Burnthrough Test Method for Aircraft Thermal/Acoustic Insulation

NexGen Burner Update

Presented to: Materials Working Group, Paris, France

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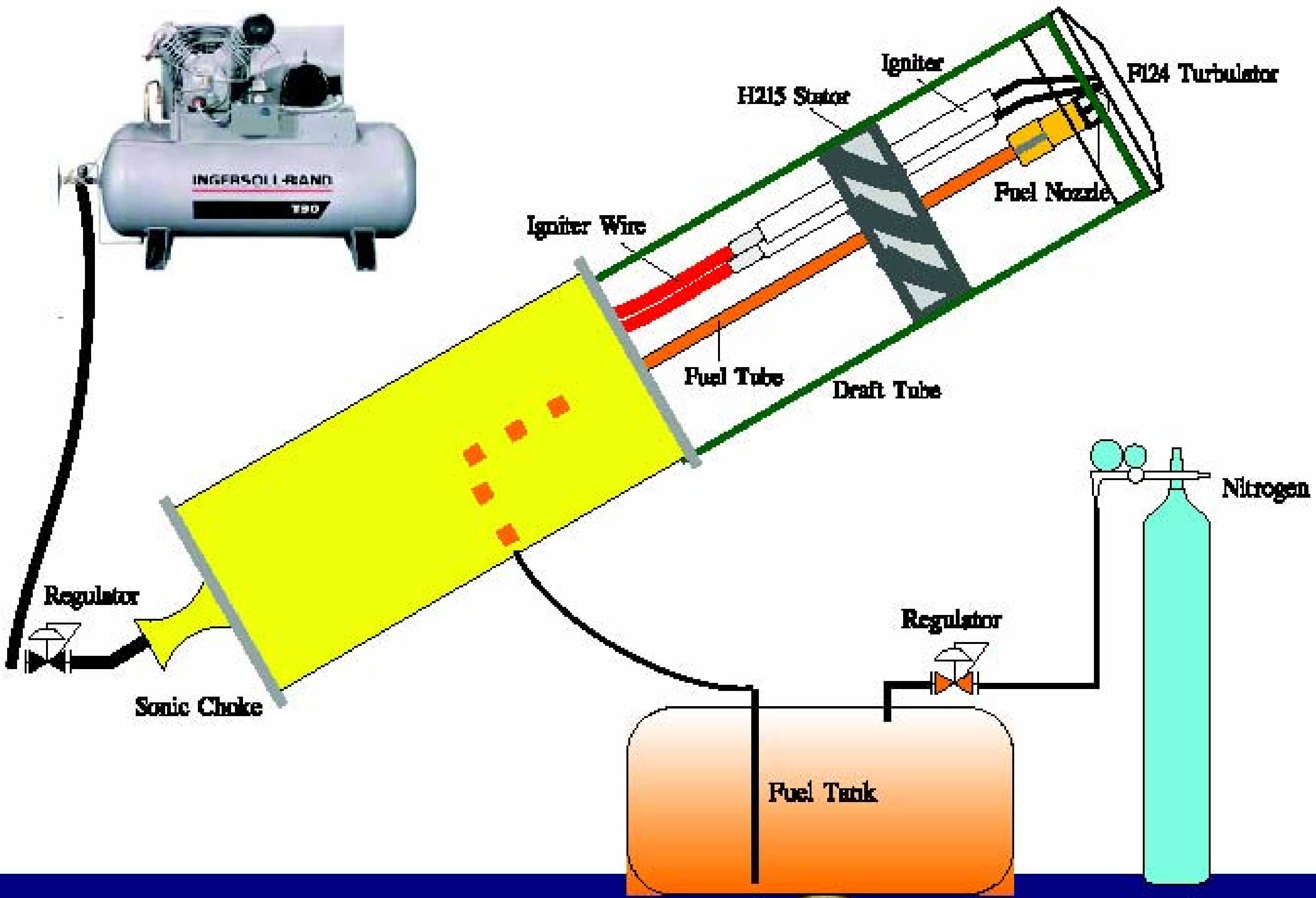
Outline

1. Description of NexGen Burners
2. NexGen Comparative Testing Results
3. Future Burner Research and Development

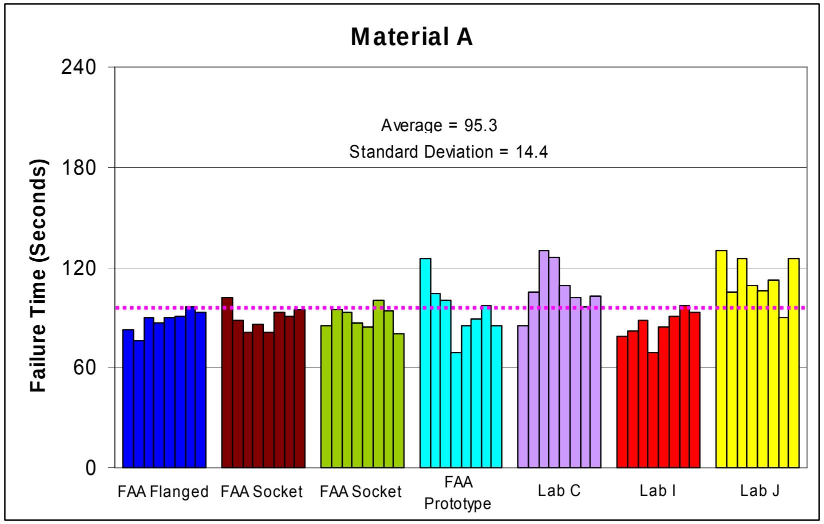
Concept

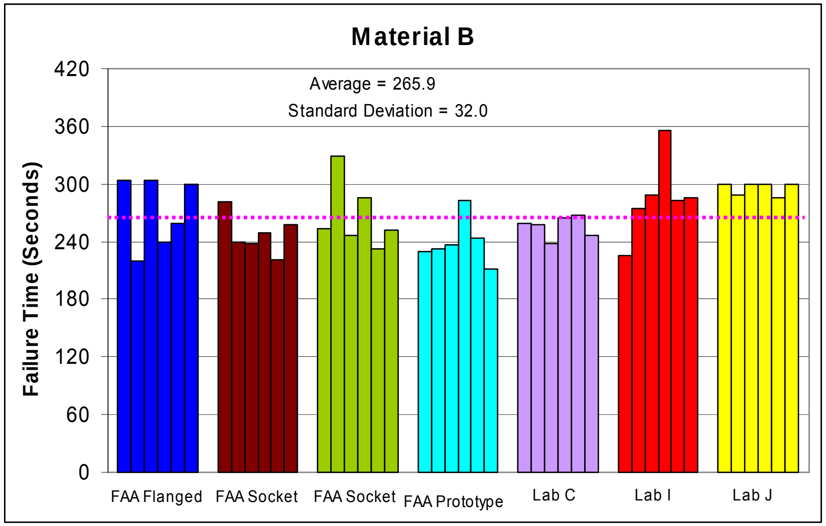


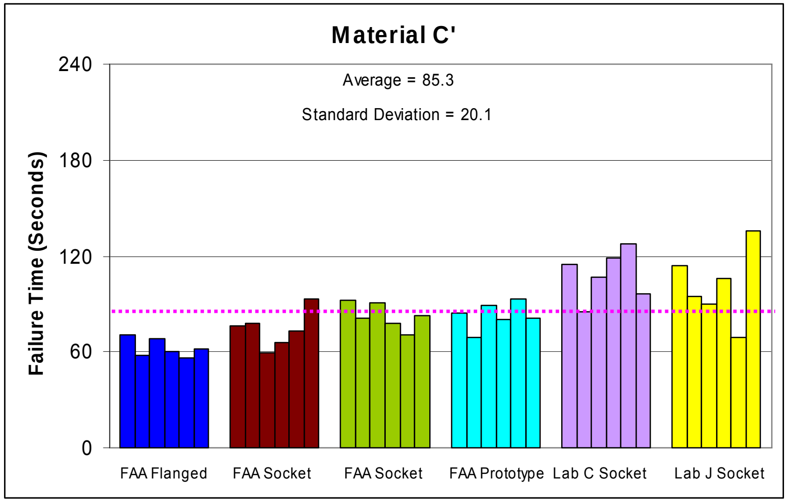
INGERSOLL-RAND
Igniter
H215 Stator
F124 Turbulator
Fuel Nozzle
Igniter Wire
Fuel Tube
Draft Tube
Nitrogen
Regulator
Regulator
Sonic Choke
Fuel Tank

Proof of Concept

Performance Comparison: RRVIII







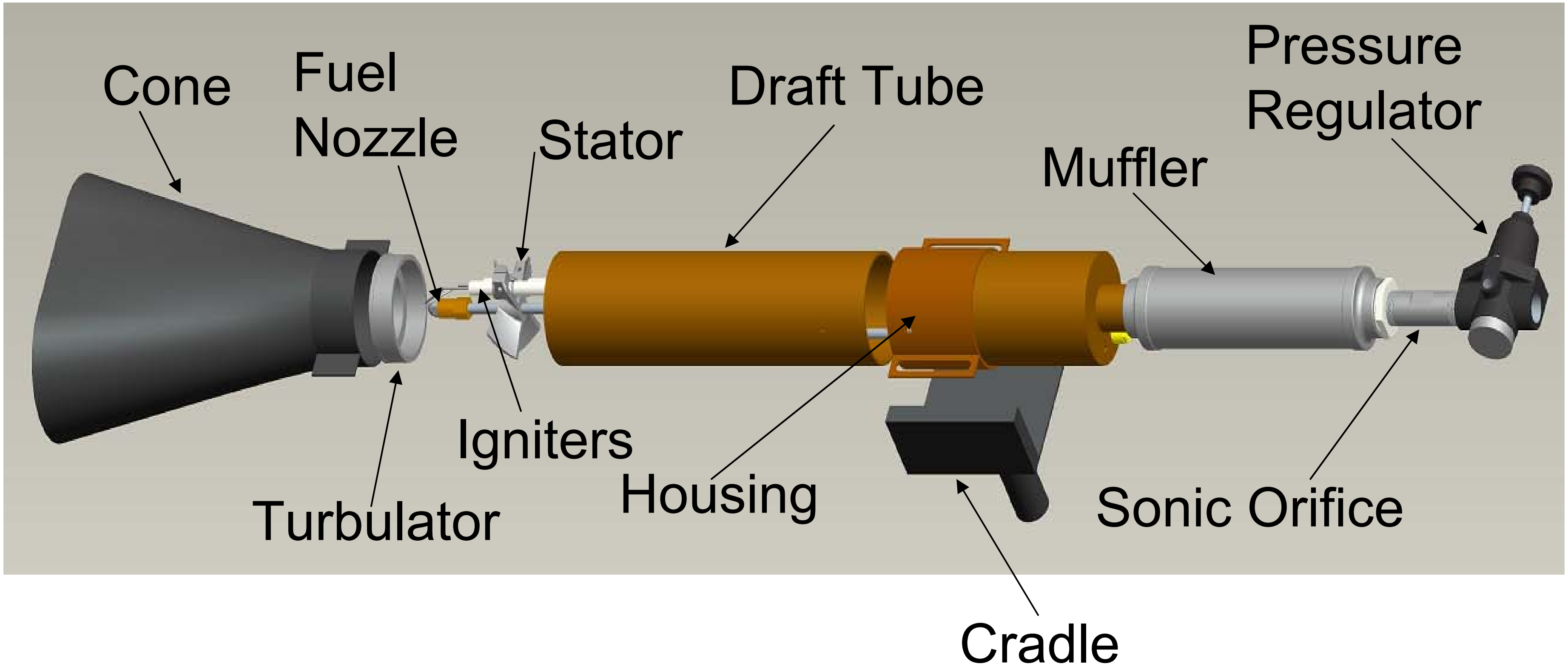
Summary of Concept Phase

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

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

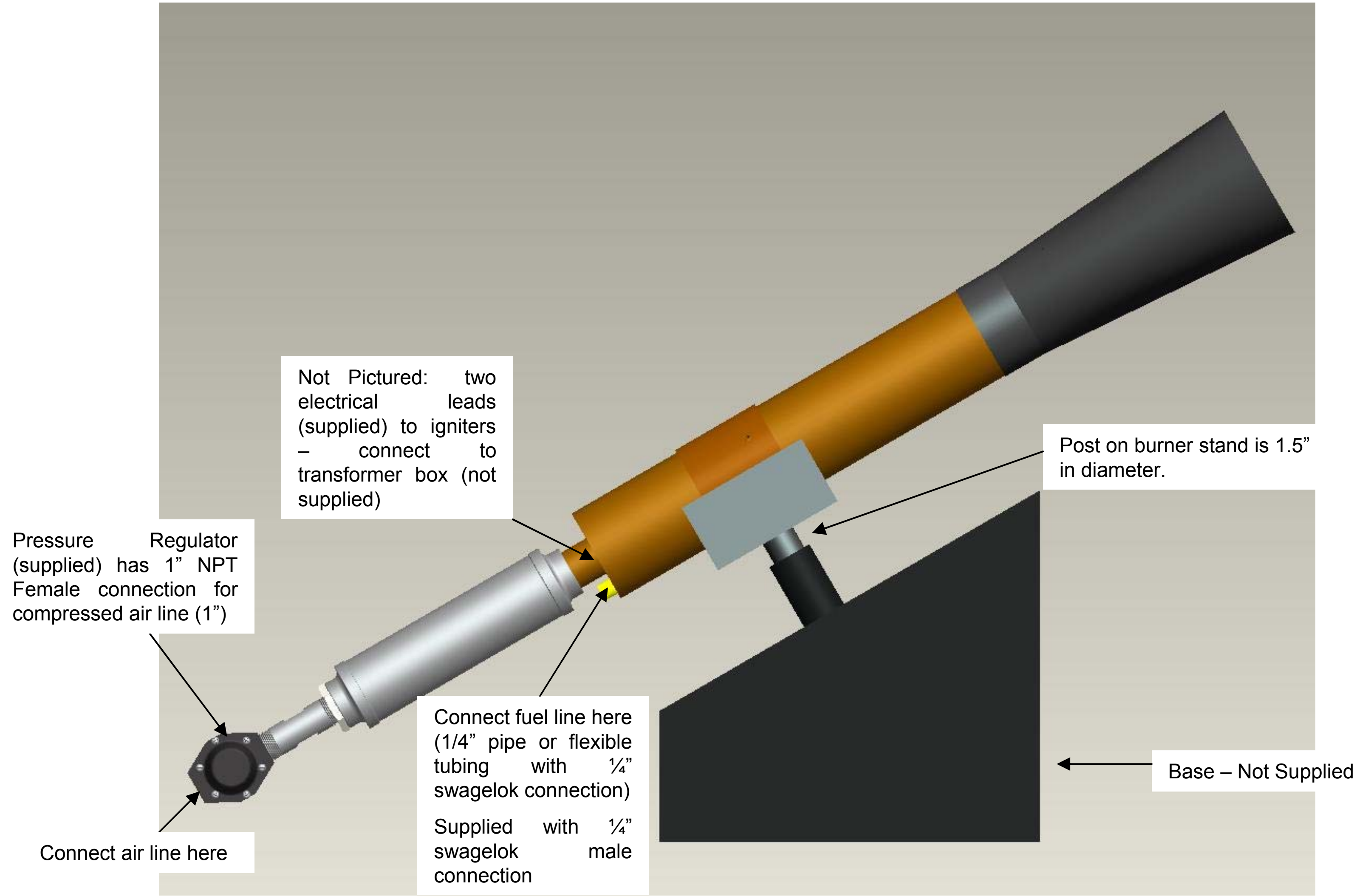
NexGen Burners



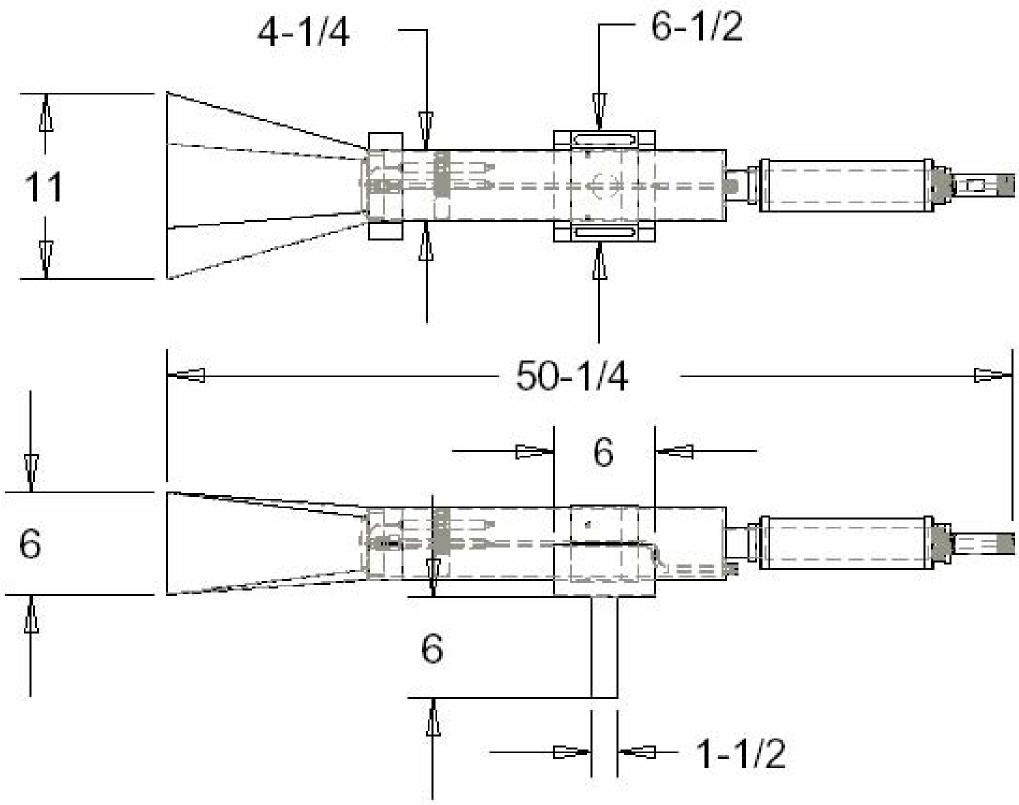
NexGen Burner Components

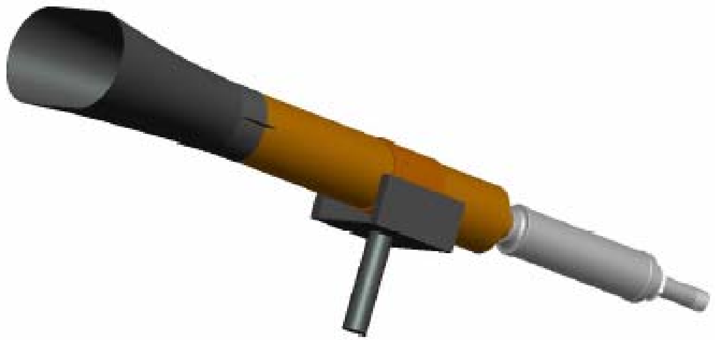
- Cone – custom fabricated burner cone built to dimensions specified in the rule
- Turbulator – Monarch F-124
- Fuel Nozzle – Monarch 5.5 gph 80° PL F-80 hollow cone spray
- Igniters – standard oil burner igniters
- Fuel Rail – custom fabricated fuel rail
- Stator – Monarch H215 replicate, modified with “liquid steel” and turned down on a lathe to increase diameter
- Draft Tube and Housing – removable draft tube allows easy access to internal components; housing “wings” allow for easy adjustment of burner position
- Muffler – drastically reduces high frequency noise from expansion of air
- Sonic Choke – regulates mass flow of air through the burner
- Pressure regulator – precision heavy-duty pressure regulator controls the sonic orifice inlet air pressure

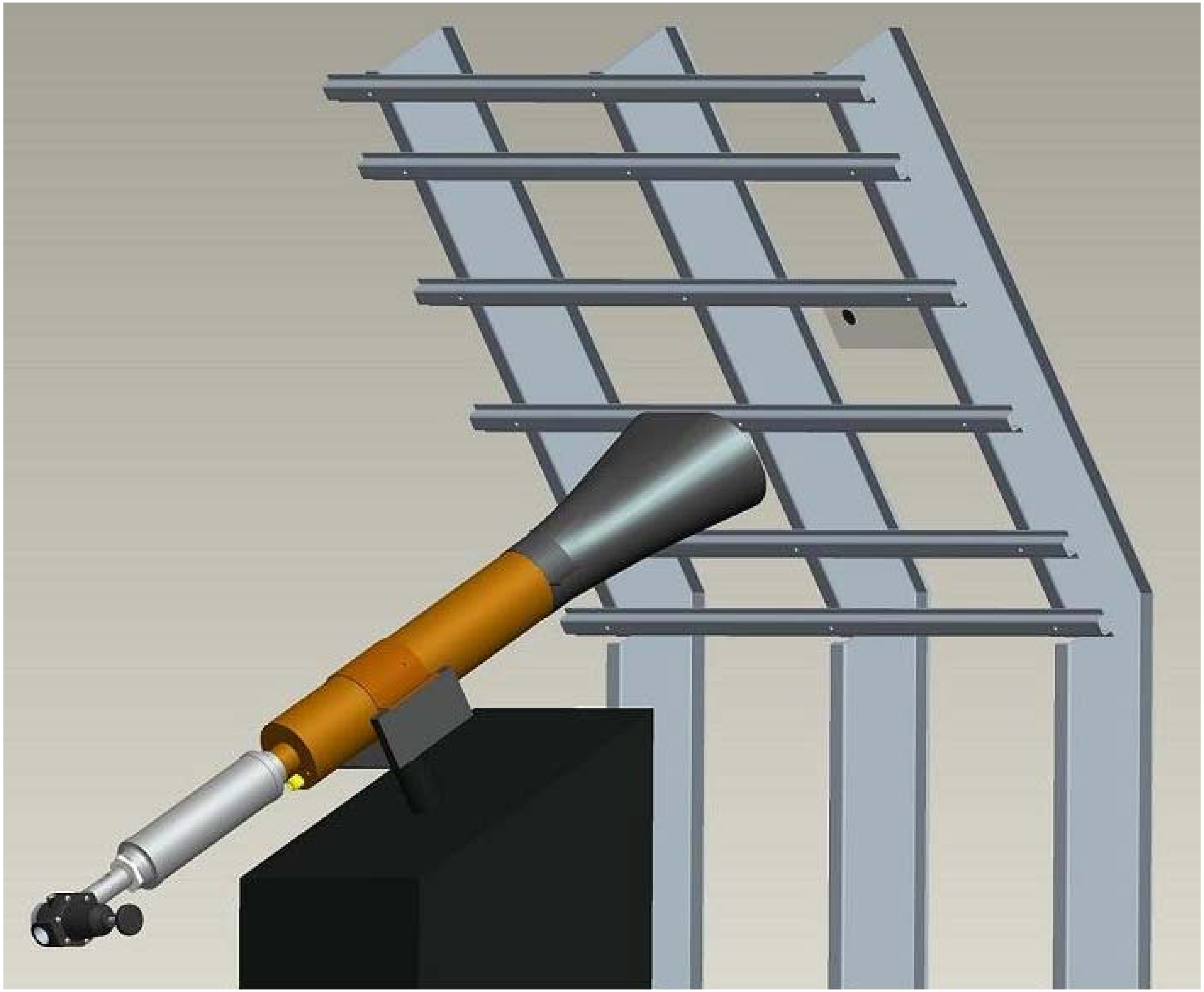
System Schematic



Dimensions are in inches



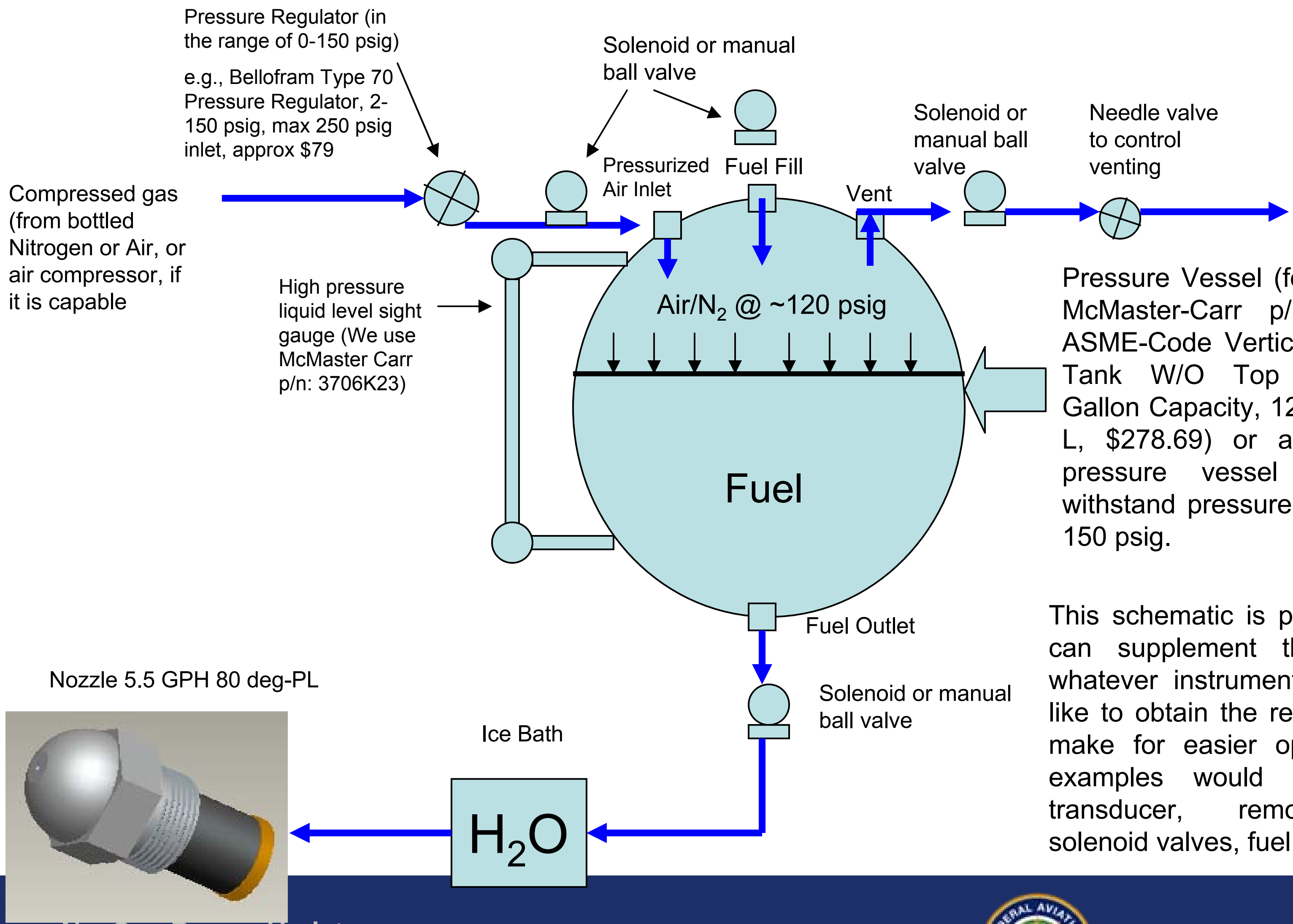




Compressed Air Supply

- **Compressor minimum requirements:**
  - Constant line pressure of at least 60 psig
  - Mass flow rate of 66 SCFM (standard cubic feet per minute)
  - Burner comes supplied with a pressure regulator upstream of the sonic orifice. To connect the burner to your compressed air supply, a 1” air line will be required
- **Regulator has 1” NPT female connection. A flexible air line will make connections easier, we use a steel braided 1” flex-line.**
- **Before receiving the burner, it may be wise to measure the temperature of your airflow as a function of time while your compressor is running, for a time duration about equal to that of a burnthrough test. This will tell you if you will have fluctuations in air temperature during a test. The temperature should be approx 40-60 deg. F. It is recommended to install an in-line water cooled heat exchanger to dampen out temperature fluctuations. We use McMaster Carr p/n 43865K78 (www.mcmaster.com) with a condensate separator, McMaster Carr p/n 43775K55**

Pressurized Fuel System

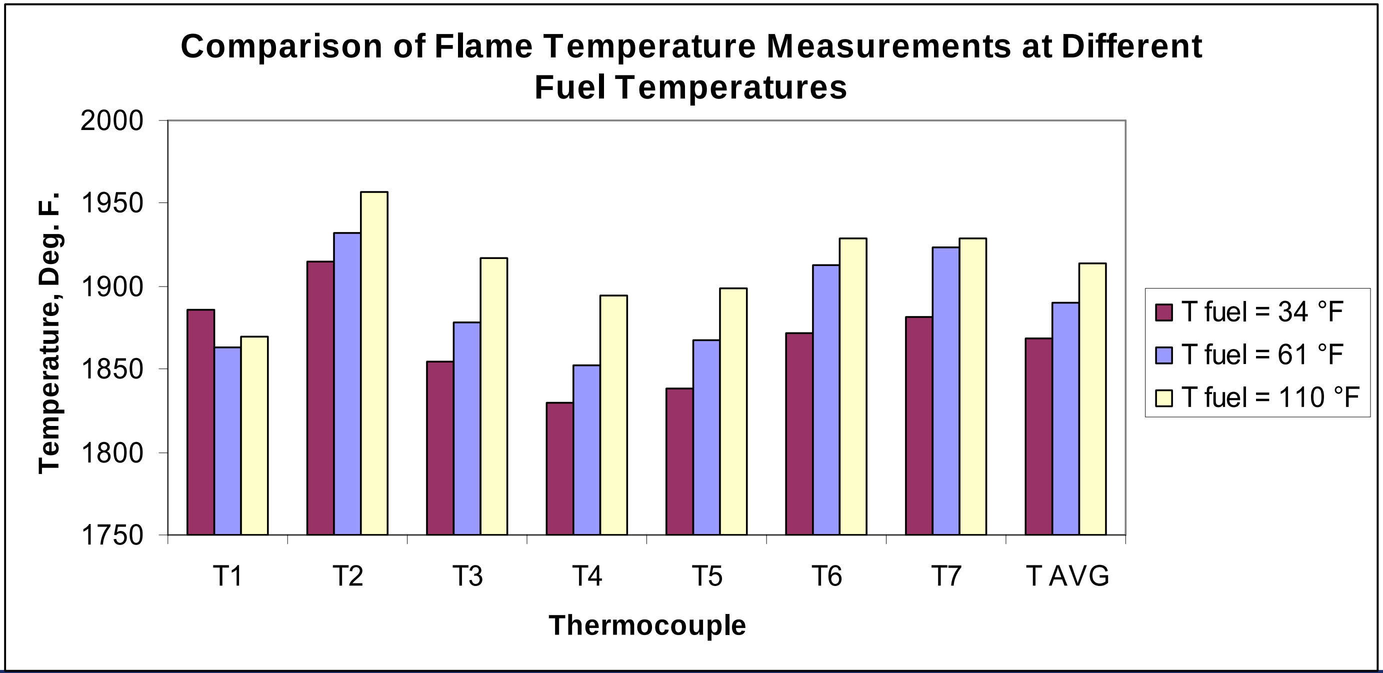


Pressure Vessel (for example, McMaster-Carr p/n 1584K7, ASME-Code Vertical Pressure Tank W/O Top Plate, 15 Gallon Capacity, 12" Dia X 33" L, $278.69) or any suitable pressure vessel that can withstand pressures of around 150 psig.

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.

Quantification of Fuel Temperature Effects

- **In general, increasing the fuel temperature results in a higher flame temperature**
  - The combined effect of increased fuel temperature and less fuel flowrate results in higher flame temperatures
  - Does this have an effect on burnthrough times?



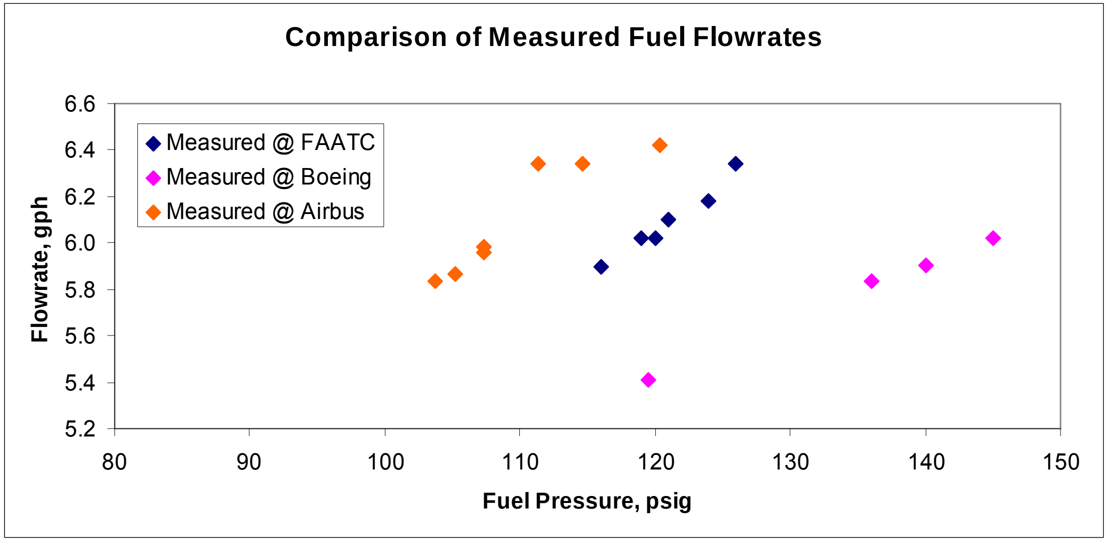
General Fuel Temperature Observations

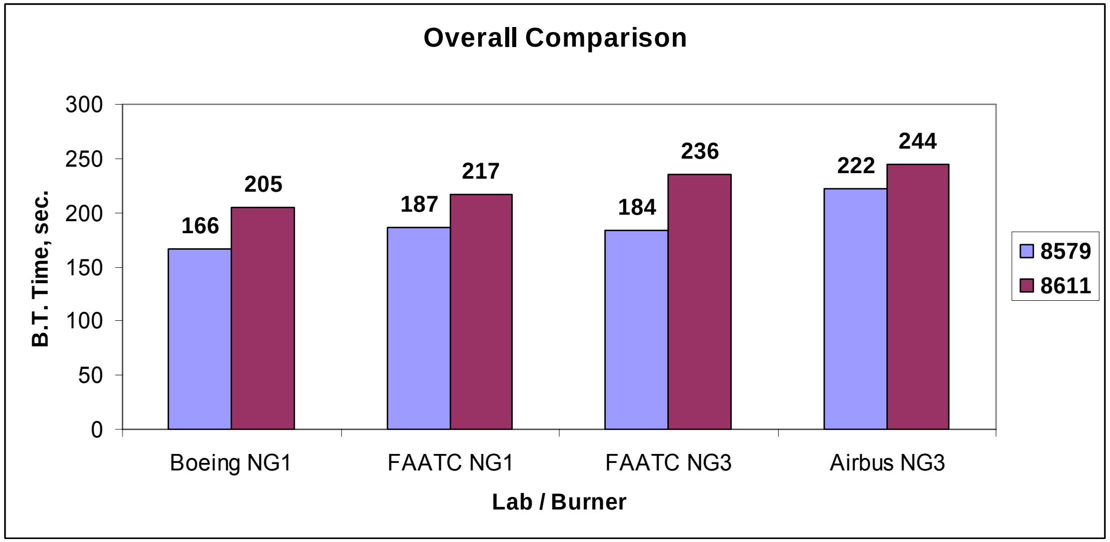
	Density	Viscosity	Droplet Size	Flowrate	Flame Temperature	8579 B.T.	8611 B.T.
Cold Fuel	+	+	+	+	-	+	unaffected
Warm Fuel	-	-	-	-	+	-	unaffected

- **Fuel temperature has an effect on several factors, possibly resulting in an effect on the b.t. time of certain materials**
- **The fuel temperature needs to be standardized**
- **The simplest way of achieving a standard fuel temperature is for all labs to use an ice bath to chill the fuel before reaching the burner**
- **Copper tubing can be coiled and immersed in a bucket filled with an ice-water mixture; this will cool the fuel to approximately 32-40°F.**

General Fuel Flow Observations

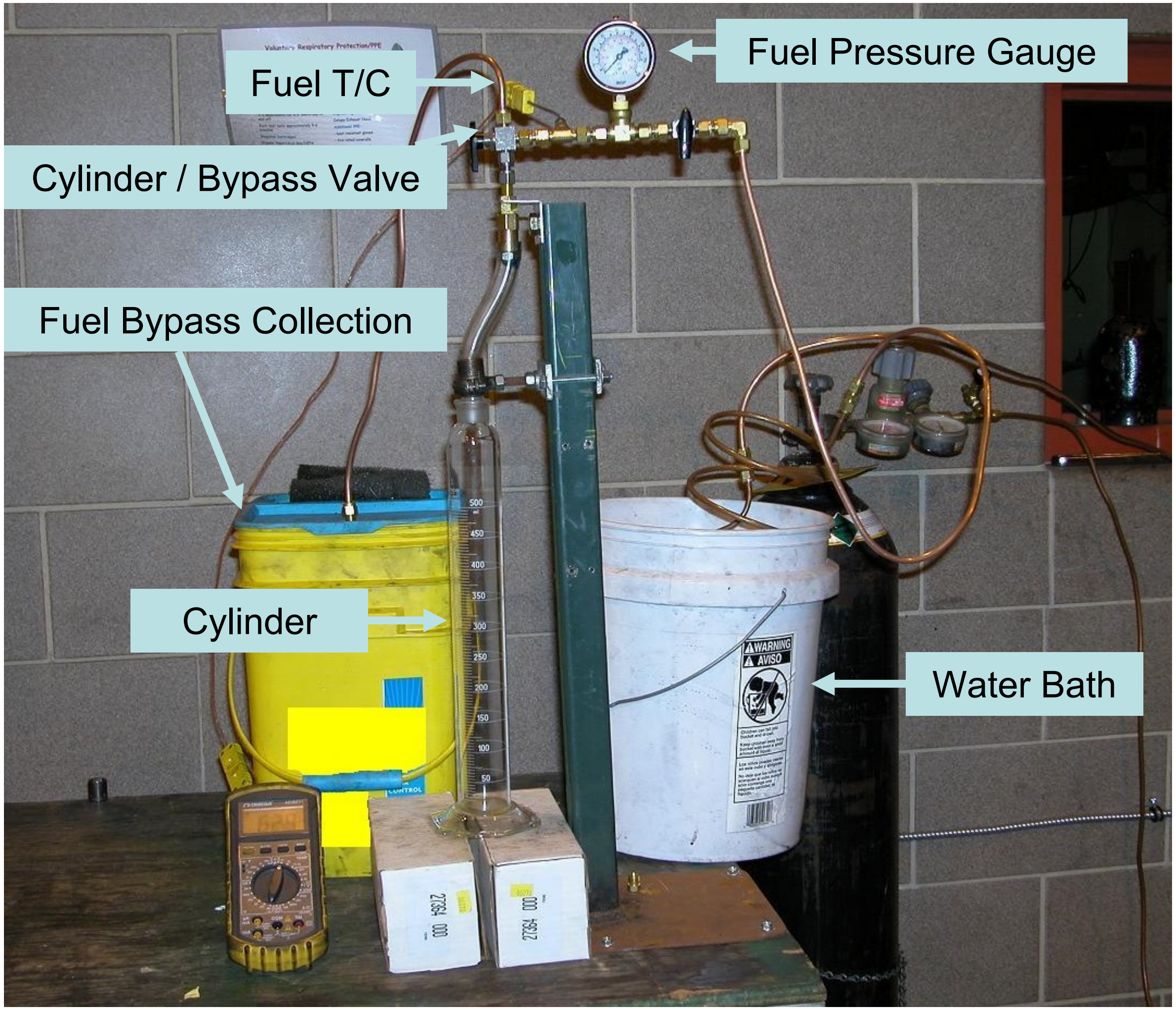
- **All labs required a different pressure to achieve the same fuel flowrate**
  - Possible causes?
    - Method of fuel pressurization
    - Fuel types
    - Fuel temperature
    - Fuel pressure measurement location and accuracy
- **Fuel pressure effect on B.T. times?**
  - Boeing: higher fuel pressure, quicker b.t. times
  - Airbus: lower fuel pressure, longer b.t. times
  - Does fuel pressure have more of an effect on b.t. times than the fuel flowrate?



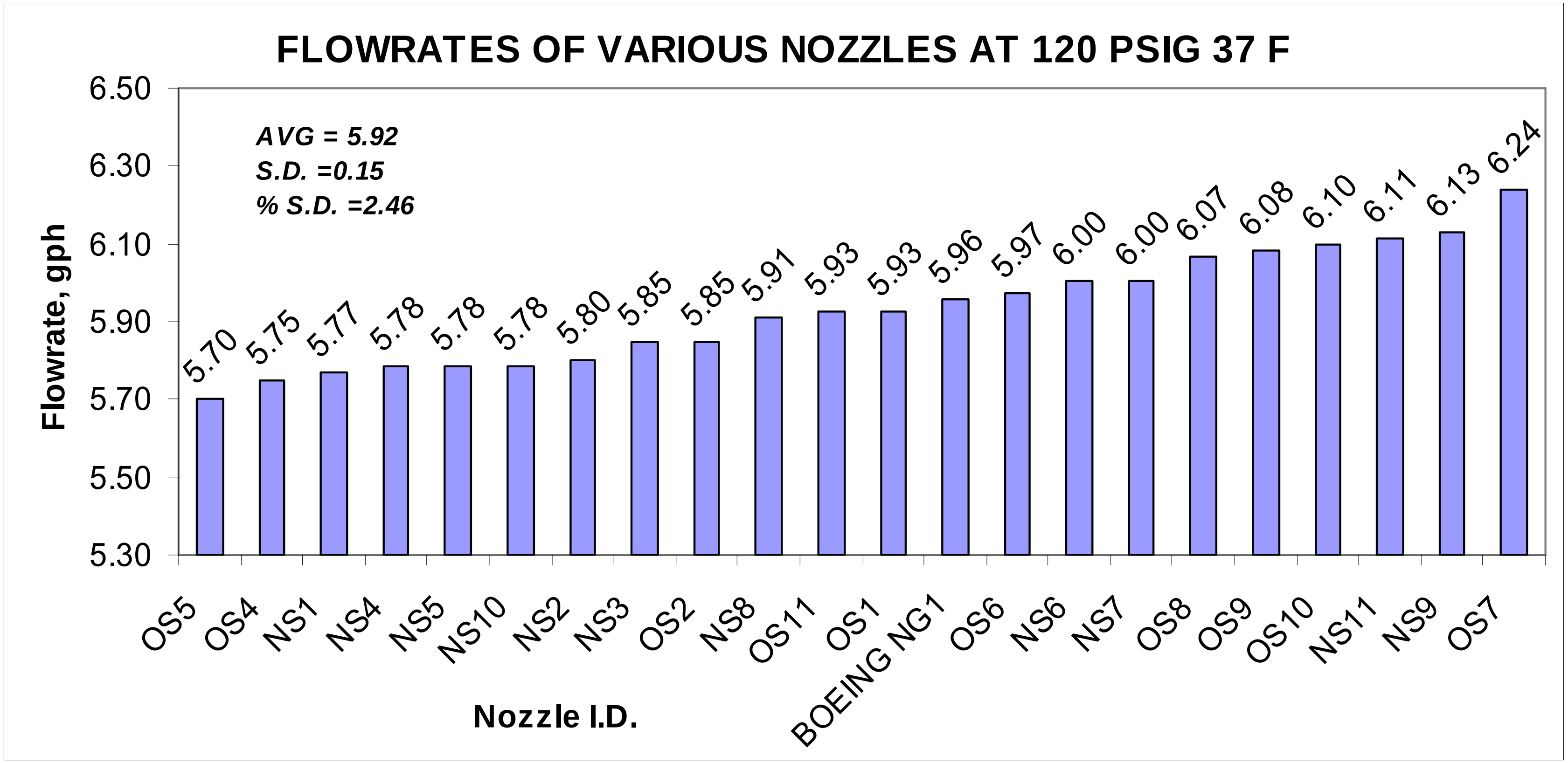


Fuel Nozzle Flowrate Bench Test Apparatus

- A bench test apparatus was developed to easily and quickly test multiple nozzles for flowrate
- Fuel temperature and pressure can be carefully monitored close to the nozzle
- Fuel pressure is supplied by the pressurized fuel vessel
- Fuel temperature can be regulated by means of fuel lines coiled through a water bath
- A calibrated graduated cylinder (500 mL, 5 mL graduations) was used to collect the fuel
- A scale was initially implemented in order to determine mass flow rate as well as volumetric flow rate, and to calculate the fuel density as a function of fuel temperature



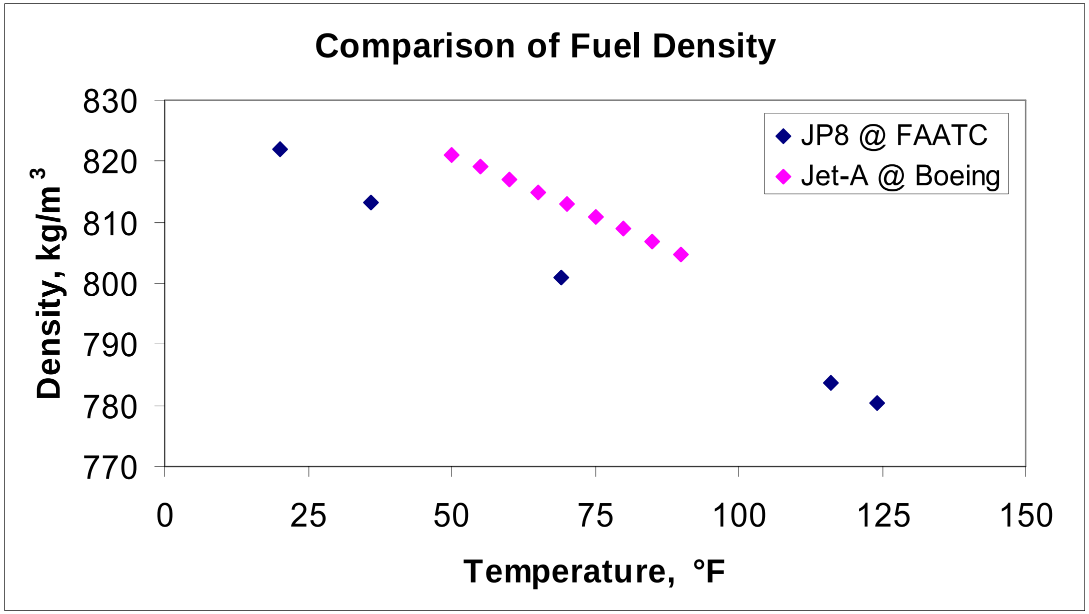
General Fuel Nozzle Observations



- **The intention here is to determine the flow properties of every nozzle in our inventory**
  - 10 “old style” (designated as OS) 5.5 gph F-80 nozzles
  - 11 “new style” (designated as NS) 5.5 gph F-80 nozzles
- **Nozzles were tested on the bench test apparatus, at a constant fuel temperature and pressure**

Fuel Density Study

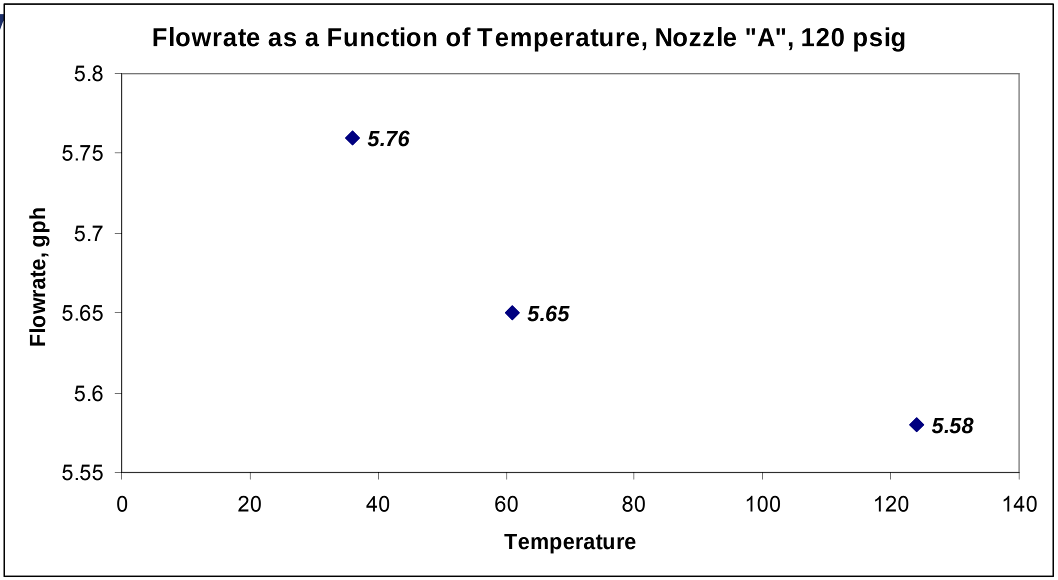
- **Fuel density was measured at FAATC and at Boeing**
  - At a given temperature, the Boeing Jet-A was more dense than the FAATC JP8
  - For example, at 70°F, ρ_{Boeing}=813 kg/m^3; ρ_{FAATC}=801 kg/m^3
  - Results in a % difference of ≈ 1.5%

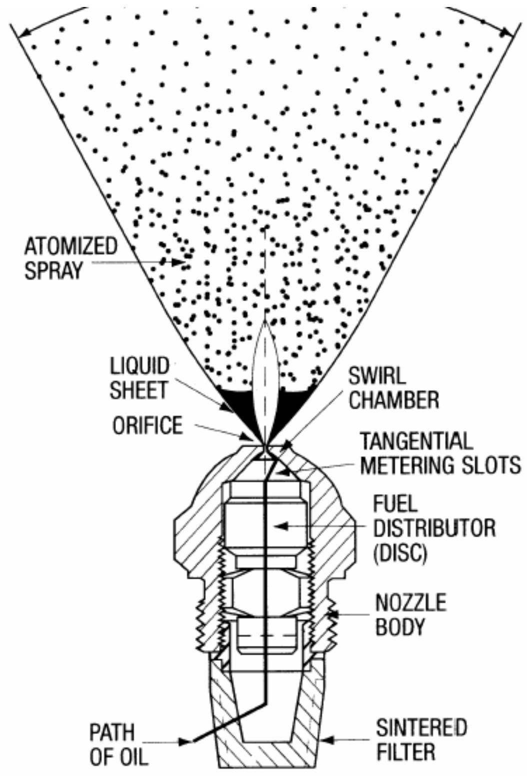


Fuel Nozzle Study

- **For a given nozzle at a standard pressure,**
  - Increasing the fuel temperature results in a decreased fuel flowrate
  - Decreasing the fuel temperature results in an increased fuel flowrate
  - For a temperature interval of ≈90°F, there can be a change in flowrate of ≈3.1%
  - Fuel that is colder (more viscous) flows more through a given nozzle than fuel that is warmer (less viscous)
  - Can be explained by the theory behind spray nozzle operation*
    - With colder, more viscous fuel, the thickness of the liquid sheet is greater as it exits the orifice
    - This reduces the diameter of the air core
    - Therefore, in the same volume, there will be more fuel than air with fuel that is more viscous

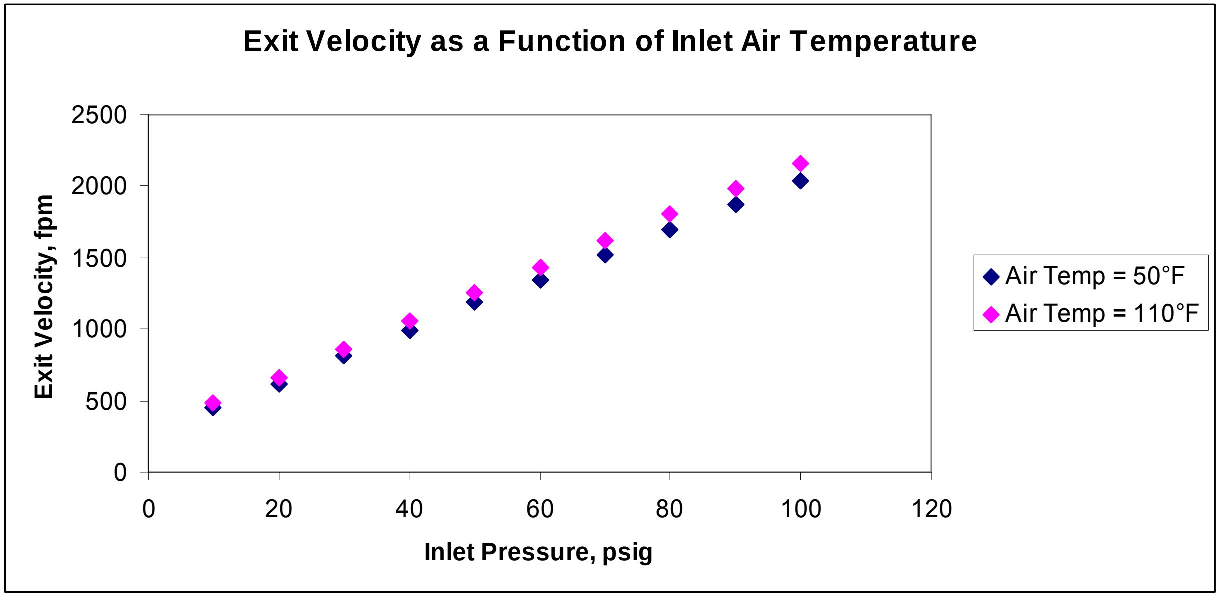
**From "A Technicians Guide To Oil Burner Nozzles", Hago Precision Nozzles, www.hagonozzles.com*

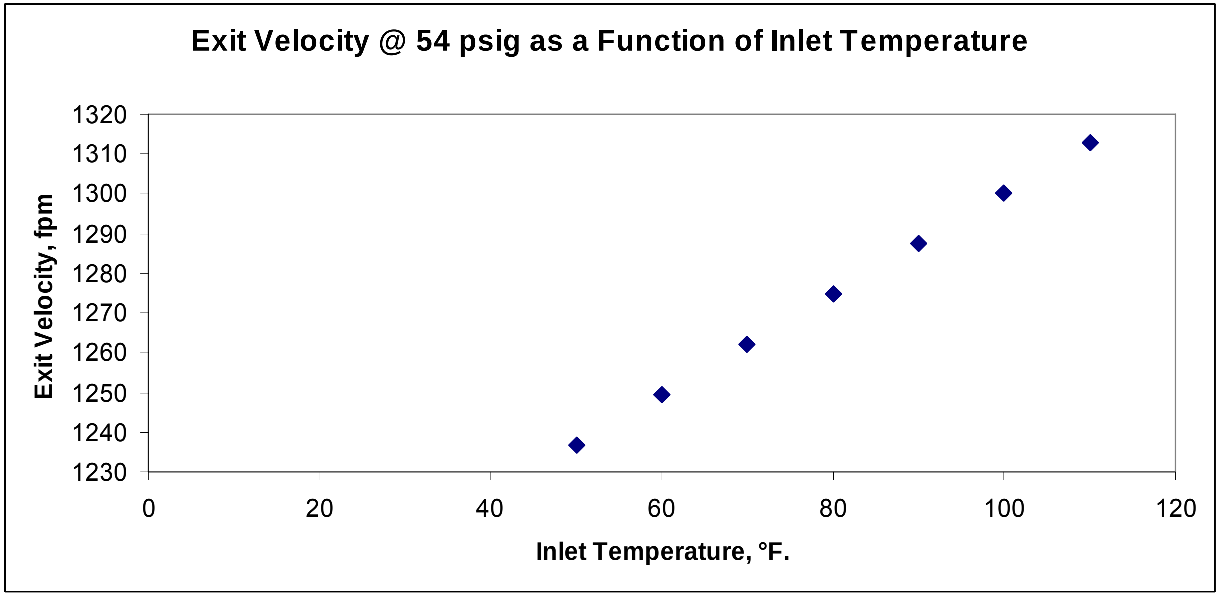




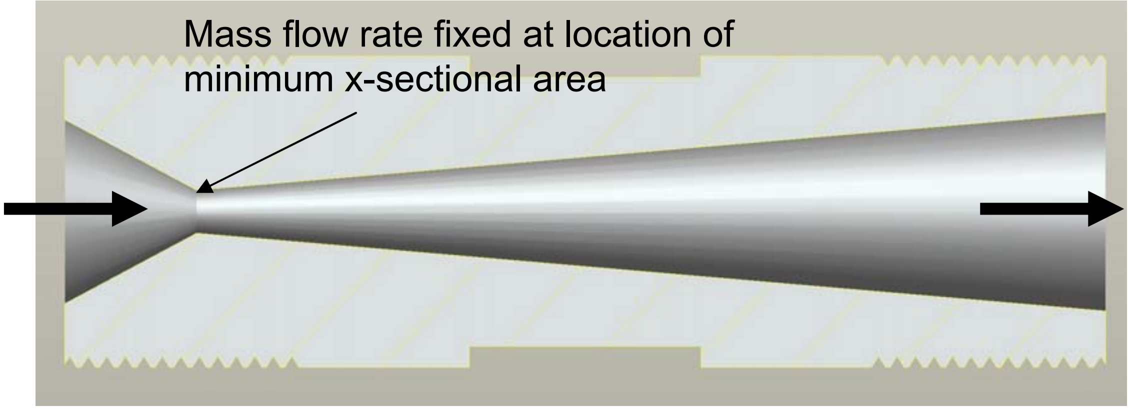
Air Velocity Observations

- Initially, Boeing did not have an in-line heat exchanger, and it was still unknown how much of an effect the air temperature may have on burner performance
- Air temperature was controlled by using heated or chilled water as the heat exchange medium for the in-line heat exchanger
- Burner exit velocity was measured with the Omega HH30 vane type anemometer
- With constant inlet air temperature, the sonic orifice inlet pressure was step increased in intervals of 10 psig, from 0-100
- Results indicate that it is critical for all labs to run at a standard inlet air temperature
- An in-line heat exchanger and an ice bath can be properly set up to give 50°F





Effect of Air Temperature on Exit Velocity



Density is inversely proportional to the inlet air temperature – increasing the inlet air temperature decreases the air density

Mass flow rate = ρ*U*A = mass/time

where:

ρ=inlet air density, mass/length^3

U=inlet air velocity, length/time

A=x-sectional area, length^2

$\uparrow$T results in $\downarrow\rho$

At the throat, the mass flow rate is fixed

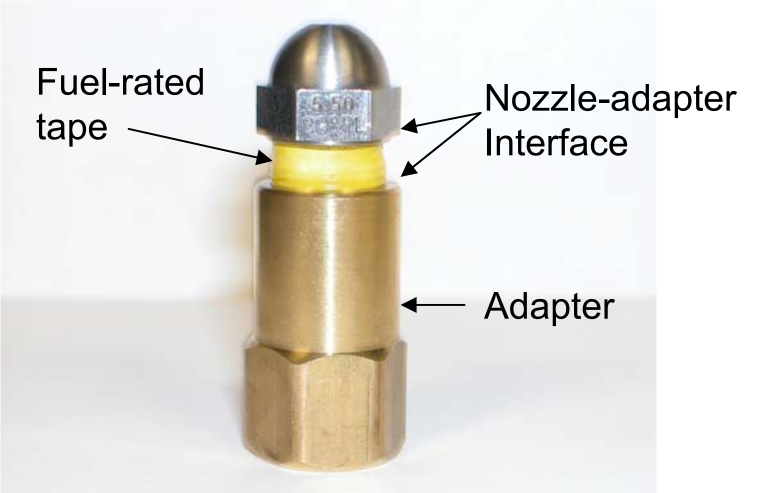
ρ*U*A =constant

If the inlet air temperature increases, the density will decrease. In order for the mass flow rate to remain constant at the throat, the product of the velocity and the area must increase accordingly. The x-sectional area can not increase because it is fixed. Therefore, the velocity at the throat must increase, resulting in an overall increase in the velocity from the throat out towards the burner exit

This is demonstrated in the experimental measurements – increases in inlet air temperature resulted in an increase in the measured burner exit velocity.

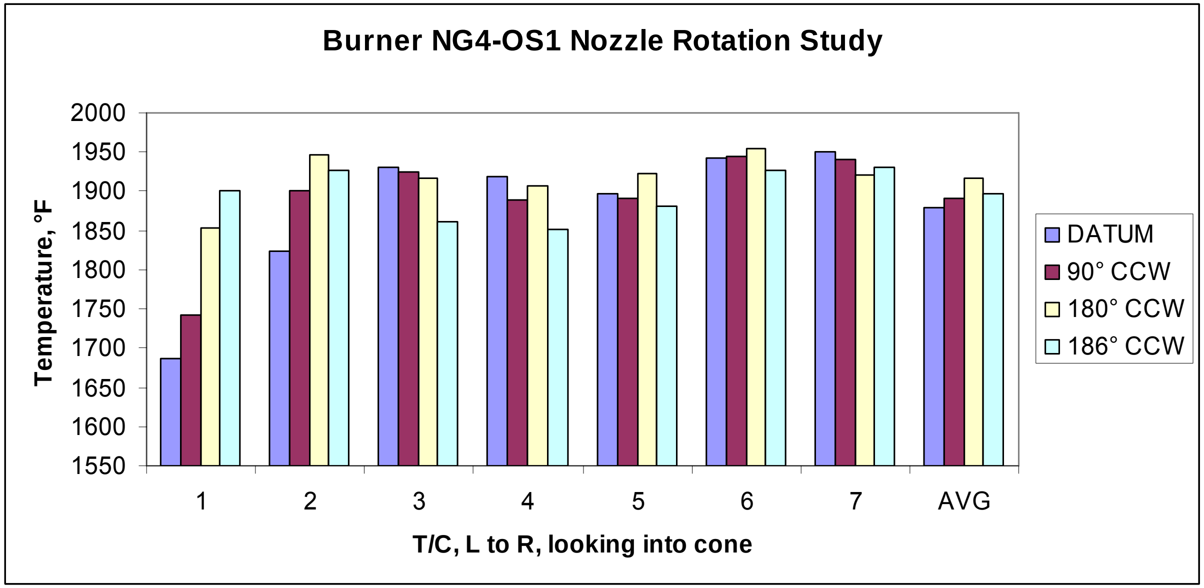
Problems found with burners…

- Fuel rails require an exact bend in order to fit properly in burners; several fuel rails were not bent properly, and caused misalignment of fuel rail
- Threading of fuel rails was not exact, and therefore some fuel nozzle adapters may be misaligned
- Fuel nozzle – adapter interface may leak, causing fuel “spitting” during burner operation. Fuel-rated Teflon tape can be used on nozzle threads to fix leakage
- Developed a method of indexing the nozzle orientation for each burner, in order to optimize the spray and therefore the flame temperature distribution



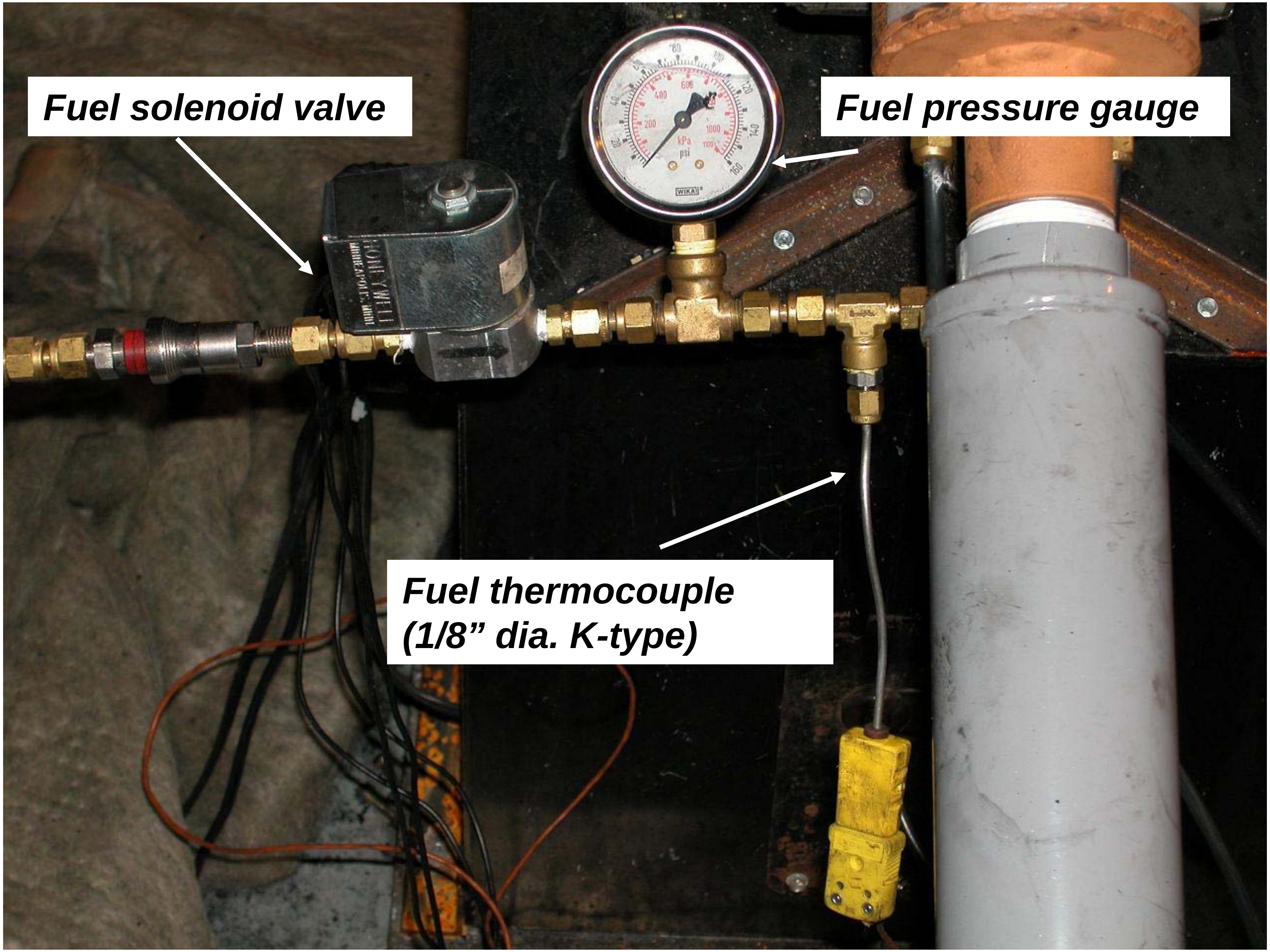
Nozzle Indexing

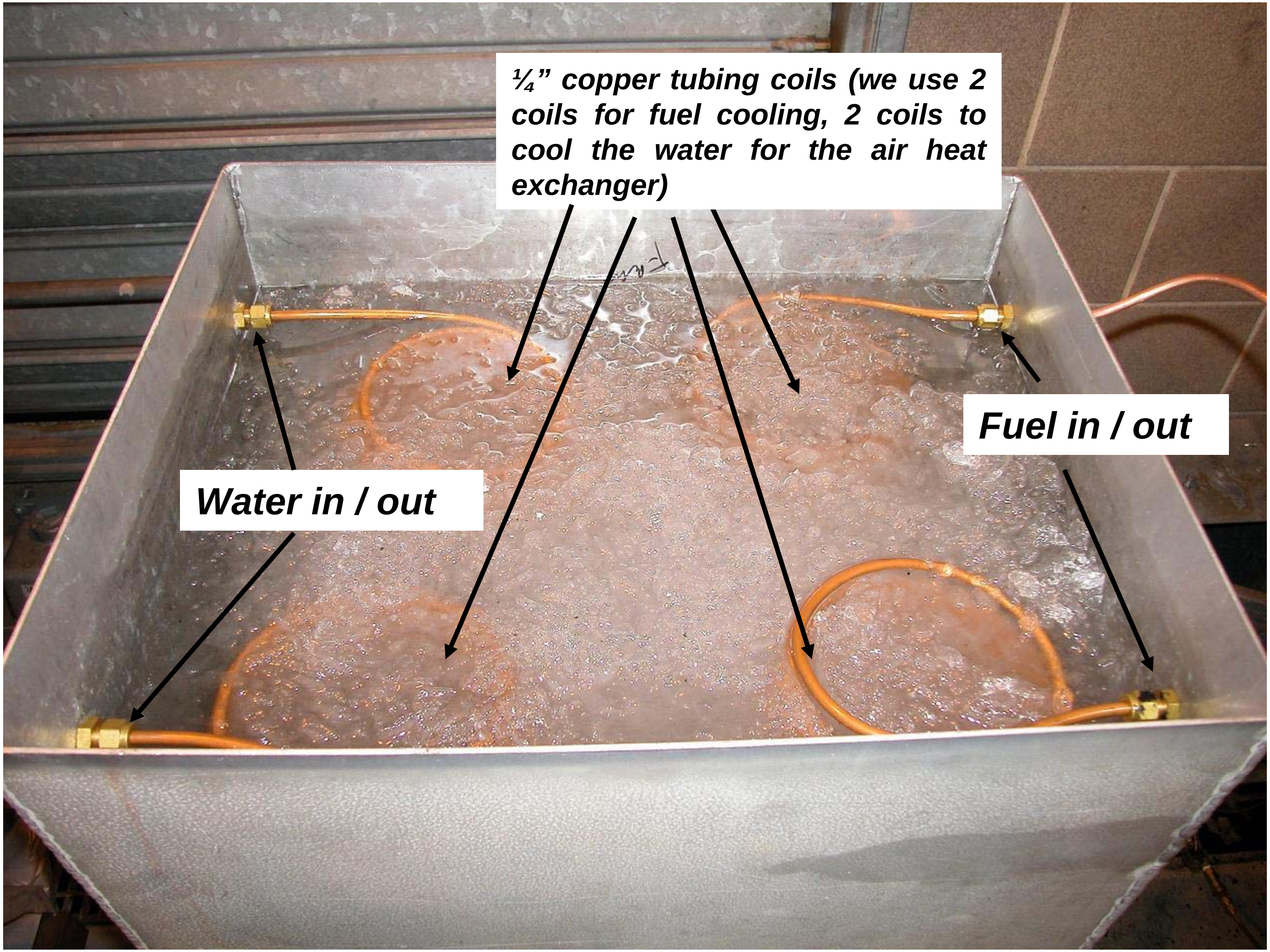
- Indexing the nozzle was found to have a significant effect on the flame temperature distribution
- Large increments of 90° were initially attempted in order to determine the effect
- The main goal was to eliminate the sooting on the #1 T/C and to even out the temperature profile to have an average near 1900°F
- In this case, an optimal setting of 180° from the arbitrary datum was found to provide the best flame temperature distribution
- This process implies that fuel nozzle spray distribution is not necessarily symmetric about the circumference of the hollow cone spray
- Further investigation is required



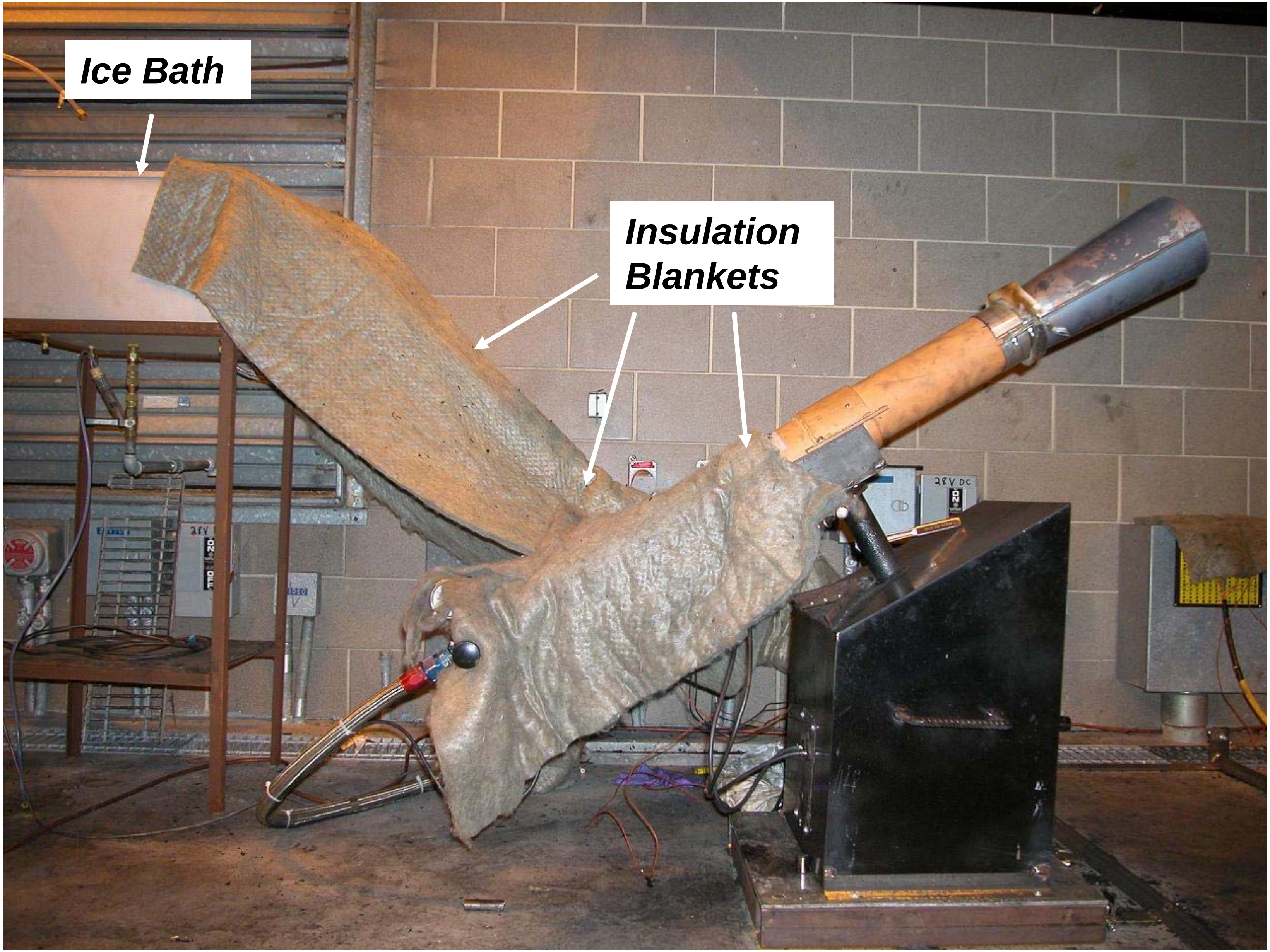
Burner Setup Checklist

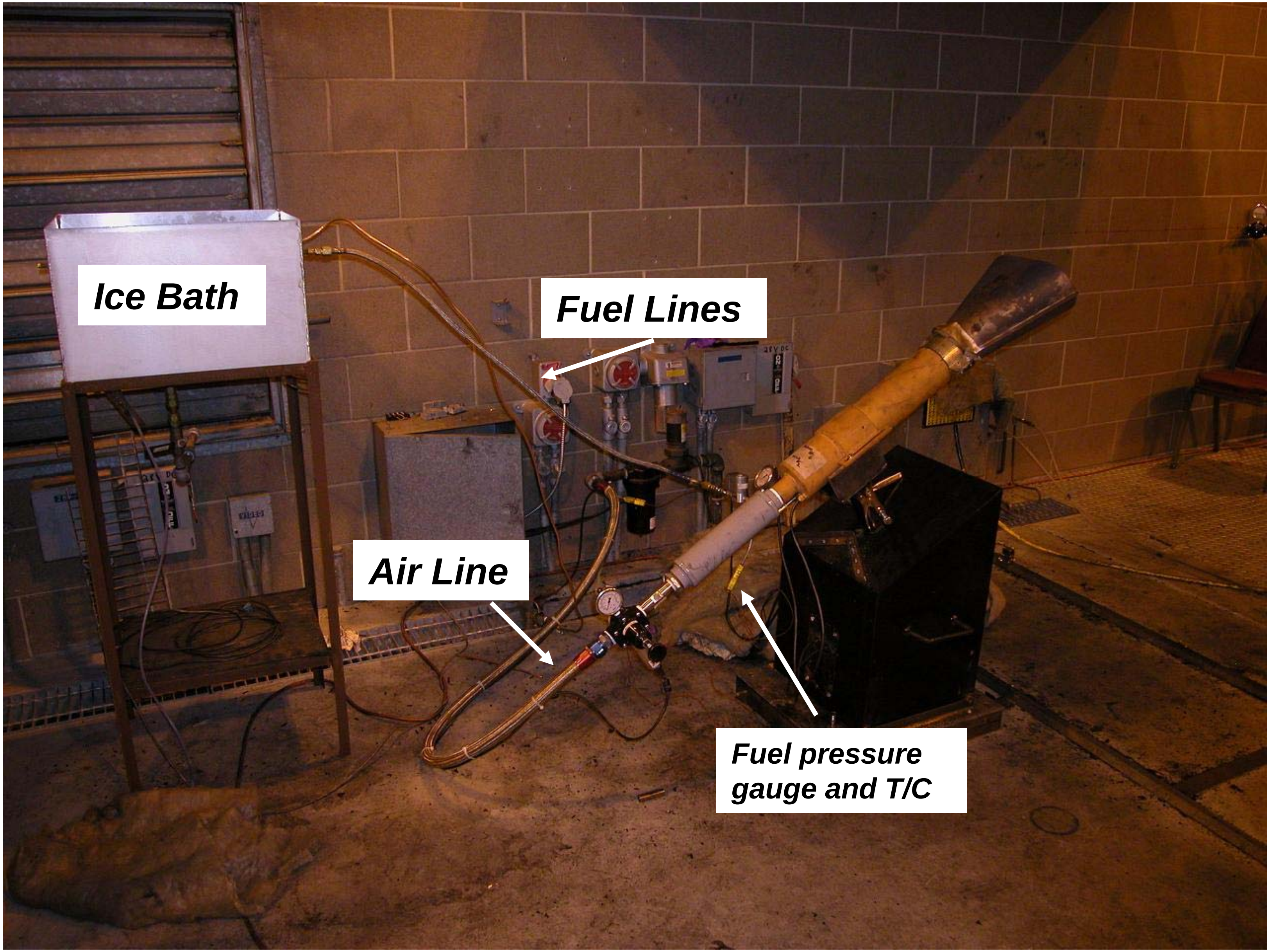
- **Fuel Temperature**
  - Fuel temperature must be measured at the back of the burner
  - A 1/8” sheathed type-K thermocouple inserted into a ¼” Swagelok t-connection should be inserted into the fuel line The liquid fuel should be cooled in an ice bath. This can be achieved by using a tub or bucket filled with an ice-water mixture (a regular beverage cooler keeps ice longer). Fuel run through copper tubing coils will cool to approximately 32-40°F by the time it reaches the fuel thermocouple. The length of the coils in the bath at the tech center is approximately 37 feet (the length of the coils will vary depending on where the ice bath is located)
  - The initial temperature of the fuel should be around 32-40°F. During the length of a test, the fuel temperature increase should not be greater than 10°F (the maximum increase seen at the tech center was around 5°F).
  - Insulation should be used to cover the ice bath, fuel, and air lines to prevent heating of the fuel or air by flame radiation.
- **Fuel Pressure**
  - Fuel pressure is to be measured in the same manner as temperature.
- **Air Temperature**
  - To regulate the air temperature, an in-line water cooled heat exchanger can be used to dampen out fluctuations in air temperature. McMaster-Carr p/n 43865K78 and 43775K55 is used at the tech center. This device keeps the change in air temperature down to approximately 5°F, with an initial temperature of approximately 40-60°F (depending on the water temperature).
  - An ice bath can be used to chill the water used as the heat exchange medium for the heat exchanger. This will expedite the cooling process, and will also help to maintain a very steady air temperature.
- **Cone**
  - The top side of the cone is marked with three hash marks to align the cone with the draft tube. Use these marks as a guide, but not to replace proper measurement and orientation.


Fuel solenoid valve
Fuel pressure gauge
Fuel thermocouple
(1/8" dia. K-type)


¼” copper tubing coils (we use 2 coils for fuel cooling, 2 coils to cool the water for the air heat exchanger)
Water in / out
Fuel in / out

New and Improved Ice Bath


Ice Bath
Insulation Blankets


Ice Bath
Fuel Lines
Air Line
Fuel pressure gauge and T/C

Adaptability to Other Test Methods

- **Currently, several FAA fire tests require the use of a modified Park oil burner to qualify materials for use in aircraft**
  - Thermal/acoustic insulation burnthrough
  - Seat cushion testing
  - Cargo liner testing
  - Power plant hose assemblies test
  - Power plant fire penetration test
- **Future test may also rely on a modified oil burner**
  - Testing of seat frames constructed of materials other than aluminum
  - Testing of components constructed of non-traditional materials (composites being used where aluminum was traditionally used)

Adjustments

- **The fuel and air flowrates can be adjusted for each different test method**
  - Any oil burner fuel nozzle can be installed to give a variety of fuel flowrates and spray patterns
  - The inlet air pressure can be adjusted to deliver a specific mass flow rate or burner exit velocity towards the sample
  - The inlet air and fuel temperature can be controlled to suit the needs of the test
  - For example, installing a 2.0 gph nozzle and adjusting the air pressure to 45 psig would make the burner suitable for a seat cushion test

NexGen Burner Distribution

- **Currently, NexGen burners are located at:**
  - NG1: CEAT*
  - NG2: FAATC
  - NG3: FAATC
  - NG4: FAATC*
  - NG5: AIRBUS*
  - NG6: BOEING*
  - NG7: FAATC*
  - NG8: FAATC
  - NG9: FAATC
  - NG10: FAATC

  * Indicates burner testing is complete
- **One burner will be used for testing seat cushions**
- **Another burner will remain at the tech center for burnthrough testing**

PART II: NEXGEN BURNER COMPARITIVE TESTING RESULTS

Initial Comparative Testing, Winter 2006

- **Burners NG1 and NG3 were sent to Boeing and Airbus, respectively.**
- **FAA visited each lab to assist in setting up and running comparative tests *on the original blanket holder* with 2 types of PAN material – 8579 (less dense) and 8611 (more dense)**
- **The general observations were:**

Observations from Boeing – FAATC Comparison

	FAATC	*Boeing*
8579	187	166
8611	217	205

- **Burnthrough time differences:**
  - Boeing lab was consistently quicker to burnthrough on both materials than FAATC
- **Fuel system differences:**
  - Boeing lab used a fuel pump from a commercial oil burner, FAATC uses pressurized fuel vessel
  - Boeing lab required a greater fuel pressure to achieve 6.0 gph fuel flow (145 vs. 120)
  - Boeing lab uses Jet-A fuel, FAATC uses JP8
  - Fuel temperature was not measured at Boeing
- **Air system differences:**
  - Boeing lab uses shop air, no cooling method; FAATC uses compressed air and in-line heat exchanger to maintain air temperature
  - Air temperature was found to fluctuate at Boeing lab
- **Recommendations:**
  - Check fuel pressure gauge for accuracy; replace if inaccurate
  - Monitor fuel and air temperature
  - Install in-line heat exchanger
  - Shield air and fuel lines from flame radiation

Observations from Airbus – FAATC Comparison

	FAATC	Airbus
8579	184	222
8611	236	244

- **Burnthrough time differences**
  - Airbus was consistently longer to burnthrough on both materials
- **Fuel System**
  - Airbus used a pressurized fuel vessel, but pressure was measured in the vessel headspace only, and not near the burner
  - Airbus used JP8 fuel
  - Airbus required less pressure to achieve 6.0 gph
  - Fuel lines were left exposed to flame radiation and possible fuel heating; fuel temperature was not measured
- **Air System**
  - Airbus used unconditioned shop air
  - Air lines were left exposed to flame radiation and possible air heating; air temperature was not measured
- **Recommendations**
  - Measure air and fuel temperature and fuel pressure near the burner inlet, check for fluctuations during testing
  - Shield air and fuel lines from flame radiation
  - Install in-line heat exchanger for inlet air

Comparison of Boeing and FAATC… Take 2 – January 2007

- **The Tech Center would set up, test, and ship out 2 burners to Boeing**
  - Burners NG4OS1 and NG6OS11 were designated to go to Boeing (note the new designation of burners – NG# for burner number, and OS# for nozzle type and number)
  - These burners have been adjusted as per our recent findings:
    - Properly aligned fuel rail
    - Fuel rated Teflon tape on nozzle threads
    - Nozzle orientation was optimized, and sooting on T/C 1 was no longer an issue
- **Now, Boeing had installed an ice bath to chill the fuel, as well as measure the fuel temperature and pressure nearer to the back of the burner**
- **Fuel and air lines were also properly shielded, and the fuel temperature stayed constant during the length of a test**
- **No method of cooling the inlet air was established at this point, and air temperatures of anywhere between 60-90°F were observed**

Observations from Boeing – FAATC Comparison, Take 2

- **Overall summary**
  - This time around, burners performed better than initial comparisons in November 2006
  - Burnthrough times were still quicker with both burners on both materials when testing on the original blanket holder
  - Proper adjustment of burners critical to operation
  - Boeing lab needs:
    - In line heat exchanger for air
    - New test frame
  - Is the cause of the discrepancy in b.t. times due to burners, materials, or test frame?
    - This comparison again implies the need for a method to determine if burners are operating properly
    - A method is desired that can:
      - Indicate an “absolute” b.t. time of a material, that is independent of the test frame, attachment method, alignment, etc.
      - Show the consistency or inconsistency of a burner or a material
    - More material is required
      - These comparisons were for materials at different ends of the same roll, does this have an effect?
      - More material was ordered, and shuffled in a manner such that each “pile” has an the same distribution of materials from throughout the entire roll

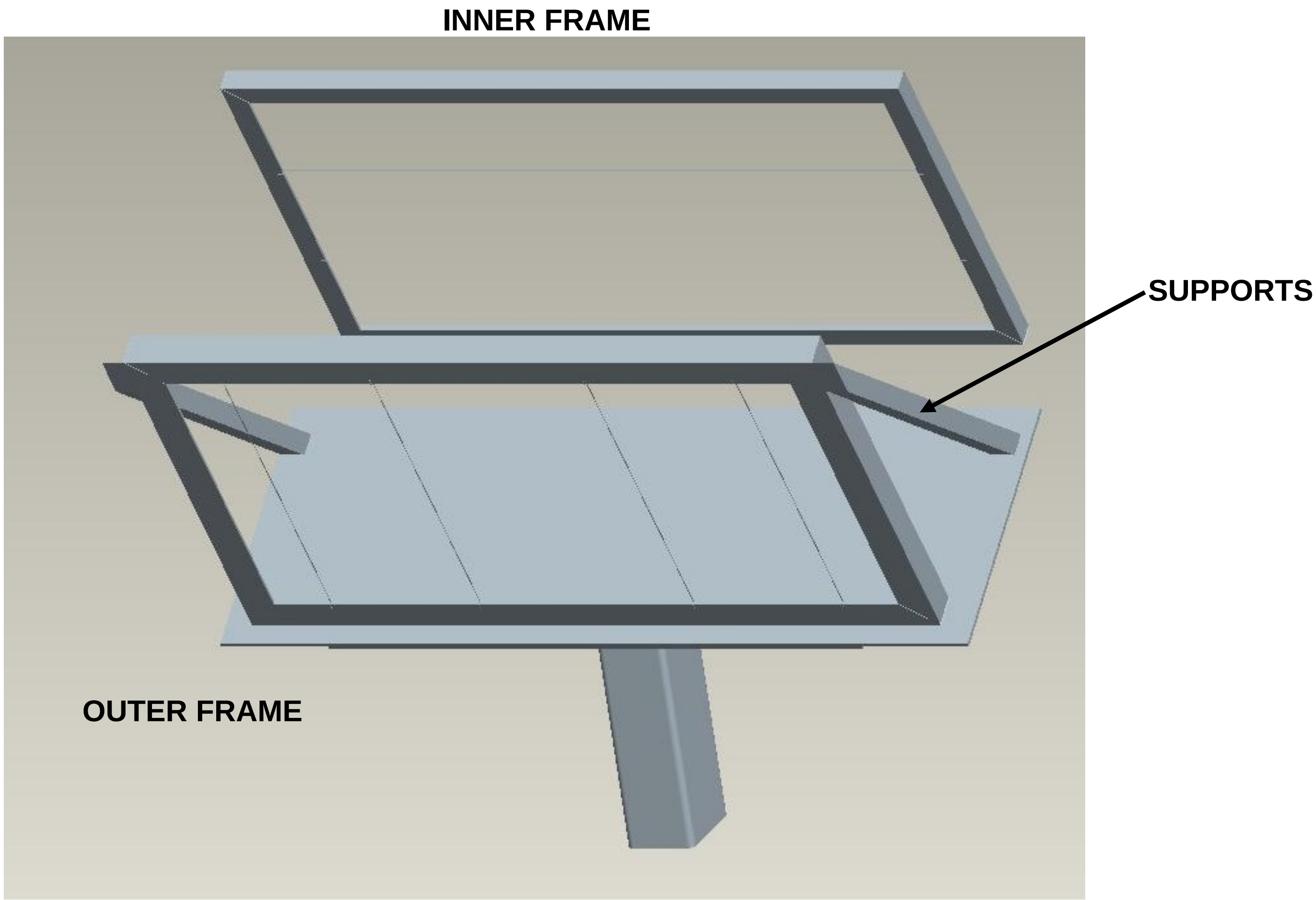
Original Blanket Holder

- It has been suspected for some time now that the differences in lab to lab comparison testing may be influenced or exaggerated by the blanket holder itself
- Differences in construction, alignment, methods and tightness of blanket attachment all may lead to results that are consistently different
- Blanket holder was designed to test materials that would be installed in an aircraft, and are traditionally more robust than single blankets of PAN material
- In order to determine if a burner is working properly at two different labs, a sample holder is required that can deliver the same sample testing scenario (tautness, distance, etc.) at all labs
- The picture frame blanket holder was designed to do just that

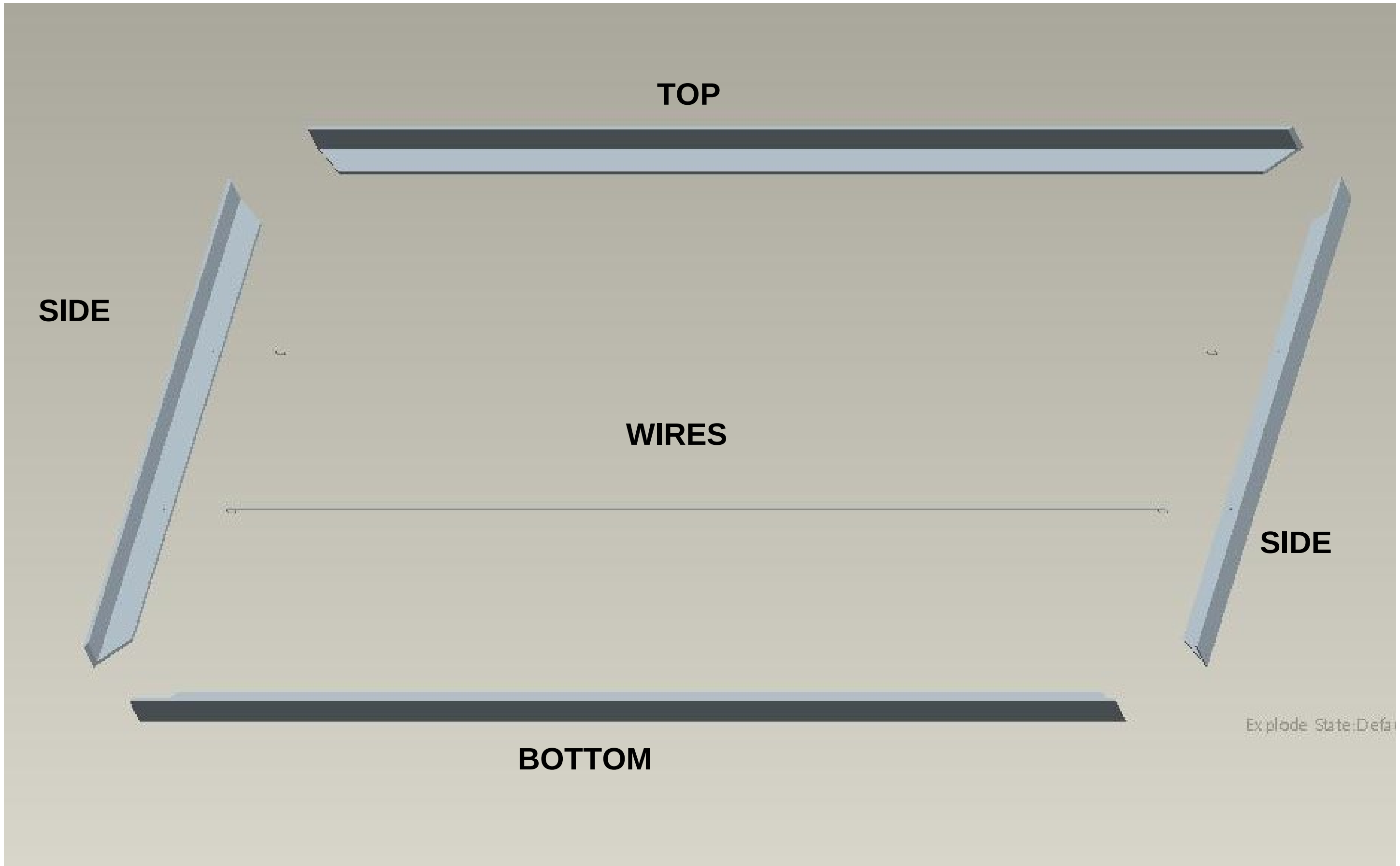
Picture Frame Blanket Holder

- **The picture frame design process went through two iterations**
  - First iteration used one 32” x 36” PAN blanket
  - Blanket was clamped on to the frame using the same clamps from the test method
  - It was found that the effect of the clamps was still present, as the material would shrink, and the tightness of the clamping would affect the burnthrough time
  - The second iteration used one half of a blanket, 32” x 18”
  - Instead of clamping the blanket in place, a smaller inner frame was made to apply slight pressure to the edges of the blanket
  - A steel wire support grid was made to keep the blanket in place
  - Results obtained with this blanket holder were much better, so it was decided to use this design to compare burners at different labs

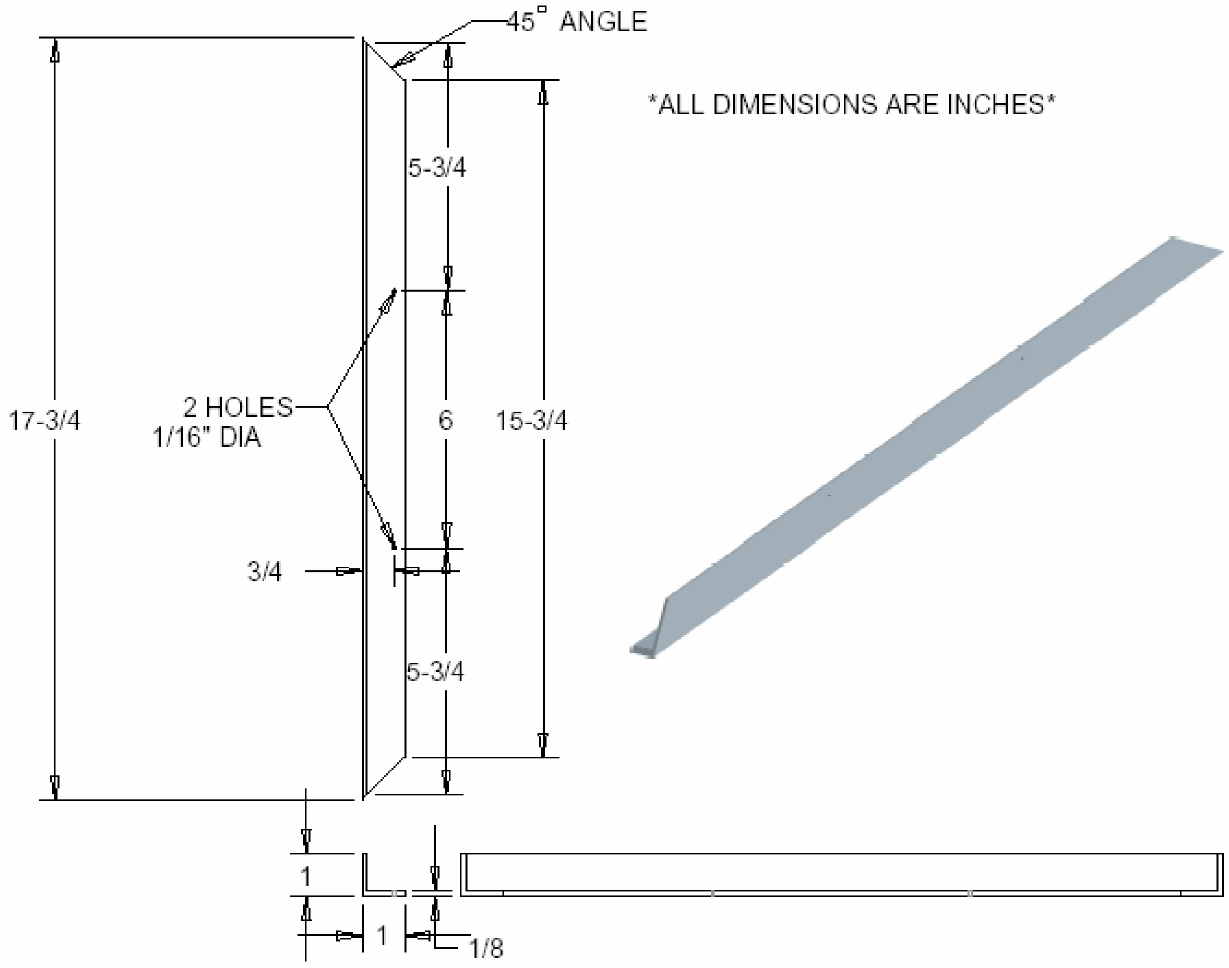
Picture Frame – Component View



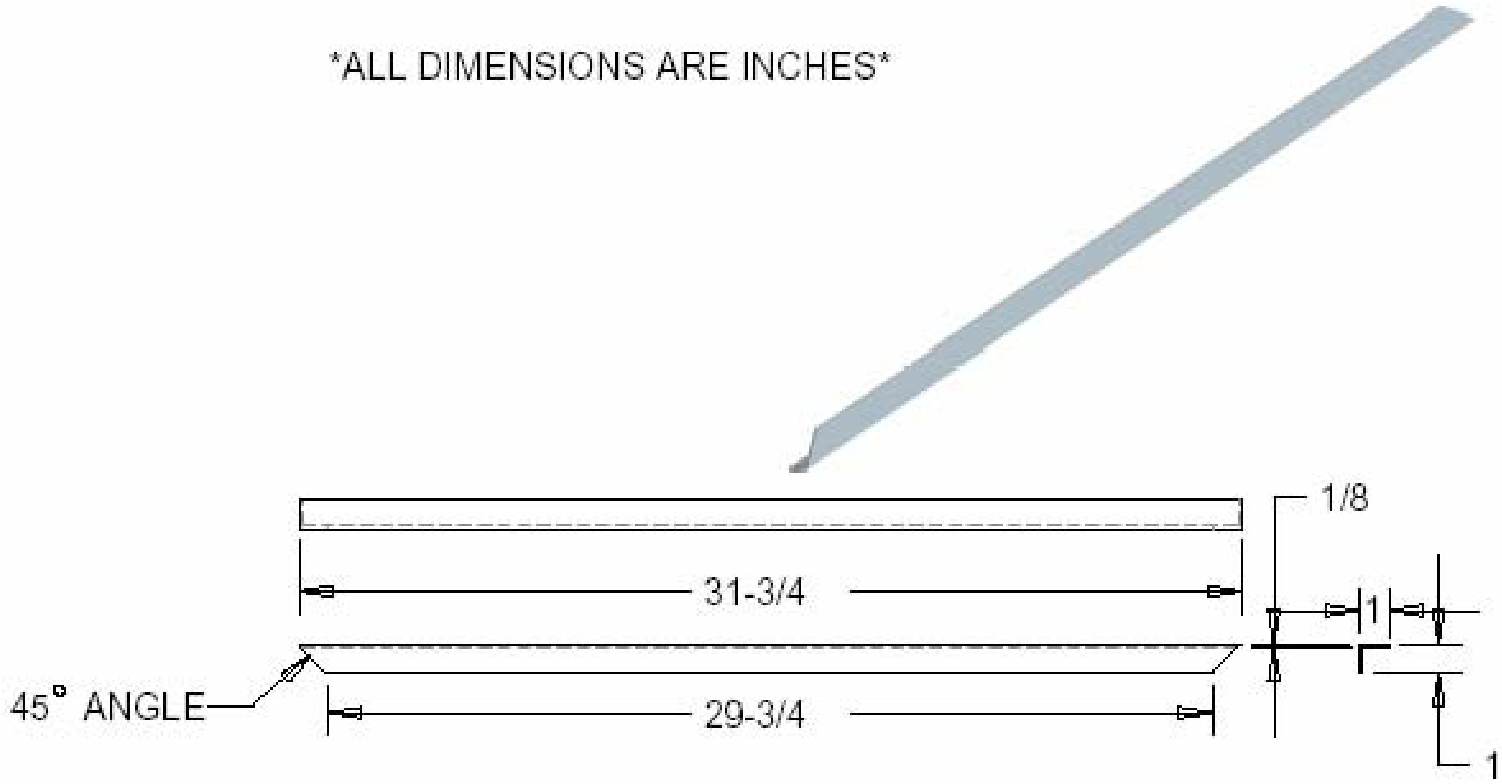
Inner Frame – Exploded View



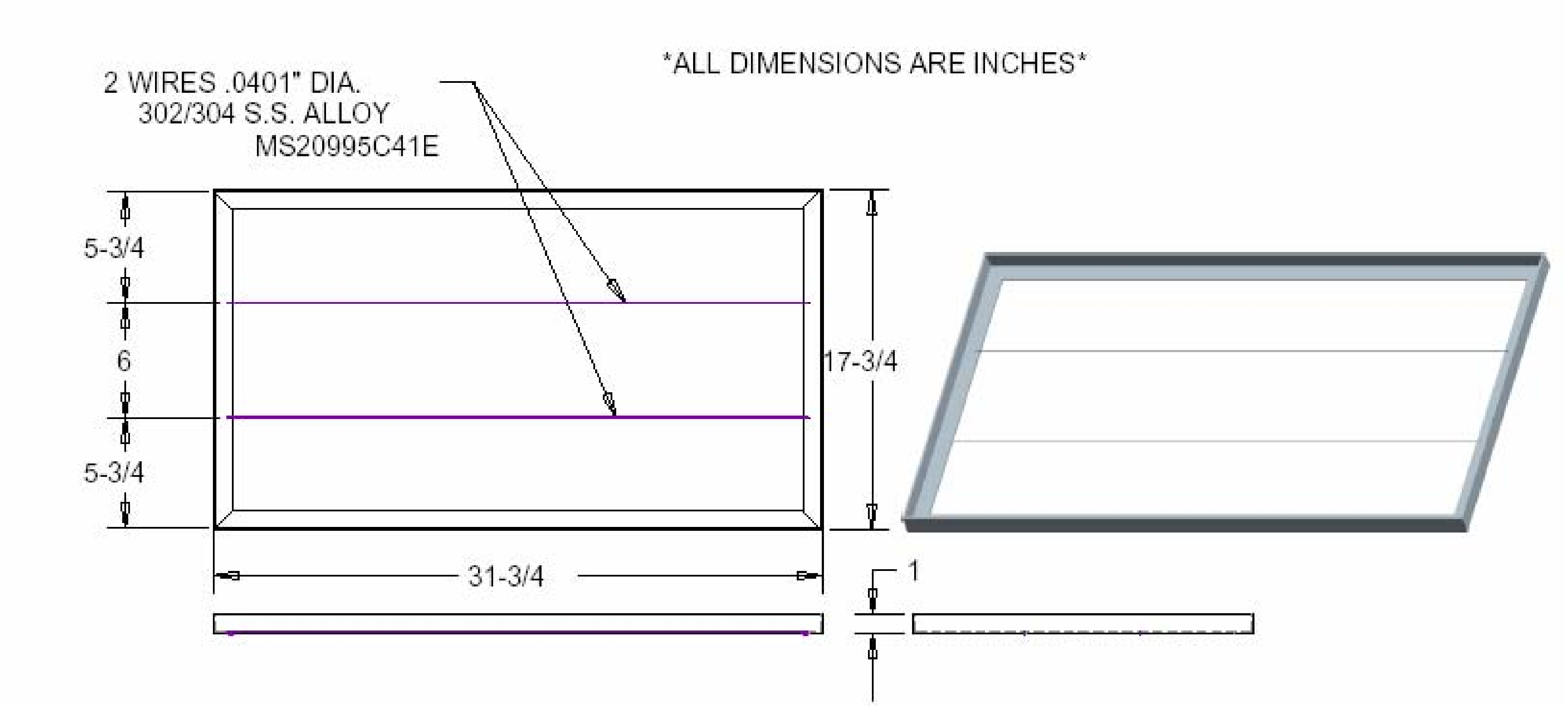
Inner Frame Components – Sides



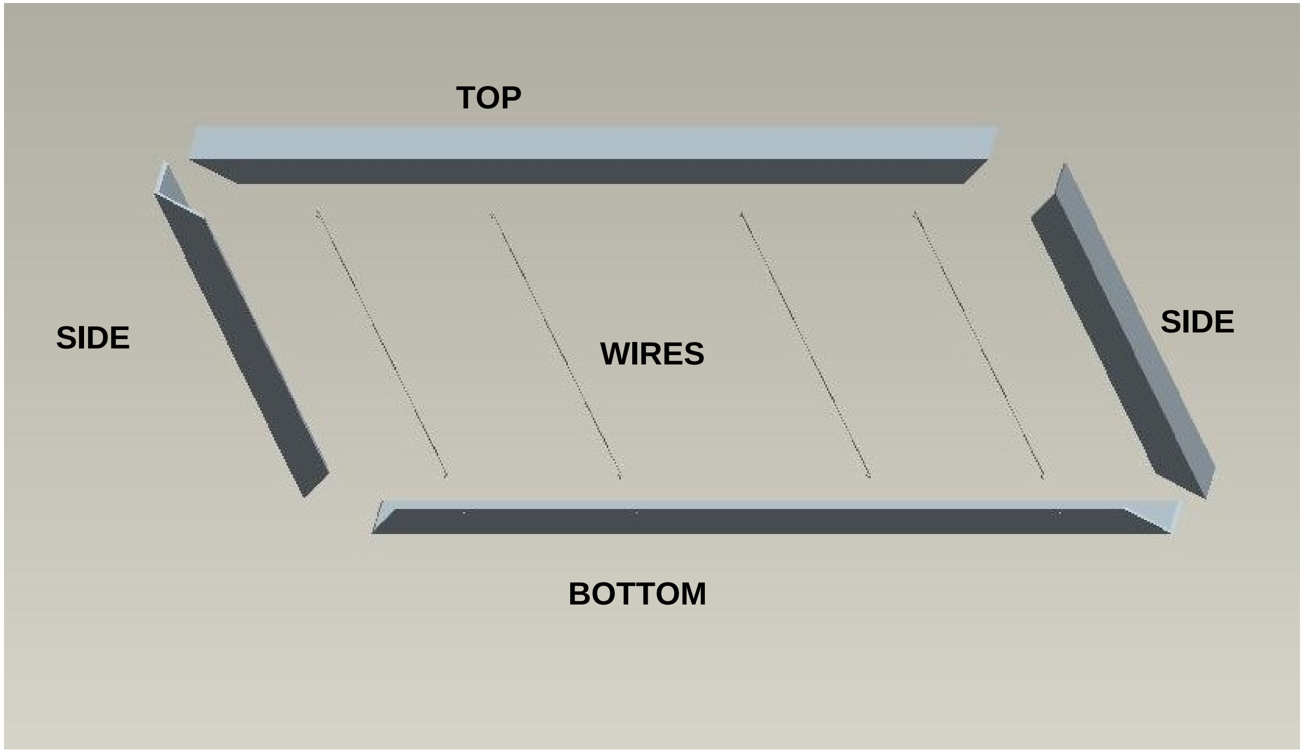
Inner Frame Components – Top & Bottom



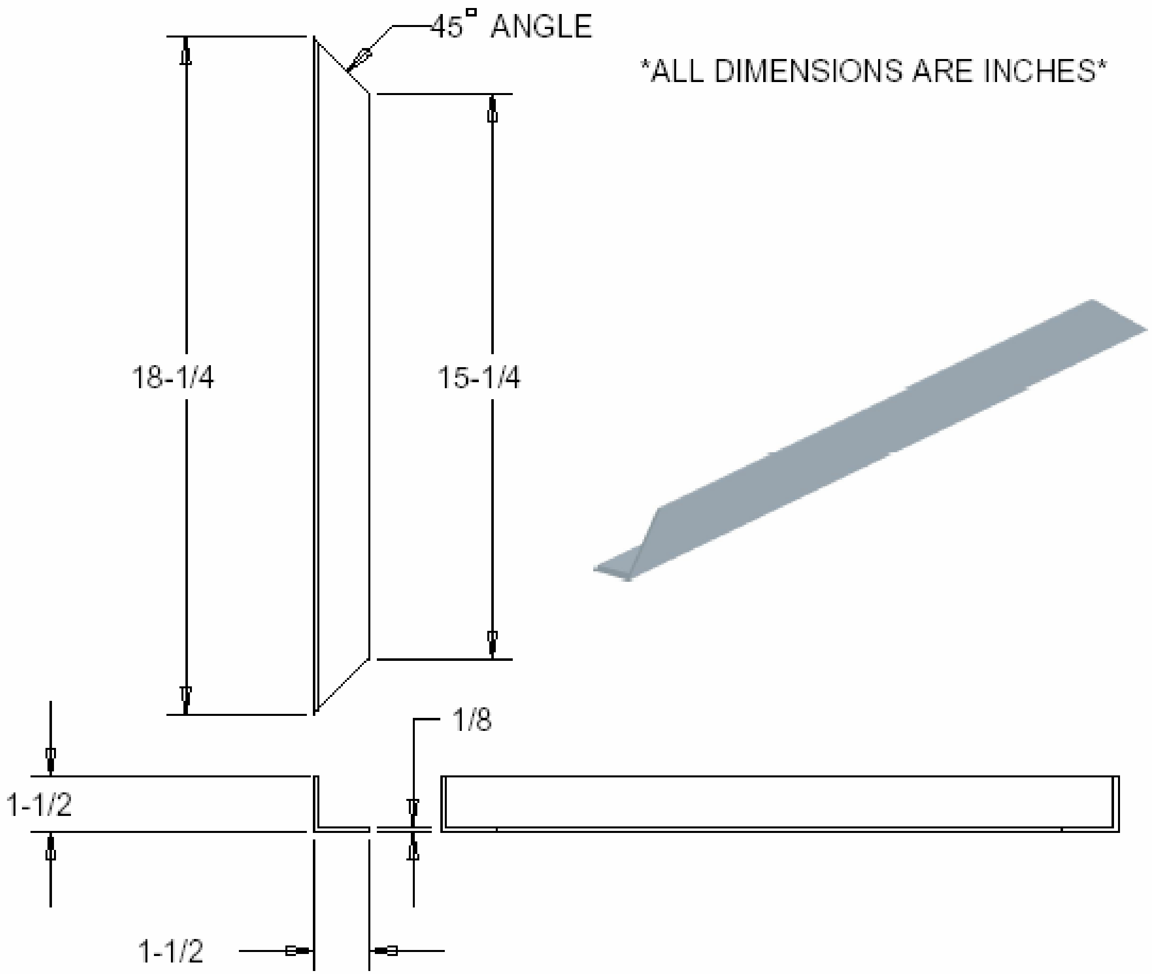
Inner Frame - Assembled



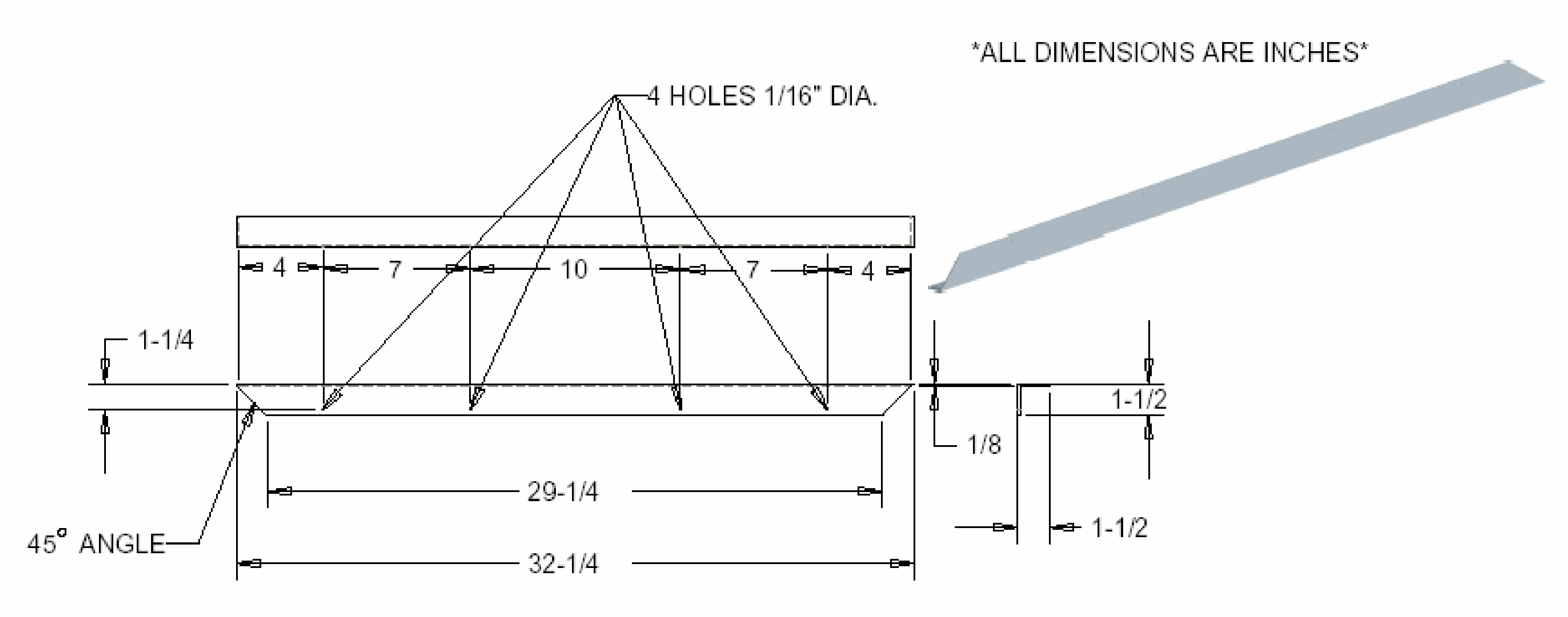
Outer Frame – Exploded View



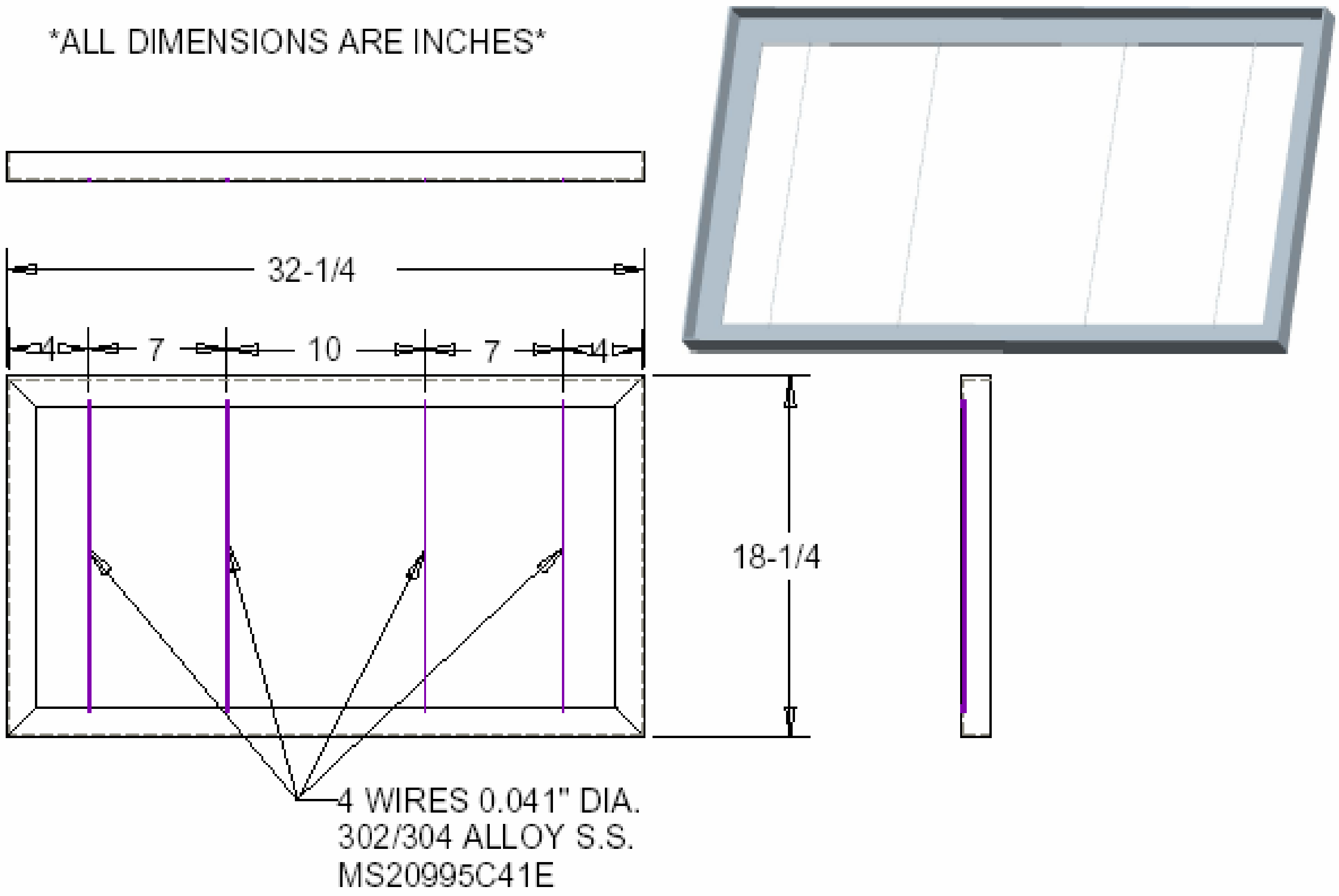
Outer Frame Components - Sides



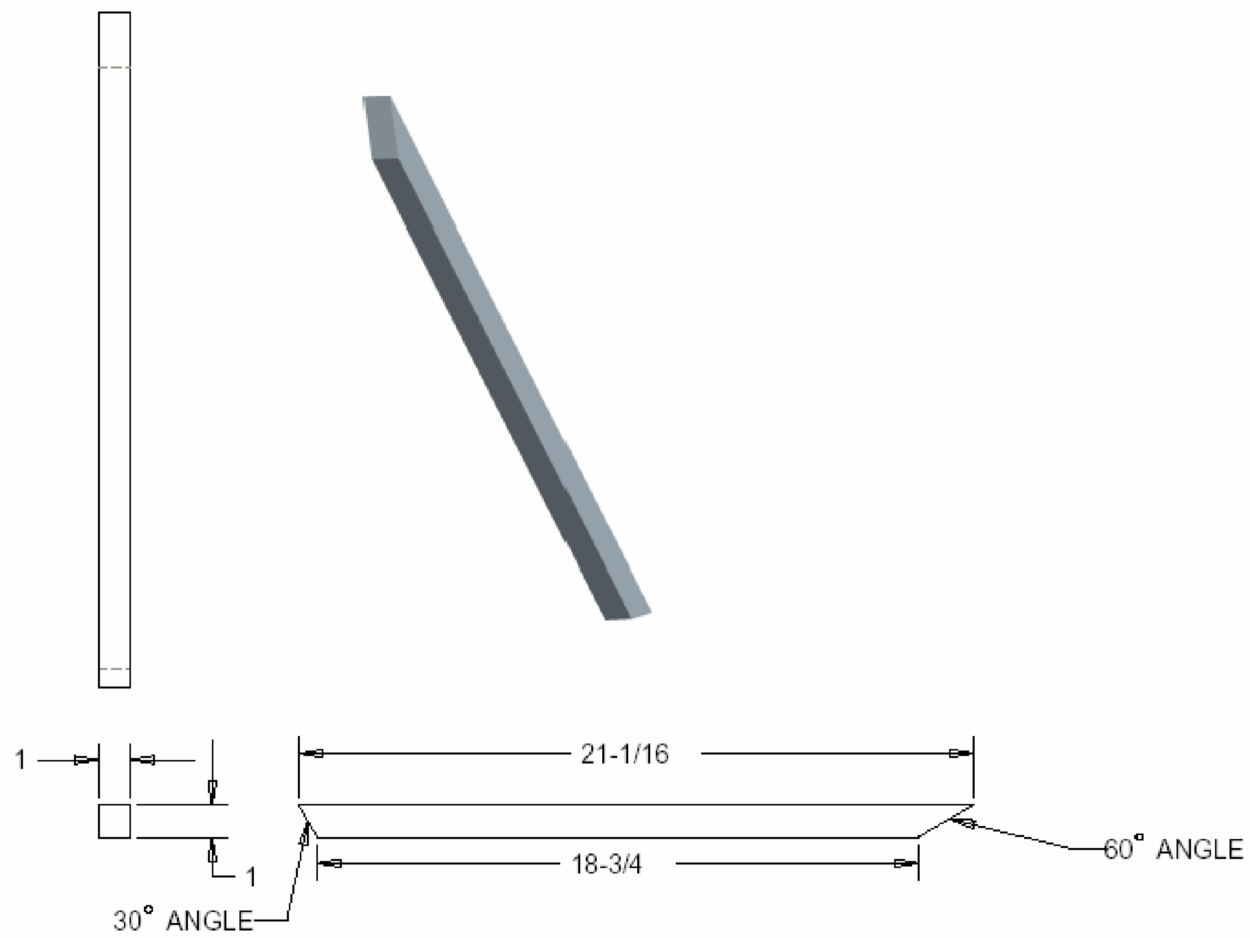
Outer Frame Components – Top & Bottom



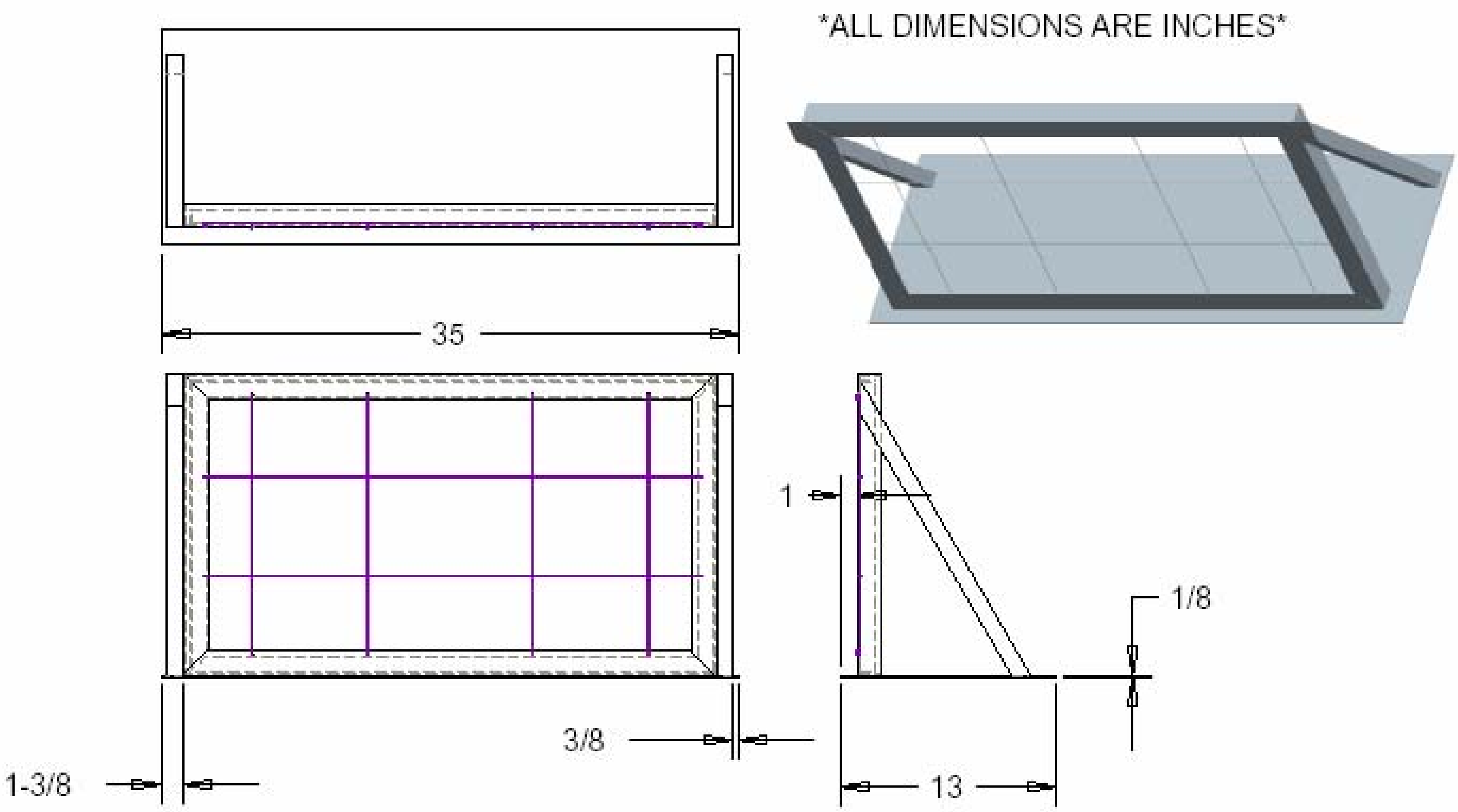
Outer Frame - Assembled



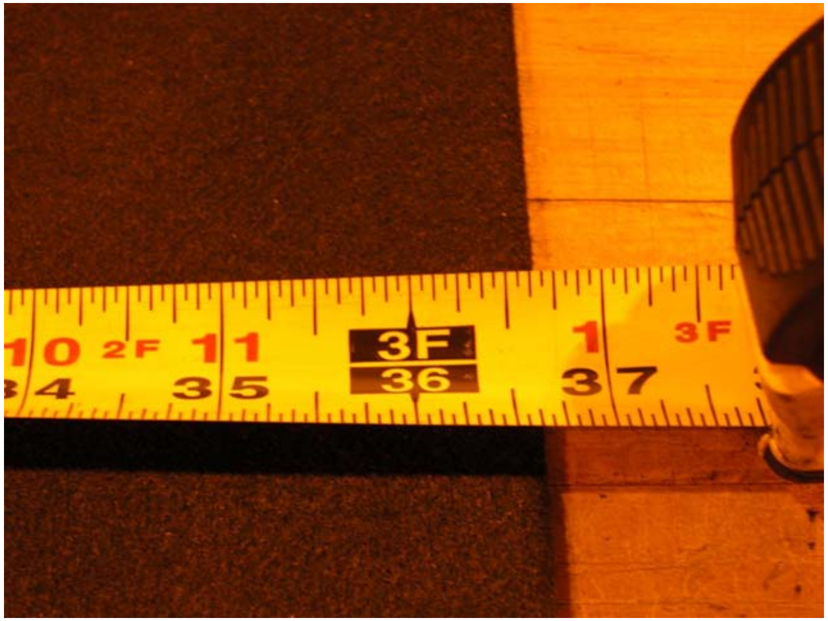
Supports



Frame Assembly

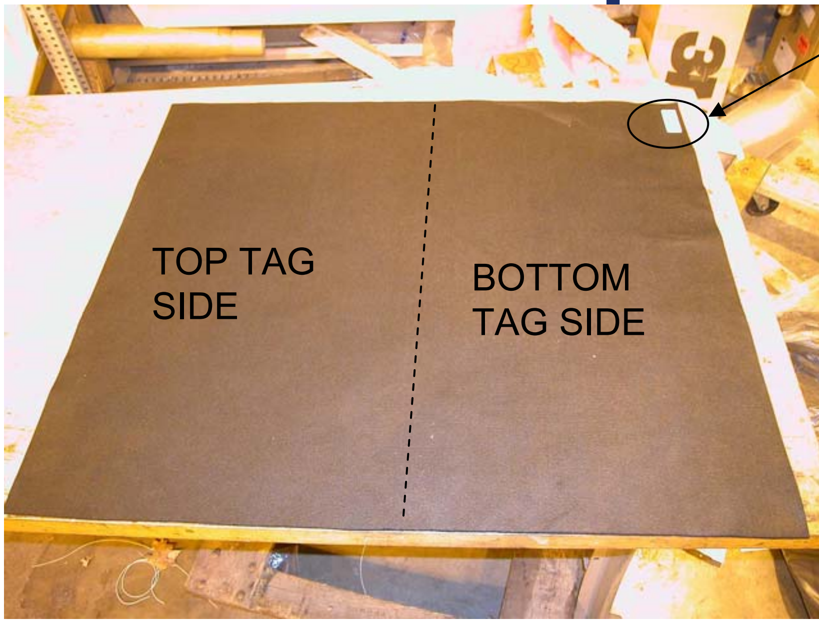


Blanket Preparation

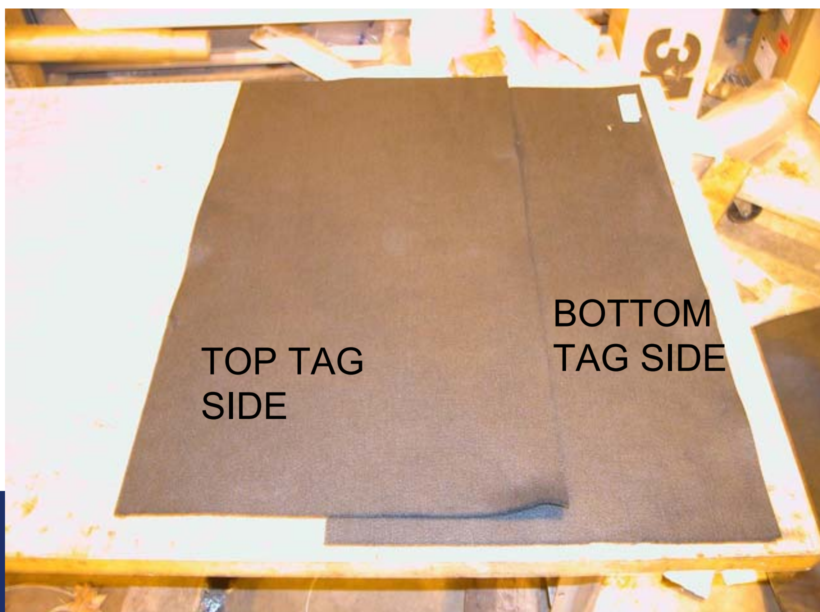


Most blankets are 36”L x 32”W, but some may be longer, like 36 ½”. Just divide the length in 2 and cut there – 18 ¼” in this case.

Blanket Preparation



Tag indicates the “bottom” blanket, and also is the backside – not facing the flame.



On the top blanket, cut edge is installed on the bottom of the frame. On the bottom blanket, the tag gets installed on the bottom of the frame.

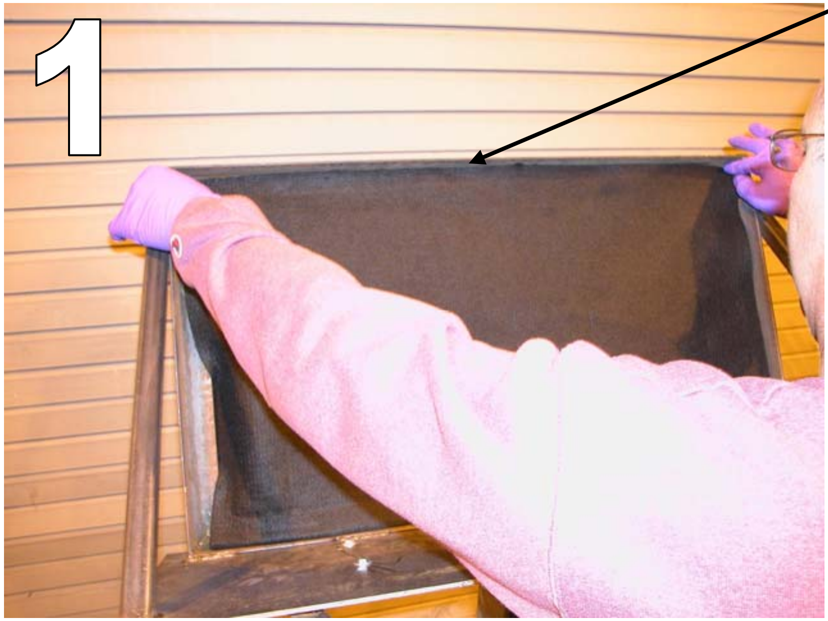
View From Back

Blanket Installation

Start from the top, align the top edge of the blanket with the inner top edge of the frame

Holding the top in place, work the blanket into the holder from left to right

1



2

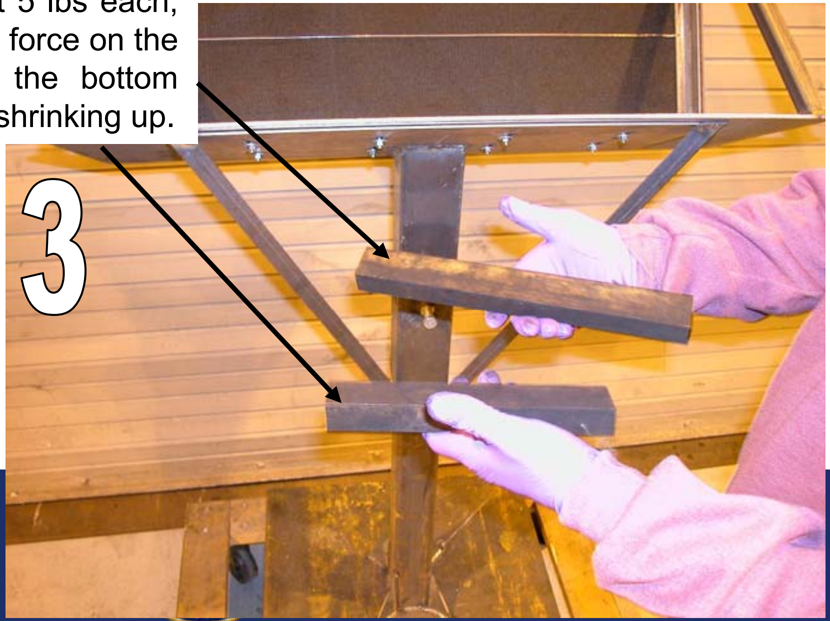
4

3

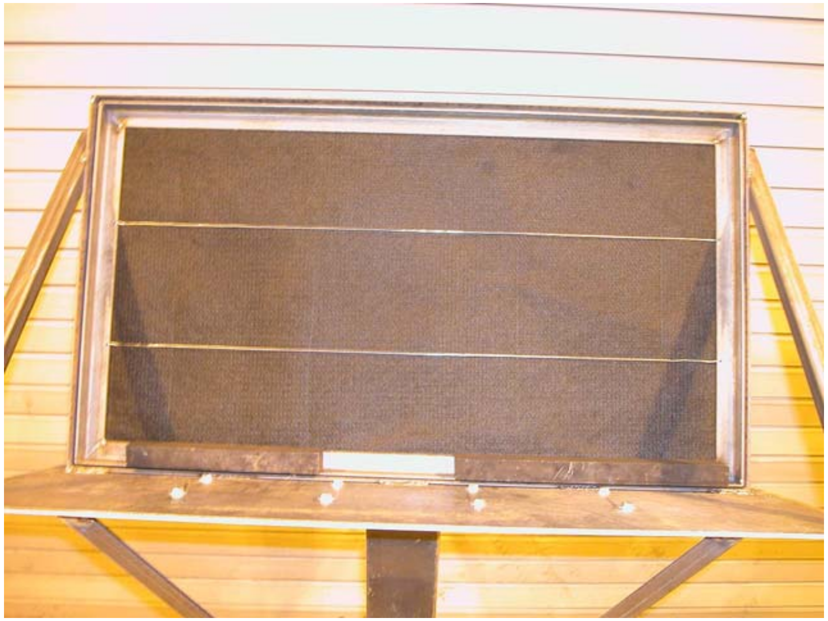
Blanket Installation

Roll the retainer frame in from the bottom to the top

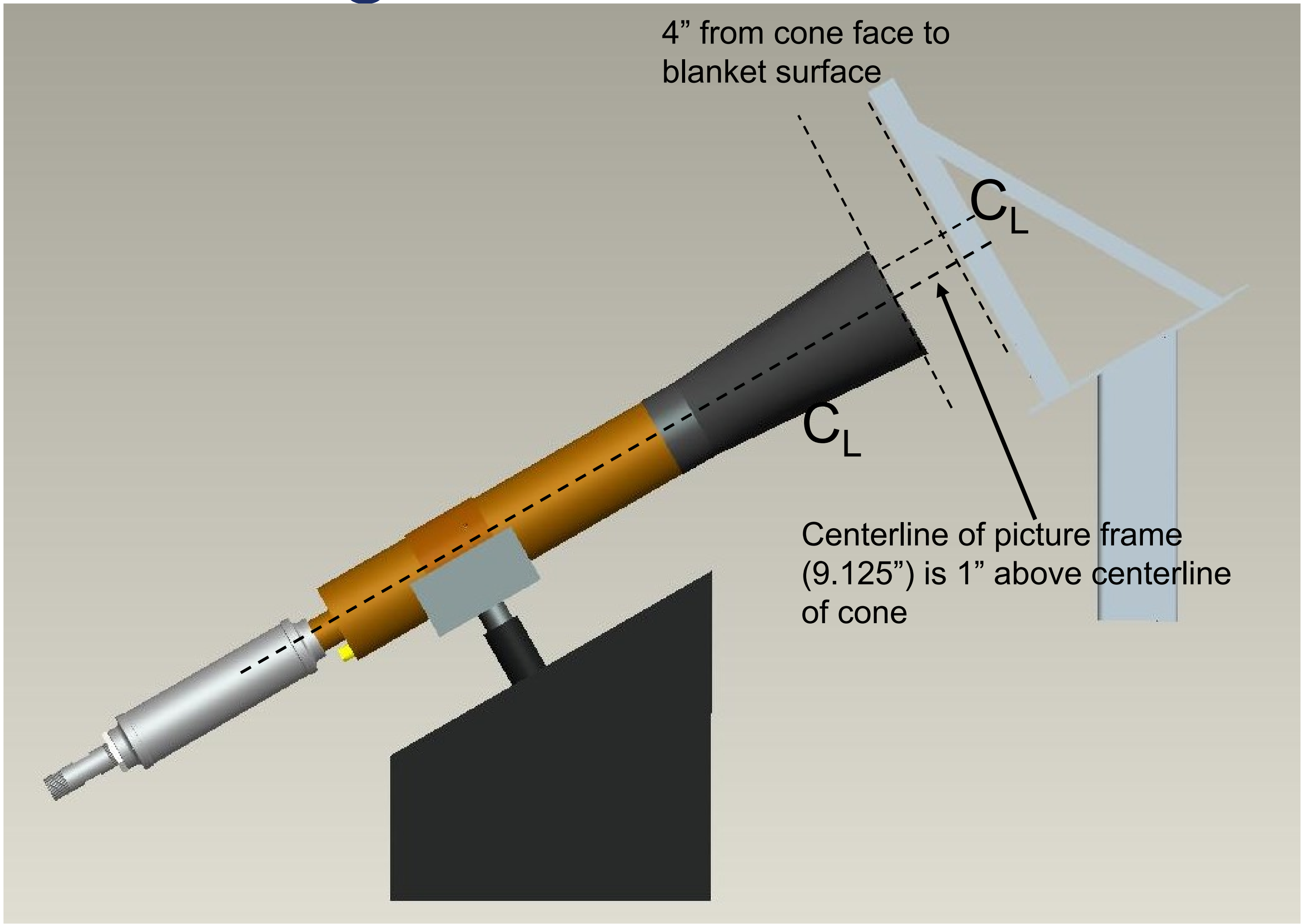
Two dead weights, about 5 lbs each, are used to put additional force on the retainer frame to keep the bottom edge of the blanket from shrinking up.



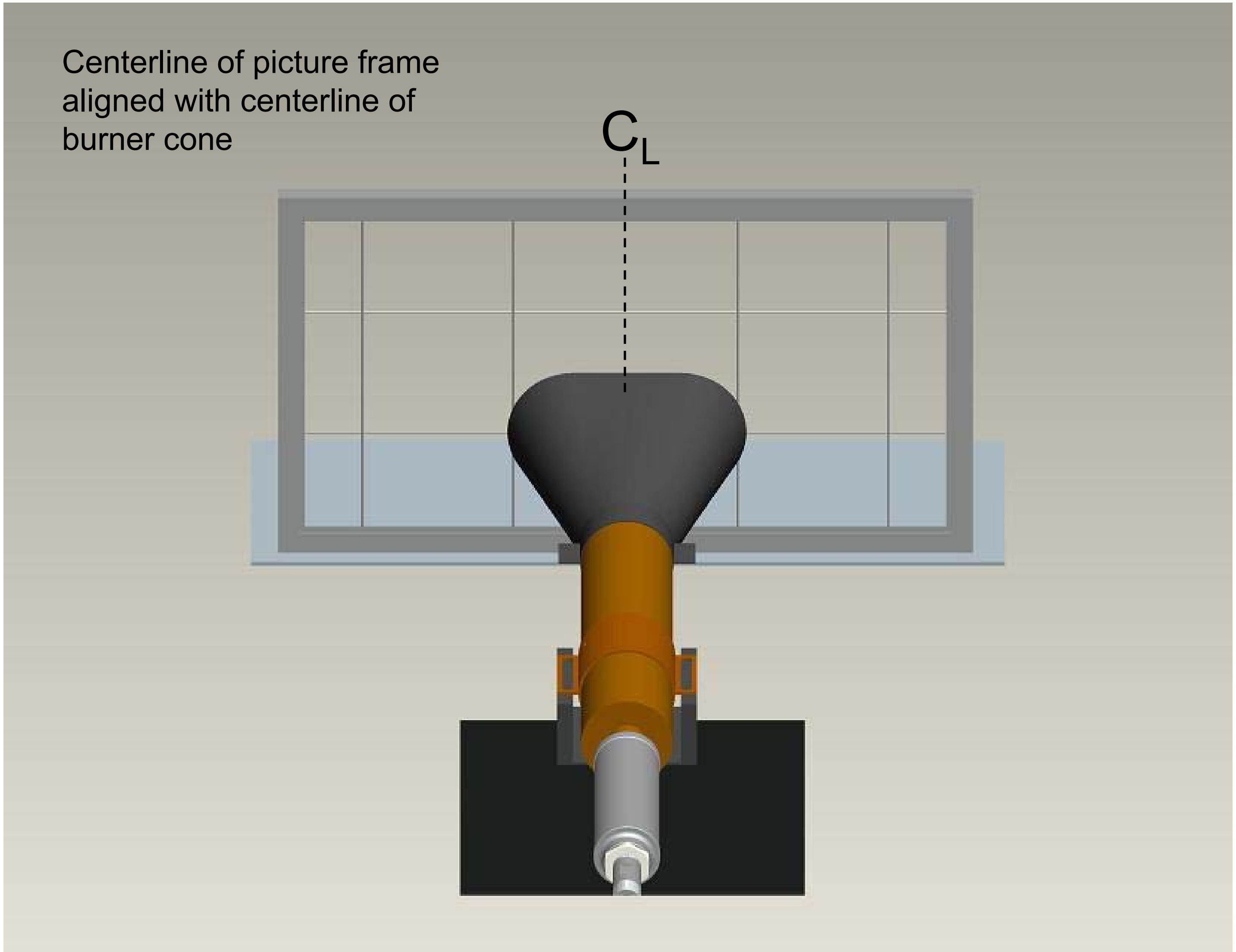
Finished Installation, Front and Back



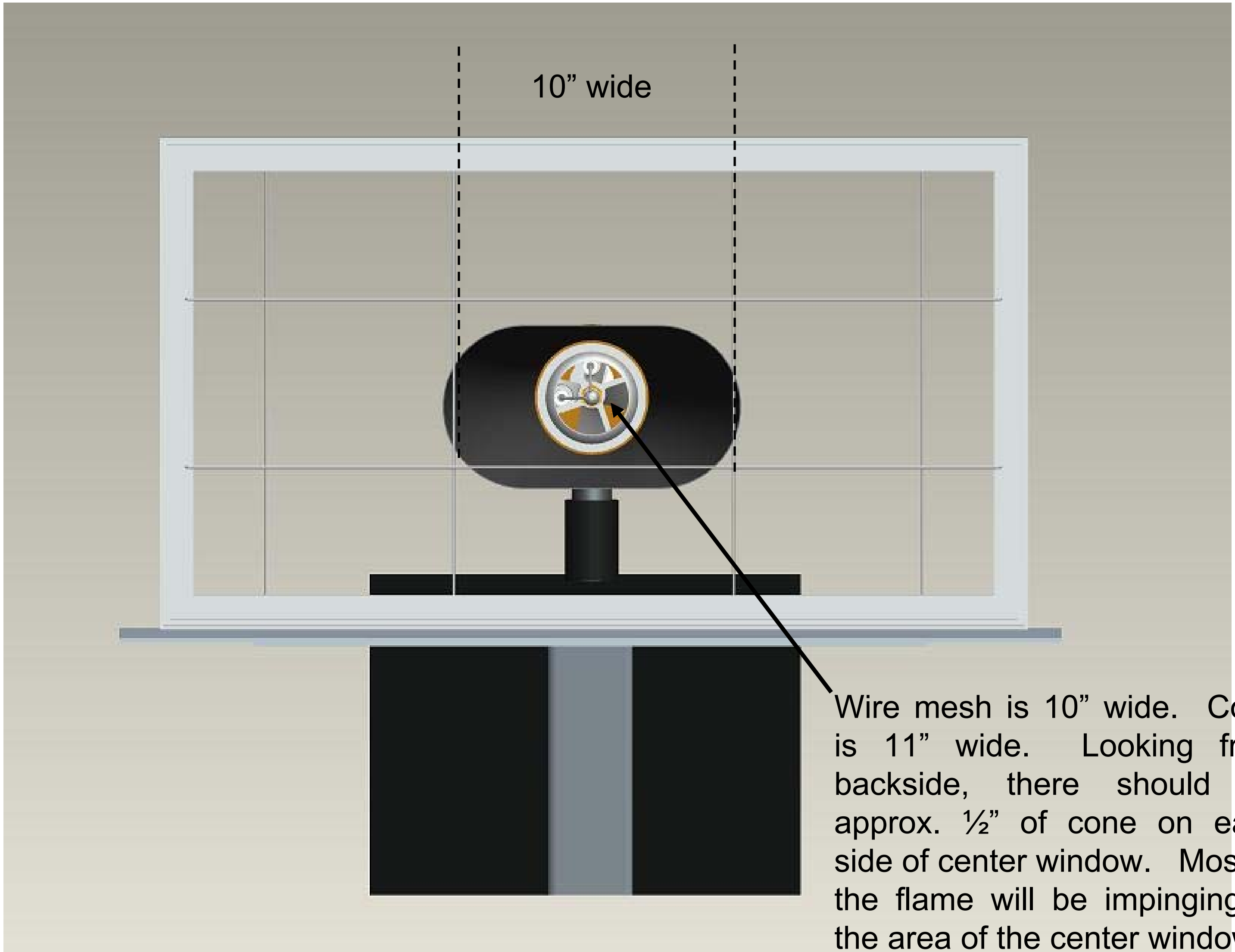
Frame Alignment



Frame Alignment

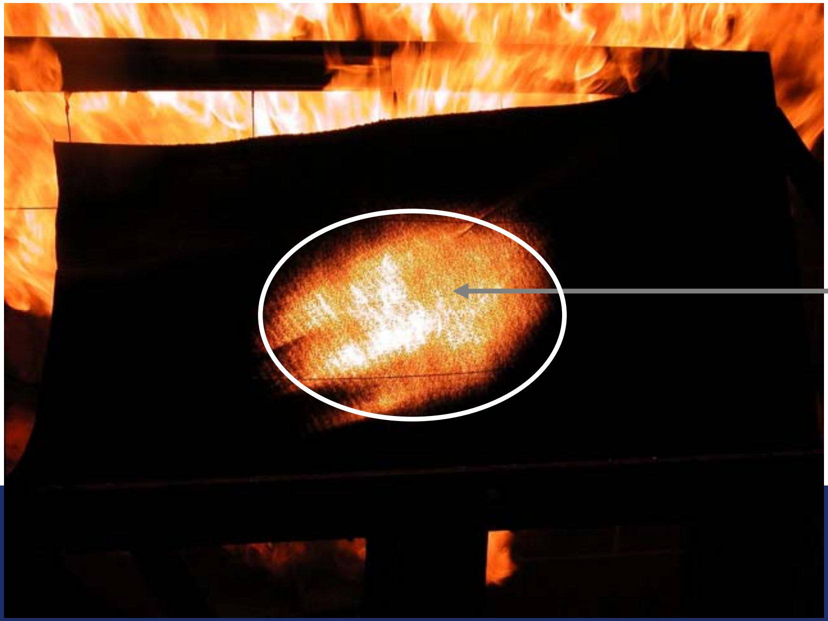


Frame Alignment



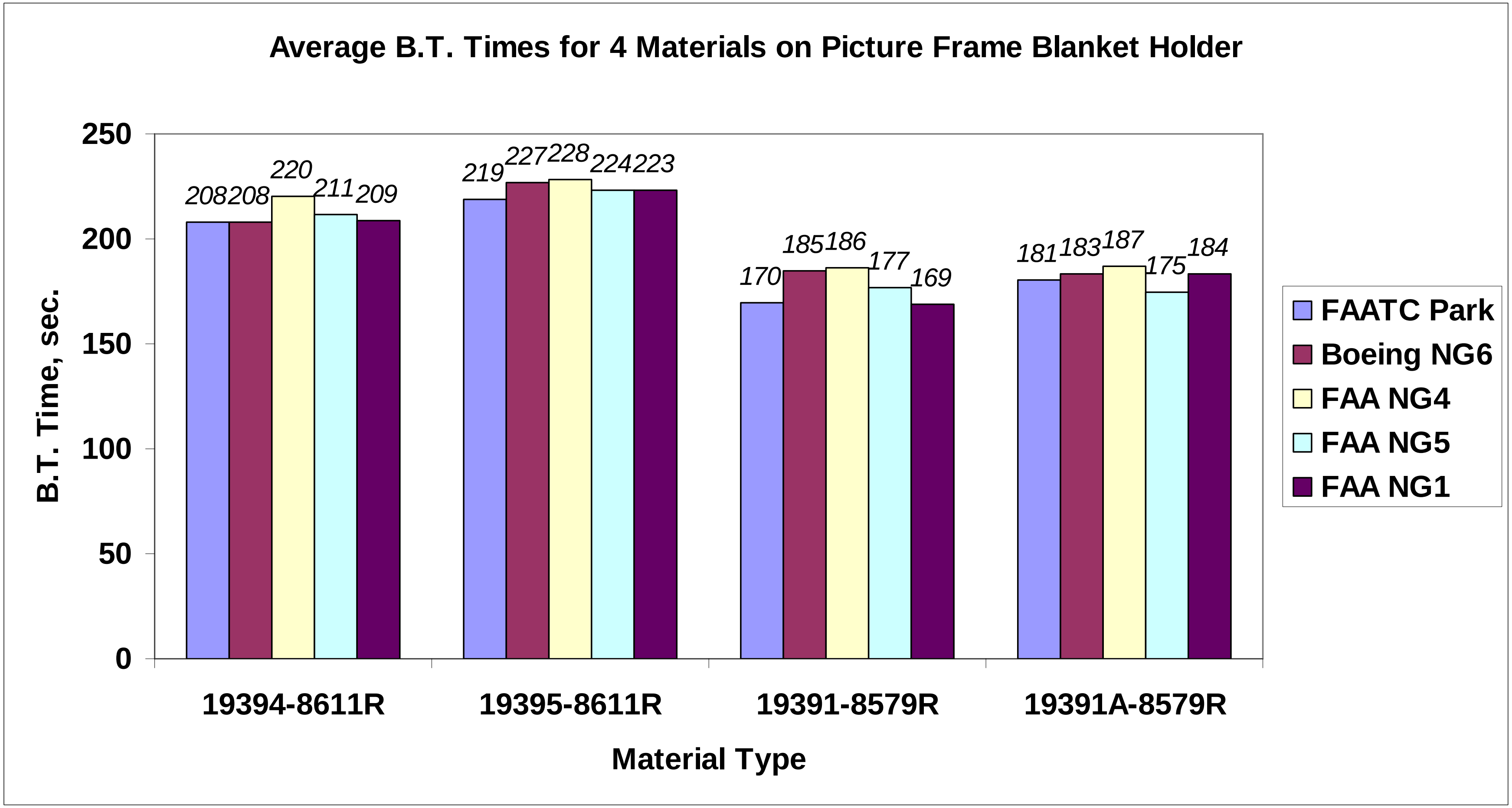
Wire mesh is 10" wide. Cone is 11" wide. Looking from backside, there should be approx. ½" of cone on each side of center window. Most of the flame will be impinging in the area of the center window.

Testing

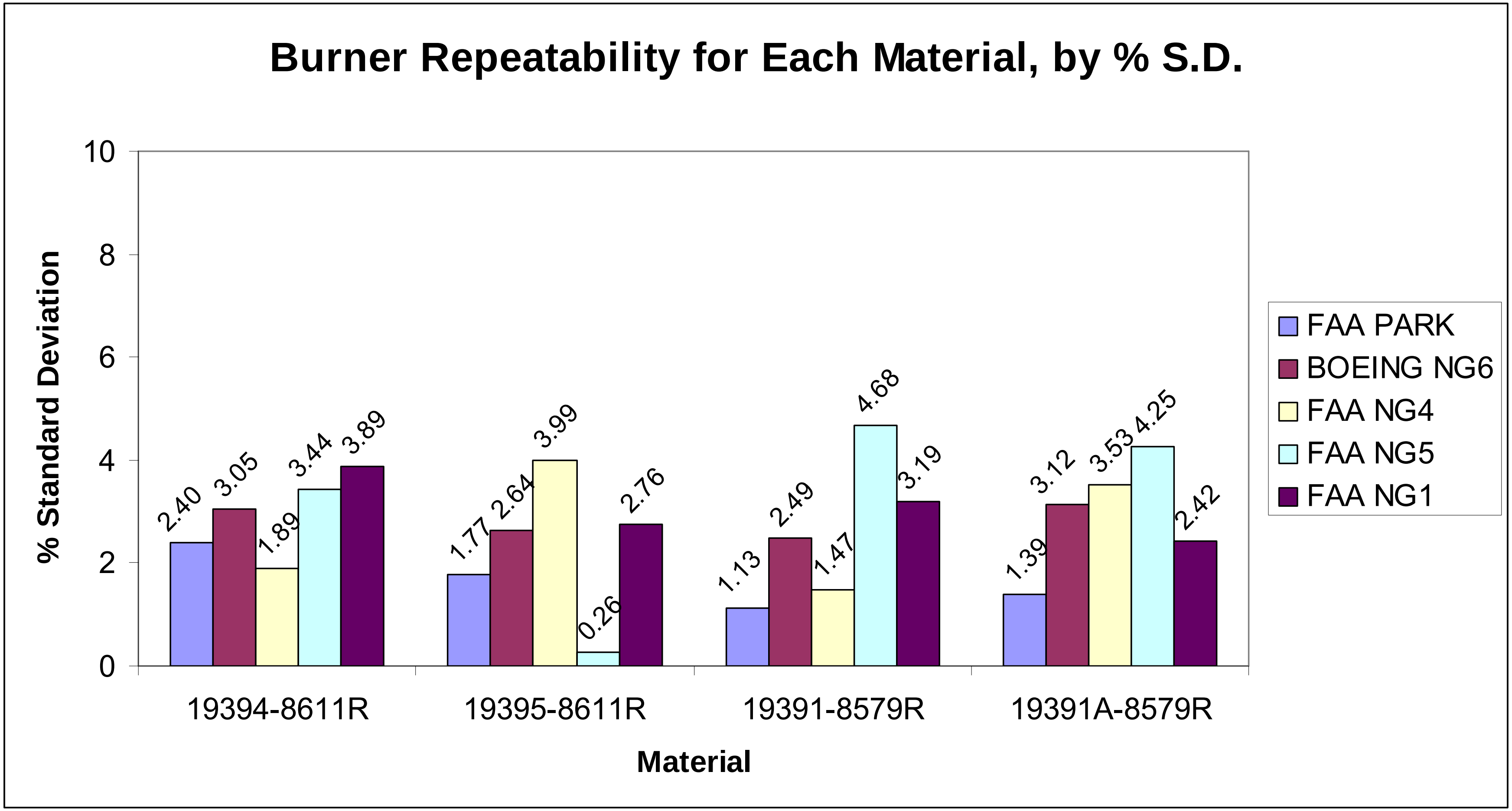


Material will typically shrink within 20 sec. from the top and the sides. The center portion, where the burnthrough is occurring, will not be affected by this. Sometimes, flashing will occur on the backside, but only lasts for a few seconds. This is acceptable.

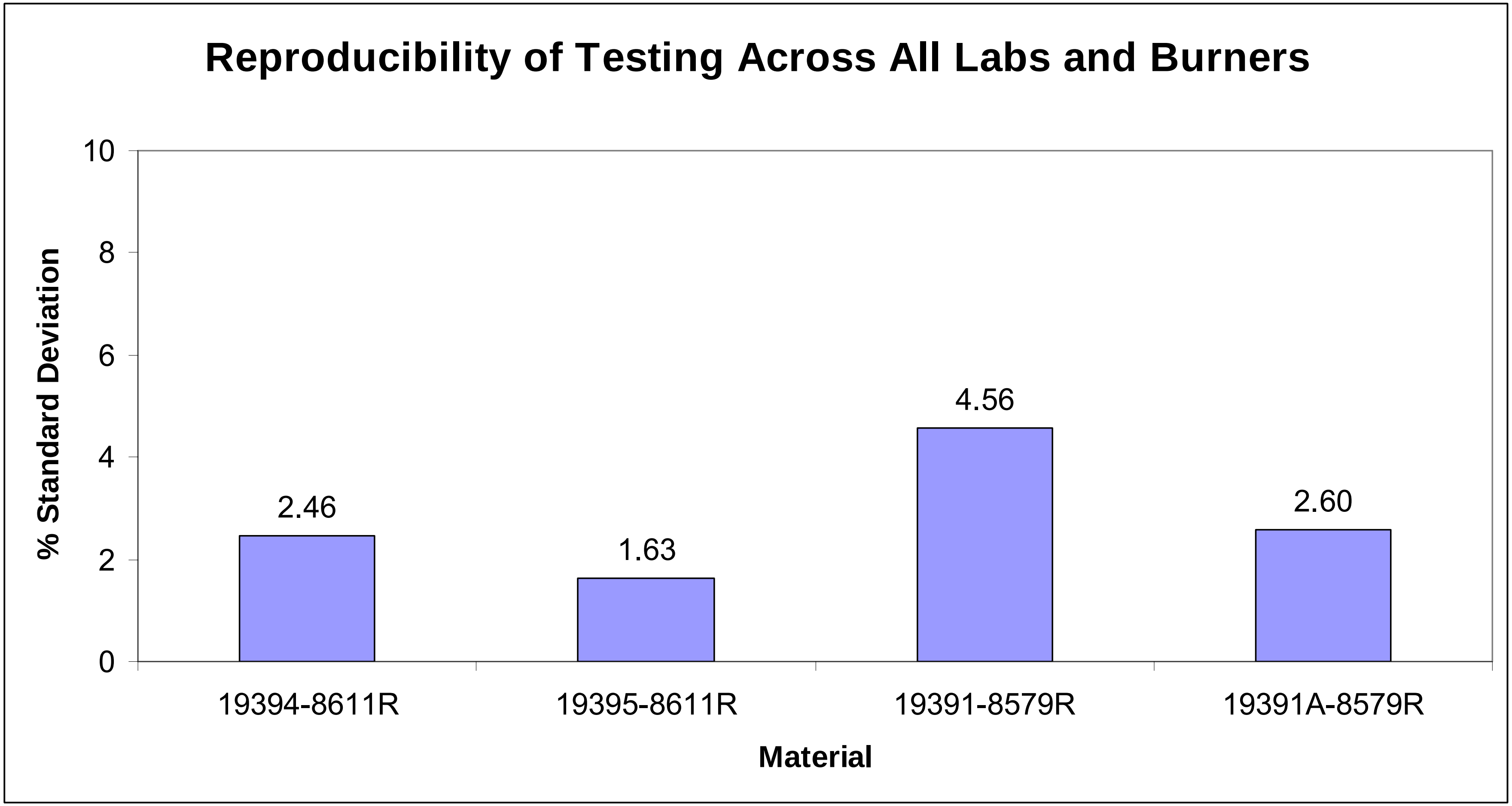
Testing Results – Picture Frame



Repeatability



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**

Questions still remain…

- After discussion of the test results with FAA and Boeing personnel, the question still remains of the difference in test results when using the original specimen holder
- Since the picture frame test results indicate that the burner is performing properly, then the only possible cause of the difference in results on the original specimen holder is the effect of the holder itself
- It has been determined that the TexTech calibration material is not suited for testing on the original specimen holder, as the felt type materials tend to shrink upon heating, and burnthrough times can be significantly impacted by differences in clamping and installation methods
- The original specimen holder was intended only to test materials that would be installed in aircraft, i.e. actual thermal acoustic specimens, consisting of a film, fire blocking layer, and insulation batting
- Therefore, it was decided that Boeing would assemble several samples of actual thermal acoustic insulation specimens that would be tested for certification in an aircraft. The samples would be tested at Boeing on their original specimen holder with burner NG6, at the tech center on the FAA Park, and on the tech center's NG4. Burnthrough time and backside heat flux would both be monitored to check for sample failures

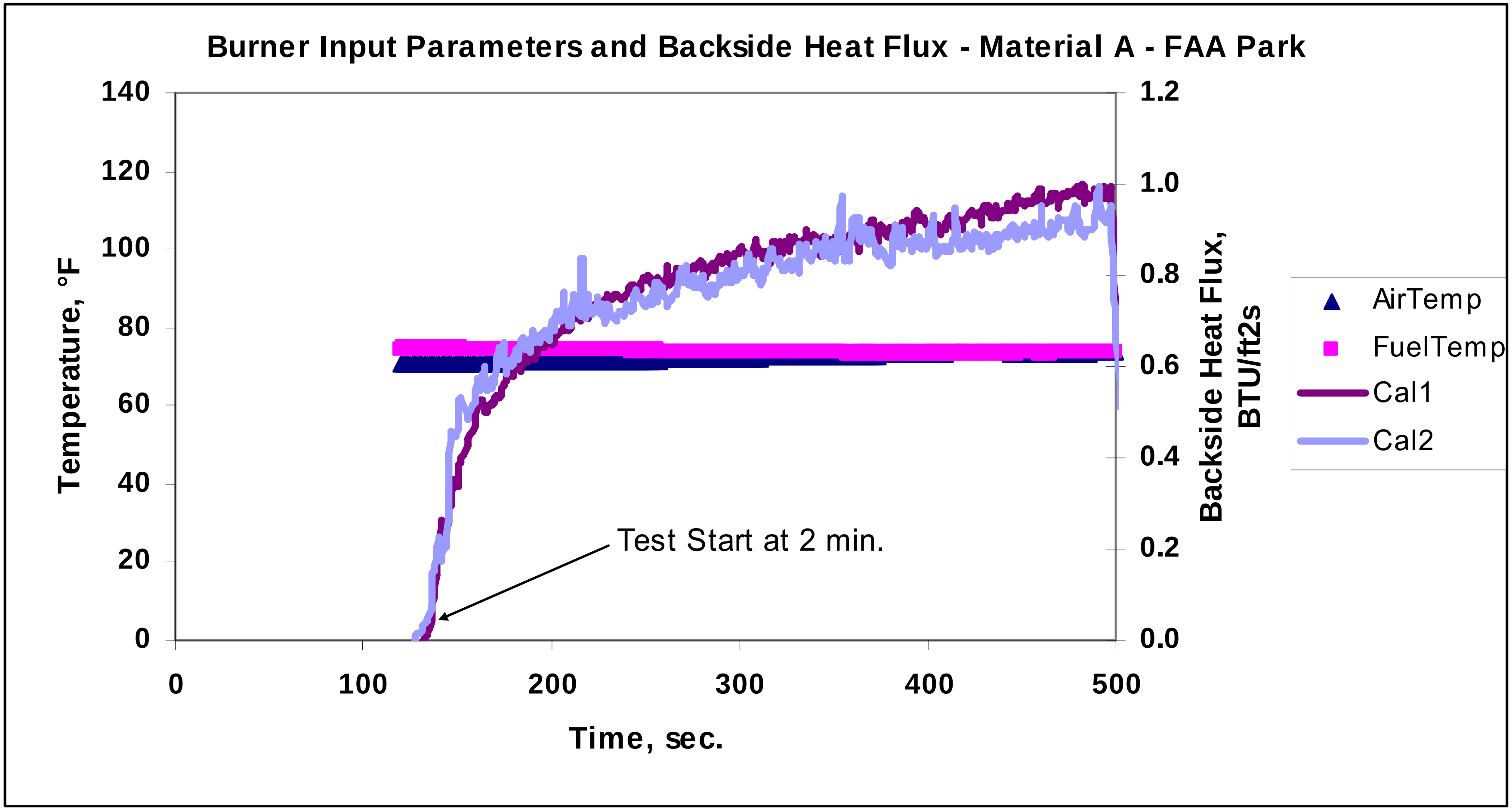
Thermal Acoustic Insulation Blanket Comparative Testing

- 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

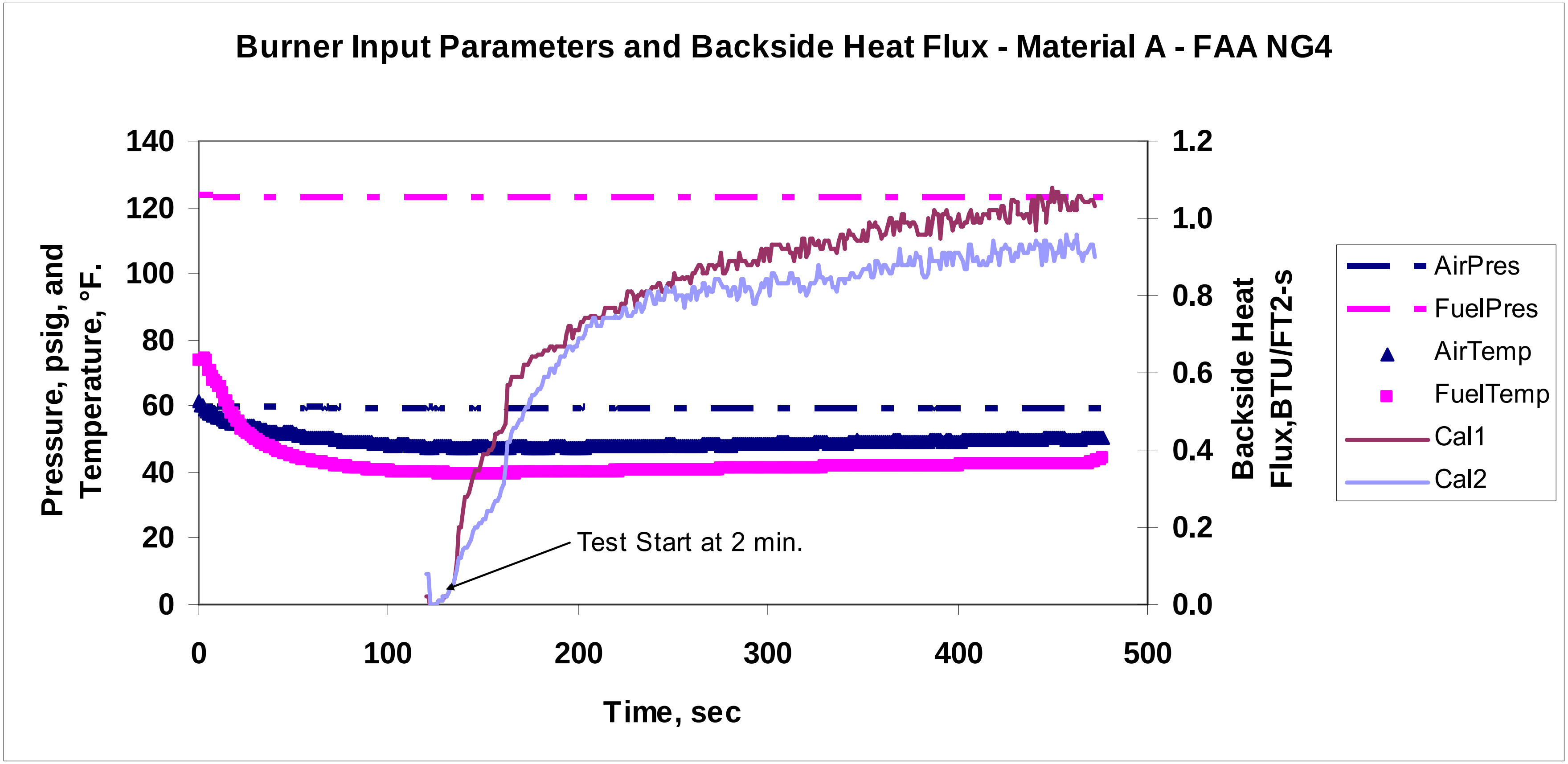
Thermal Acoustic Insulation Blanket Testing

- **Of the three material types tested, only one (material A) failed the burnthrough test**
  – Material A had sporadic behavior, and could last over 6 minutes or fail in 20 seconds
  – This behavior was seen at Boeing and on both FAA burners
- **Materials B and C were good performers**
  – Withstood the burner flame for 5 ½ - 6 minutes without burning through
  – Backside heat flux under 2.0 BTU/ft2*s for 5 ½ - 6 minutes on all burners

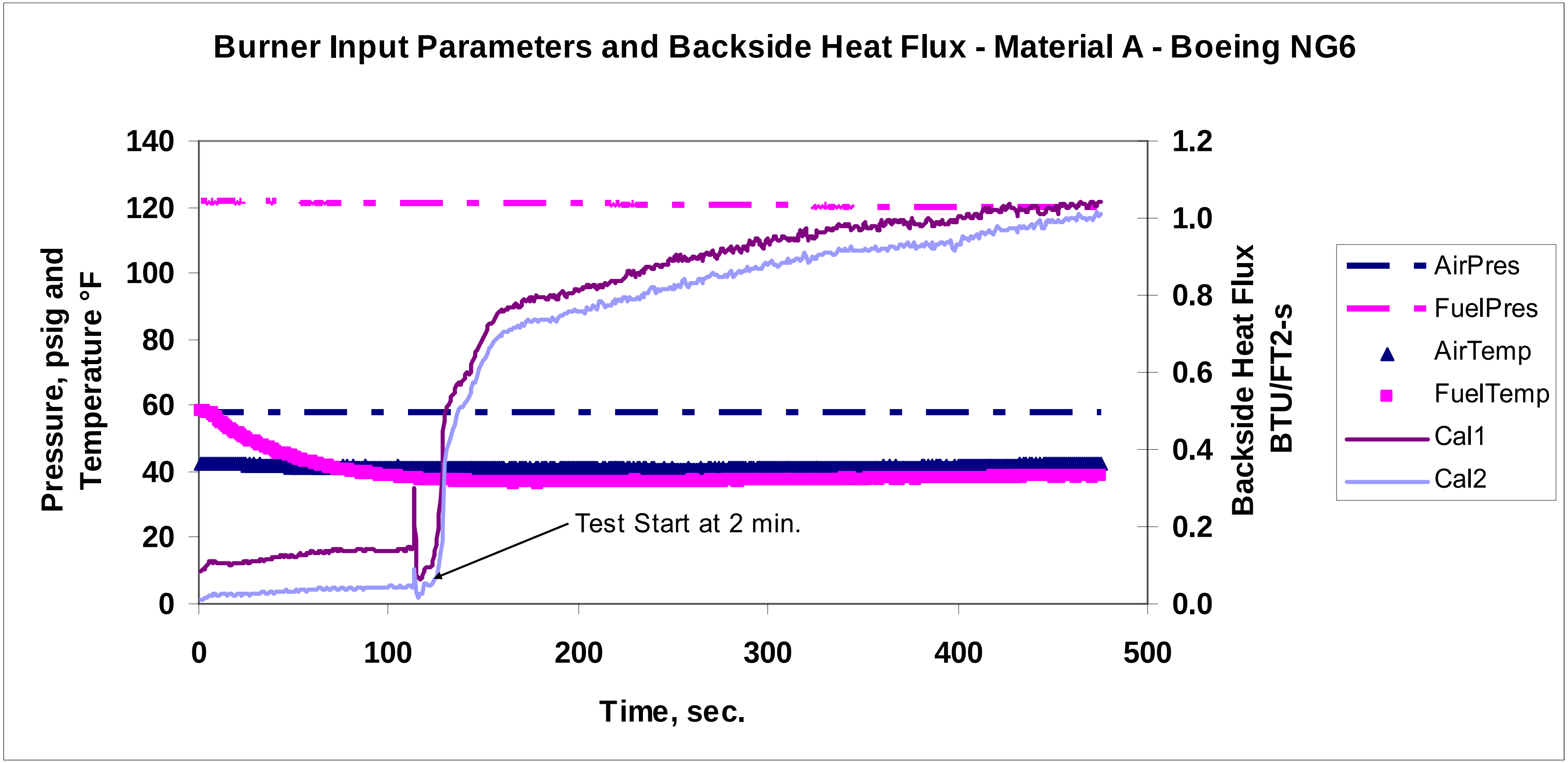
Results – FAA Park, Material A



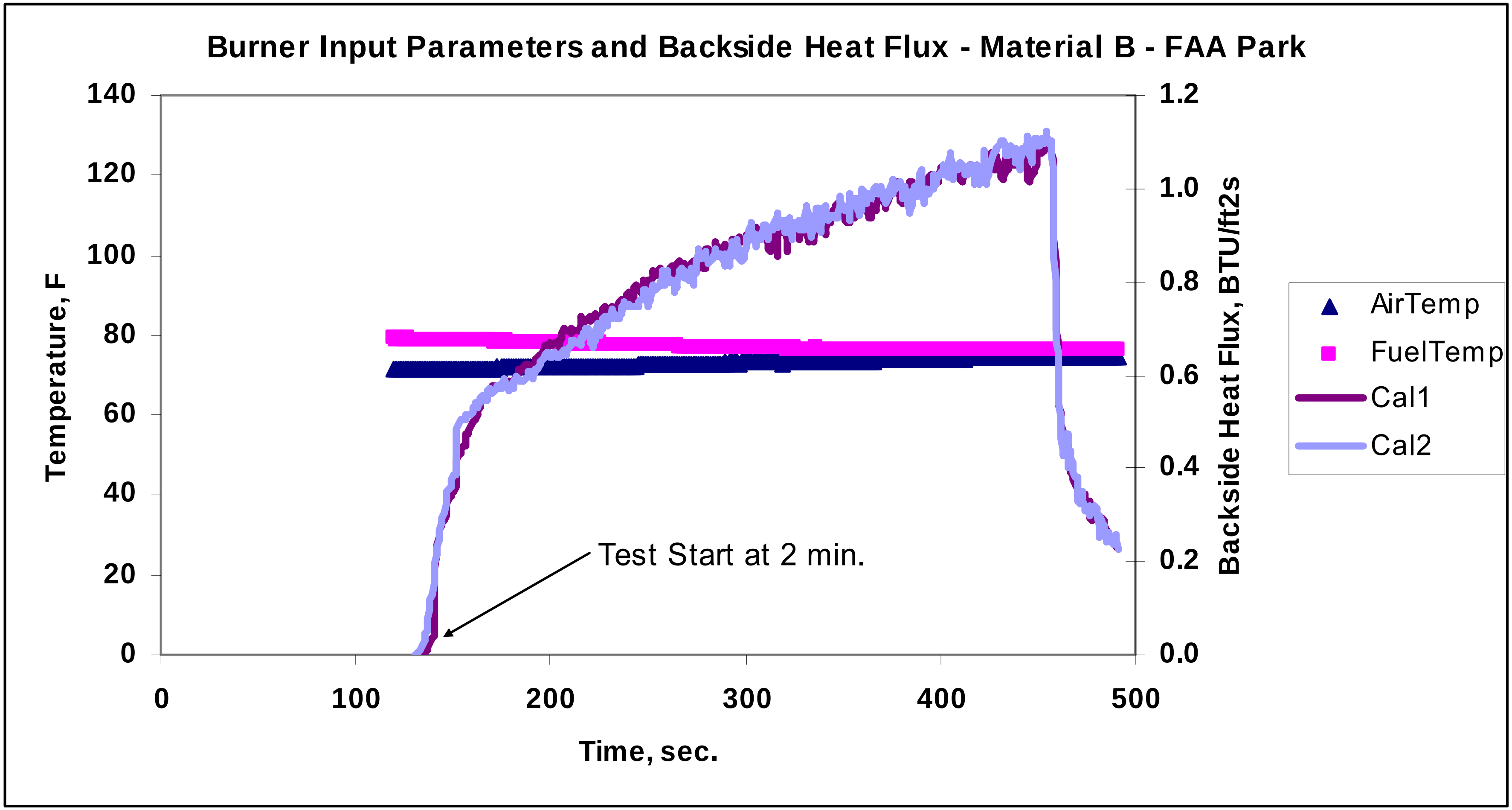
Results – FAA NG4, Material A



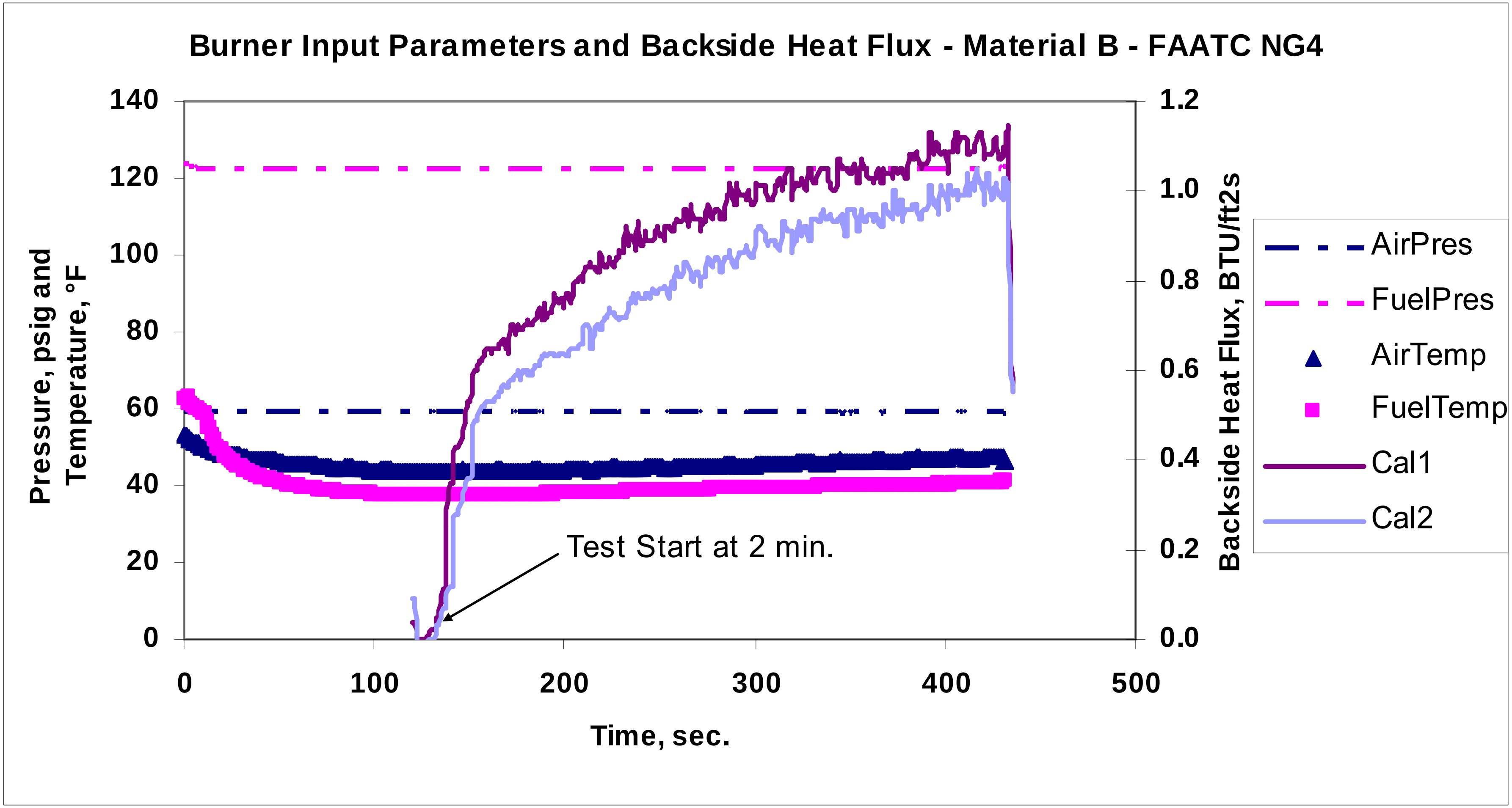
Results – Boeing NG6, Material A



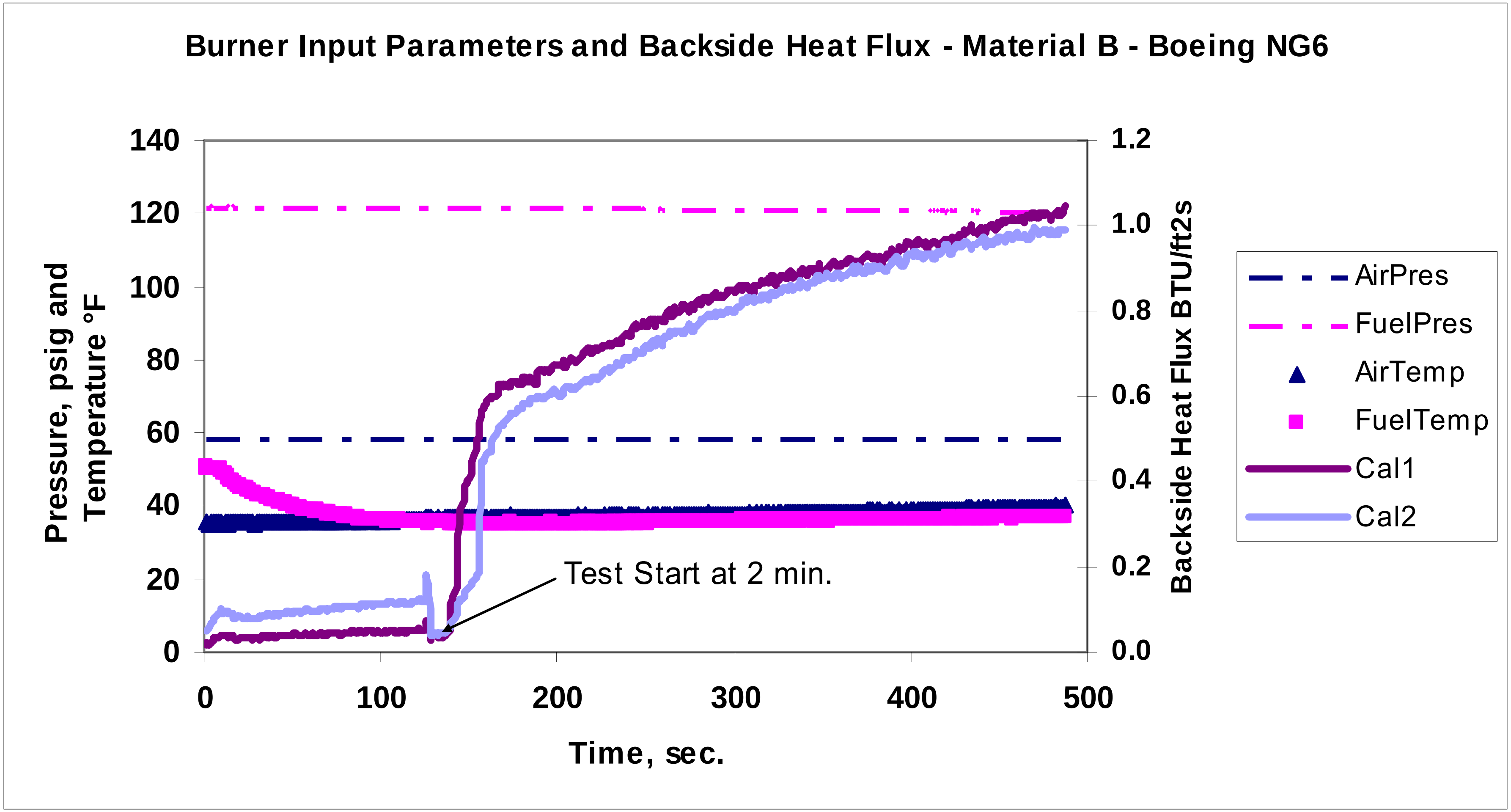
Results – FAA Park, Material B



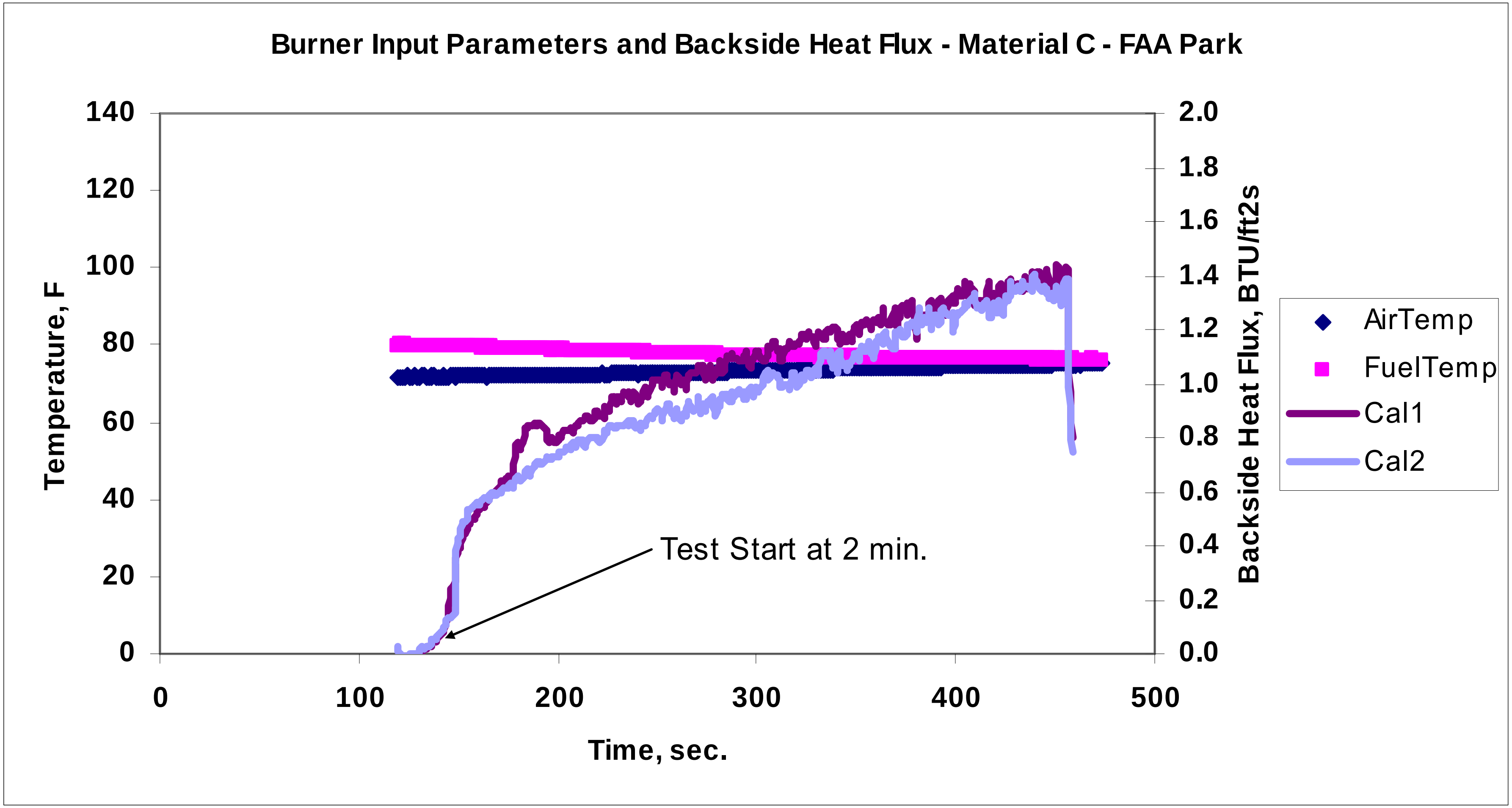
Results – FAA NG4, Material B



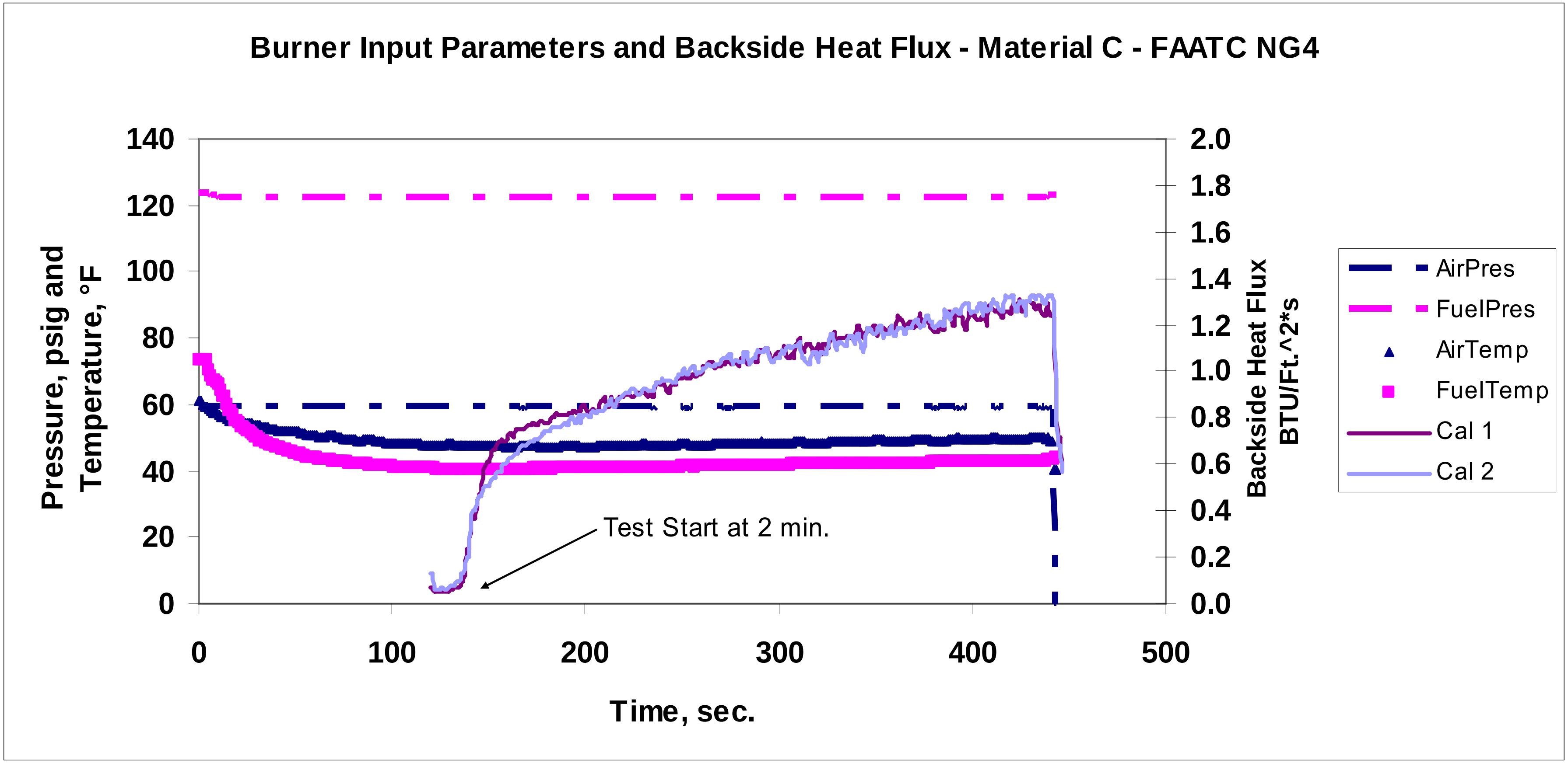
Results – Boeing NG6, Material B



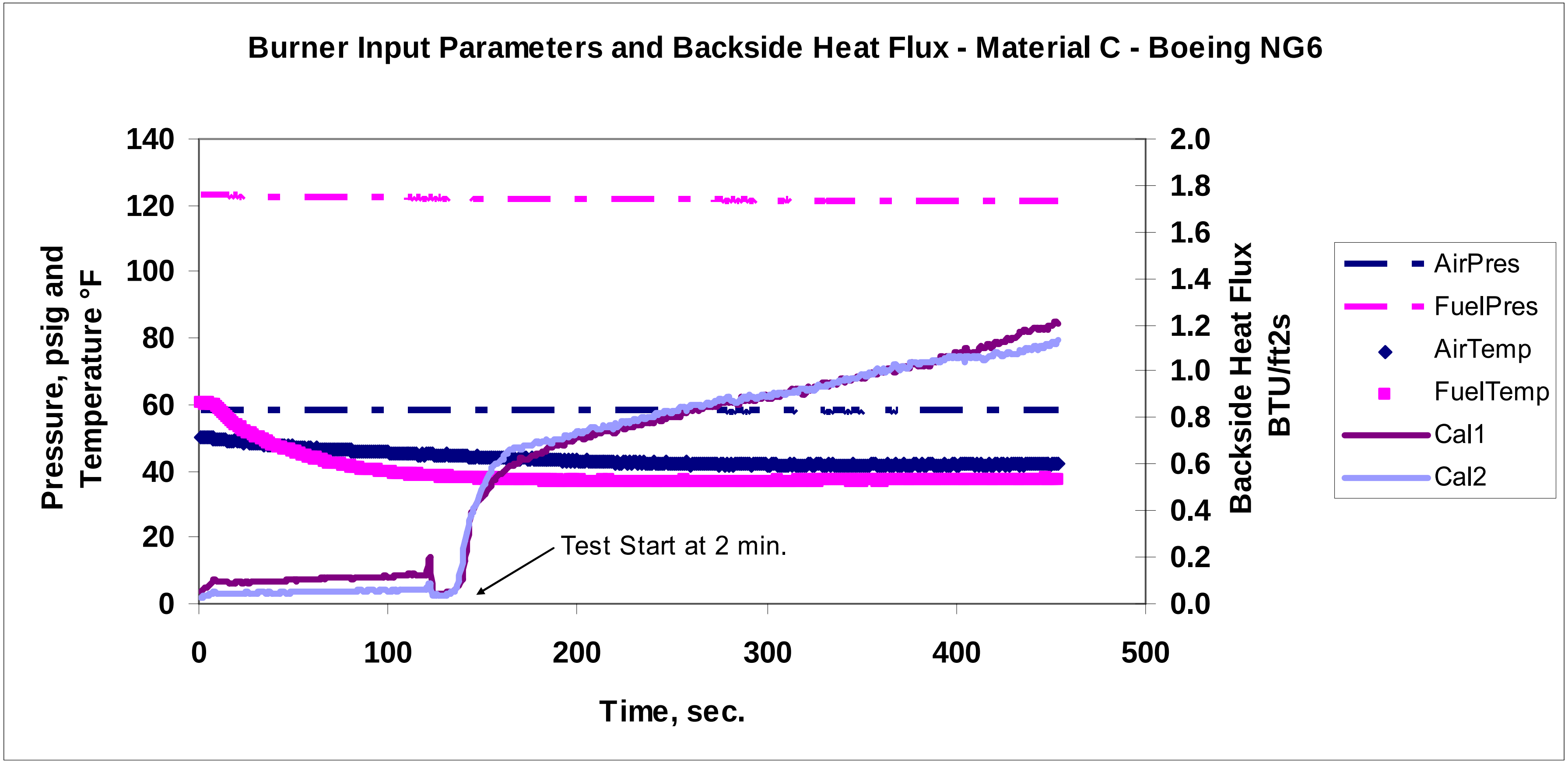
Results – FAA Park, Material C



Results – FAA NG4, Material C



Results – Boeing NG6, Material C



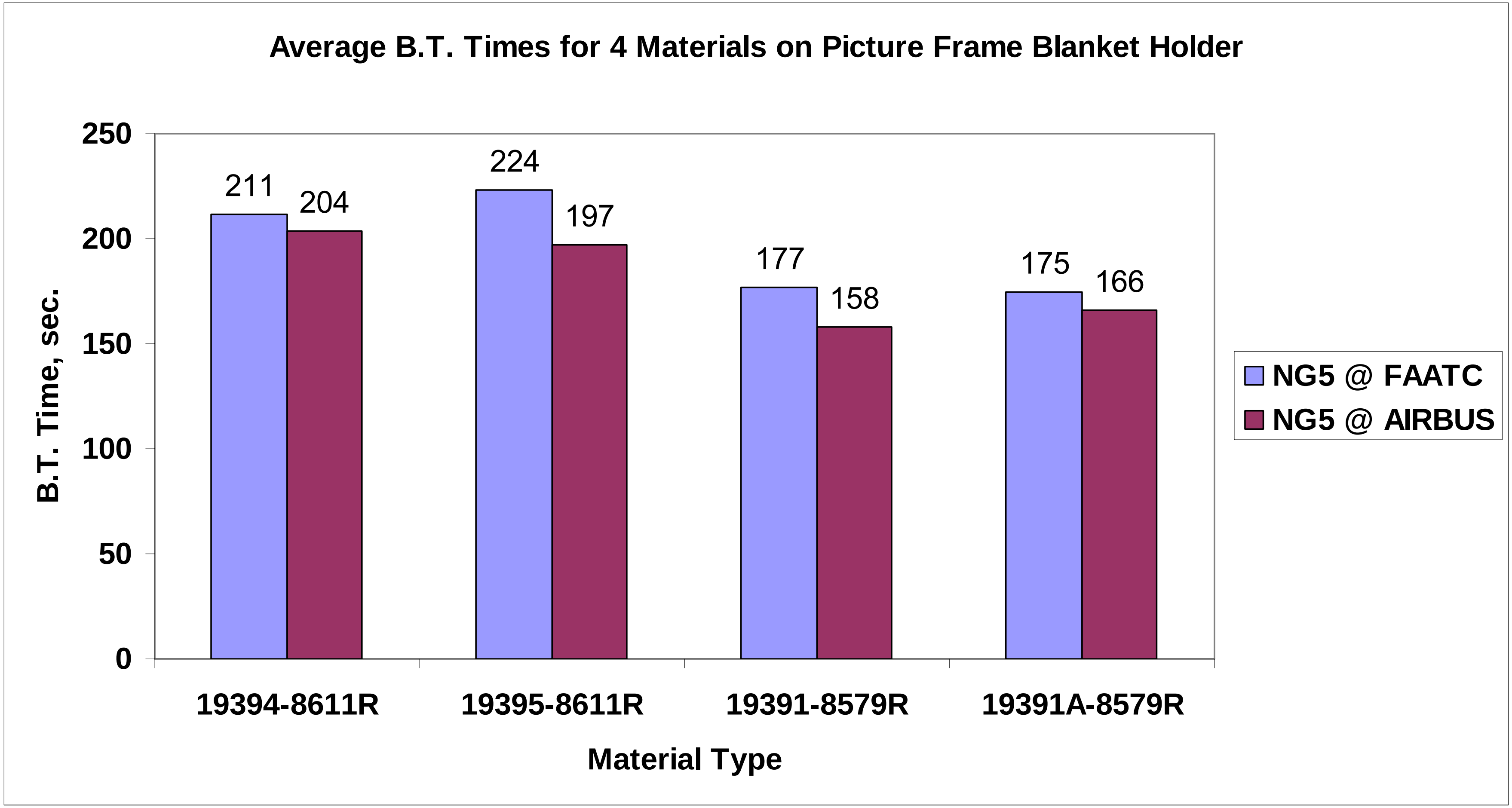
Thermal Acoustic Insulation Blanket Testing Summary

- **Very similar results were obtained on all three burners**
- **Backside heat flux profiles were found to be in agreement across all three burners**
- **NexGen burner inlet parameters were found to be in very good agreement between Boeing and FAA**
- **Although the test frames may influence the test results when testing felt-type materials, *no difference is observed when testing actual thermal acoustic insulation blankets on different blanket holders at different labs with different burners***

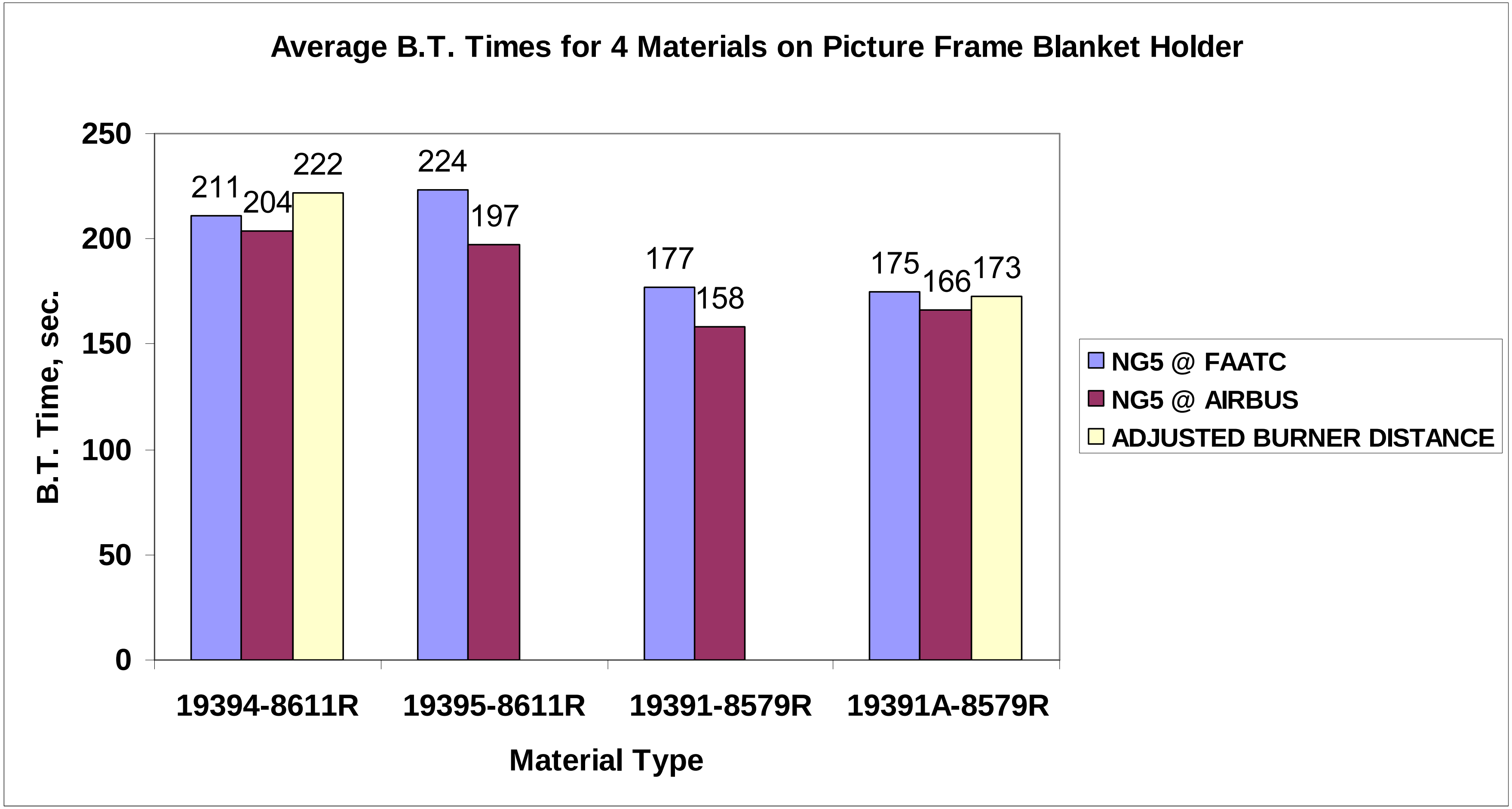
Picture Frame Testing – Comparisons with Airbus Lab

- **Burner NG5 was shipped to Airbus, along with a TexTech sample set of materials 8579 and 8611**
- **Airbus constructed a picture frame blanket holder to test the burner performance**
- **FAA personnel witnessed testing at Airbus**

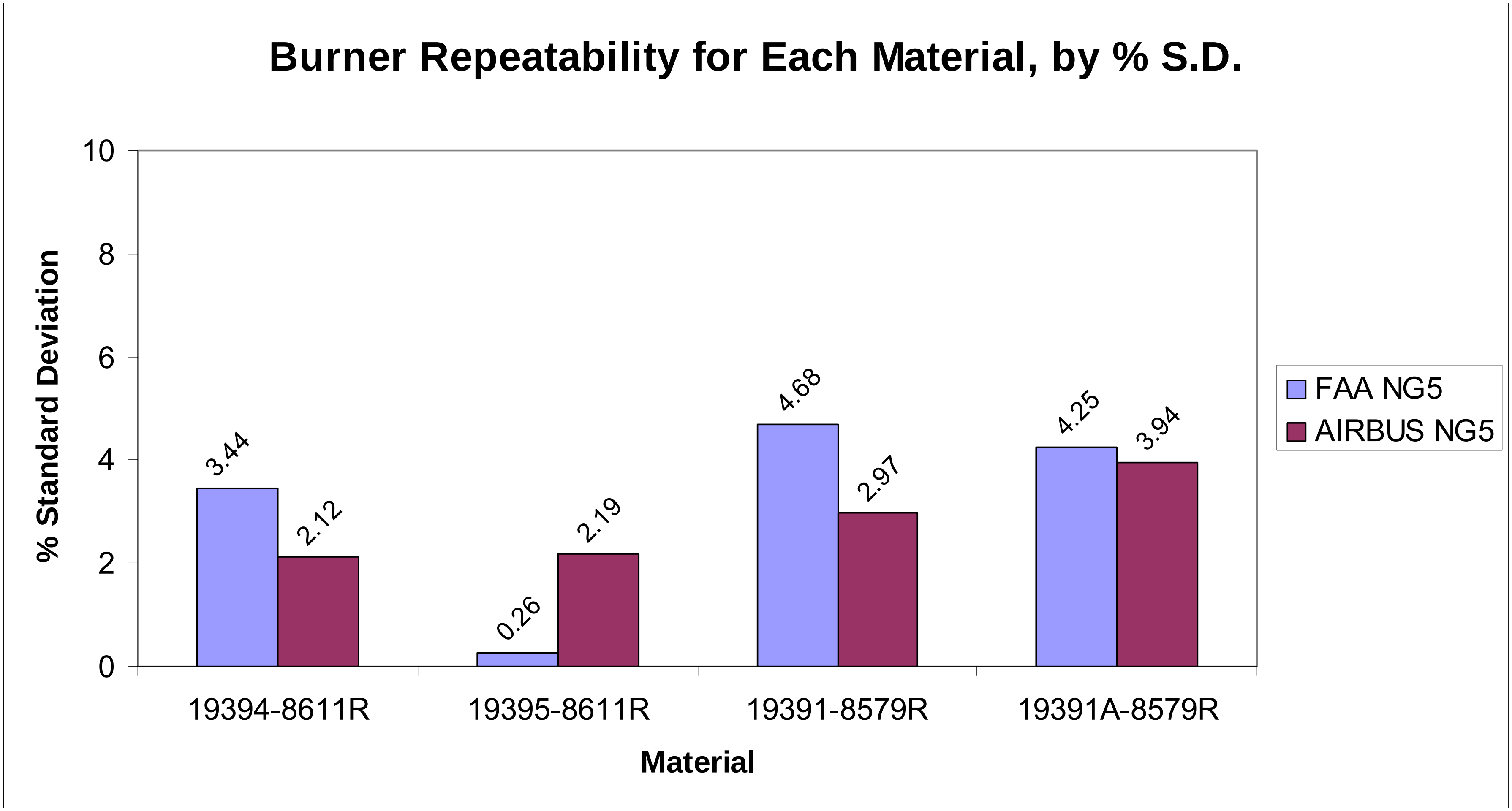
Comparison – FAATC vs. Airbus



Comparison – Adjusted Burner Distance



Burner Repeatability – FAATC vs. Airbus



Summary – Airbus Comparison Testing

- The burner NG5 was a consistent performer, and gave similar results from test to test
- The burner gave burnthrough times that were slightly quicker than when tested at the FAATC
- The burner distance from the sample was found to be critical, and a new method of alignment was suggested
- After adjusting the burner to the proper distance, based on a limited number of samples the burner seemed to be performing properly

Summary – Comparative Testing

- **The picture frame blanket holder is a great comparative tool for determining proper burner performance at different places *when testing the same material***
- **The original blanket holder is intended for testing thermal acoustic insulation blankets and not for testing thin, felt-like materials; doing so will result in erratic performance that is not consistent**
- **Although the original blanket holders may have warped and be of different construction, when testing thermal acoustic insulation blankets, the fire performance of the blankets is insensitive to these test frame differences**
- **The picture frame test method is very sensitive to slight changes in NexGen burner inlet parameters and burner-to-test frame configuration. Proper adjustments must be made in order to compare results with other labs *with the same materials***

PART III: FUTURE BURNER RESEARCH AND DEVELOPMENT

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?