Burnthrough Test Method for Aircraft Thermal/Acoustic Insulation:

Alternative Burner Apparatus

Presented to: Materials Working Group

By: Robert I. Ochs

Date: March 20, 2006

Outline

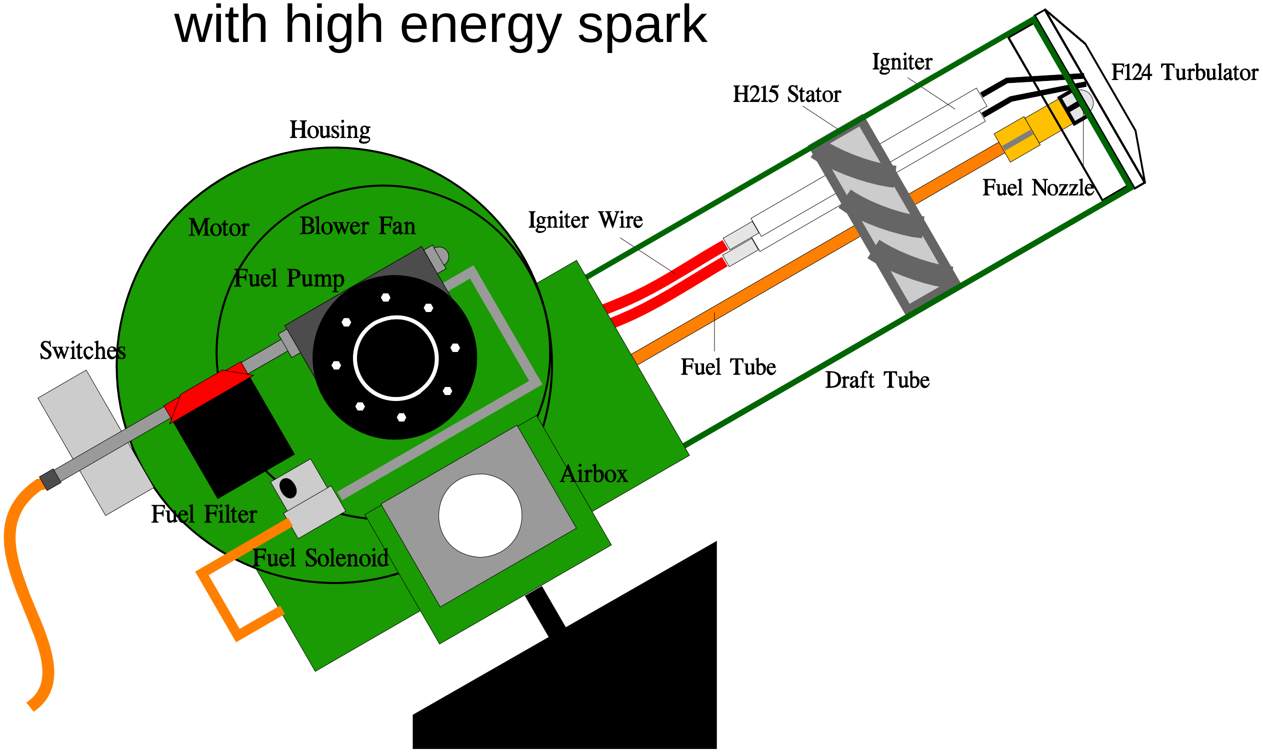
- Motivation
- Original Burner Operation
- Problems
- Solutions
- New Burner Performance
- Comparison with FAA burner performance

Motivation

- **Need for new test apparatus**
  - Inconsistencies in burner performance
    - Reproducibility of experiment critical for compliance
    - Burner performance dependent upon several factors
      - Electric motor
        - » Supply voltage differences and fluctuations
        - » Does motor/fan supply constant, steady flow rate of air?
      - Variability in construction
        - » Flange-type burners
        - » Socket-type burners
        - » Differences in blower castings
      - Laboratory conditions
        - » Local air temperature, humidity affect supply air density, fuel to air mass ratio

Operation of Oil Burner

- **Simple design**
  - Turbulent airflow is mixed with fuel spray
  - Air/fuel mixture is ignited with high energy spark



Problems

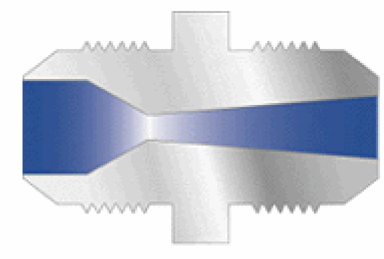
- **Remove dependence upon electric motor**

  What does the motor do?

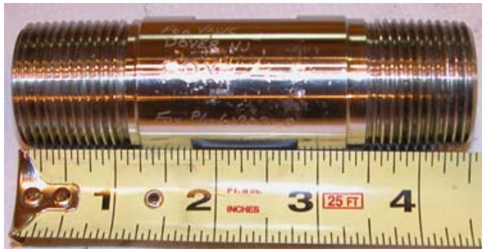
  1. Directs lab air through the blower housing and draft tube towards the sample at a fixed velocity/flow rate
  2. Pressurizes liquid fuel to approx. 100 psi, which is required for Monarch-type fuel nozzles

Replacement of Electric Motor

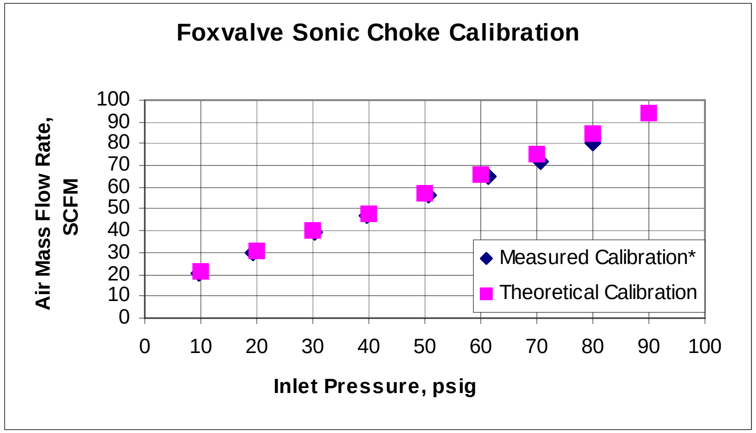
- **Task 1: To supply air to the draft tube at a controllable velocity / flow rate**
- **Solution: Utilize compressed air from laboratory compressor**
  - More control over level of conditioning of supply air
    - Humidity
    - Temperature
    - Pressure
  - Flow can be metered with a sonic choke to deliver a constant mass flow rate of air
    - Mass flow rate will be fixed for choked flow
    - Choked flow for positive pressure conditions can be achieved by maintaining a constant inlet pressure and certain range of backpressures
    - Required parts / instrumentation:
      - » Sonic choke
      - » Precision air pressure regulator (moderate to high flow)
      - » Pressure gauge (0-200 psig) and transducer to measure and record sonic choke inlet pressure
      - » Solenoid valve to remotely operate the compressed air supply
      - » Type-K thermocouple for inlet air temperature



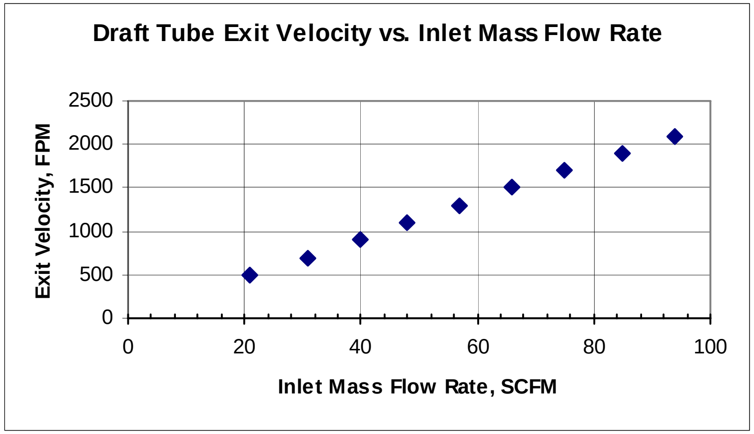
www.foxvalve.com



Sonic Nozzle Calibration

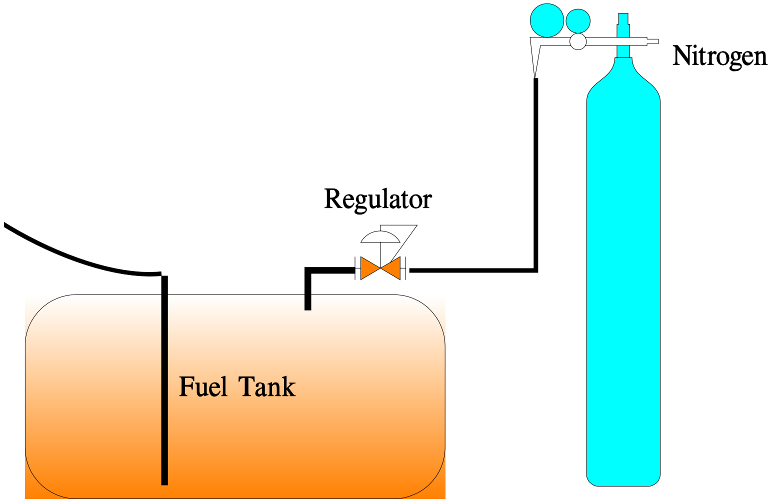


- Theoretical calibration checked with Sierra Instruments, Inc. vortex-shedding mass flow meter
- Exit velocity measured with vane anemometer inserted into the flow at the end of draft tube
- FAA burner exit velocity = 1300 fpm



Replacement of Electric Motor

- **Task 2: To supply the fuel rail / nozzle with fuel (JP-8) at an adjustable pressure**
- **Solution: Construct a pressurized fuel tank**
  - Fill partially with JP-8
  - Pressurize the headspace with compressed N_2 from gas bottle with pressure regulator
  - Required parts / instrumentation:
    - Pressure vessel
    - Pressure gauge and transducer to monitor fuel pressure
    - Bleed valve to reduce pressure
    - Compressed nitrogen and bottle regulator
    - Liquid level sight gauge to monitor fuel level
    - Solenoid valves for remote operation of fuel flow and fuel tank pressurization

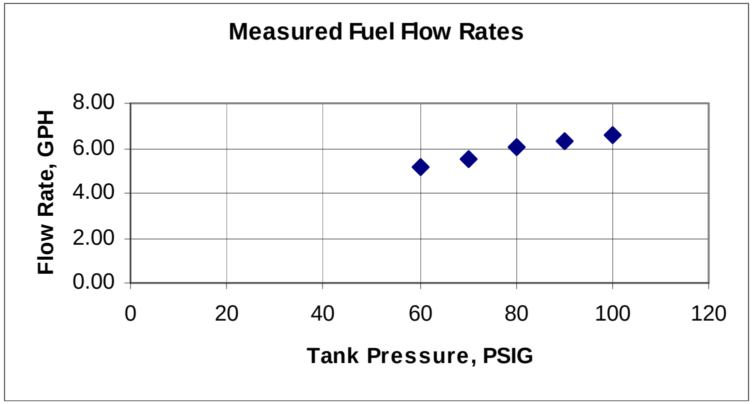


Pressurized Fuel Delivery System: Description

- **Constructed fuel tank out of an old Halon bottle**
  - Welded fittings on top and bottom
  - Mounted upright on stand with front panel for fuel level and tank pressure gauges
  - Solenoid valves and control box for remote operation
  - Coated inner surfaces with fuel tank liner

Pressurized Fuel Delivery System: Performance

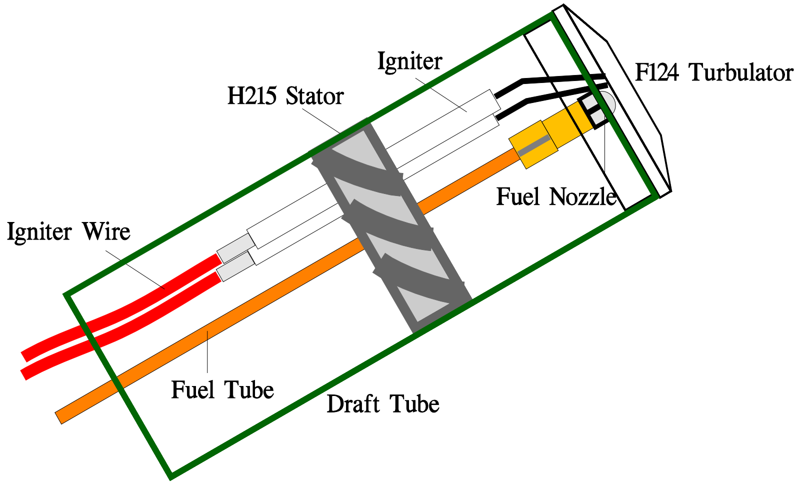
- **Performed fuel flow rate measurements with graduated cylinder and stopwatch**
- **Used a Monarch 6.5 GPH 80° PL type nozzle**
- **Measured fuel flow rates for a range of fuel tank pressures**



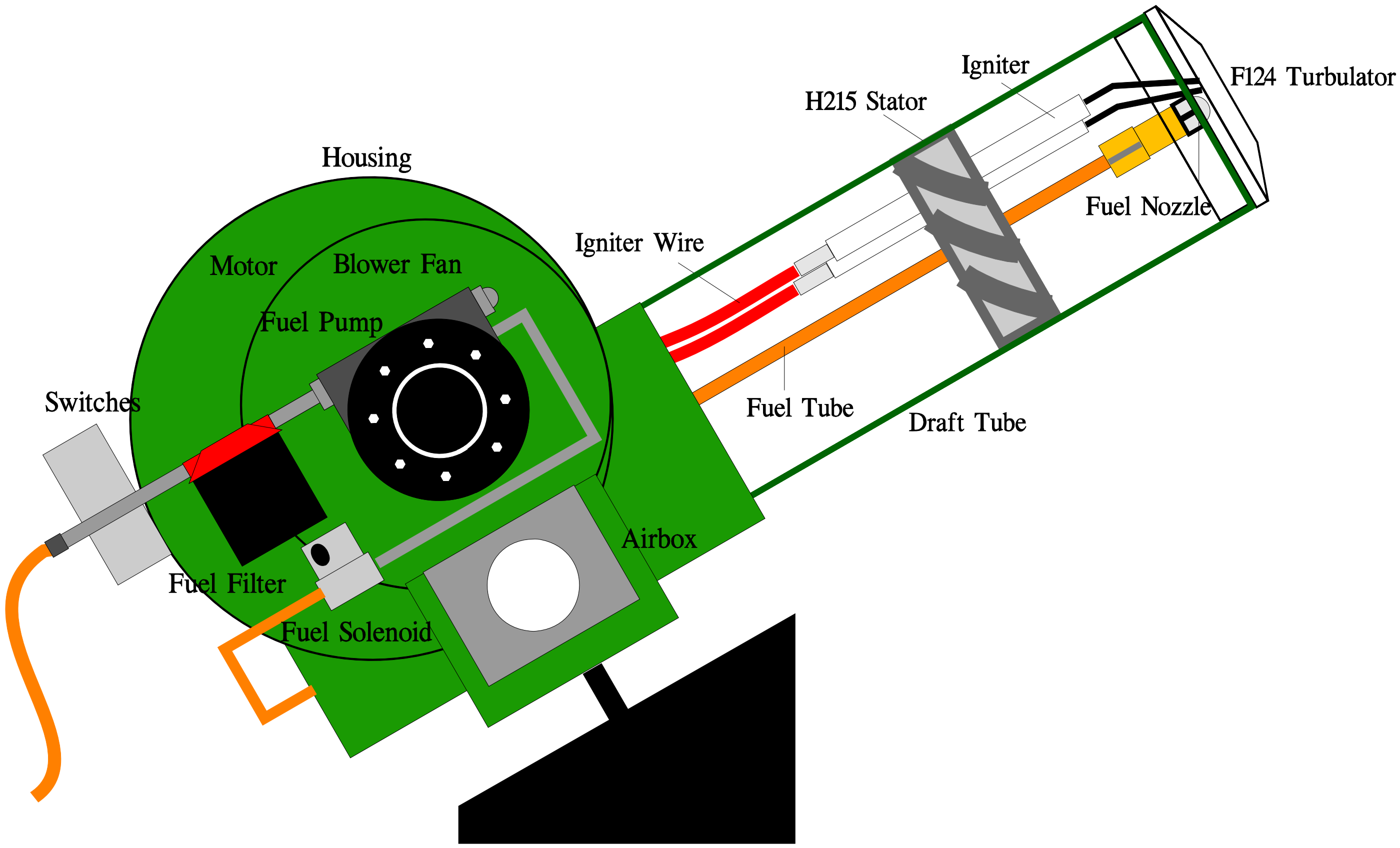
MEASURED FLOW RATE - PRESSURE RELATIONS	
FUEL TANK PRESSURE	FUEL FLOW RATE
PSIG	GPH
60	5.14
70	5.55
80	6.01
90	6.28
100	6.60

Draft Tube / Ignition

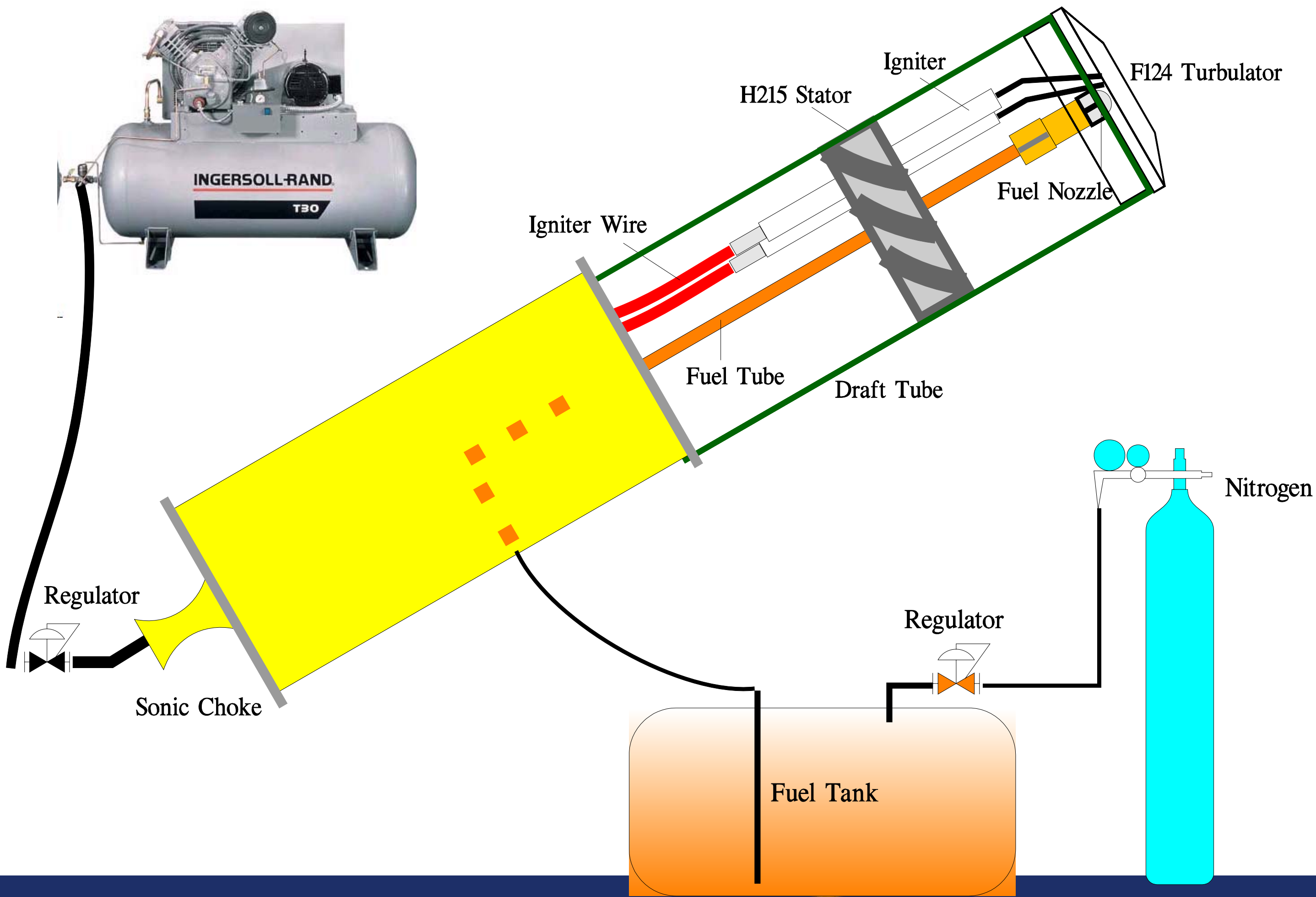
- **Plan to reconstruct a draft tube to similar specifications of original draft tube**
  - Construct out of 4.25” O.D. , 4” ±0.01” steel tubing (mild seam)
  - This size tubing will fit the stator / ignitor assembly from the original burners
    - Use same ignition source
    - Use same end cap (turbulator) as original burner
    - Use cone specified in rule



Current Test Apparatus

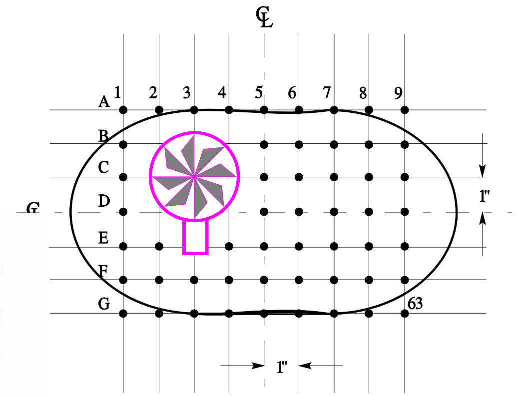


Proposed Replacement Apparatus

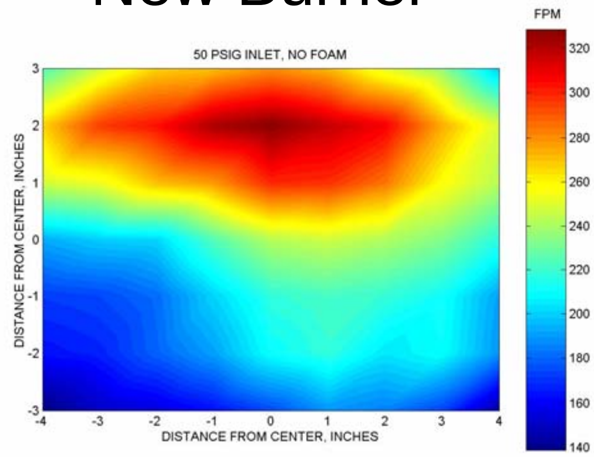


Alternative Burner Apparatus

Velocity Mapping

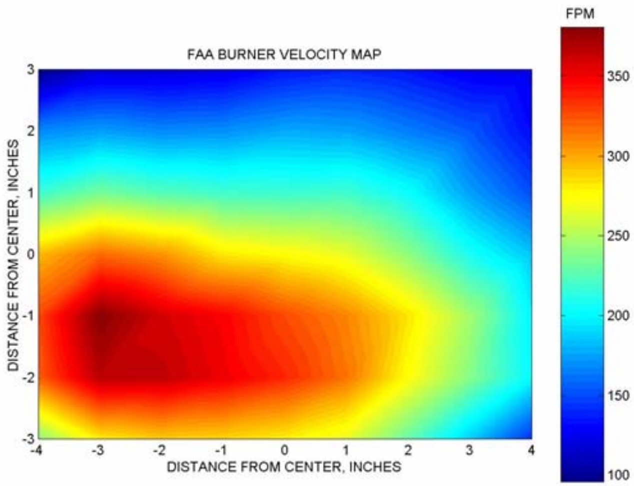


New Burner

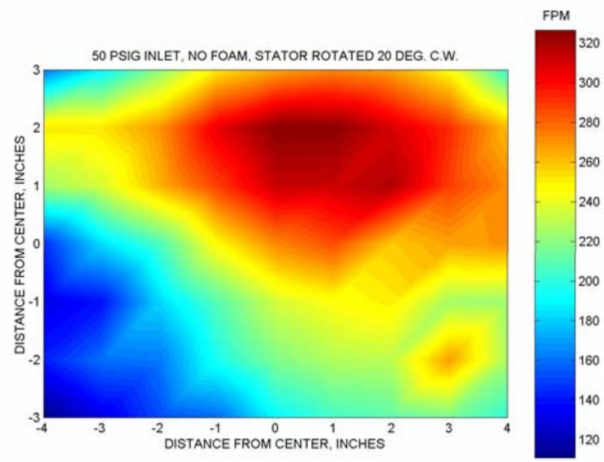


Average Velocity =
227 fpm

FAA Burner

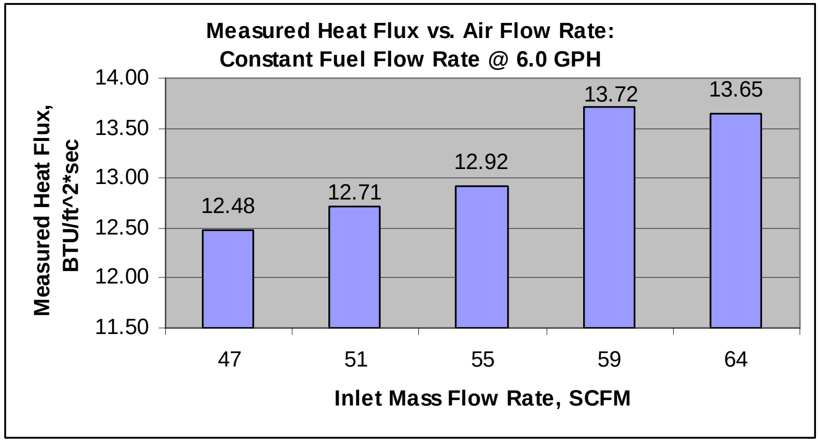


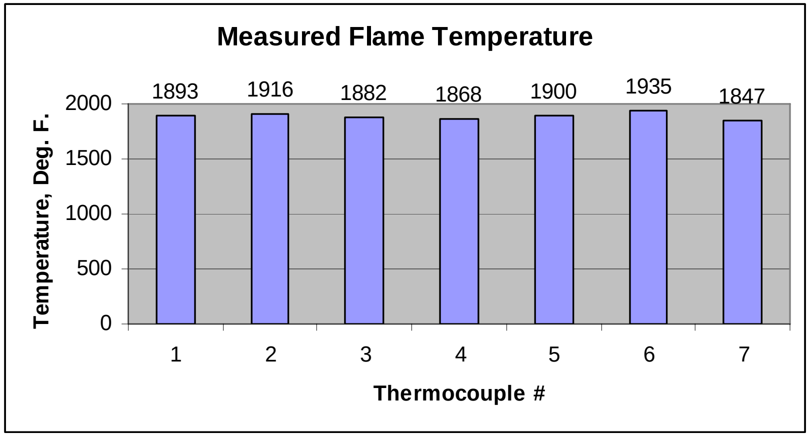
Average Velocity =
231 fpm

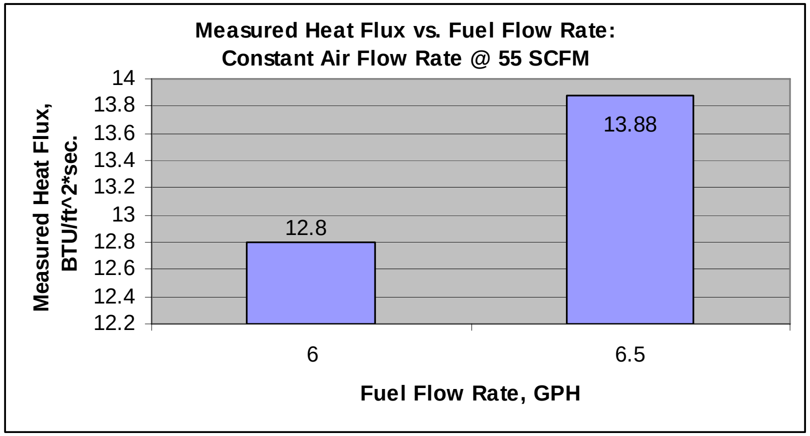


Average Velocity =
231 fpm

Initial Calibration – Heat Flux and Temperatures

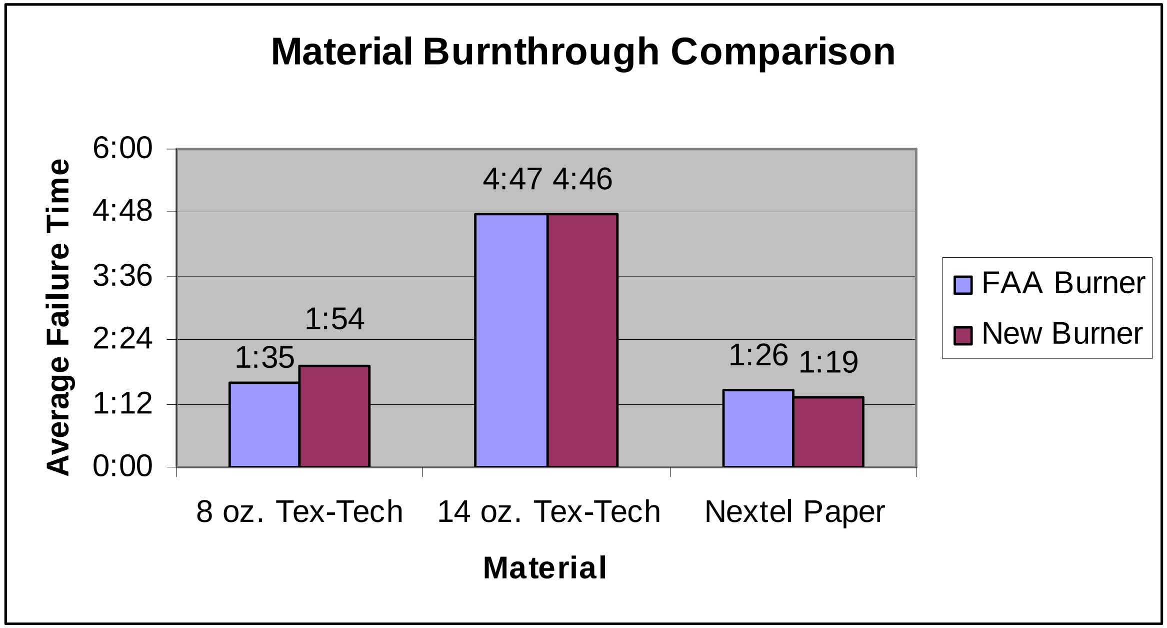






Initial Burnthrough Times

- **3 materials were chosen for comparing burner performance with FAA burner**
  - 8 oz. Tex-Tech (consistent burnthrough times)
  - 14 oz. Tex-Tech (consistent burnthrough times)
  - Nextel Paper (consistent backface heat flux failure times)



Plan

1. **Construct apparatus to similar specifications as original burner**
2. **Characterize output, compare with desired output from specifications**
3. **If output is not similar, determine variables in the apparatus and characterize the effect of the variables on burner performance**
   - Possible variables:
     - Draft tube / flow straighter length
     - Swirl / vorticity of flow
     - Symmetry of draft tube innards
     - etc.
   - Try to remove any ambiguities or uncertainties in this apparatus
     - Reduction of complexity results in simplification of operation and adjustability

Questions, Concerns, Comments, Input?