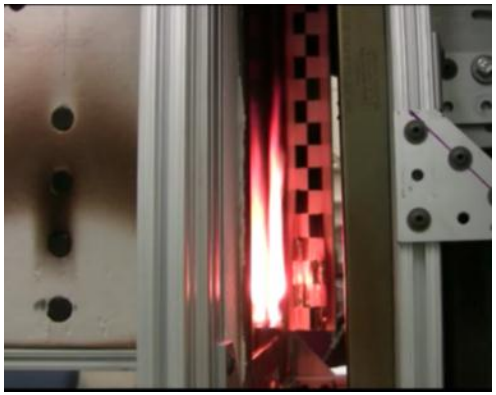
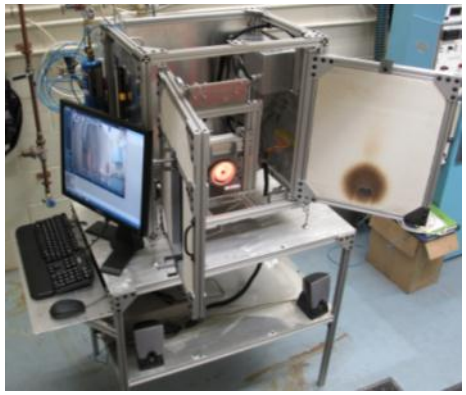
Composite Flame Propagation Update

Federal Aviation Administration

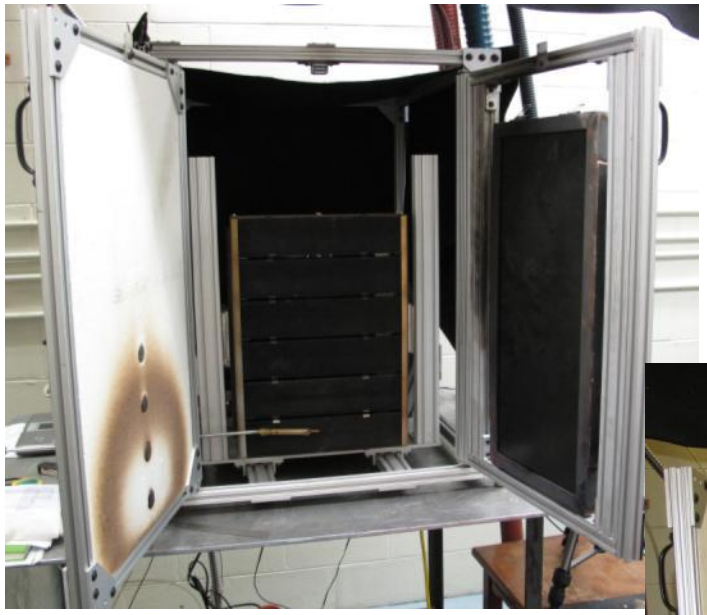


Presented to: IAMFTWG
By: Robert I. Ochs
Date: March 6-7, 2013, Seattle, WA

Overview

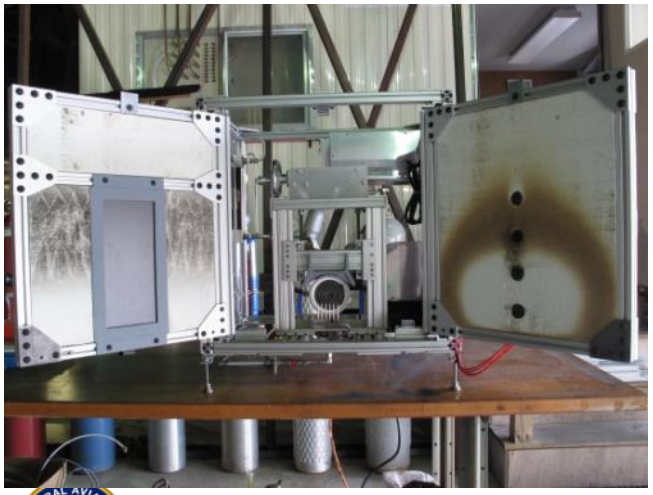
- Objective: to develop a standardized flammability test method for composite structure
- An intermediate scale test was designed to evaluate large samples of composite material against the standard block of foam fire source
- The temperature and heat flux gradient was measured in the foam block test and transferred to a lab-scale vertical flame propagation test with radiant heat source and piloted ignition



Gen 1

Gen 2

Gen 3

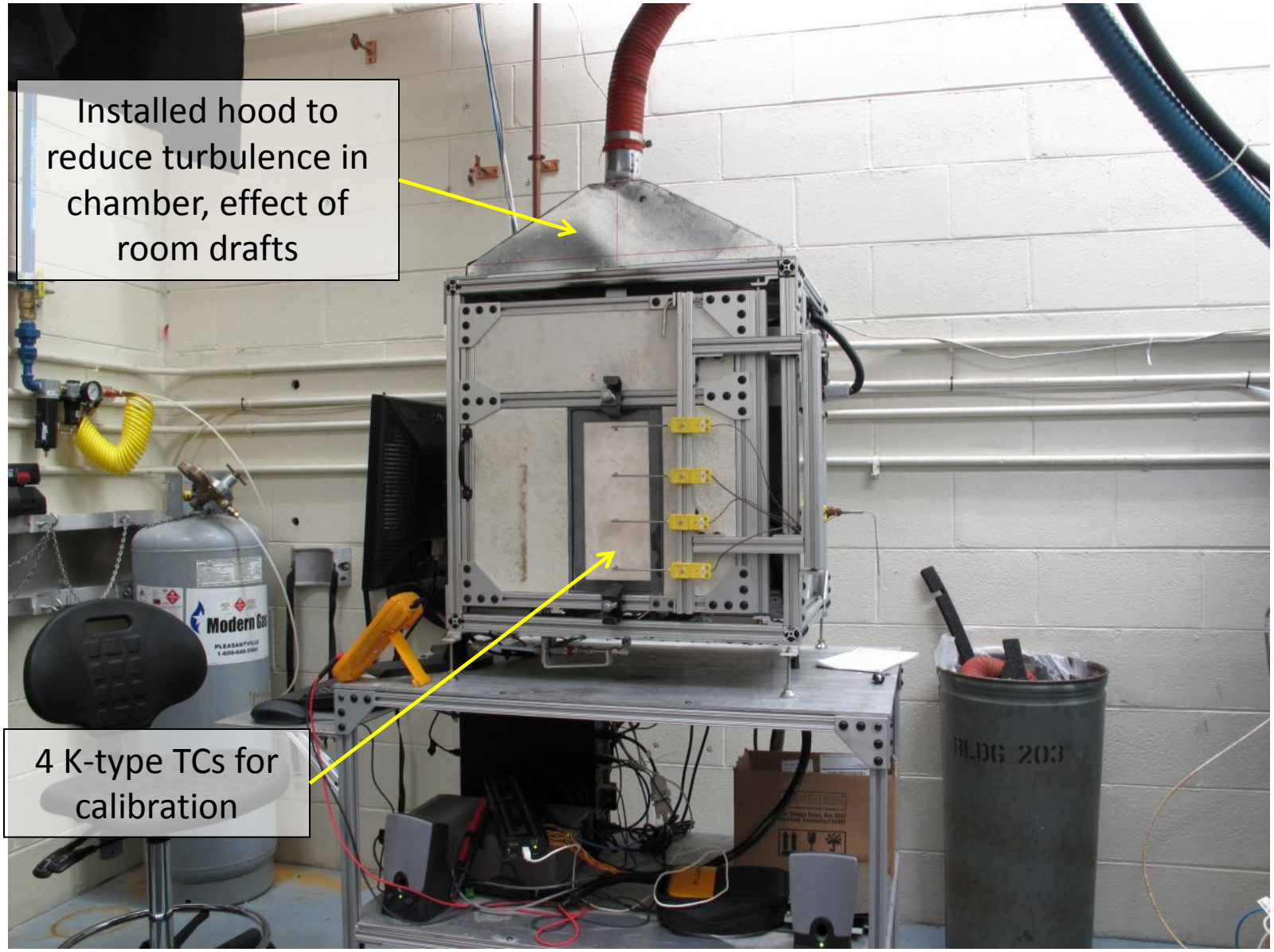


Status as of 10/2012

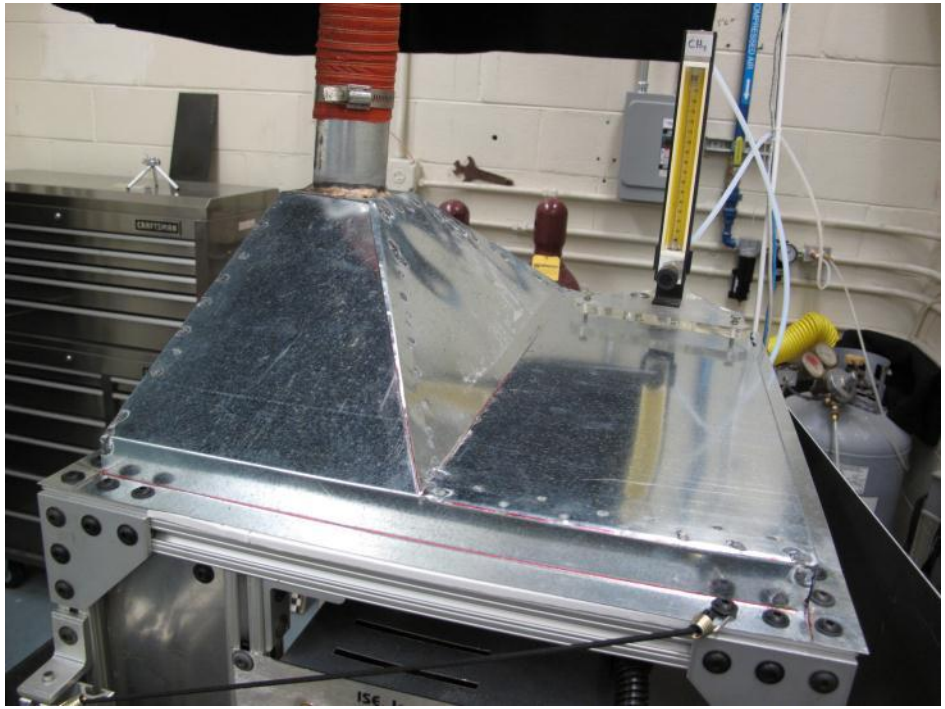
- A variety of materials were tested on the gen 3 apparatus
- Burn lengths correlated reasonably well with foam block testing
- Consistency testing is underway to determine critical test parameters in order to define a repeatable, reproducible test method

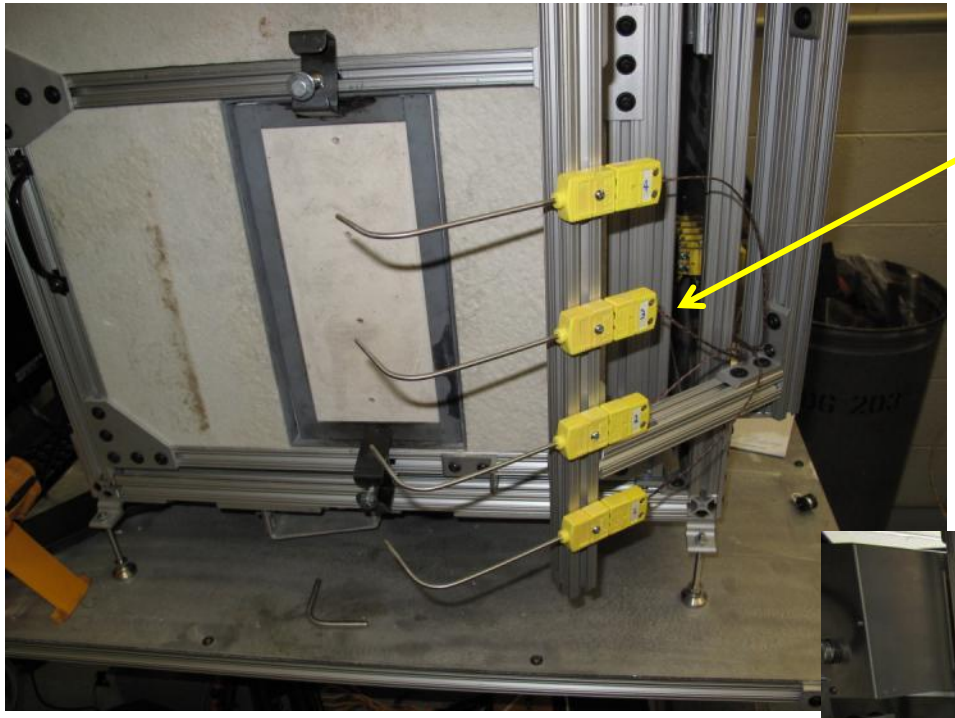
What's New

- Heat flux transducers were removed to simplify calibration of device
  - Heat flux gradient was obtained with 110 V, set heater to sample distance, height
  - Thermocouples were installed in test frame in same locations as HFGs as to monitor chamber equilibrium and consistency
  - Voltage, current probes accurately measure electrical input to furnace


Installed hood to reduce turbulence in chamber, effect of room drafts
4 K-type TCs for calibration
BLDG 203

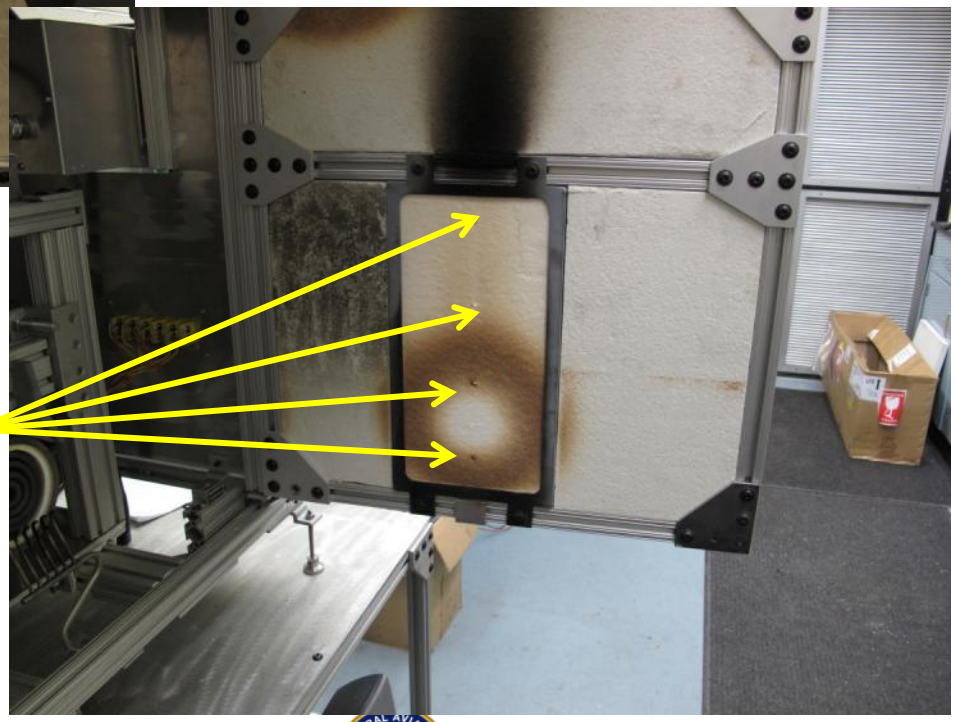
Hose directs smoke and gases into smoke hood

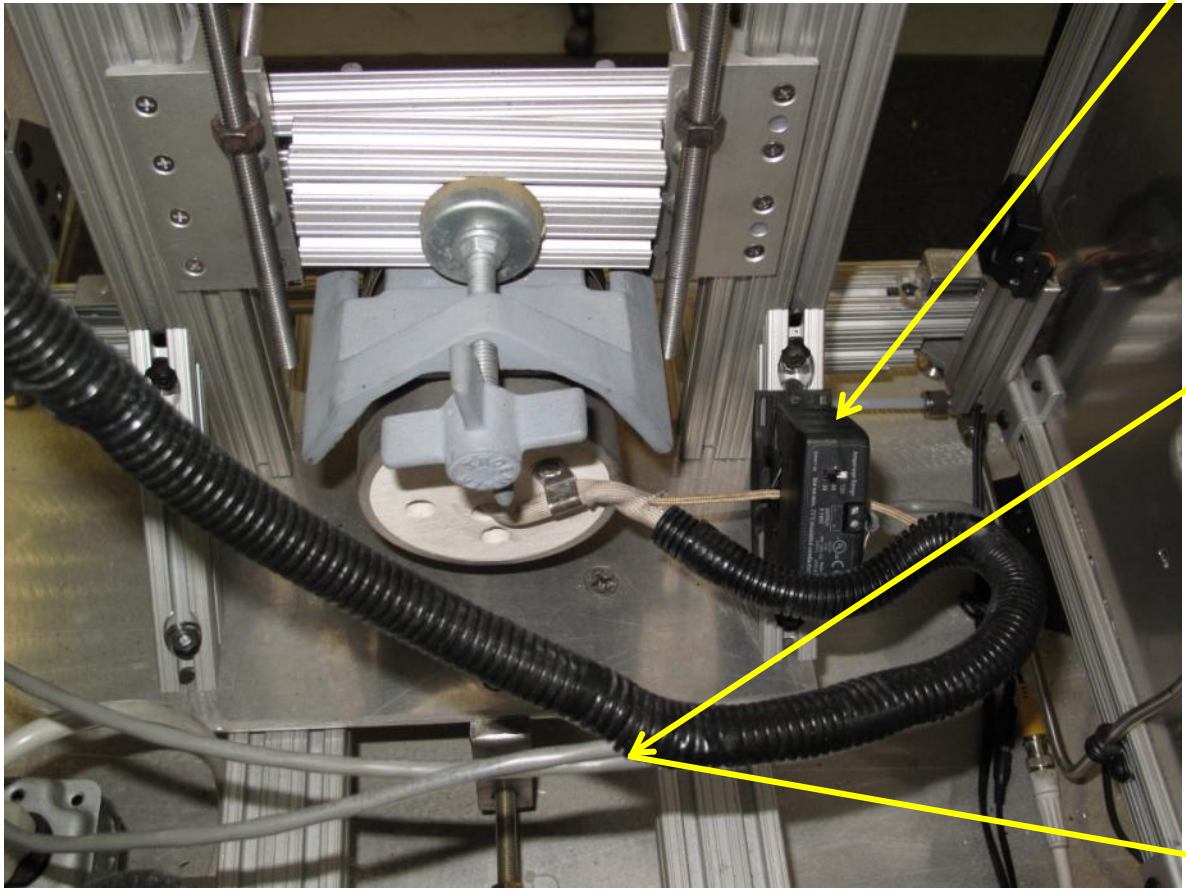




TCs can swing out of the way to open door, can be used to measure backside sample temp during test

TC locations on ceramic board

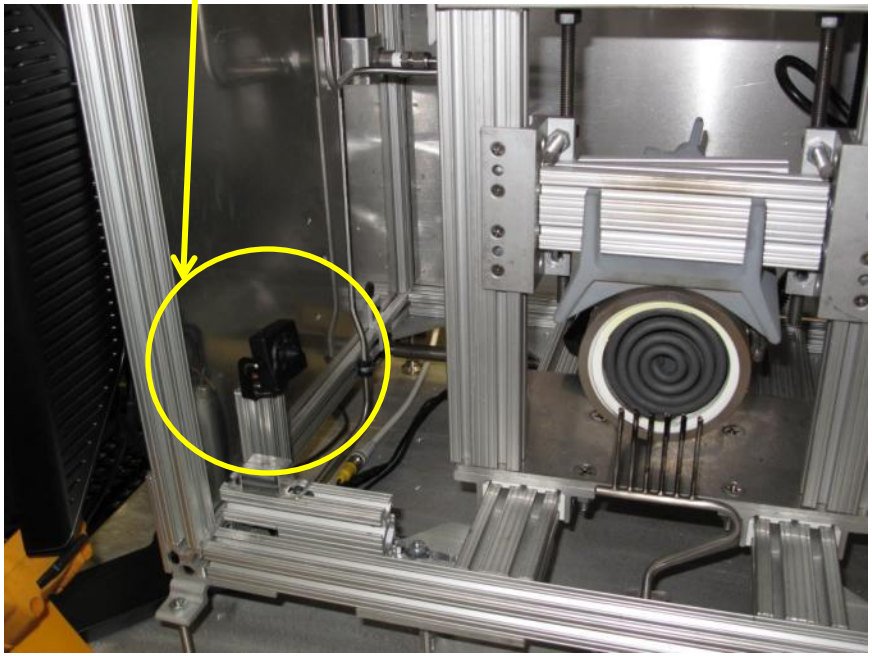


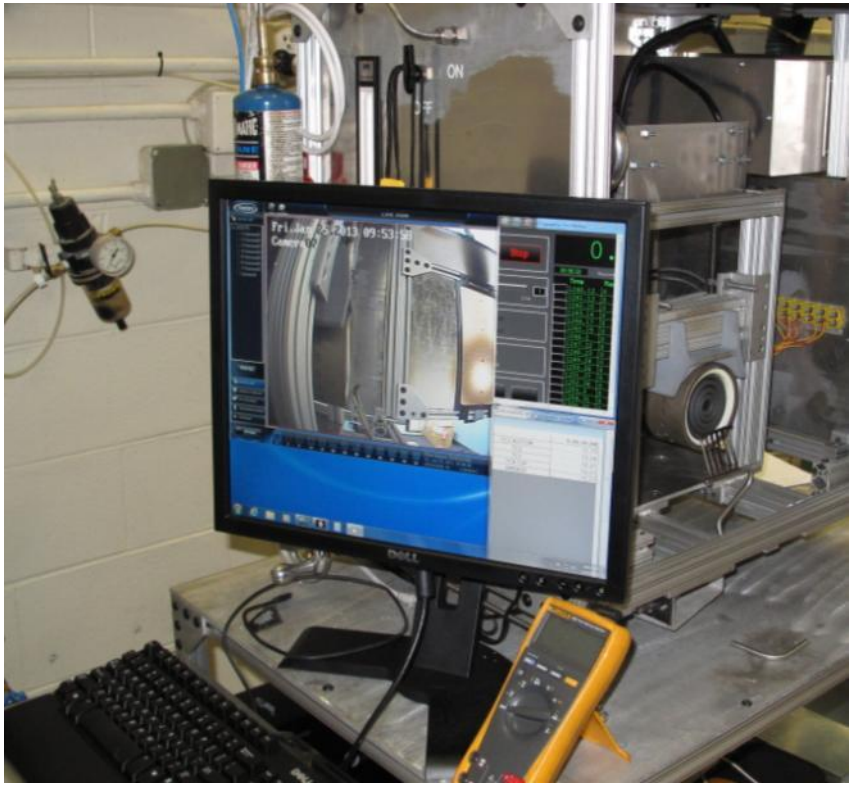


Around-conductor current probe converts true RMS AC current to 0-5 VDC signal for DAS

AC voltage is measured close to the furnace, signal is sent to DMM for true RMS AC voltage measurement

Small camera used to observe test progression



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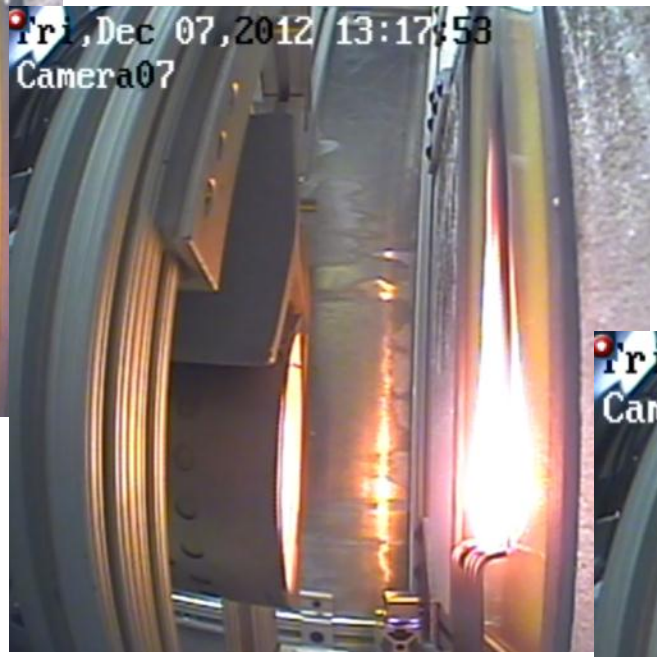
Camera07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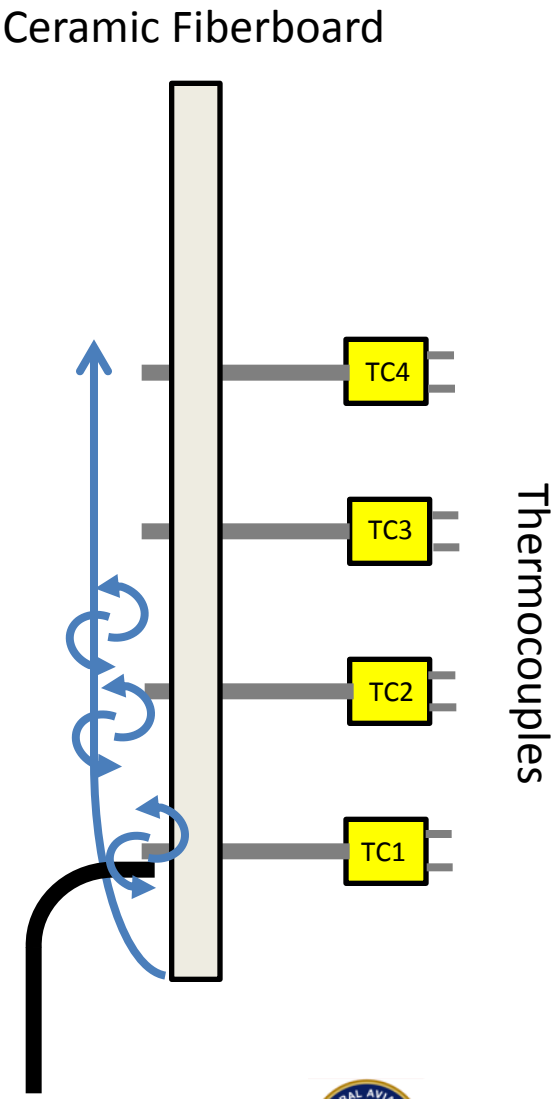
What are the TCs measuring?

$$T_{measured} = \sum Radiation + Convection$$

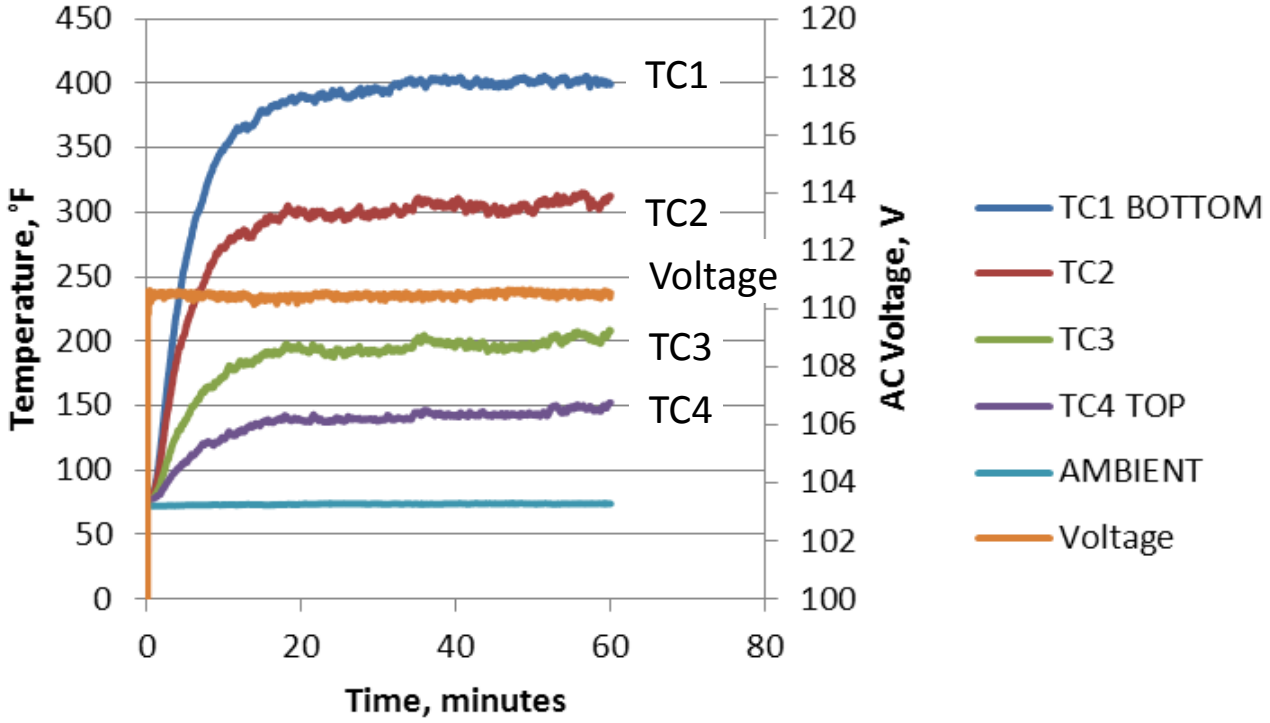
Furnace→TC
Furnace→Board
TC→Surroundings

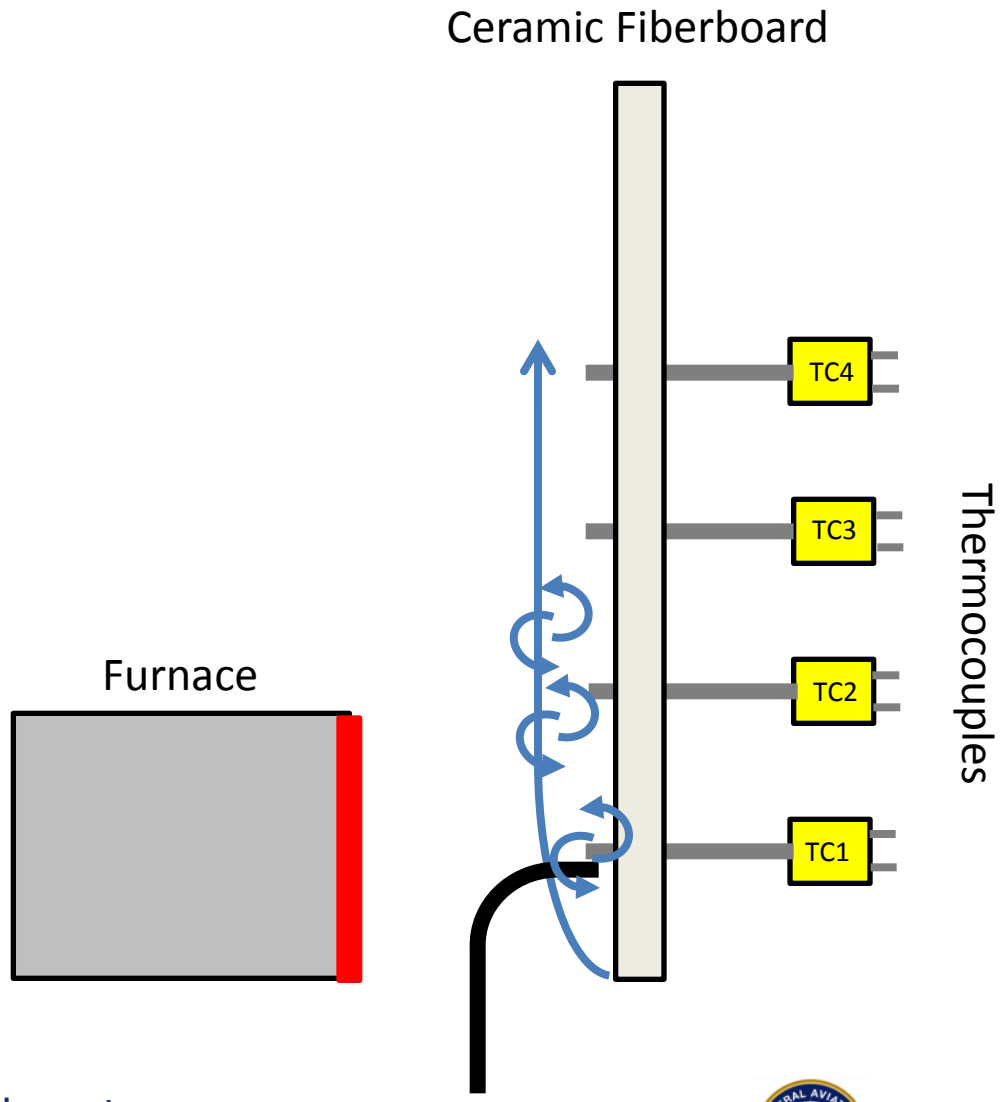
BL→TC

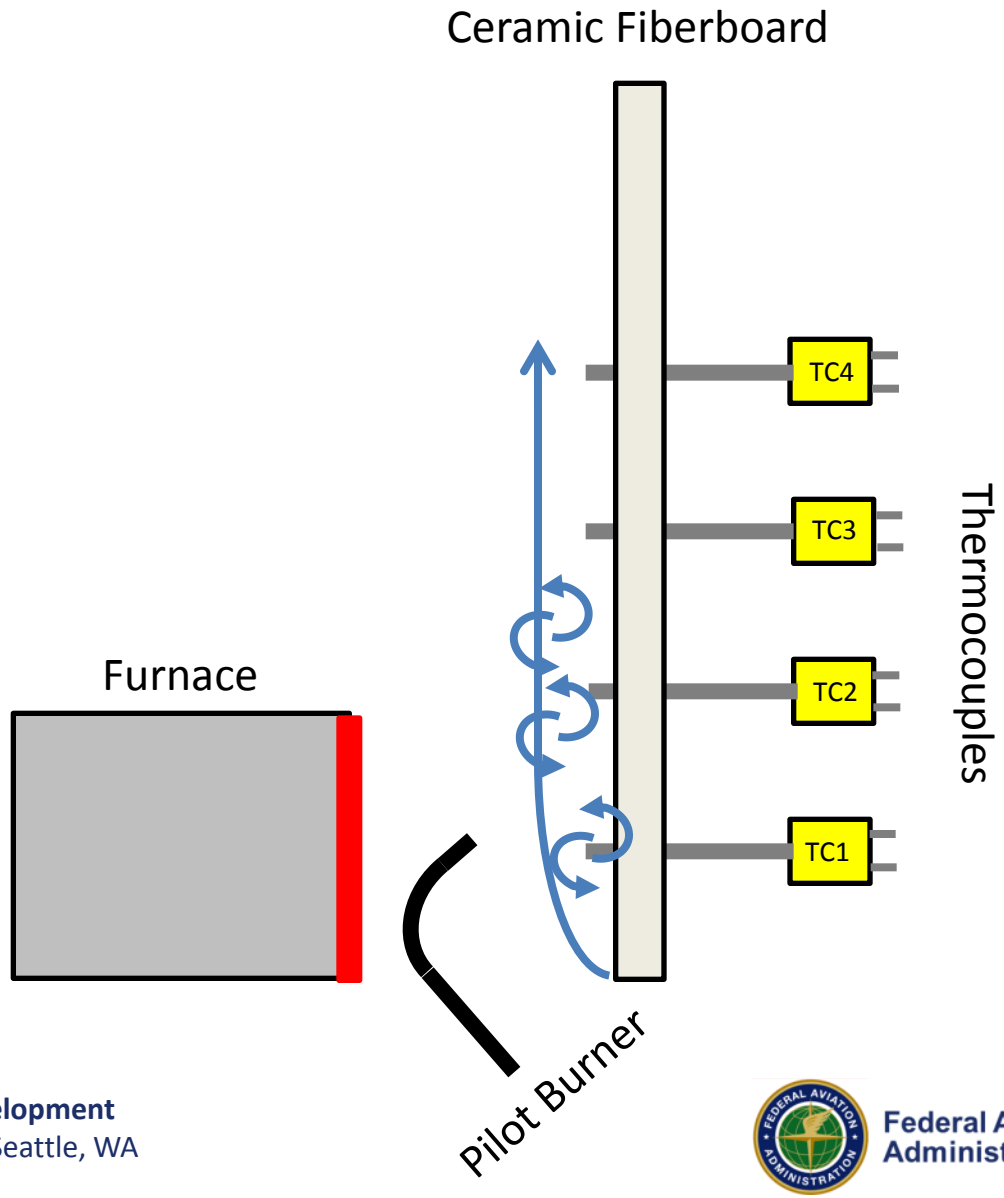


Temperature, Voltage vs. Time

- Thermocouples indicate equilibrium within chamber
- Can be used to determine steady-state condition to compare test conditions from other tests
- Voltage is very steady during extended periods of time
  - Average 110.5 V
  - Std Dev 0.07
  - % SD 0.06
- Fluctuation of TC readings at steady state indicate relative level of turbulence




Ceramic Fiberboard
TC4
TC3
TC2
TC1
Thermocouples
Furnace
Pilot Burner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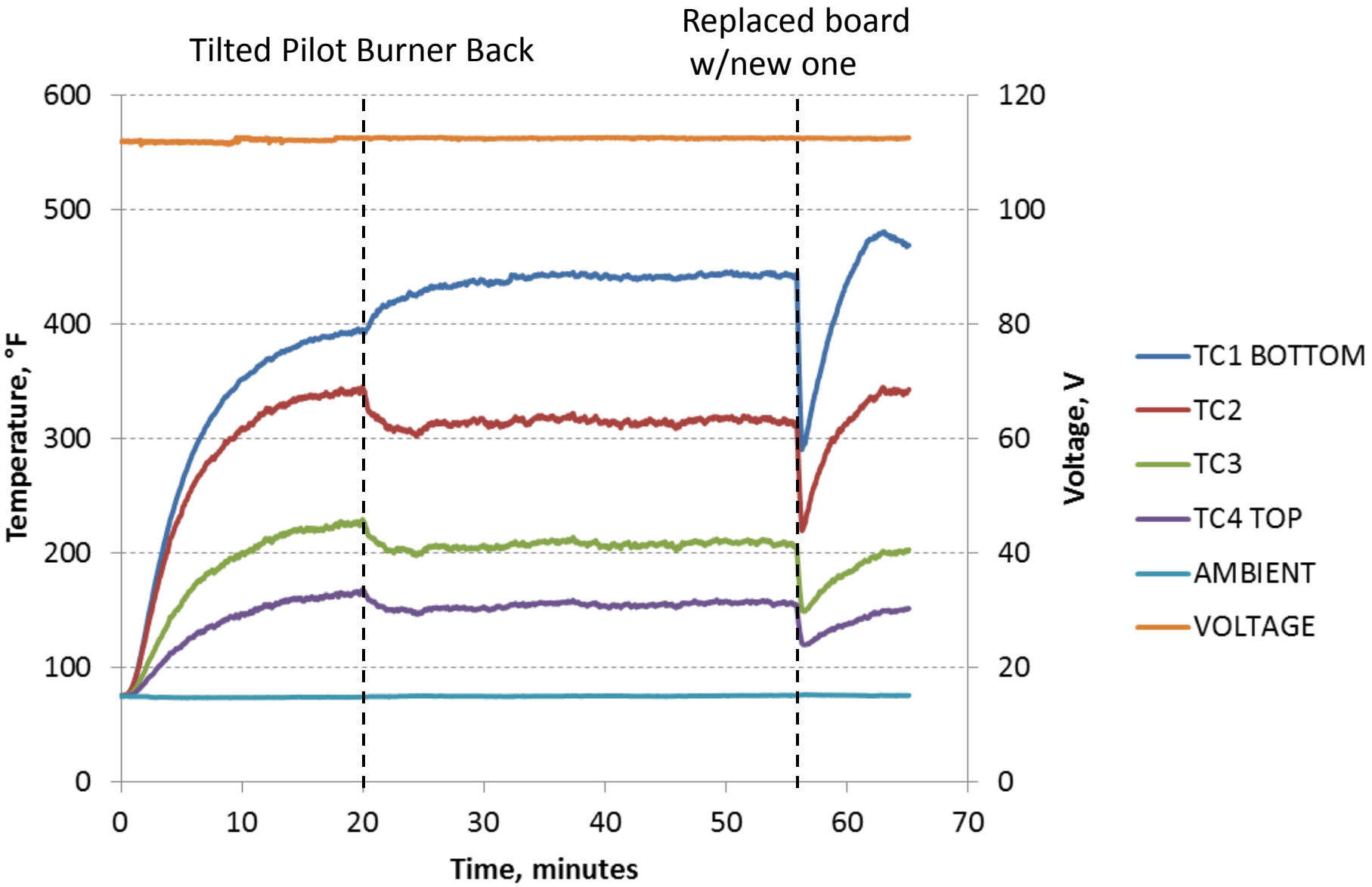
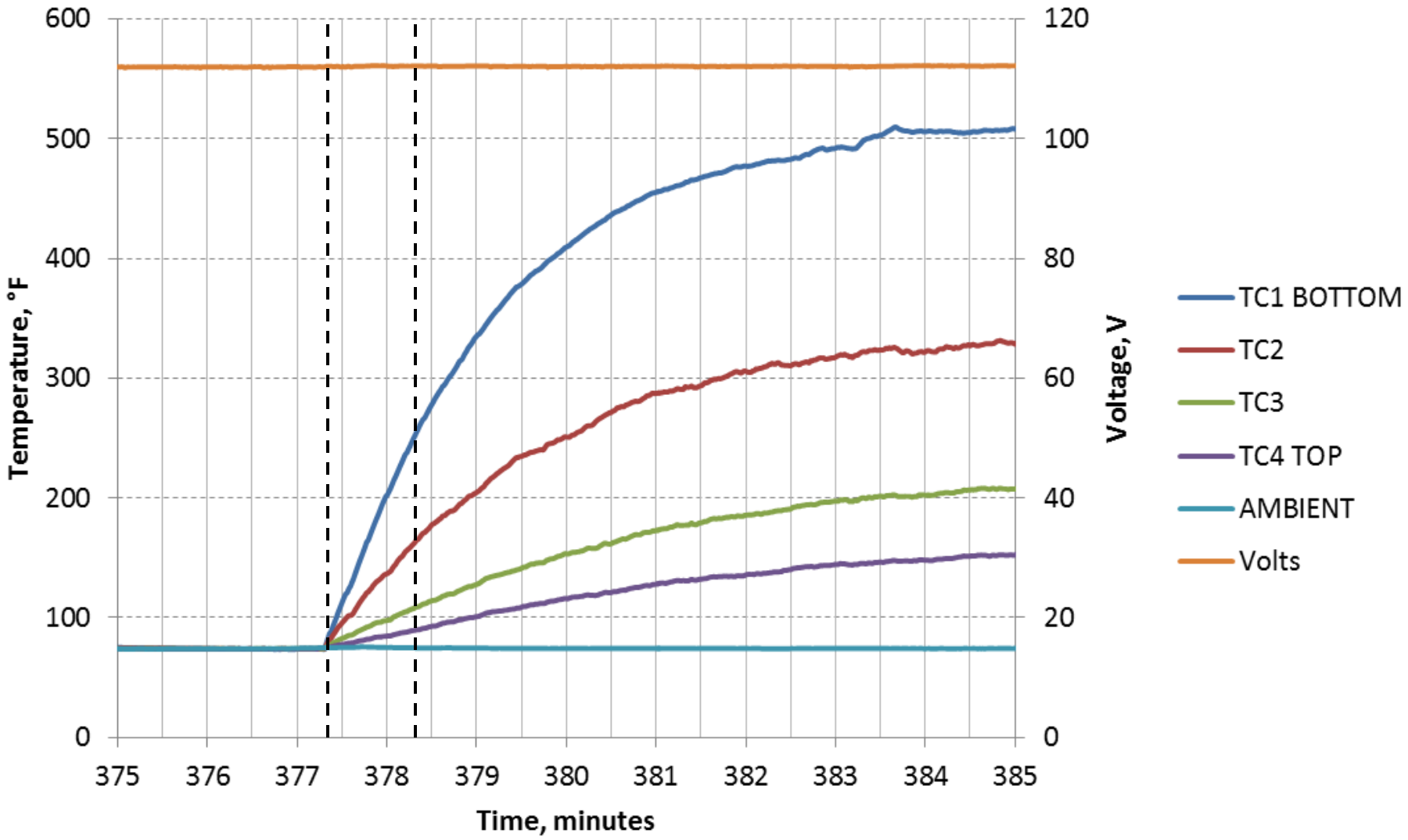

Tilted Pilot Burner Back
Replaced board w/new one
600
500
400
300
200
100
0
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Temperature, °F
Voltage, V
Time, minutes
TC1 BOTTOM
TC2
TC3
TC4 TOP
AMBIENT
VOLTAGE

Replaced board
w/ ACF1 w/ TC holes

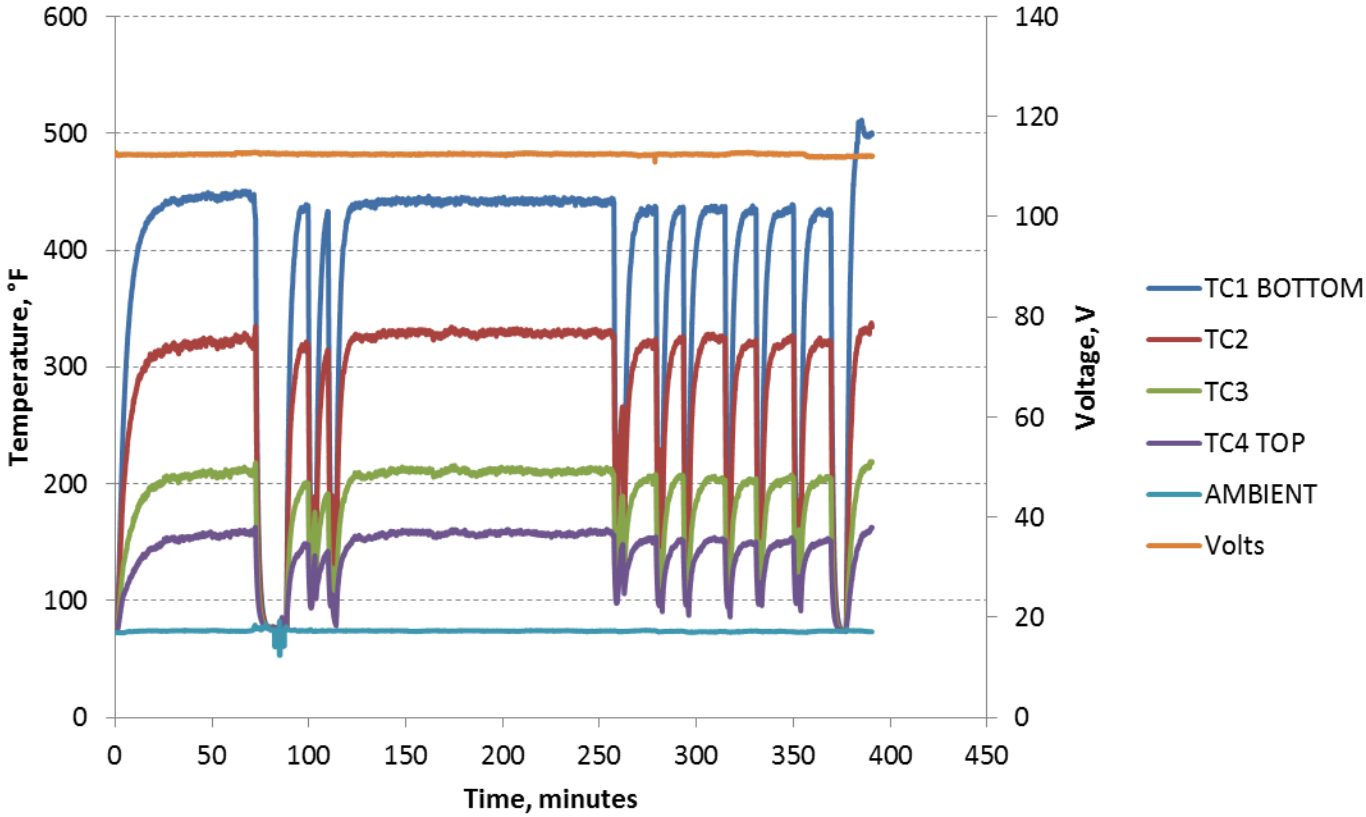

600
500
400
300
200
100
0
Temperature, °F
120
100
80
60
40
20
0
Voltage, V
375
376
377
378
379
380
381
382
383
384
385
Time, minutes
TC1 BOTTOM
TC2
TC3
TC4 TOP
AMBIENT
Volts

Repeatability Testing

- It is critical to establish repeatable test conditions in order to have repeatable test results
- A test procedure was developed to achieve similar test conditions in the chamber for every test
  - Initial chamber warm-up period about 1 hour

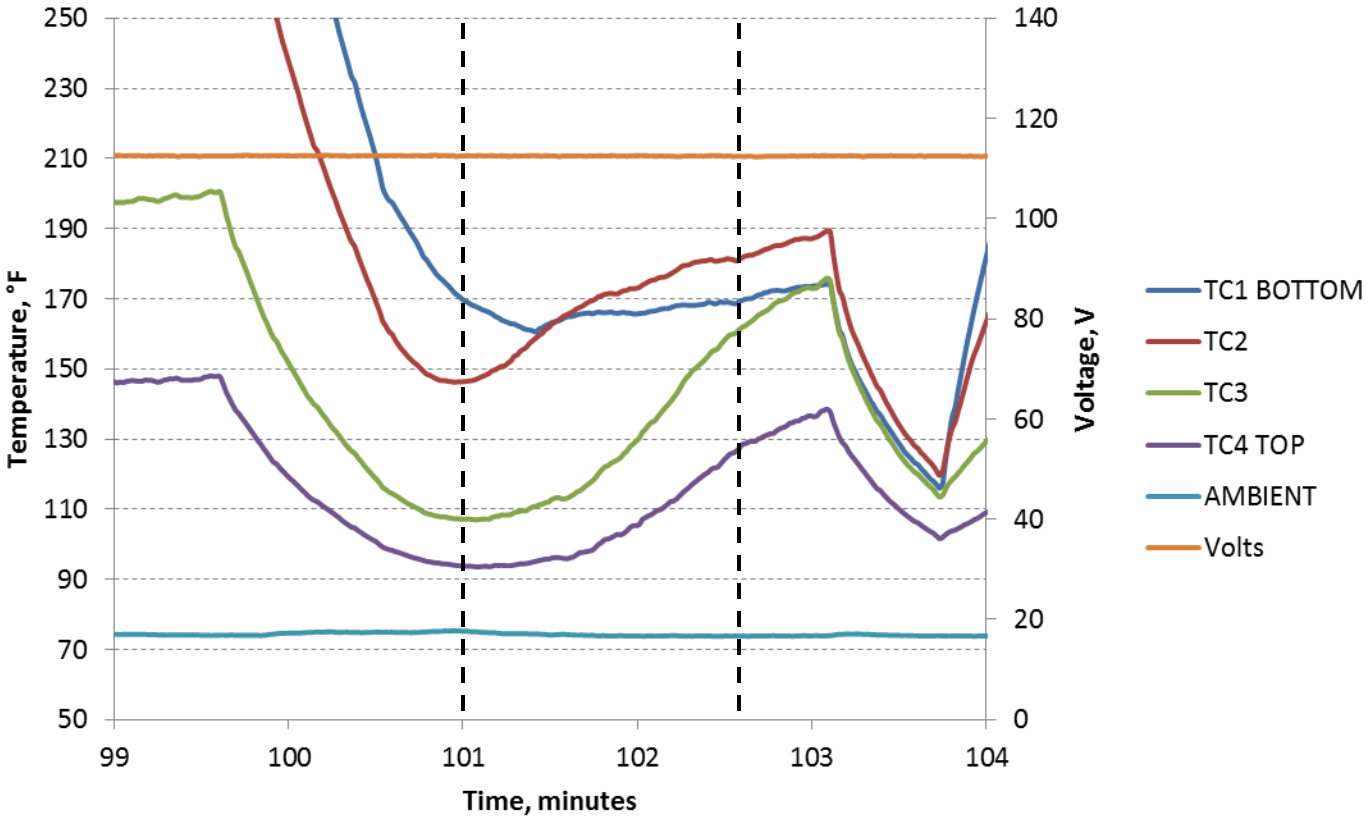
Repeatability Testing

- Test conditions were repeated for each test
  - Minimum 10 minute break between tests
- 2 materials tested
  - G10 Glass/Epoxy
  - ACF1 16 ply aerospace grade carbon fiber unidirectional layup, 350°F cure epoxy
  - Both sampels 1/8” thick (3.2 mm)



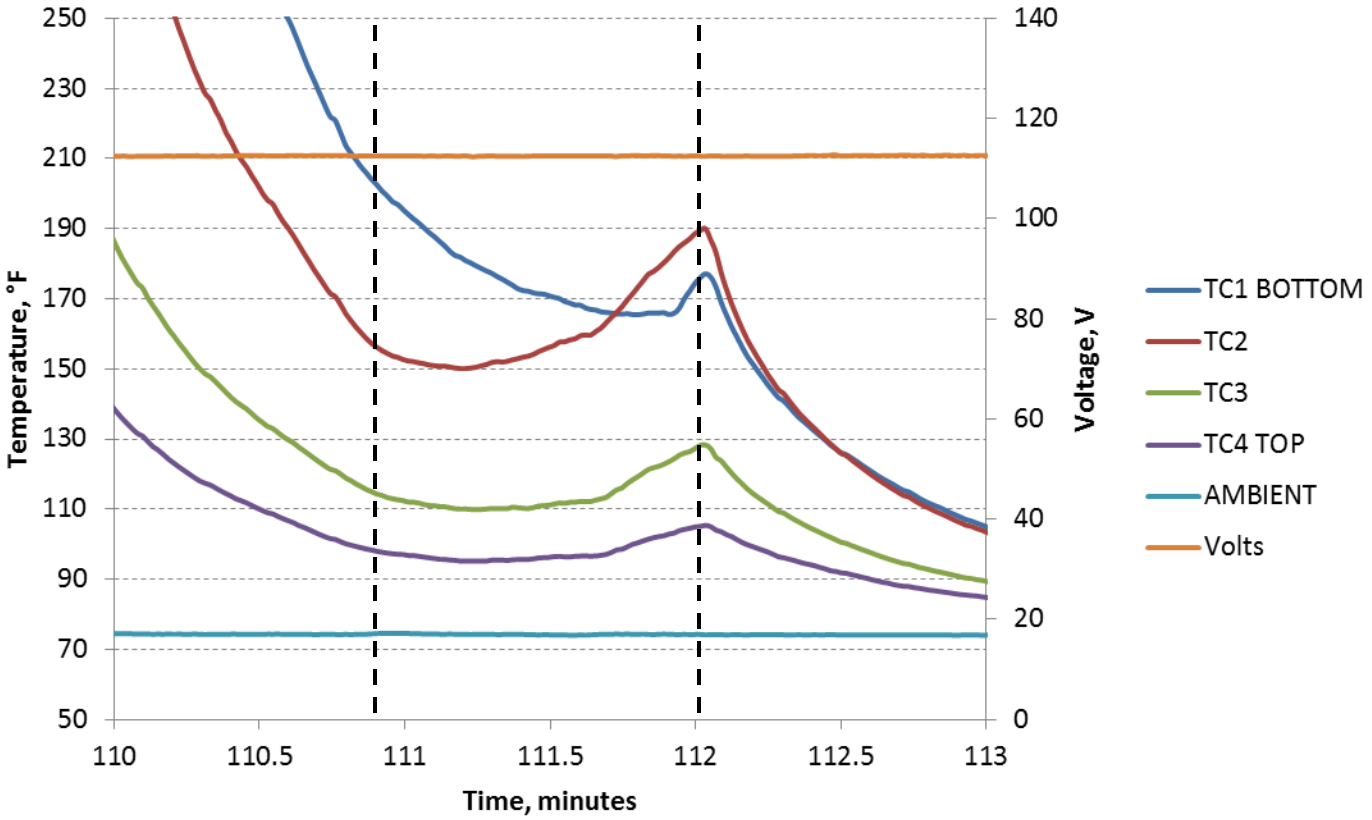
Glass-Epoxy T1 Backside Temperatures

- Burn Length
  - 5.33 in.
- Burn Width
  - 4.15 in.
- After Flame
  - 93 sec.

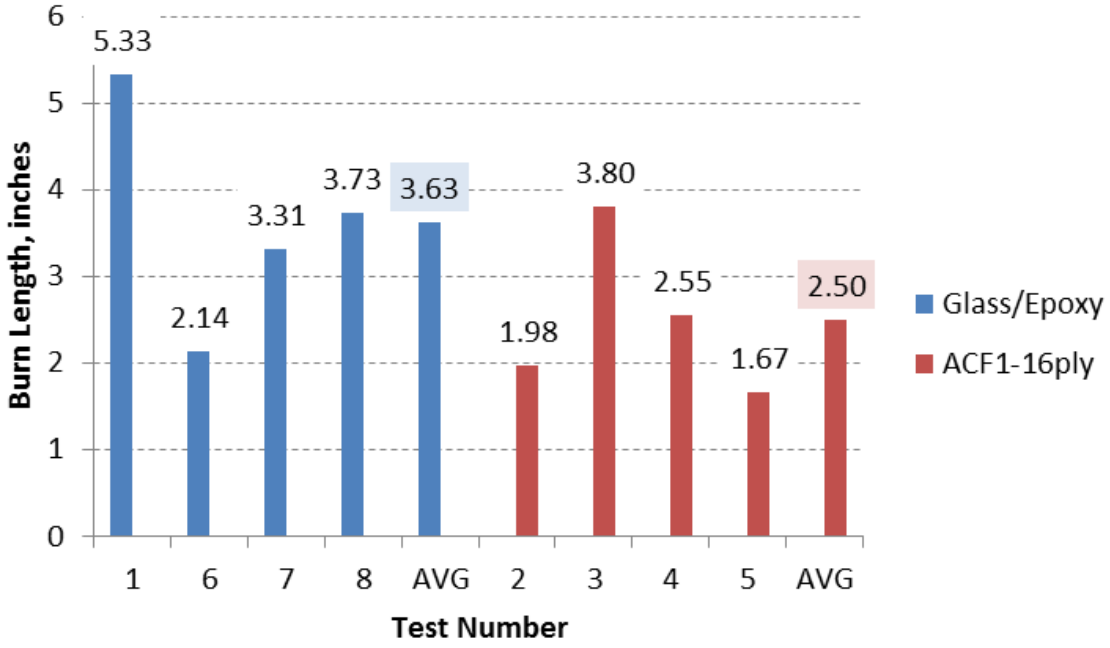


ACF1 16 ply T2
Backside Temperatures

- Burn Length
  - 1.98 in.
- Burn Width
  - 2.11 in.
- After Flame
  - 15 sec.



Test Results – Burn Length



- Overall, mean burn length shows that G-10 tends to propagate more than ACF1
- Previous foam block tests
  - G10: 16.5”
  - ACF1: 2.5-6.0”
- Consistency is not there yet
  - G10
    - %SD: 36.3%
  - ACF1
    - %SD: 37.6%

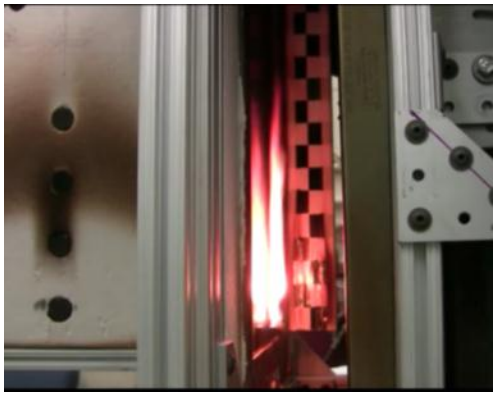
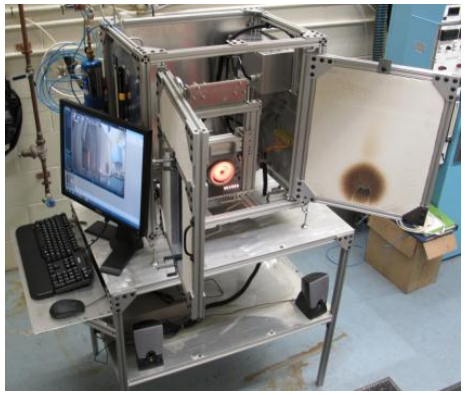
Next Steps

- Need to improve repeatability
  - Eliminated room/environment effects
  - TCs used to show steady state initial conditions
  - Standardized test procedure
- Possible material effects
  - Inconsistencies may be caused by materials
- Attempt pre-mixed pilot flame
  - Similar to NBS smoke chamber
  - Introducing air may help to
    - Reduce buoyancy
    - Provide more direct impingement to sample
    - Provide more repeatable first-layer penetration

Next Steps

- Continue construction of additional units to determine apparatus reproducibility



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