Development of a Lab-Scale Flame Propagation Test Method for Composite Fuselage Materials

Federal Aviation Administration



Presented to: IAMFTWG, Renton, WA

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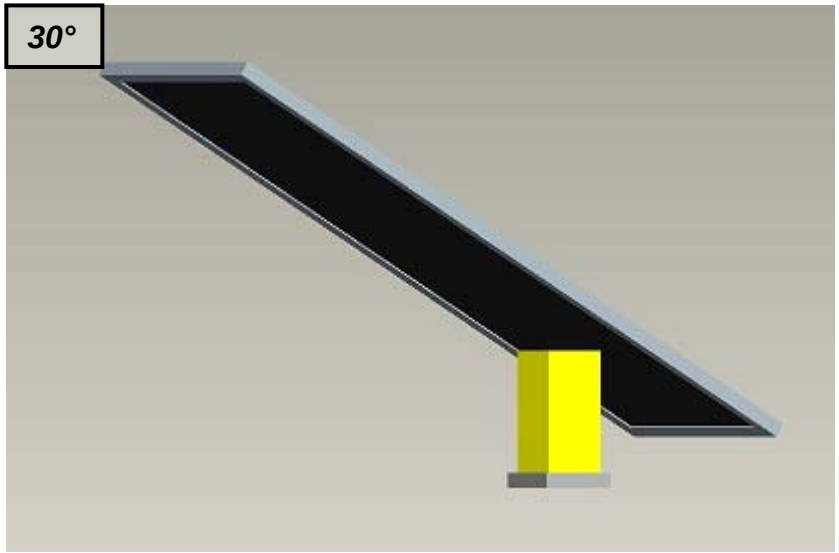
Objective

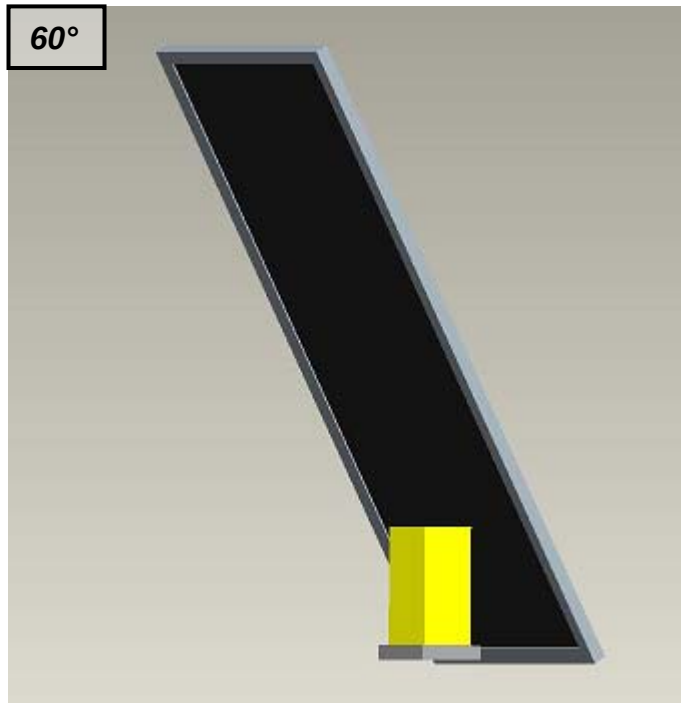
- **Develop a lab-scale test to determine the propensity of a non-traditional fuselage material to propagate a flame or to sustain flaming combustion when subjected to a standardized hidden fire threat**
- **Lab-scale test criteria is to be based upon intermediate scale testing**
  - Standard fire source used to simulate a hidden fire
    - 4” x 4” x 9” untreated urethane foam block
    - 10cc of heptane soaked into foam to provide more uniform burning
  - Various materials of similar mass and rigidity will be tested, both aircraft grade and non-aircraft

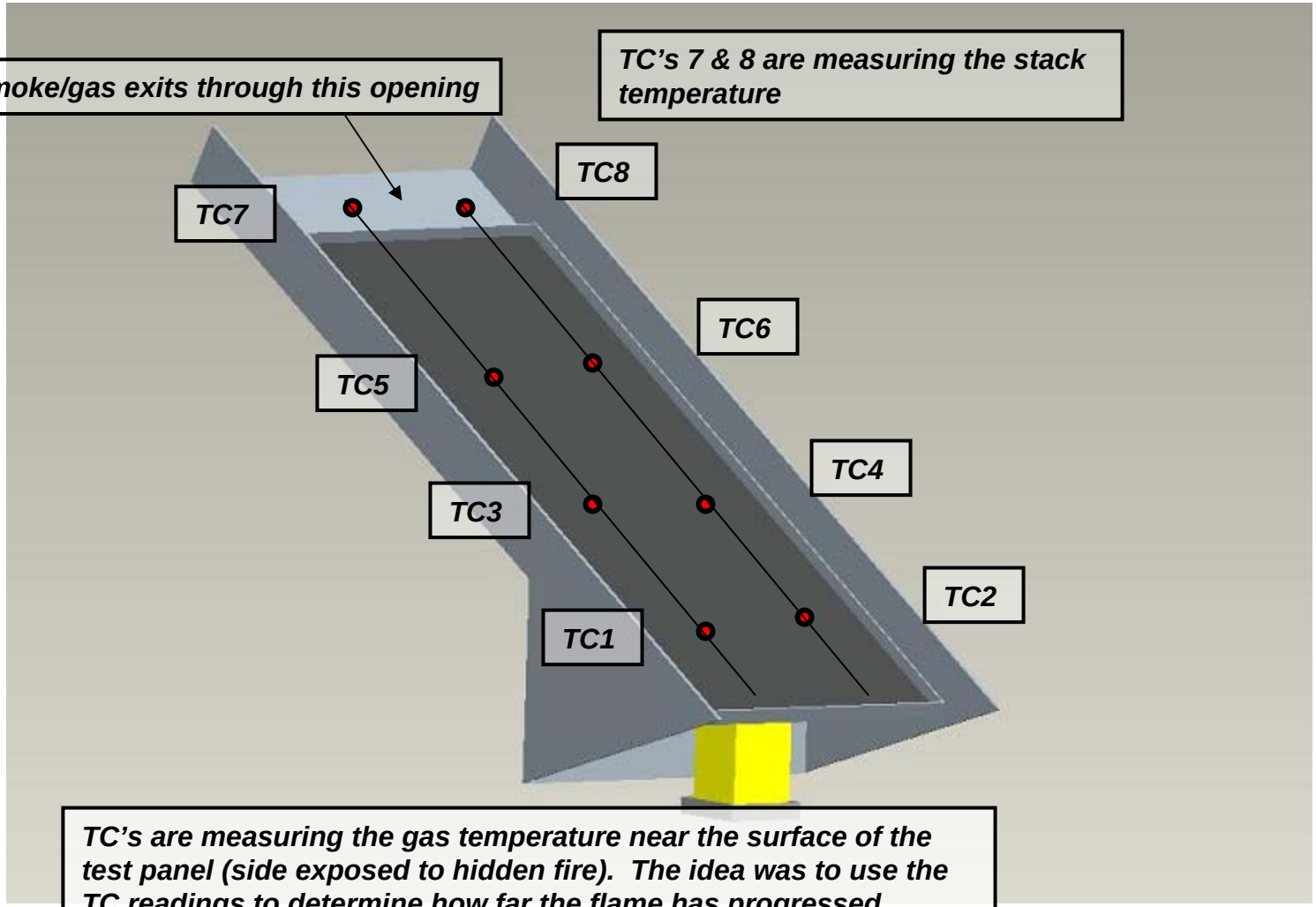


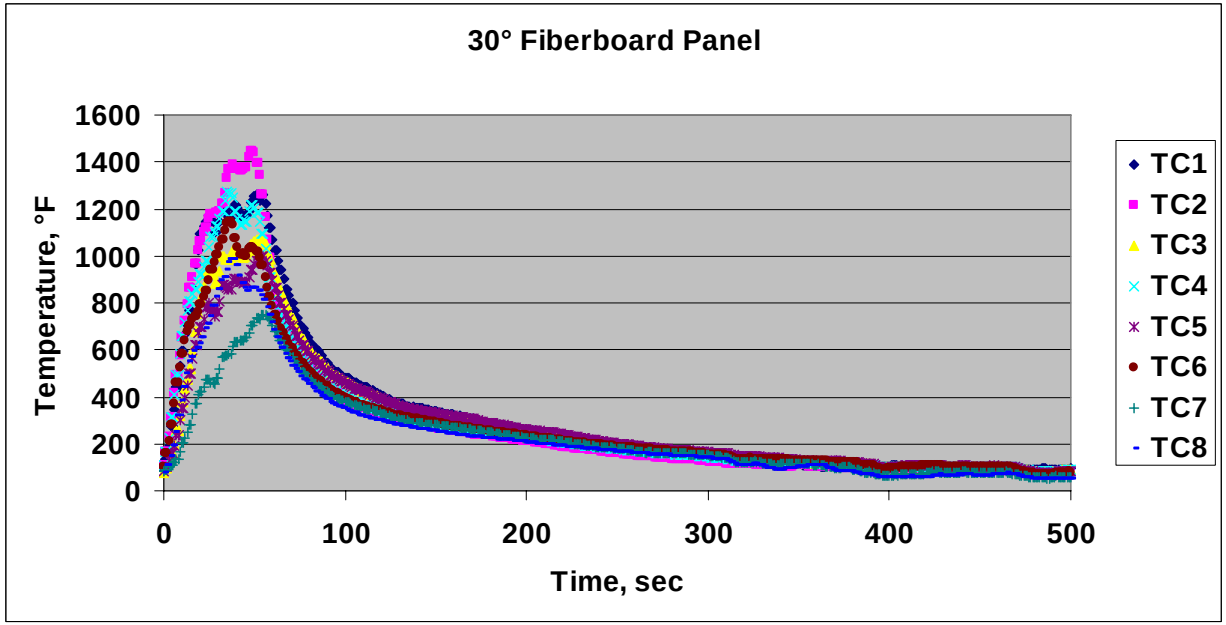


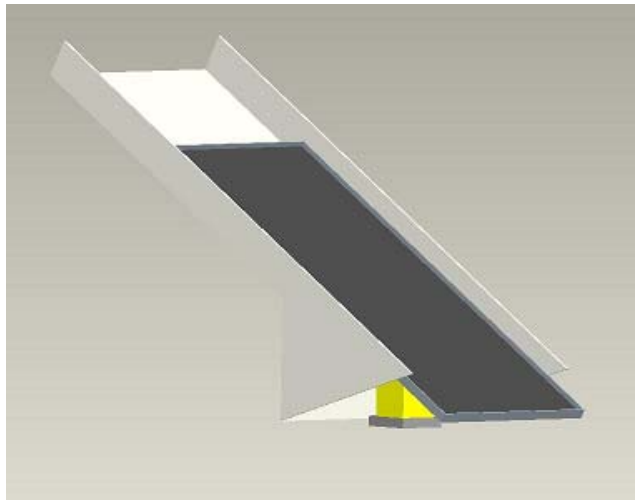


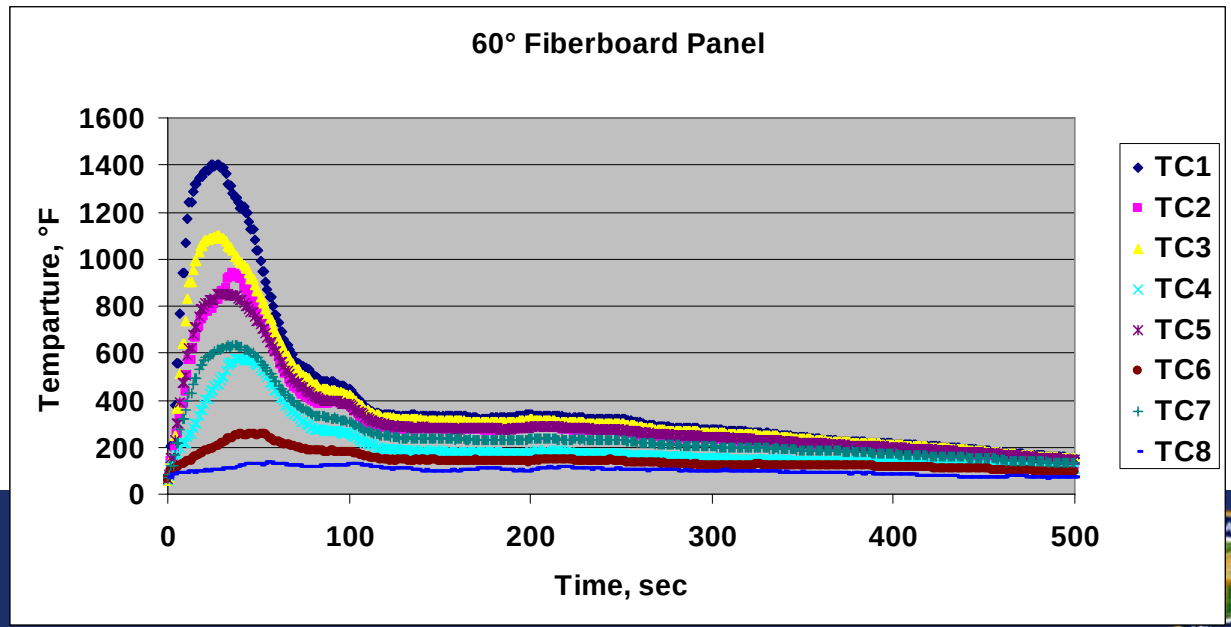

30°


60°


All smoke/gas exits through this opening
TC's 7 & 8 are measuring the stack temperature
TC8
TC7
TC6
TC5
TC4
TC3
TC2
TC1
TC's are measuring the gas temperature near the surface of the test panel (side exposed to hidden fire). The idea was to use the TC readings to determine how far the flame has progressed during the test.


30° Fiberboard Panel
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8




60° Fiberboard Panel
Temparture, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8

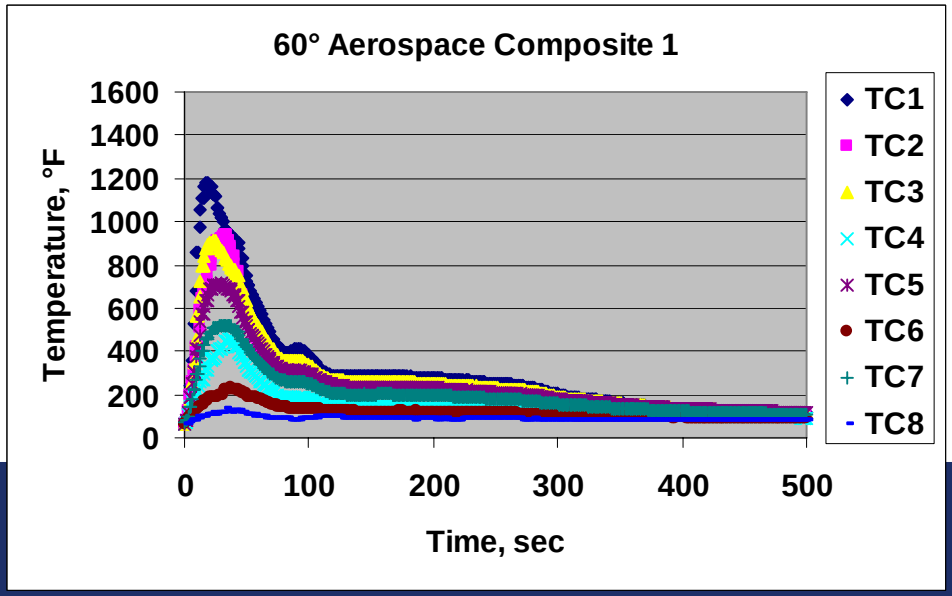


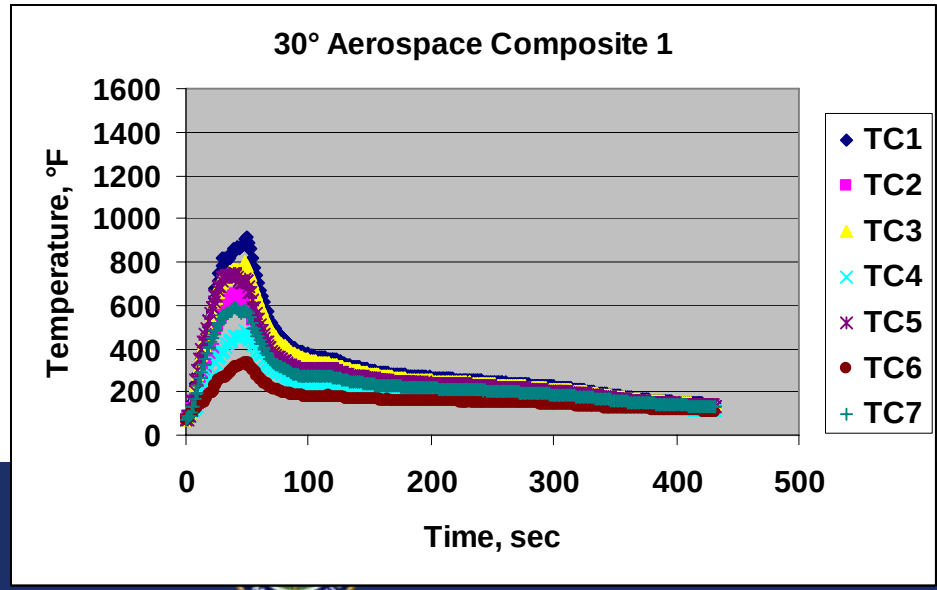
Materials in this Test Series

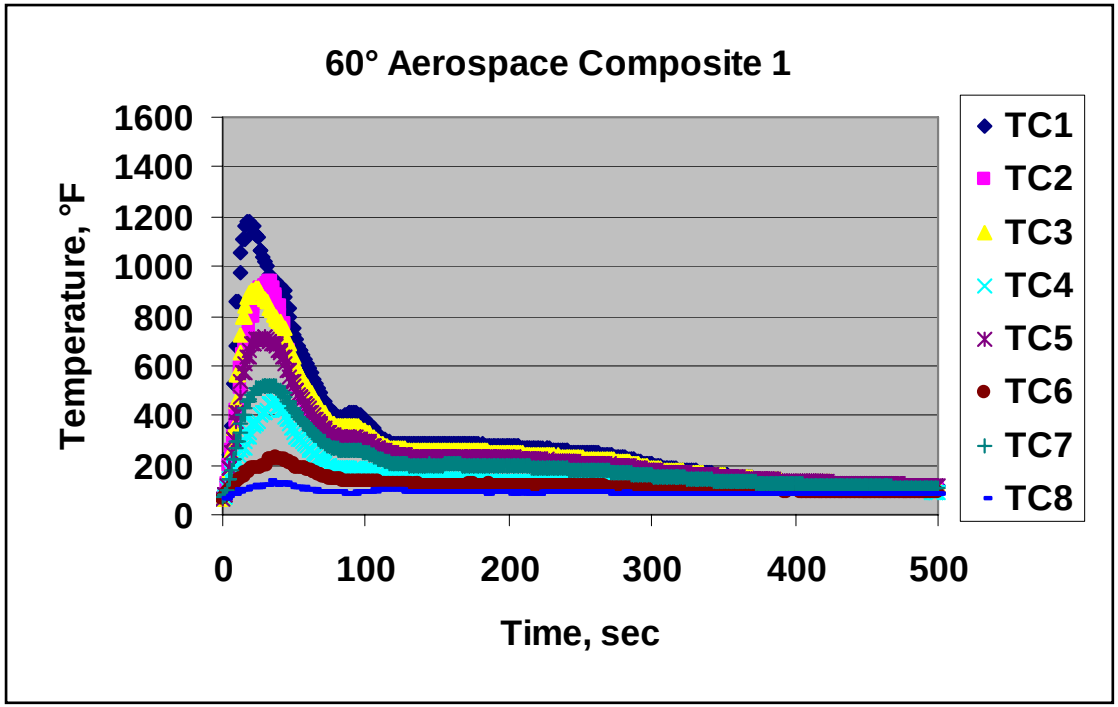
- **Aerospace Composites**
  - Unidirectional carbon fiber prepreg (ACF1)
  - Unidirectional carbon fiber prepreg (ACF2)
  - Woven carbon fabric composite (ACF3)
- **Non-aerospace Composites**
  - Garolite (phenolic laminate materials)
    - Grade CE canvas phenolic laminate (GARCE)
    - Grade LE linen phenolic laminate (GARLE)
  - Fiber reinforced polymer fiberglass (FRP)
  - Rigid woven carbon fiber (RGDCF)
  - Flexible woven carbon fiber (FLXCF)
- **All panels were 1/8” thickness**



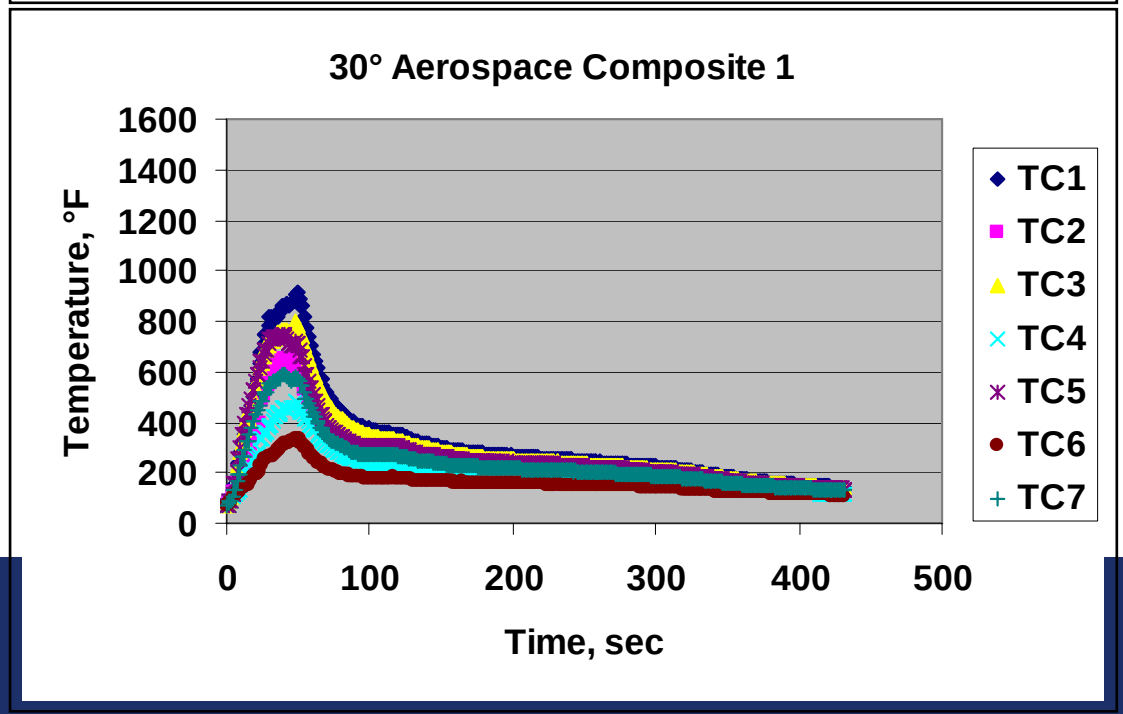



60° Aerospace Composite 1
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8

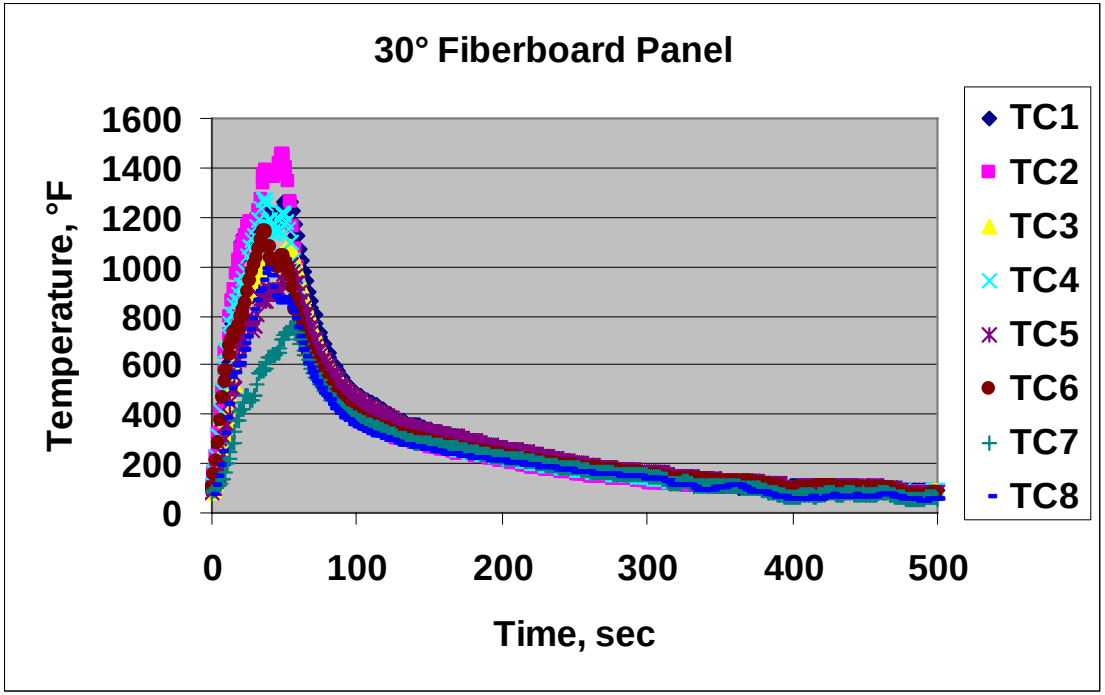

30° Aerospace Composite 1
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7

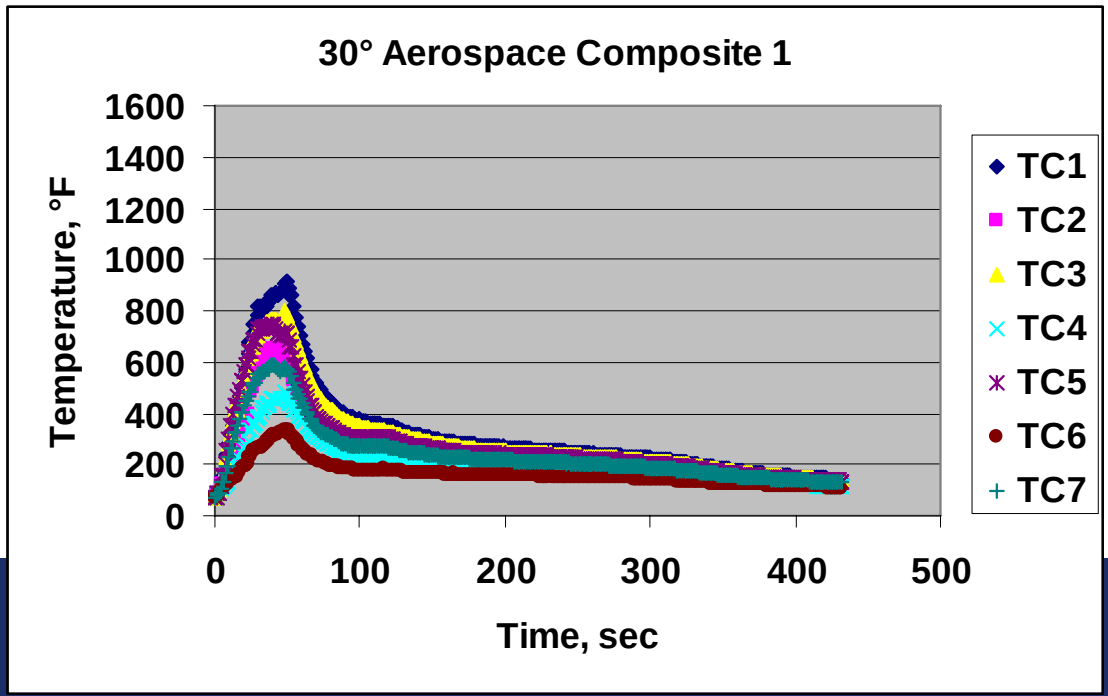

60° Aerospace Composite 1
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8

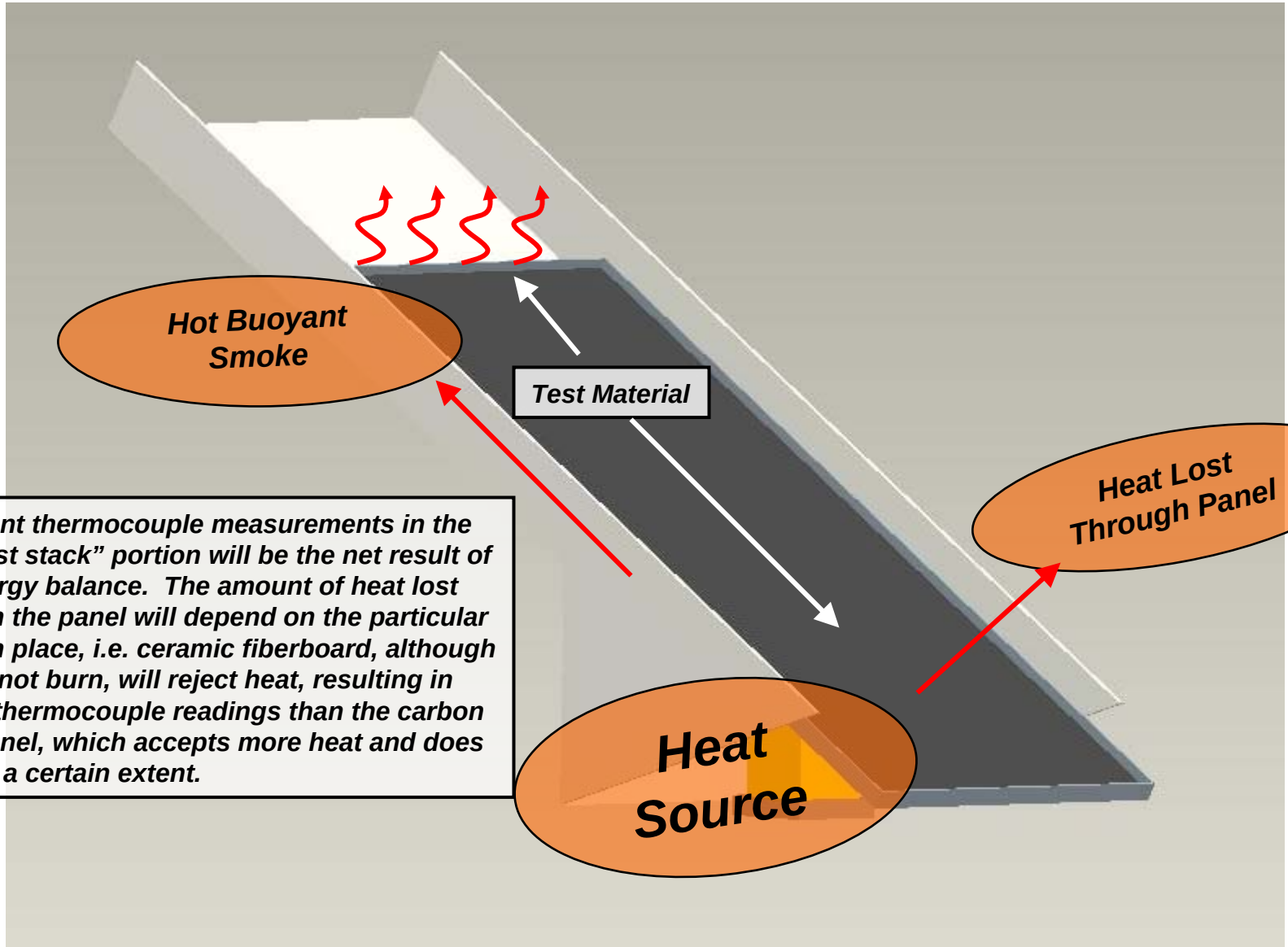

Burn Length = 0”
Burn Width = 0”
Burn Area = 0”


30° Aerospace Composite 1
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7


Burn Length = 2.5”
Burn Width = 2”
Burn Area = 5”


30° Fiberboard Panel
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8

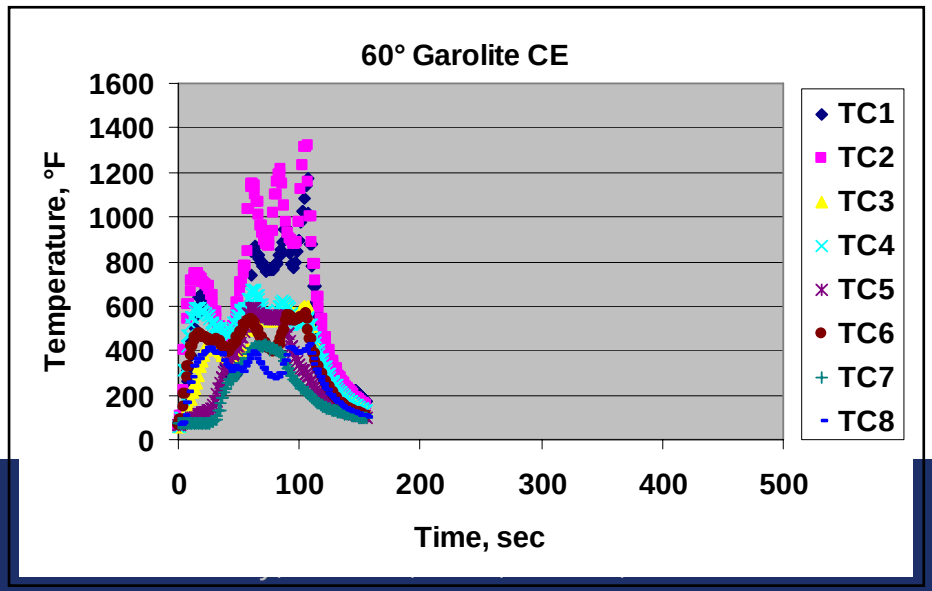

30° Aerospace Composite 1
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7

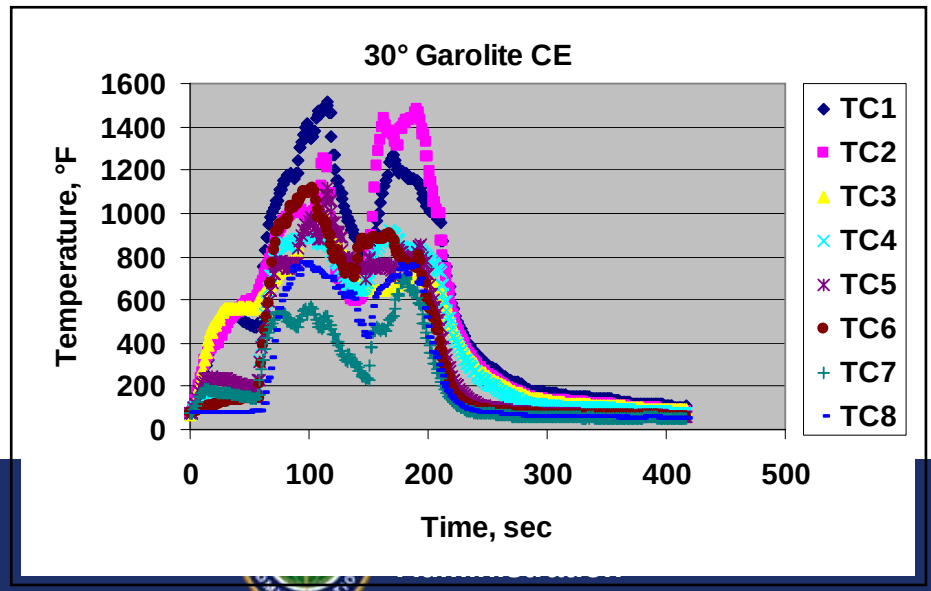


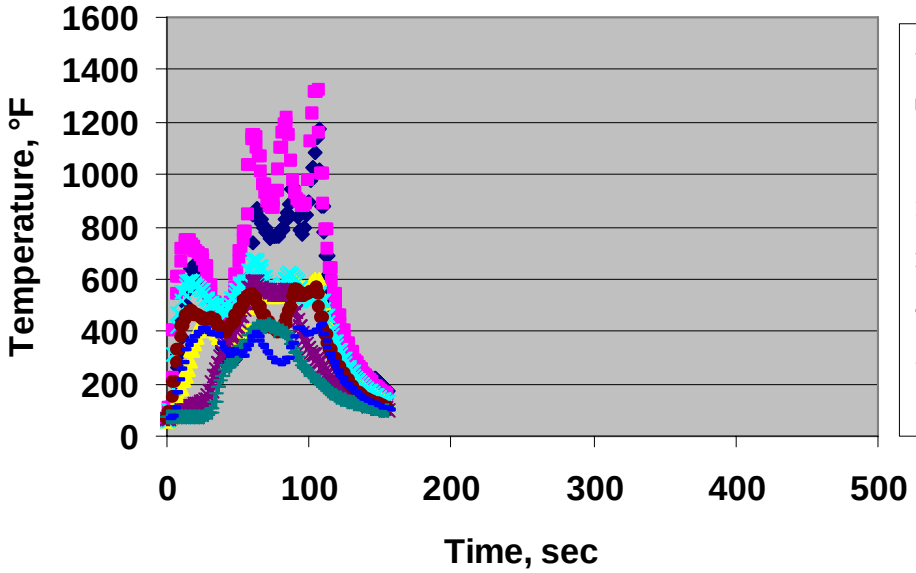
Resultant thermocouple measurements in the "exhaust stack" portion will be the net result of the energy balance. The amount of heat lost through the panel will depend on the particular panel in place, i.e. ceramic fiberboard, although it does not burn, will reject heat, resulting in higher thermocouple readings than the carbon fiber panel, which accepts more heat and does burn to a certain extent.






60° Garolite CE
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8


30° Garolite CE
Temperature, °F
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Time, sec
TC1
TC2
TC3
TC4
TC5
TC6
TC7
TC8



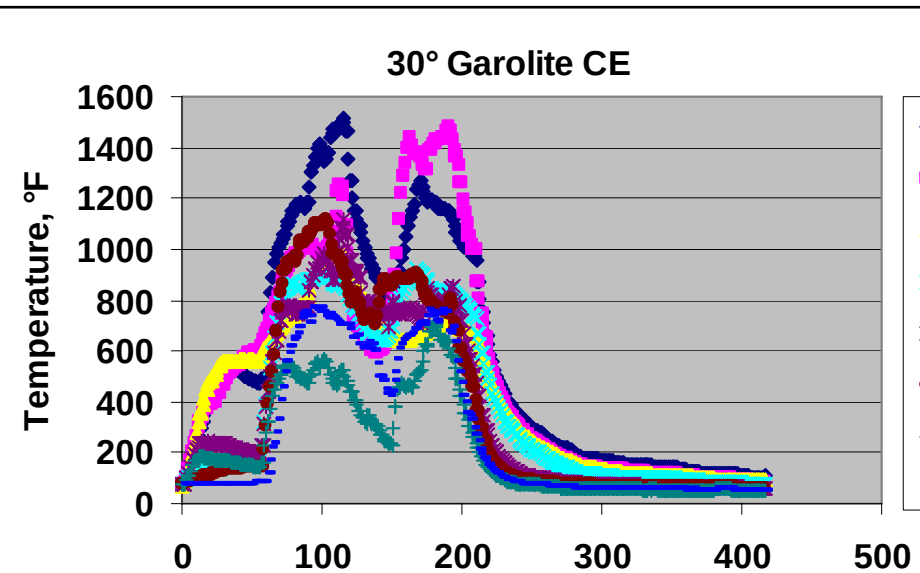
Burn Length = 22”

Burn Width = 13”

Burn Area = 286”



Note: GARCE fell out of 60° test rig, burn length would most likely be much higher



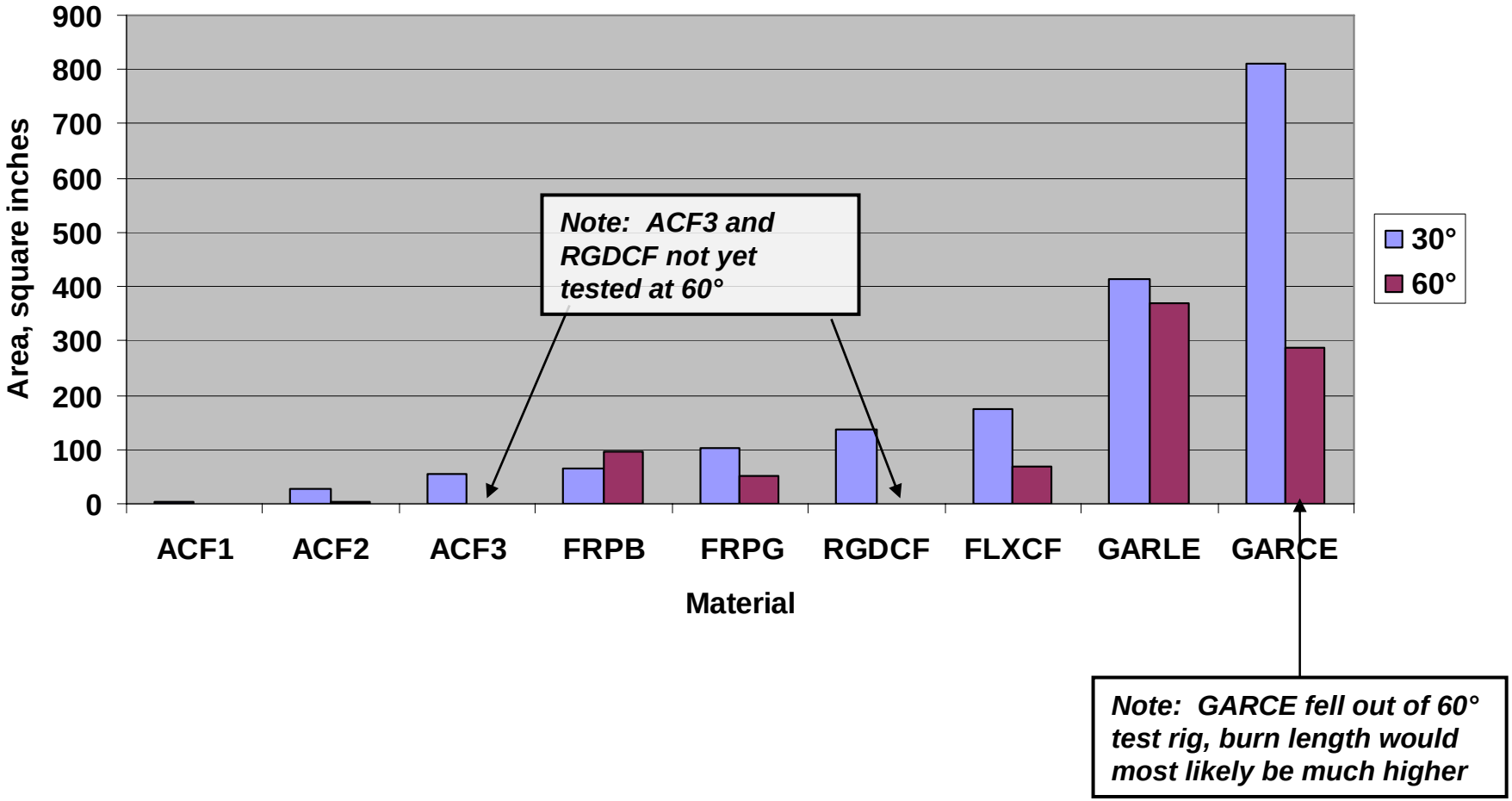
Burn Length = 45”

Burn Width = 18”

Burn Area = 810”



Intermediate Scale Measured Burn Area





2 layers of .34pcf fiberglass
Metallized tedlar film

Insulation is pressed up to the surface of the panel







Aluminum Panel

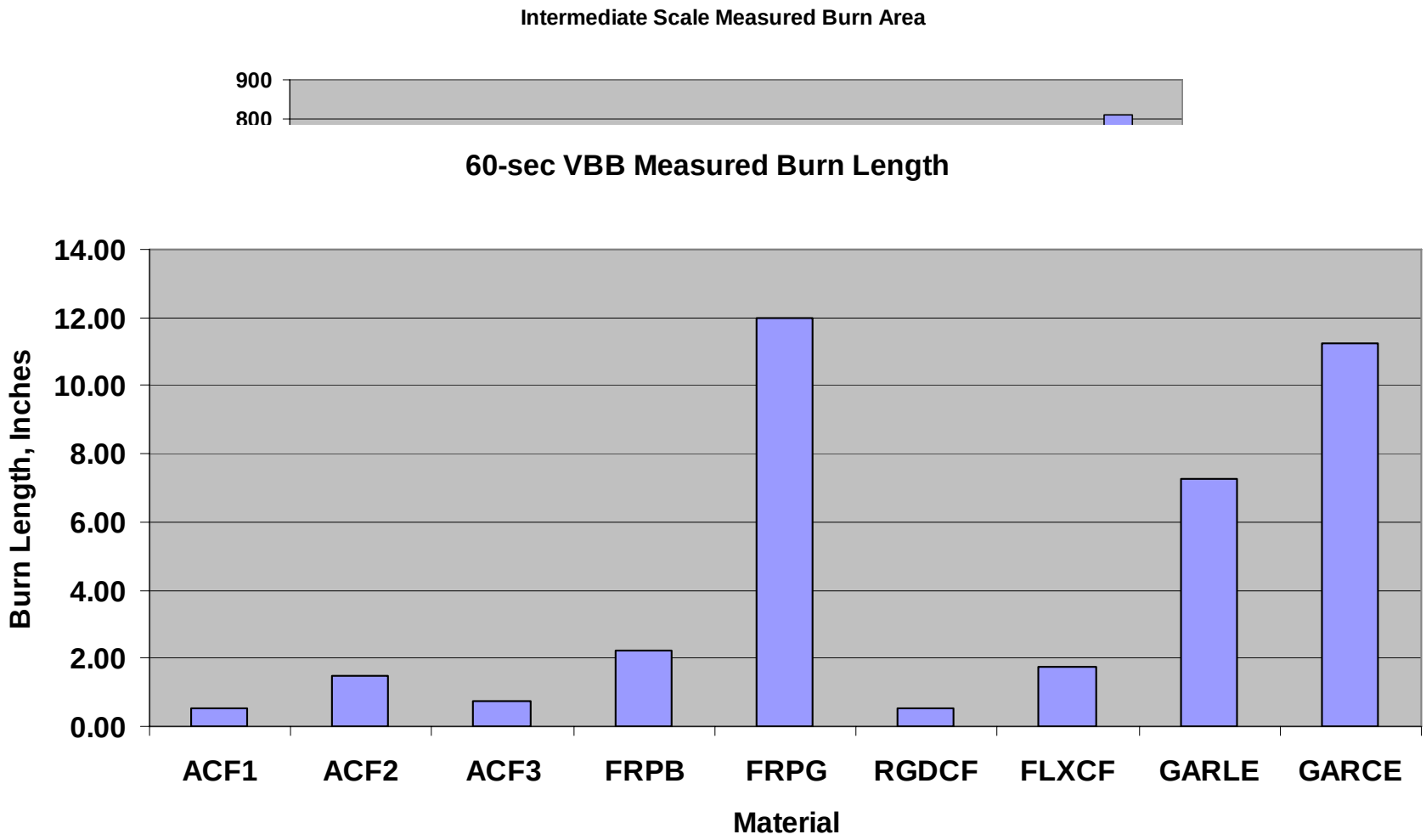


ACF 1


Aluminum Panel

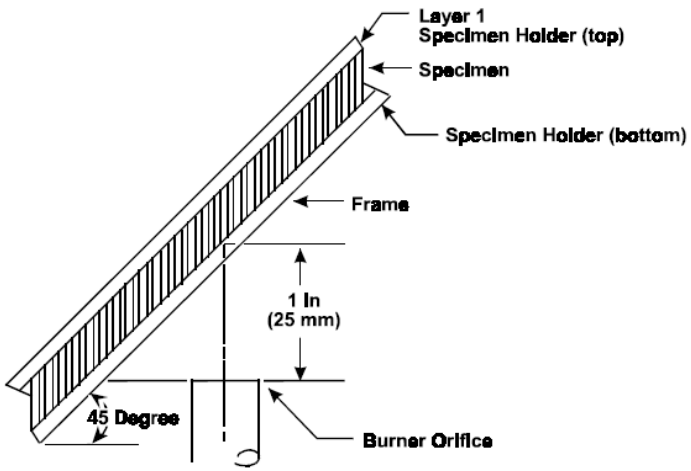

ACF 1


GAR CE

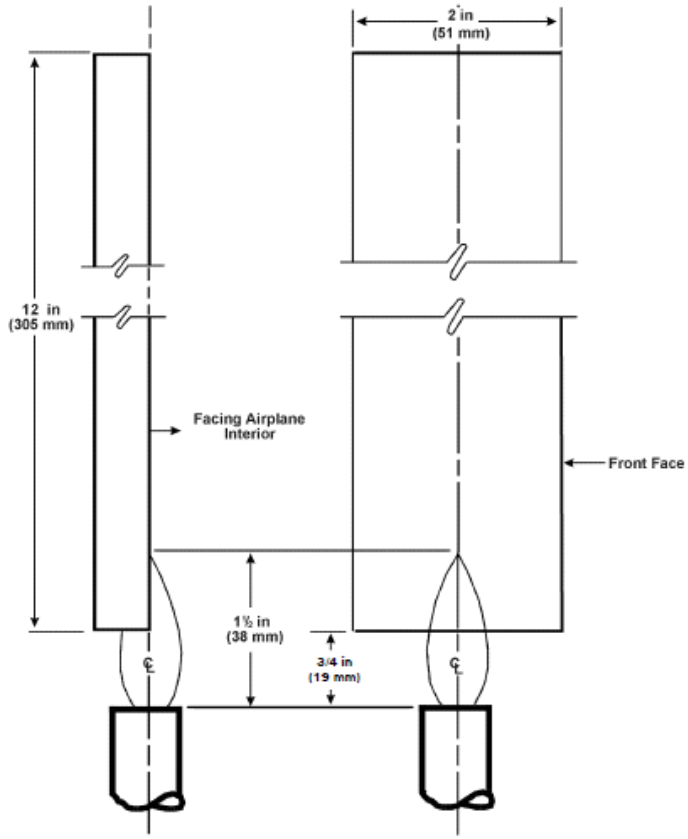

Intermediate Scale Measured Burn Area
900
800
60-sec VBB Measured Burn Length
Burn Length, Inches
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
ACF1
ACF2
ACF3
FRPB
FRPG
RGDCF
FLXCF
GARLE
GARCE
Material

- **Discrepancy between VBB and intermediate scale test results**
  - Intermediate scale flame propagation test is a surface burning test
    - Only the outer layer of epoxy/resin is exposed to flame
    - Unless significant heat is present to delaminate first layer, inner layers will remain intact
  - VBB is an edge test
    - Exposure of the entire thickness of the composite panel to the flame results in more epoxy/resin being exposed to heat
    - Jets of high pressure resin vapor shoot out sideways and down from the exposed edge
  - 45° BB may be more applicable for comparison with the intermediate scale test rig
  - Radiant panel test is surface test as well, more severe than 45° BB

45° BB Test Configuration

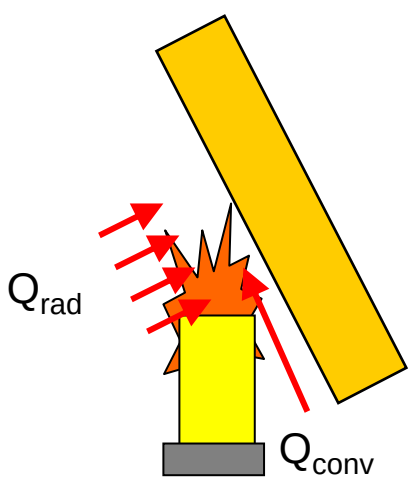


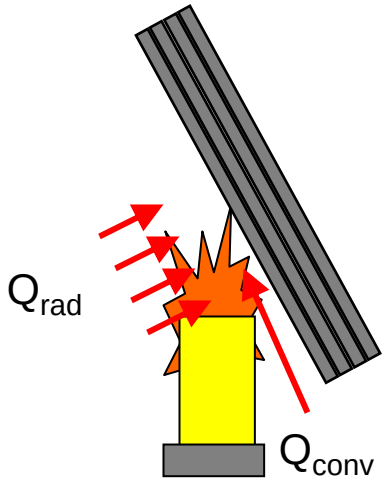
VBB Test Configuration

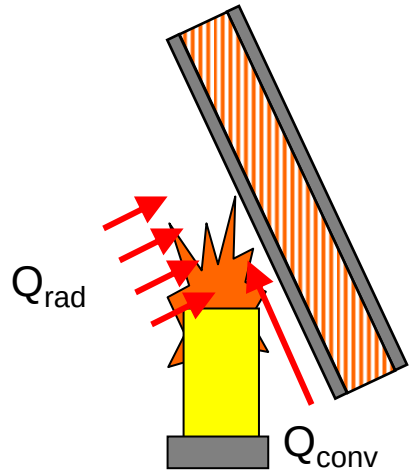


Sample Configuration

Solid Materials	Laminates	Honeycomb Sandwich Panels





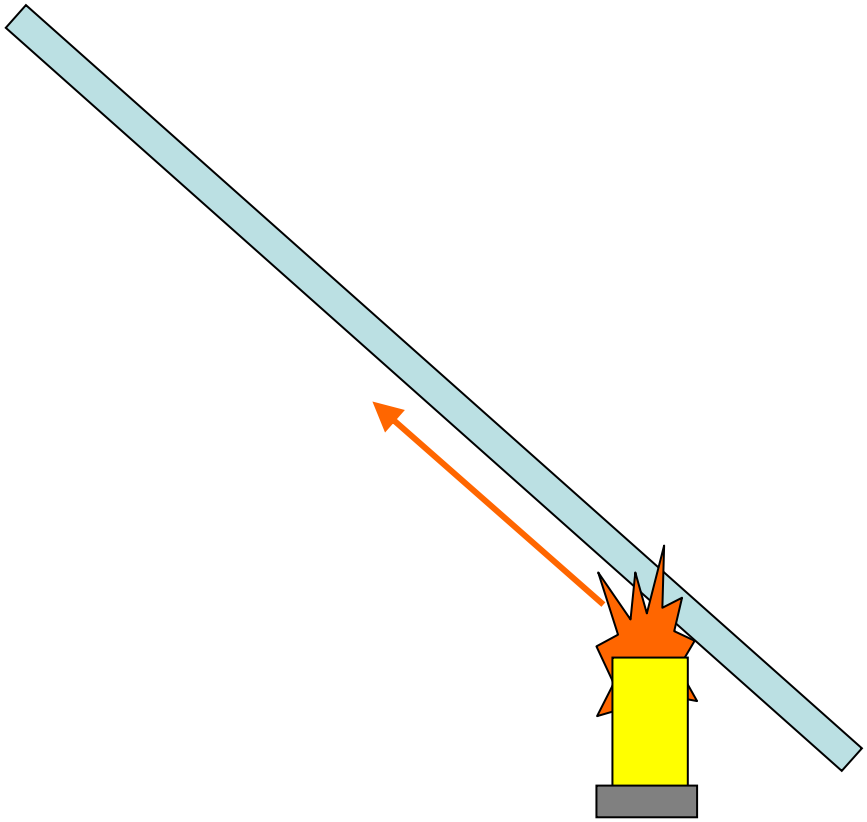


Need to test composite materials as laminates and as sandwich panels. Although a material may perform well in laminate form, a sandwich panel may have only 2-3 layers of structural composite on the face, backed by an air-filled honeycomb insulator.

Test Configuration
Lab Scale

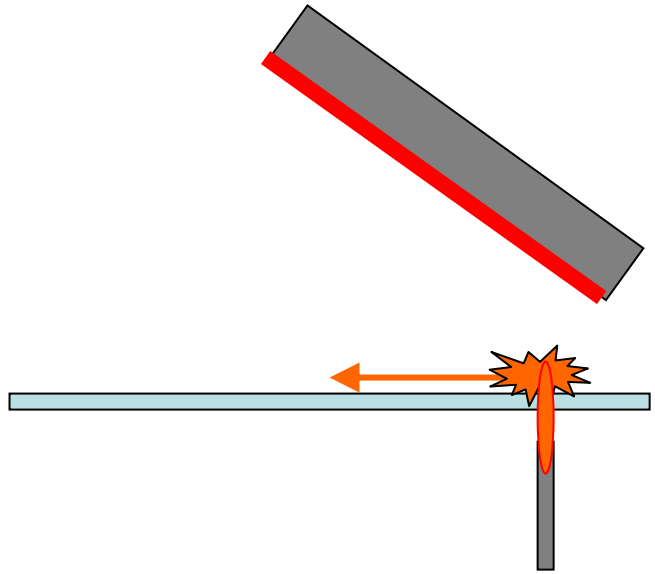
- **Use identical materials from intermediate scale**
  - Sample size 12” x 24”
- **Use radiant panel apparatus for lab scale testing**
  - Develop test parameters based on intermediate scale results
    - Calibration heat flux
    - Pre-heat
    - Flame impingement time
    - Pass/fail criteria

Intermediate Scale



=
?

Lab Scale



Summary

- **Intermediate scale testing has been performed for 2 different specimen-flame configurations**
  - These tests were able to discern between poor performing composites and more fire-resistant aerospace grade composites
  - 30° configuration was generally more severe than the 60° configuration
- **Vertical Bunsen burner tests were performed**
  - The configuration of the VBB does not match the configuration of the intermediate scale test (surface burning)
  - The VBB results did not exactly correlate with int. scale tests
  - A 45° BB may be more appropriate for this testing

Upcoming Work

- **Perform radiant panel tests to determine ability to rank materials**
- **Gather sandwich panel materials for testing**

Composites Task Group

- **Discuss approach to intermediate scale flame propagation**
- **Materials**
- **Lab scale test parameters**

Questions, Comments, Concerns?

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