Burnthrough and NexGen Burner Update

Federal Aviation Administration

IAMFTWG

June 22-23, 2011 – Bremen, Germany

Robert I. Ochs, FAA Fire Safety Team AJP-6322

Genesis of the Next Generation Fire Test Burner

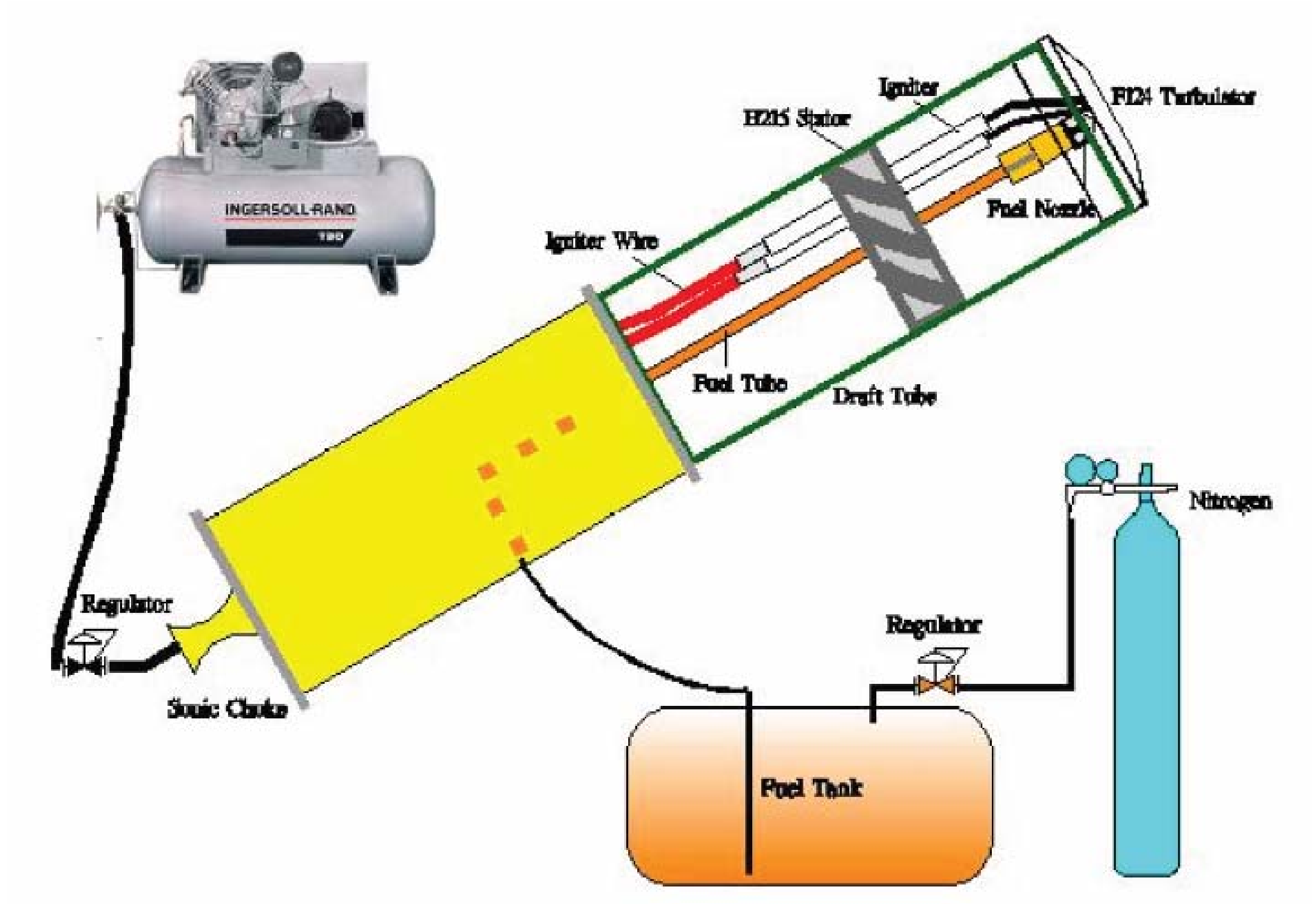
- **During development and implementation of the Thermal Acoustic Insulation Burnthrough Rule, it was discovered that the Park DPL 3400 was no longer in production**
- **Options**
  - Find another commercial off the shelf oil burner
  - Develop a new burner that will not suffer the same fate

Objectives

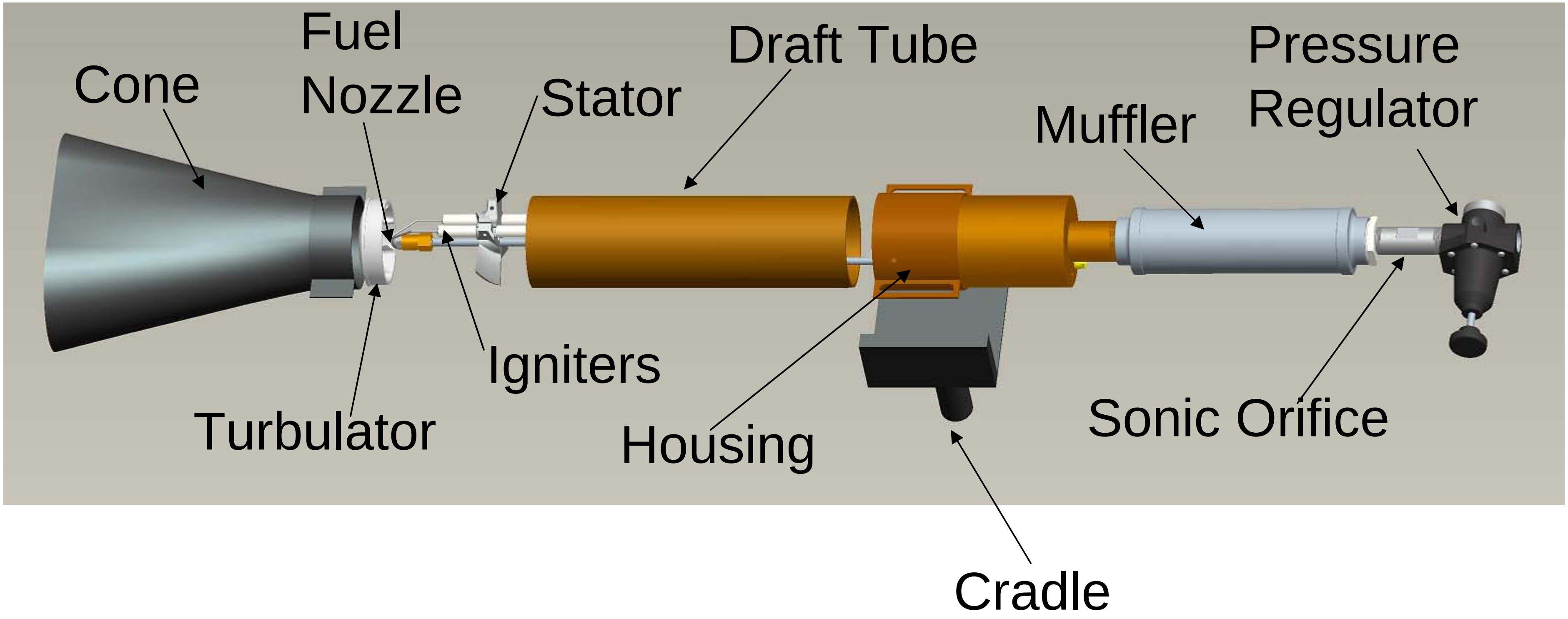
- **Design a fire test burner that can be constructed in-house with easily obtainable components**
  - Simple design
  - Simple operation
  - Simple maintenance
- **Burner output must be comparable to the Park DPL 3400**
- **Burner should achieve a higher level of repeatability and reproducibility**
- **Burner should be versatile and easily adaptable to any of the fire tests calling for a “modified gun-type burner”**

Initial Concept

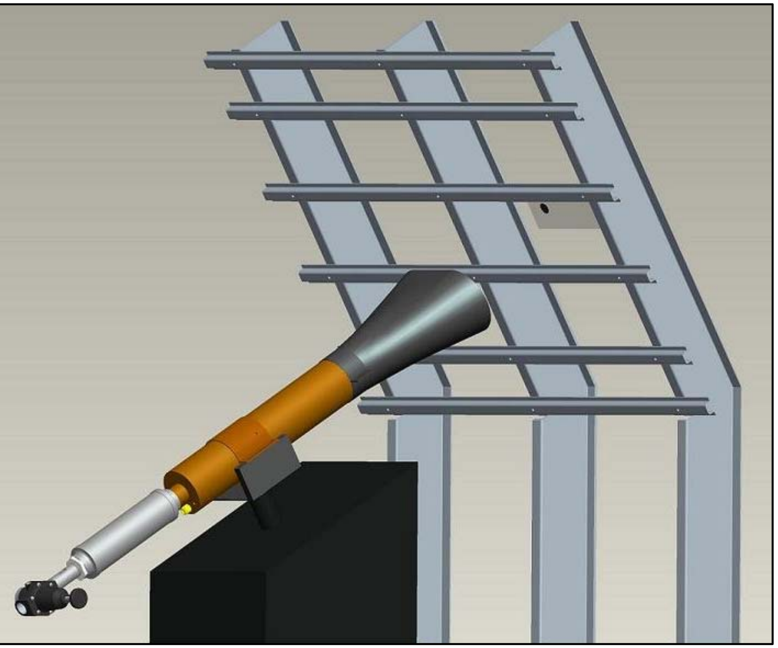
- Compressed air metered with a sonic nozzle
- Fuel provided by a pressurized fuel tank
- Utilize original Park DPL 3400 components



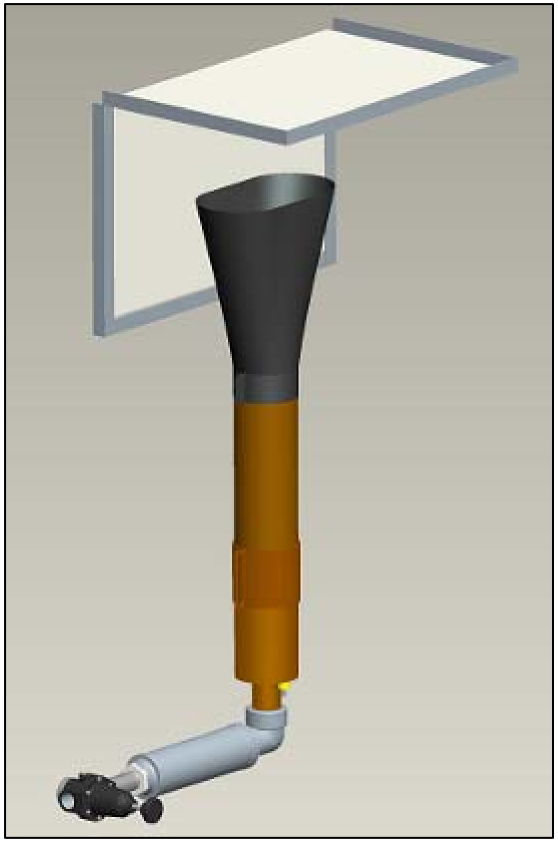
NexGen Burner Design



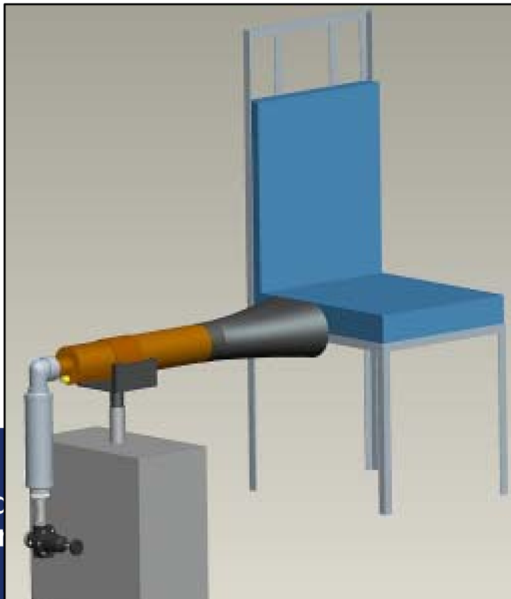
Thermal/Acoustic Insulation Burnthrough



Cargo Liner Burnthrough

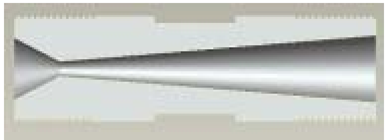


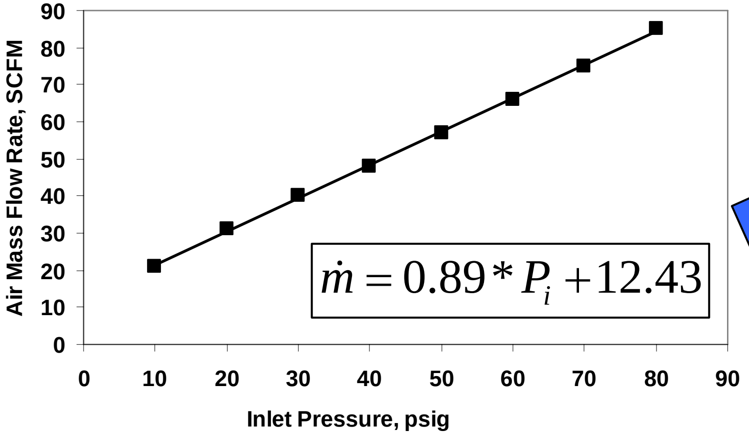
Seat Cushion Flammability



Burner Control

Air Flow



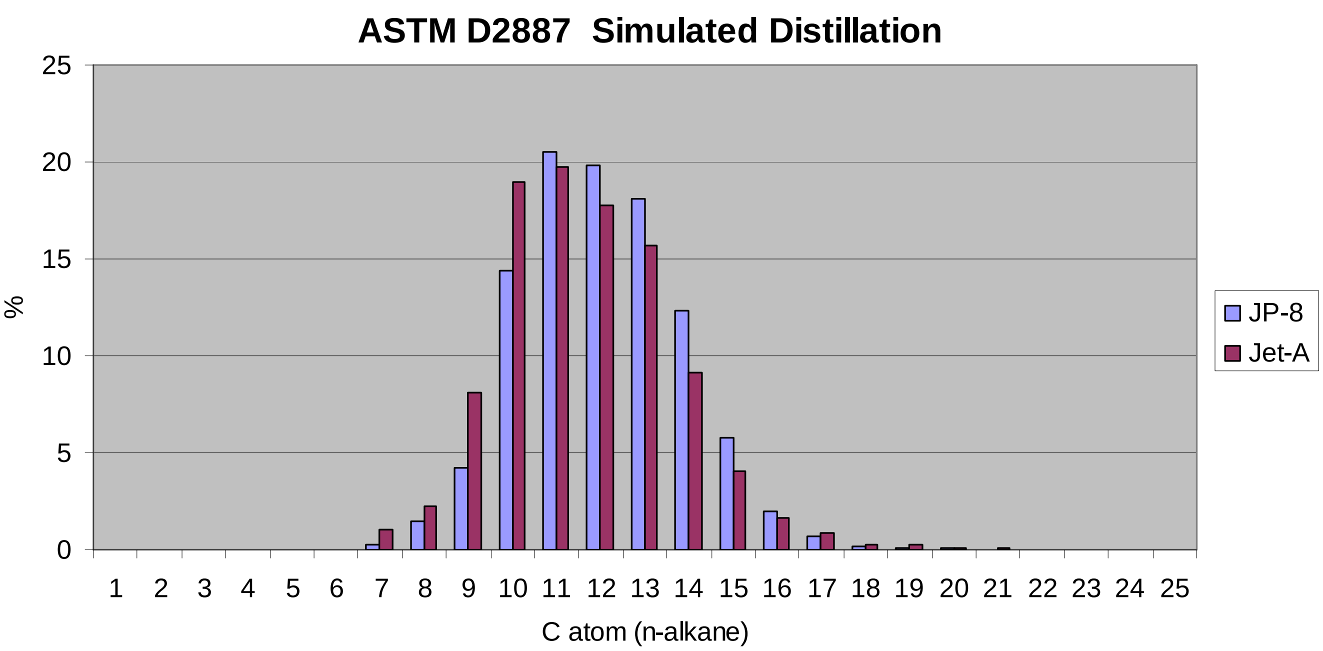


Fuel Flow

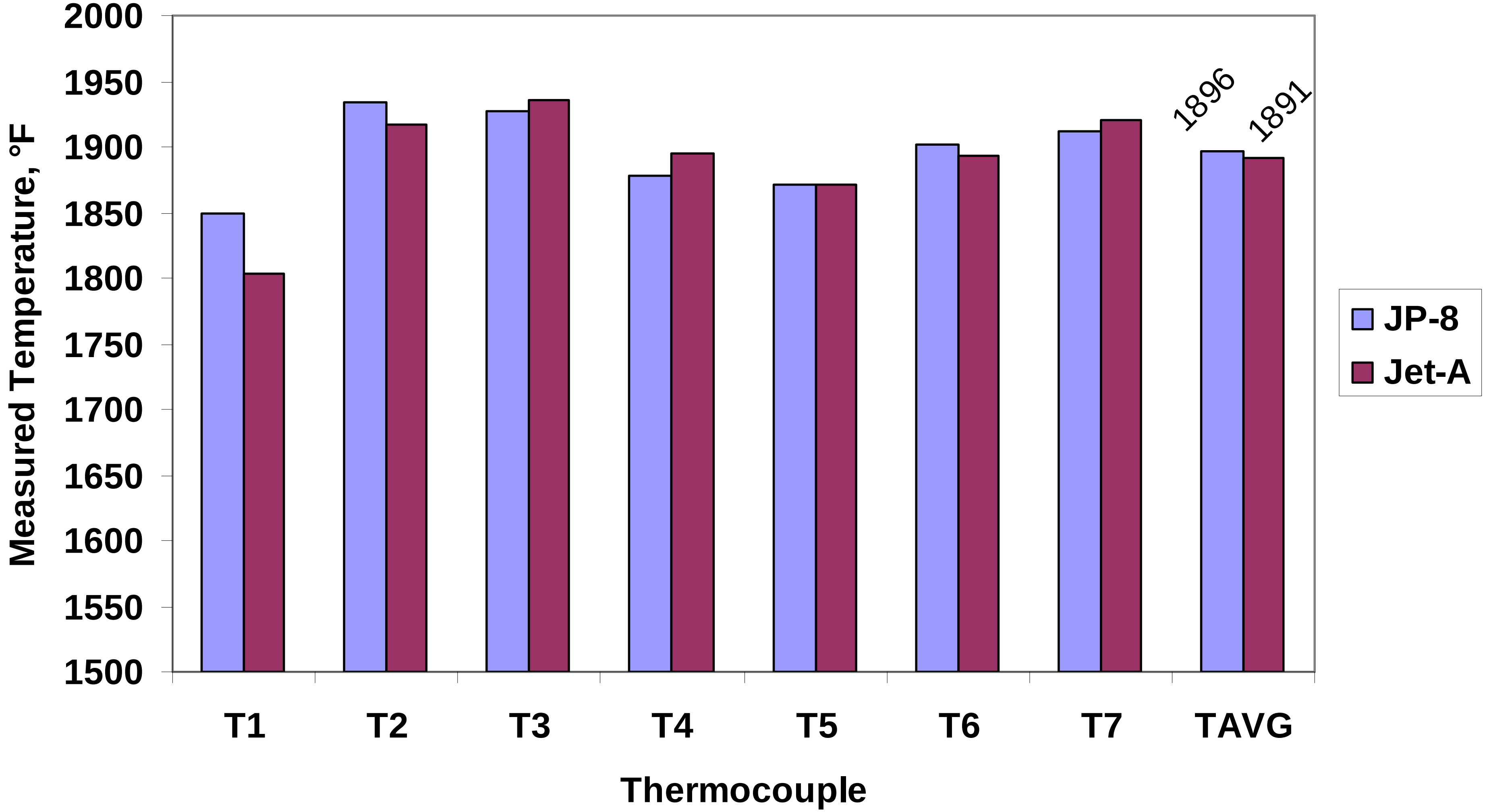
Regulated and conditioned air and fuel to burner

Jet Fuel Comparison

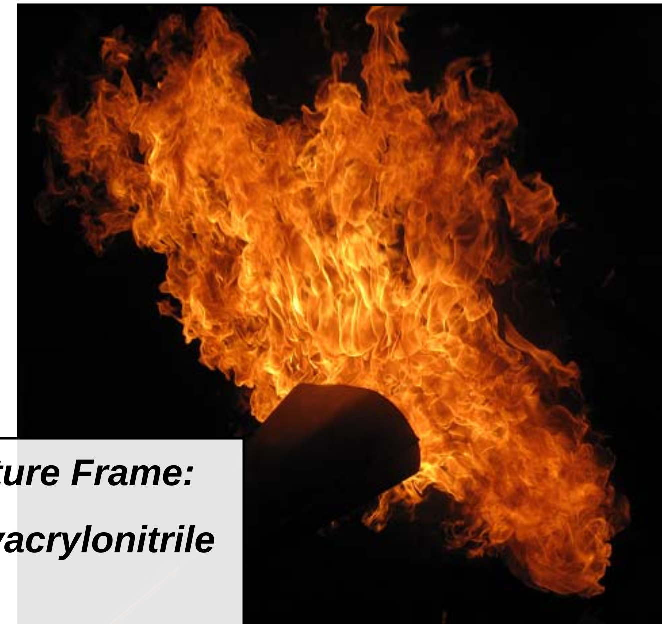
- **FAATC fuel is supplied by NJANG, JP-8 military specification jet fuel**
- **A barrel of Jet-A was purchased from AC Int'l Airport for comparison**
- **Fuel Flashpoint was measured according to ASTM D65 Tag Closed Cup Tester**
  - JP8: 128°F
  - Jet A: 126°F



JP-8 vs. Jet-A: Flame Temperature



120 psig fuel pressure, both nozzles flowed exactly 385 mL/min=6.1gph

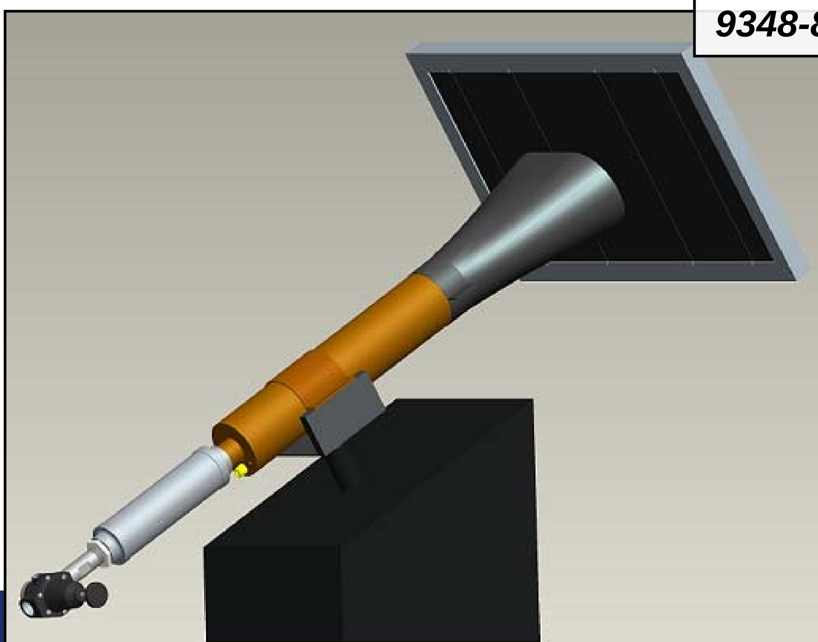


Materials Tested on Picture Frame:

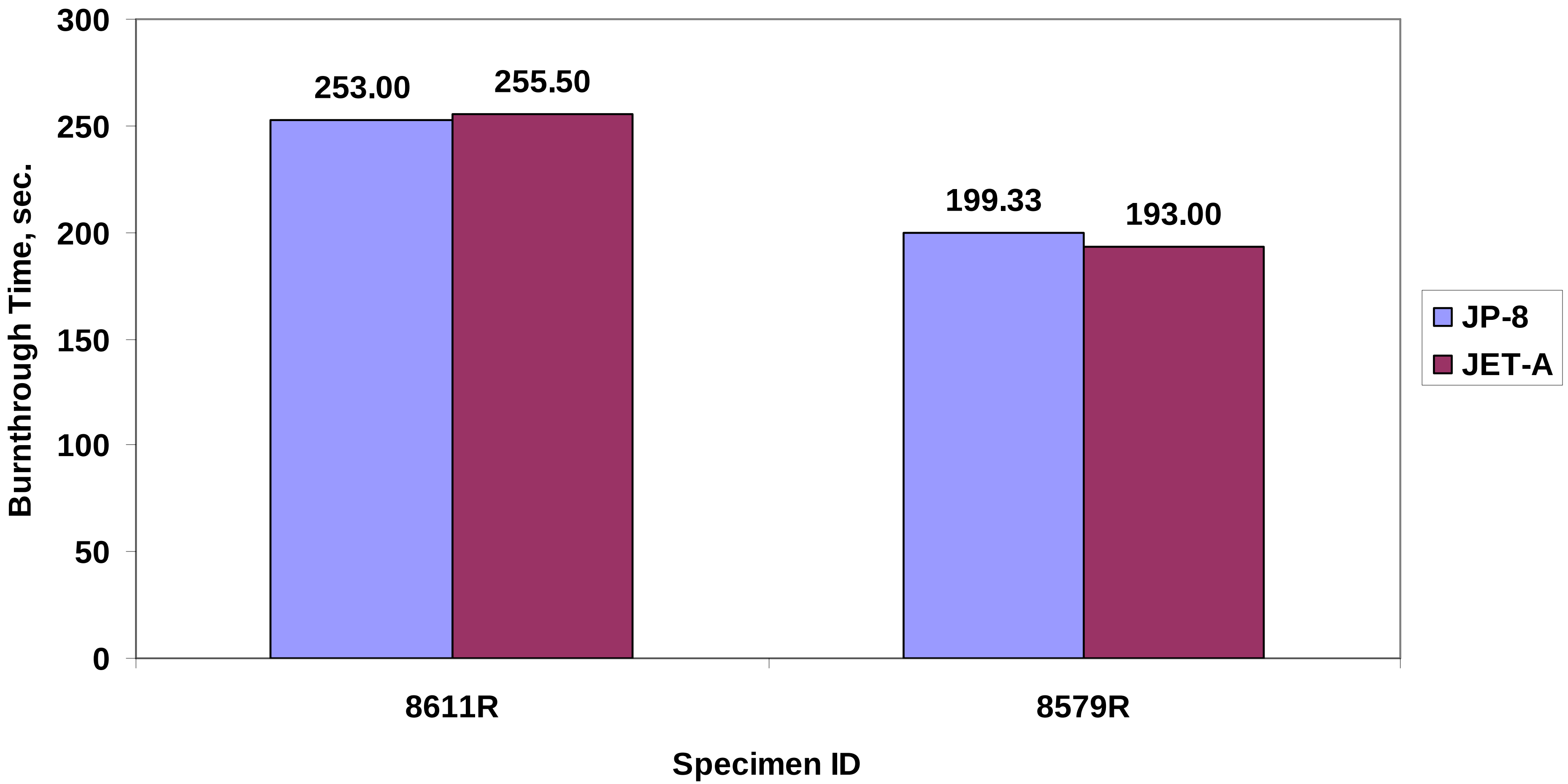
TexTech Industries Polyacrylonitrile

19186-8579R: 9 oz/yd^2

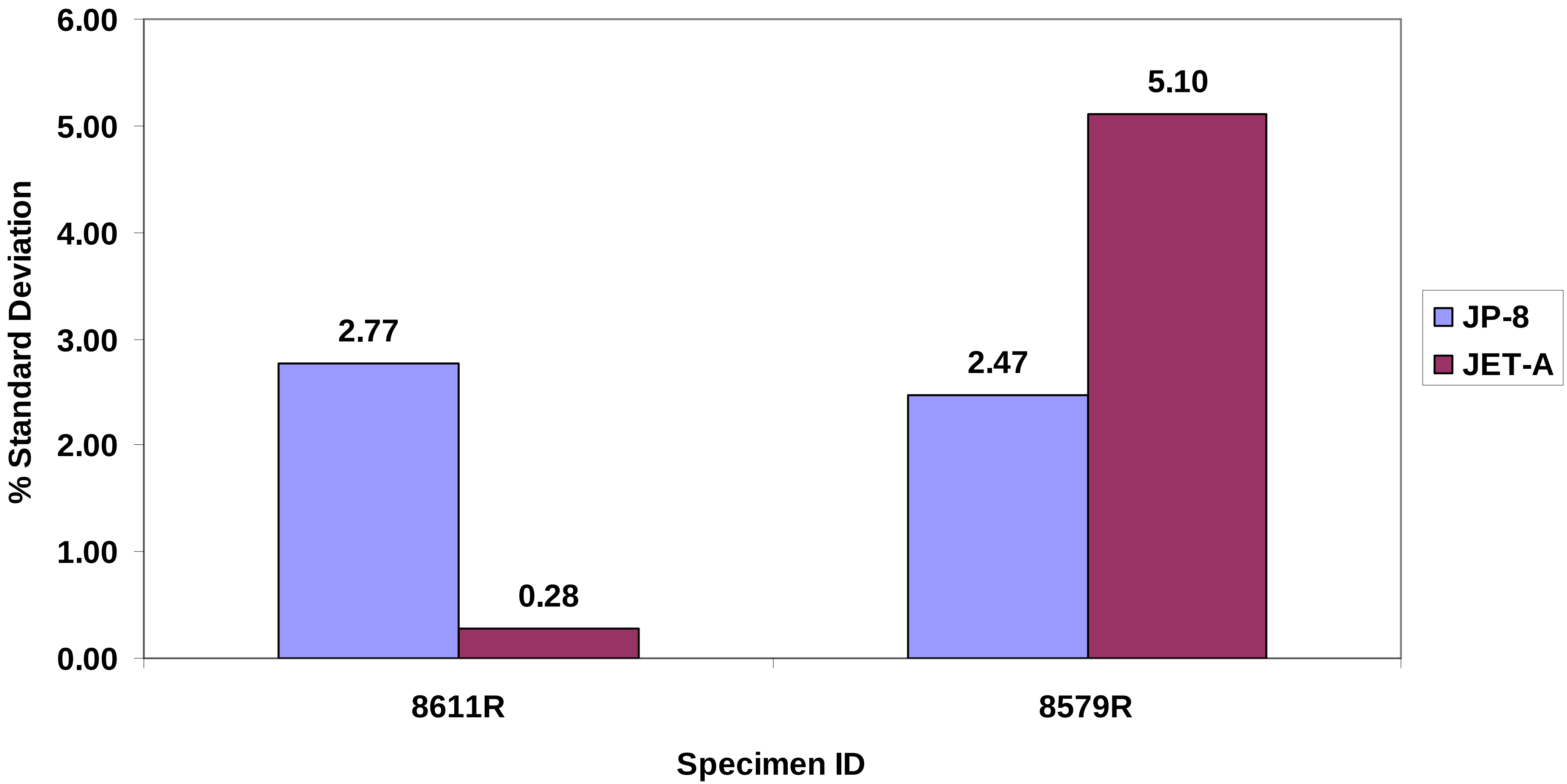
9348-8611R: 16 oz/yd^2



JP-8 vs. Jet-A: Average Burnthrough



JP-8 vs. Jet-A: Repeatability

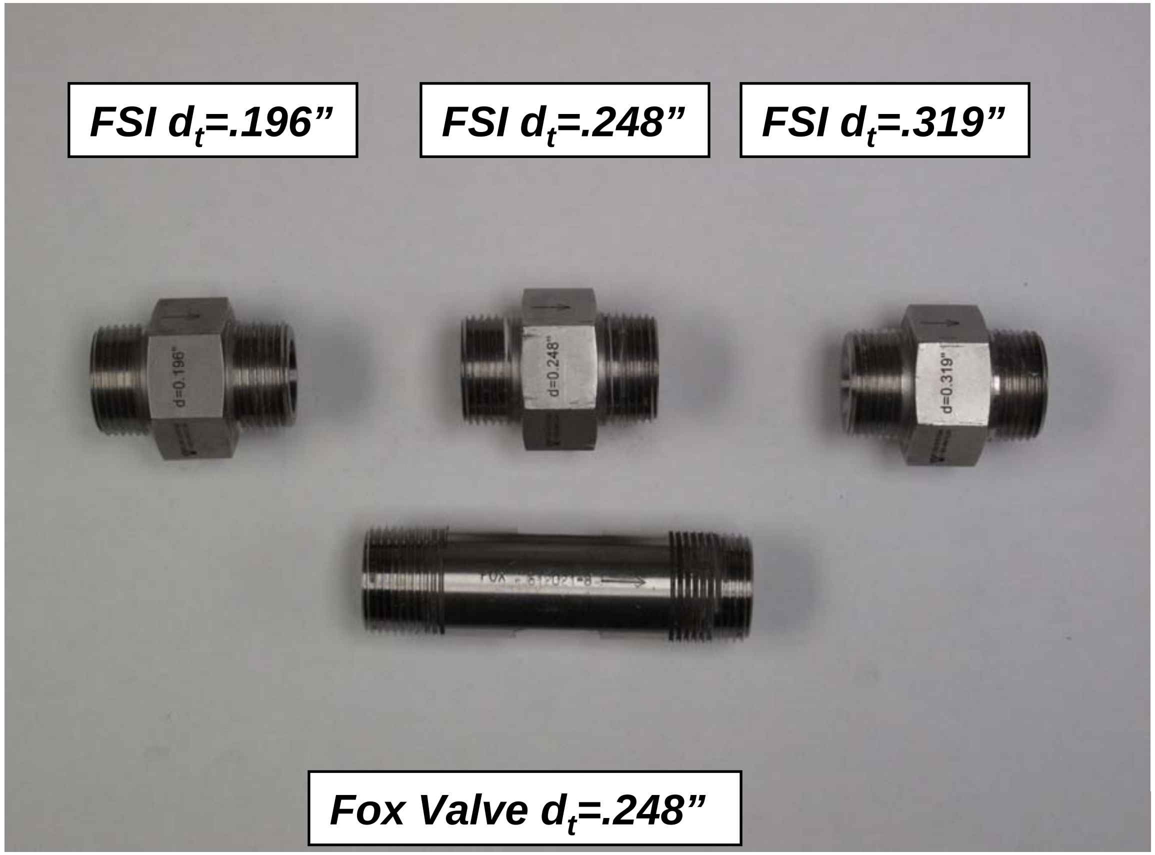


JP-8 vs. Jet-A: Summary

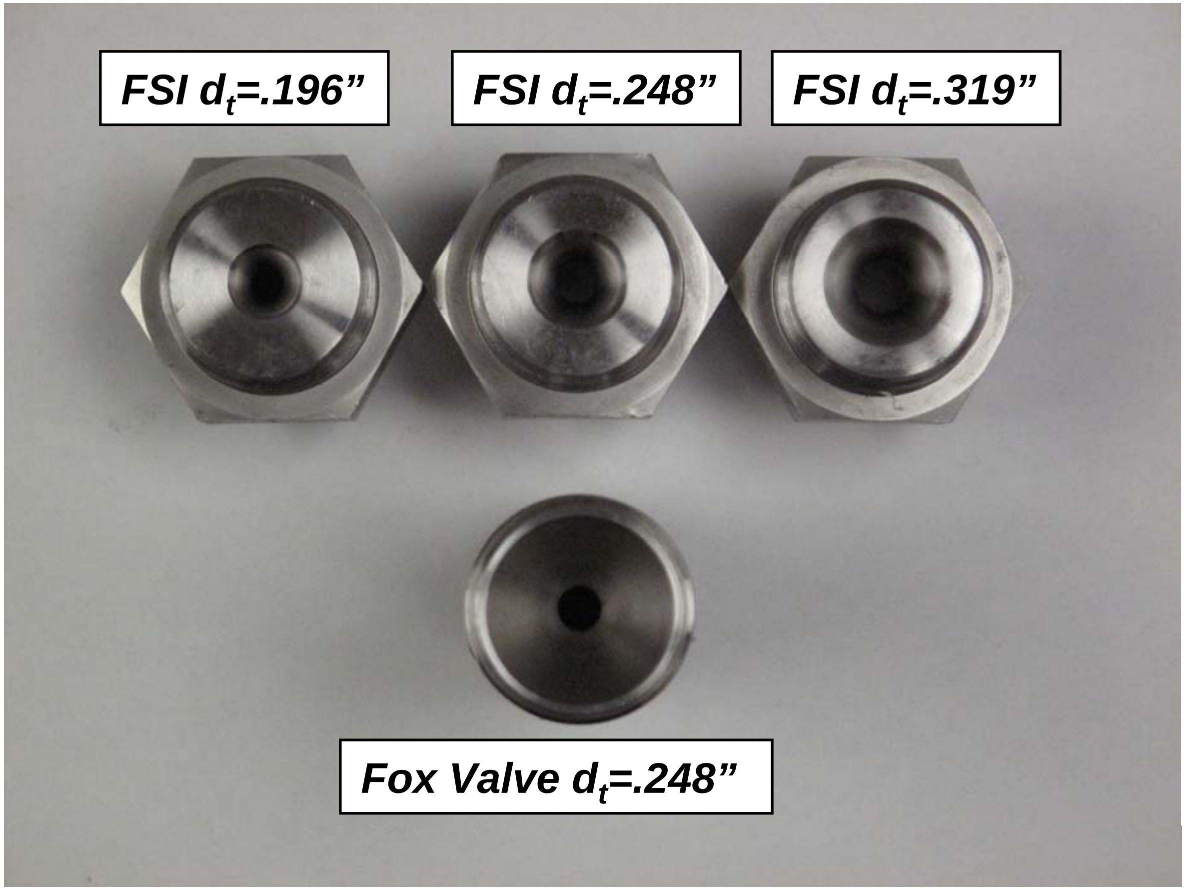
- **Comparative flame temperature measurements and picture-frame burnthrough tests were performed on the NexGen burner**
- **Both fuels had the exact same flow rate when measuring 120 psig, 40°F at the back of the burner**
- **Both fuels had a measured average flame temperature of ~1895°F with very similar flame temperature profiles**
- **Both fuels had very similar burnthrough times for the PAN material on the picture frame blanket holder**
- **For burnthrough testing, these two fuels can be considered equivalent for testing purposes**
- **Further work needs to be done with other fuel types (kerosene, etc) and with significantly different flash points (105°F vs. 140°F)**

What’s New?

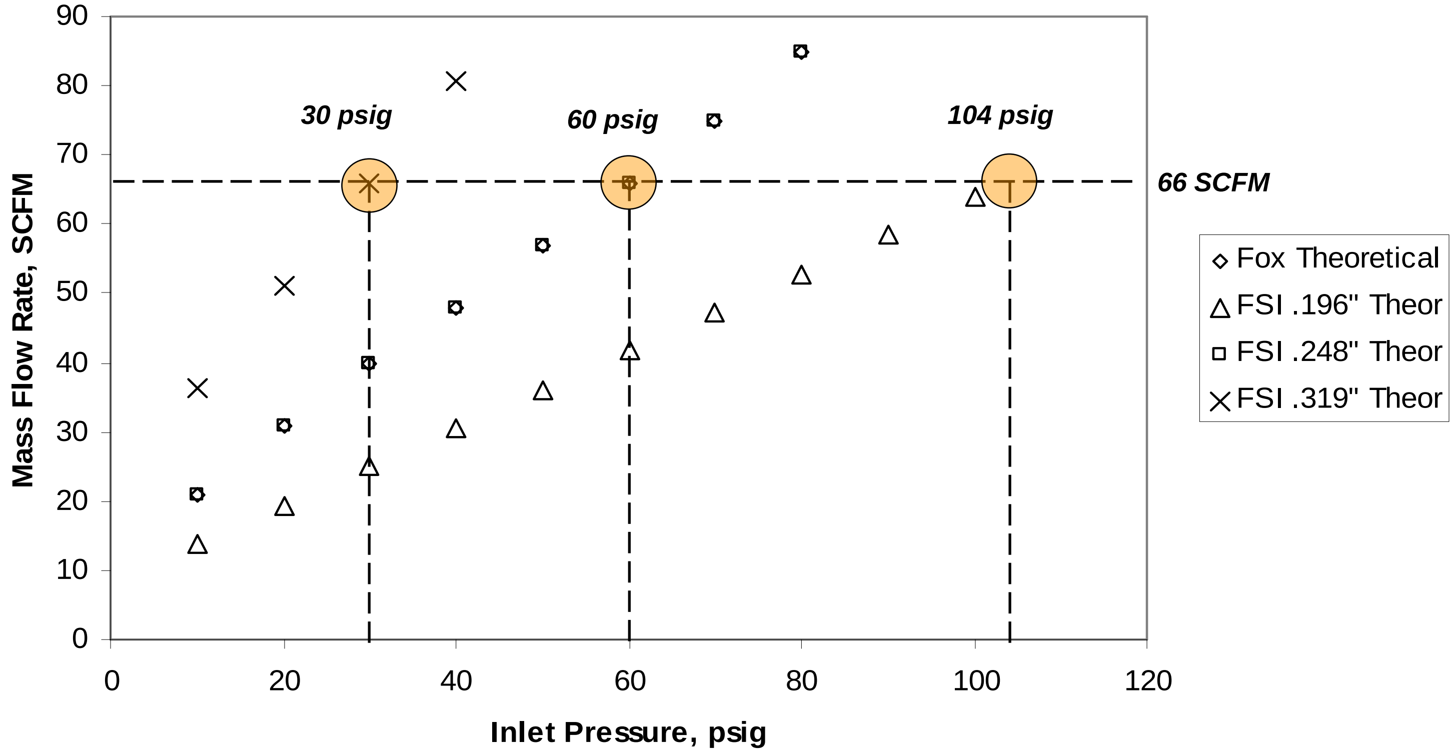
New Sonic Chokes



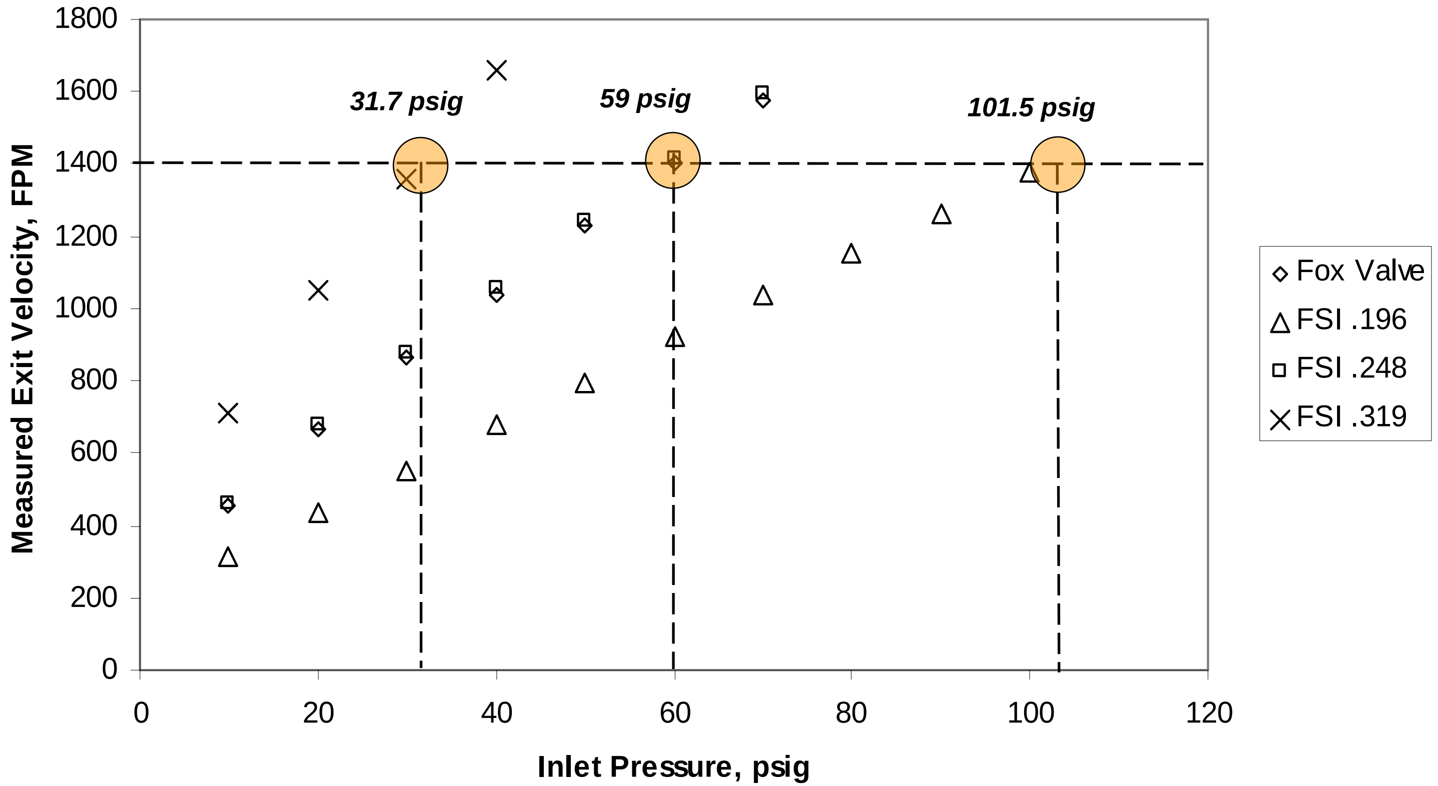
New Sonic Chokes



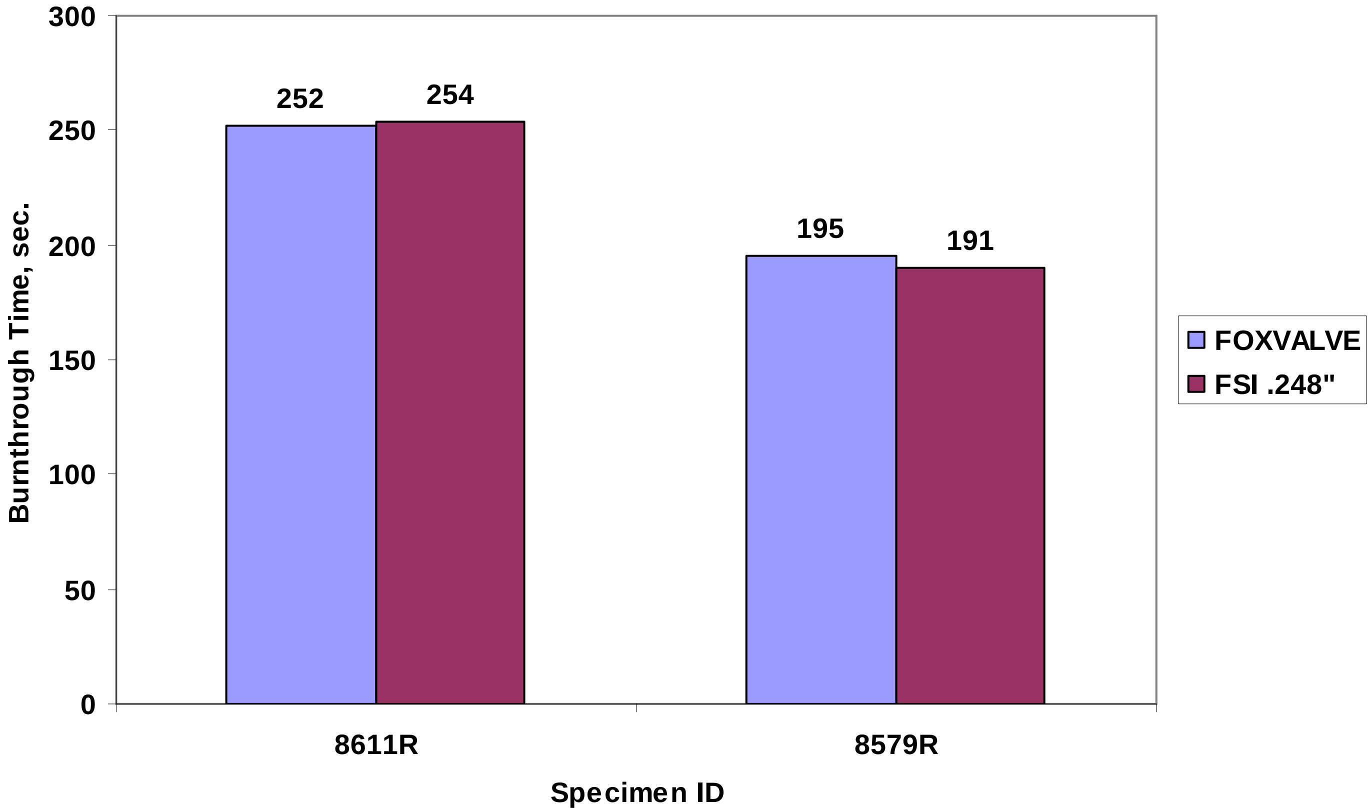
Theoretical Mass Flow Rates



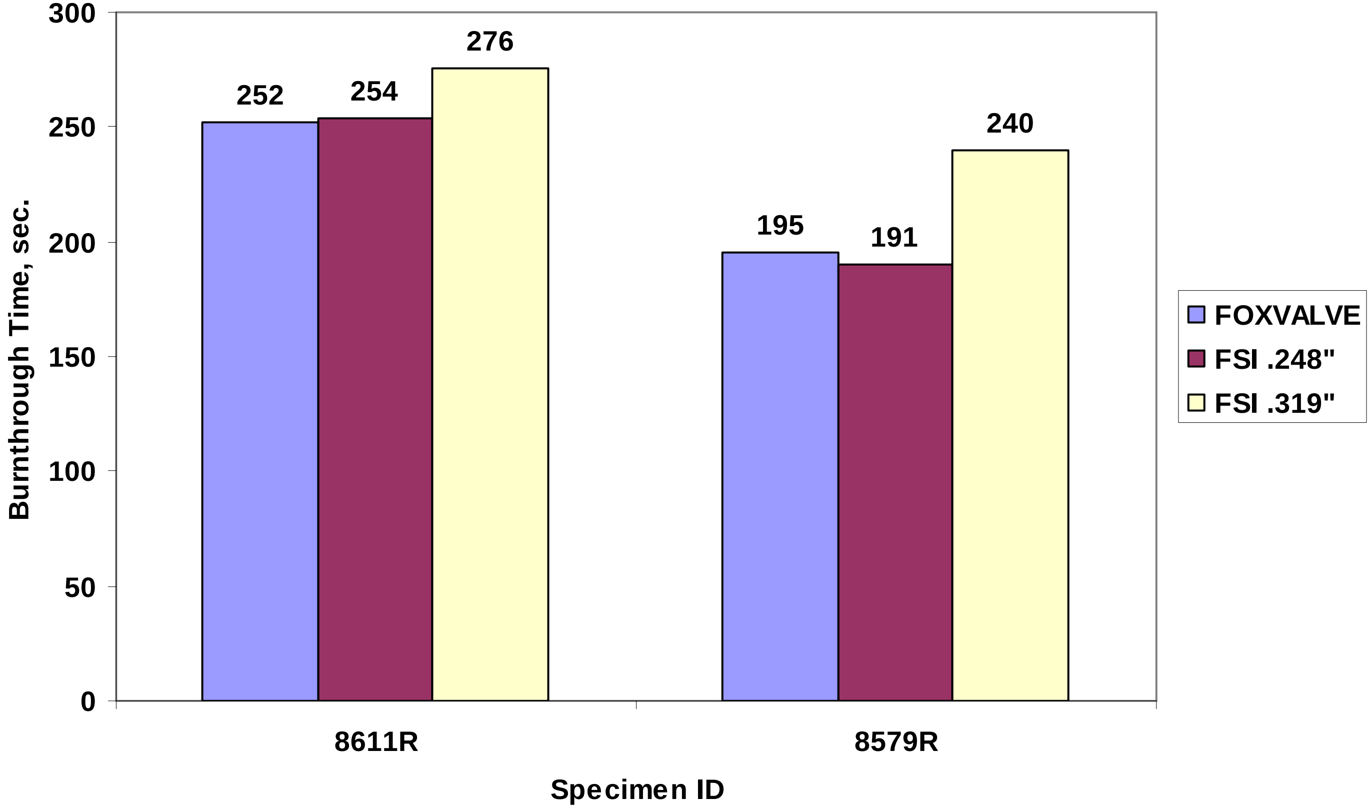
Measured Exit Velocity



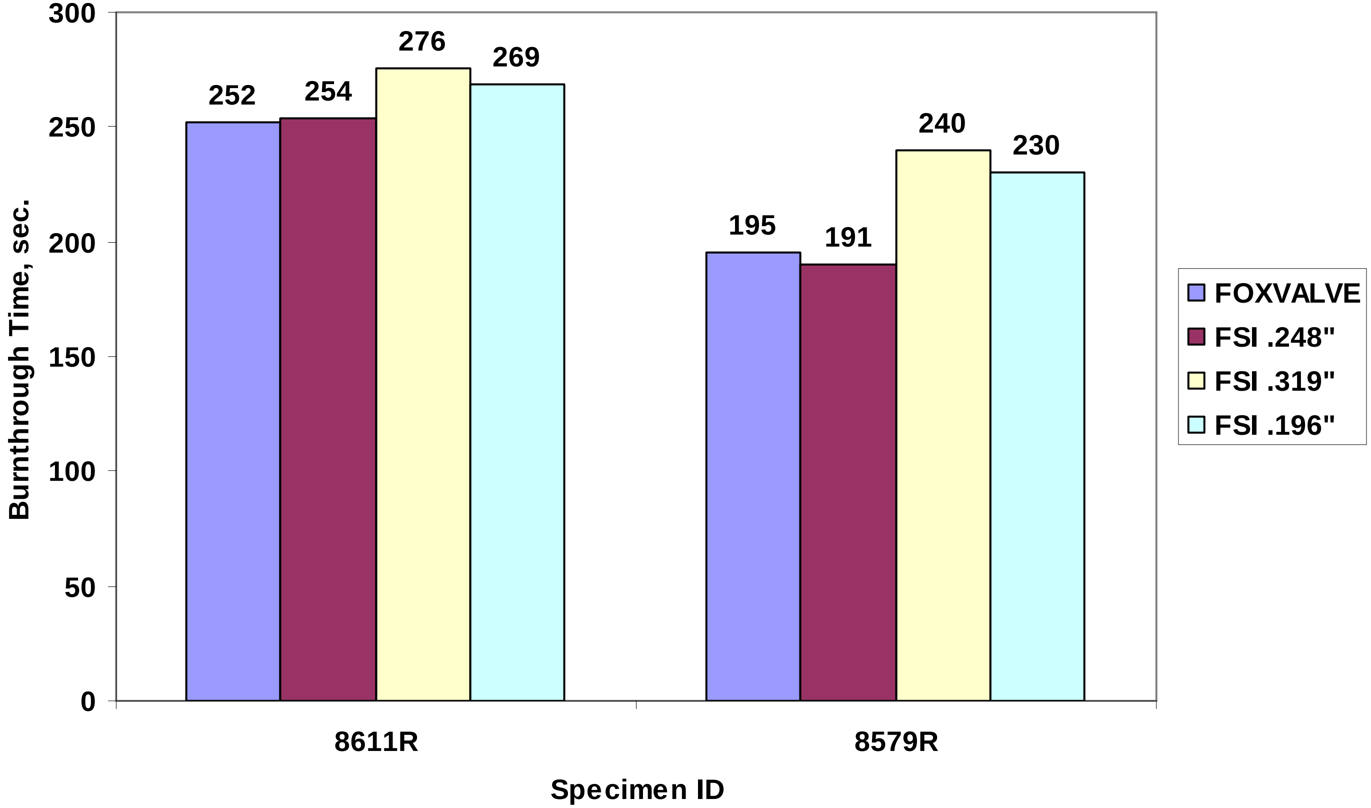
Fox Valve vs. FSI @ 60psig – Picture Frame



FSI .319”@ 30 psig

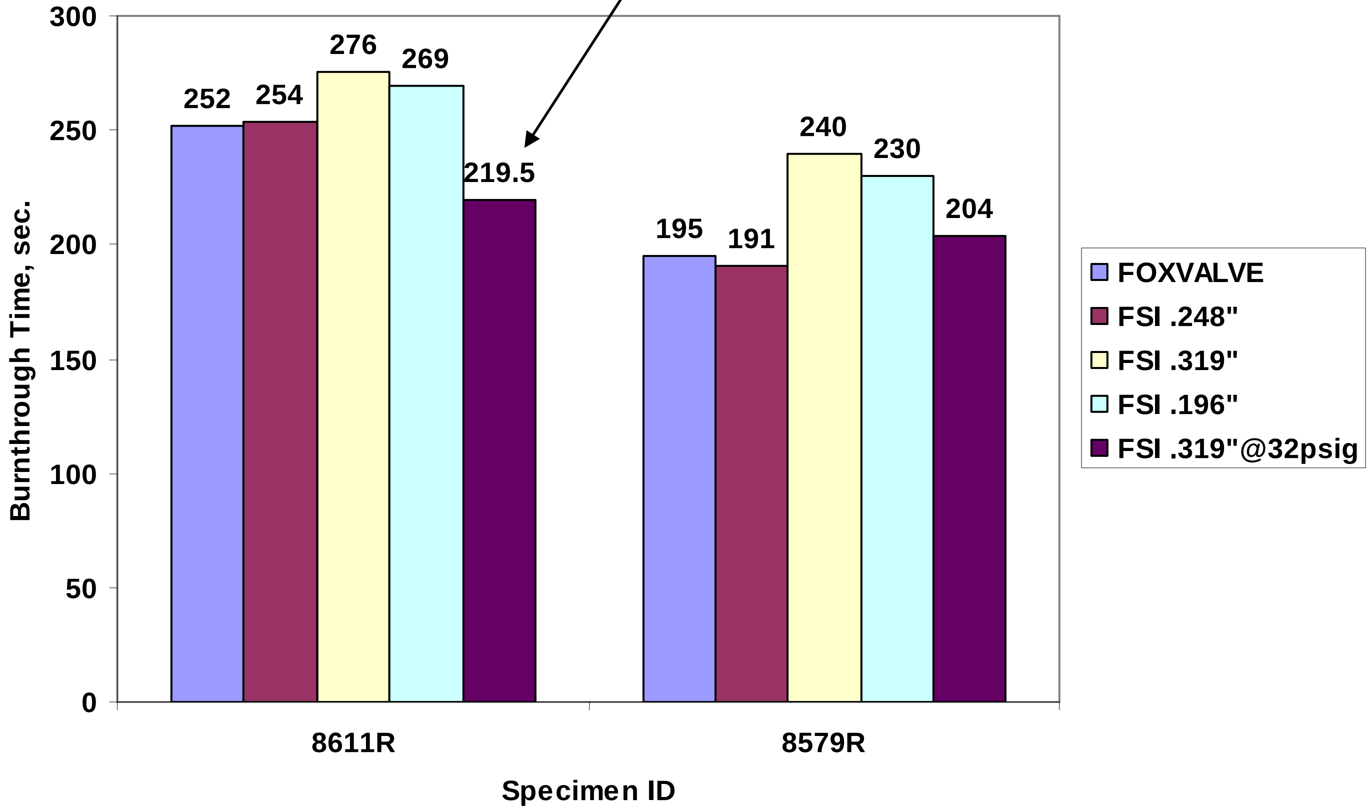


FSI .196” @ 96 psig



FSI .319" @ 32 psig

Note: The 8611 roll that was run for previous tests was depleted; a different, older roll of 8611 was used for the last test series

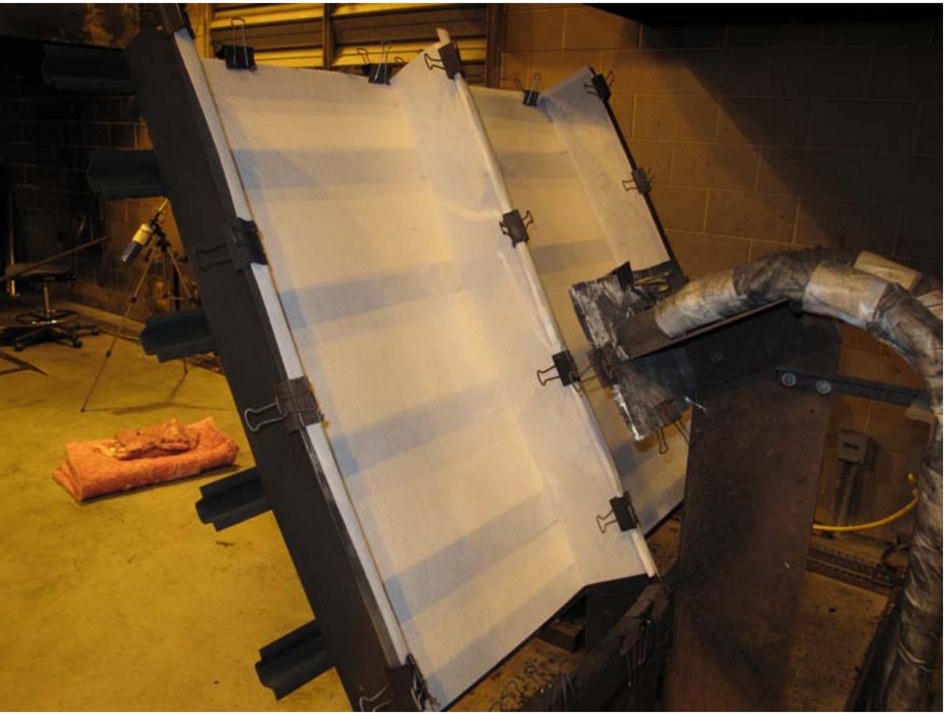


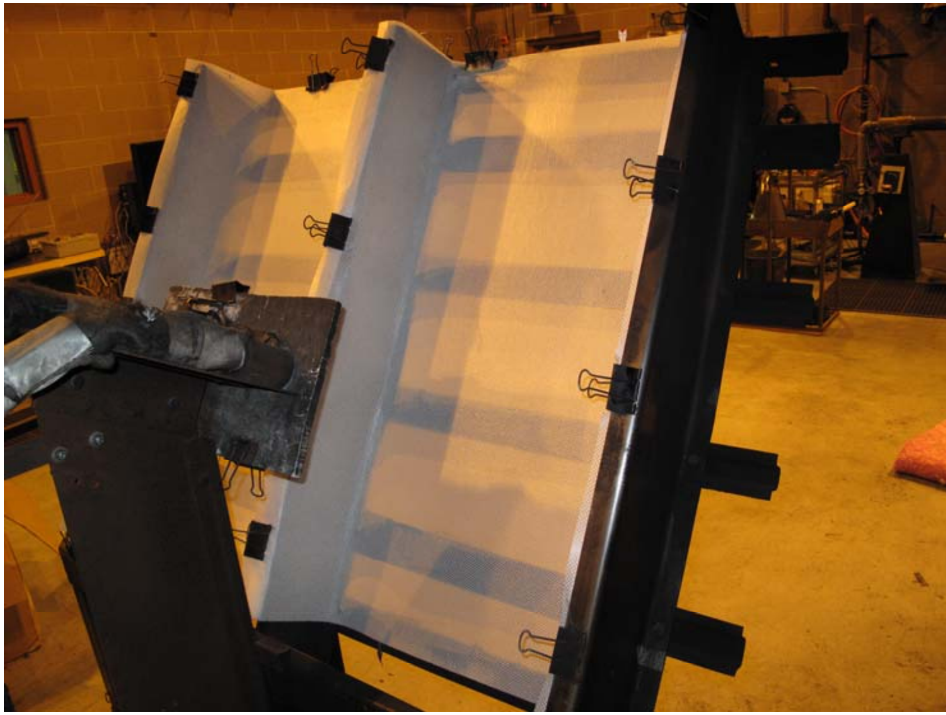
Results

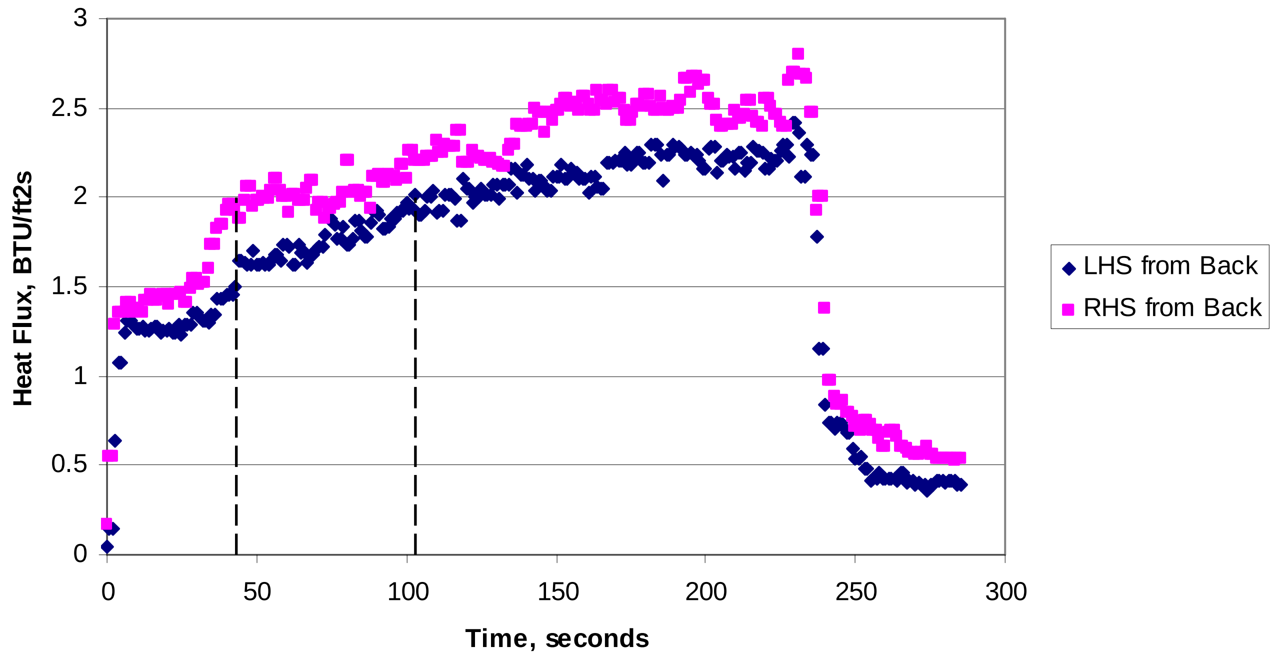
- **Sonic chokes from different manufacturers with the same throat diameter at the same inlet pressure produce similar BT results**
- **Sonic chokes with different throat diameters with inlet pressures corresponding to the same mass flow rate provide different BT results**
- **More work needs to be done to determine sensitivity of BT to mass flow rate / exit velocity**

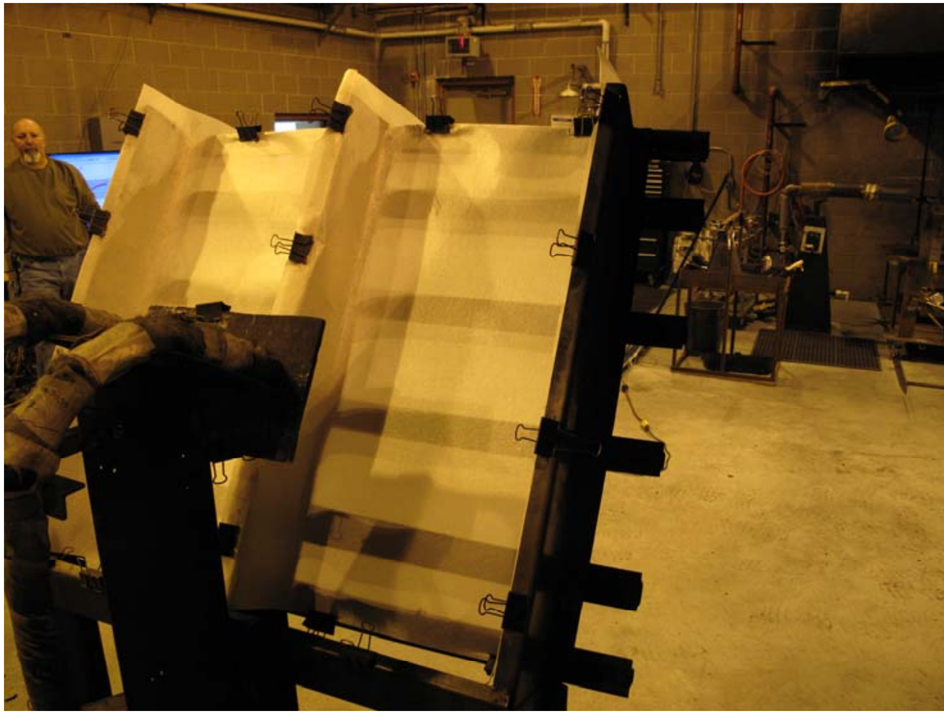
Backside Heat Flux

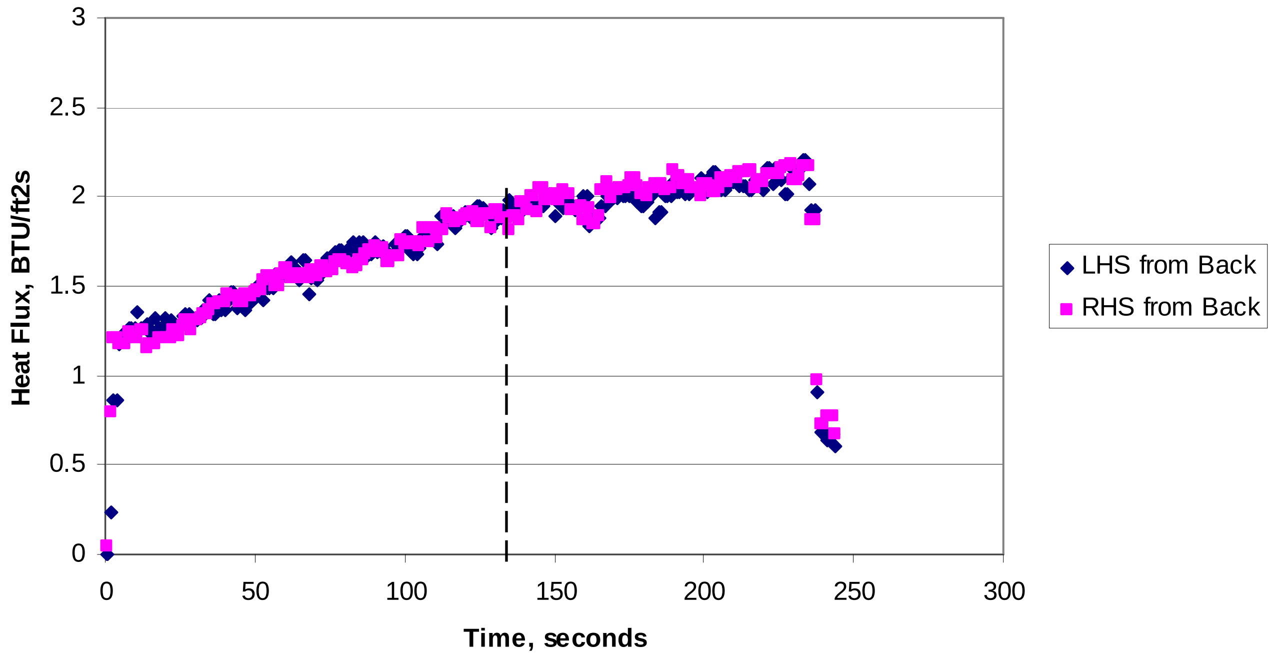
- Investigating the effect of securing the samples to the test rig
- Premature heat flux failures are suspected to occur if the material "balloons" or is pushed back towards the calorimeters






Heat Flux, BTU/ft2s
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
Time, seconds
LHS from Back
RHS from Back




3
2.5
2
1.5
1
0.5
0
Heat Flux, BTU/ft2s
0
50
100
150
200
250
300
Time, seconds
LHS from Back
RHS from Back

Results

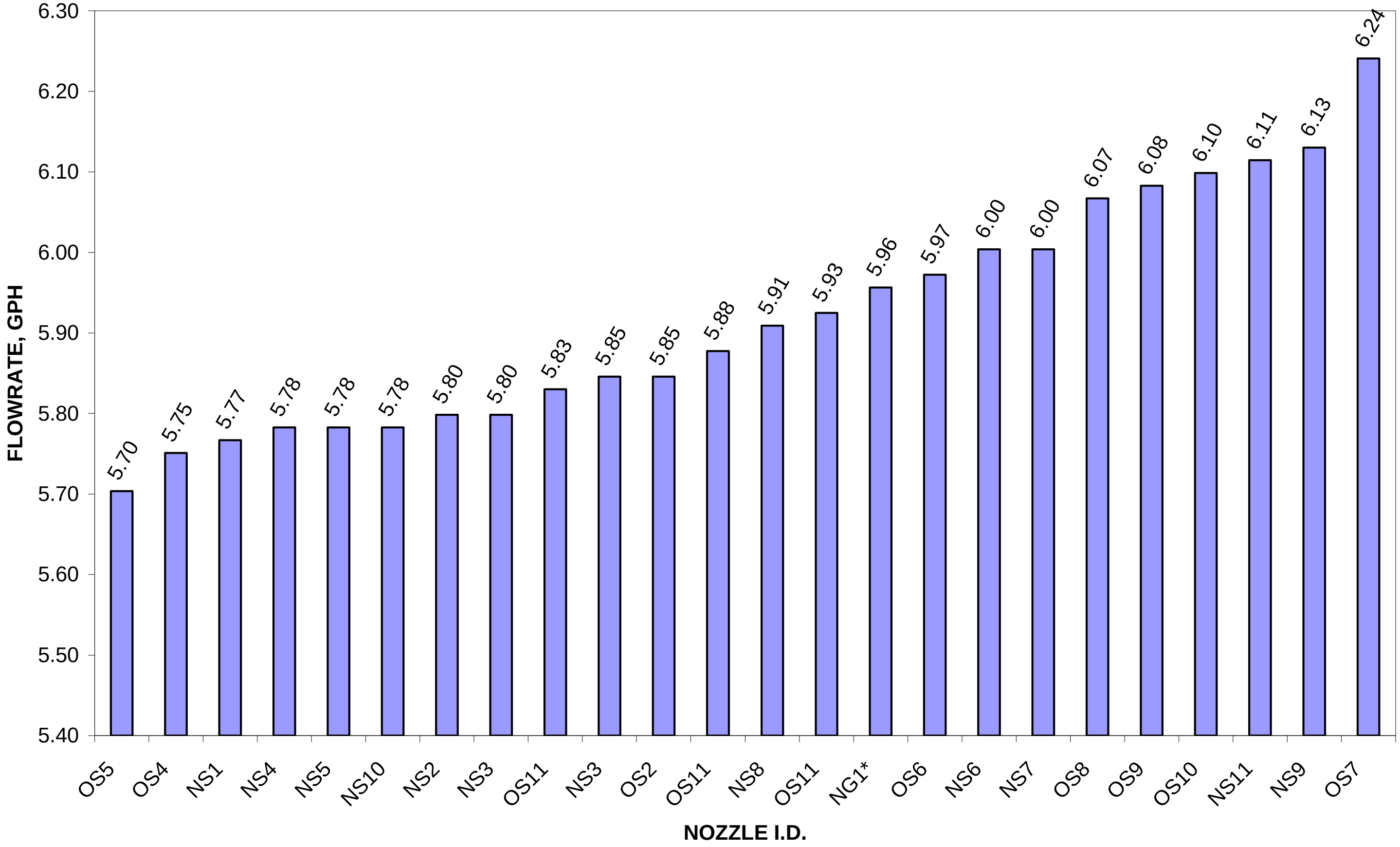
- **Clamping method is critical for heat flux failure mode**
- **Additional clamps on top and bottom are effective at restraining material**
- **Caution must be taken when restraining material, however, as mechanical BT failures can occur due to shrinking of material when exposed to flame**

Spray Nozzles

- **Discussed with a spray industry expert / representative**
  - Industry standard on flowrate is about ±10%
    - 2.0 gph nozzles -> 1.8 - 2.2 gph
    - 6.0 gph nozzles -> 5.4 - 6.6 gph
  - Typical orders include thousands of nozzles, if FAA were to have a specially produced nozzle, price would be very high
- **Received 25 2.0 gph and 25 6.0 gph spray nozzles from Everloy (Japan)**

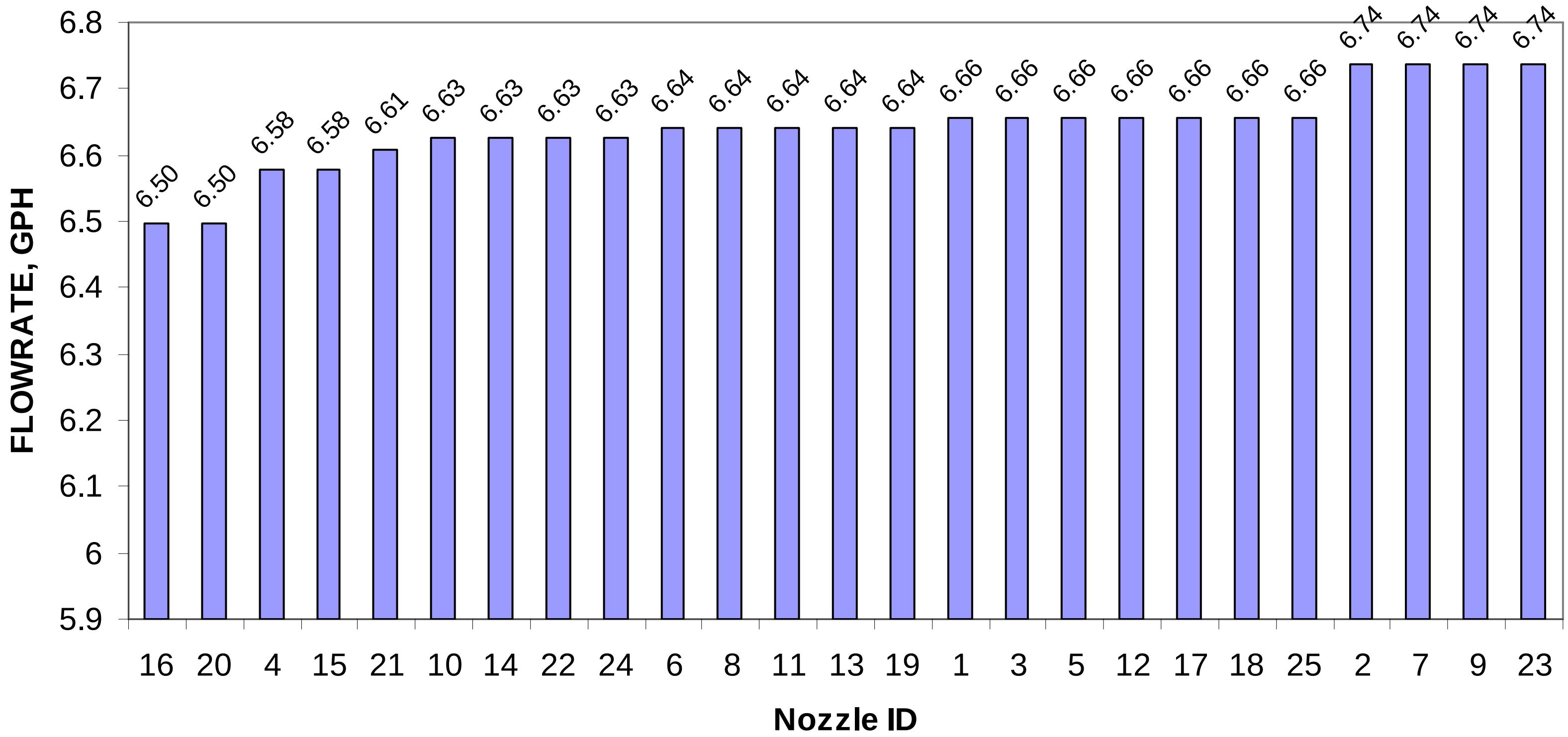

Monarch
Delavan
Everloy

Monarch Spray Nozzles



- **Average: 5.92 @ 120 psig**
- **%SD: 2.46%**

Everloy Spray Nozzles



- **Average: 6.64GPH @ 100psig**
- **%SD: 0.91%**

Everloy Nozzle

$$F_2 = F_1 * \left(\frac{P_2}{P_1}\right)^{.5} \quad \Longrightarrow \quad P_2 = P_1 * \left(\frac{F_2}{F_1}\right)^2$$

F_1 = calibrated flow rate at P_1 (6.6 gph)

F_2 = desired flow rate at P_2 (6.0 gph)

P_1 = calibrated nozzle pressure (100 psig)

P_2 = pressure to deliver F_2 (unknown)

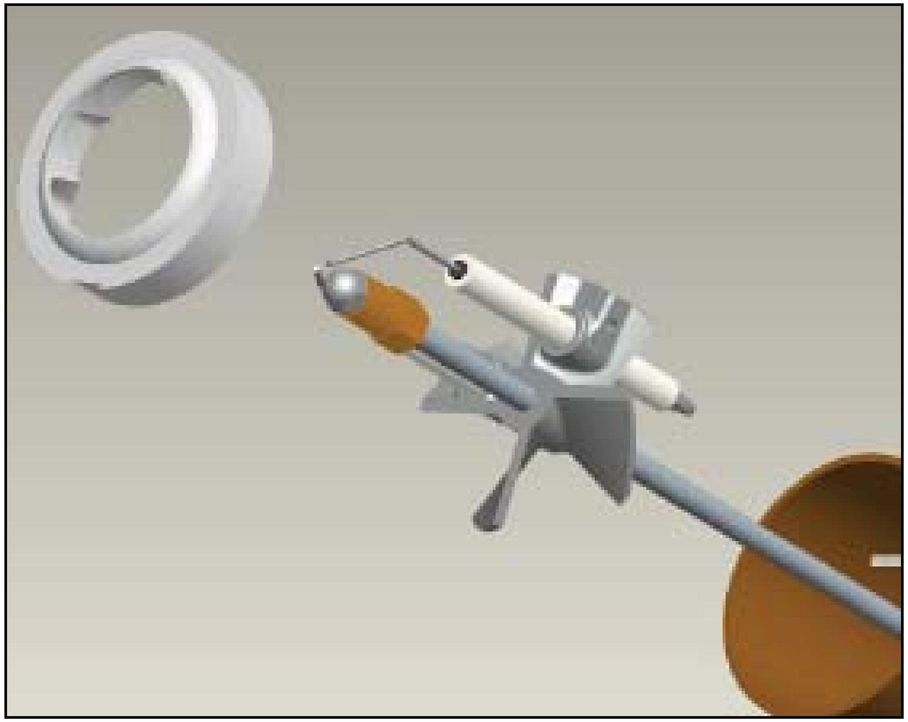
$$P_2 = 82 \text{ psig}$$

Nozzle ID	Pressure, psig	T Start	T Final	mL/min	GPH
1	100	51	44	420	6.66
1	82	51	44	385	6.10

What’s Next?

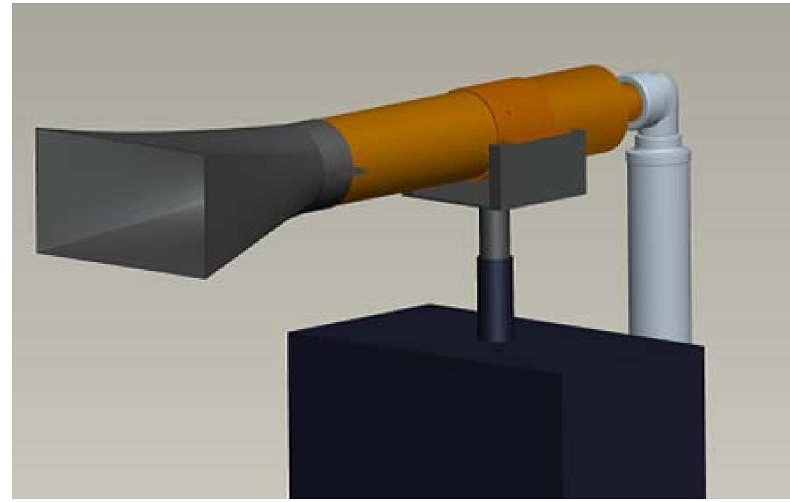
CNC Stator and Turbulator

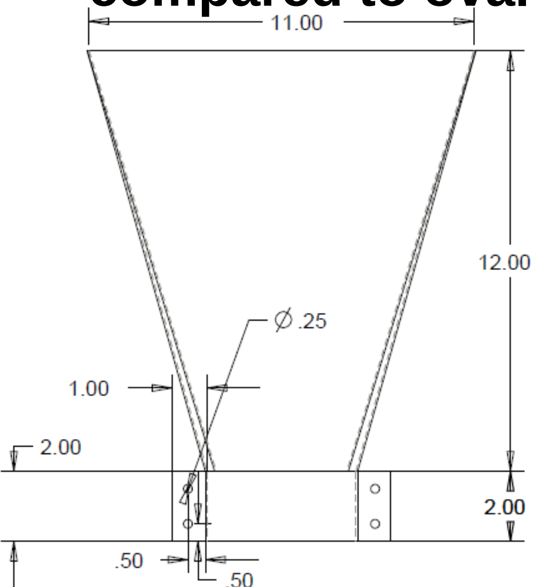
- 3D CAD drawings of the stator have been made at FAATC and by Marlin Engineering
- CNC parts have been made from both drawings
- Comparative BT tests will be run using both components to determine if they are equivalent
- CAD files will be on Fire Safety Website with the NexGen burner plans for download

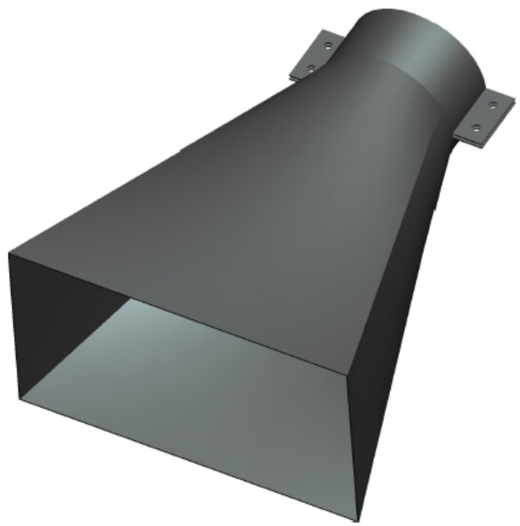


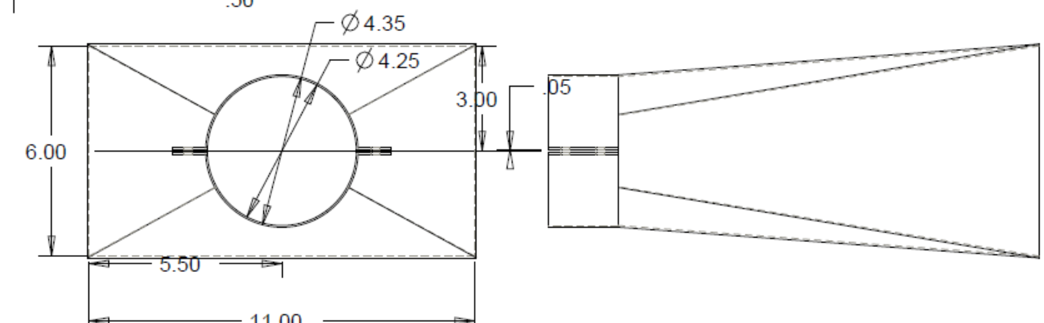
Cone Experiments

- Difficulty in manufacturing cone to specified tolerances
- Cone loses shape after typical usage, dimensions are out of specification
- Rectangular exit area will be compared to oval cone









Task Group Update

- **A draft test method was uploaded to the KSN site**
- **It includes complete descriptions of test procedure, definitions, etc.**
- **It can be used as a template to build upon over the coming months, and submitted to Transport Directorate for inclusion in updated Appendix F**

Scope

This specification defines a method to determine the burn through resistance characteristics of aircraft thermal/acoustic insulation materials or insulation material arrangements when exposed to a high intensity open flame. It is used for evaluation of materials or construction for thermal and/or acoustical insulation used in the pressurized section of aerospace vehicles.

The properties of thermal/acoustic insulation materials, products or assemblies are measured and described in response to heat and fire under controlled laboratory conditions.

This test method should not be used to describe or appraise the fire hazard or fire risk of materials, products or assemblies under actual fire conditions. However results of this test may be used as elements of a fire risk assessment, which takes into account all of the factors that are pertinent to an assessment of the fire hazard of a particular end use. It shall be applied when mentioned in the relevant standard, material specification, process specification, drawing, order or inspection schedule.

Normative References

This specification incorporates by dated or undated reference provisions from other publications. All normative references cited at the appropriate places in the text are listed hereafter. For dated references, subsequent amendments to or revisions of any these publications apply to this specification only when incorporated in it by amendment of revision. For undated references, the latest issue of the publication referred to shall be applied.

[1]		FAR 25.856(b)	"Improved Flammability Used in Transport Cate
[2]		FAR §25.856(b), Appendix F, Part VII	"Test Method to detern Insulation Materials" - A
[3]		AC 25.856-2A, (Date 29-07-2008)	Advisory Circular Dra Burnthrough Protection
[4]		ISO/TR 2685:1998(E)	"Aircraft – Environmenta to fire in designated fire
[5]	IEC 584-1	Thermocouples – part 1: reference tables	

Definitions

Thermal/acoustic insulation	Thermal/acoustic insulation is defined as a material, system or components of materials used to provide thermal/acoustic protection.
Lower half	The area of the fuselage below the horizontal line that bisects the cross section of the fuselage. This may be determined using the height of the fuselage as a basis.

Questions, Comments, Concerns?

Contact:

Robert Ochs

DOT/FAA Tech Center

BLDG 287

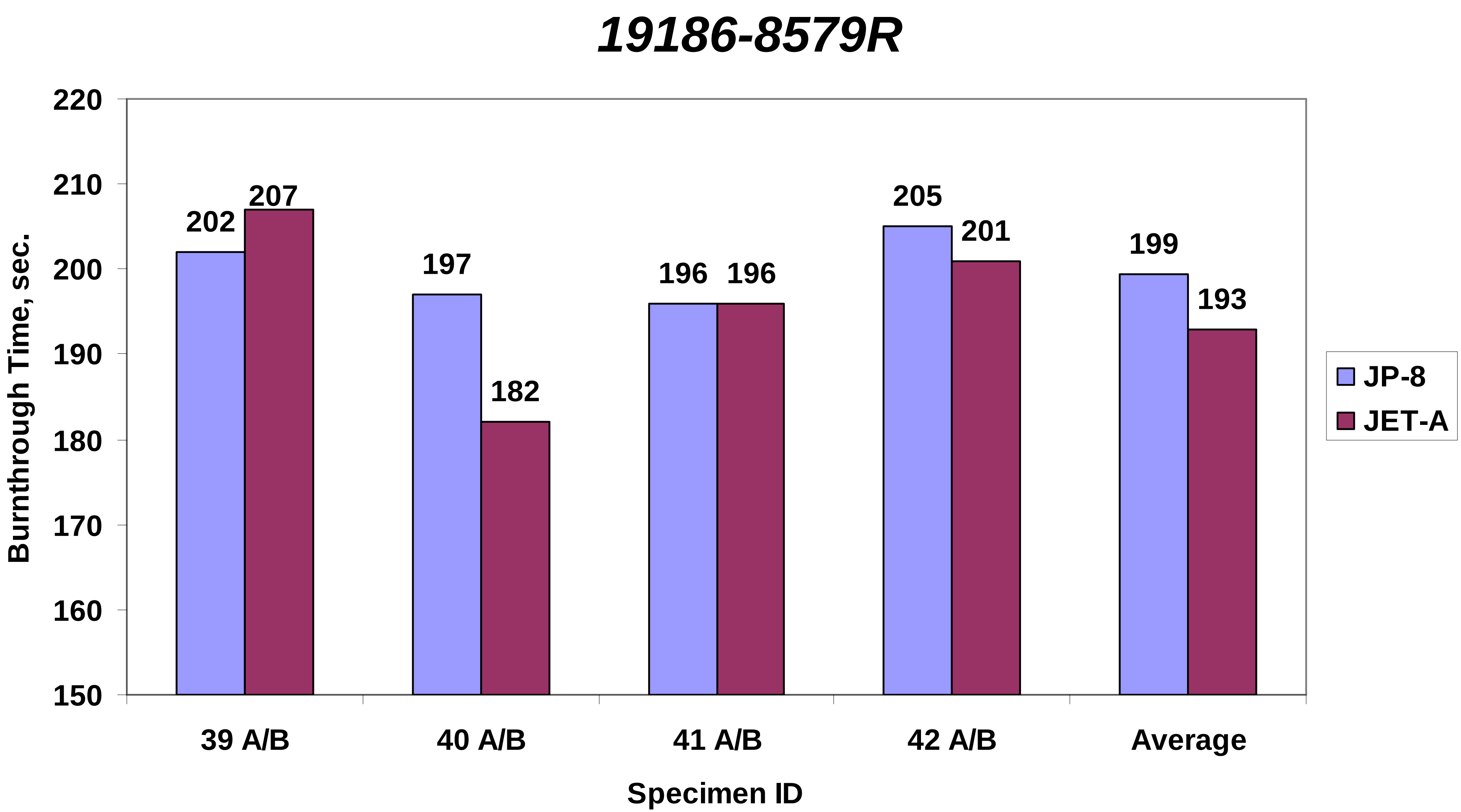
Atlantic City Int'l Airport

NJ 08405

robert.ochs@faa.gov

1 (609) 485 4651

JP-8 vs. Jet-A: PAN Burnthrough



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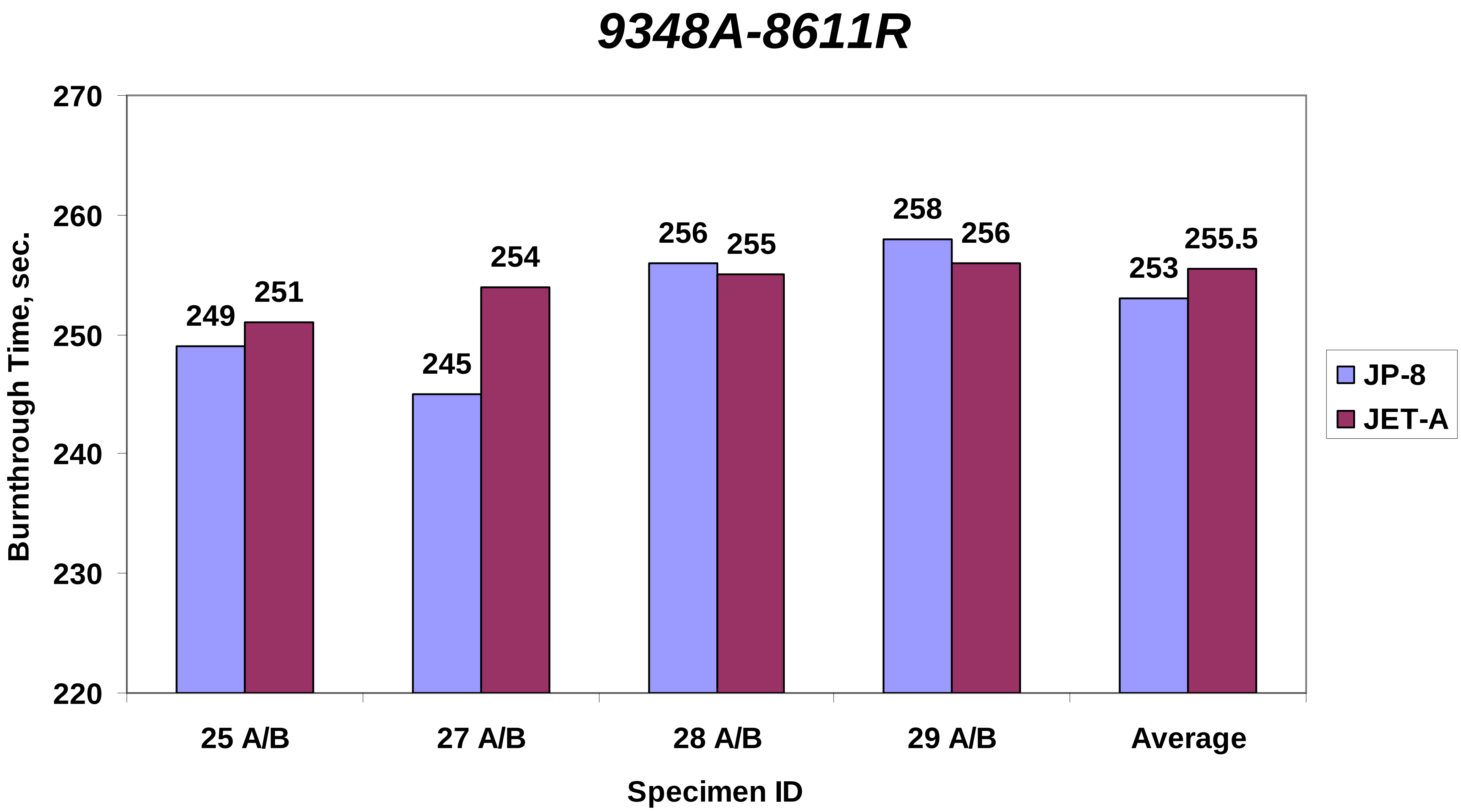

About Jet Fuel

- **In the US, ASTM D 1655 defines the exact requirements for the purchase of aviation turbine (jet) fuel**
  - Jet A, Jet A1: kerosene based, only have differing freeze points, boiling range 160-300°C
  - Jet B: naptha based, wide cut fuel, boiling range 50-300°C
- **Military specifications for similar fuels are JP-8 (Jet A) and JP-5 (Jet B).**
  - JP-8 contains extra additives over Jet A, including icing inhibitors, corrosion inhibitors, lubricants, and anti-static agents.
- **ASTM D 1655 has 23 specifications which set limits for certain properties of jet fuel**
  - Exact composition of fuel is not specified, rather aviation turbine fuel shall consist of refined hydrocarbons derived from crude petroleum, natural gasoline (light hydrocarbons), or blends thereof with synthetic hydrocarbons (processed or alternative-source streams)
  - Resulting fuels are comprised of over 200 different components, actual composition is very dependent upon crude oil sources
  - Minimum flash point of 100°F