Development of a Next-Generation Burner for Testing Thermal Acoustic Insulation Burnthrough Resistance

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Outline

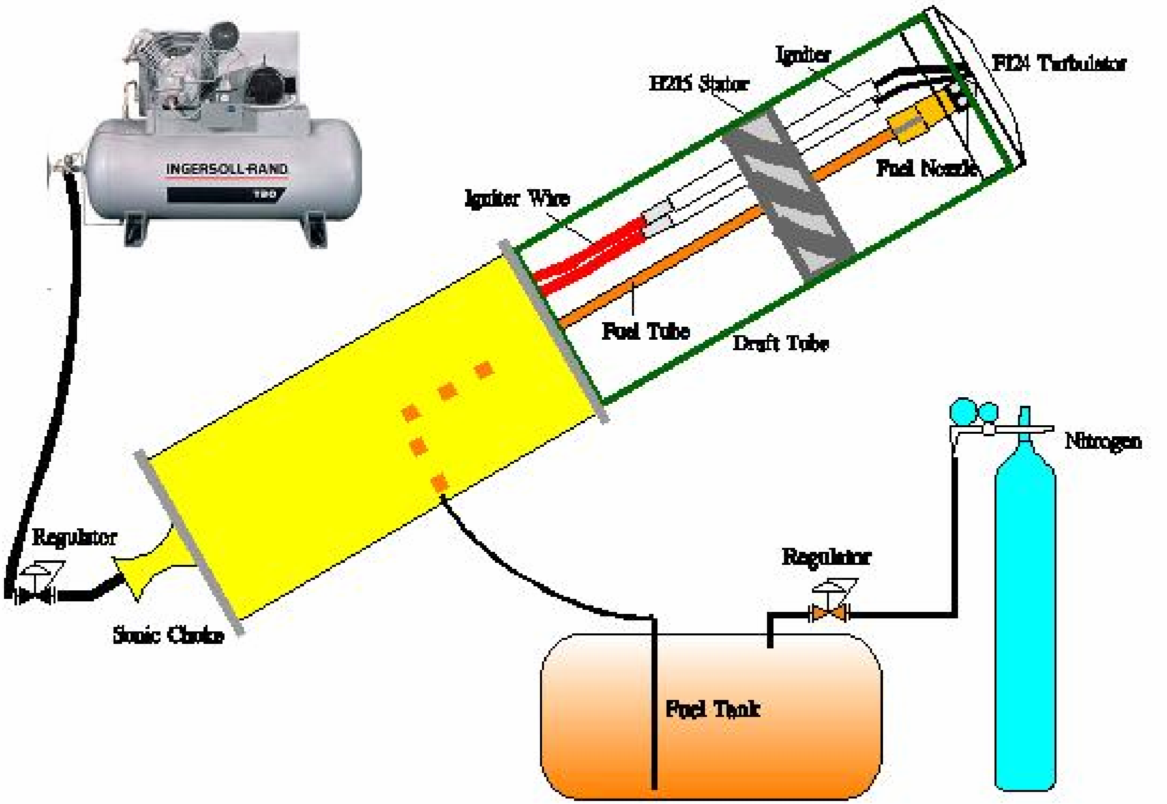
- Background
- Next Generation Burner Design
- Operational Parameters
- Proof of Concept
- Construction and Calibration of Multiple NexGen Burners
- Comparative Testing of NexGen Burners at Various Locations

Background

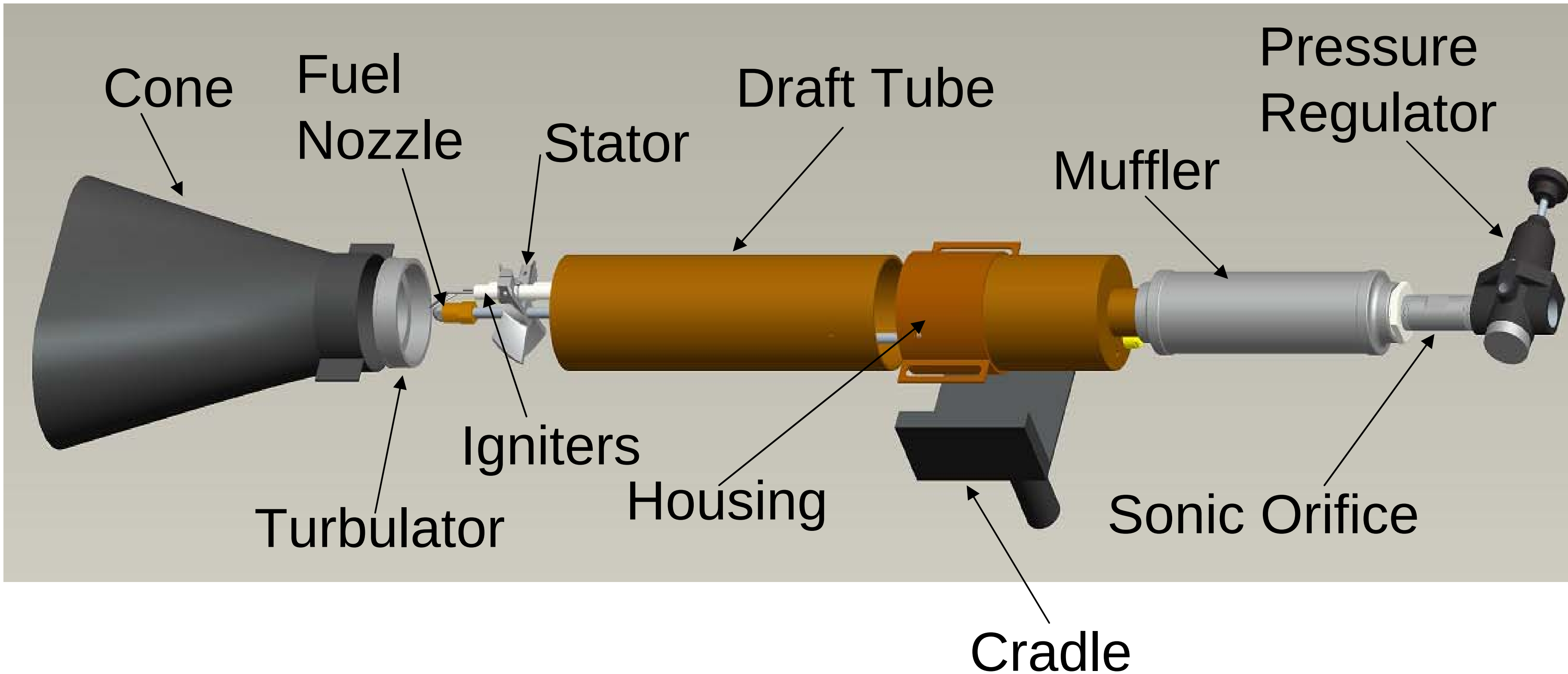
- **Final Rule on thermal acoustic insulation burnthrough was issued in August 2003, but the compliance date was delayed until September 2009**
  - Airframe manufacturers had concerns with the availability and reliability of the specified test apparatus (Park DPL 3400 oil burner)
    - The Park oil burner was found to be out of production
    - Two different types of DPL 3400 were manufactured over the years, producing different flames

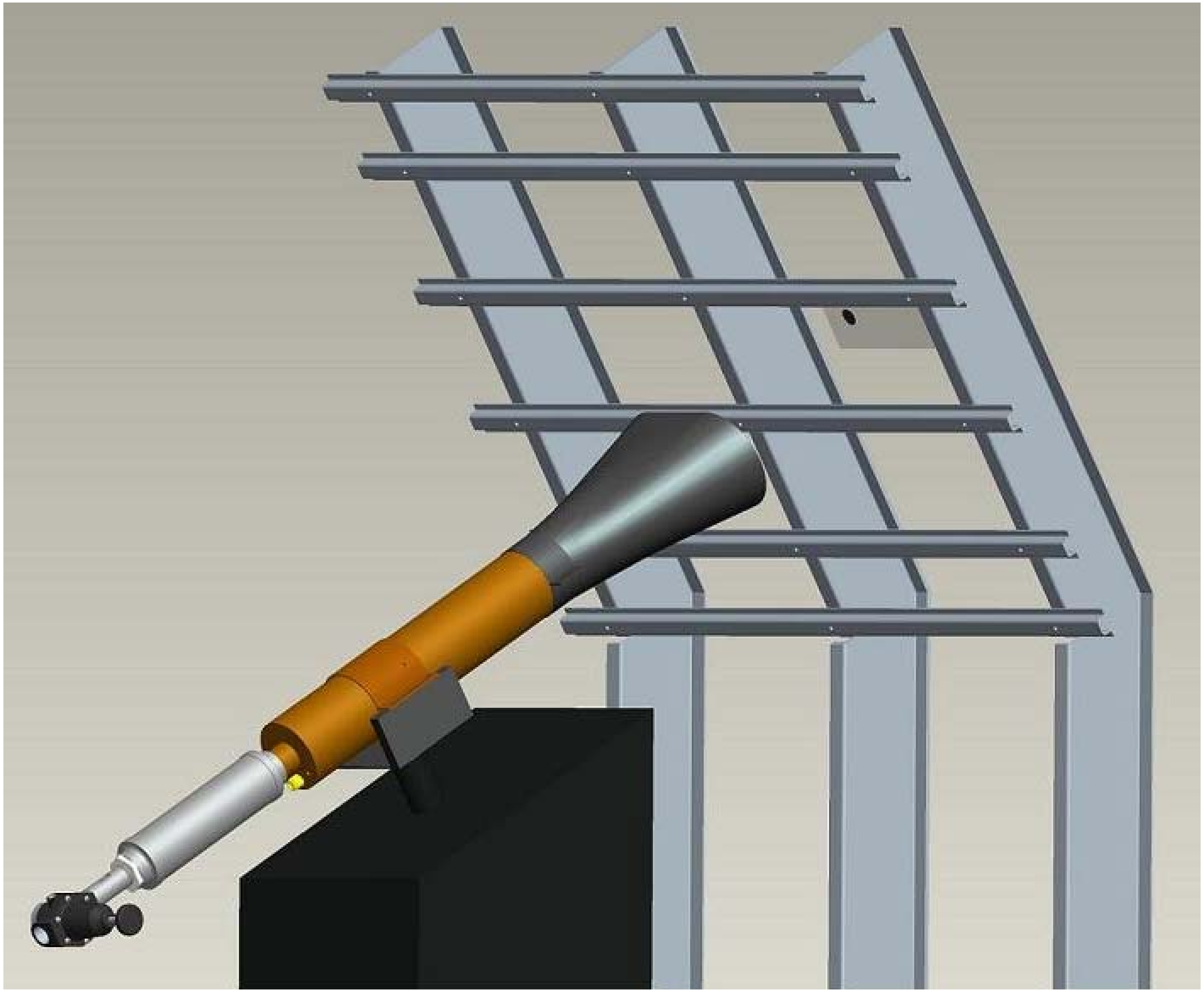
NexGen Burner Concept

- **Initial Concept:**
  - Compressed air metered with a sonic nozzle (critical flow venturi)
  - Fuel provided by a pressurized fuel tank
  - Utilize the original Park draft tube components
    - Stator
    - Igniters
    - Nozzle
    - Turbulator
  - By using the same components and matching the air velocity and fuel flow rate, the overall character of the flame is unchanged

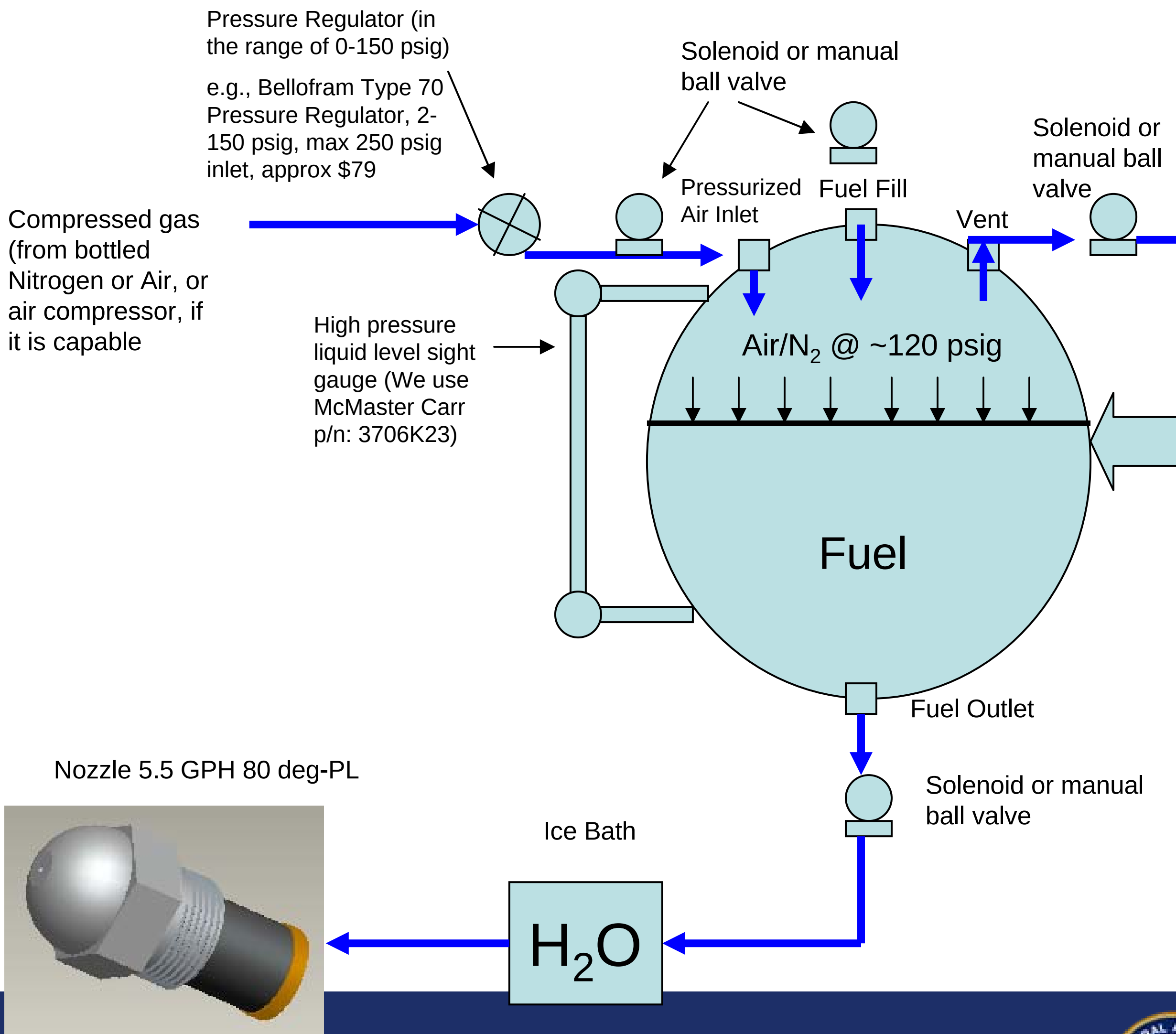


NexGen Burner Design





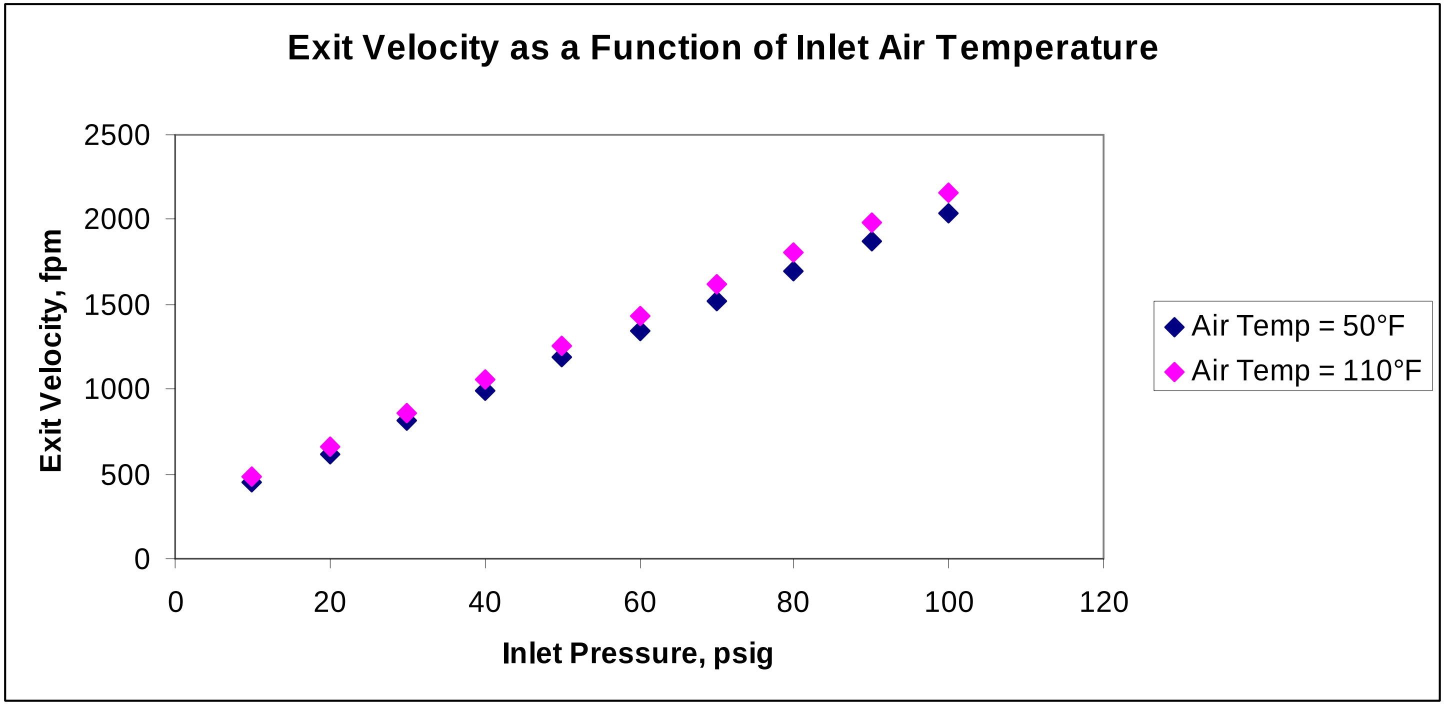
Pressurized Fuel System

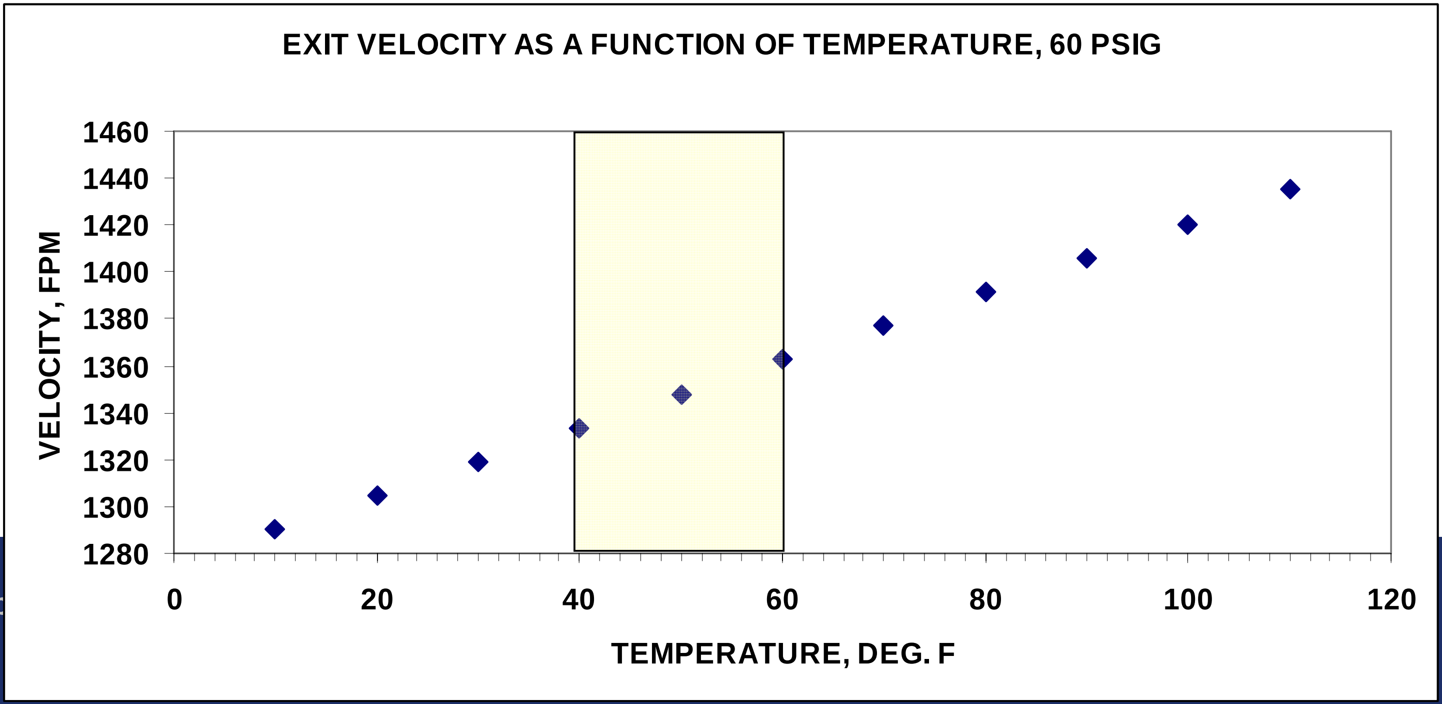


Pressure Vessel (for example, McMaster-Carr p/n 1584K7, ASME-Code Vertical Pressure Tank W/O Top Plate, 15 Gallon Capacity, 12" Dia X 33" L, $278.69) or any suitable pressure vessel that can withstand pressures of around 150 psig.

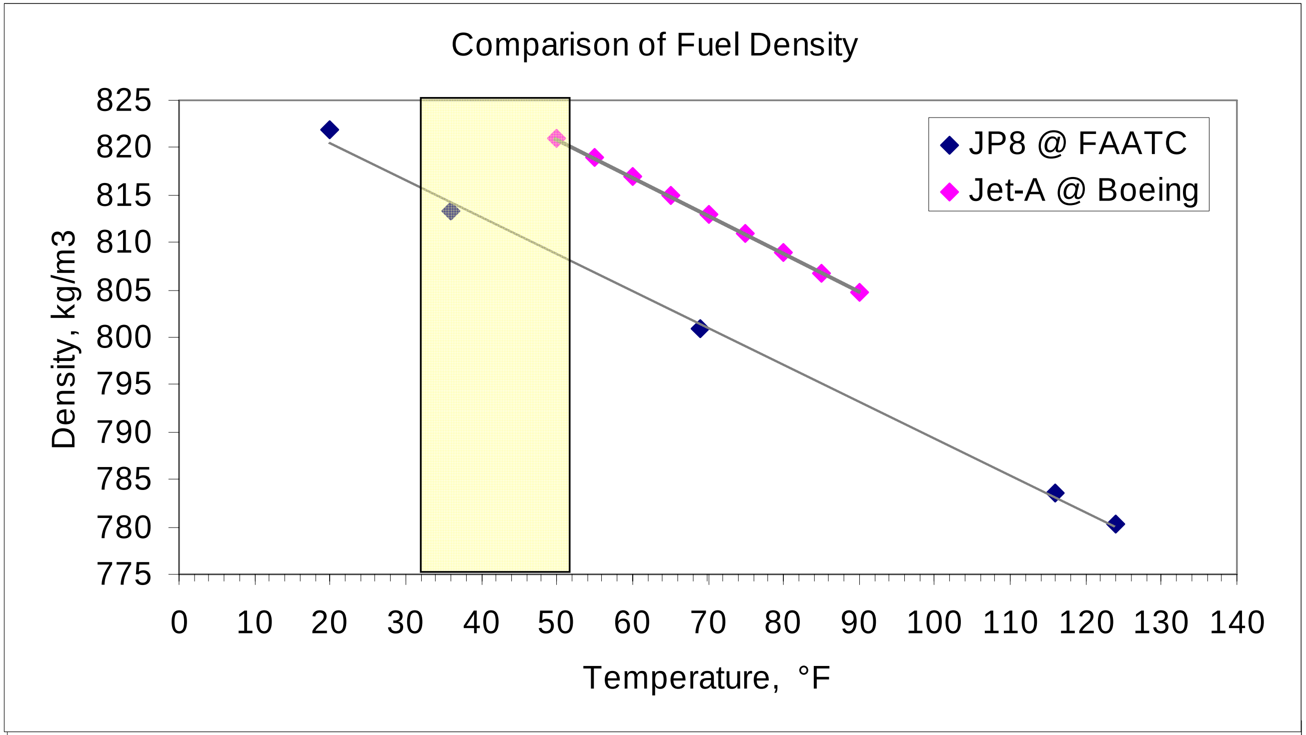
This schematic is pretty basic. You can supplement this design with whatever instrumentation you would like to obtain the required data or to make for easier operation. Some examples would be a pressure transducer, remotely operated solenoid valves, fuel flow meter, etc.

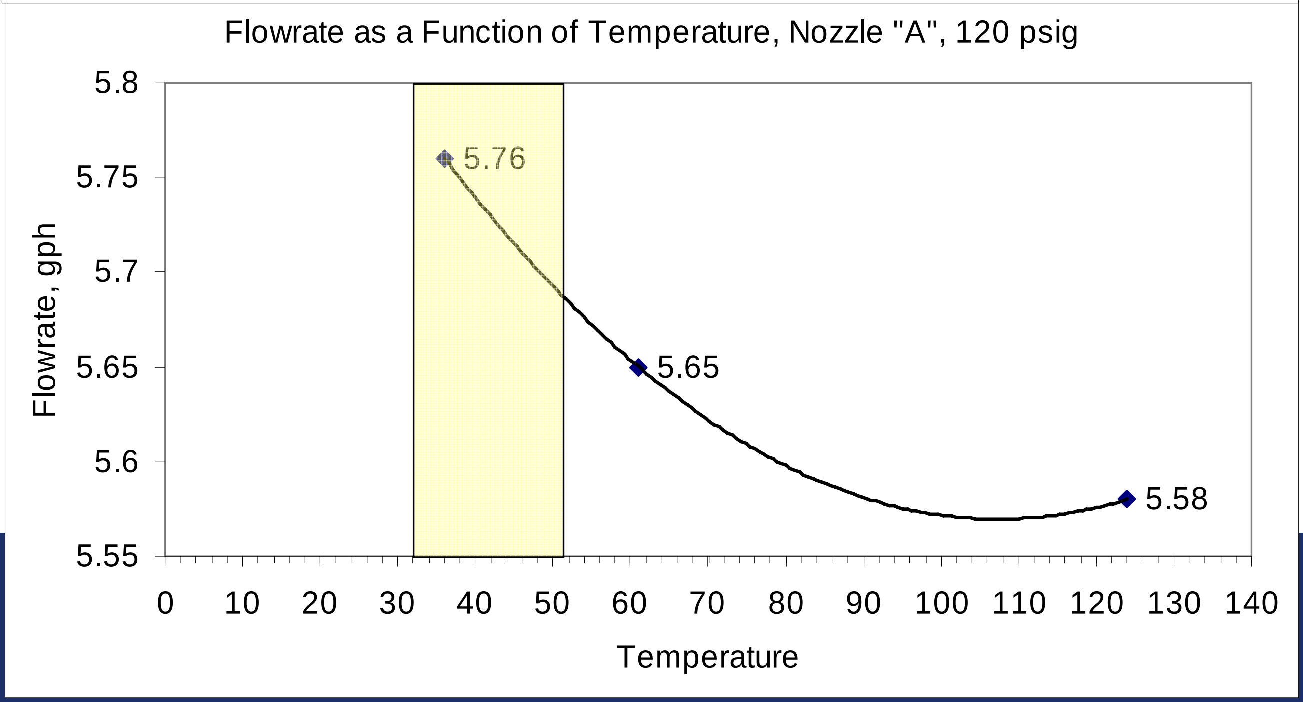
Air Velocity Observations



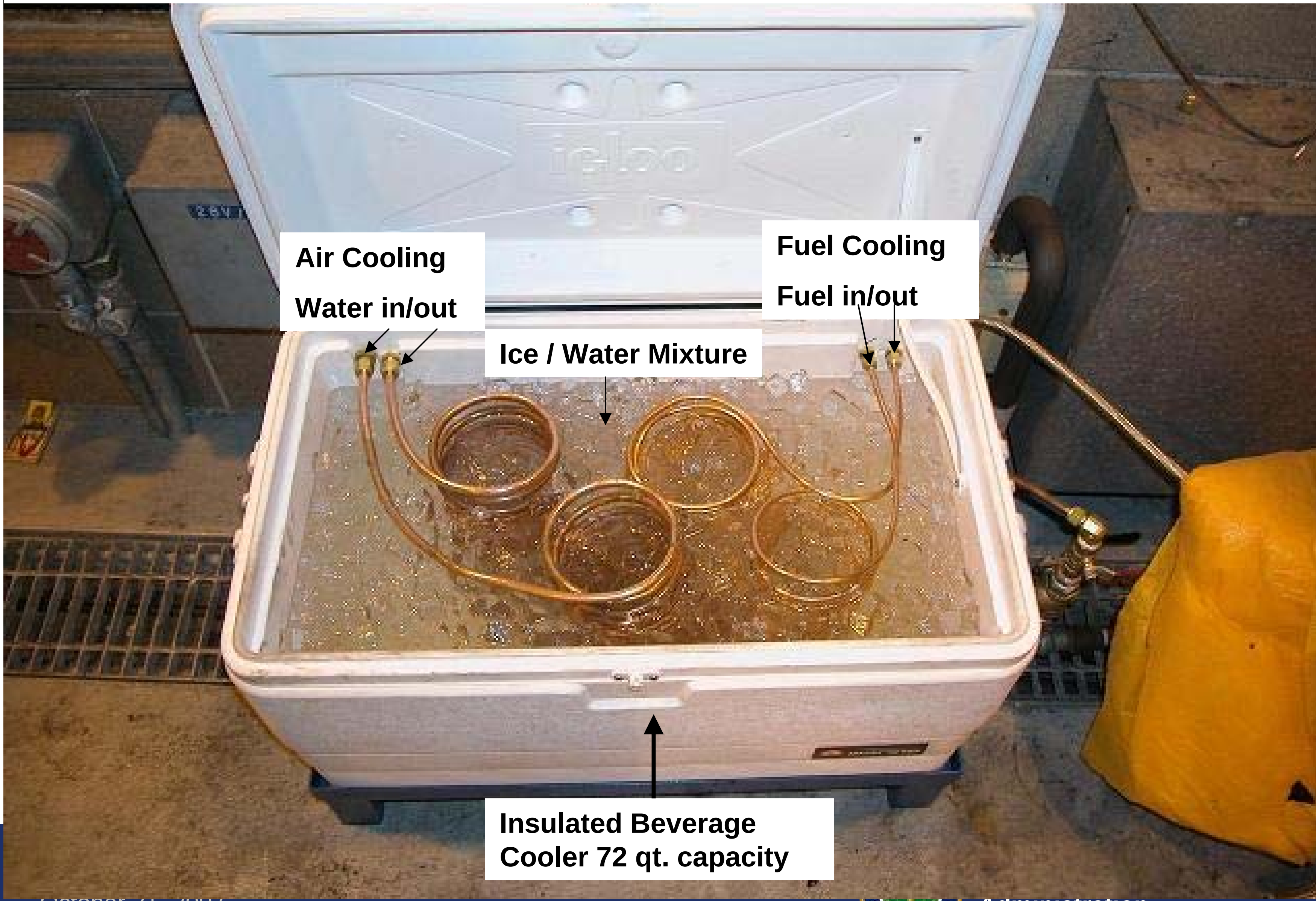


Fuel Temperature Observations



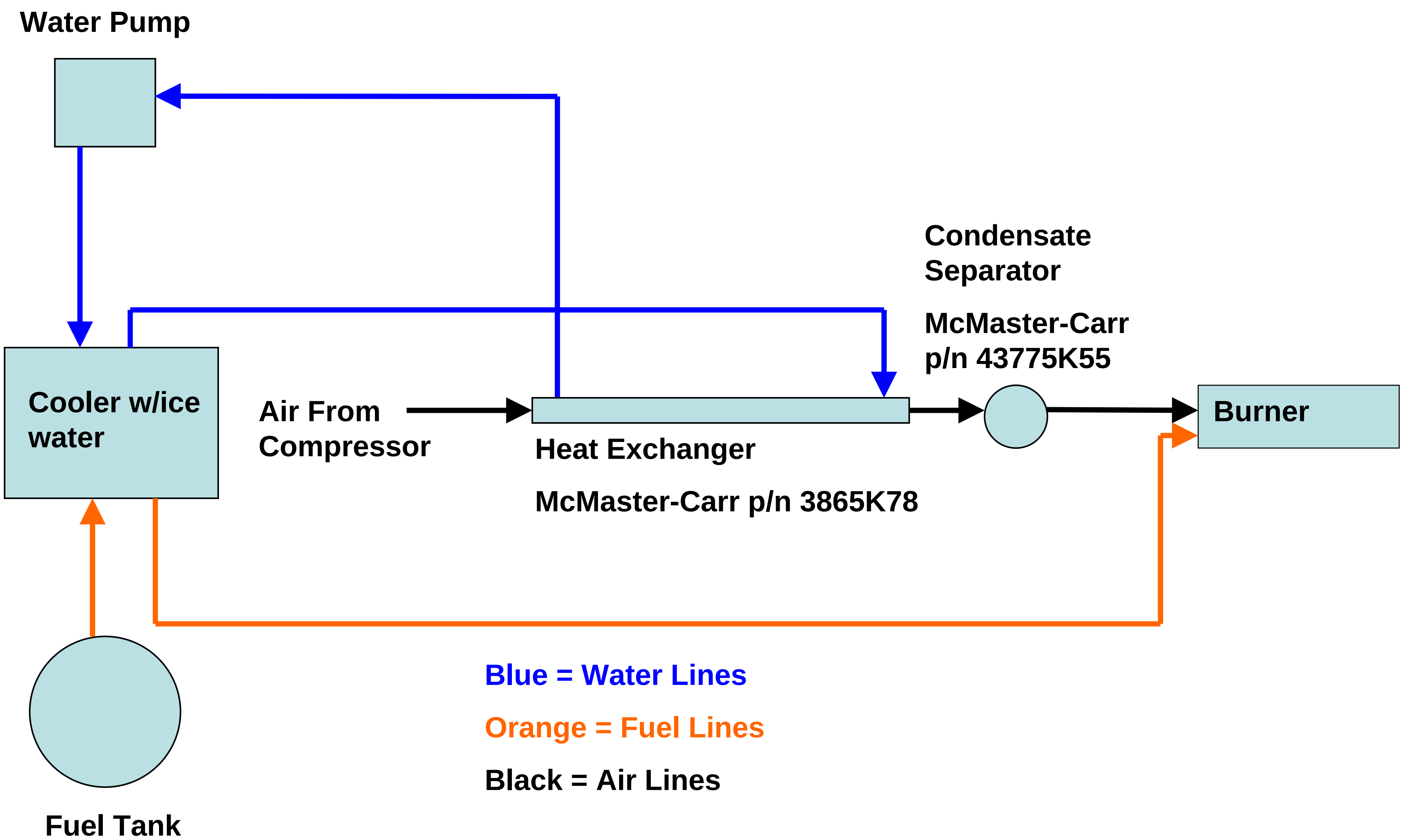


Ice Bath



Air Cooling
Water in/out
Fuel Cooling
Fuel in/out
Ice / Water Mixture
Insulated Beverage
Cooler 72 qt. capacity

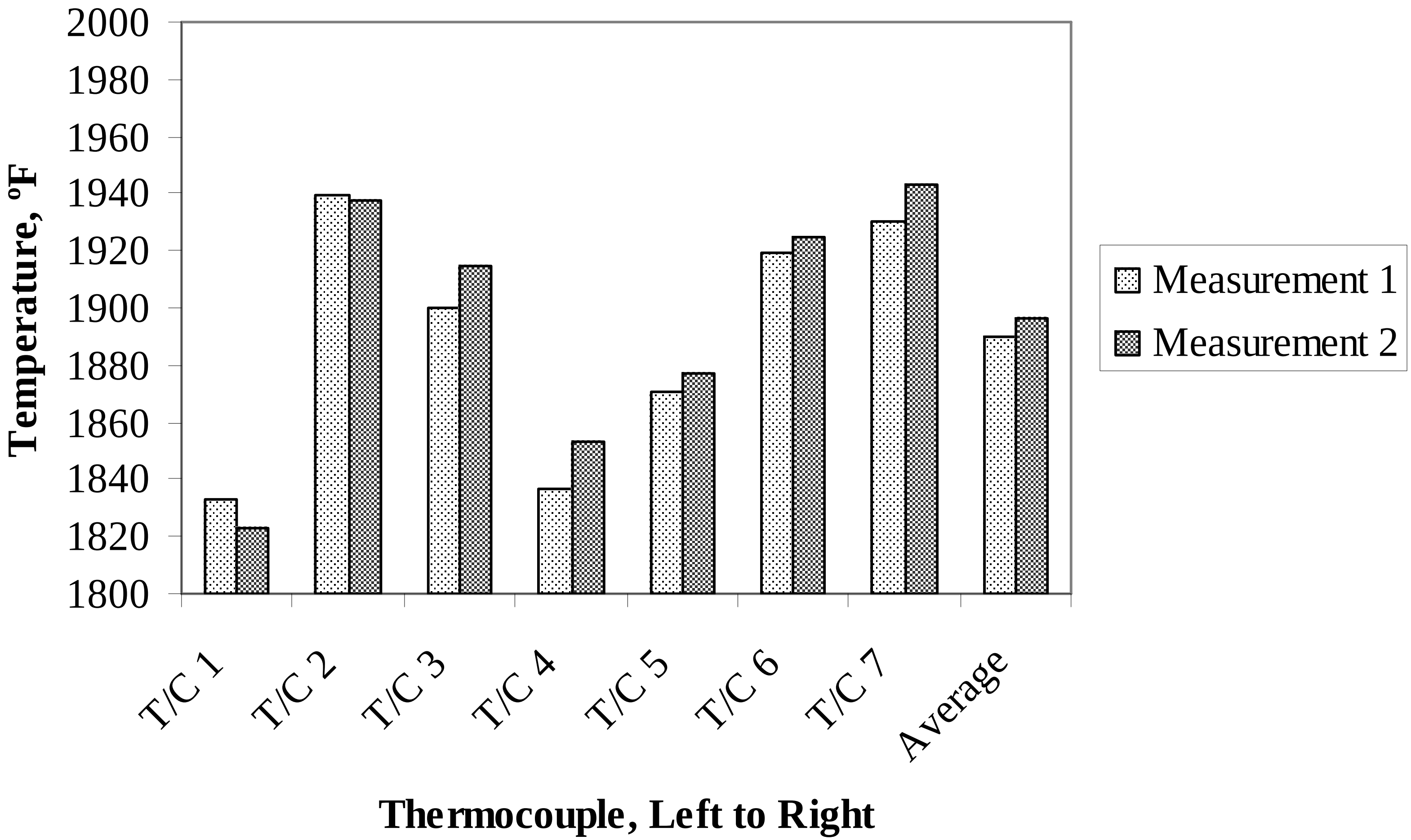
Heat Exchange System



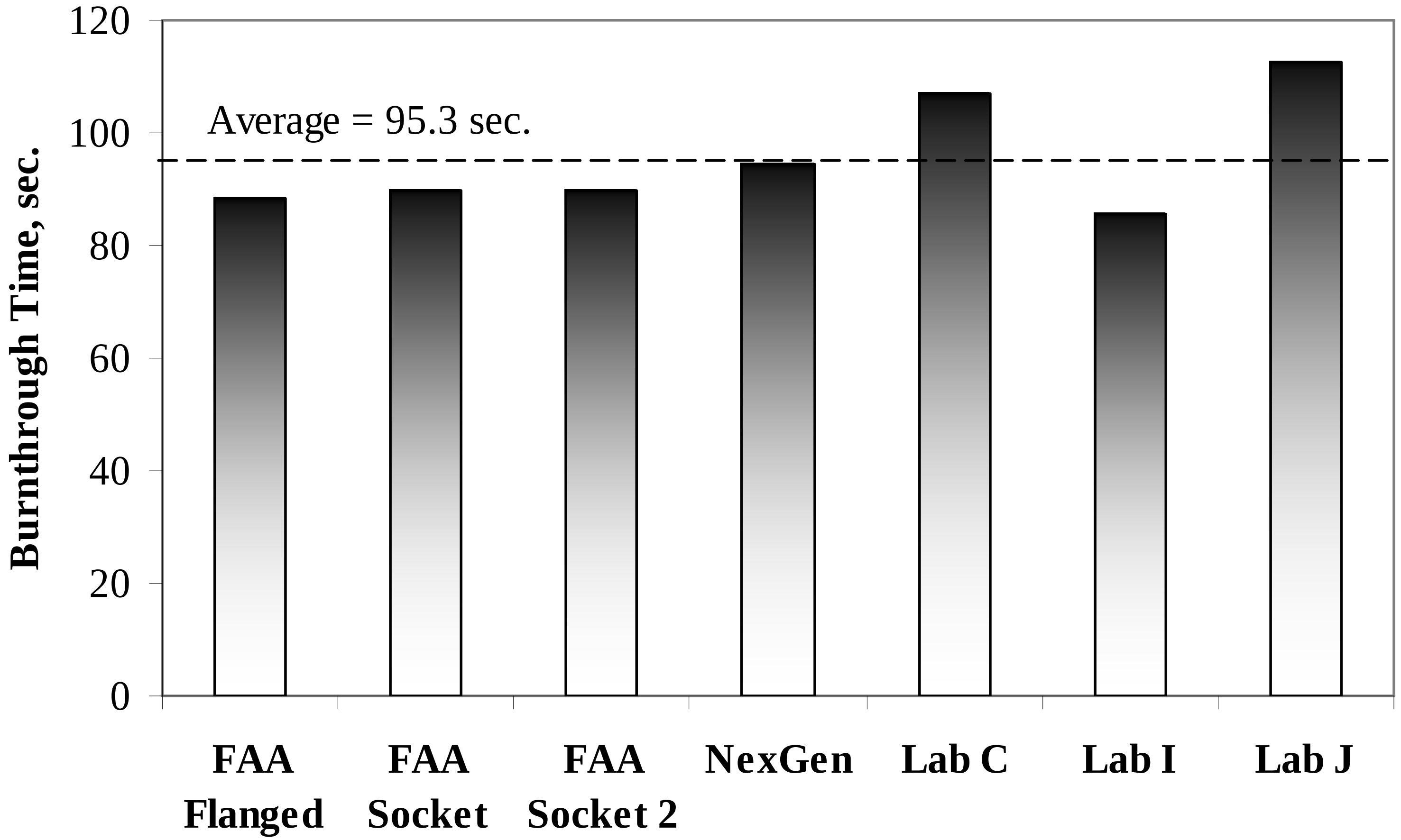
Burner Operational Parameters

- **Fuel**
  - Type: JP8, Jet A or equivalent
  - Nozzle: Monarch 5.5 gph 80°PL
  - Pressure: 120 psig (±2 psig)
  - Temperature: 42°F (±10°F)
  - Flowrate: 6.0 gph (±0.3 gph)
- **Air**
  - Pressure: 60 psig (±2 psig)
  - Temperature: 50°F (±10°F)
  - Mass Flow Rate: 66 SCFM (dictated by pressure)

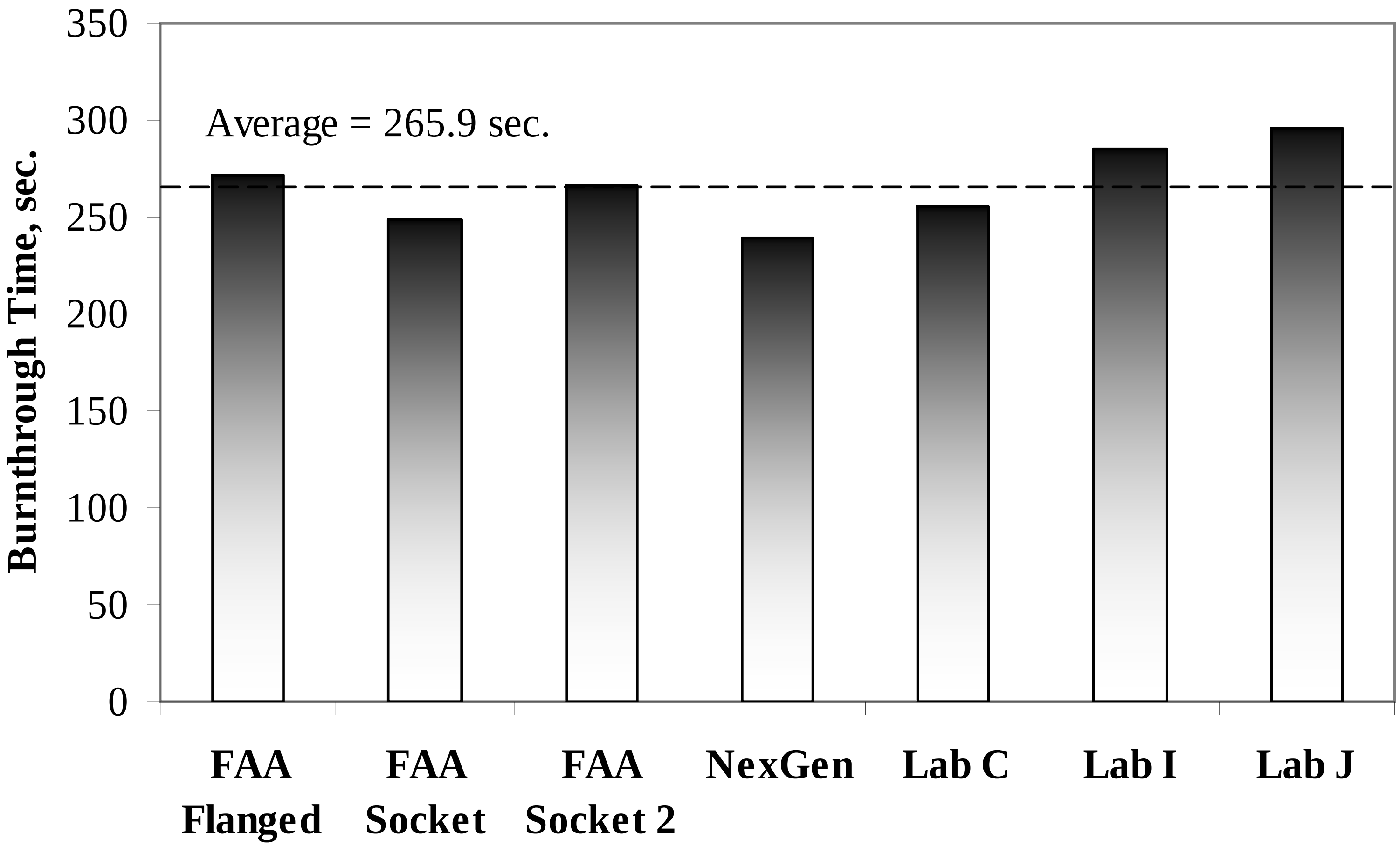
Flame Temperature Measurement



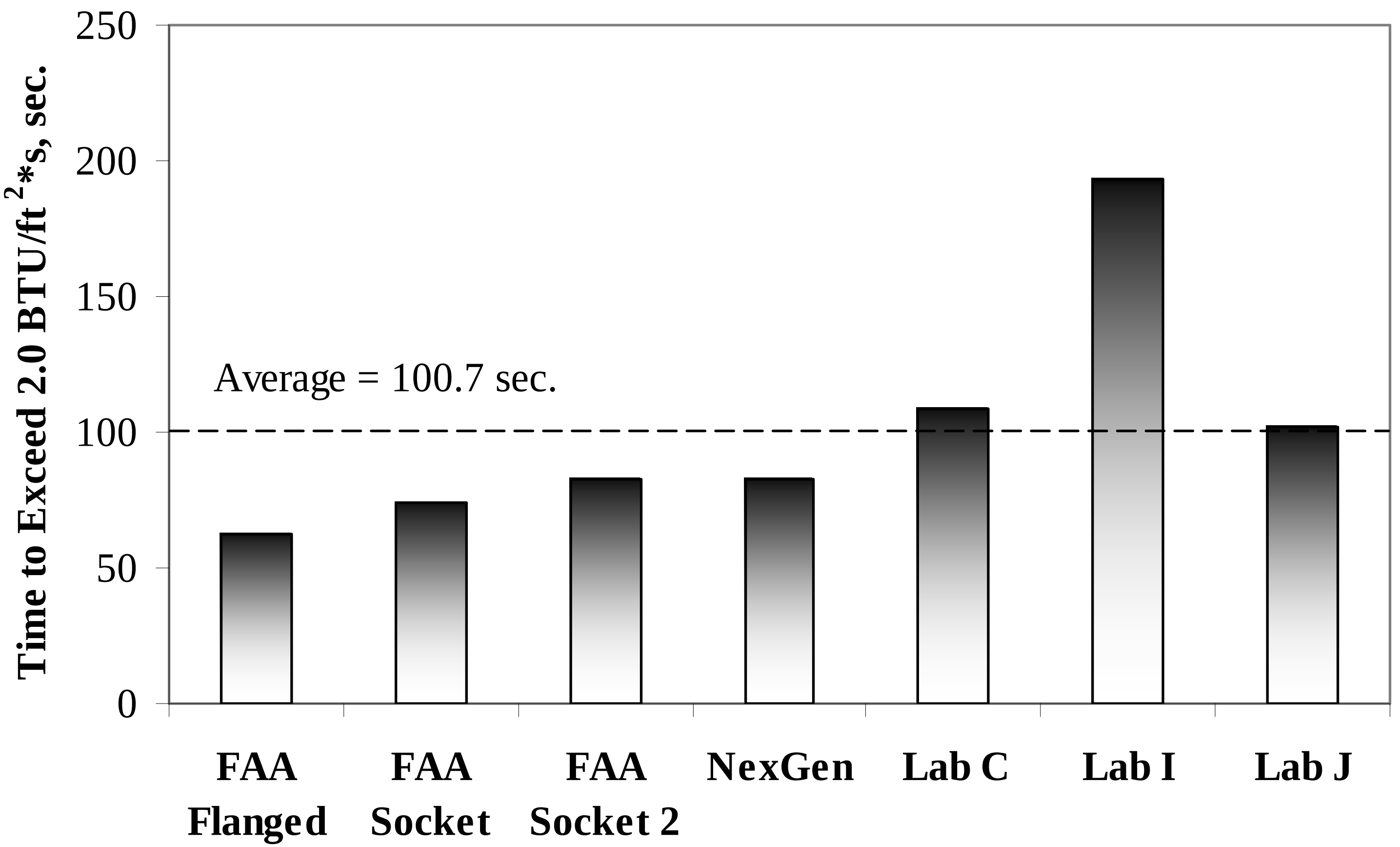
Proof of Concept: RRVIII-Mat'l A



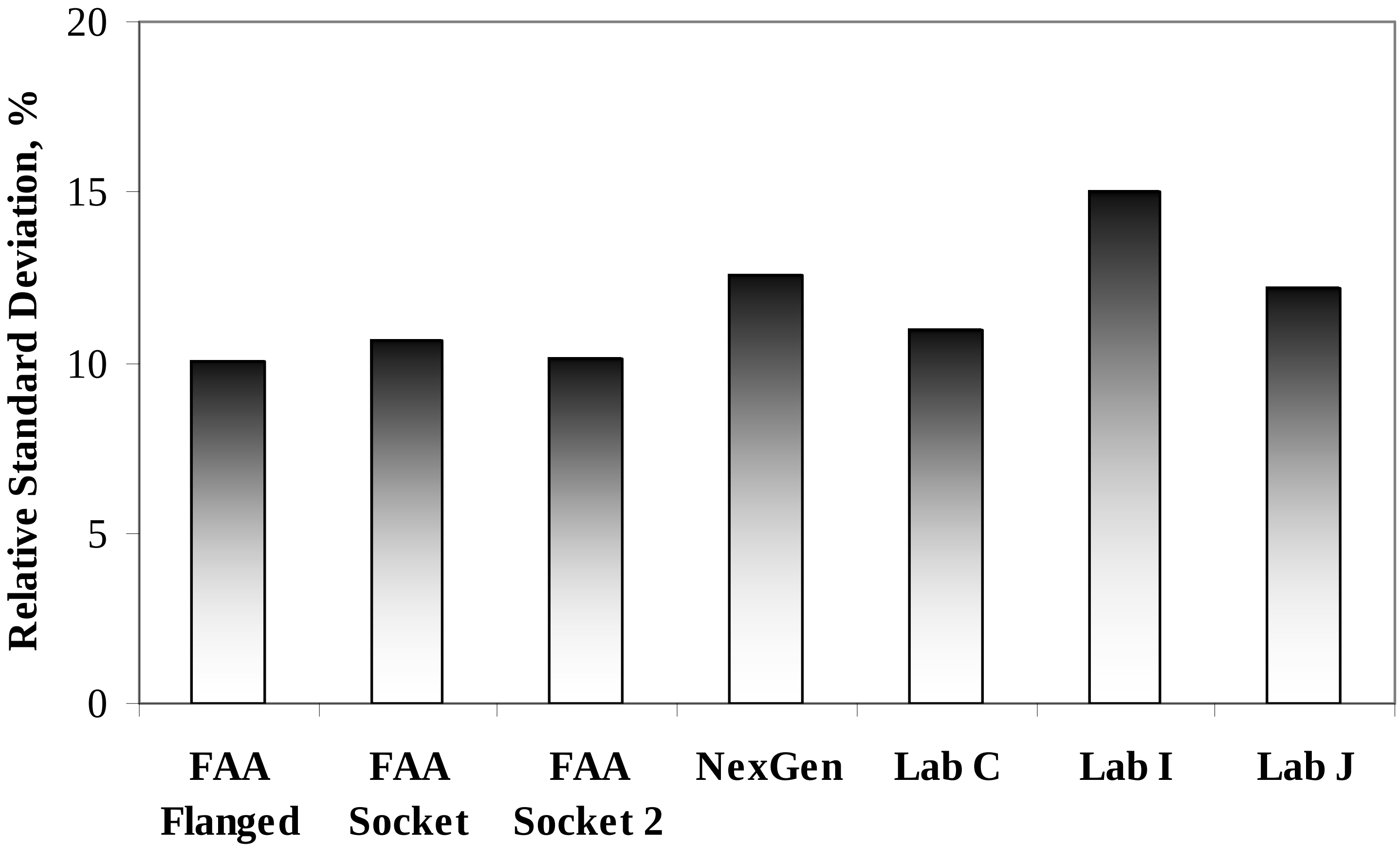
Proof of Concept: RRVIII-Mat'l B



Proof of Concept: RRVIII-Mat'l C



Repeatability – Relative Standard Deviation



Summary of Concept Phase

- **A burner can be fabricated from easily obtainable parts and materials**

- **By replicating the input/output parameters of the Park oil burner, the concept burner could deliver a flame similar in character to that of the Park**

- **The concept burner's burnthrough performance was shown to be similar to the FAA Park oil burner, as well as several other "socket" type Park oil burners**

- **A better method of measuring the burner performance is desired with a higher level of accuracy**

Construction and Calibration of Multiple Burners

- **Objective**
  - Construct 10 identical burners
  - Show reliability of performance from test to test (one burner)
  - Show repeatability of burner performance from burner to burner
  - Show reproducibility of burner performance at various locations
- **Procedure**
  - Assemble and designate a burner (i.e., NG1, NG2, etc.)
  - Burner components are unique to each designated burner (stator, turbulator, cone, fuel rail, fuel nozzle, pressure regulator, muffler, sonic orifice)
  - Measure burner performance at FAATC lab (fuel flow, air flow, flame temperature, burnthrough times)
  - Package burner, ship to participating laboratory
  - Lab will perform same tests and compare results
  - If results are similar to those obtained at the FAATC, then burner is performing properly

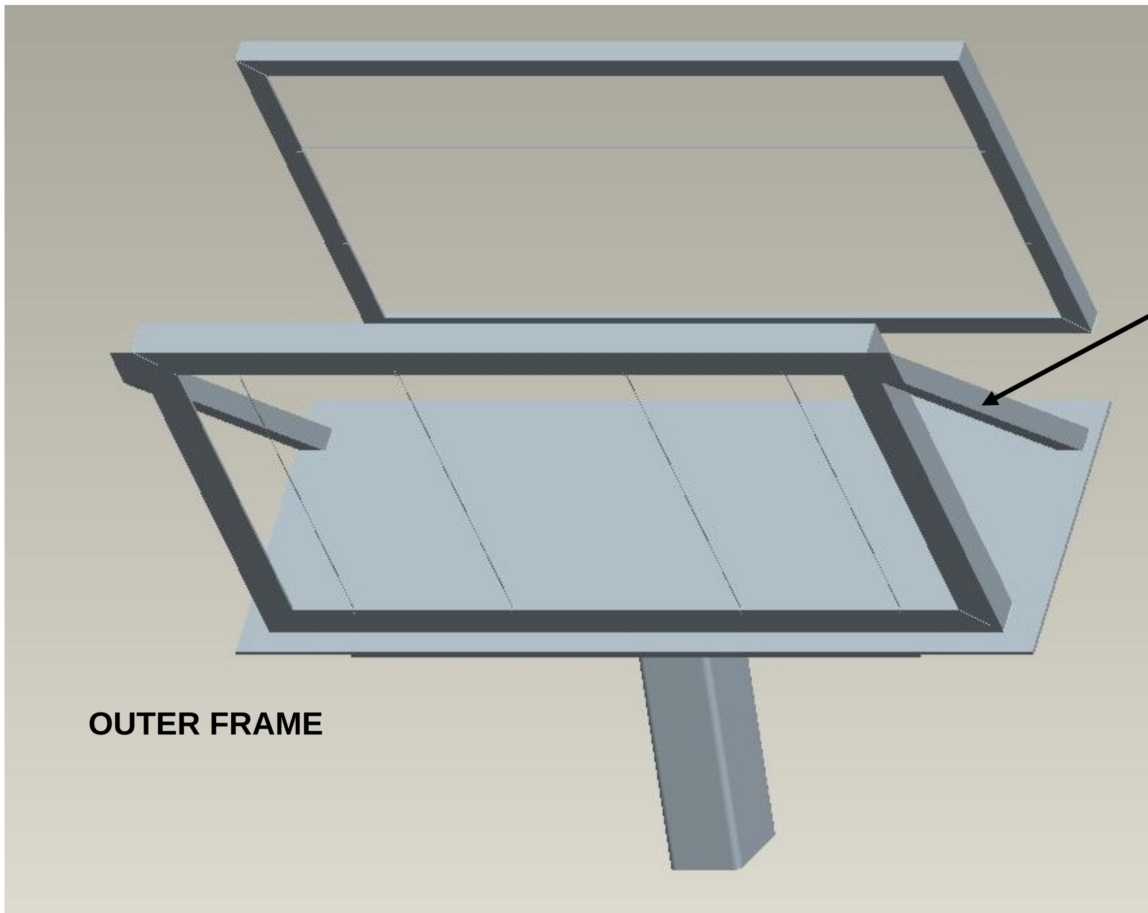
NexGen Burner Distribution

- **Currently, NexGen burners are located at:**
  - NG1: CEAT, Toulouse, France
  - NG2: FAATC
  - NG3: FAATC
  - NG4: Mexmil, Santa Ana, CA, USA
  - NG5: AIRBUS, Bremen, Germany
  - NG6: BOEING, Seattle, WA, USA
  - NG7: FAATC
  - NG8: FAATC
  - NG9: FAATC
  - NG10: FAATC
- **Parts for more burners will be ordered soon!**

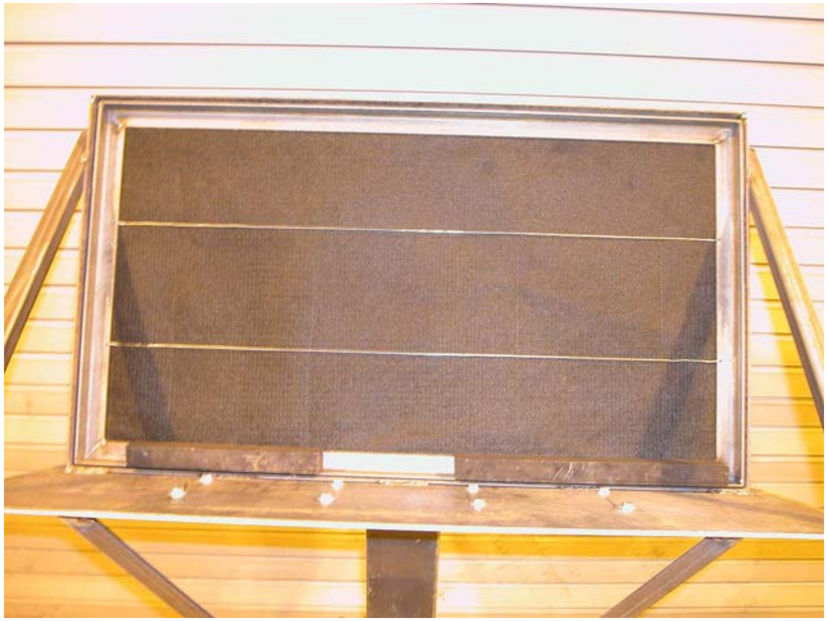
New Blanket Holder

- **Lightweight PAN (TexTech) materials have been found to have a high level of consistency with characteristic burnthrough times related to the material density (8579 or 8611)**
- **These materials were also found to be greatly affected by the original blanket holder, the test rig that simulates the structure of an aircraft fuselage**
- **A new sample holder was designed to increase the consistency of the burnthrough times in order to isolate the performance of the NexGen burners from all other effects**

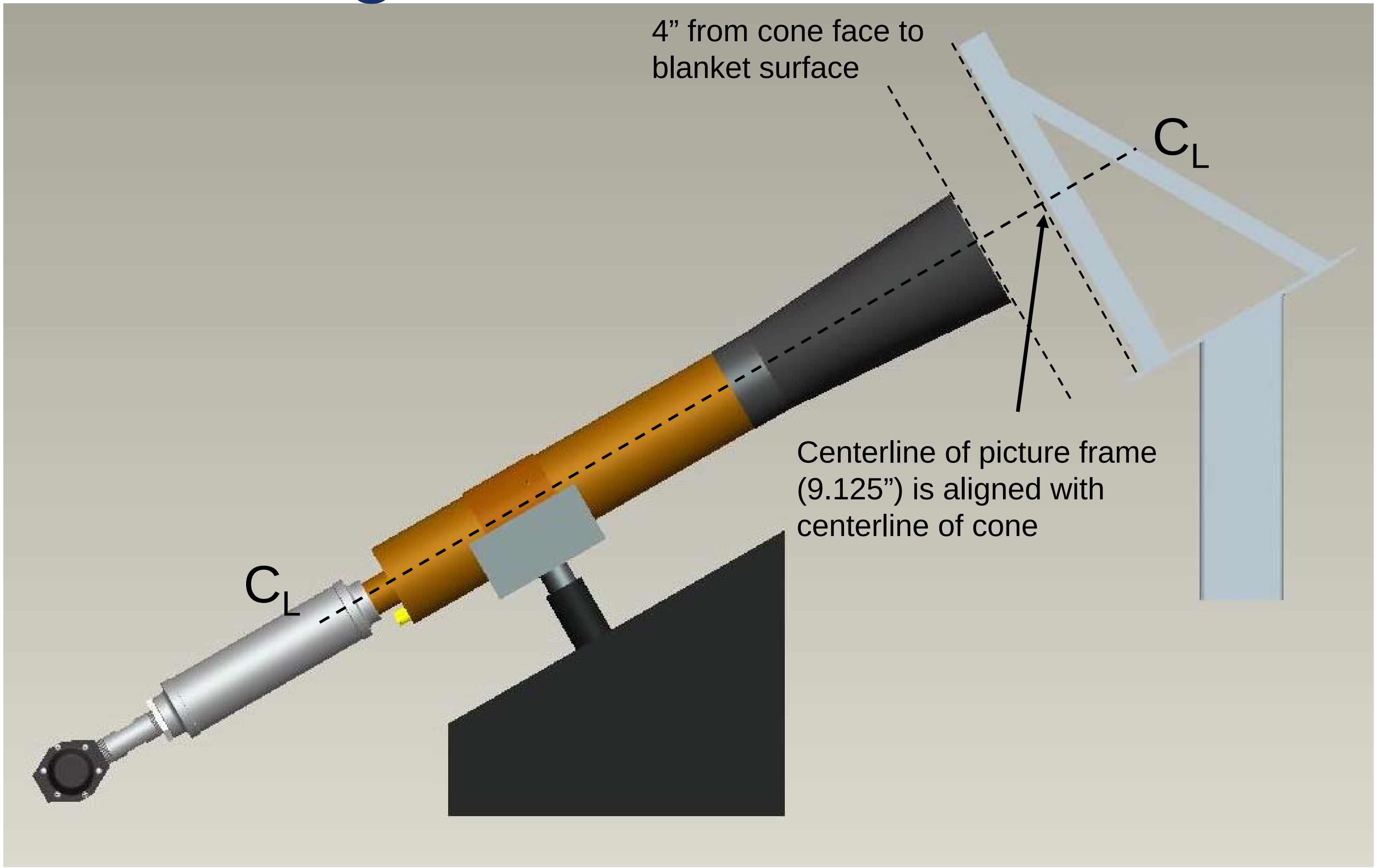
Picture Frame Blanket Holder



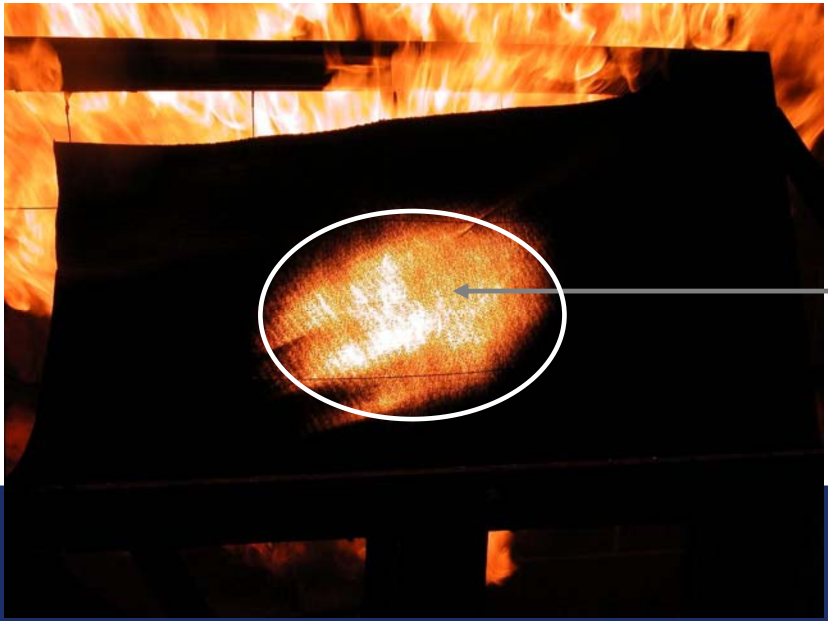
Picture Frame Blanket Holder



Frame Alignment

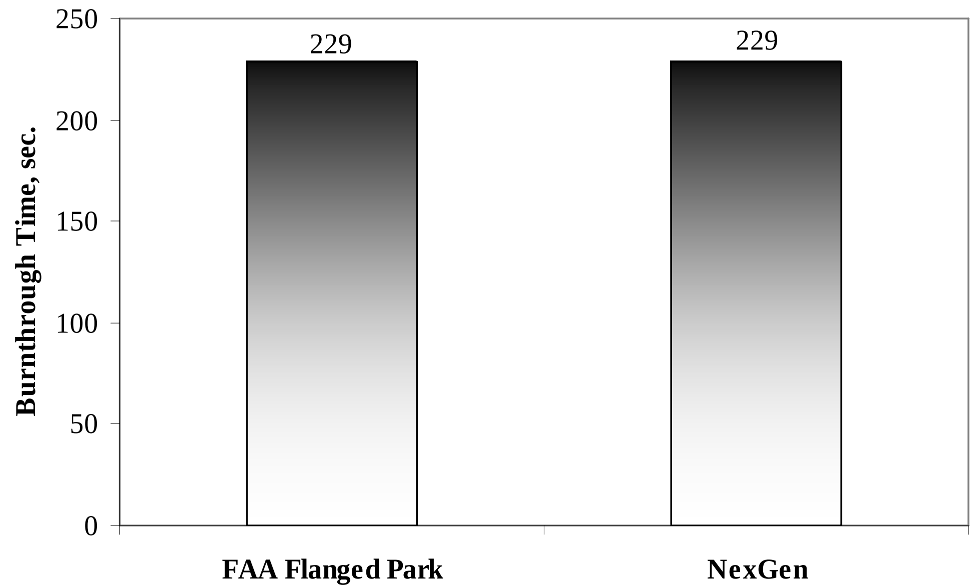


Testing

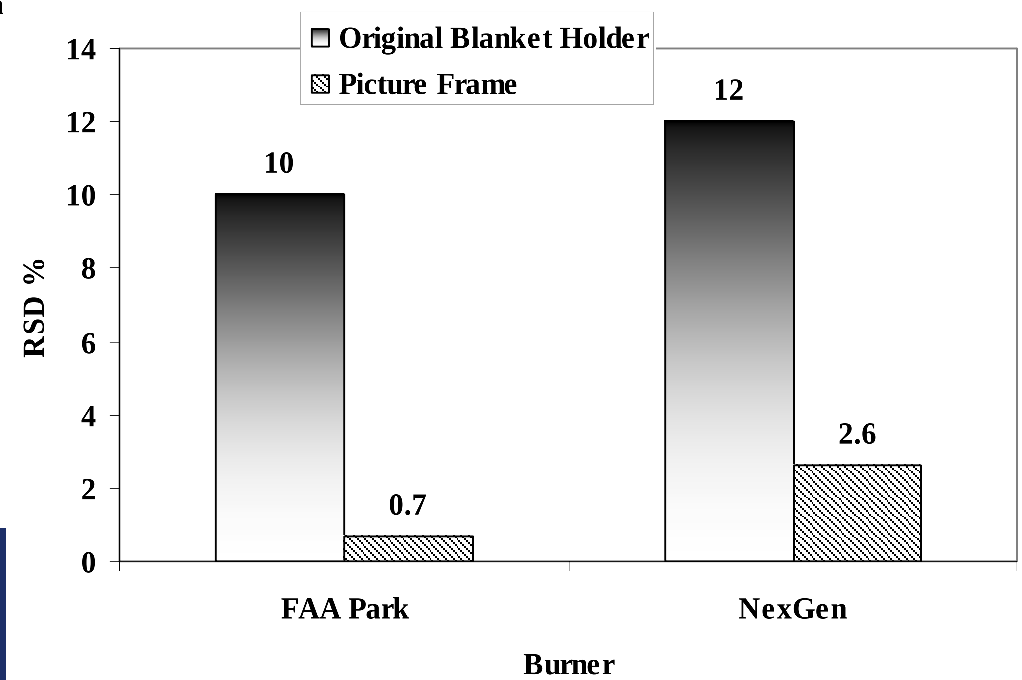


Material will typically shrink within 20 sec. from the top and the sides. The center portion, where the burnthrough is occurring, will not be affected by this.

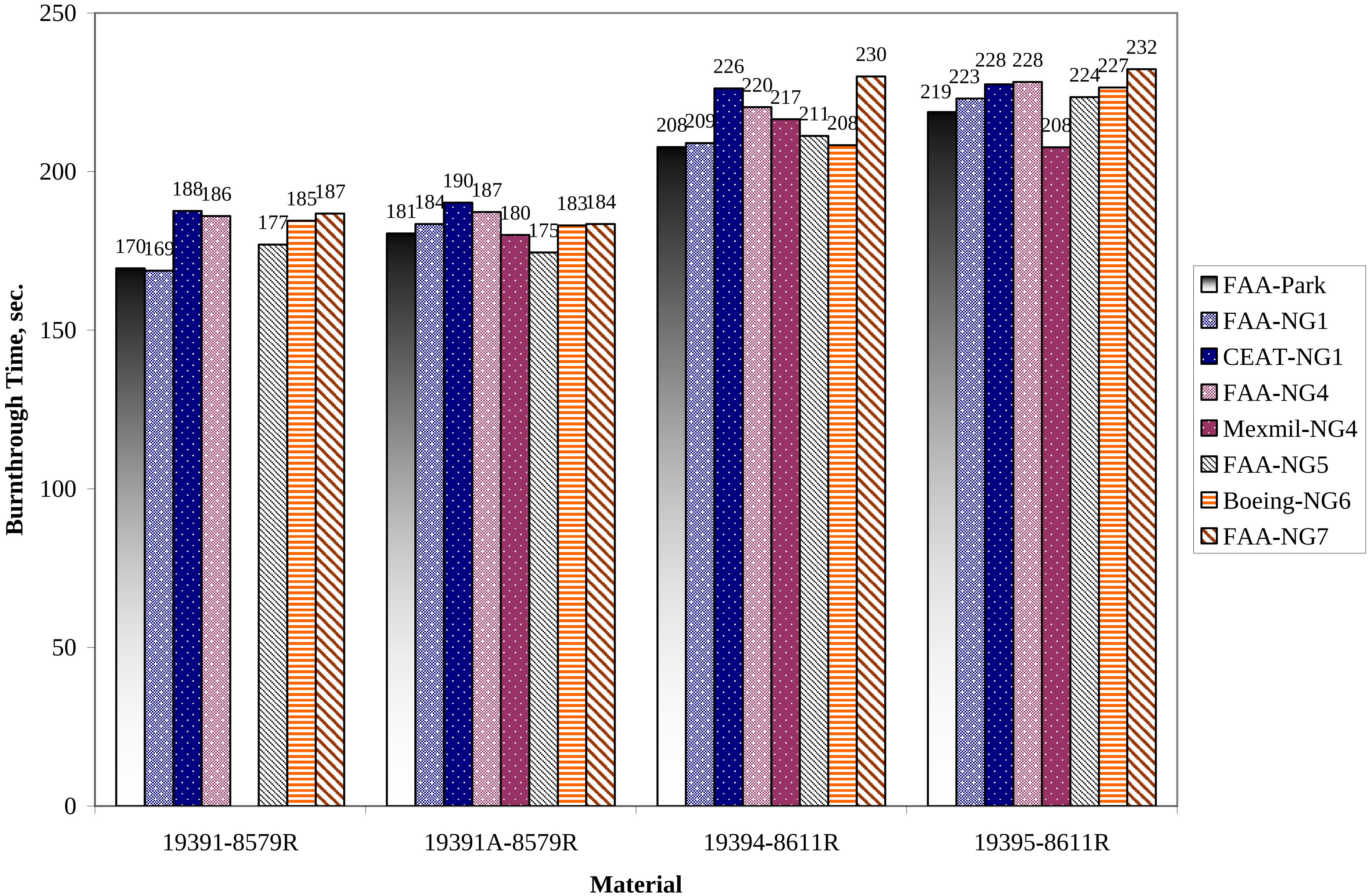
Picture Frame Initial Results



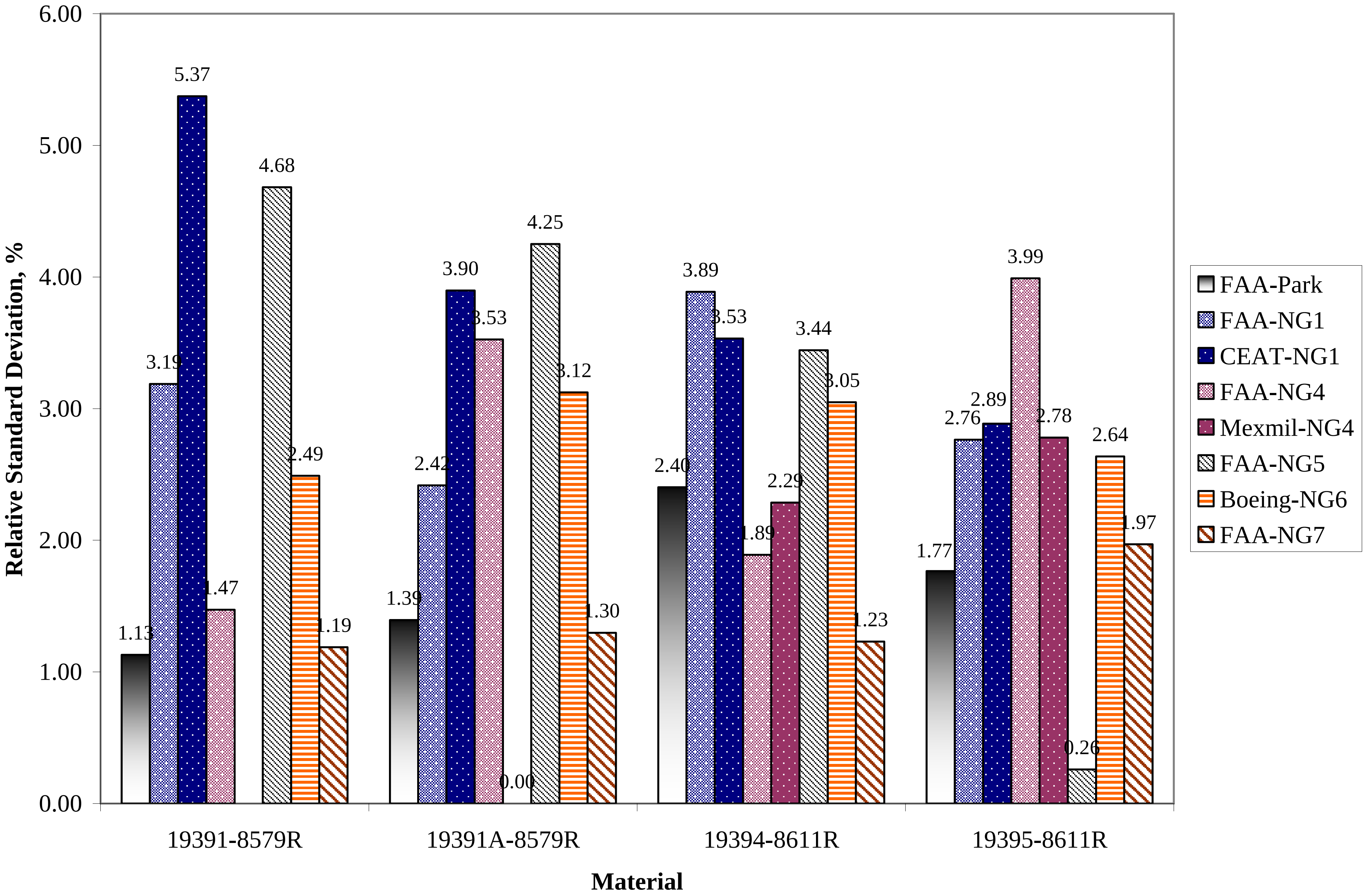
- **High level of repeatability was observed**
  - Identical results observed with the FAA Park and the NexGen
  - Much higher level of repeatability
  - Relative Standard Deviation decreased by a factor of 10



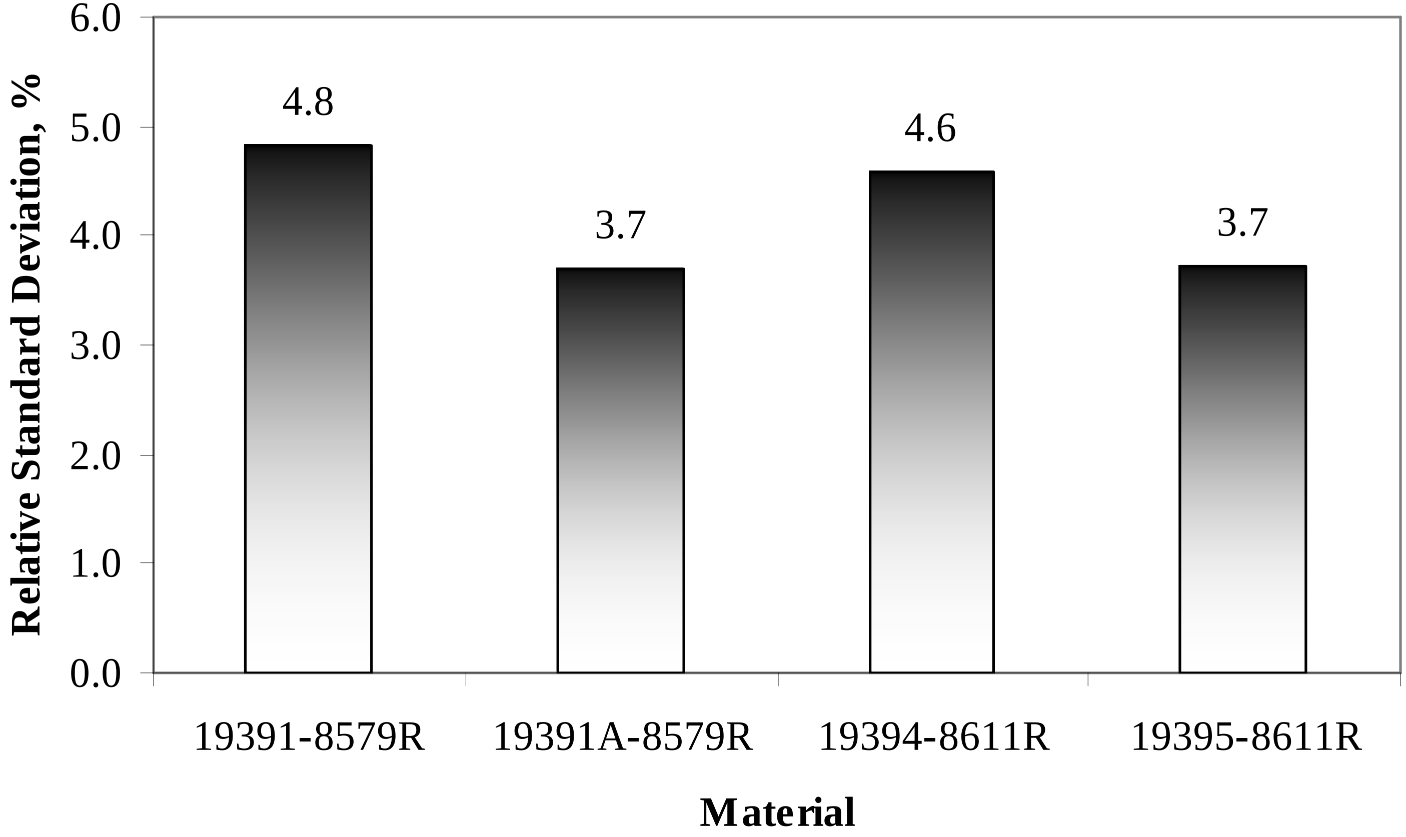
NexGen Comparative Test Results



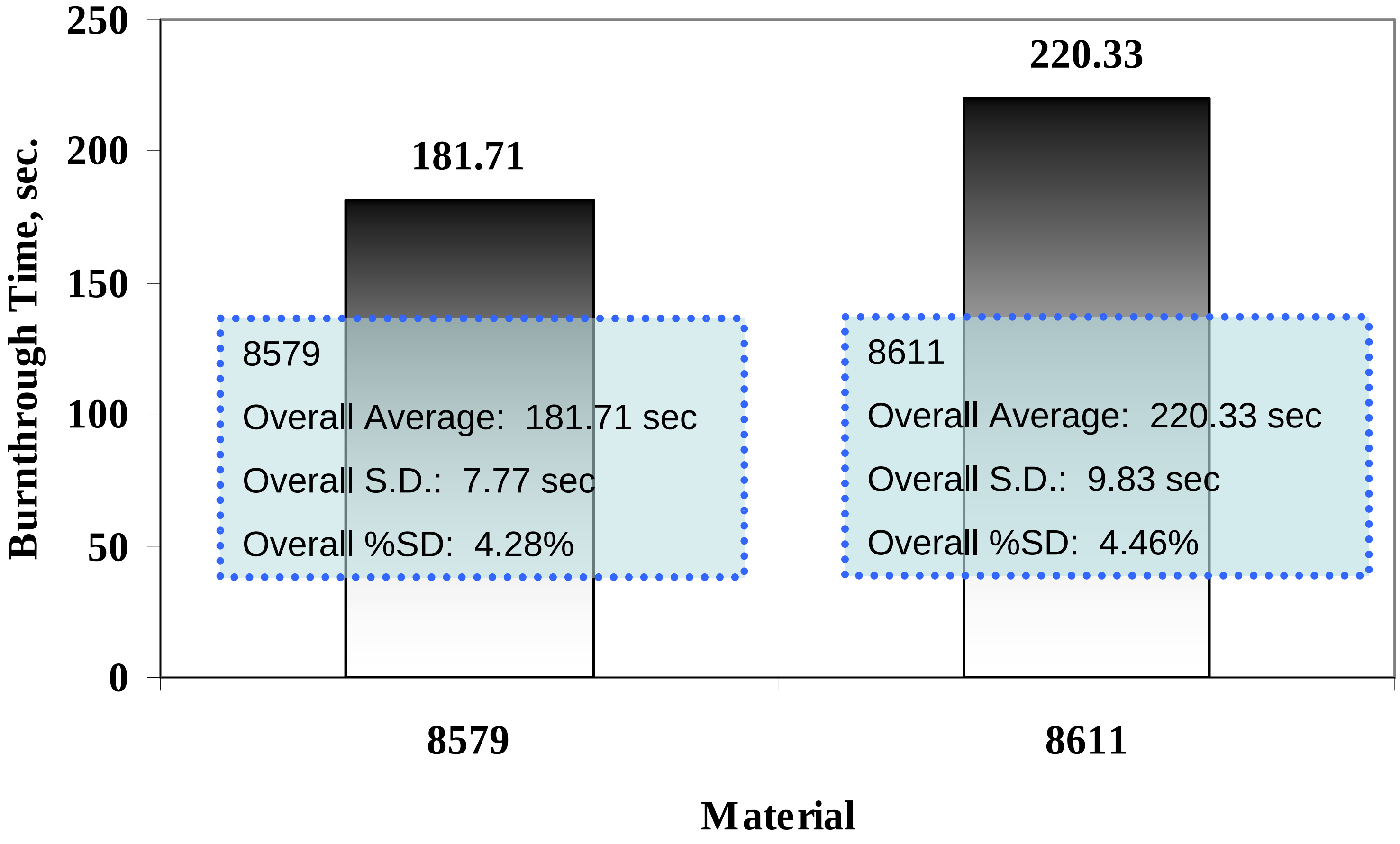
NexGen Repeatability



Reproducibility



Overall Reproducibility



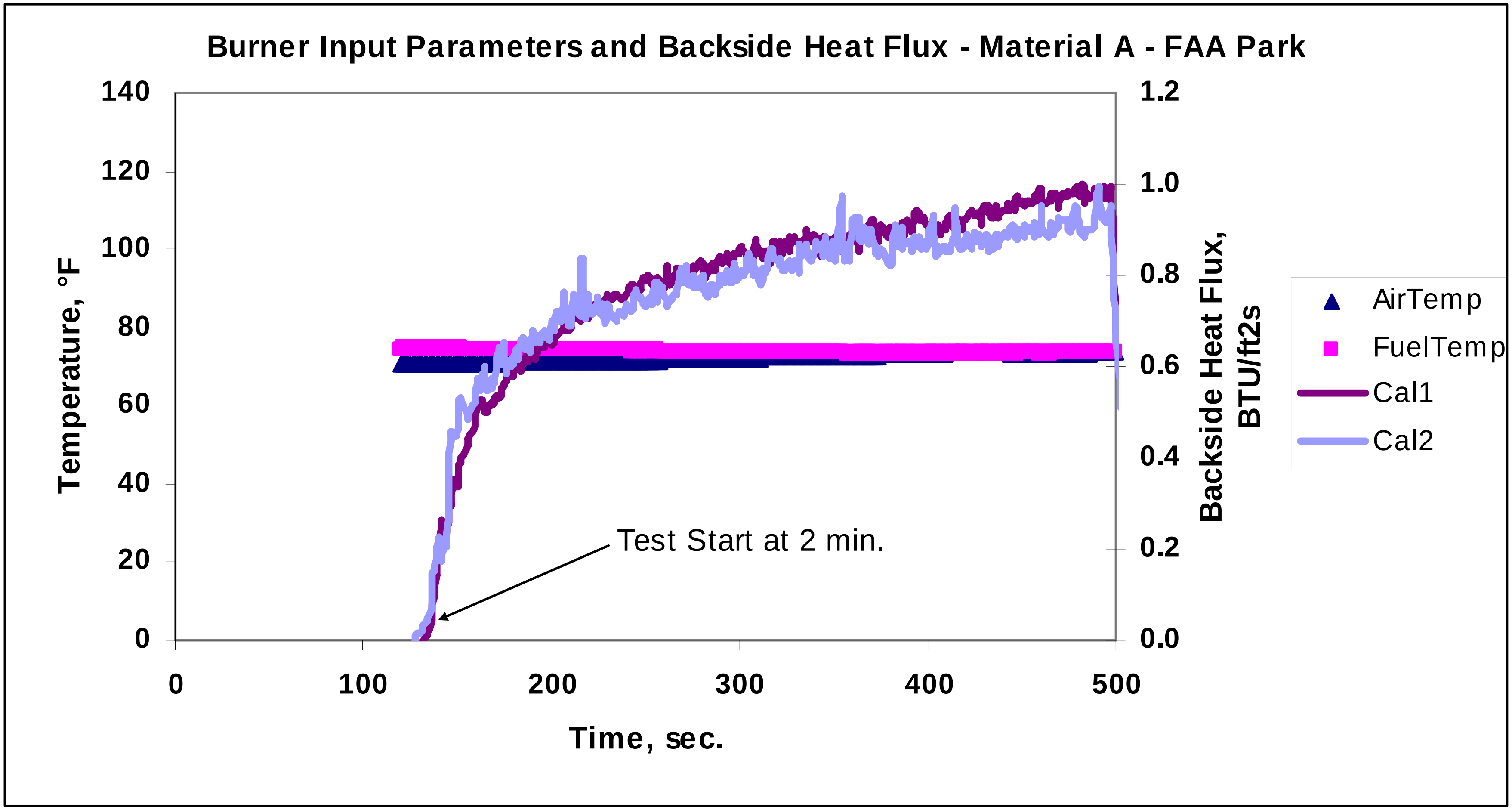
Summary of Results

- Overall, the picture frame test method was useful in determining if burners are performing properly at different locations
- The test method was found to be more repeatable and reproducible than when testing the same materials on the original blanket holder
- Although this test method provides highly accurate results, it is in no means intended to replace the original test method
- This testing method will not be required for calibrating NexGen burners; rather it can be used to ensure that a burner is not deviating from it's original performance

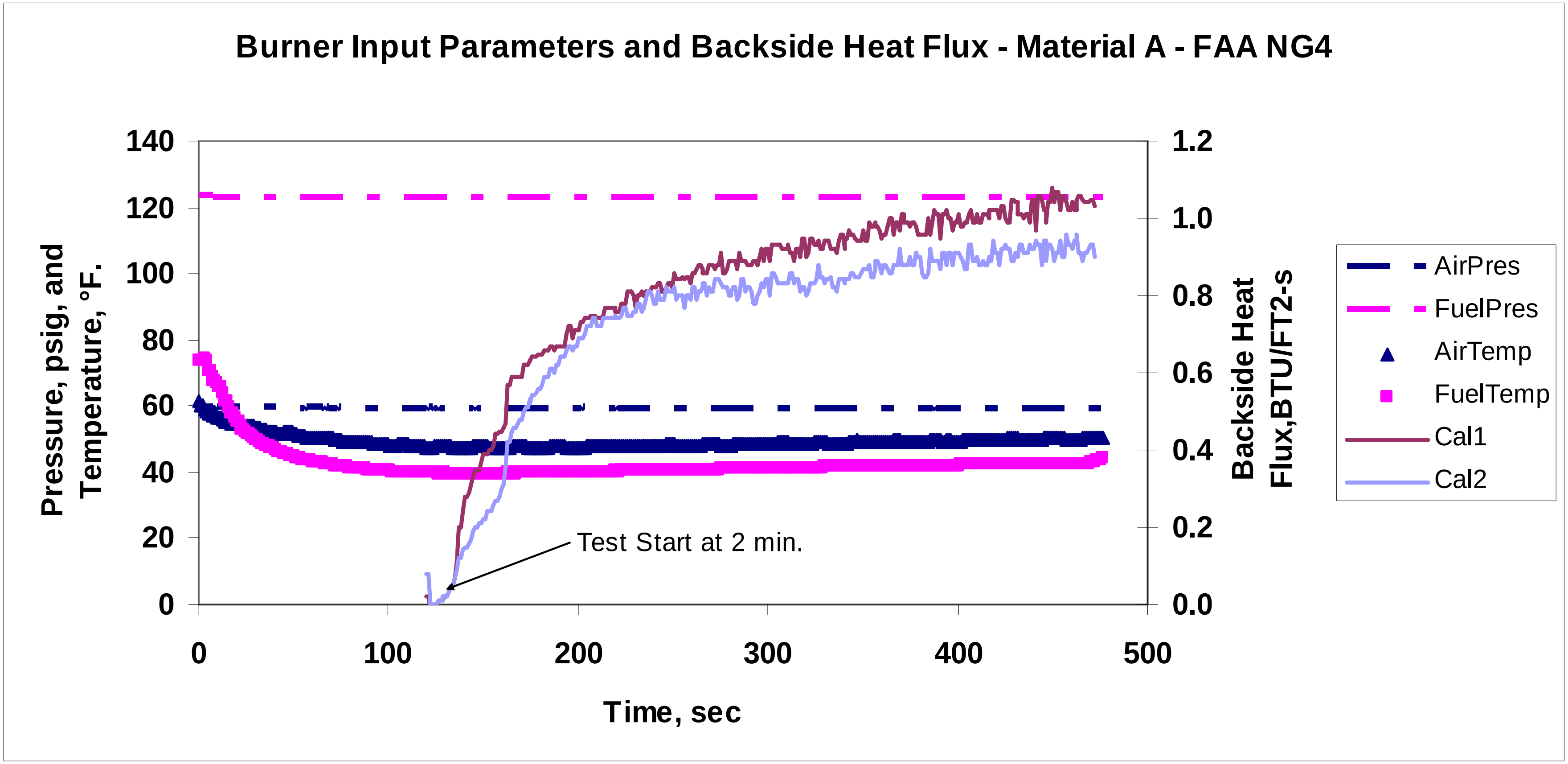
Thermal Acoustic Insulation Blanket Comparative Testing

- Boeing created 3 types of thermal acoustic insulation specimen samples: Material A, B, and C
- Three tests worth of each material were created for each burner; therefore, each burner would run 9 tests total
- Tests were run initially at Boeing then at the tech center on the FAA Park and FAA NG4 with Boeing personnel witnessing testing

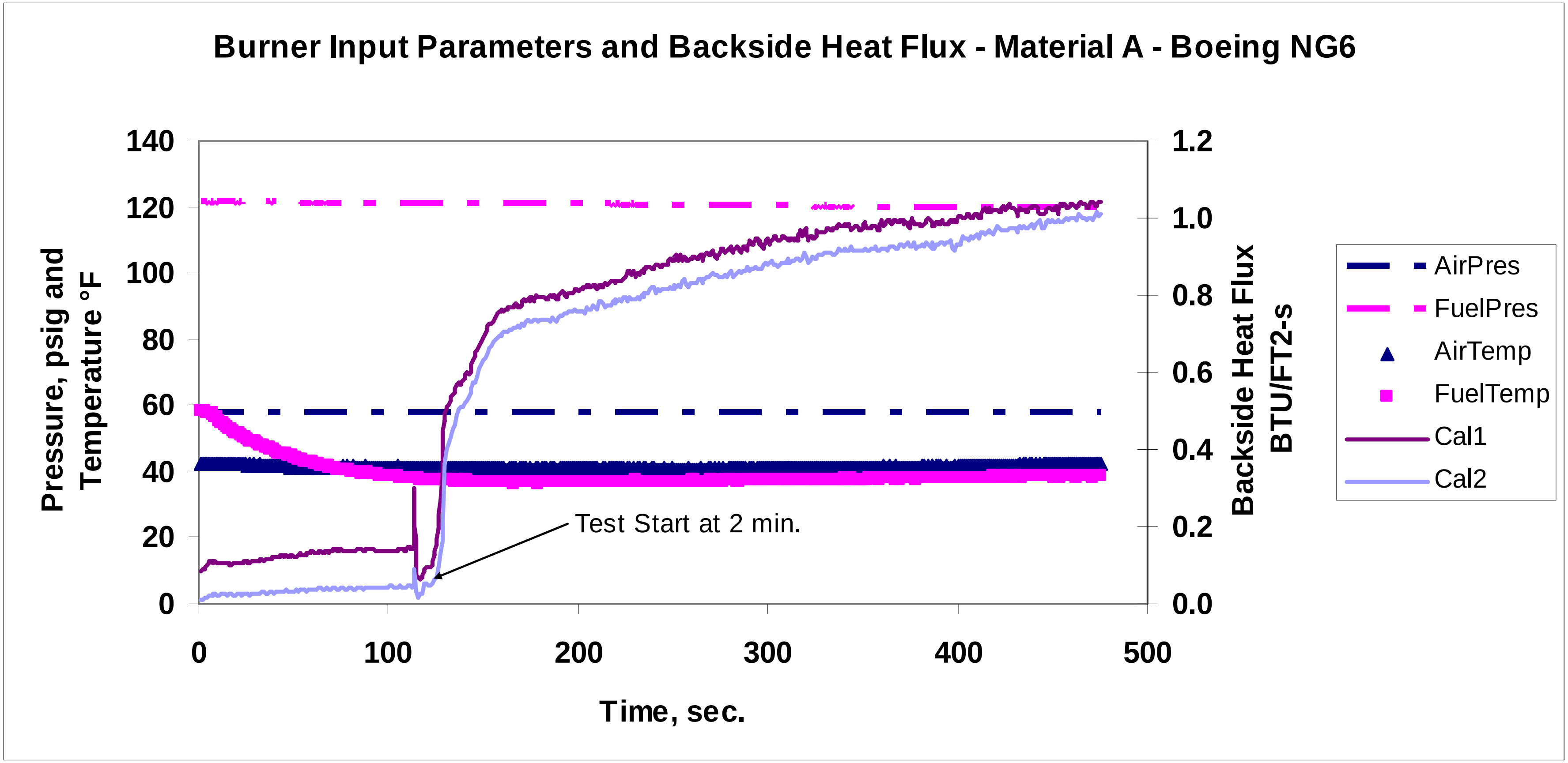
Results – FAA Park, Material A



Results – FAA NG4, Material A



Results – Boeing NG6, Material A



Summary

- **A next-generation burner was developed for testing the burnthrough resistance of thermal acoustic insulation**
  - The burner was constructed from readily available parts and materials
  - The burner performance was proven to be similar to that of the FAA Park
  - The burner was shown to perform similarly when moved from one laboratory to another
  - Multiple burners were constructed, and all were found to be in good agreement with each other and the FAA Park
- **A method was developed for quantifying the burnthrough performance of the NexGen burners**
- **When testing thermal acoustic insulation blankets, the NexGen burners provided very similar results to that of the FAA Park**
- **More fundamental research is required in order to have a burner with a higher level of accuracy**

Future Work - Analysis

- Further insight into the fundamental physical problem is necessary
- Although the current burner will suffice for now, advances in material science may require a burner that can be highly accurate
- Literature search – review papers on droplet studies, swirl flow, soot formation, etc. will be necessary
- Separate physical analyses of the airflow and fuel spray of the current burner configuration
- Parametric study – determination of parameters that have the most significant effects on burnthrough
- Use this knowledge to design an optimally configured burner that can operate at high levels of precision anywhere in the world

Techniques

- Flow visualization techniques will be used to study the physical problem
- Particle Image Velocimetry (PIV) can be used to determine the 3-dimensional velocity field at any plane in the flow; and can be used to measure the magnitude of the swirl flow
- Software can be used to determine the pressure field, temperature, density, etc.
- PIV can also indicate the density of the spray in the airflow, as well as droplet size distribution
- All of this data can be useful in optimizing the burner configuration
- CAD software can be used to develop prototype swirl inducing devices

Questions, Comments, Suggestions, Input?