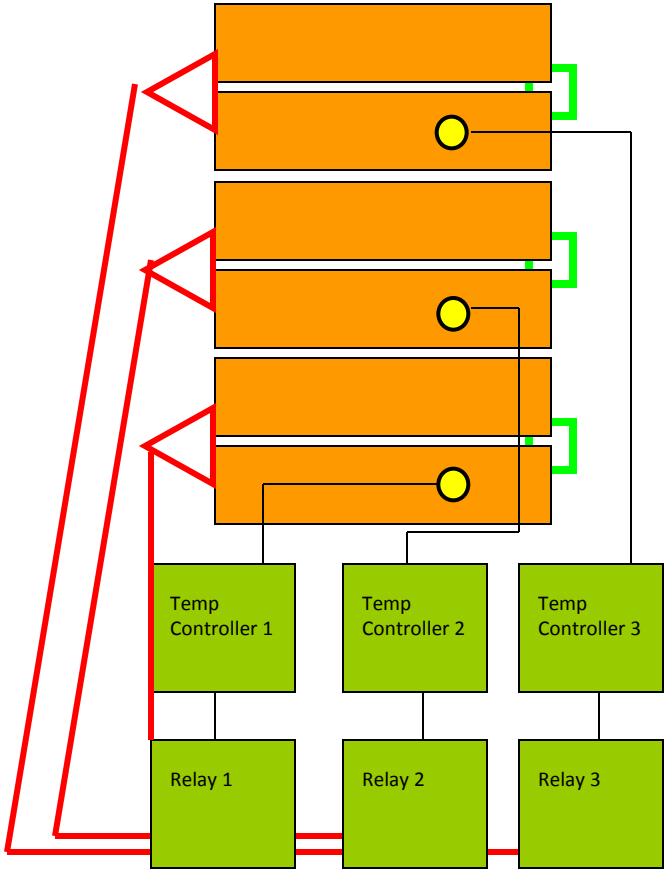
VRP Configuration

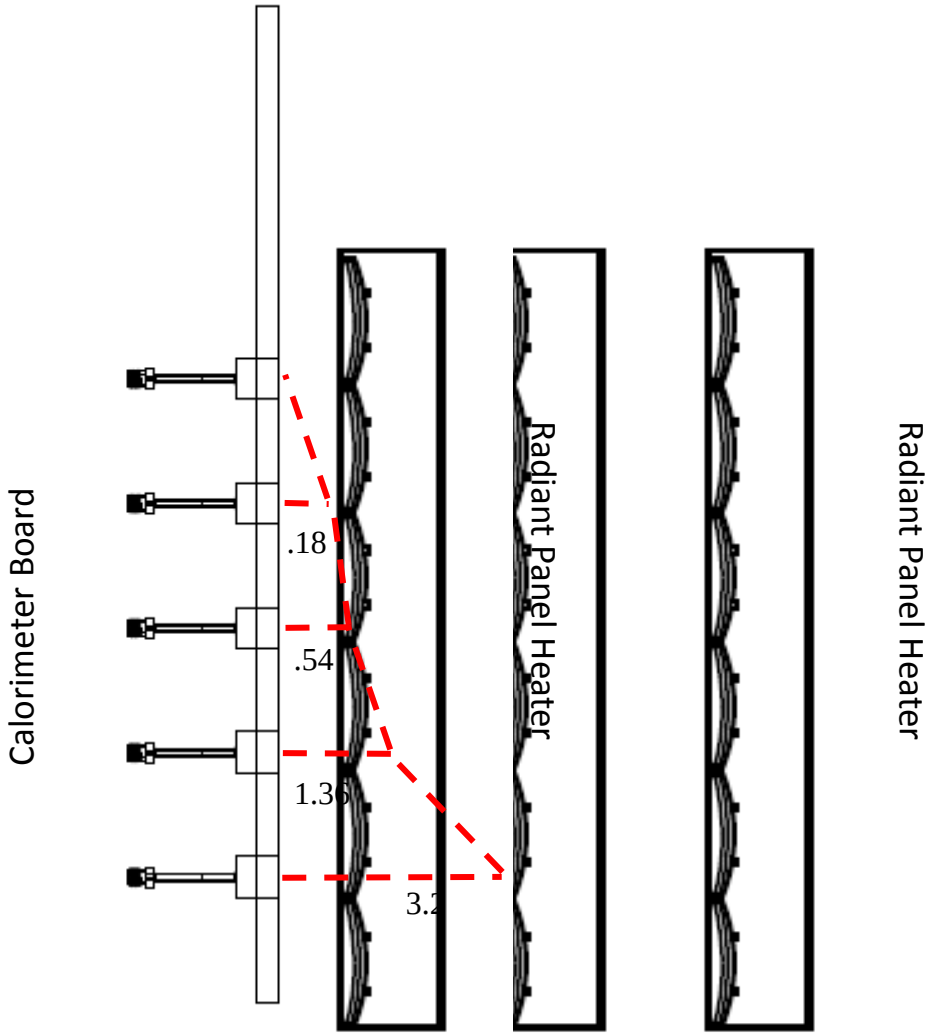
- Heat flux gradient
  - A tilted panel was used to attempt to achieve the same measured gradient as the foam block test
  - Furthest backward tilt (70°) could not achieve steep enough gradient
  - Zero position heat flux too low
- Next attempt:
  - Separate emitter strips into 3 individually controlled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

Current Configuration

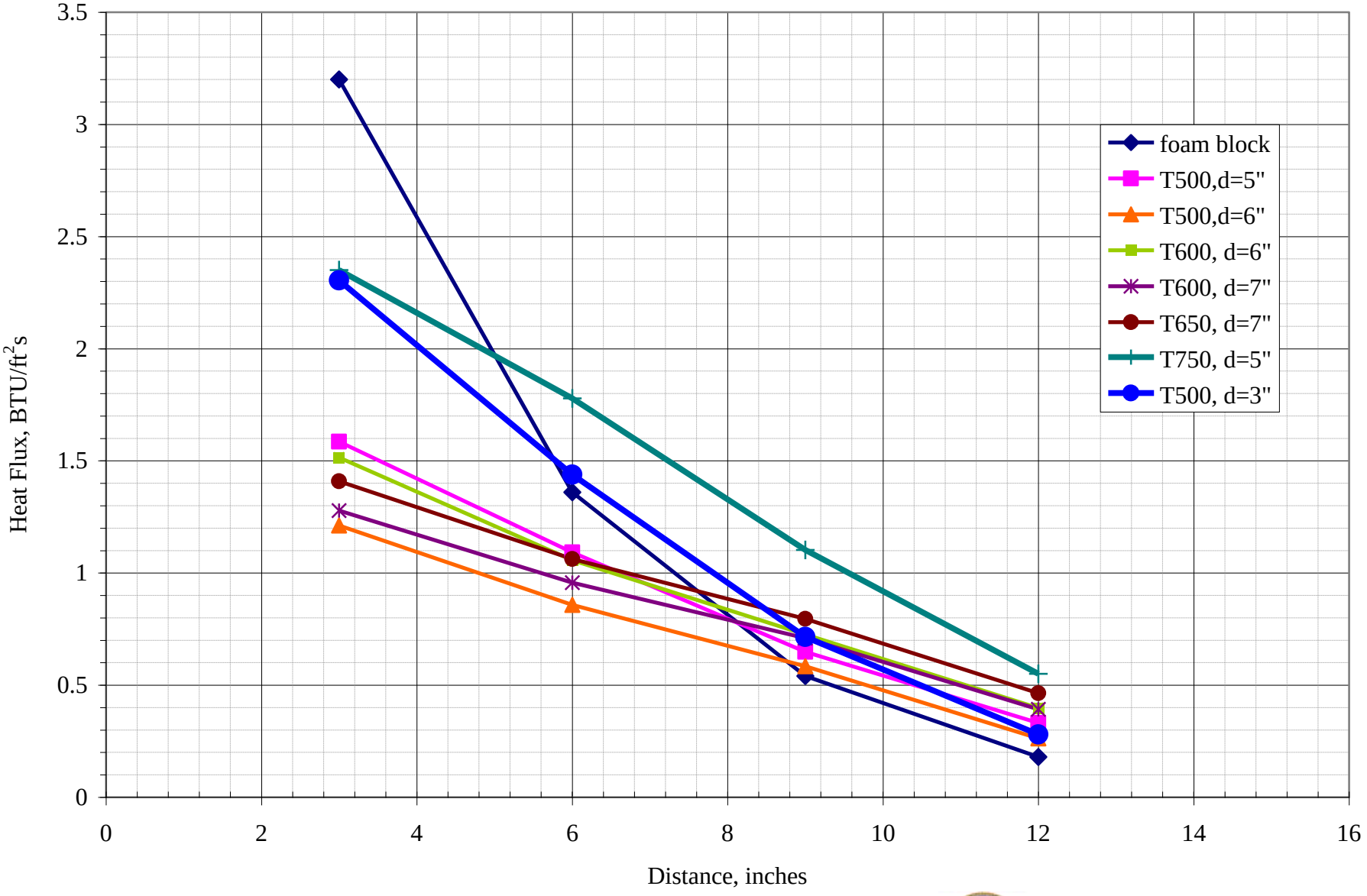


New Configuration




Calorimeter Board
.18
.54
1.36
3.2
Radiant Panel Heater
Radiant Panel Heater

Bottom 2 Strips Only

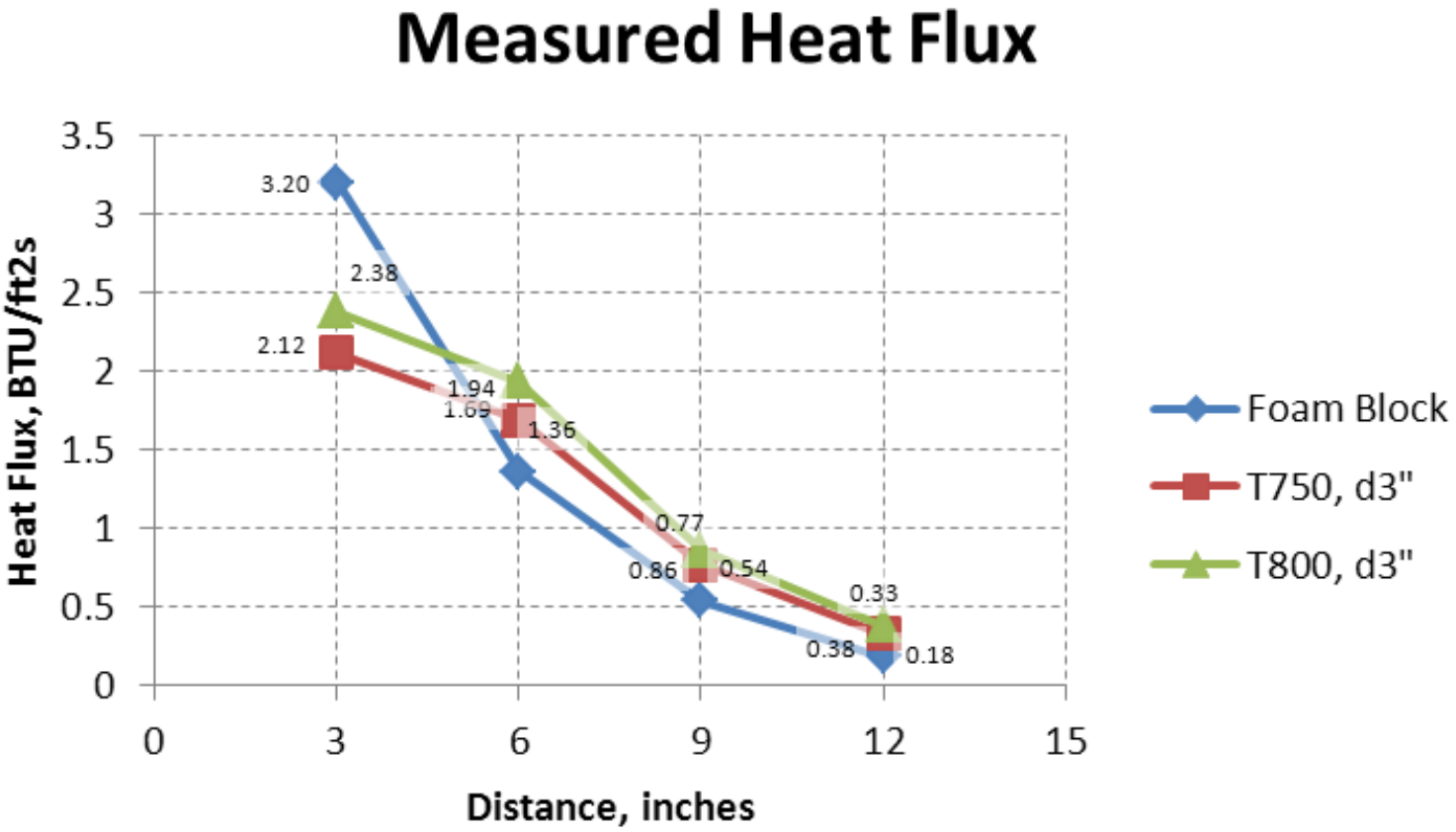


RECENT RESEARCH

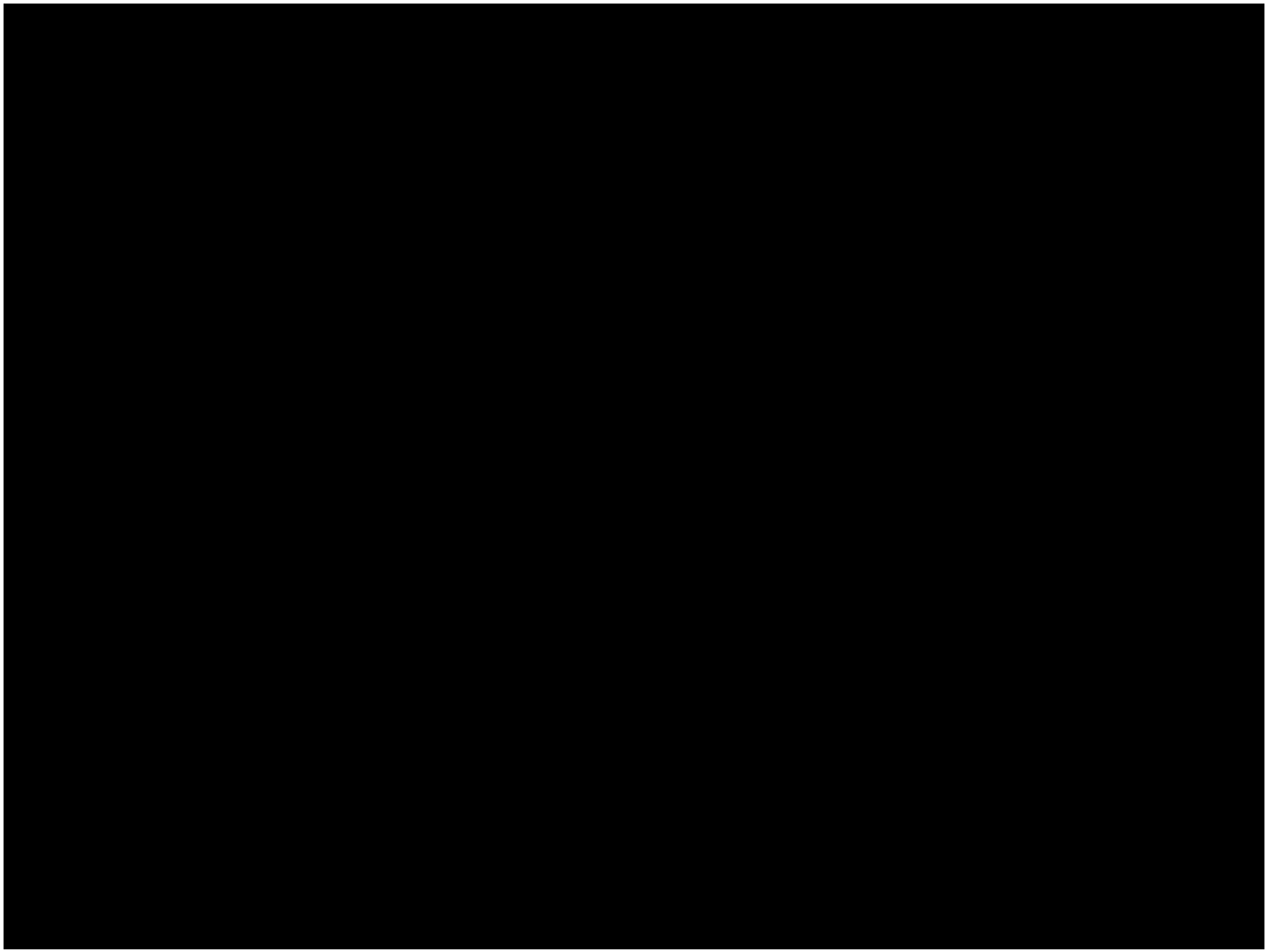
Modifications to VRP

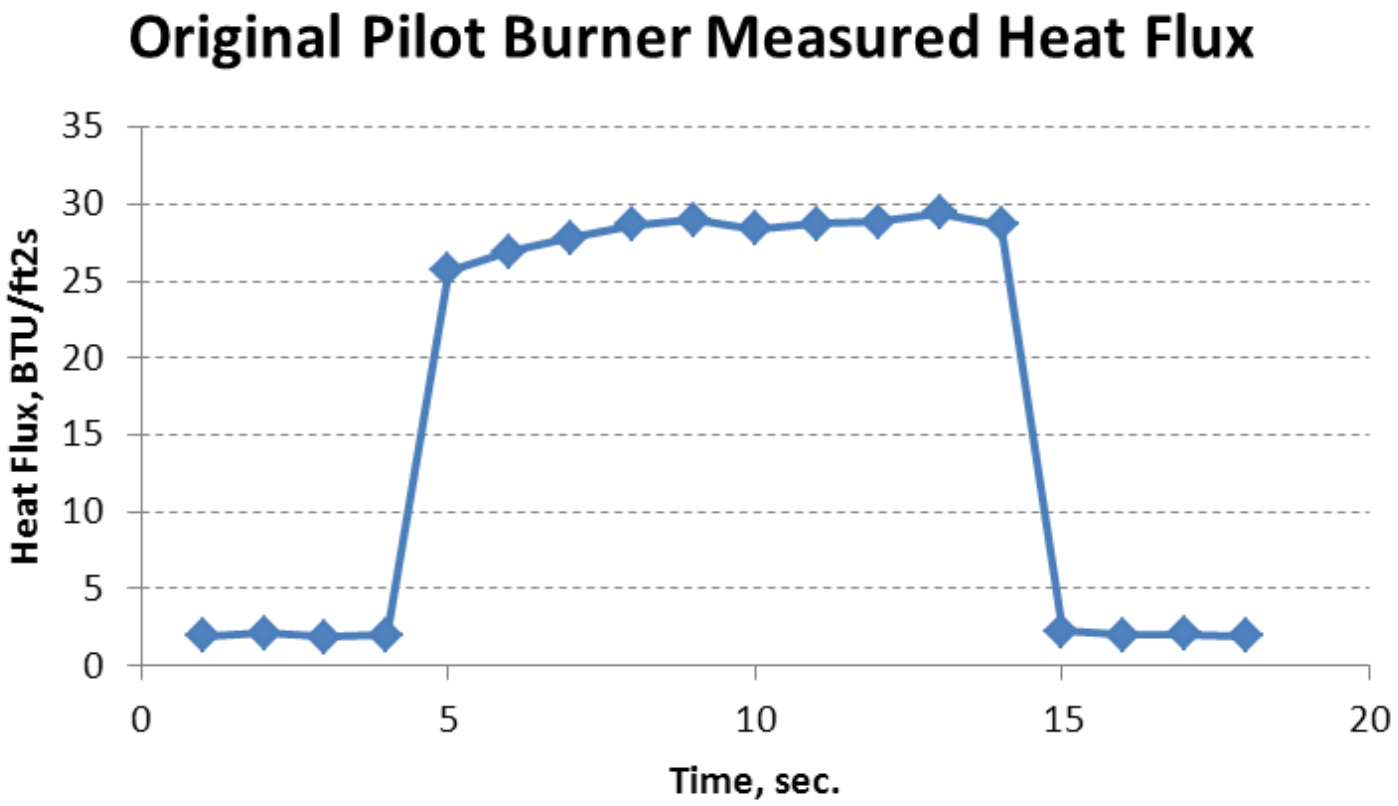
- Swivel doors added to make switching between calibration and testing quick and easy

Original Pilot Burner

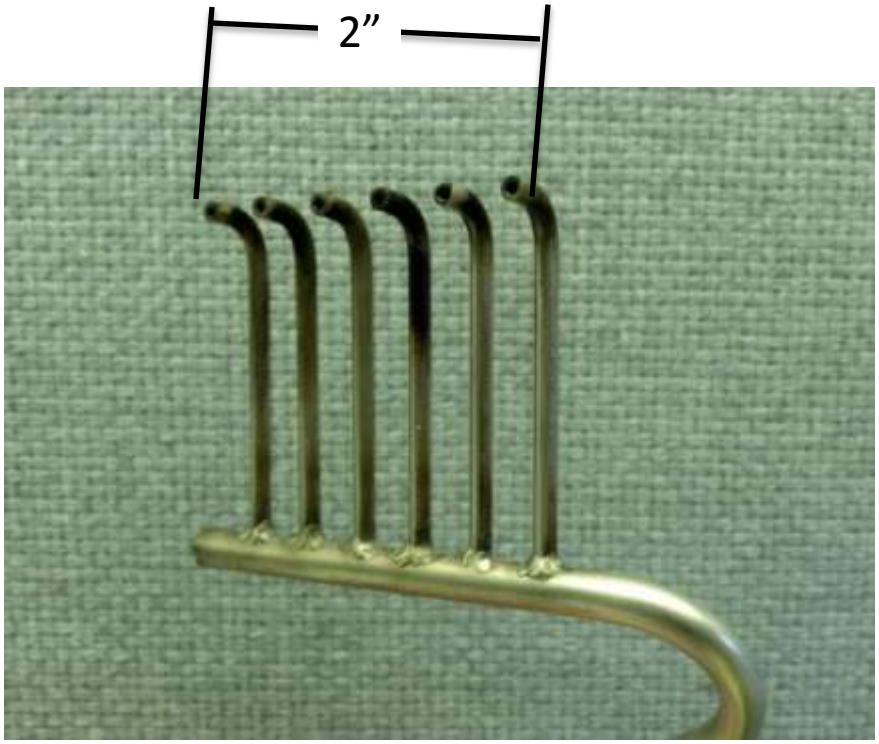


Original Radiant Panel Pilot Burner



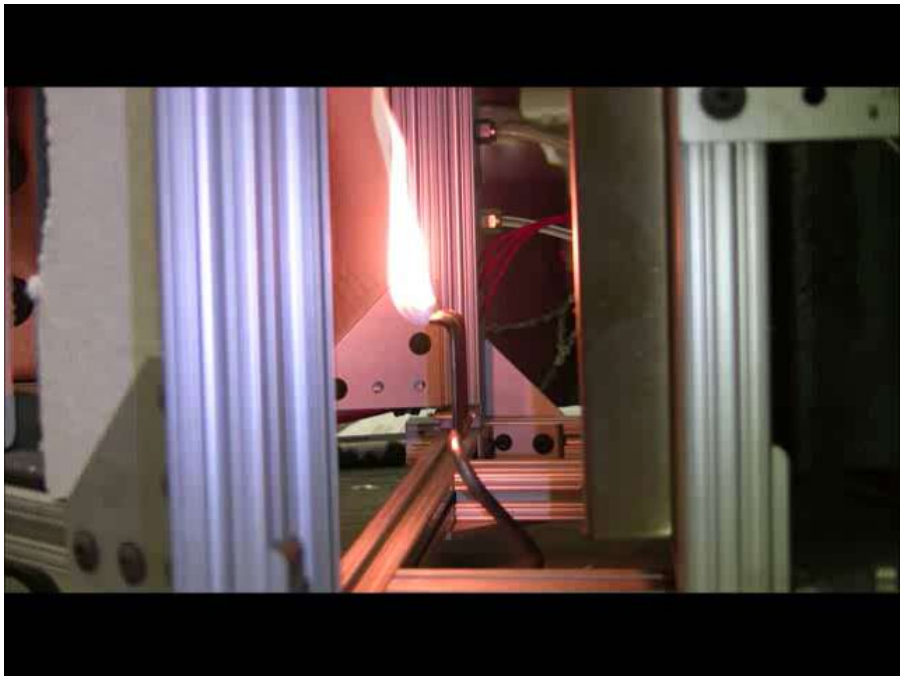

Original Pilot Burner Measured Heat Flux
Heat Flux, BTU/ft2s
35
30
25
20
15
10
5
0
0
5
10
15
20
Time, sec.

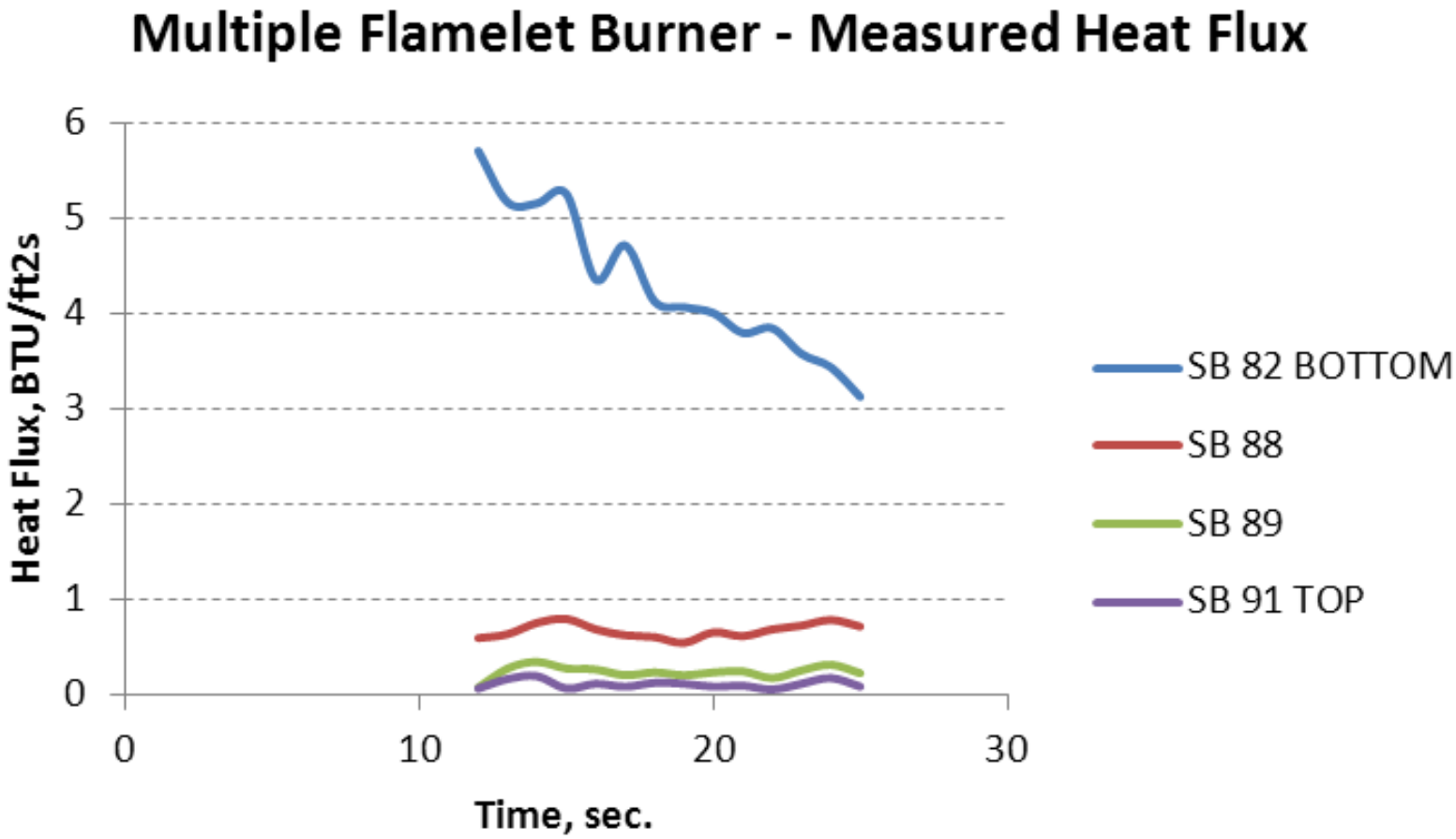
Unidirectional NBS Chamber Pilot Burner

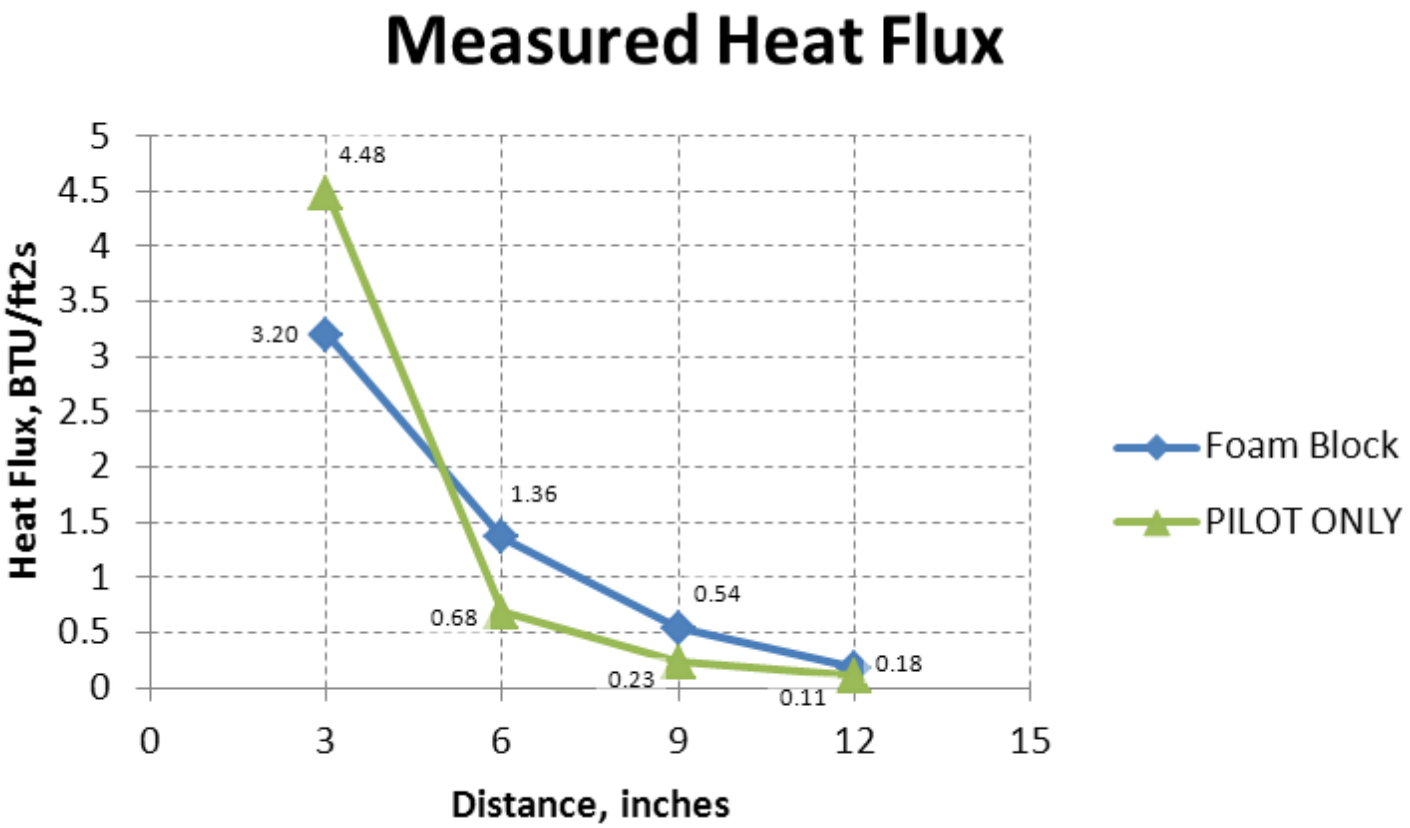


Foam Block

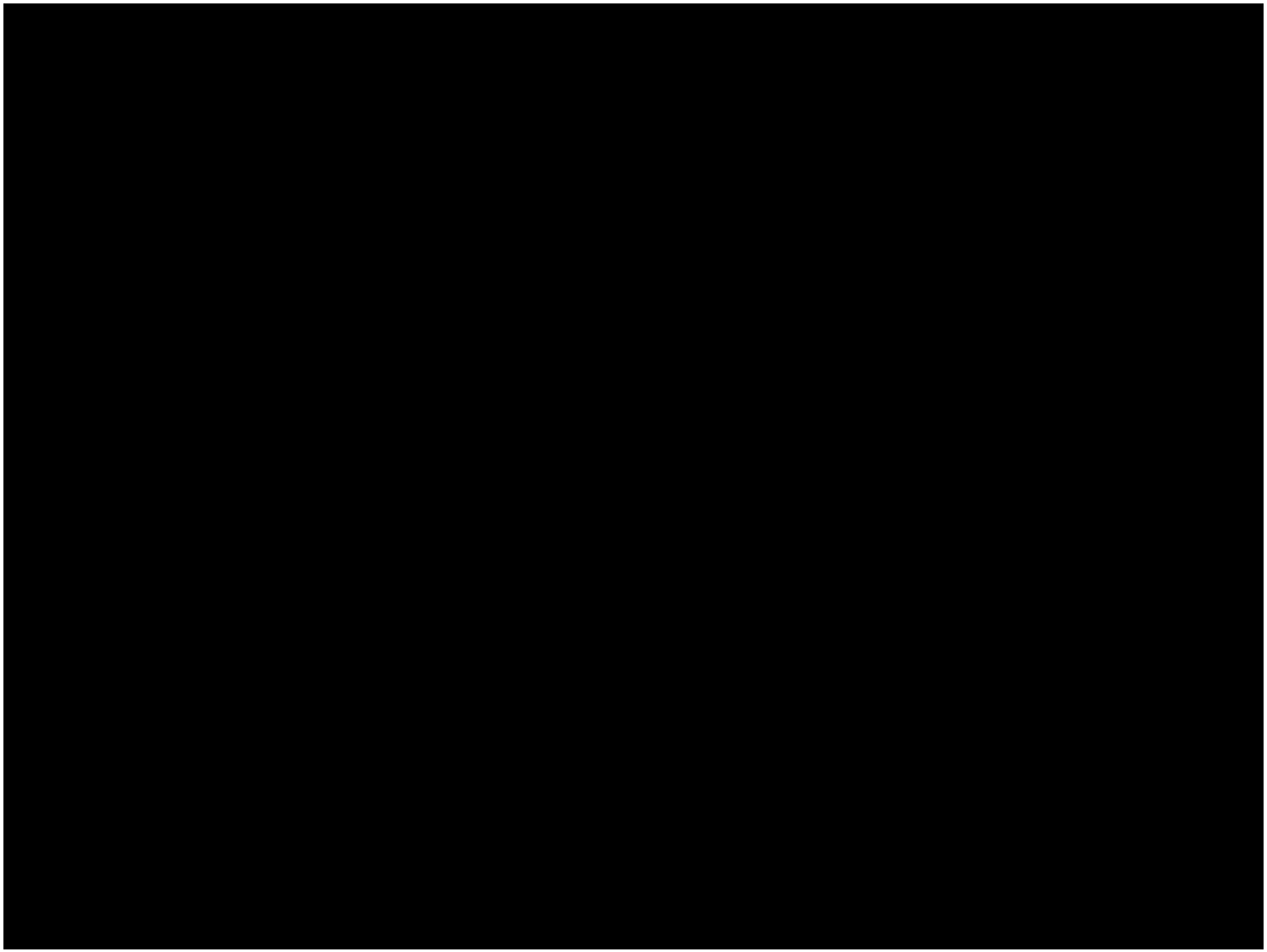
Multiple Flamelet Burner




Multiple Flamelet Burner - Measured Heat Flux
Heat Flux, BTU/ft2s
6
5
4
3
2
1
0
0
10
20
30
Time, sec.
SB 82 BOTTOM
SB 88
SB 89
SB 91 TOP


Measured Heat Flux
Heat Flux, BTU/ft2s
Distance, inches
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
3
6
9
12
15
4.48
3.20
1.36
0.68
0.54
0.23
0.18
0.11
Foam Block
PILOT ONLY

16 ply ACF1



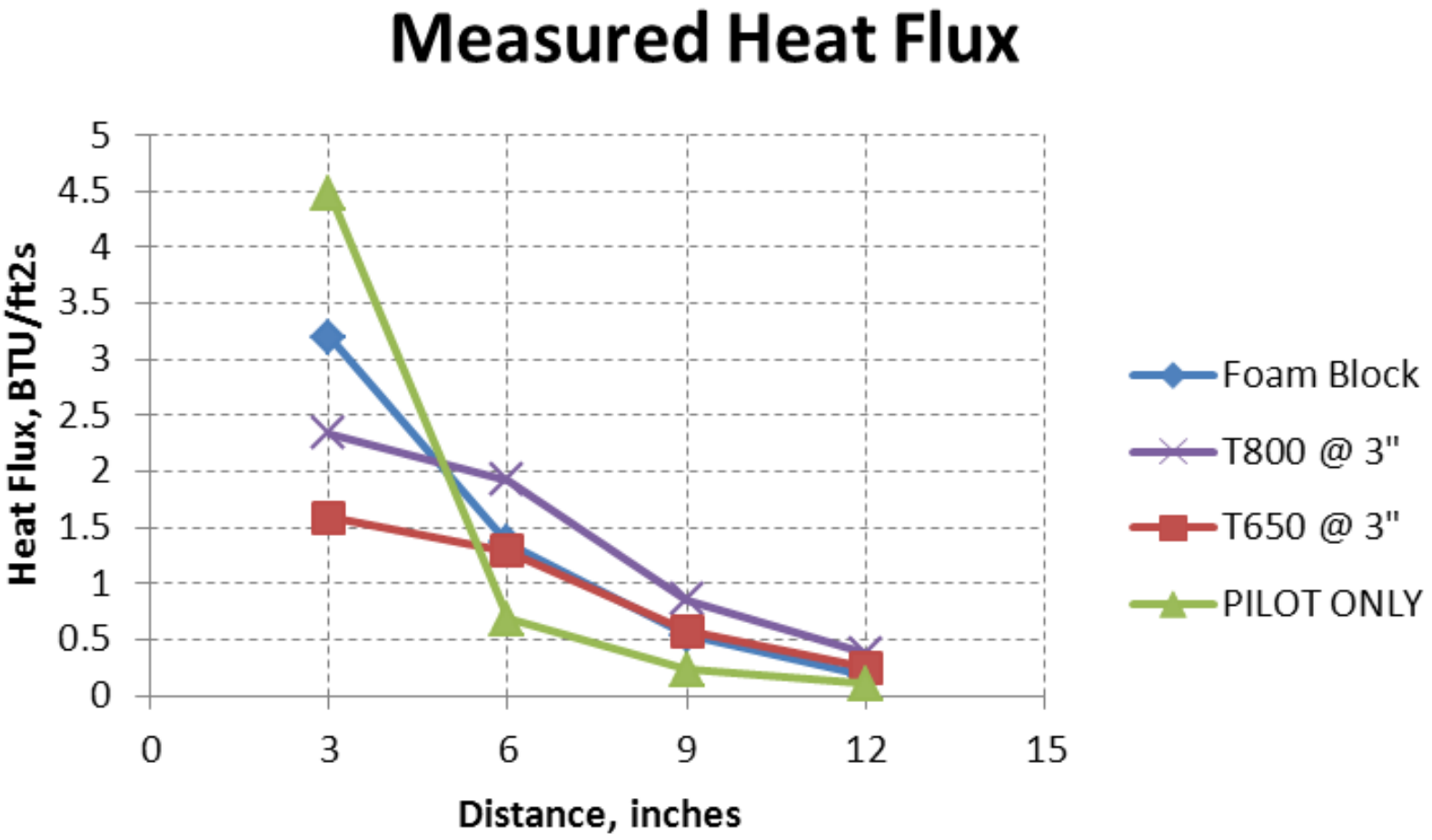
Observations

- 16 ply ACF1 performed very well in all foam block tests with minimal evidence of burning
- Pilot flame gas flow rate for this test produced a tall flame with a large footprint
- Reduce flow rate and re-test

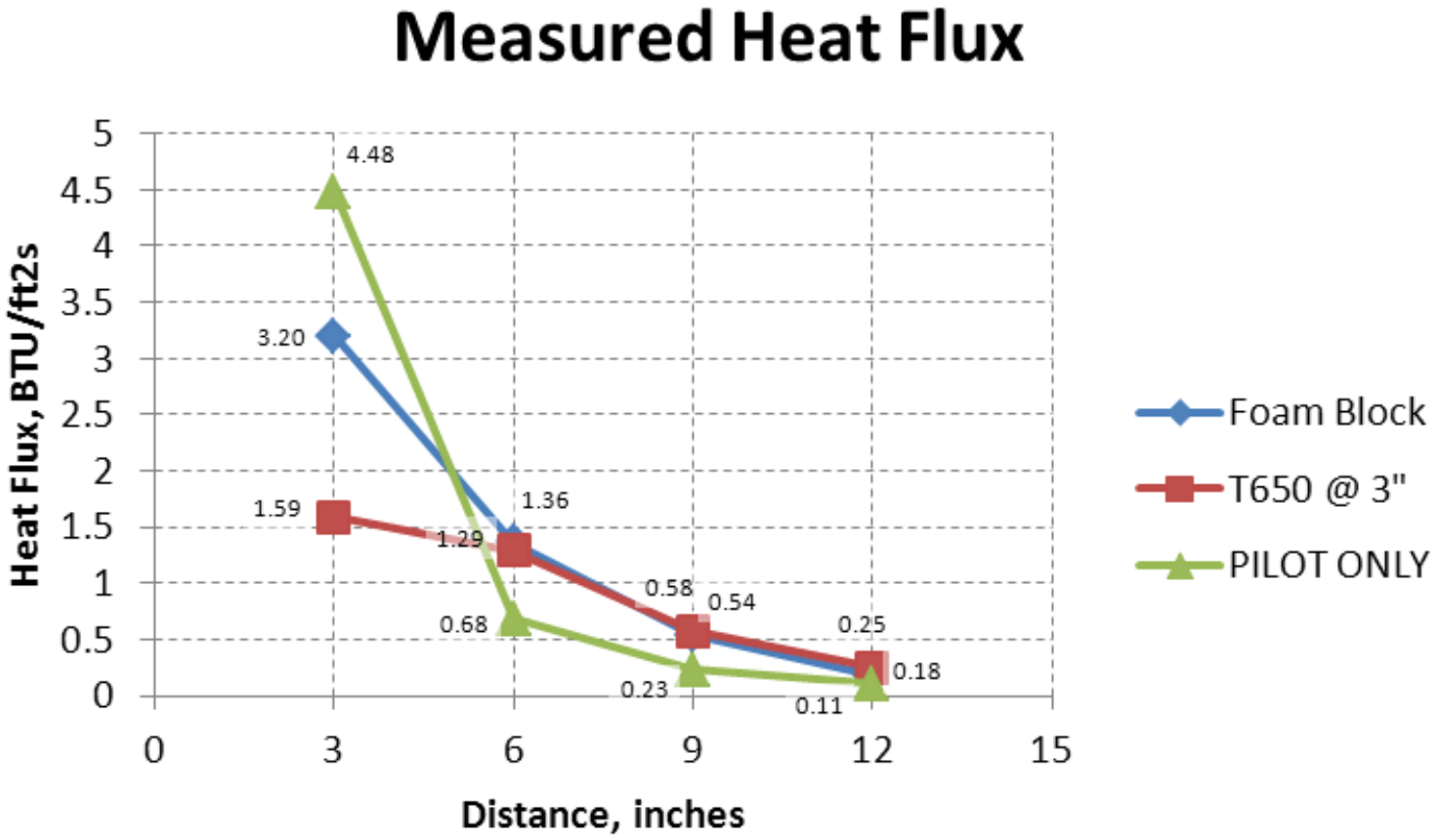
16 ply ACF1 – smaller flame

Observations

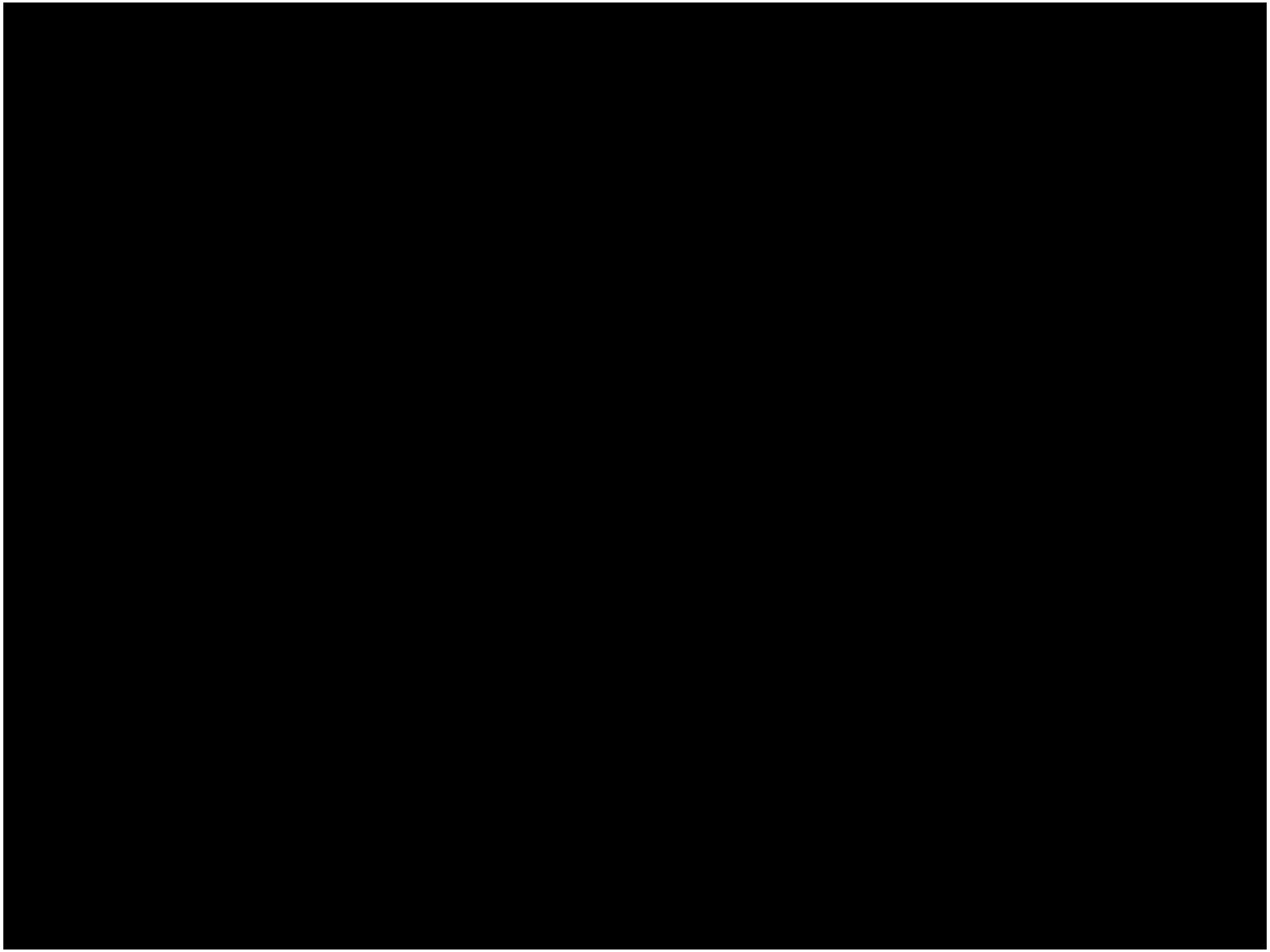
- Reducing the gas flow rate resulted in a much smaller flame with smaller footprint, making it easier to observe flame propagation from the ignition point
- Under these test conditions, 16 ply ACF1 still burned more than the foam block tests indicated
- Panel heat flux should be changed to get closer to measured foam block heat flux


Measured Heat Flux
Heat Flux, BTU/ft2s
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
3
6
9
12
15
Distance, inches
Foam Block
T800 @ 3"
T650 @ 3"
PILOT ONLY

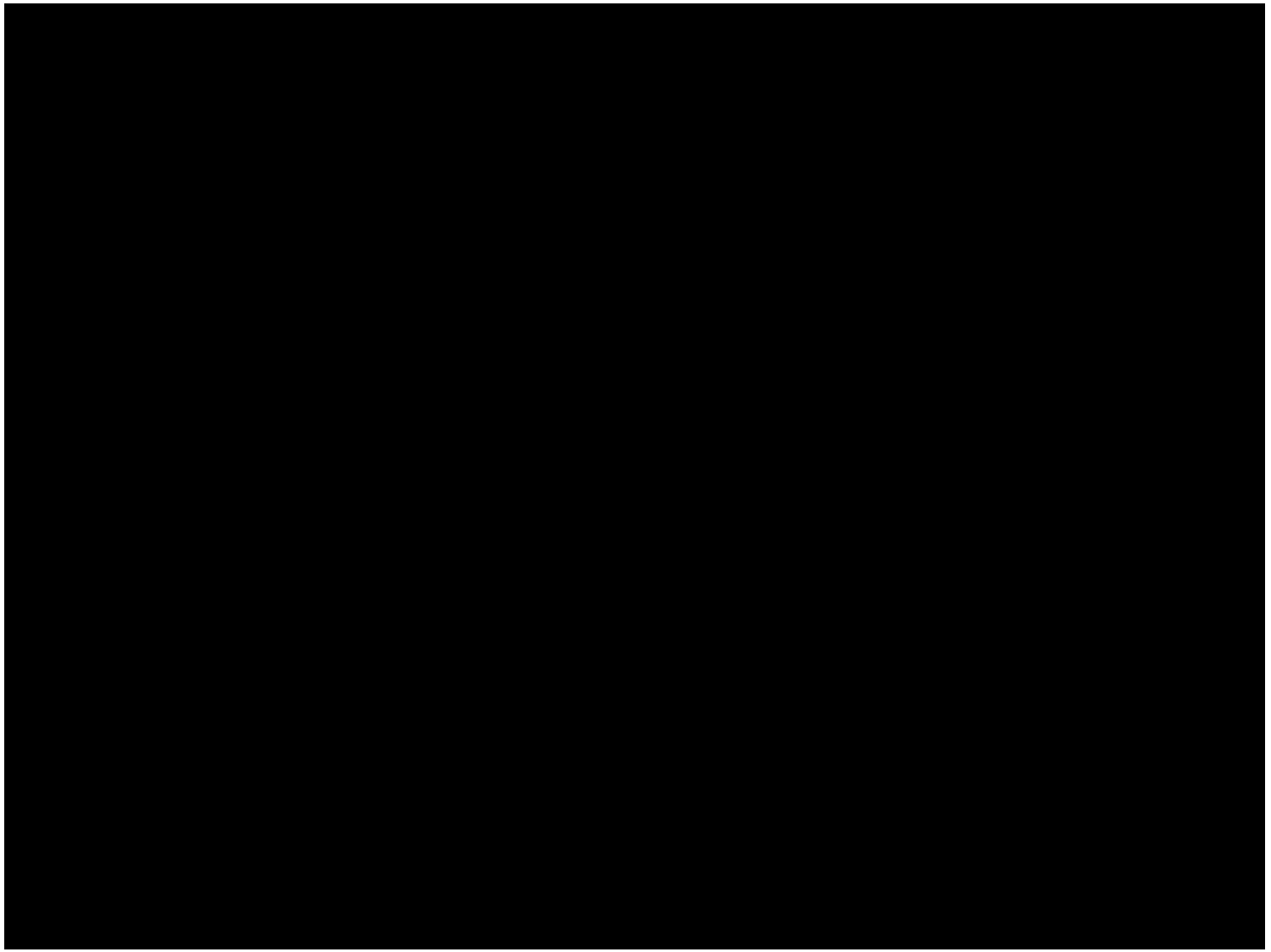
Multiple Flamelet Burner

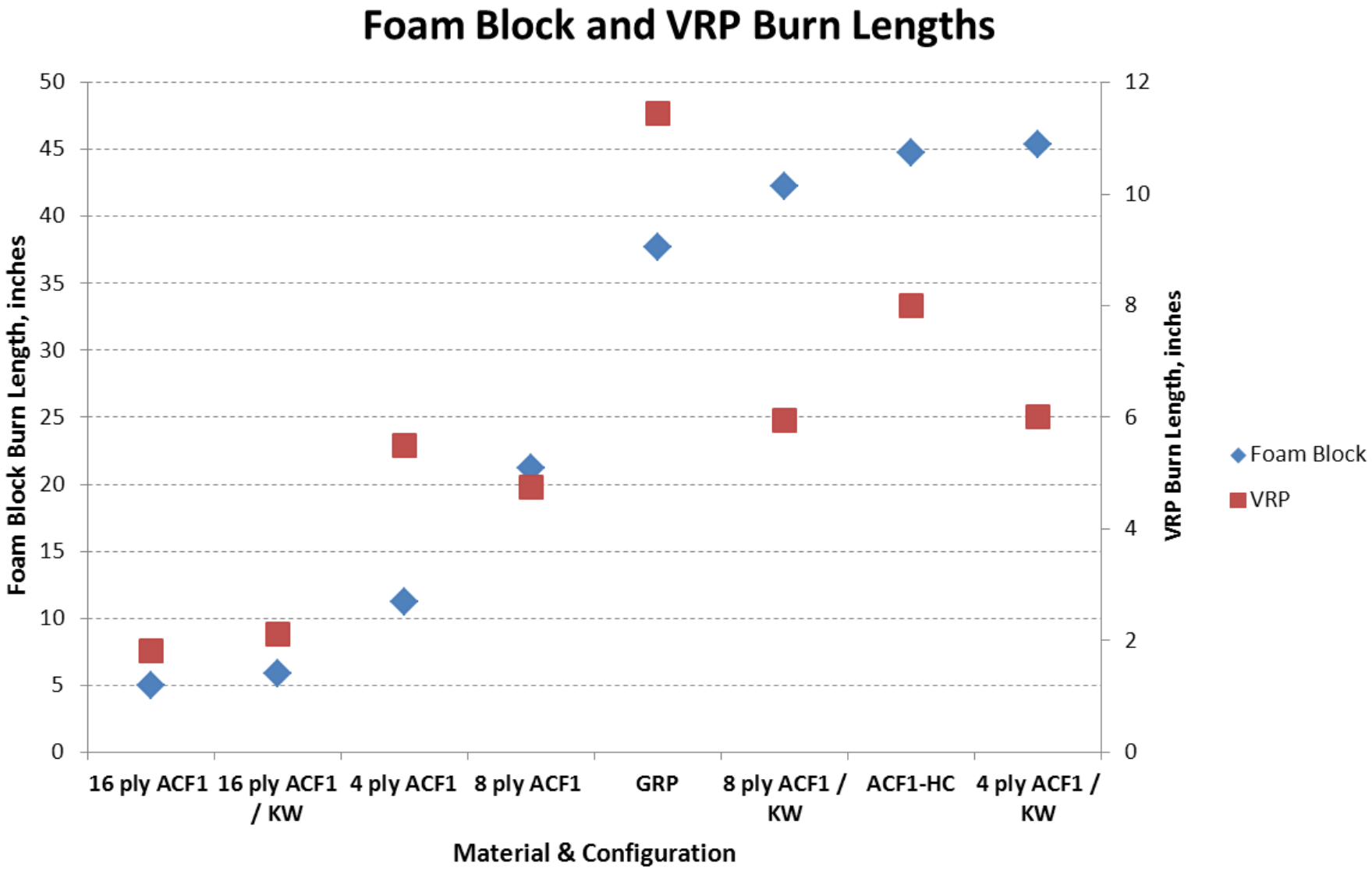


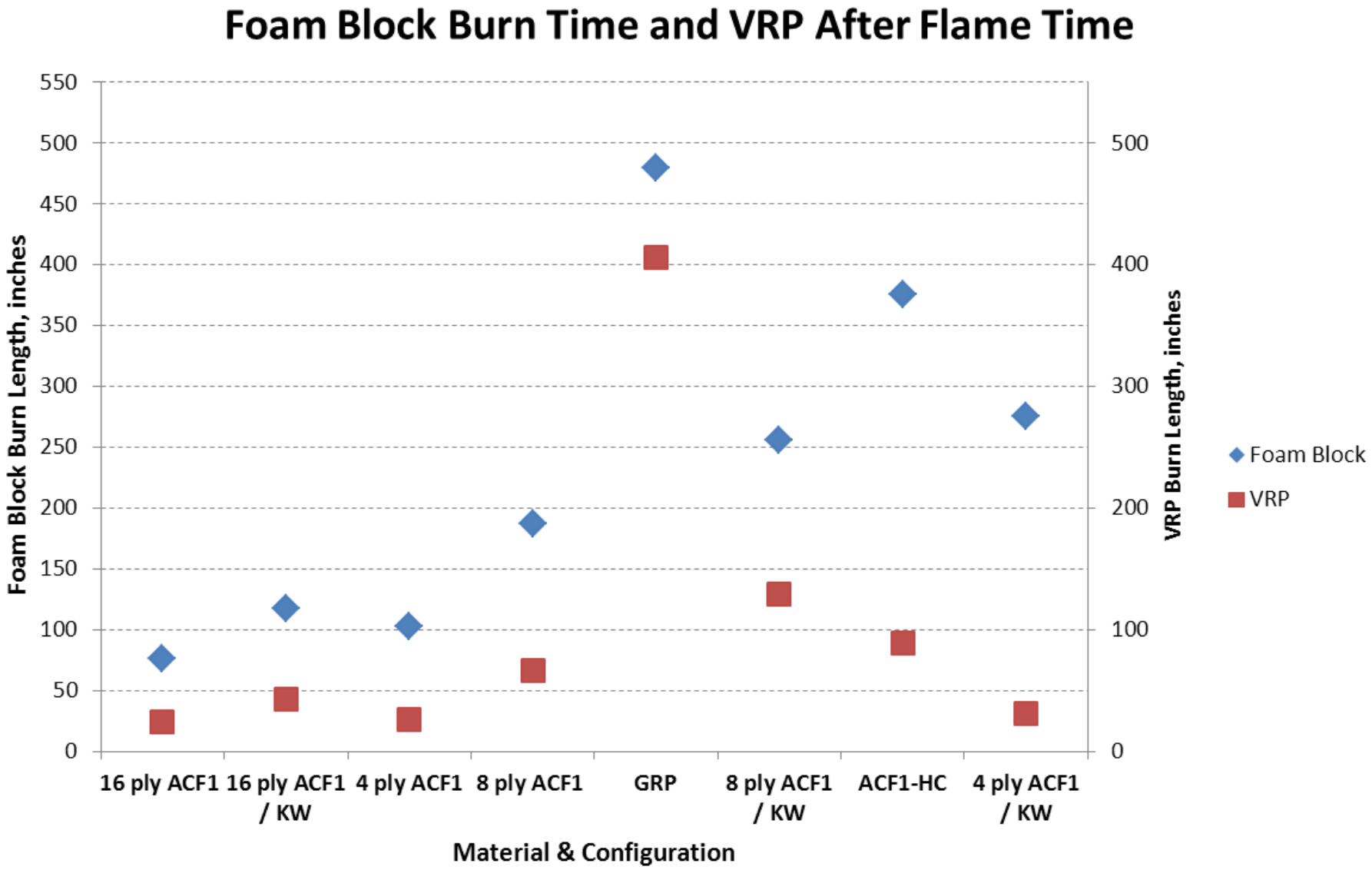
16 ply ACF1 – smaller flame, lower heat flux



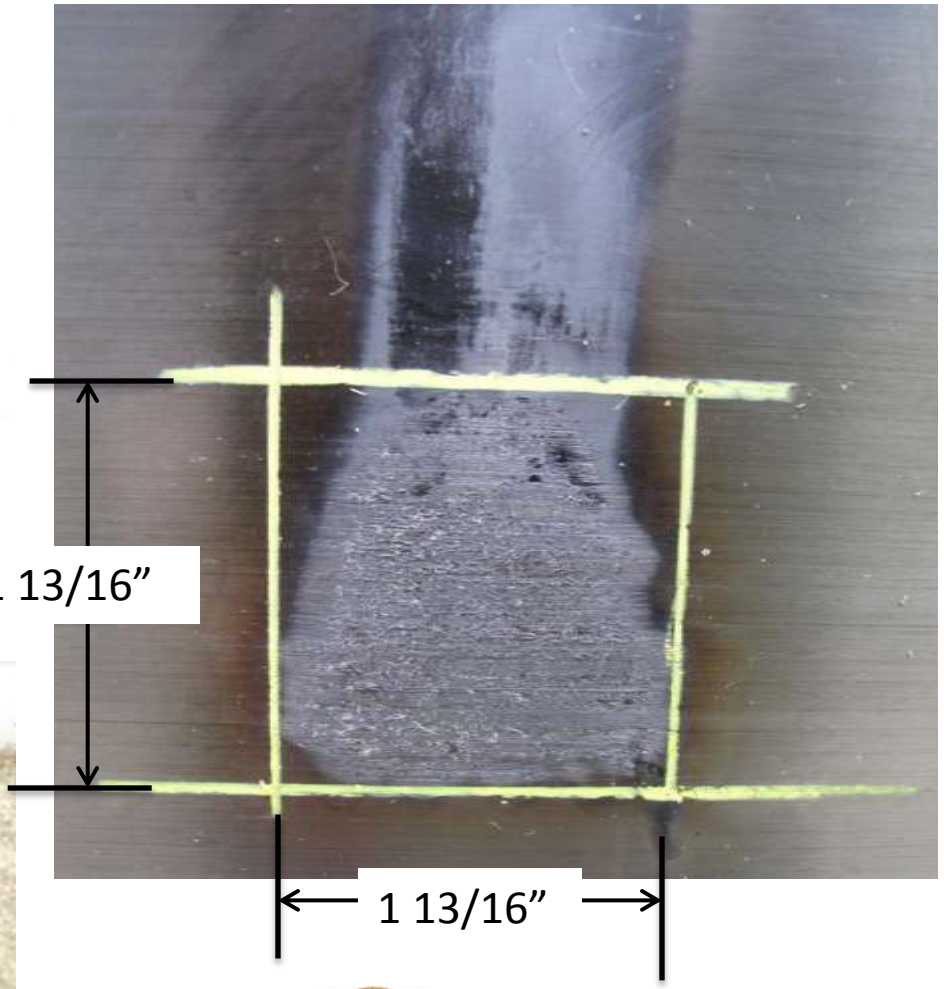
ACF1-HC




Foam Block and VRP Burn Lengths
Foam Block Burn Length, inches
VRP Burn Length, inches
0
5
10
15
20
25
30
35
40
45
50
0
2
4
6
8
10
12
16 ply ACF1
16 ply ACF1 / KW
4 ply ACF1
8 ply ACF1
GRP
8 ply ACF1 / KW
ACF1-HC
4 ply ACF1 / KW
Material & Configuration
Foam Block
VRP

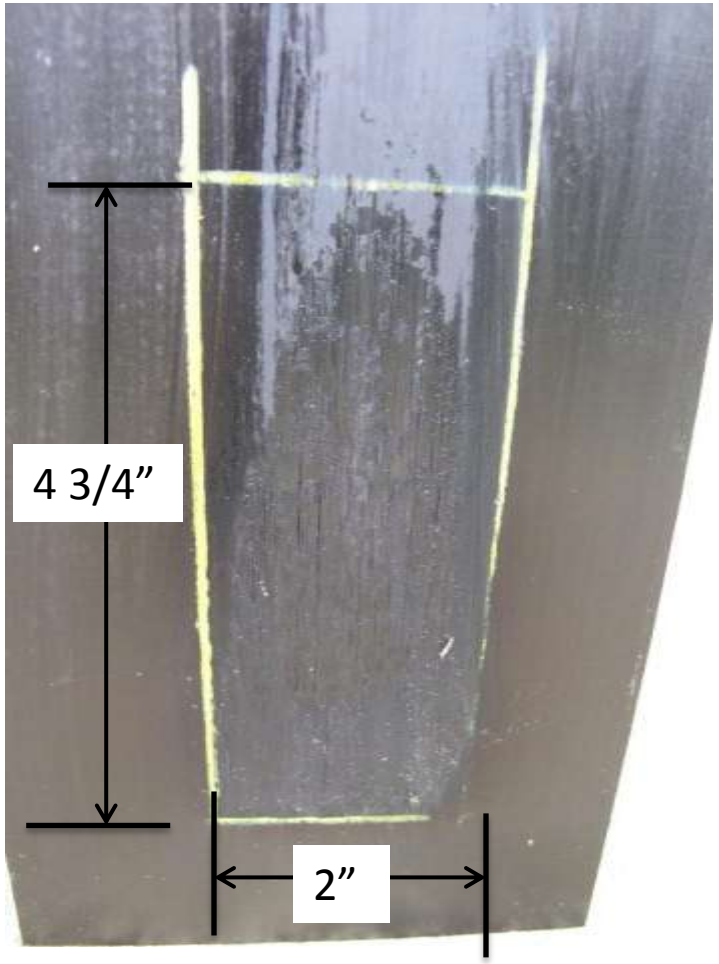

Foam Block Burn Time and VRP After Flame Time
Foam Block Burn Length, inches
VRP Burn Length, inches
550
500
450
400
350
300
250
200
150
100
50
0
500
400
300
200
100
0
16 ply ACF1
16 ply ACF1 / KW
4 ply ACF1
8 ply ACF1
GRP
8 ply ACF1 / KW
ACF1-HC
4 ply ACF1 / KW
Material & Configuration
Foam Block
VRP

16 Ply ACF1

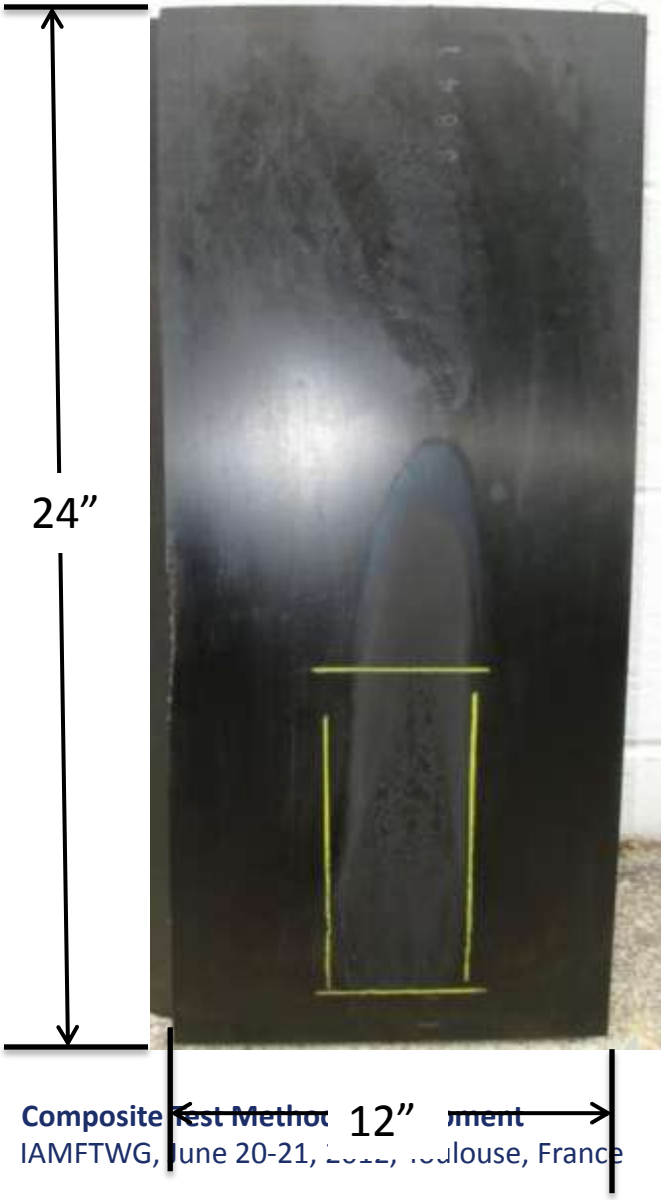


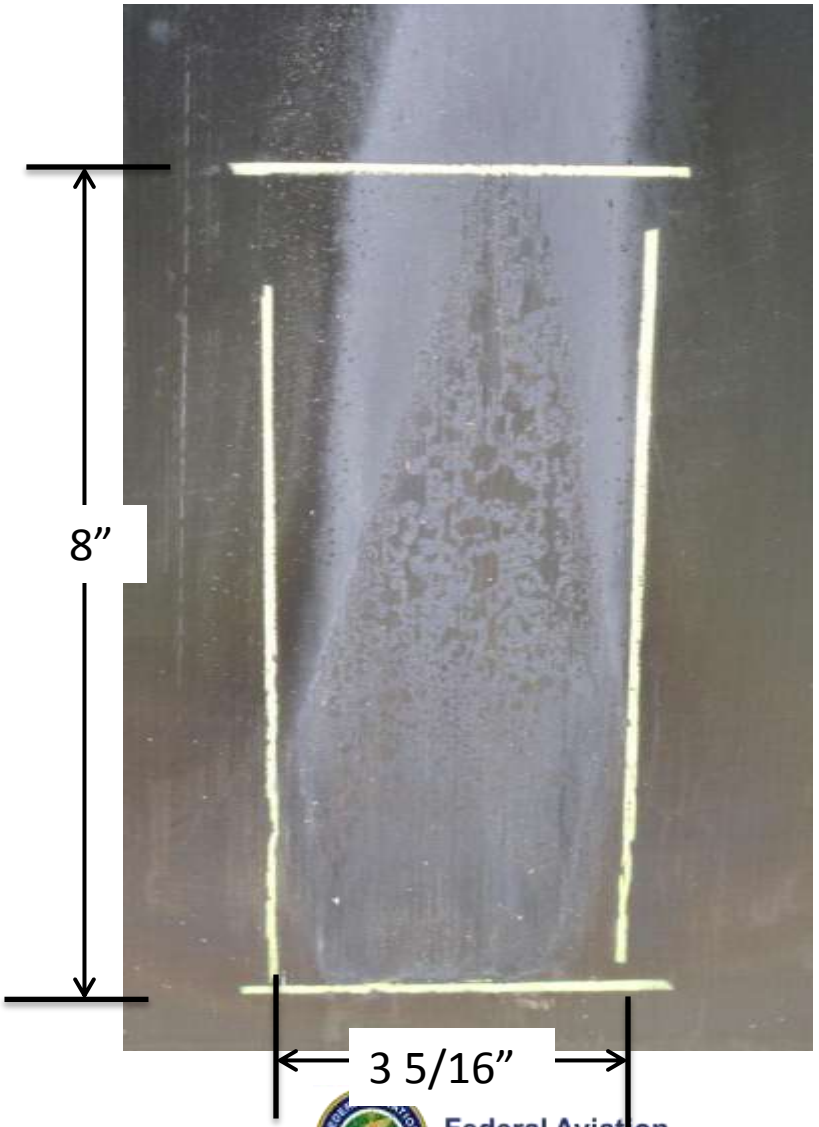
Federal Aviation Administration

8 Ply ACF1

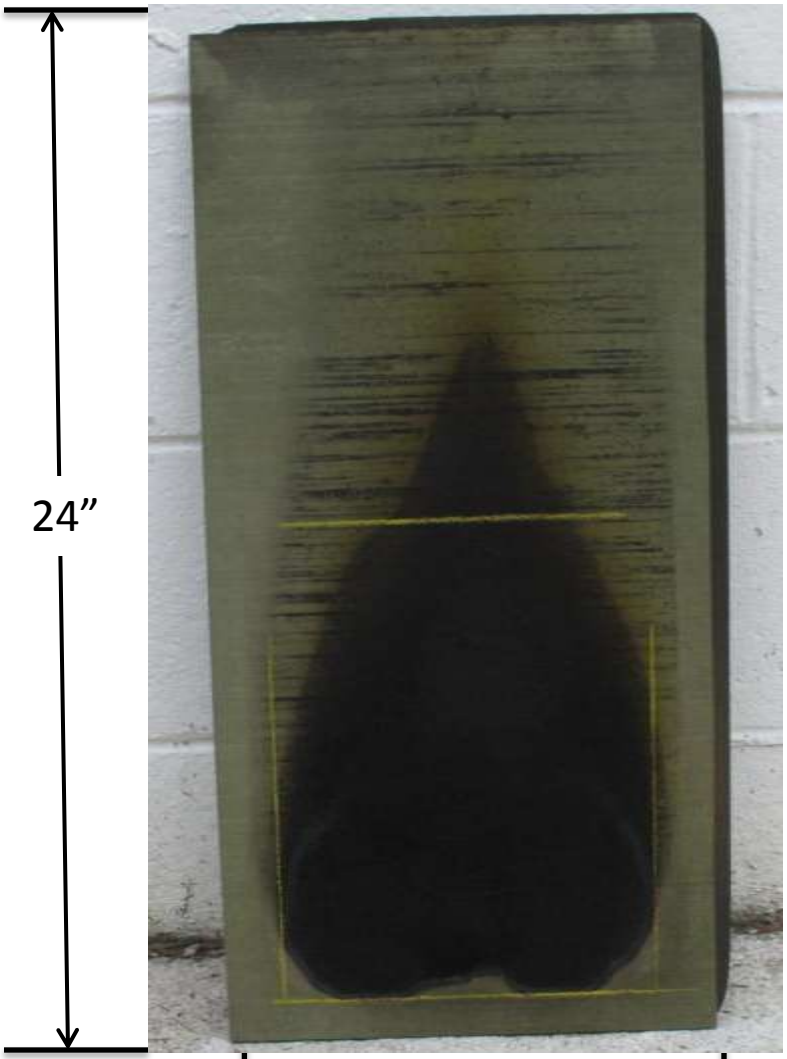


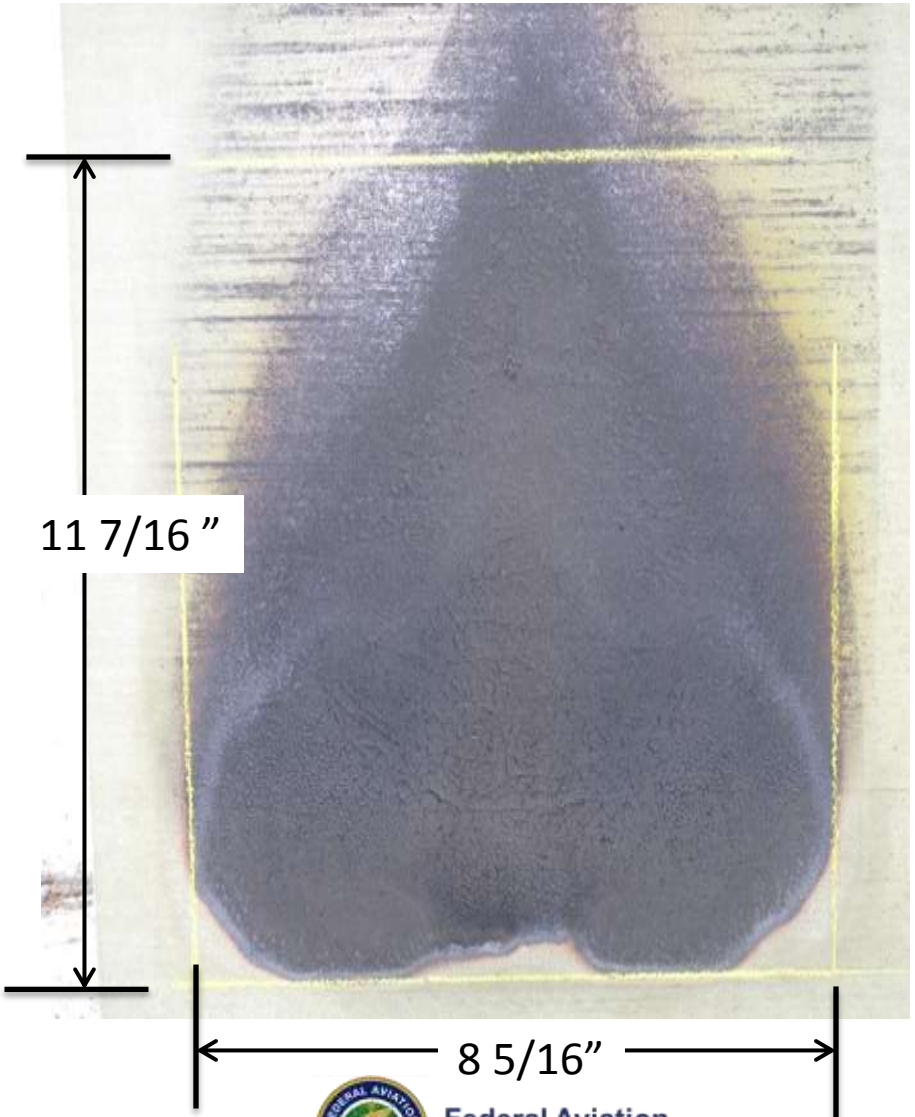
ACF1-HC





GRP





Observations

- The smaller flame and lower heat flux settings correlate reasonably well with foam block test for the materials tested
- More materials are to be tested in both foam block and VRP



Contact:
Robert I. Ochs
Fire Safety Branch
William J. Hughes Technical Center
ANG-E212; Bldg 287
Atlantic City, NJ 08405
T 609 485 4651
E robert.ochs@faa.gov

Federal Aviation Administration