Burnthrough Workshop

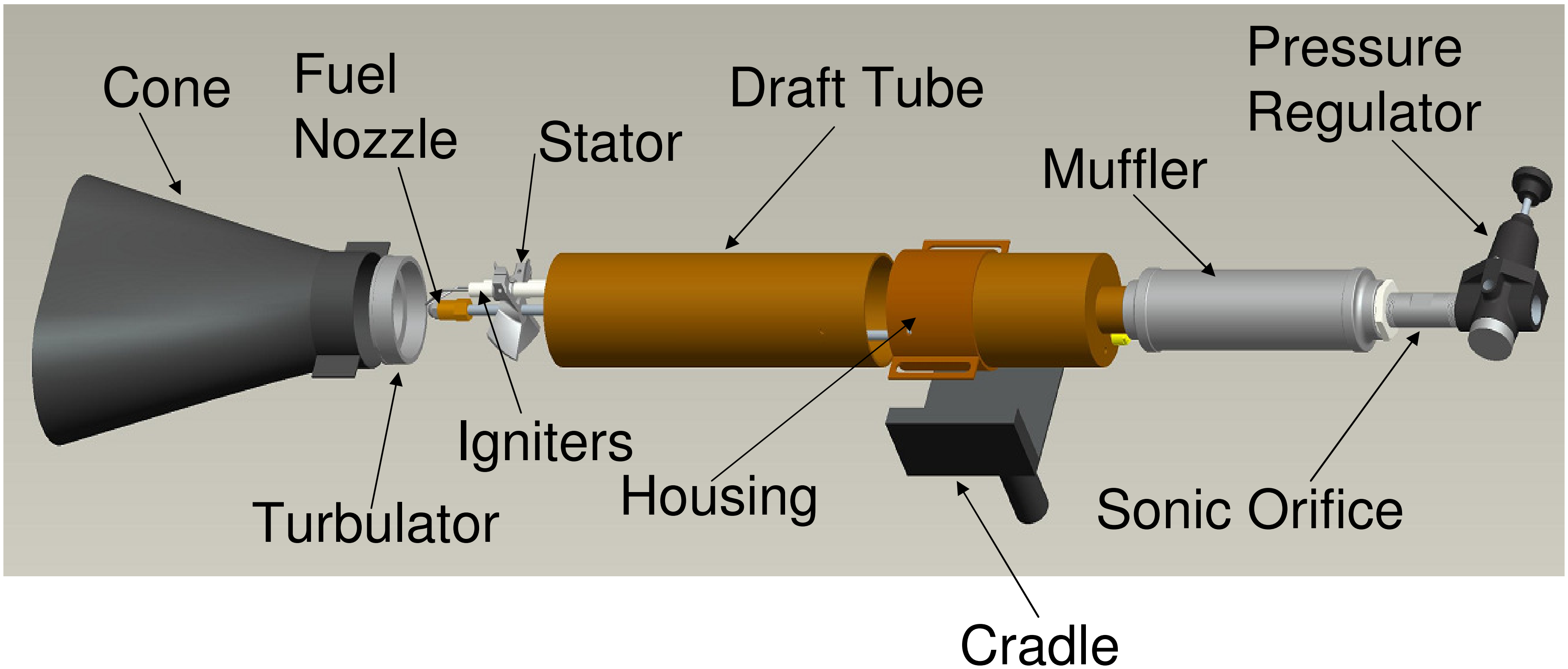
NexGen Burner Session

Presented to: Burnthrough Workshop

By: Robert I. Ochs

Date: July 24-26, 2007

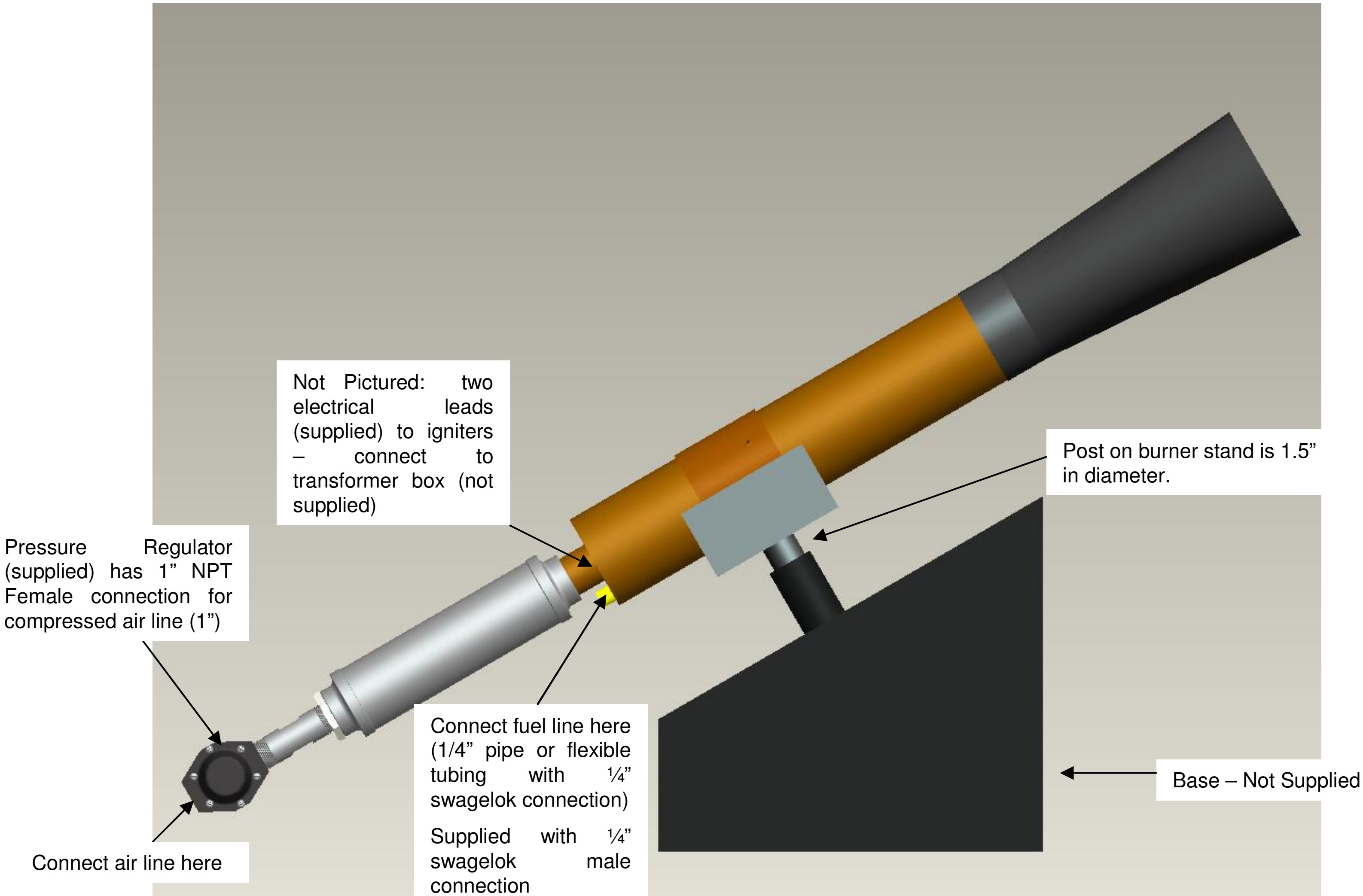
NexGen Burners



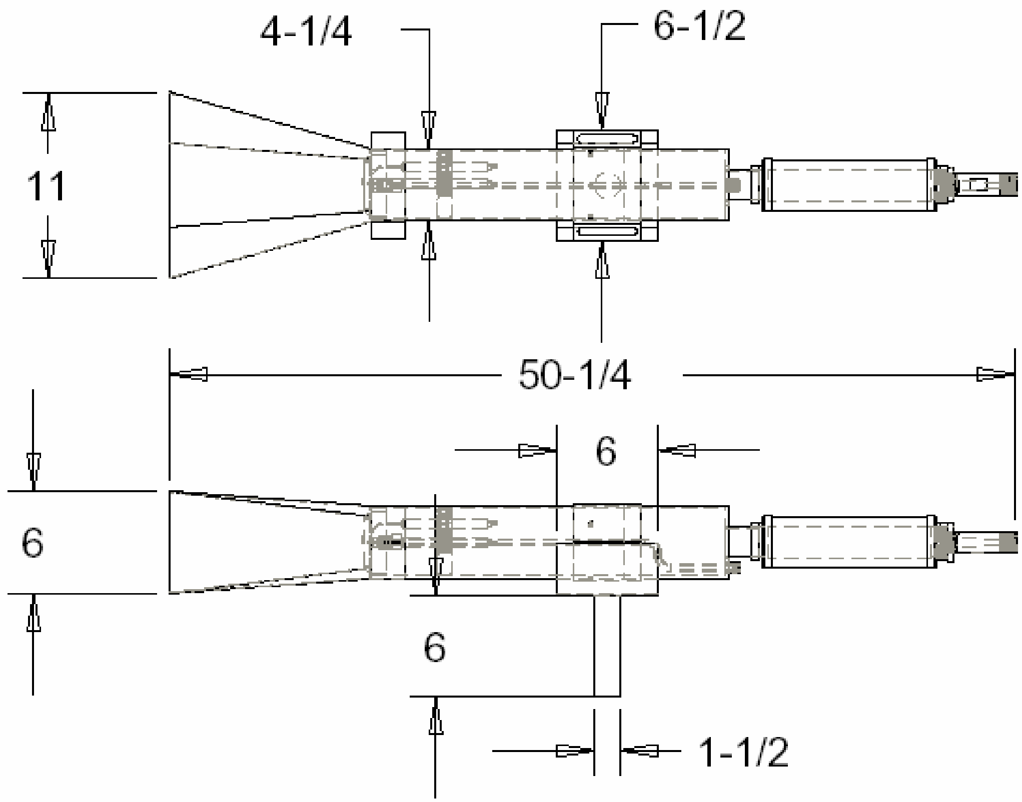
NexGen Burner Components

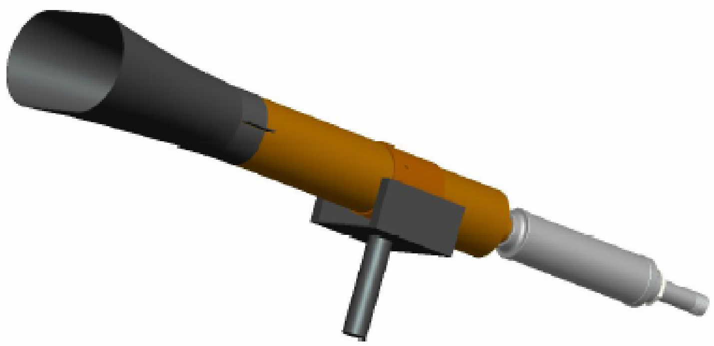
- Cone – custom fabricated burner cone built to dimensions specified in the rule
- Turbulator – Monarch F-124
- Fuel Nozzle – Monarch 5.5 gph 80° PL F-80 hollow cone spray
- Igniters – standard oil burner igniters
- Fuel Rail – custom fabricated fuel rail
- Stator – Monarch H215 replicate, modified with "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

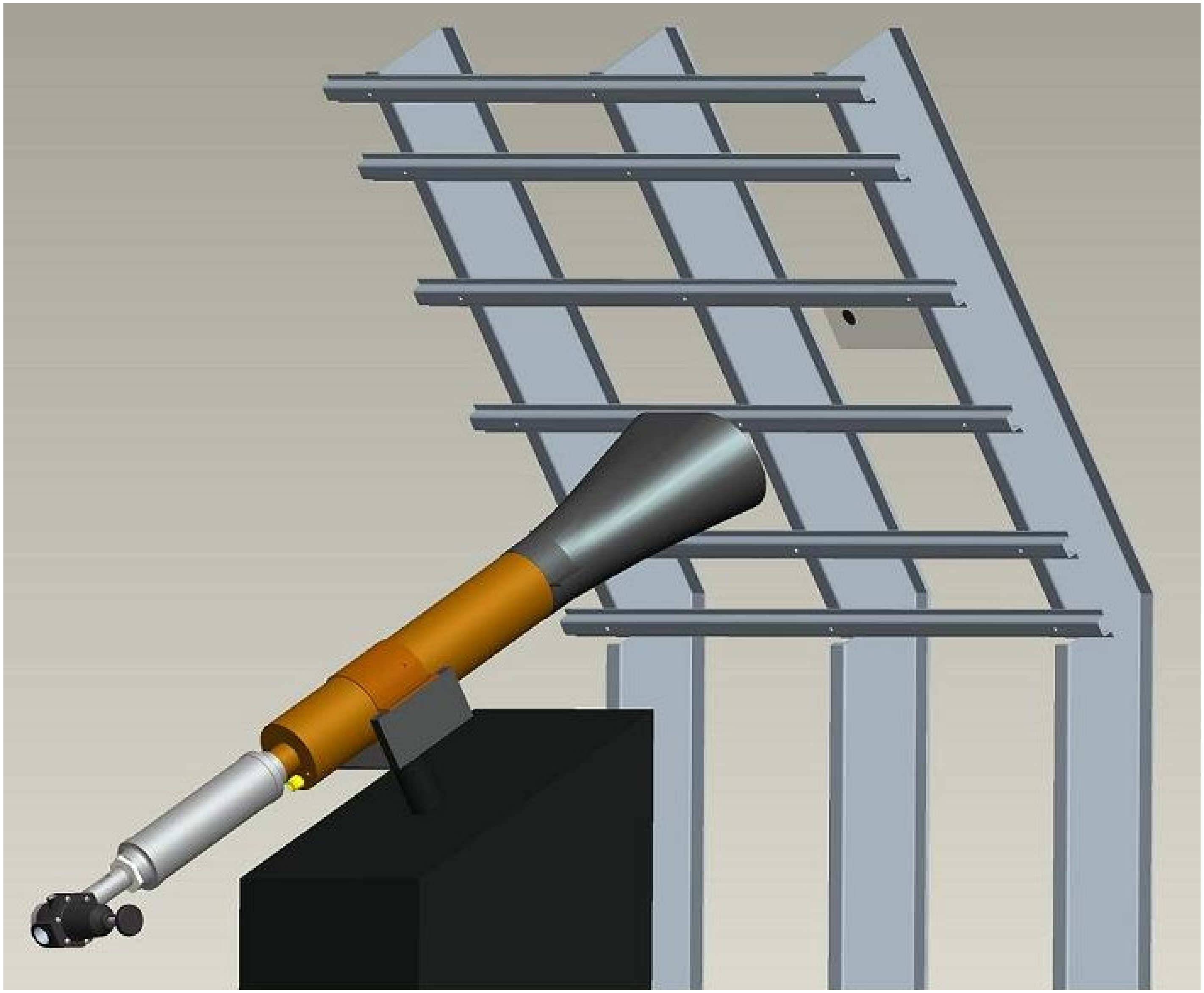
System Schematic



Dimensions are in inches



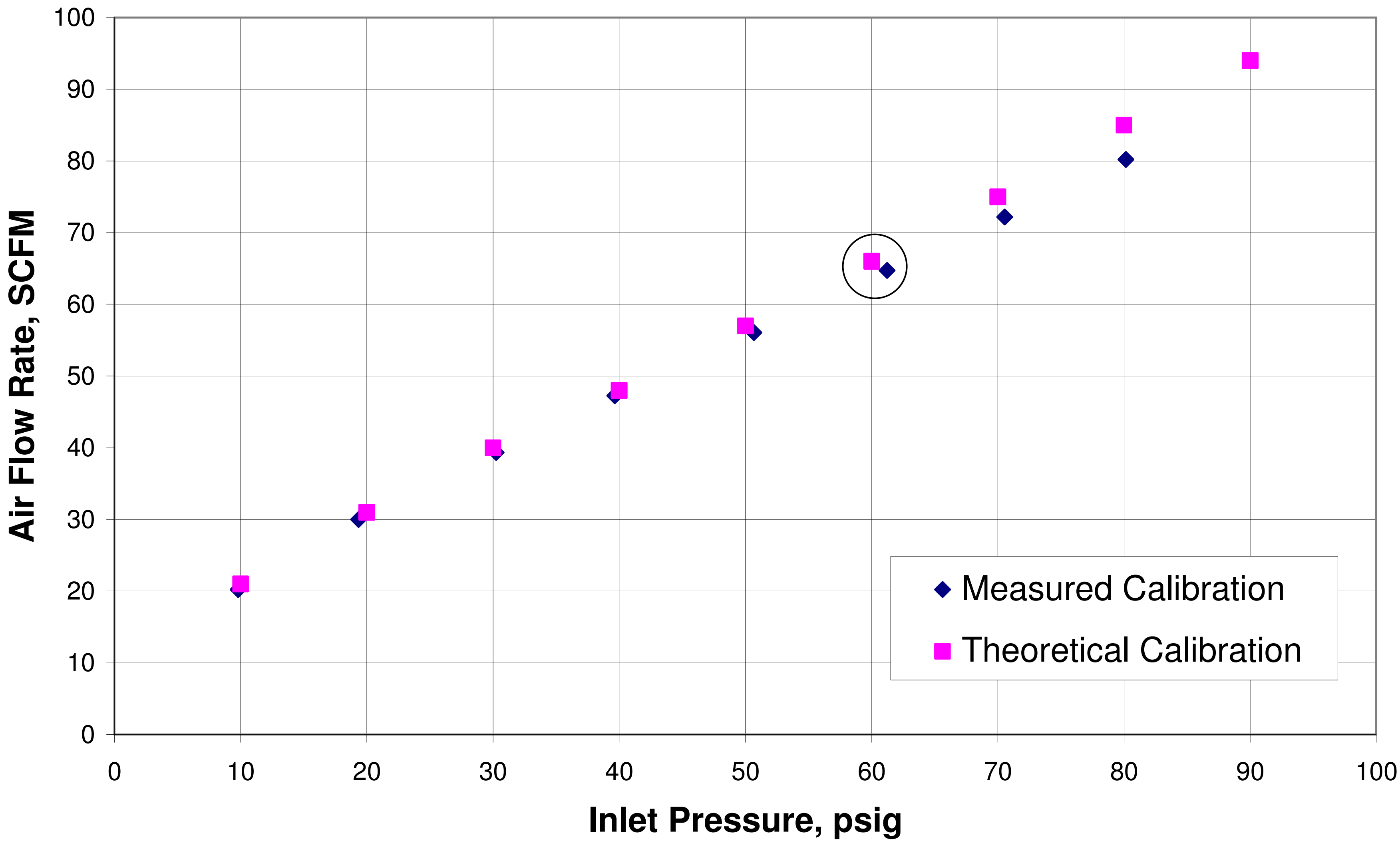




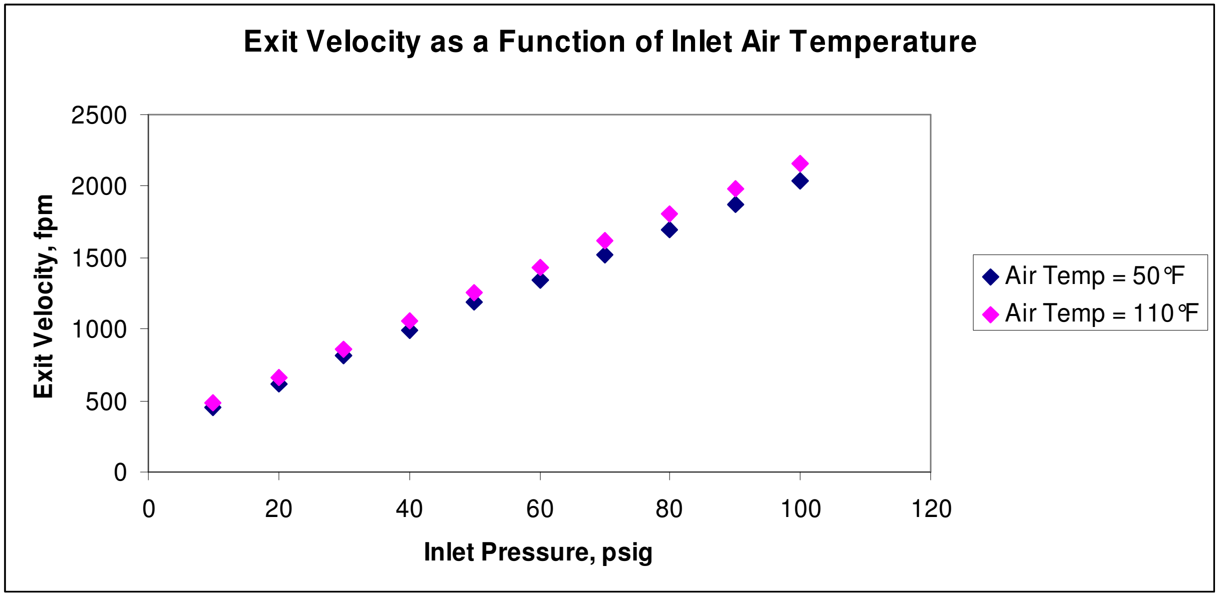
Compressed Air Supply

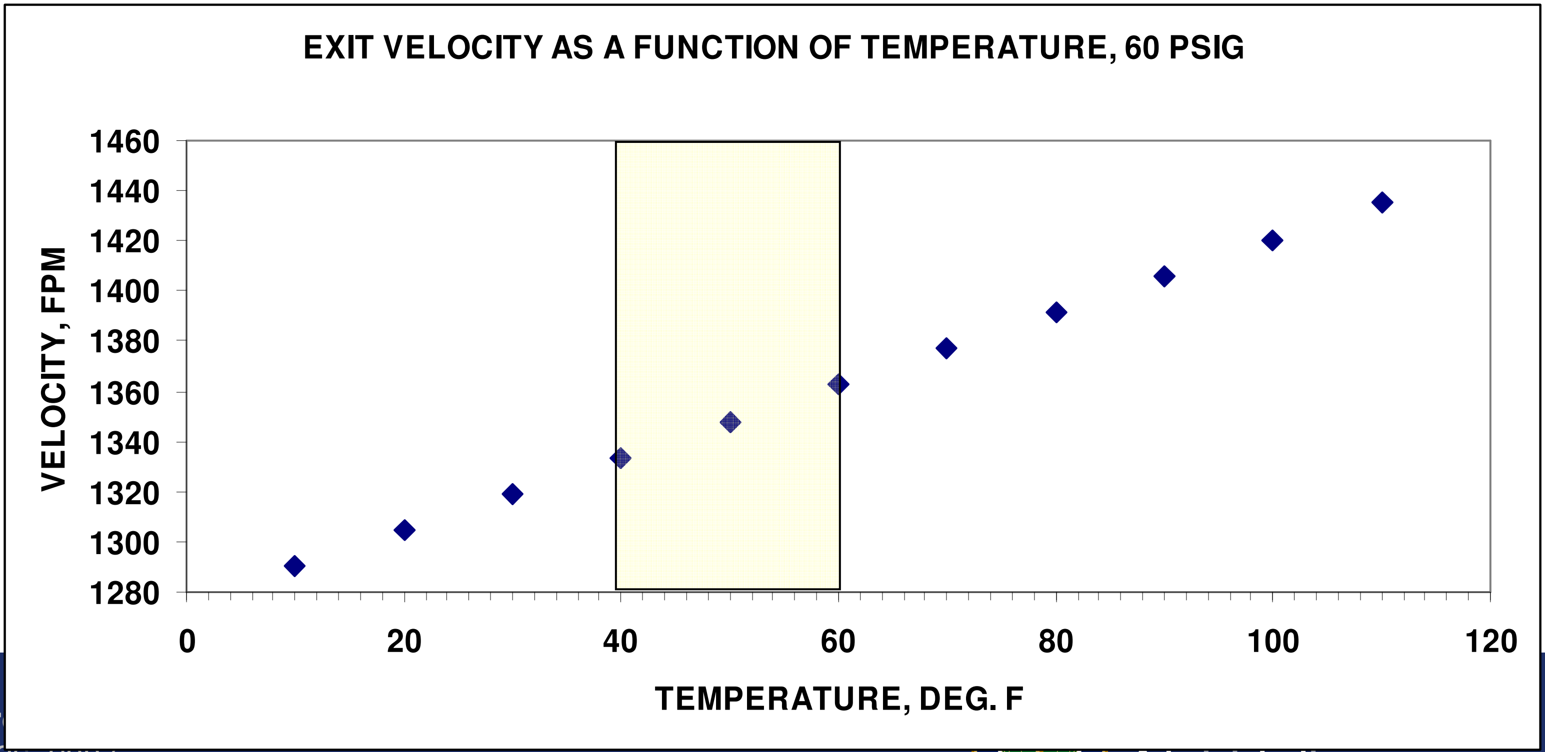
- **Compressor minimum requirements:**
  - Constant line pressure of at least 60 psig
  - Mass flow rate of 66 SCFM (standard cubic feet per minute)
  - Burner comes supplied with a pressure regulator upstream of the sonic orifice. To connect the burner to your compressed air supply, a 1” air line will be required
- **Regulator has 1” NPT female connection. A flexible air line will make connections easier, we use a steel braided 1” flex-line.**
- **The air 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**

Foxvalve Sonic Choke Calibration

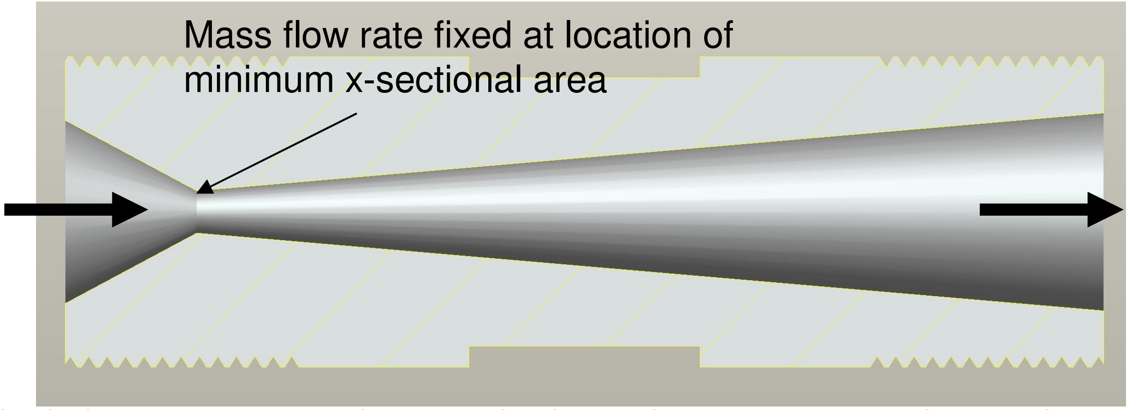


Air Velocity Observations





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

↑T results in ↓ρ

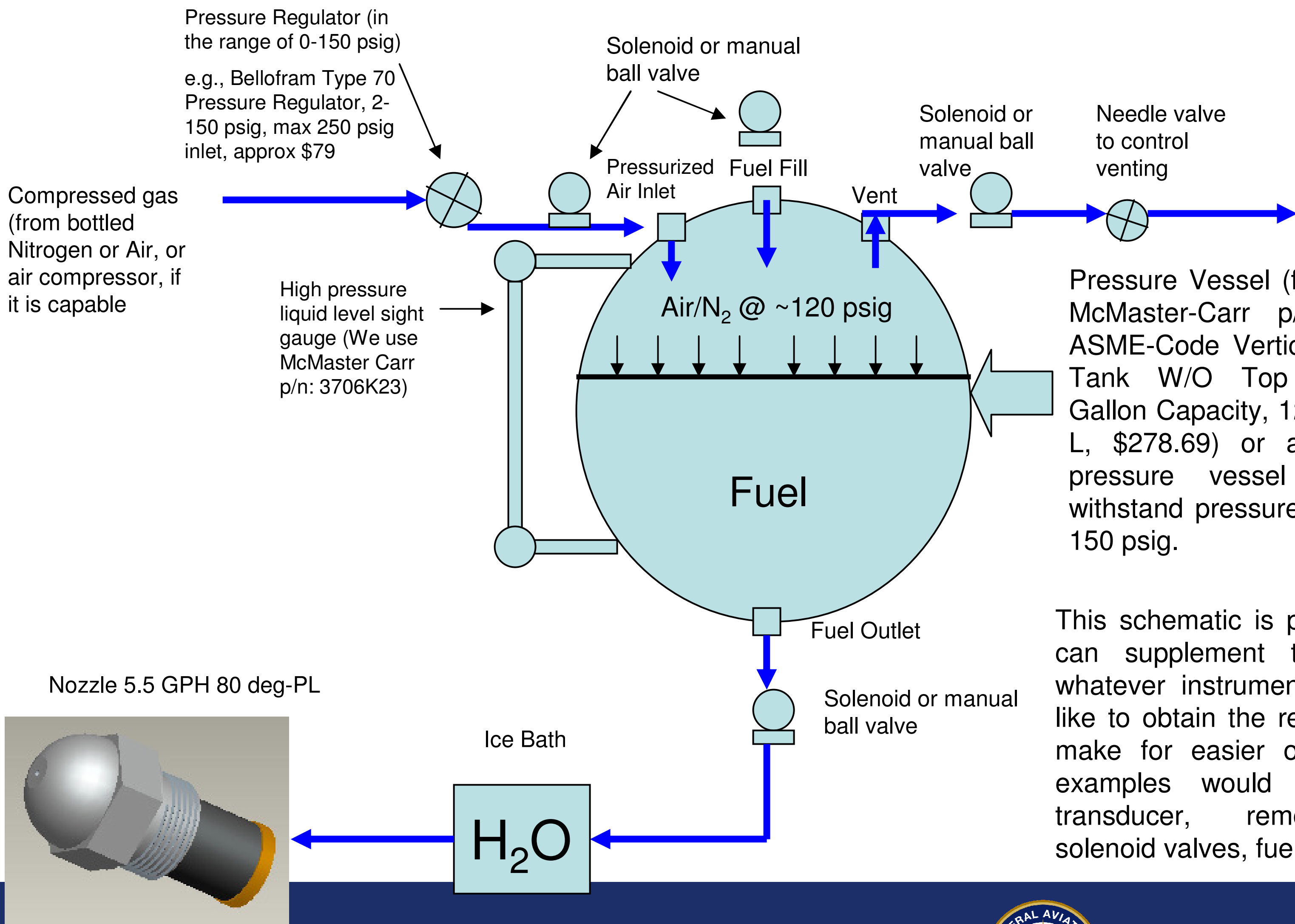
At the throat, the mass flow rate is fixed

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.

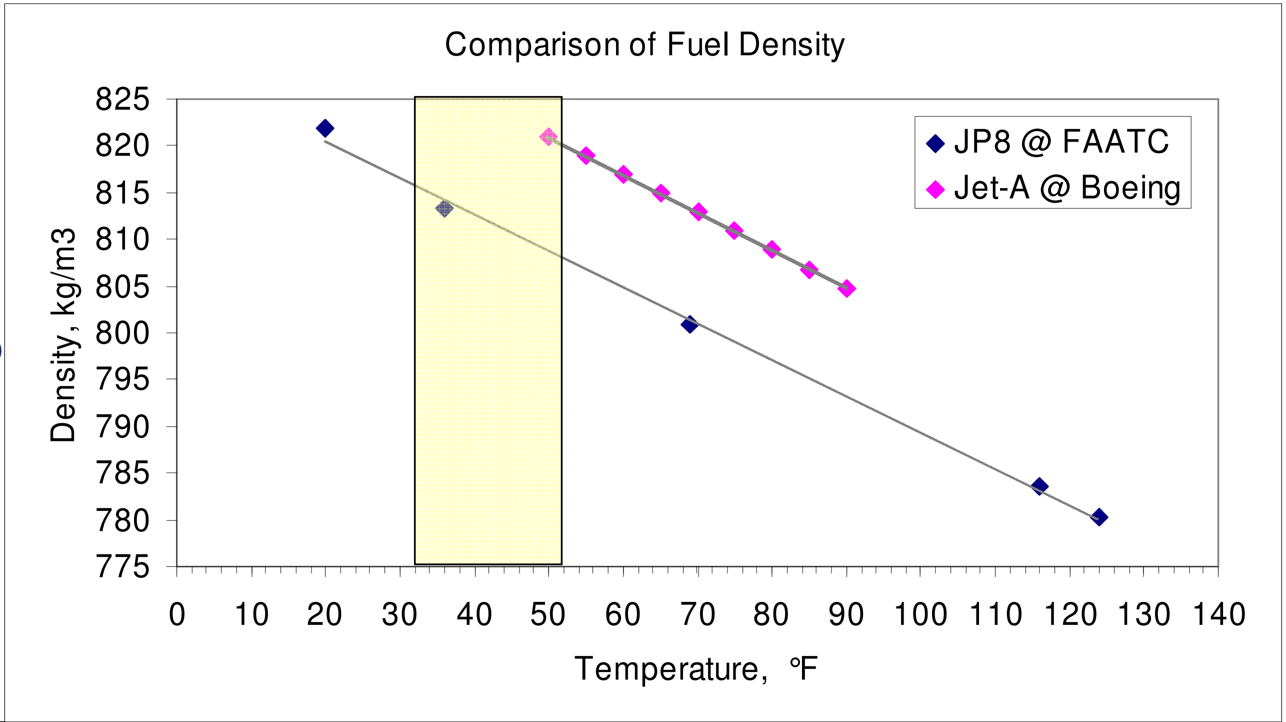
Pressurized Fuel System

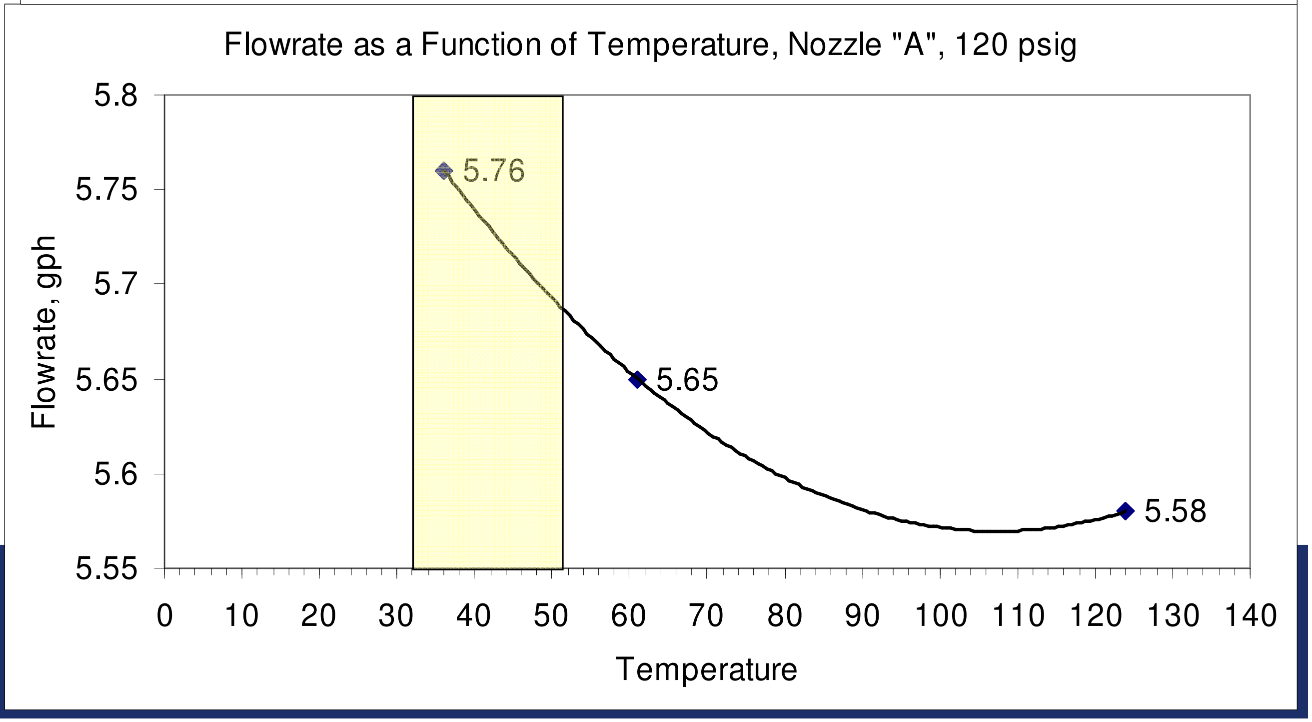


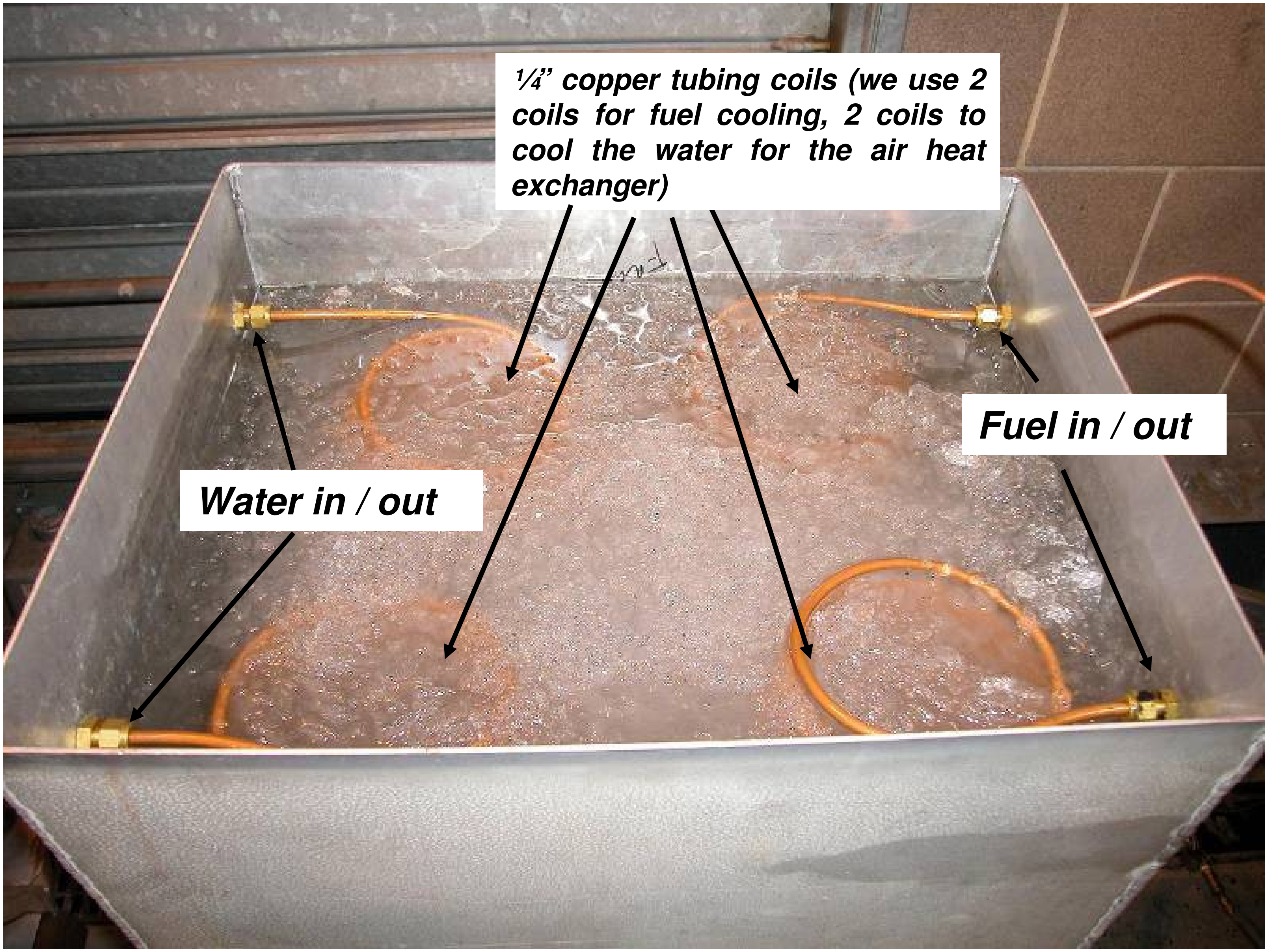
Pressure Vessel (for example, McMaster-Carr p/n 1584K7, ASME-Code Vertical Pressure Tank W/O Top Plate, 15 Gallon Capacity, 12" Dia X 33" L, $278.69) or any suitable pressure vessel that can withstand pressures of around 150 psig.

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.

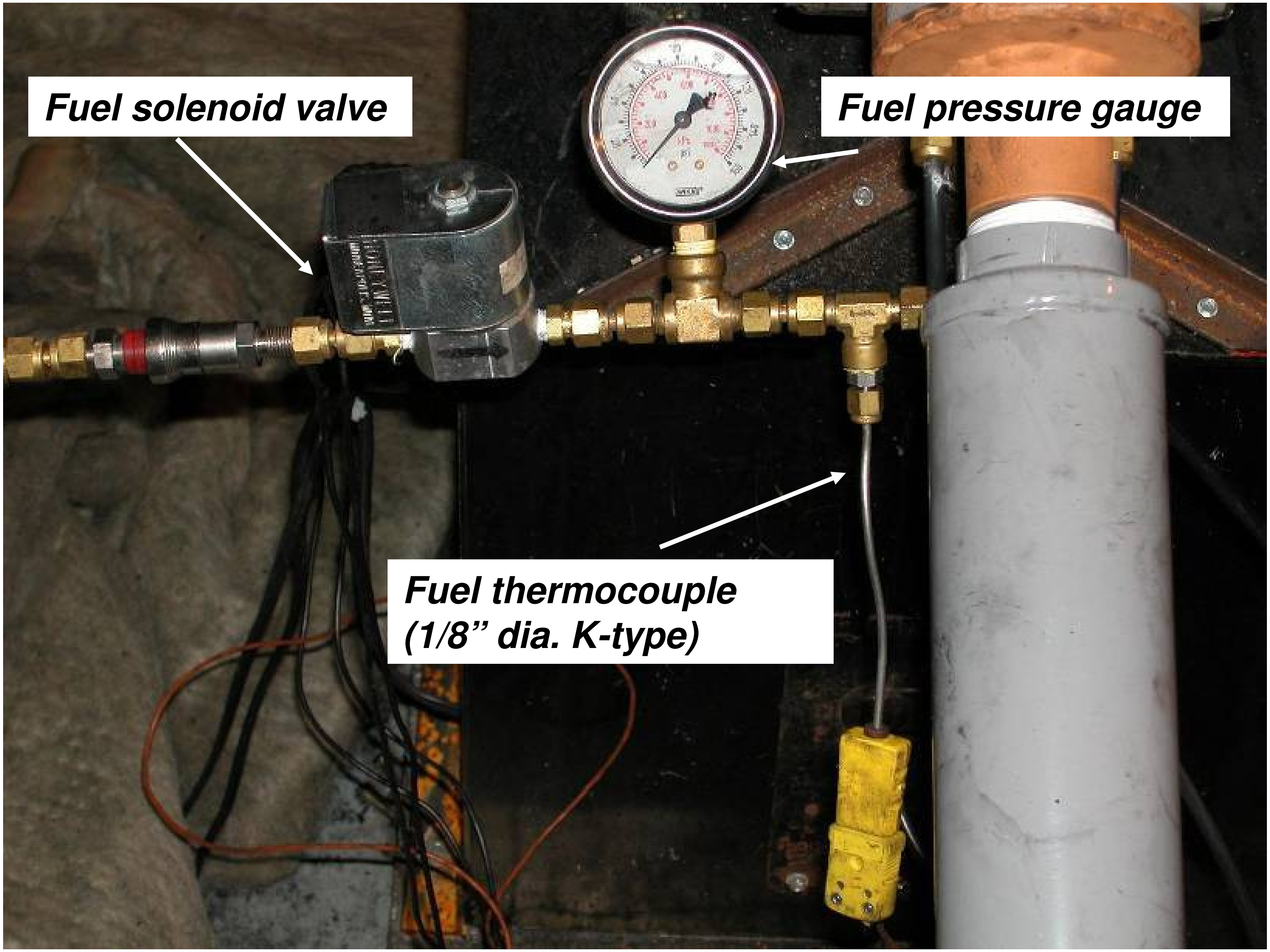
Fuel Temperature Observations






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


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

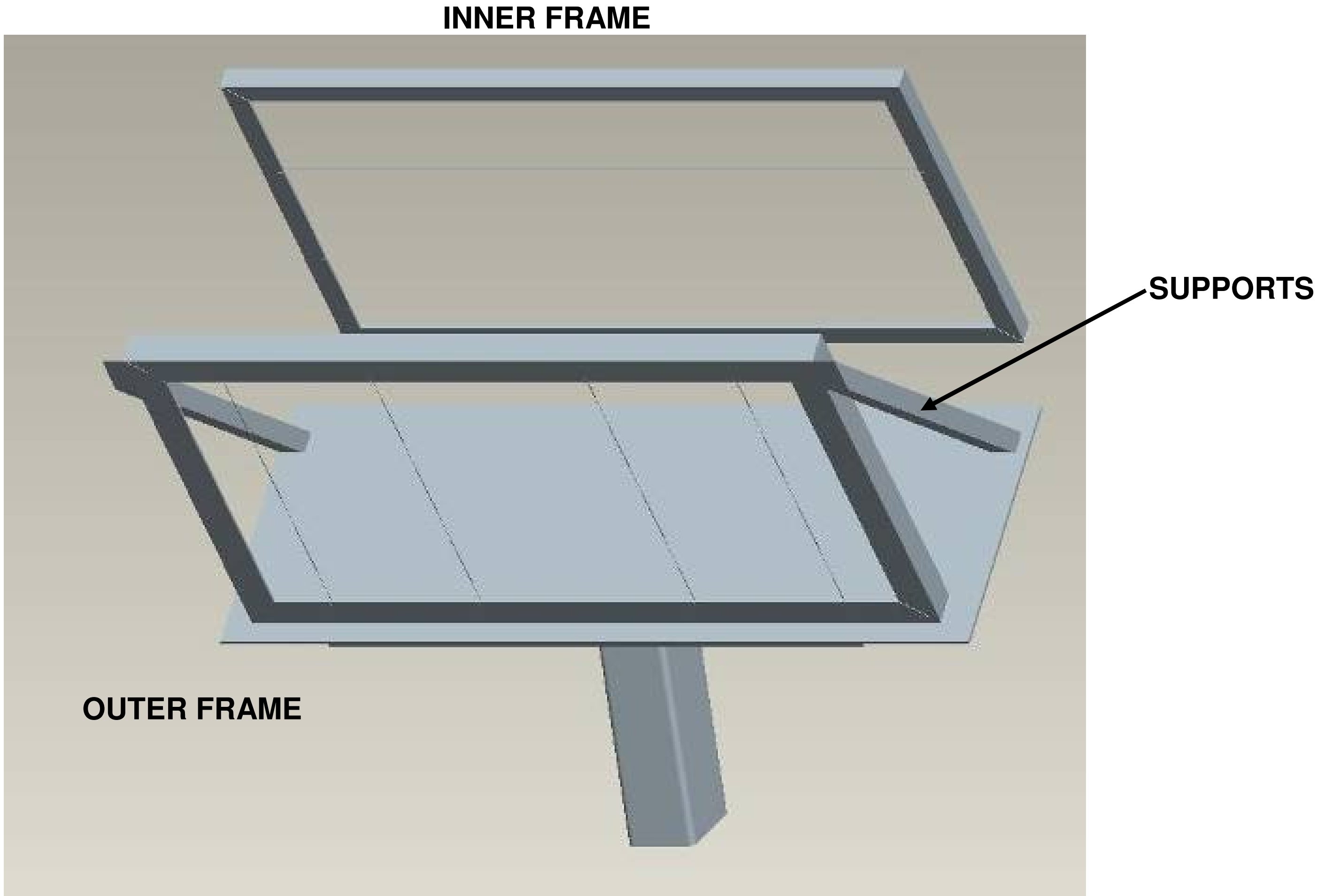
Burner Setup Checklist

- **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 32-52°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 32-52°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.

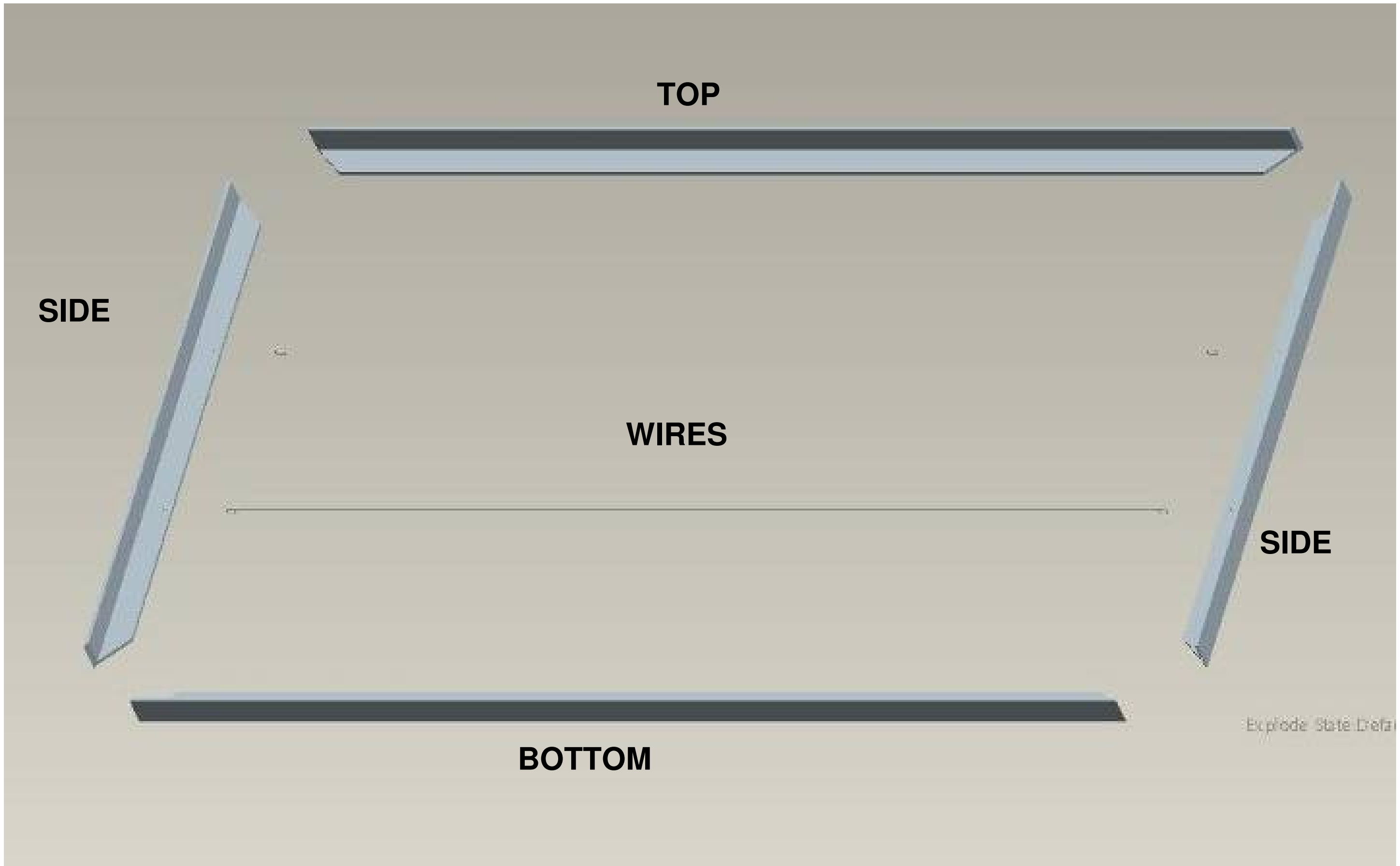
Picture Frame Blanket Holder

- **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

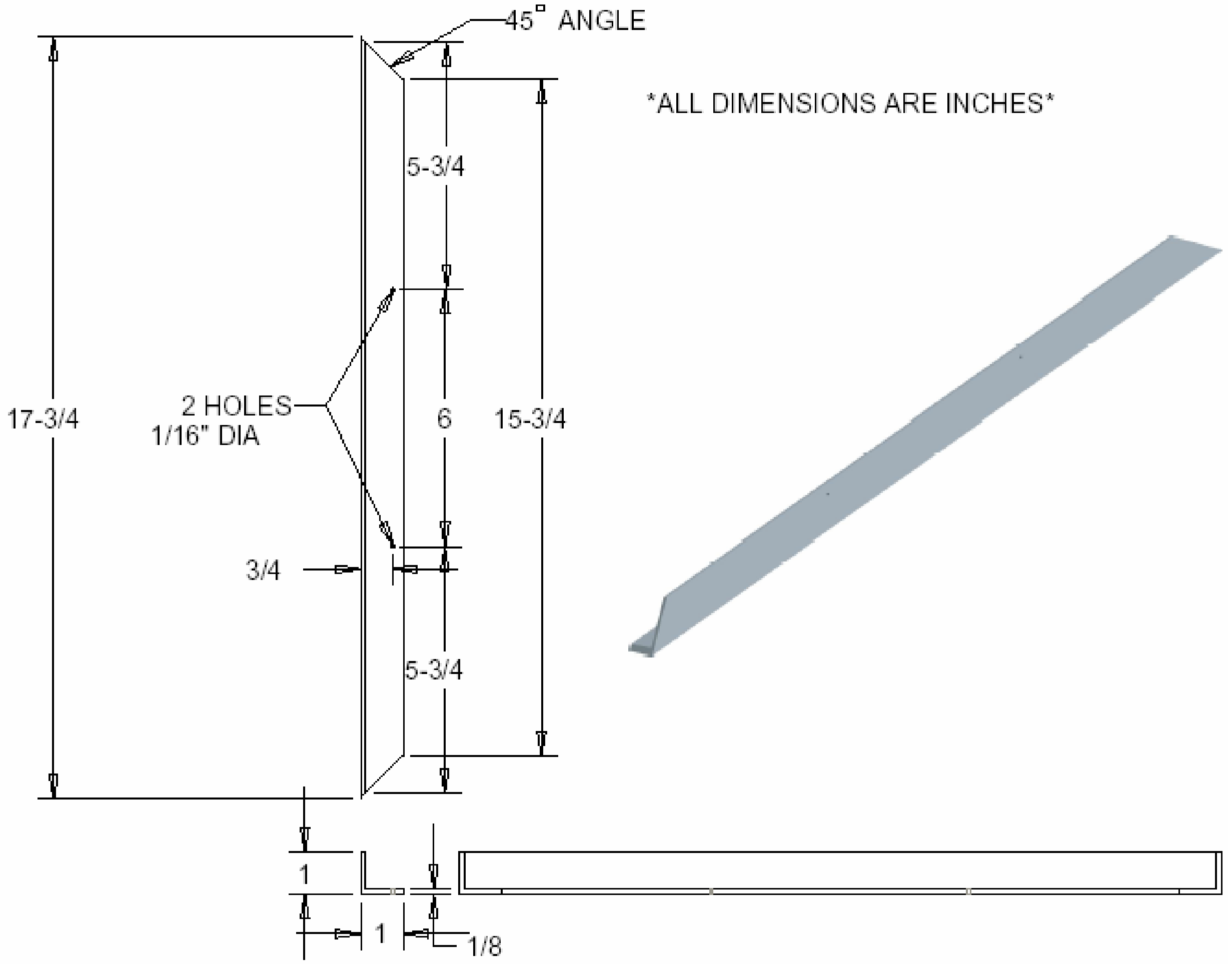
Picture Frame – Component View



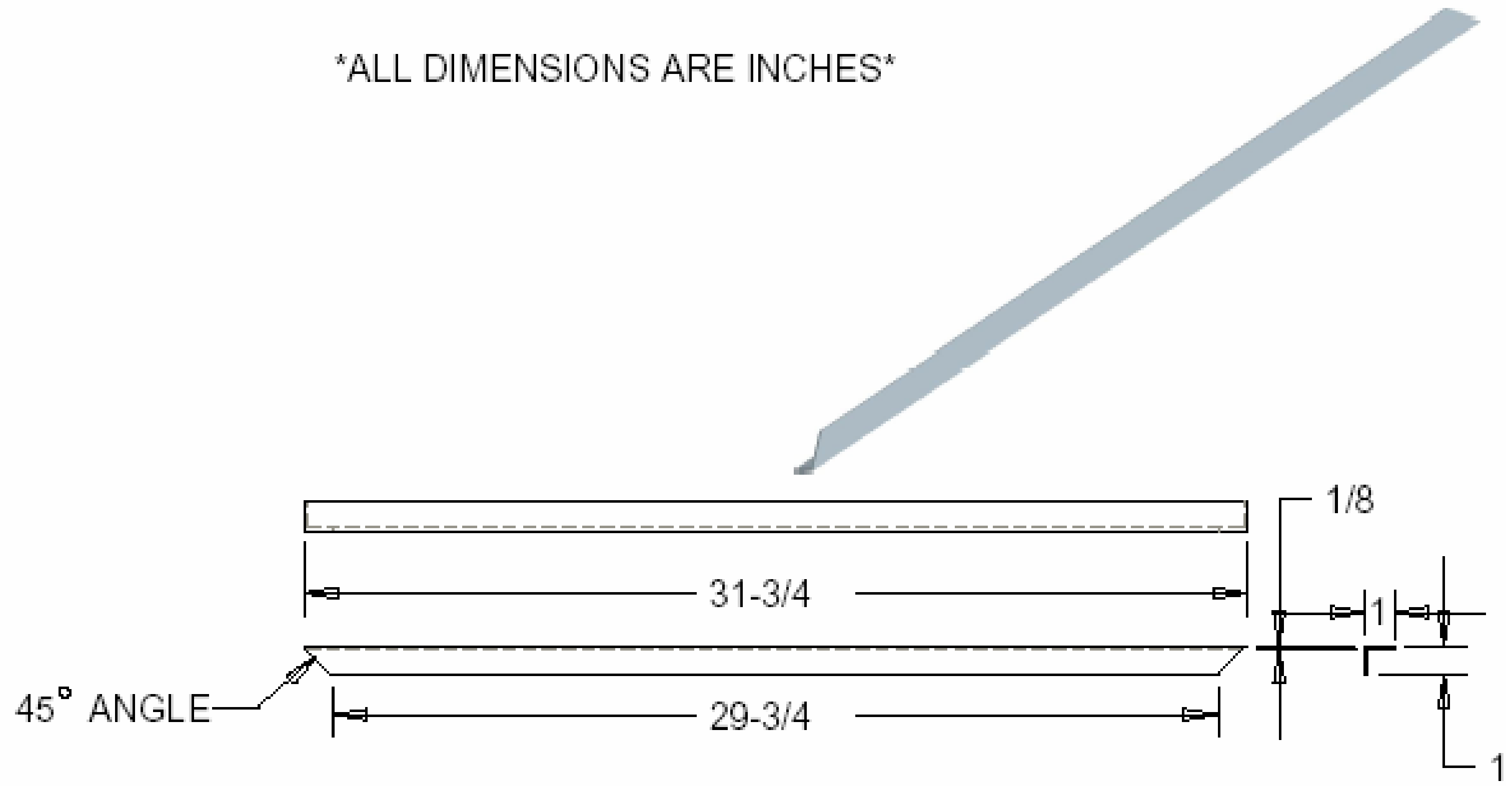
Inner Frame – Exploded View



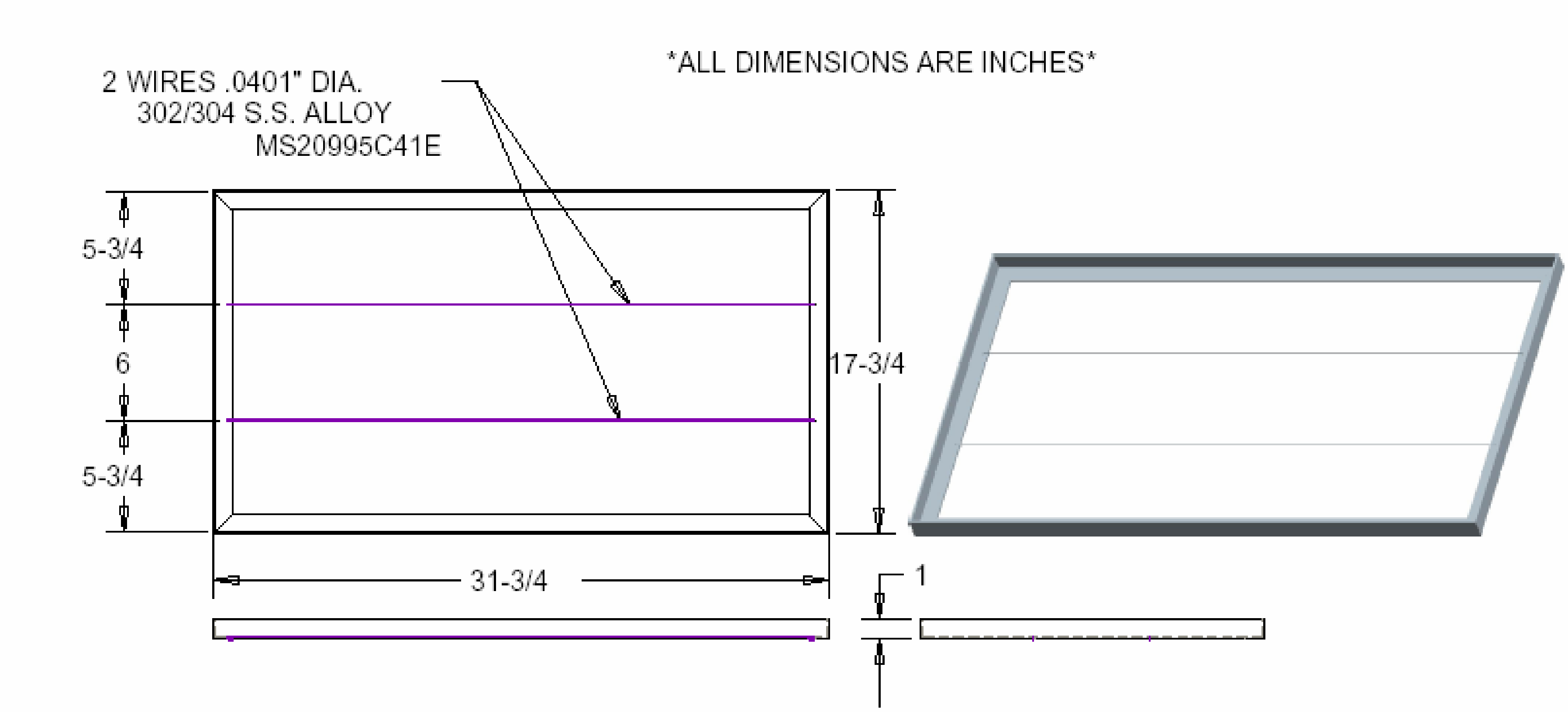
Inner Frame Components – Sides



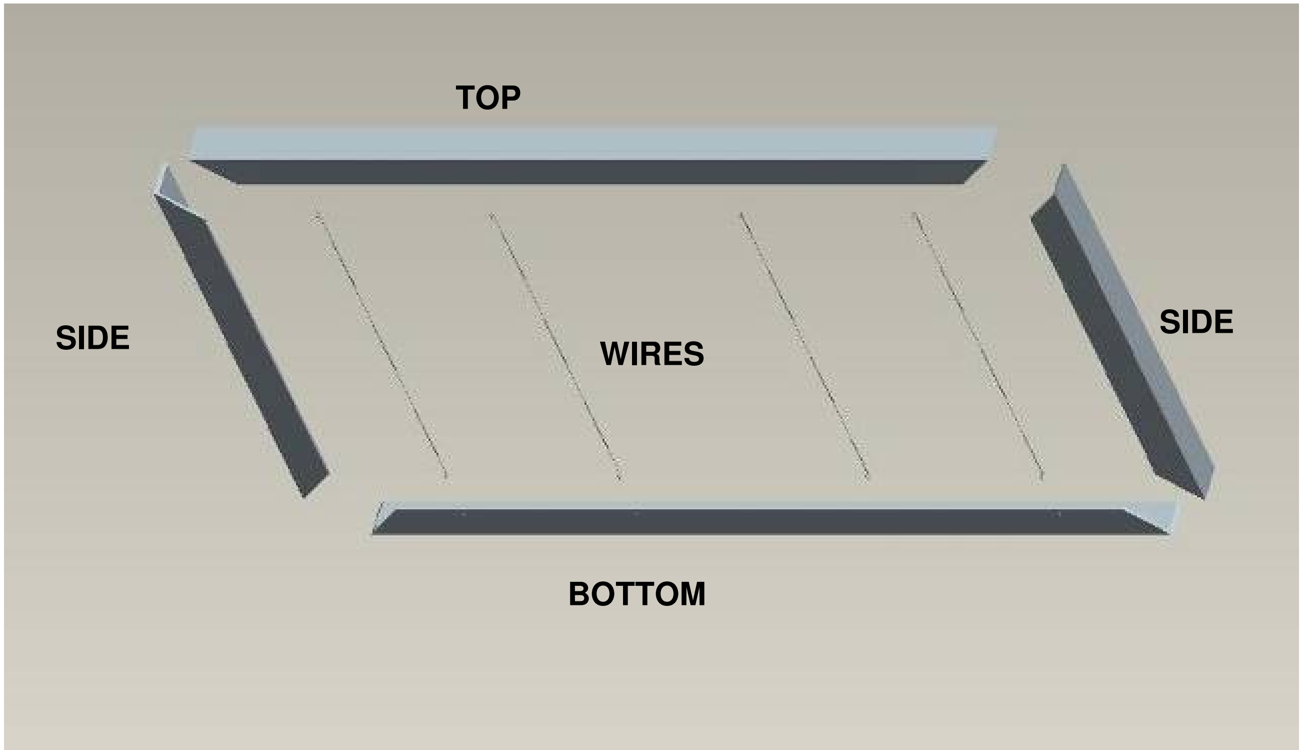
Inner Frame Components – Top & Bottom



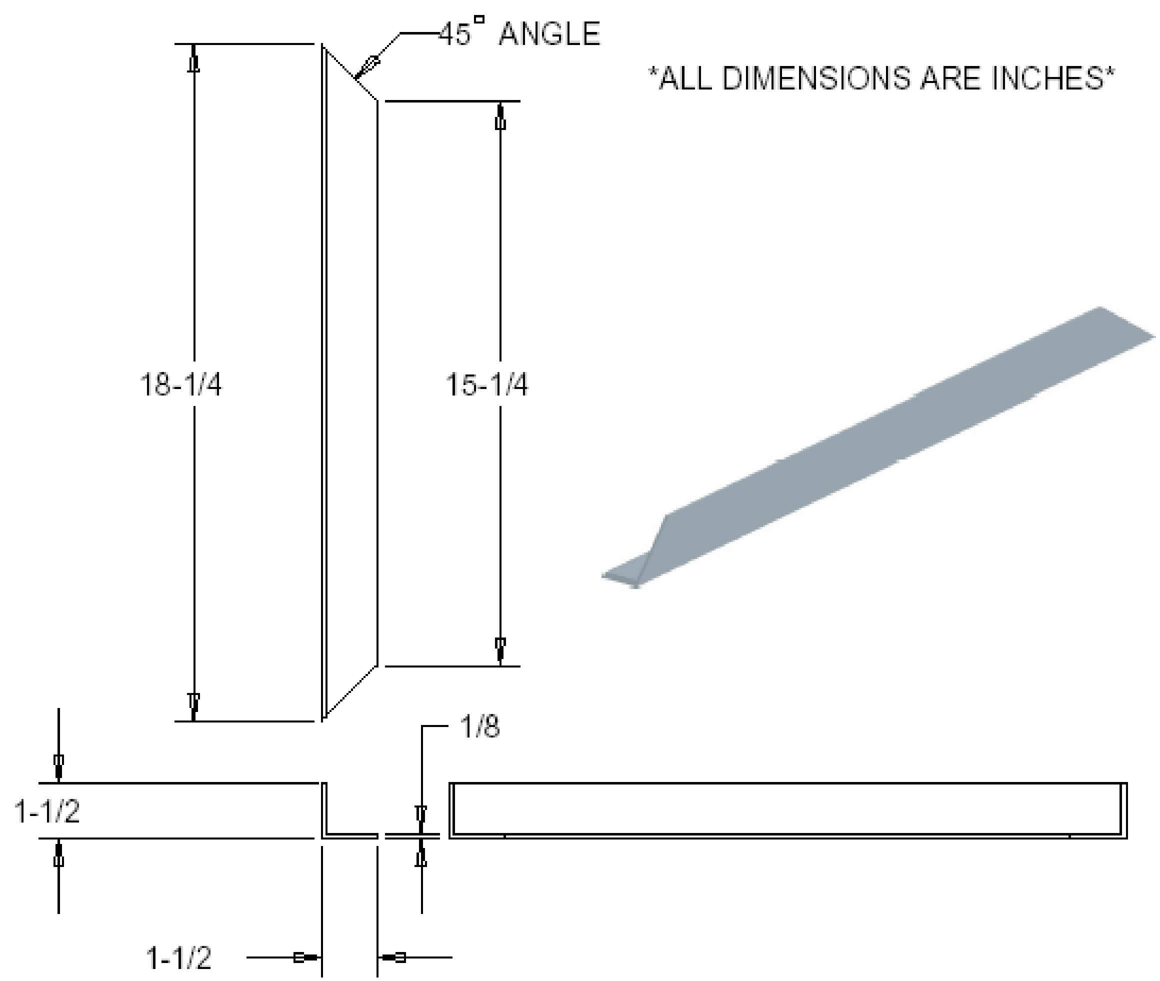
Inner Frame - Assembled



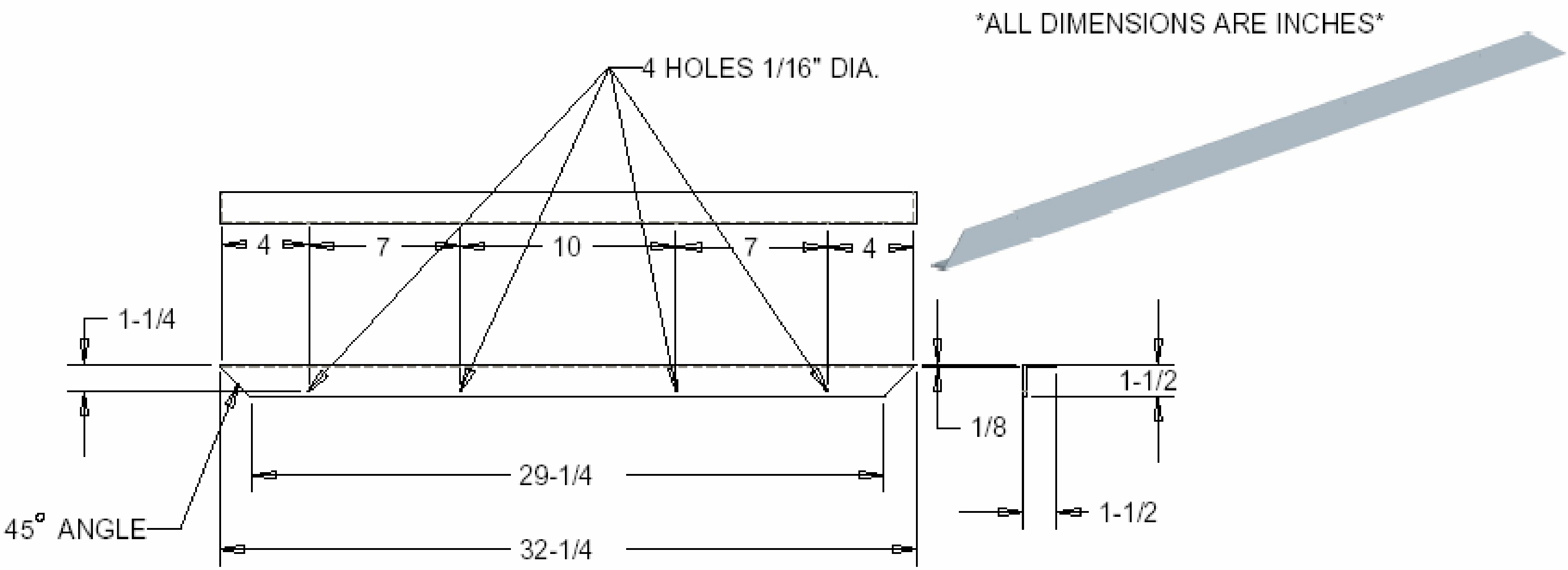
Outer Frame – Exploded View



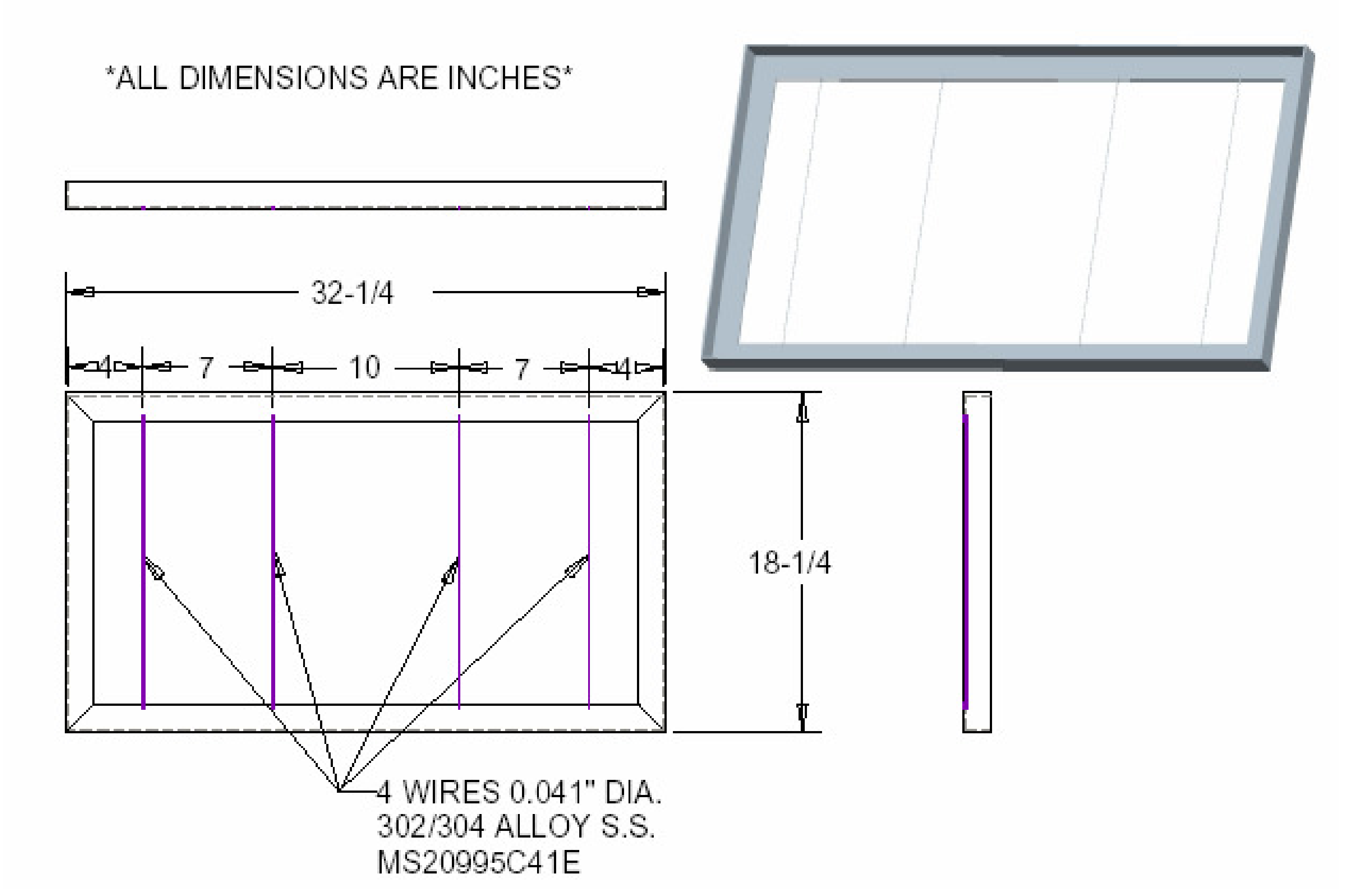
Outer Frame Components - Sides



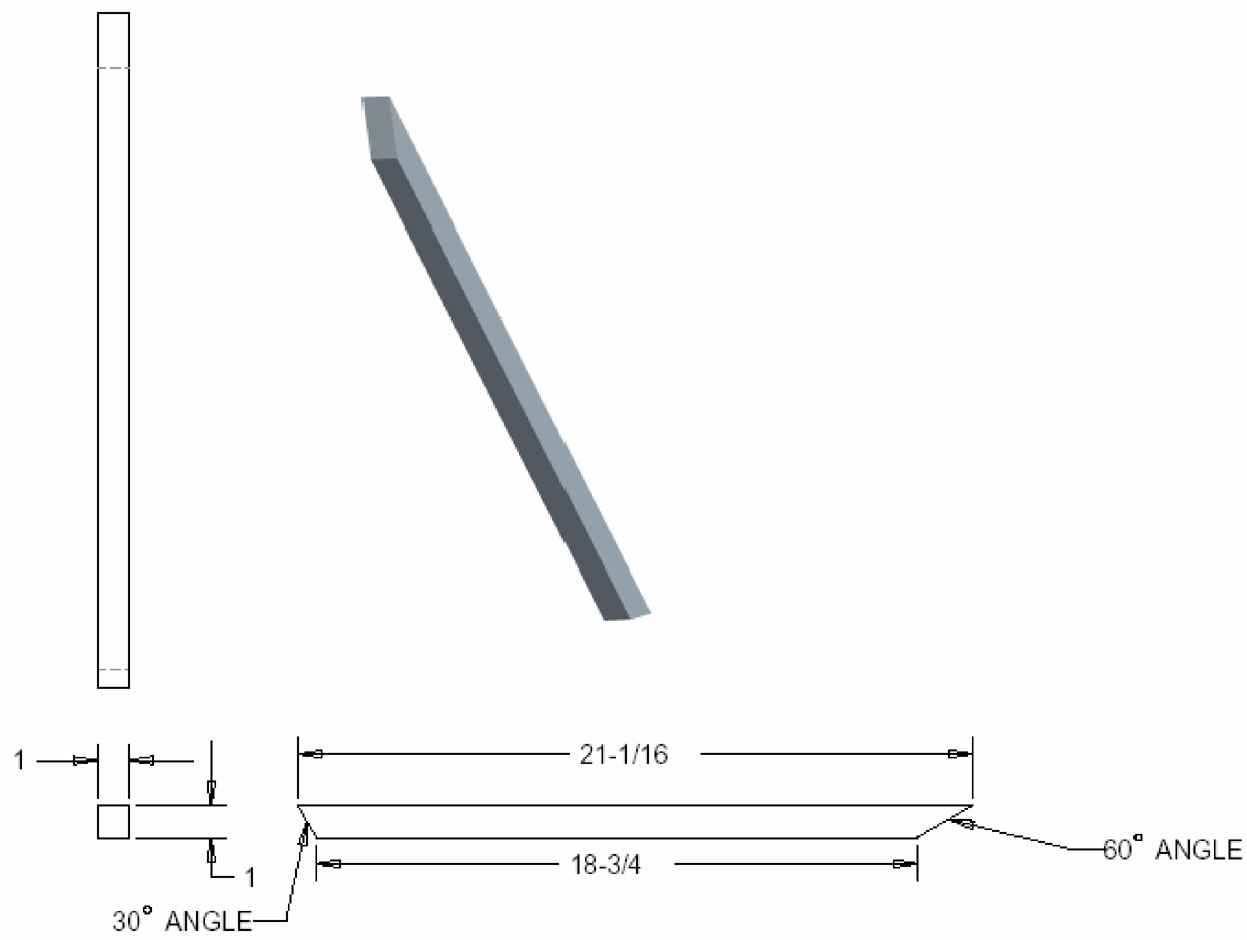
Outer Frame Components – Top & Bottom



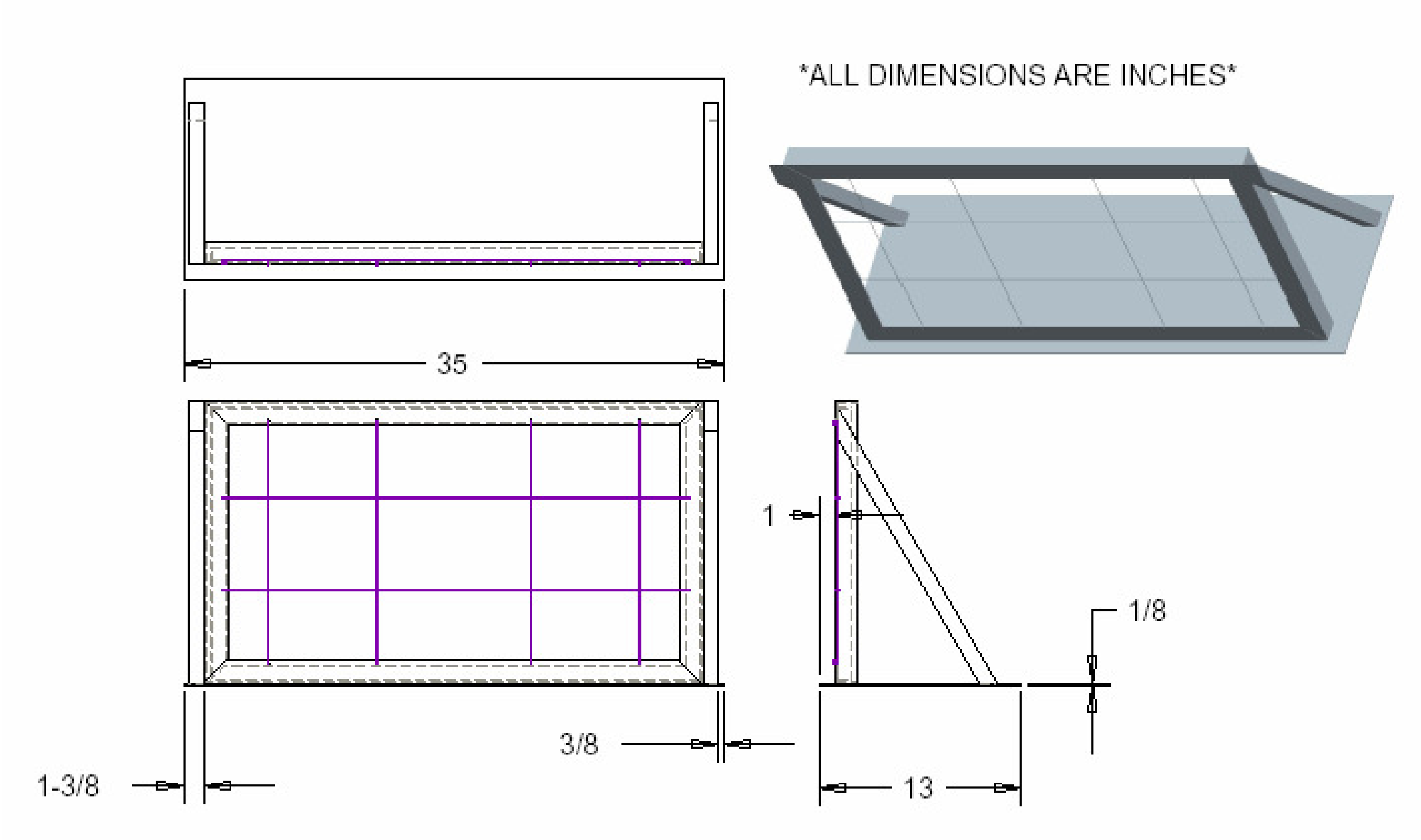
Outer Frame - Assembled



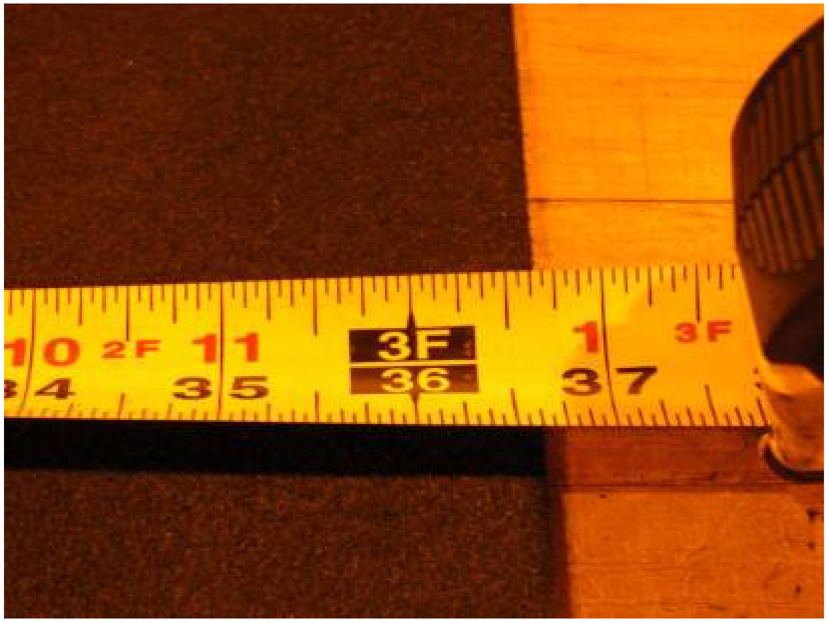
Supports



Frame Assembly

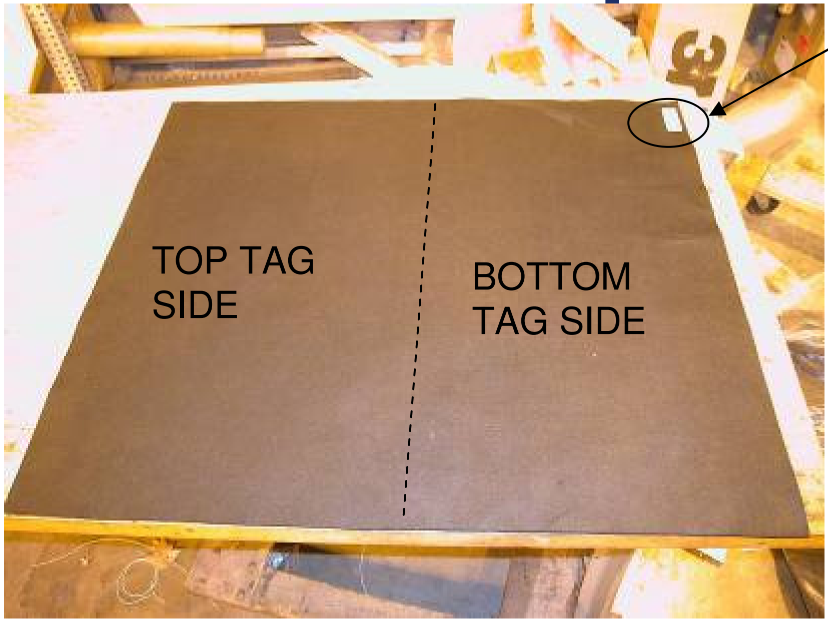


Blanket Preparation

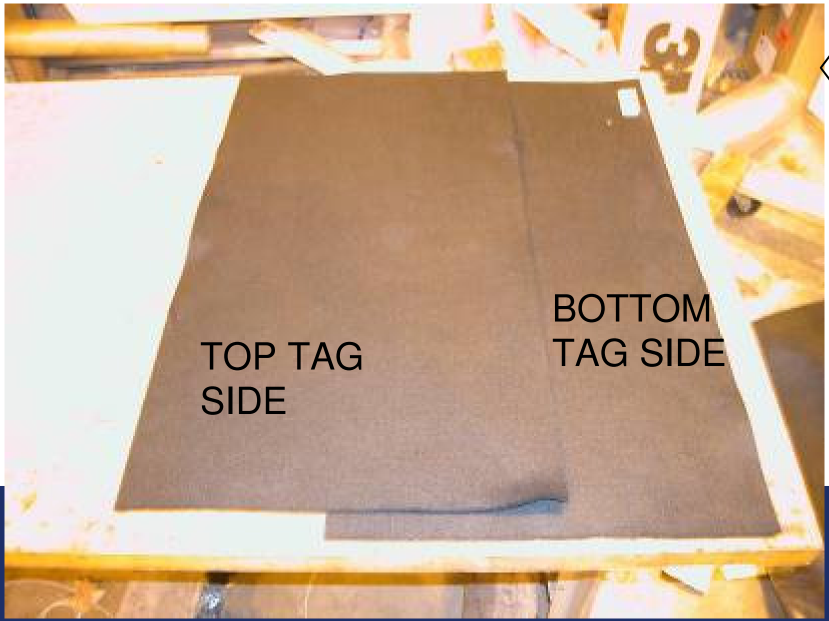


Most blankets are 36"L x 32"W, but some may be longer, like 36 ½". Just divide the length in 2 and cut there – 18 ¼" in this case.

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

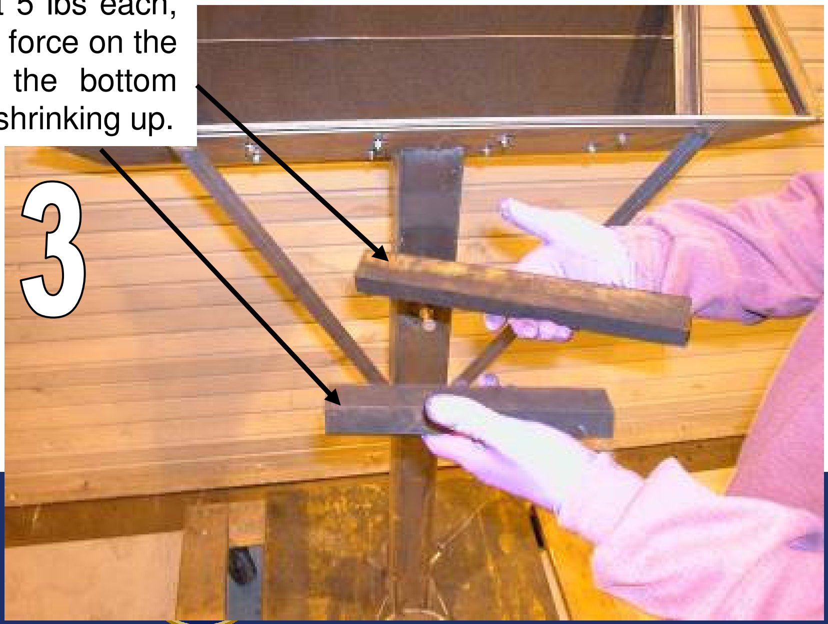
Start from the top, align the top edge of the blanket with the inner top edge of the frame

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

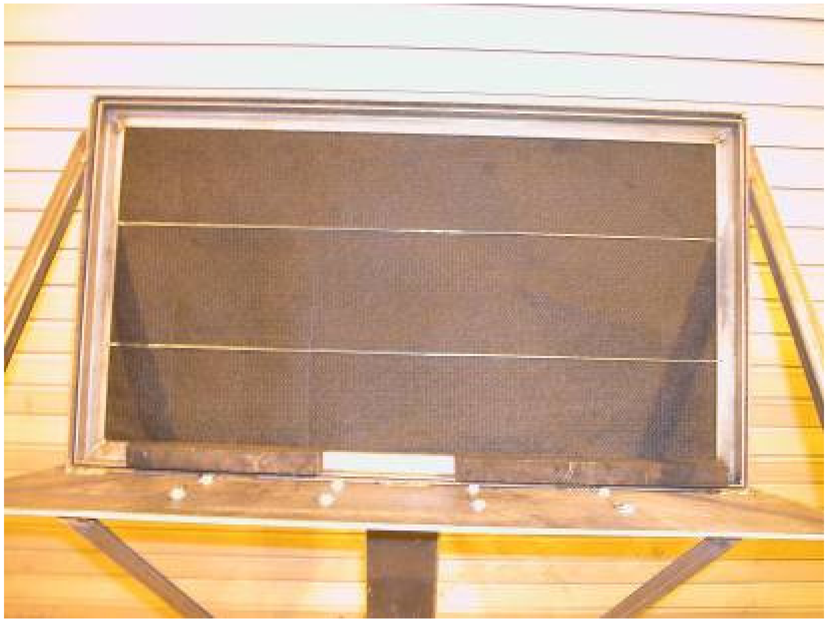
Blanket Installation

Roll the retainer frame in from the bottom to the top

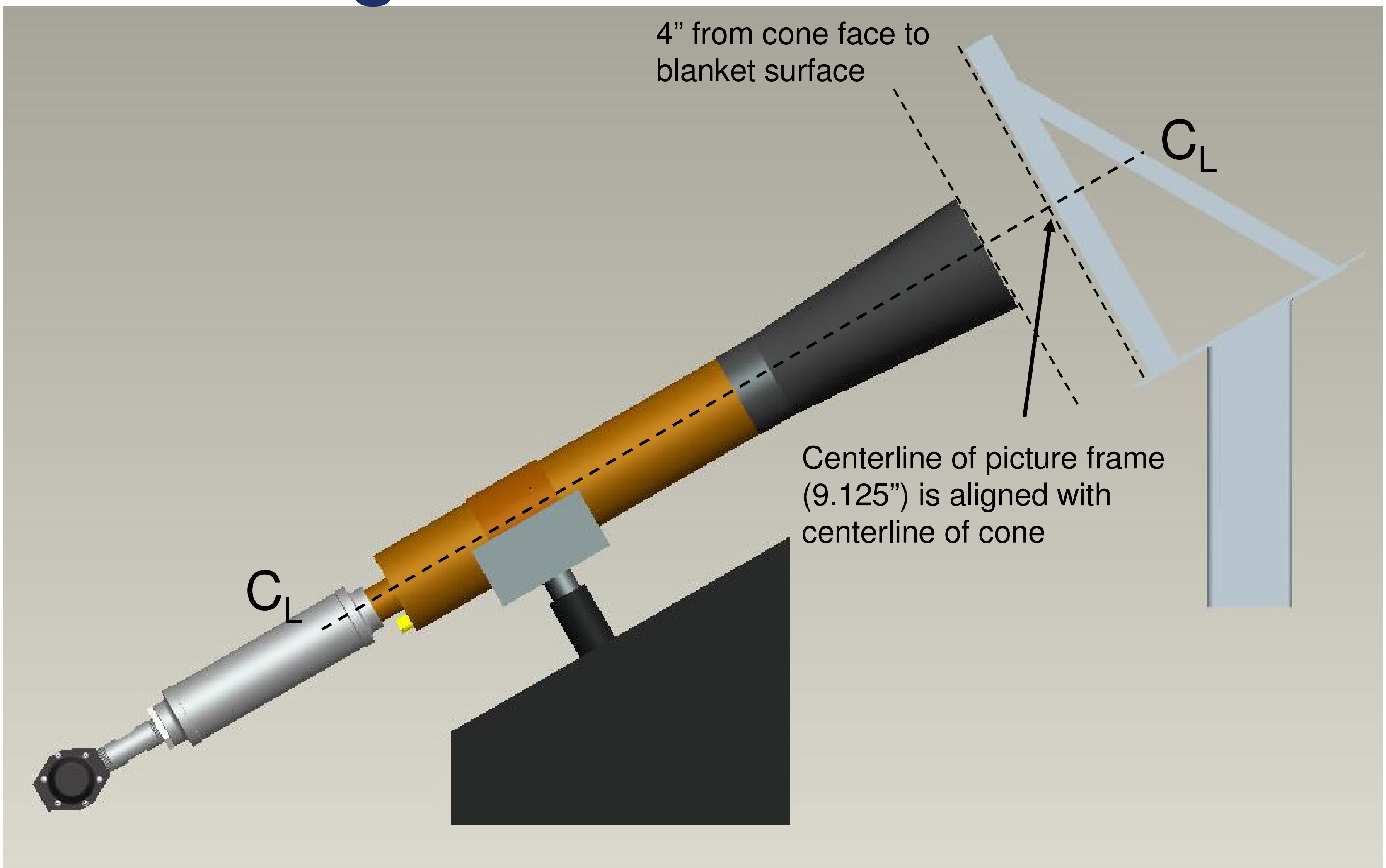
Two dead weights, about 5 lbs each, are used to put additional force on the retainer frame to keep the bottom edge of the blanket from shrinking up.



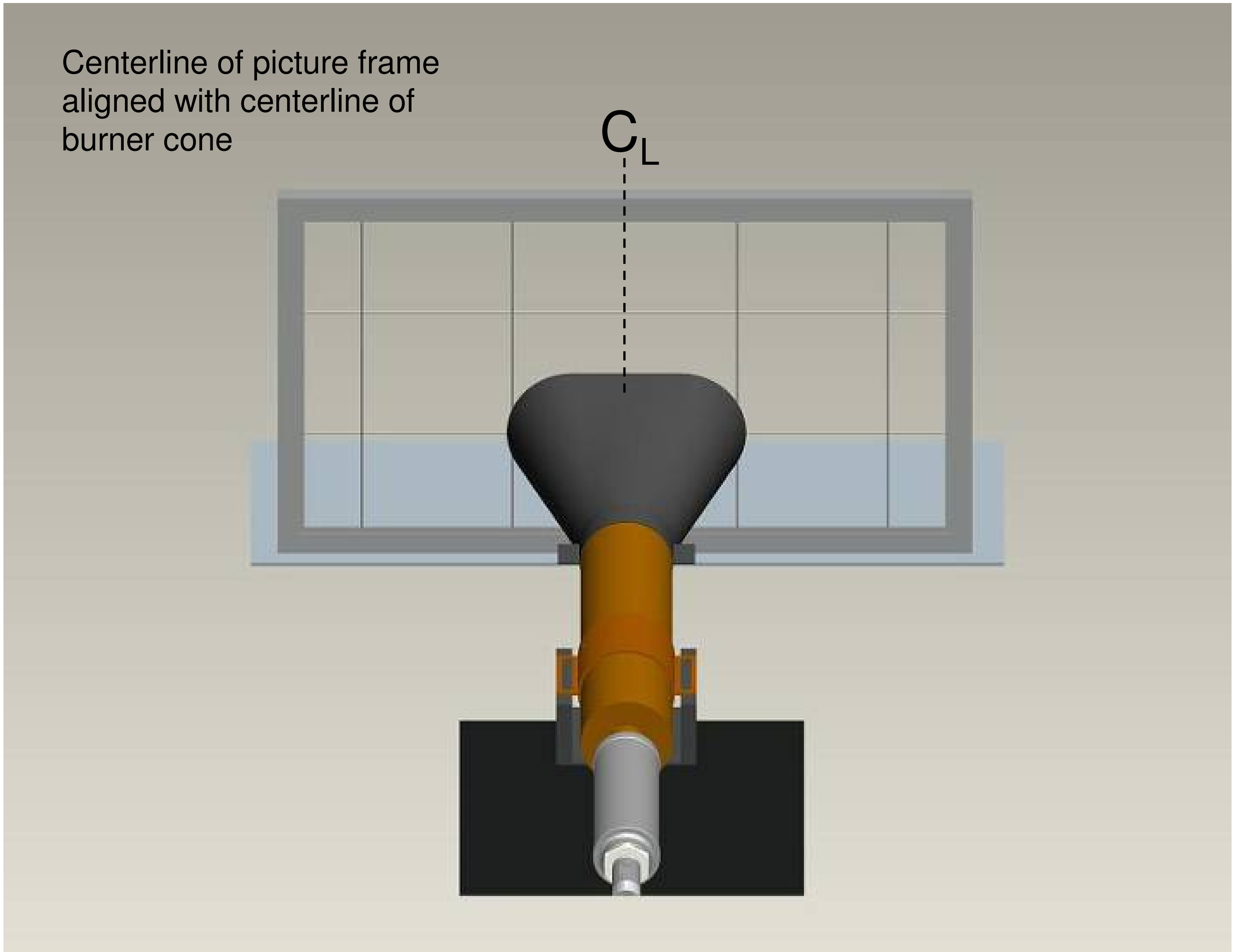
Finished Installation, Front and Back



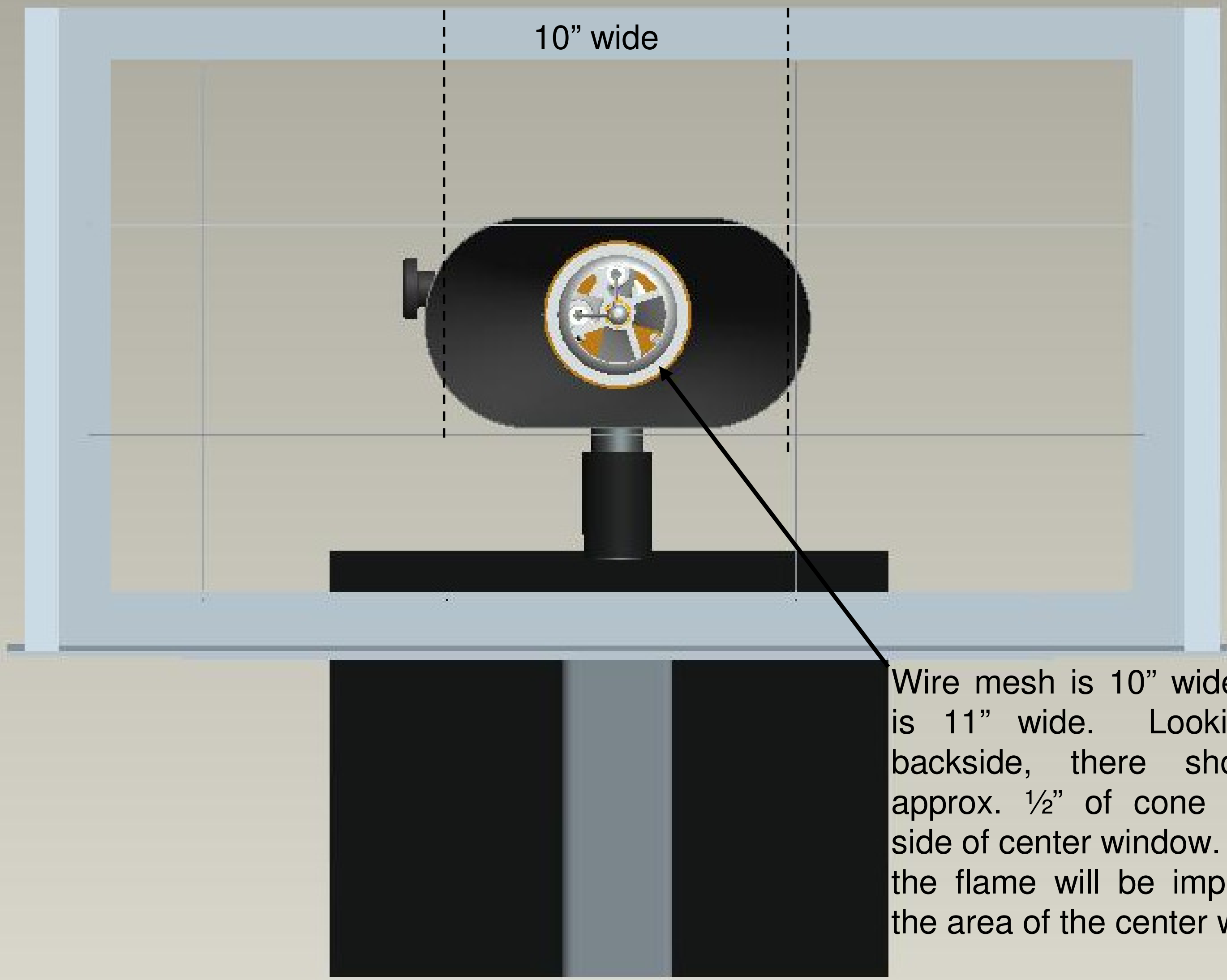
Frame Alignment



Frame Alignment

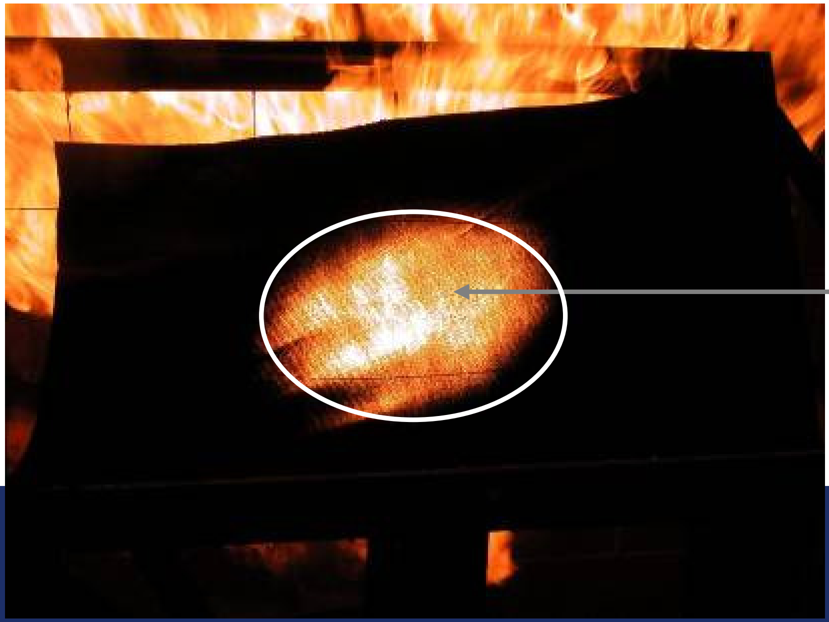


Frame Alignment

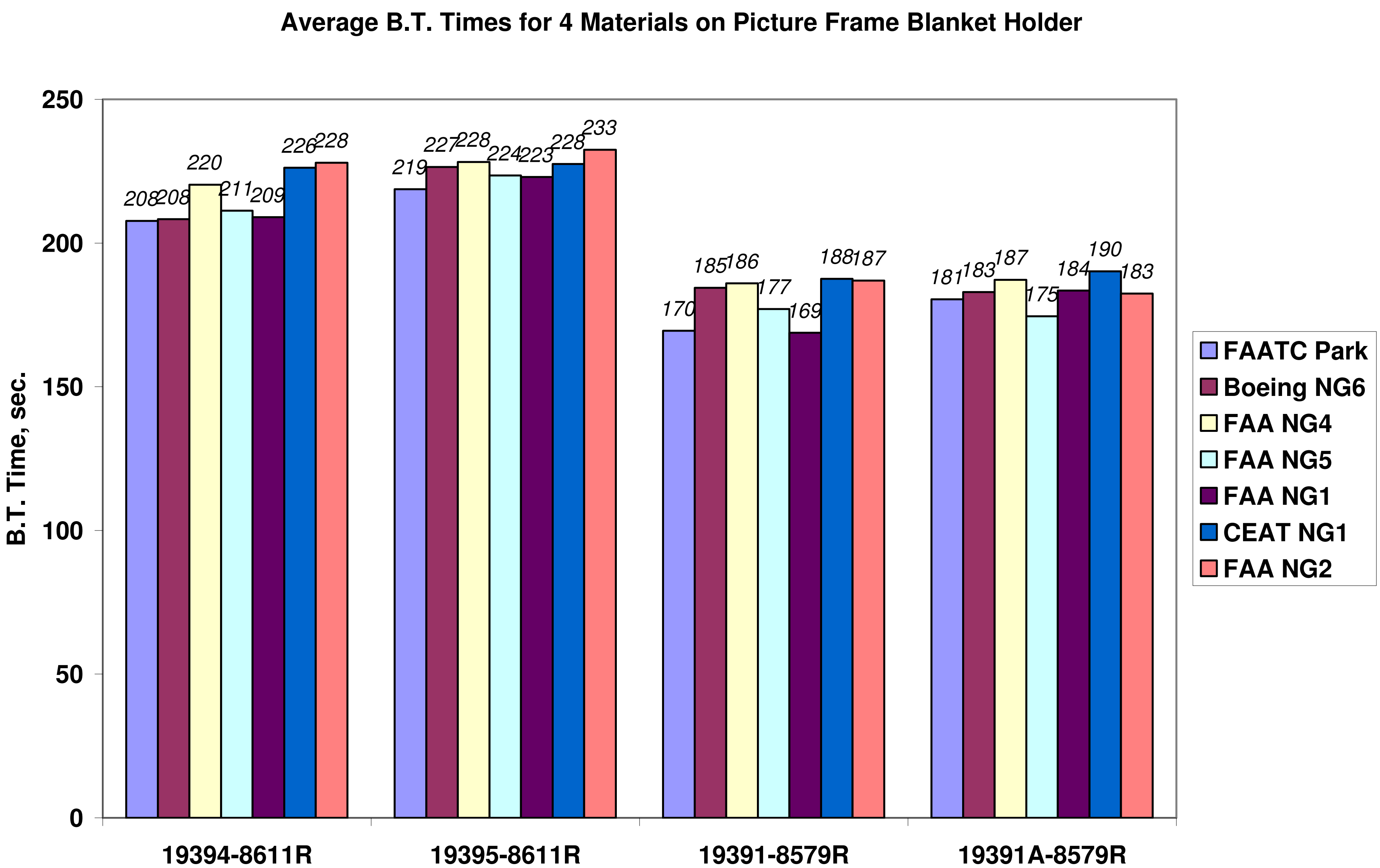


Wire mesh is 10” wide. Cone is 11” wide. Looking from backside, there should be approx. ½” of cone on each side of center window. Most of the flame will be impinging in the area of the center window.

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.



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%SD=4.45

AVG=226
%SD=2.91

AVG=180
%SD=4.91

AVG=183
%SD=3.89