International Aircraft Materials Fire Test Working Group Meeting

Task Group Session on Revised Cargo Liner Test

Presented to: International Aircraft Materials Fire Test Working Group, Singapore

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Date: February 8-9, 2012

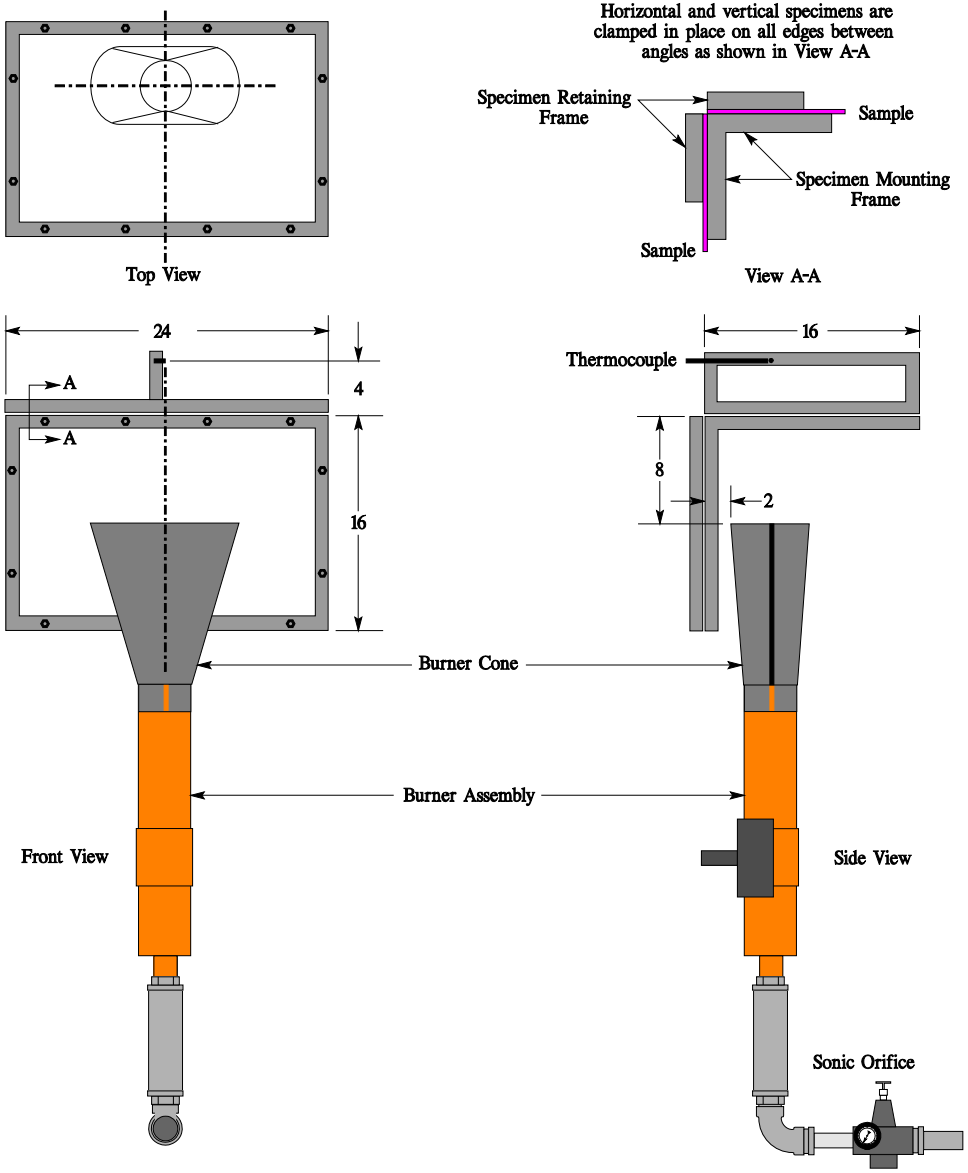


Figure CL-1. Test Apparatus for Horizontal and Vertical Mounting for Cargo Liner Oil Burner Testing

Summary of Activities: Apparatus

1. Generate calibration temperature results with FAATC Park burner apparatus
    - Results will be used to calibrate Sonic burner apparatus

Status: ***completed***. Significant base of calibration data compiled using Park burner

Summary of Activities: Apparatus

2. Generate test results with FAATC Park burner apparatus
    - Results will be used to correlate sonic burner (B/T times and temp vs. time plots)
    - 3 styles of liner and 1 PAN felt have been tested
    - 2 additional materials also tested

Status: ***completed***. Significant base of data compiled on various samples using Park burner

Summary of Activities: Apparatus

3. Construct new sonic burner apparatus using parts from Marlin Engineering

Status: ***completed***.

Determine impact of 90^{o} elbow position (repositioning will make apparatus much higher, but should calibrate easier)

Summary of Activities: Apparatus

4. Construct new calibration rake using 1/8-inch thermocouples **(completed)**

Summary of Activities: Apparatus

5. Construct test sample rig to fit sonic burner equipment.

Status: ***complete***.

Summary of Activities: Apparatus

6. Initial Set-up/Calibration of NexGen burner to match Park burner temperature results.

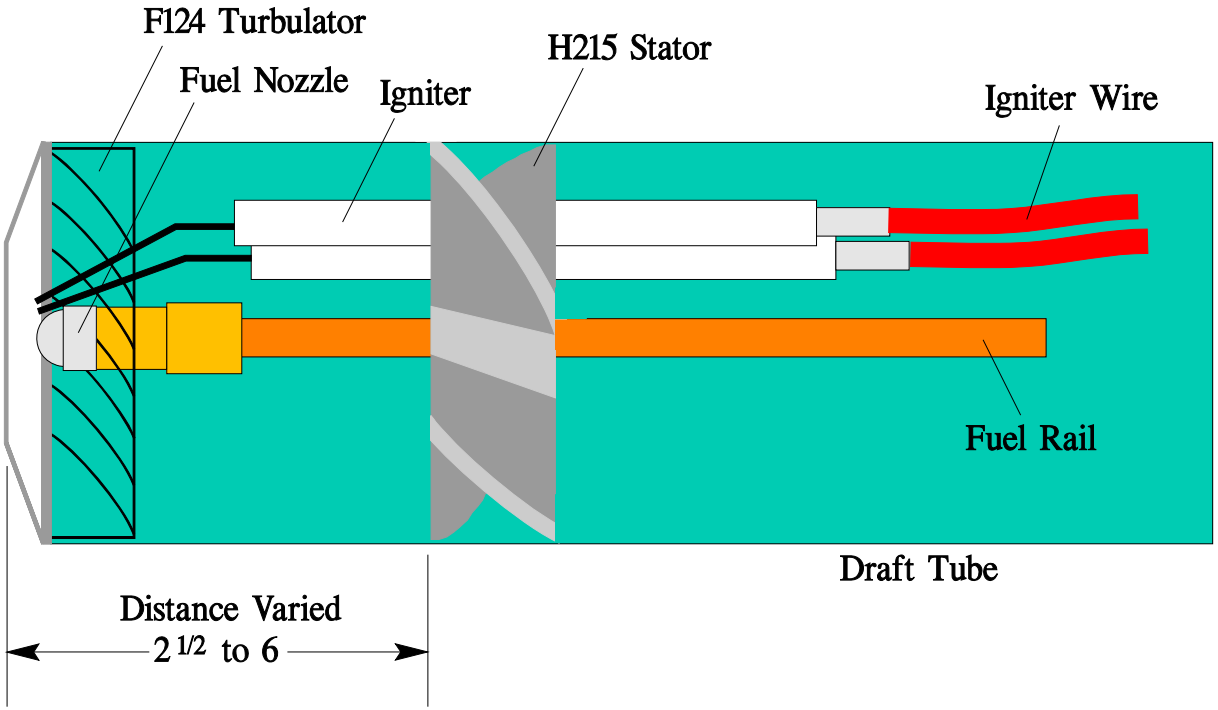
Status: ***in progress***.

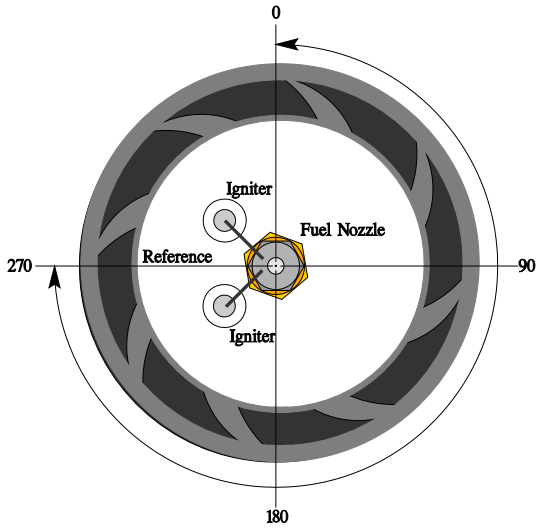
Initial Burner Settings and Calibration

- Calibration runs were conducted to determine an approximate starting point for the stator position
- Initially, the stator was tested in 8 different axial locations on the fuel rod, over a 3.5 inch range, in increments of 0.5 inches
- The stator was rotated through 4 different rotational orientations at each position

  = 32 unique stator positions tested
- It is necessary to vary both parameters as they have a combined affect on the flame
- The data was reviewed to determine an approximate “starting point” for stator settings
  - Based on flame temperature profile, or most even flame
- Best performance was shown to be with the stator face located ~3.0 inches from turbulator exit plane

Initial Burner Settings and Calibration





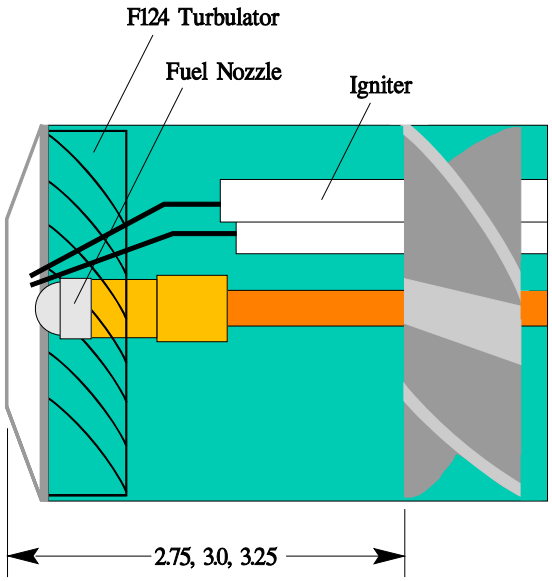
8 Positions (2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0) X 4 Angles (0º, 90º, 180º, 270º)

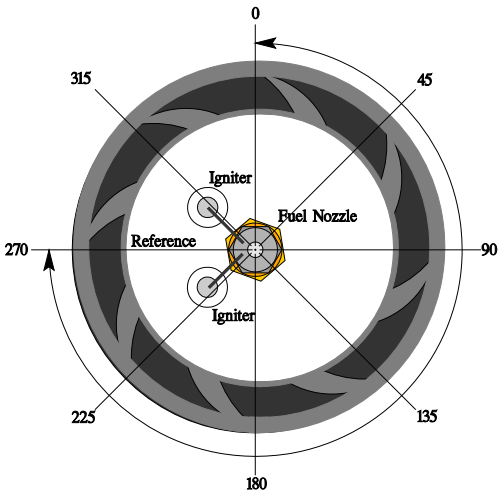
= 32 Combinations

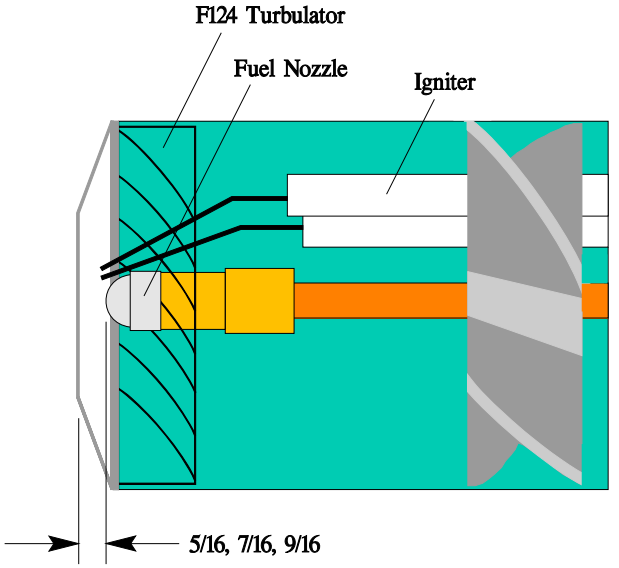
Refining Burner Settings

- Burner then tested using a number of smaller adjustments
- Stator face to turbulator exit plane varied:
  - 2.75, 3.0, and 3.25 inches (3 positions)
- Stator rotational position on fuel rod
  - 0-360° in increments of 45° (8 positions)
- Nozzle depth from turbulator exit plane
  - 5/16, 7/16, and 9/16 inches (3 positions)
- Total of 72 unique combinations tested

Refining Burner Settings







3 Positions X 8 Angles X 3 Depths

= 72 Combinations

= LOTS OF DATA

Continue Refining Burner Settings

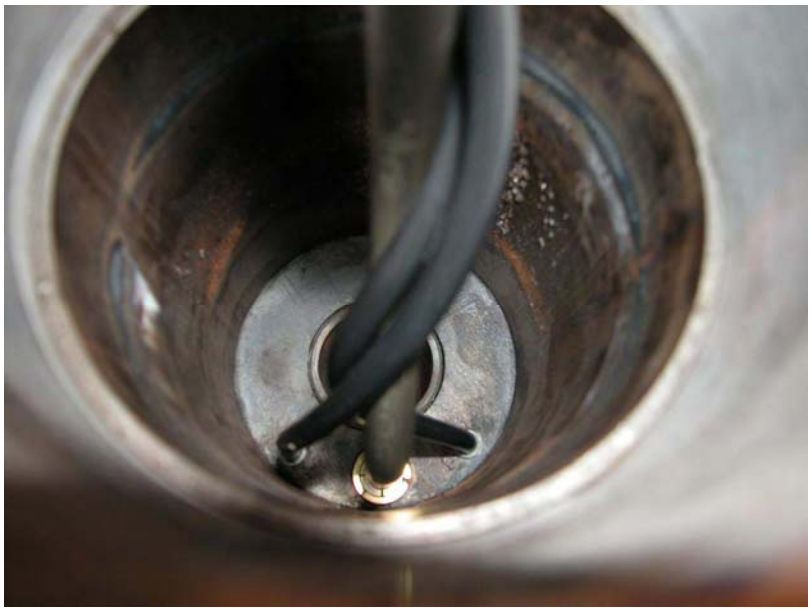
- Stator/nozzle position combinations were selected which showed adequate flame properties
  - Temperature distribution
  - Repeatability
  - Full, even flame coming from cone (visual)
- Of the 72 positions tested, only 10 seemed adequate for further testing
- The burner was then returned to these 10 settings and tested multiple times to prove repeatability
- The 10 positions were then reduced to 2 or 3 possible selections

Repeatability Issues

- During this process, some repeatability issues were noticed
- Unable to reproduce results although stator and nozzle settings were identical to previous tests
- Only other parts in burner which had changed position were ignition wires
- Keeping all other factors the same, changing the ignition wire positions proved to affect flame characteristics

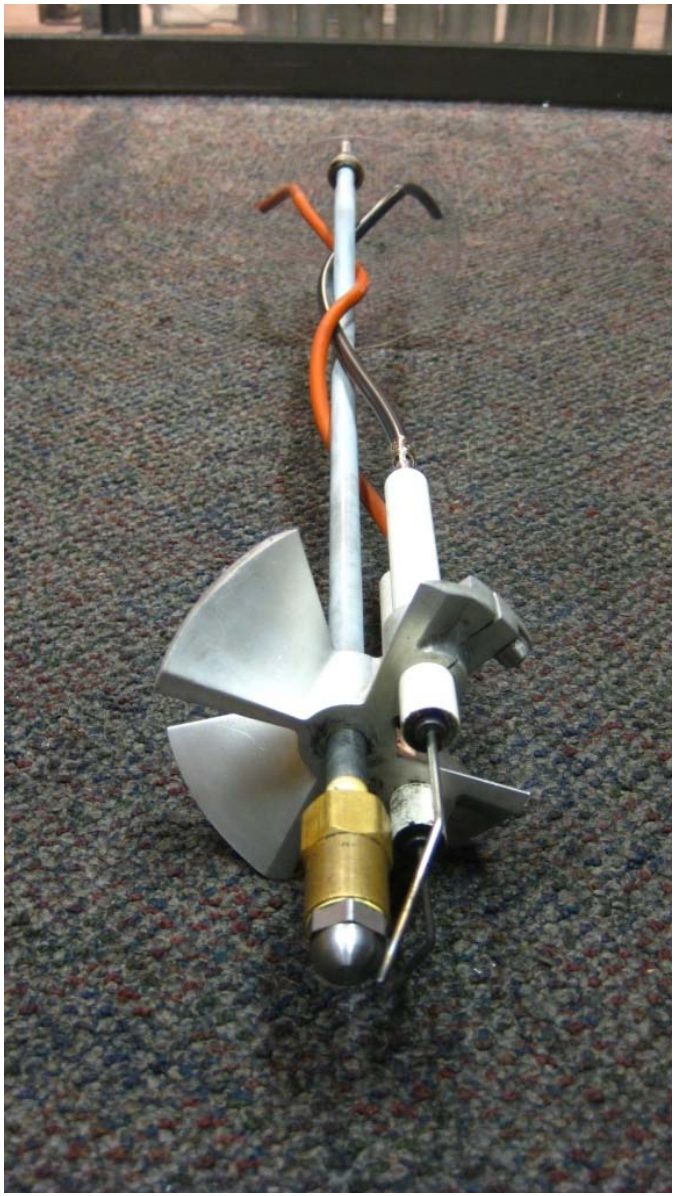
Ignition Wires

- **Ignition wires previously wrapped around fuel rod**
- **No standardized length or position for wires**
- **Position of wires can impede or redirect airflow within the draft tube and can affect the flame characteristics**

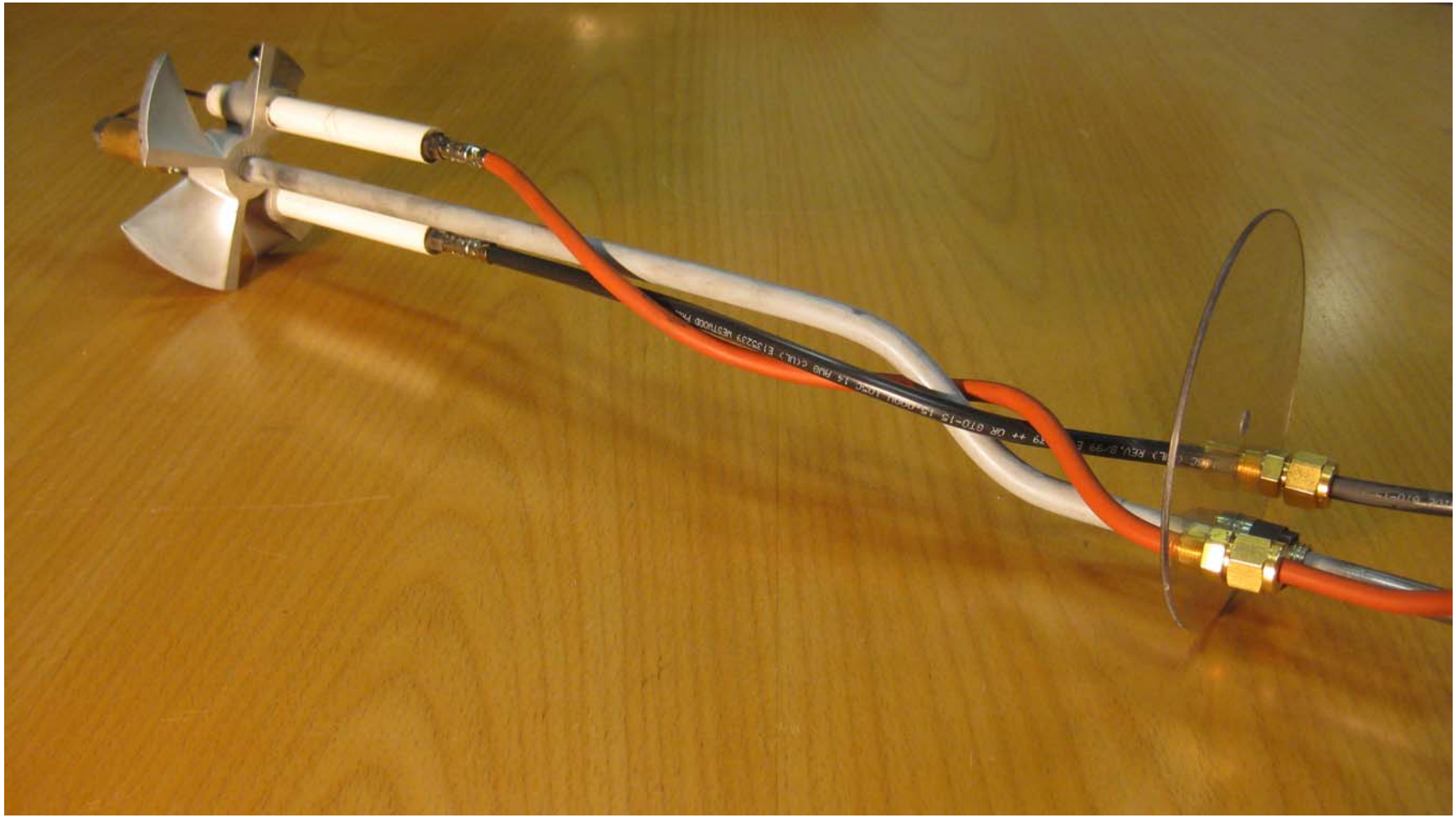


Ignition Wires

- New wire length and positions minimize the airflow disturbance
- Standardized wire position minimizes variability in burner performance and data results
- Improved repeatability

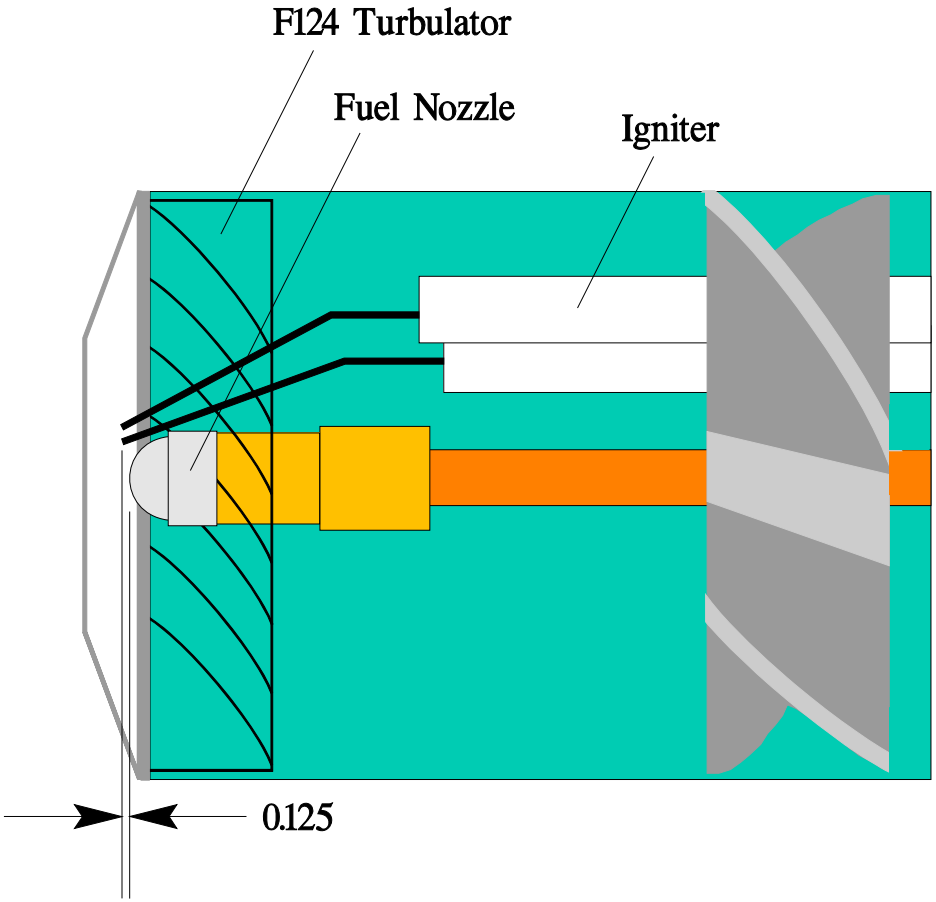


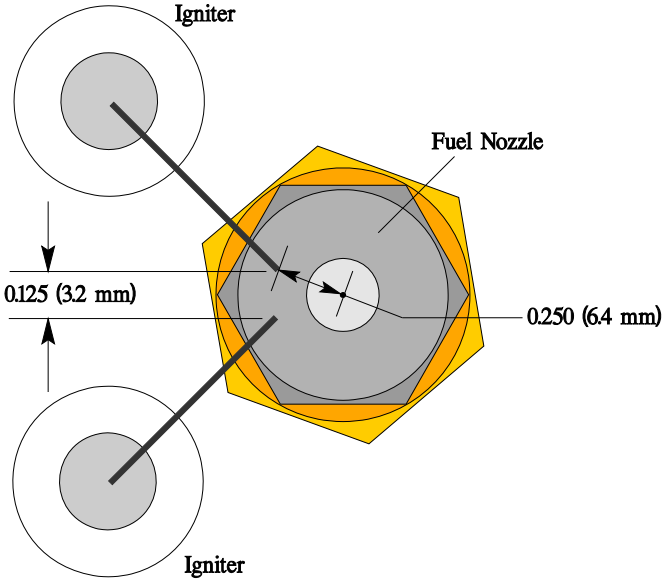
New Ignition Wire Positions



* Determine length of wire, including connector

Igniter Positions





Primary Burner Settings Impacting Calibration

- **Fuel Nozzle Depth**
  - Distance from turbulator exit plane
- **Stator Position**
  - Axial and rotational position on fuel rod
- **Ignition Wires**
  - Length, location, and path within burner tube
- **Igniters**
  - Location in relation to each other and nozzle

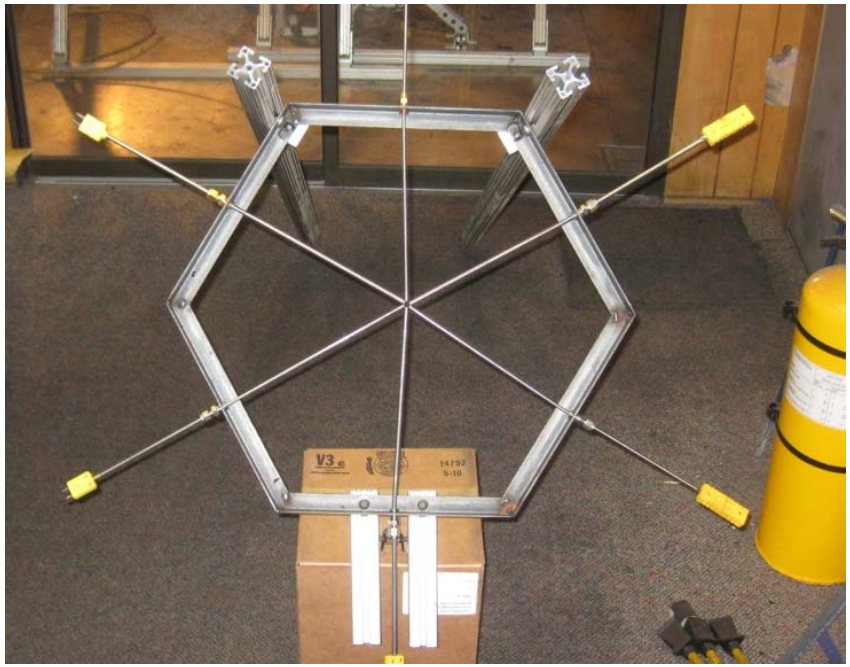
Thermocouple Degradation

- Repeated extreme heat cycling by taking thermocouples from room temperature to flame temperature (~1800°F) can cause them to read incorrectly
- The more the thermocouples are heat cycled, the worse the problem becomes
- Smaller diameter thermocouples are more susceptible to this due to their lower mass
- It was believed that a larger diameter thermocouple with more mass should not heat as quickly, and not be affected to the same extent as the smaller thermocouples

Large Thermocouple Test Rig

- Purpose: To test different diameter thermocouples from different manufacturers all measuring at the same point in the flame
- Manufacturers: JMS, Omega, ThermoElectric
- Thermocouple Sizes: 3/16 and ¼ inch

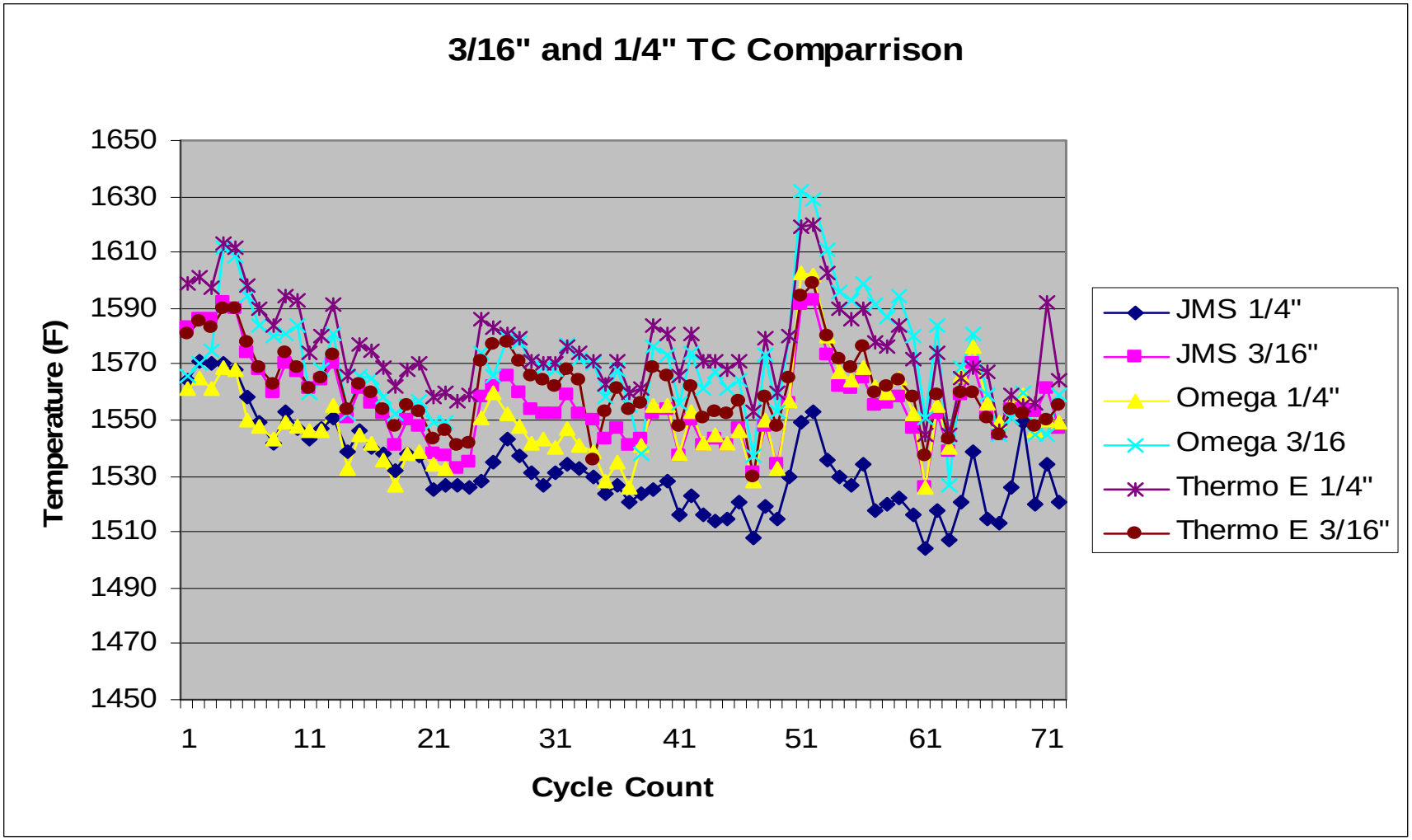
Large Thermocouple Test Rig



Large Thermocouple Test Rig

- Process: The burner was run and thermocouples heated for 3 minutes. Data was collected over a 30-second period and averaged. The burner was shut down and thermocouples allowed to cool until all read below 200°F. This process was then repeated.
- Results: Inconclusive
  - Not clear if larger diameter thermocouples are an improvement over smaller diameter thermocouples
  - Burner performance may be slightly different from one day to the next
  - Data still shows general downward temperature trend
  - Larger thermocouples have noticably longer response time

Larger TC Test Rig



Planned Activities (from October 2011)

Finalize burner settings by conducting temperature calibrations 

Complete testing of samples to ensure sonic equivalency to Park (iterative process)

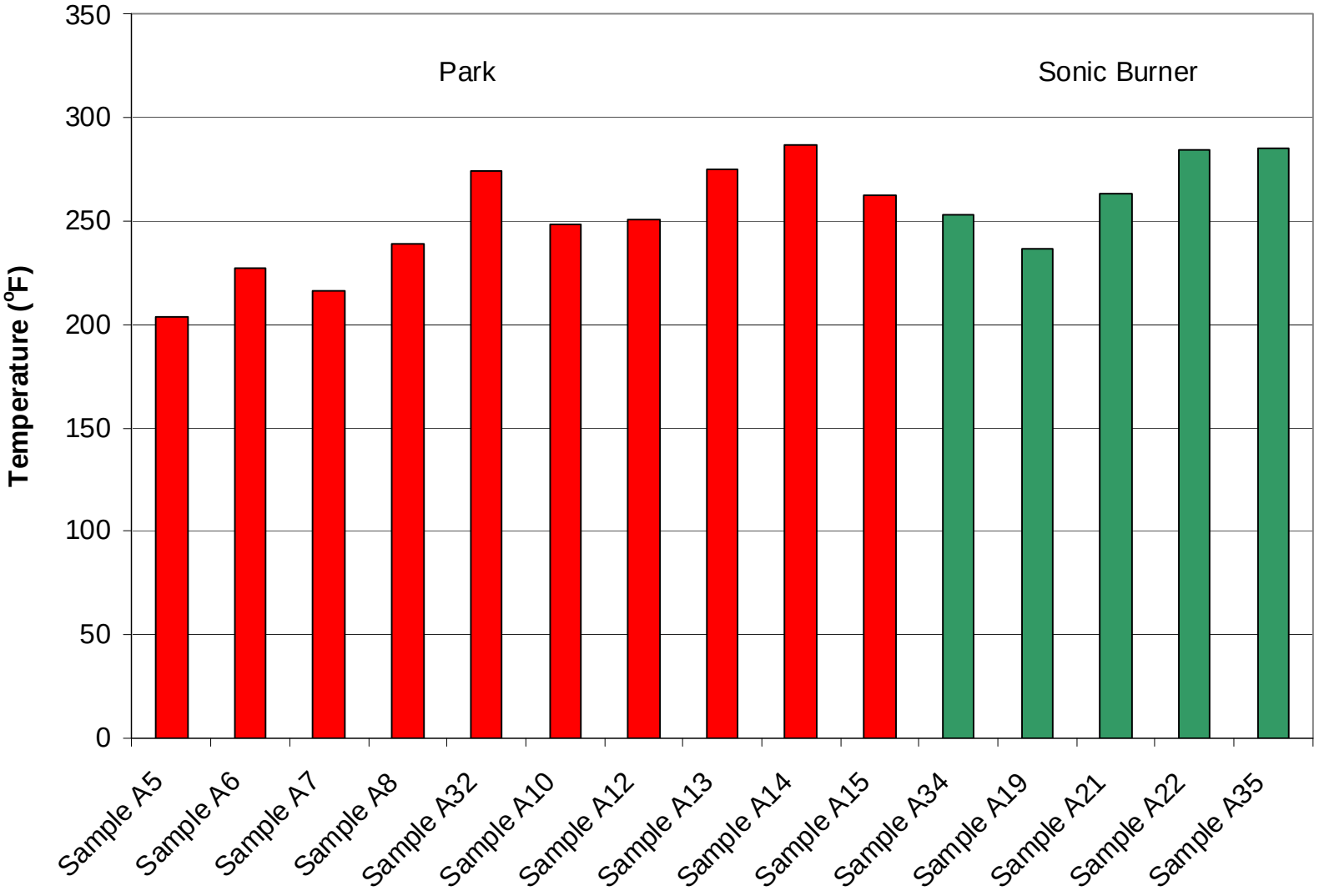
Average of NexGen test results must be within 5-10% of Park burner results??

Check comments from KSN site and incorporate changes to test procedure

Development of advisory material for cargo design features? Possible ARAC recommendation

Conduct Round Robin?

Maximum Temperature above Test Specimen, Thick Liner



Questions?