

Development of a Next Generation Fire Test Burner

The Sixth Triennial International Fire & Cabin
Safety Research Conference

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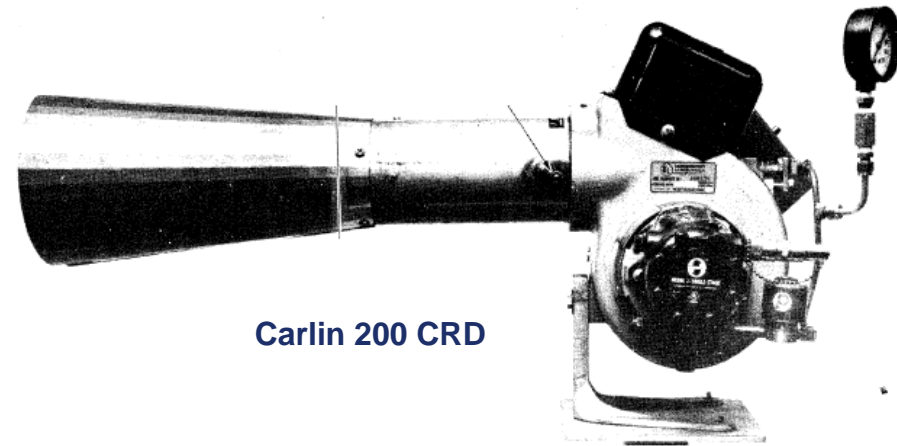


Federal Aviation
Administration

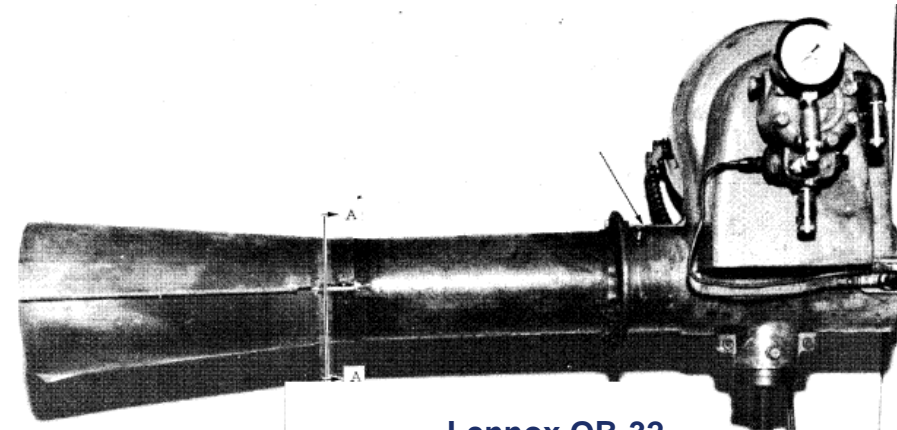


Introduction

- **The FAA has utilized various forms of a modified home heating oil burner for aircraft material and system fire testing**
 - The flame produced by this type of burner is used to simulate the effects of a severe fire in a controlled laboratory-scale test
- **As aircraft fire safety evolved over the past 50 years, more test methods were developed that employed the oil burner as the test apparatus**
 - Powerplant components and firewalls
 - Cargo compartment liners
 - Seat cushions
 - Thermal acoustic insulation
- **At the same time, the oil burners specified in the regulations went out of production and were no longer obtainable**
 - Newer oil burners were specified and considered equivalent if the required heat flux and temperature could be achieved



Carlin 200 CRD



Lennox OB-32



Park DPL 3400

Evolution



Powerplant Components (1950's)

- Multiple acceptable burners
- Various testing configurations
- Various test materials
 - Metallic components, firewalls, hoses, etc
- Requirements
 - 2000°F, 9.3 BTU/ft²s



Cargo Liner (1984)

- Multiple acceptable burners
- Single testing configuration
- Single test material
 - Thin, flat fire barriers
- Requirements
 - 1700 ± 100°F, 8.0 ±0.5 BTU/ft²s
 - Exit air velocity



Seat Cushion (1984)

- Multiple acceptable burners
- Single testing configuration
- Single test material
 - Thick, soft cushions
- Requirements
 - 1900 ± 100°F, 10.5 ±0.5 BTU/ft²s



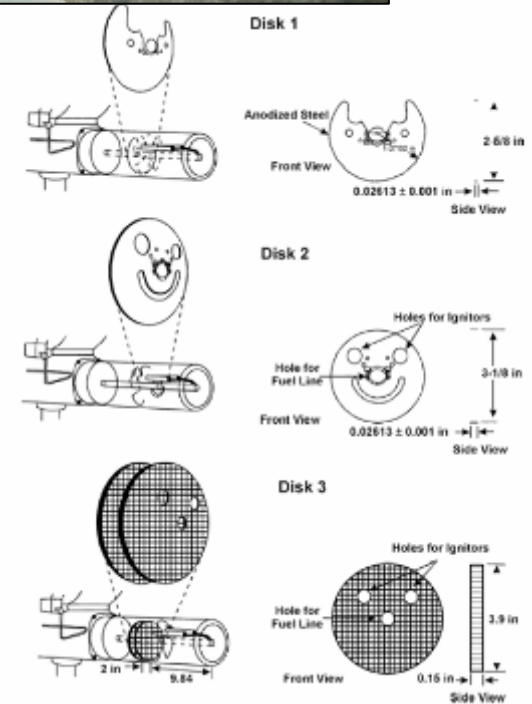
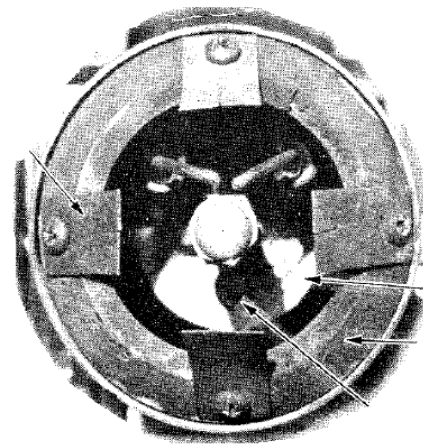
Thermal Acoustic Insulation (2008)

- Single acceptable burner
- Single testing configuration
- Single test material
 - Thin, flexible fire barriers
- Requirements
 - 1900 ± 100°F, 16.0 ±0.5 BTU/ft²s
 - Inlet air velocity



Lessons Learned Over the Years

- Not all burners are created equal
- Configuration of burner components can drastically alter flame
- Burner air flow can have a significant effect on test results, especially for lighter weight materials
- It's an oil burner, not precision lab equipment!



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

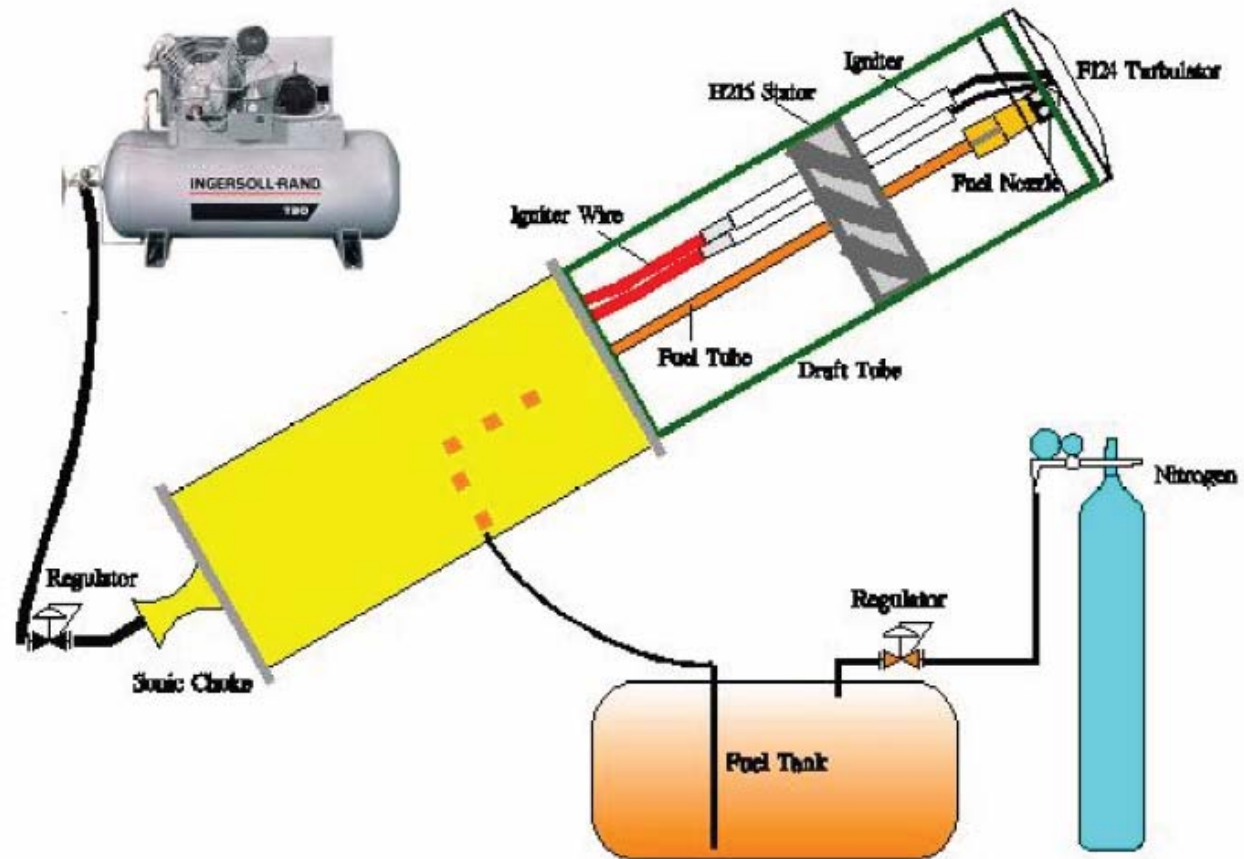


Objectives

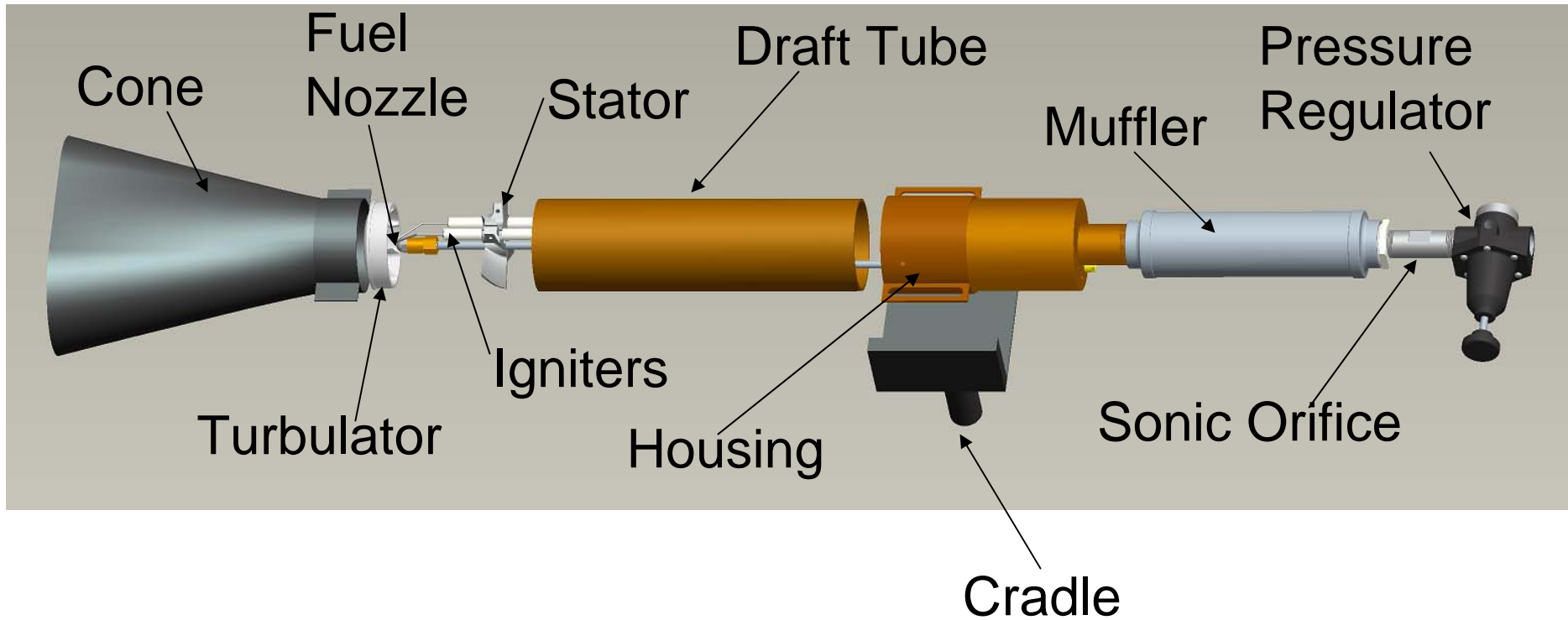
- **Design a fire test burner that can be constructed in-house with easily obtainable components**
 - Simple design
 - Simple operation
 - Simple maintenance
- **Burner output must be comparable to the Park DPL 3400**
- **Burner should achieve a higher level of repeatability and reproducibility**
- **Burner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

Initial Concept

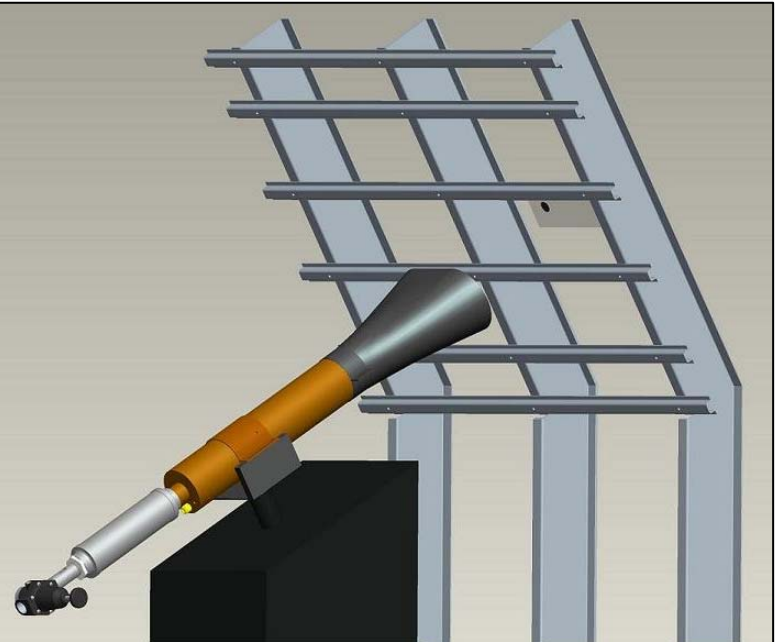
- Compressed air metered with a sonic nozzle
- Fuel provided by a pressurized fuel tank
- Utilize original Park DPL 3400 components



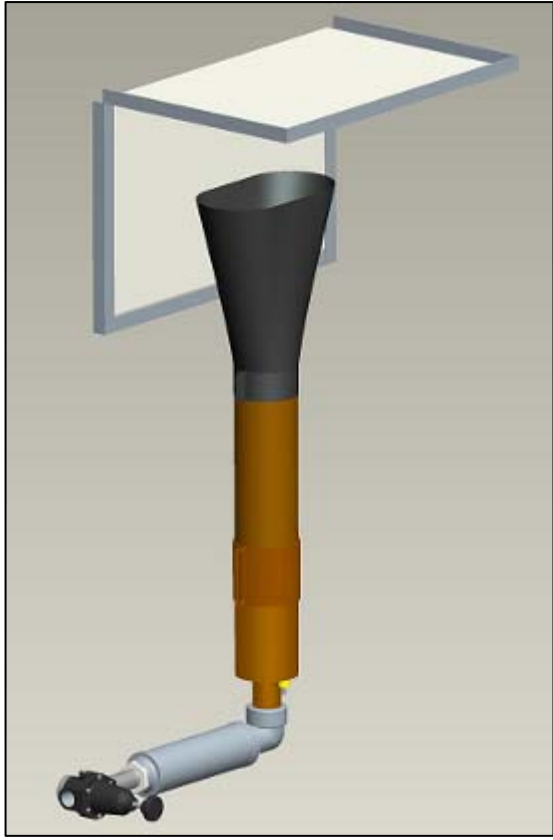
NexGen Burner Design



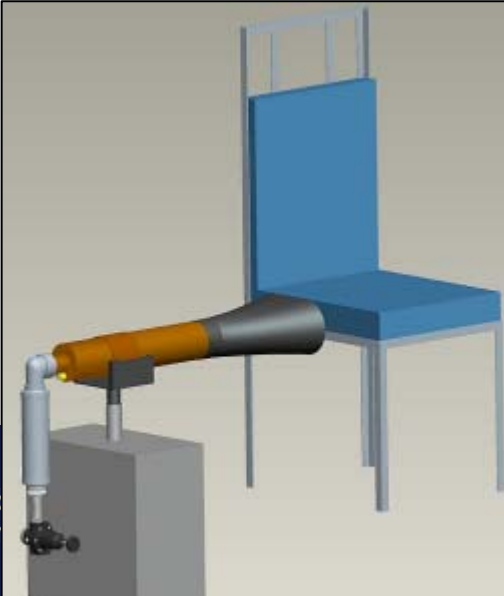
Thermal/Acoustic Insulation Burnthrough



Cargo Liner Burnthrough



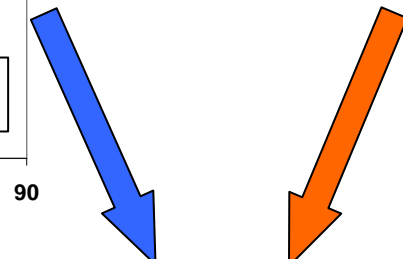
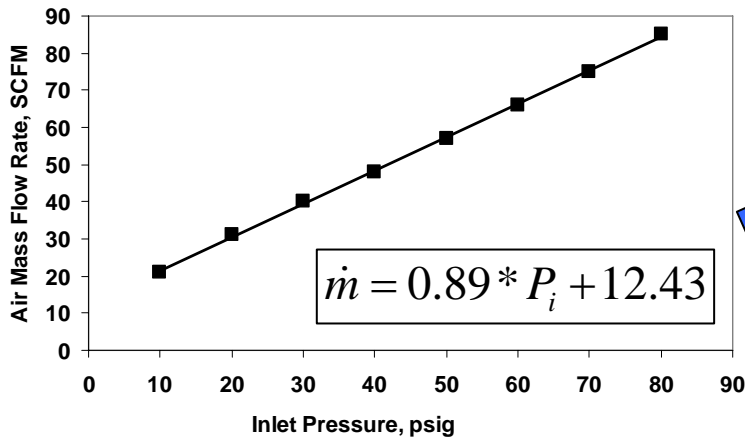
Seat Cushion Flammability



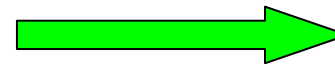
Burner Control

Air Flow

Fuel Flow

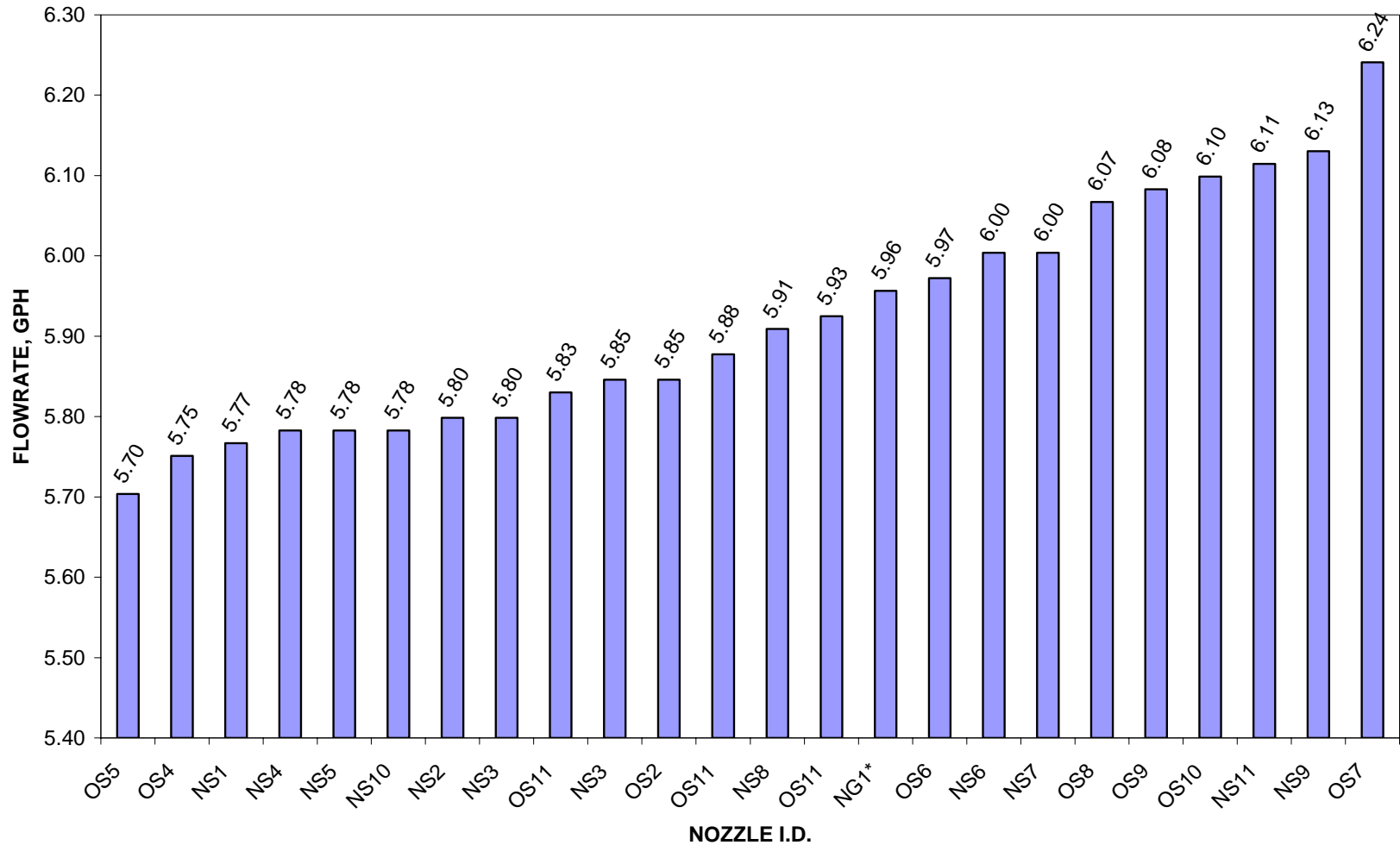


Regulated and conditioned air and fuel to burner



Spray Nozzles

FLOWRATES OF VARIOUS NOZZLES AT 120 PSIG, 38F



Components

- A working group participant was able to digitize the original stator and turbulator
- Noticing the irregularities in the originals, they were able to correct it in design software
- A computer numerical controlled (CNC) mill was used to cut new, corrected stators and turbulators
- Comparison testing validated the performance of the new components

Original Turbulator

Prototype Turbulator



Original Stator

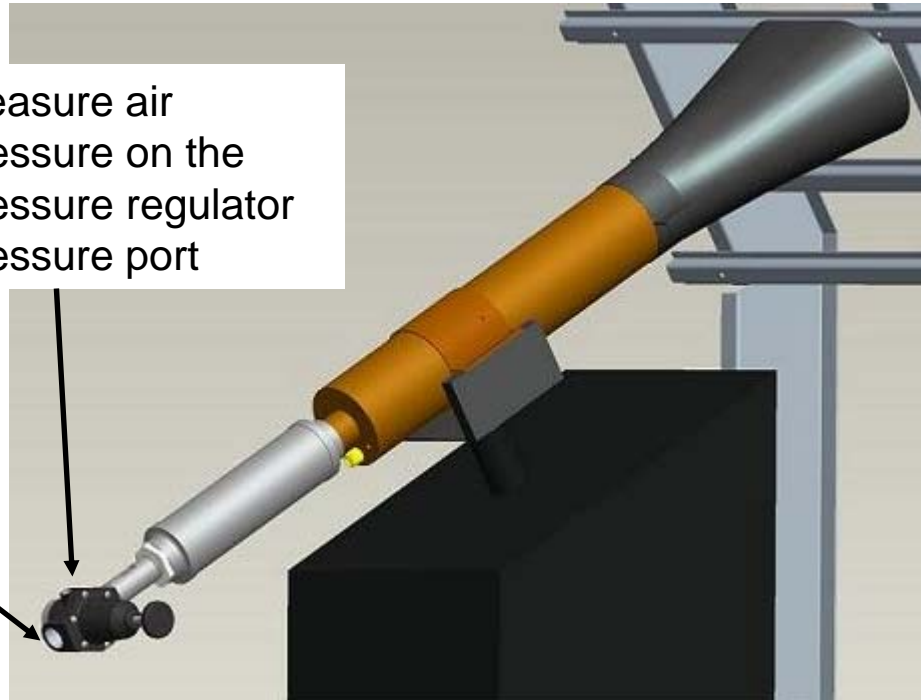
Prototype Stator



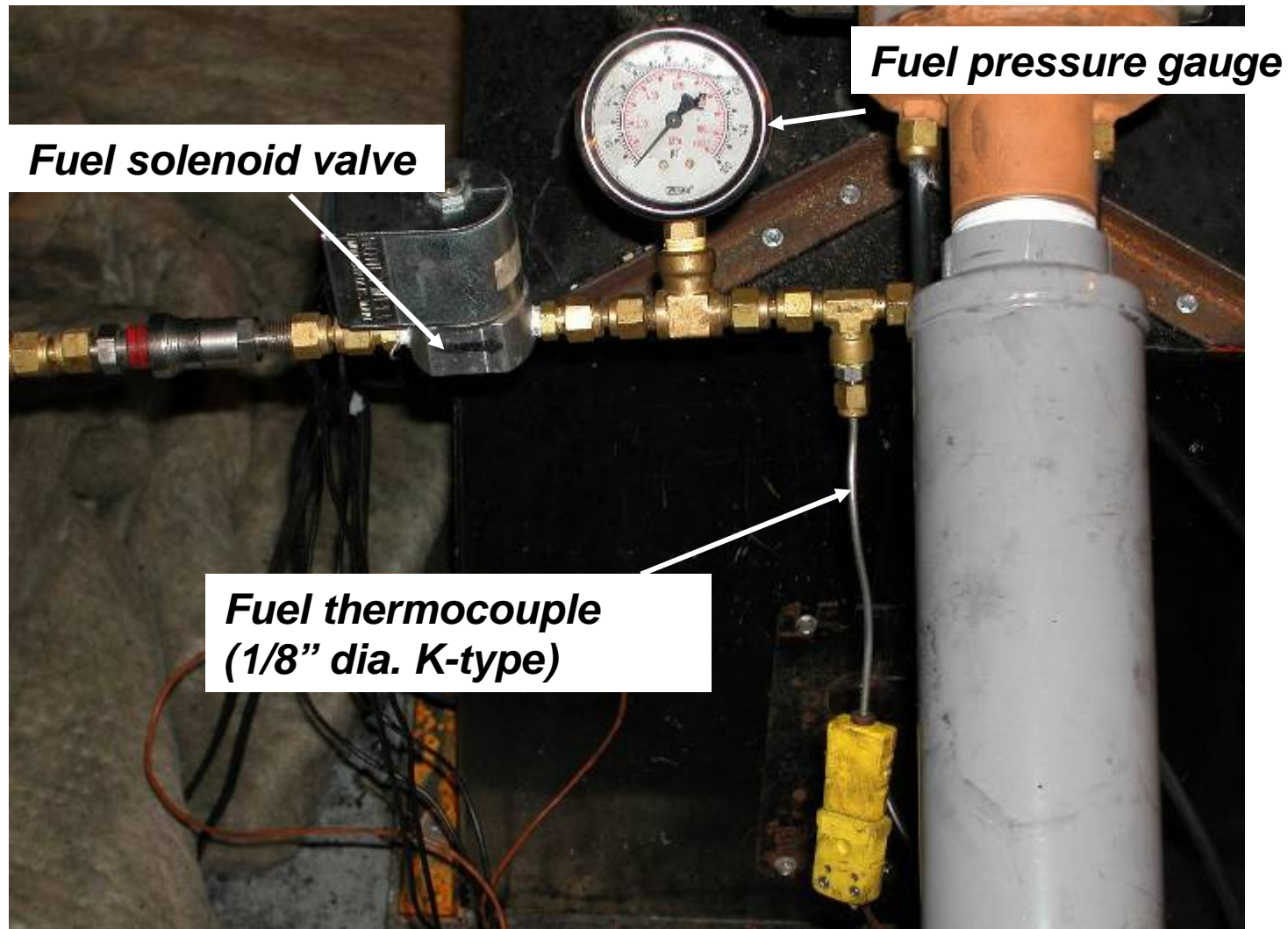
Air Measurement

Measure air temperature just upstream of the pressure regulator with a 1/8" K-type thermocouple

Measure air pressure on the pressure regulator pressure port

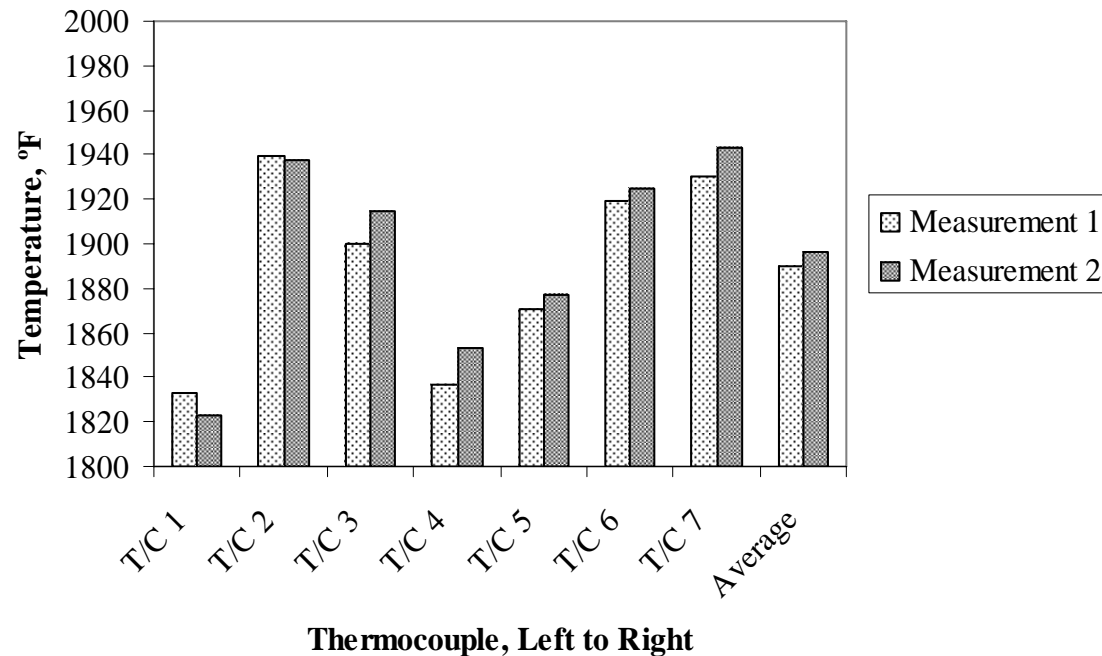


Fuel Measurement



Burner Performance

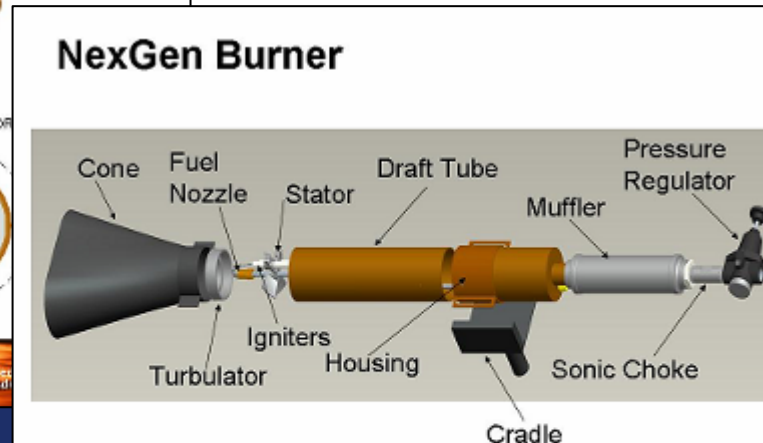
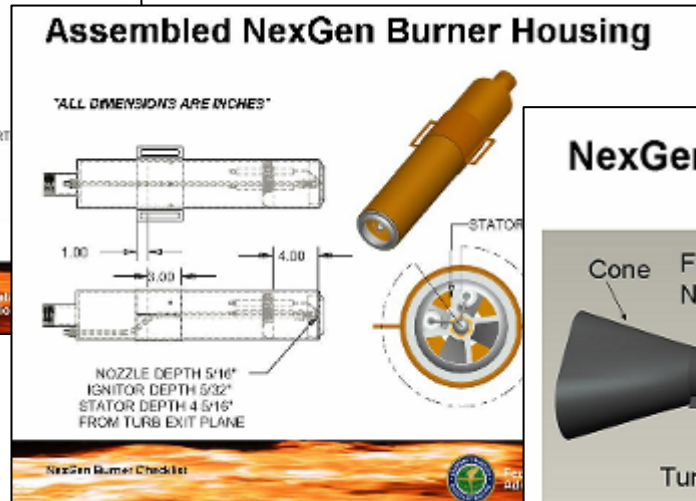
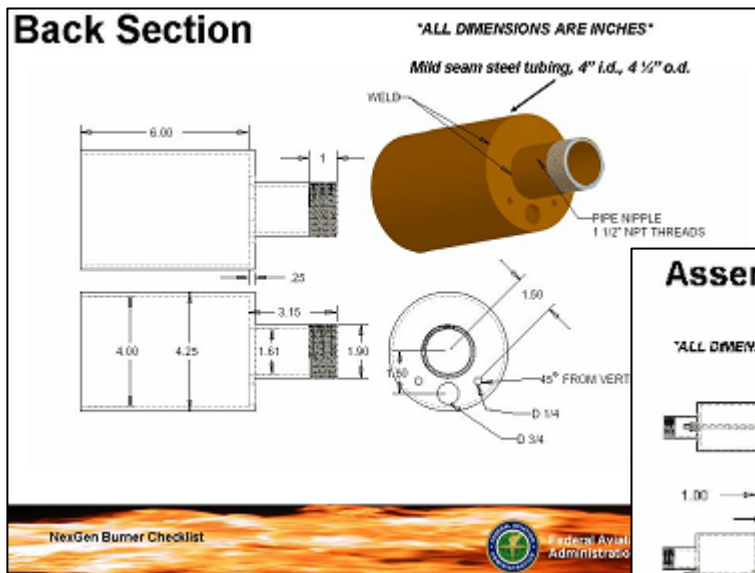
- **Burner operational parameters depend on the test being performed**
 - Powerplant, Cargo Liner, Seat Cushion
 - 2.0 gph fuel flow rate
 - Thermal Acoustic Insulation Burnthrough
 - 6.0 gph fuel flow rate



NexGen Drawings

- Drawings are available online at

<http://www.fire.tc.faa.gov/pdf/materials/NexGenPlans.pdf>



Development of a Next Generation Fire Test Burner
6th Triennial Int'l Fire & Cabin Safety Research Conference

NexGen Burner Calibration

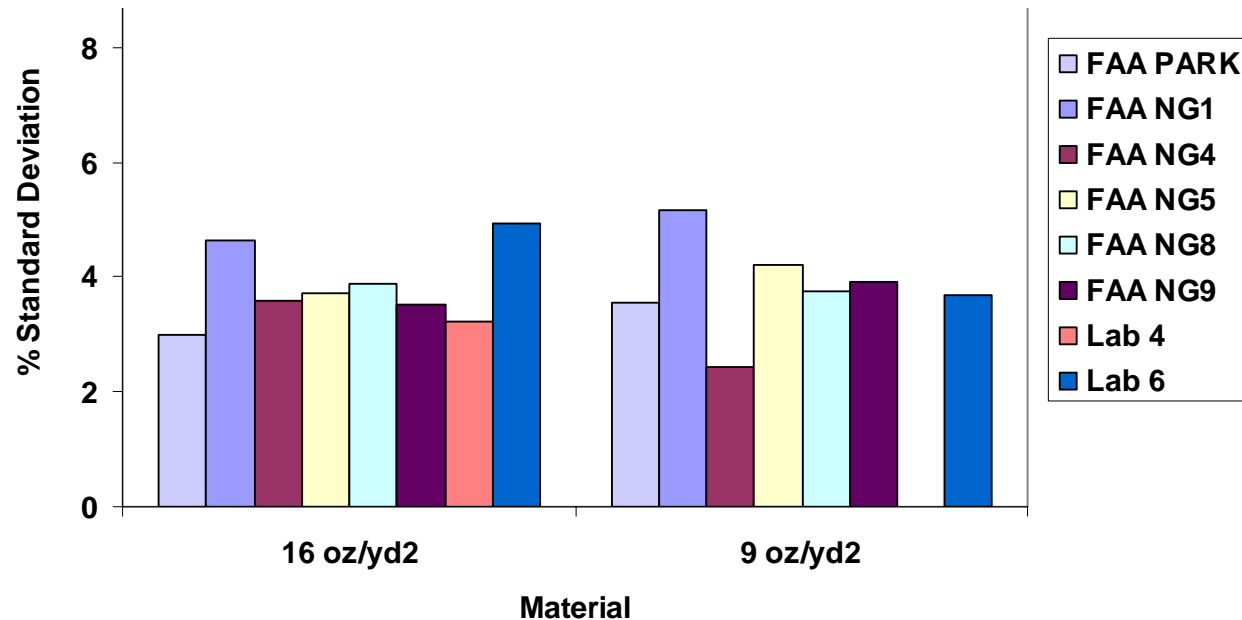
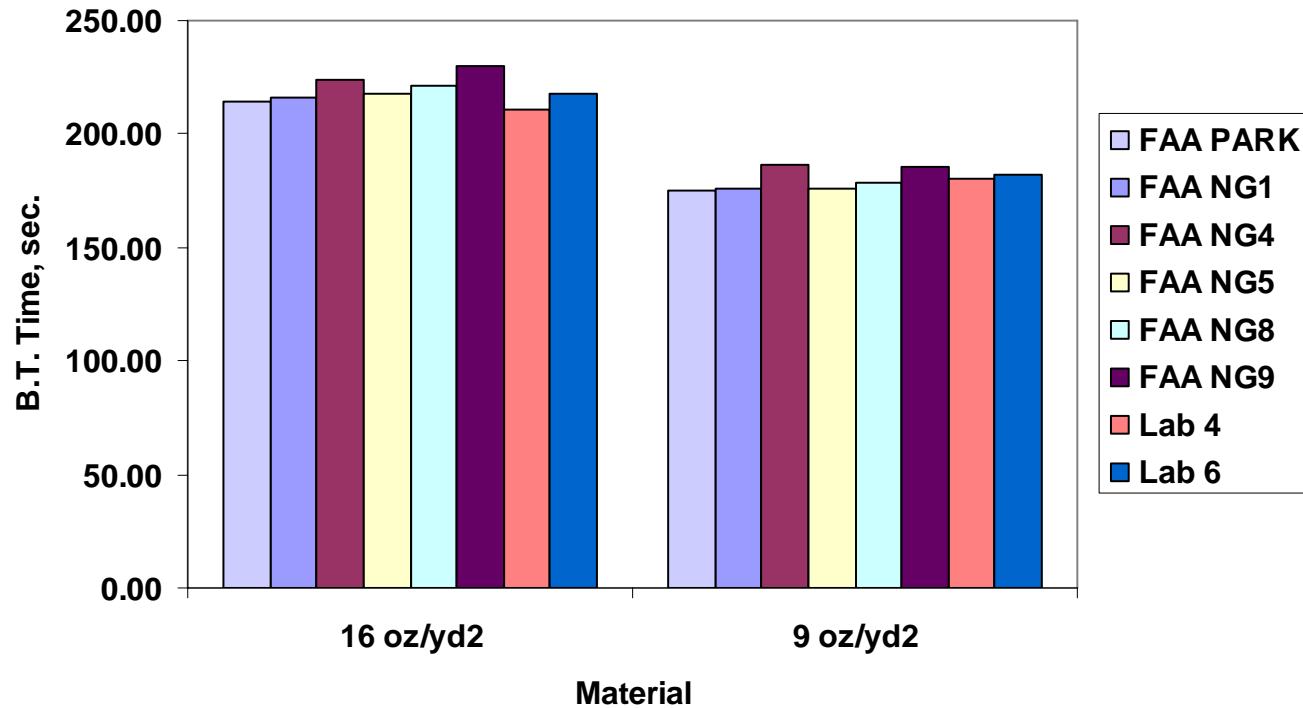
- **For the NexGen burner, the heat flux measurement has been removed from the calibration procedure**
 - Heat flux transducers measure instantaneous heat flux at a very small point in the flame
 - Specifically, Gardon gauges were designed and are intended for measuring intense thermal radiation only
 - Use in an intense, mixed-mode heat transfer environment introduces significant measurement uncertainty
 - Since all inlet parameters and burner dimensions are fixed, no adjustments can be made to achieve a specified heat flux
- **Flame temperature is measured and used to determine proper burner output**
 - 1/8" S.S. sheathed ceramic packed K-type thermocouples
- **Ultimate test of similarity between Park DPL 3400 and NexGen was comparative burnthrough and seat cushion testing**
 - Polyacrylonitrile (PAN) fabric material of 2 different densities was chosen due to their typical burnthrough times
 - 16 oz/yd² ~ 4 min. BT
 - 9 oz/yd² ~ 3 min. BT
 - 25.856b pass/fail criteria is 4 min BT resistance
 - A “picture-frame” sample holder was created to hold material
 - Tests were performed on the Park DPL 3400 and several NexGen burners at different labs

Validation Testing - Burnthrough



Results

- NexGen burners were shipped out to participating laboratories in order to determine the repeatability of the test results in various environments
- Very good agreement was found between labs 4 and 6 and the rest of the NexGen's tested at the FAATC
- All labs and burners were found to have less than 5% relative standard deviation, indicating good repeatability
- Labs 4 and 6 were approved by their respective A.C.O.'s to perform certification tests according to the rule



Validation Testing – Seat Cushion



Figure 1. Fire-Hardened Foam 1

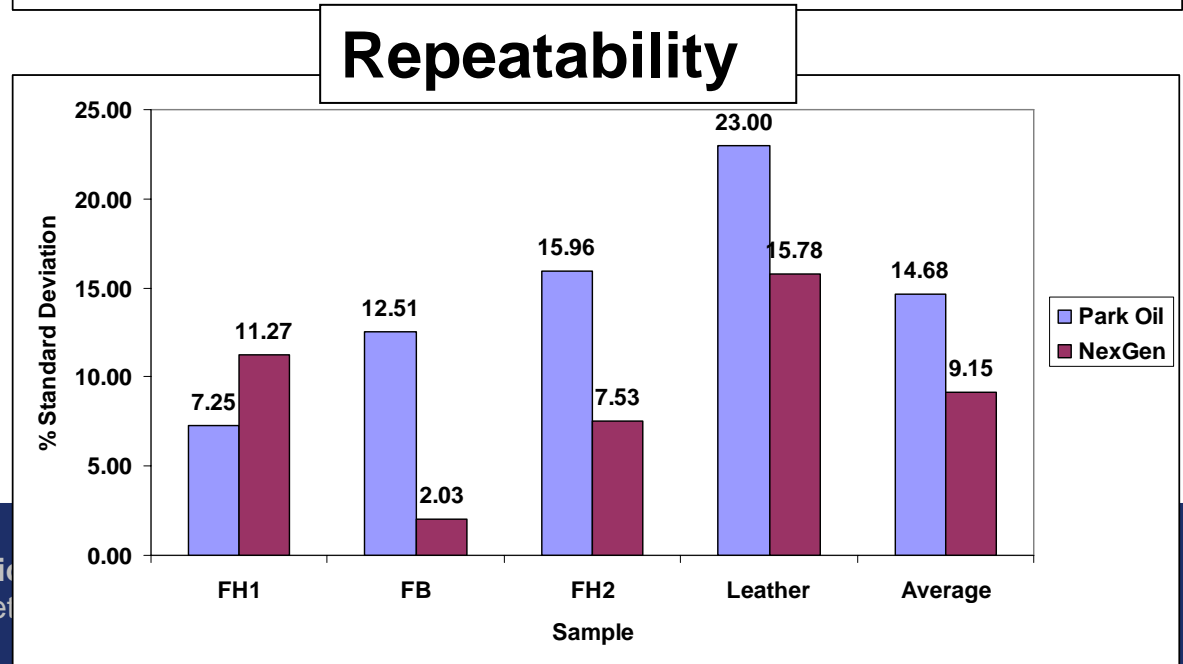
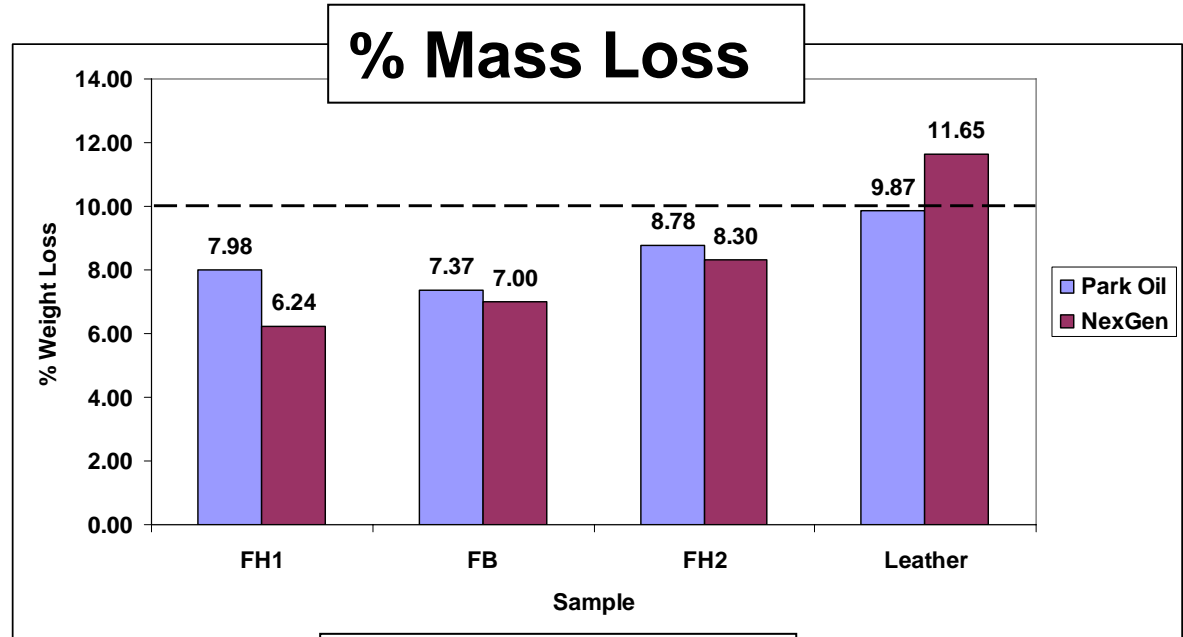


Figure 2. Fire-Blocking Layer



Figure 3. Fire-Hardened Foam 2

a Next Generation
Fire & Cabin Safety



NexGen Burner Development - Summary

- **The NexGen burner has been proven to produce a flame similar to an oil burner calibrated according to**
 - 25.853 seat cushion flammability test
 - 25.856b insulation burnthrough test
- **Comparative testing was used to validate burner performance**
- **Measurement of flame heat flux has been eliminated due to tighter control of burner inlet parameters**

Questions?



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