International Coordinating Council of Aerospace Industries Associations

ICCAIA - Industry Cabin Safety Group

Airbus – Boeing – Bombardier - Embraer

Industry Burnthrough Development & Implementation

December 6-7, 2006

Current Situation

- The original Park burner and test process were not ready for production.
  - **The few 'accepted' burners are not usable for industry**
  - **Research and development for acceptable burners still underway**

- Industry (Airbus and Boeing) is developing new burners to ensure repeatable performance. Embraer and Bombardier are supporting with additional test facilities to confirm performance.
  - Industry burners (per FAA) not likely acceptable w/o additional validation to ensure equivalent performance matching mass flow of air, fuel pressure/flow rate, temperature profile and general configuration.

- FAA TC is developing a sonic burner as an alternative solution for industry.
  - Industry is supporting with materials and technical input.
  - Installation and validation of sonic burners at multiple locations underway

- Calibration (methods/documentation, calibration transfer/reference materials, and maintenance) and statistical validation still in-work for all burners (Industry and FAA-TC).

- Heat flux and temperature inadequate to define complex flame and/or calibrate for repeatable and reproducible performance.

18-24 months are required beyond standardized and acceptable burners are commercially available.

Accomplishments

Airbus

- High quality precise custom design capable of evaluating a wide range of fire performance parameters
- Expert in burner design supporting efforts for optimizing burner performance

Boeing

- Six (2 of 3 different manufacturers) commercially available burners being evaluated
- Precise airflow measurement and adjustment allows for a reliable means to obtain desired output. i.e. burnthrough time on a common material(s)
- Including experts in calibration, ignition, combustion and statistical process control

Accomplishments

Bombardier

- Gathering cost information to present proposal to upper management and obtain approval of expenses to build test facility to evaluate sonic and/or industry burners.

Embraer

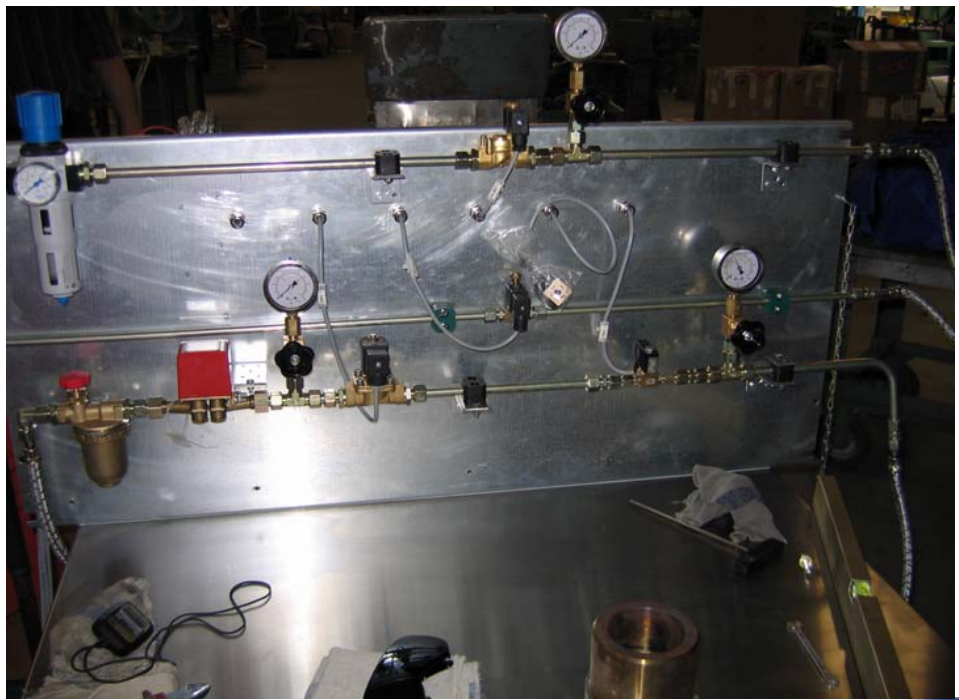
- Test facility is available.
- Purchased two burners: one from R. W. Beckett Corp and another from Carlin Combustion Technology Inc.
  The burners are yet to be delivered.
- Plan in work to install sonic burner

Airbus Evaluation of Fire Performance Parameters

Burner / control panel

Burner

Control panel to fix parameters

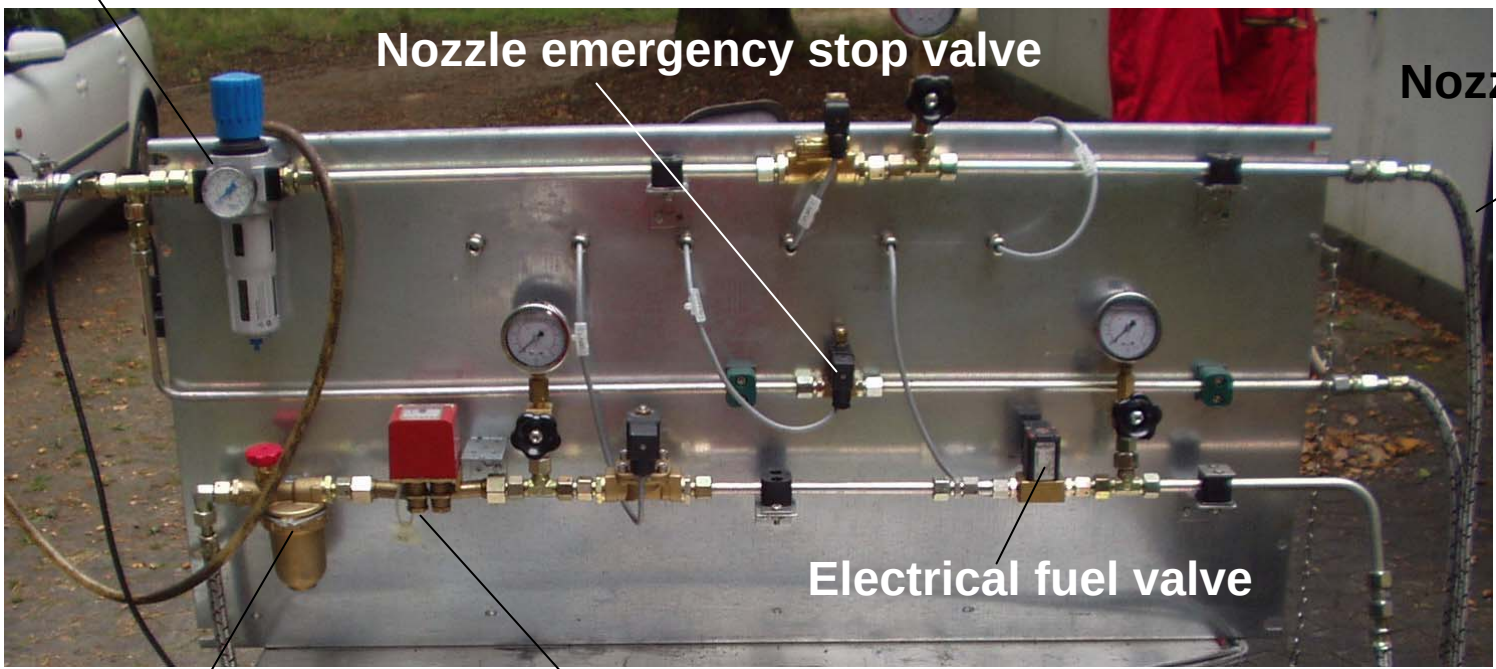


Functional Requirements

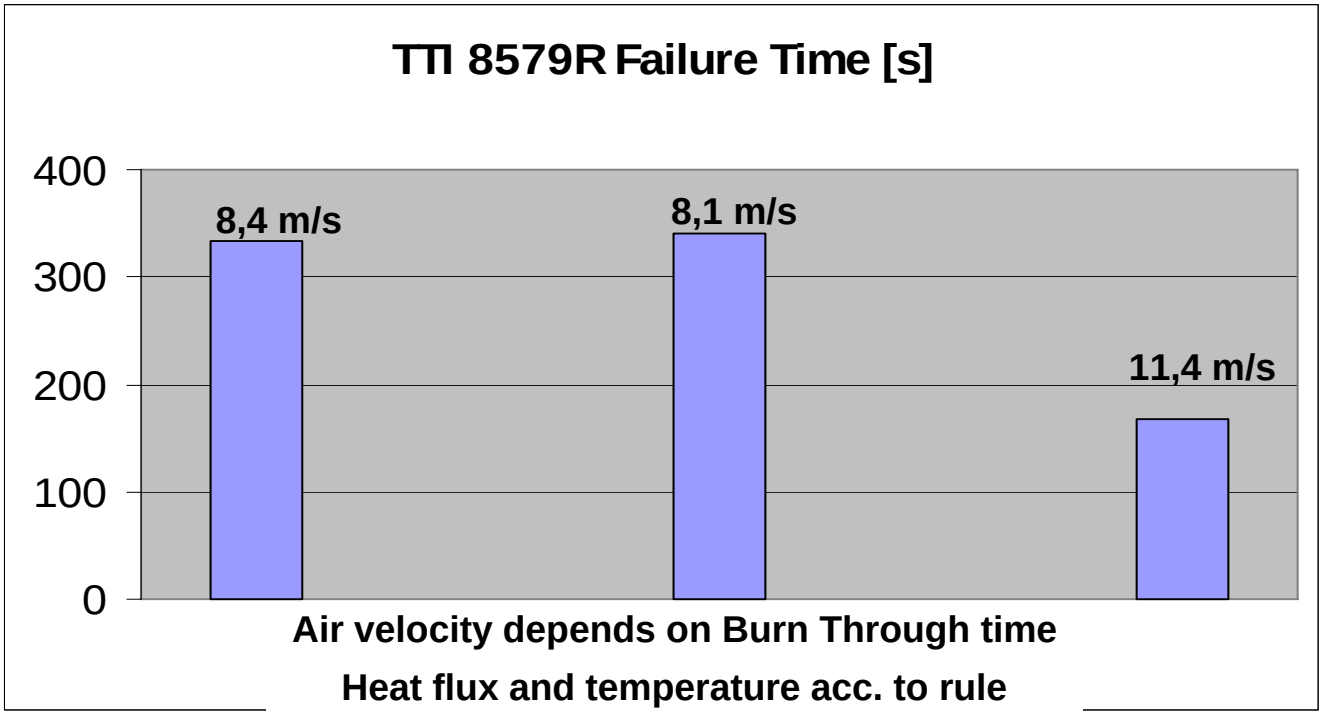
- ✓Target of the new Küppersbusch burner development is to be able to vary all physical properties specified in the final rule very easily.
- ✓General use of this burner for all oil burner based test standards (cargo, seat, thermal/acoustic insulation)

  - Air velocity: adjustable and linear as possible
  - Fuel rate
  - Nozzle- and spray-characteristic
  - Simple adjustment: nozzle distances, air distribution
  - Variable burner position, vertical, horizontal, 30°, etc
  - Industrialisation

Control panel



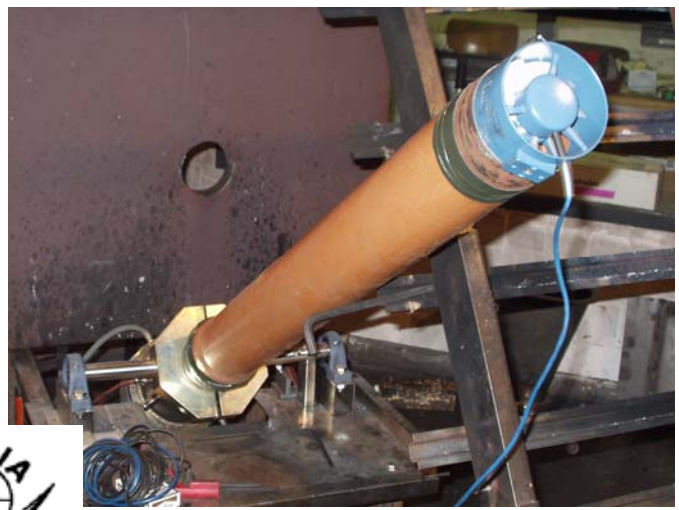
Air velocity

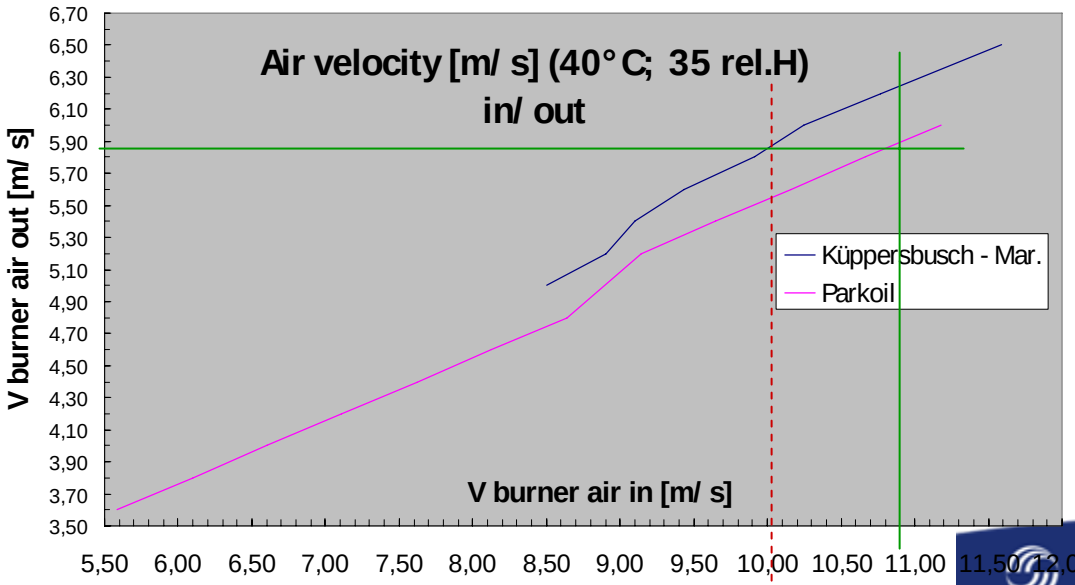


This results demonstrate the big influence of air velocity on burn through time

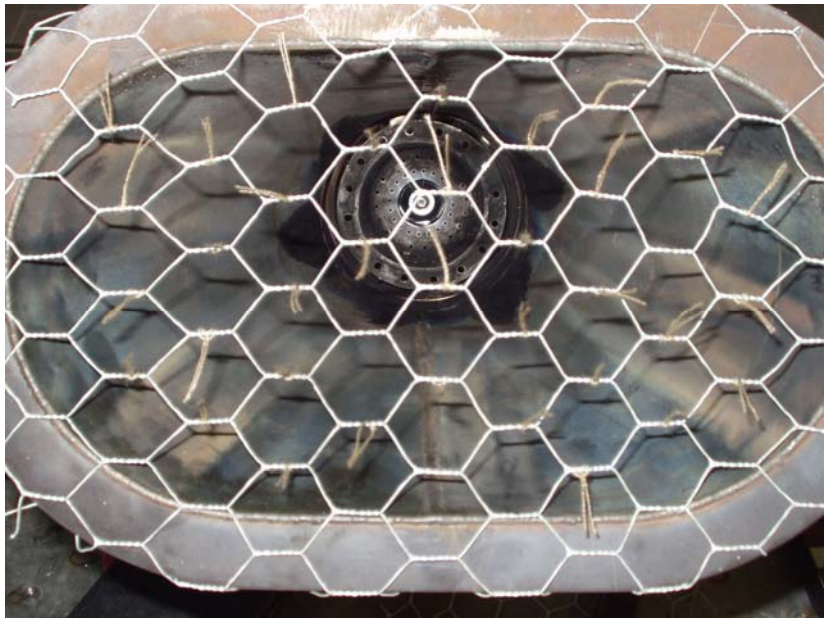
Air velocity

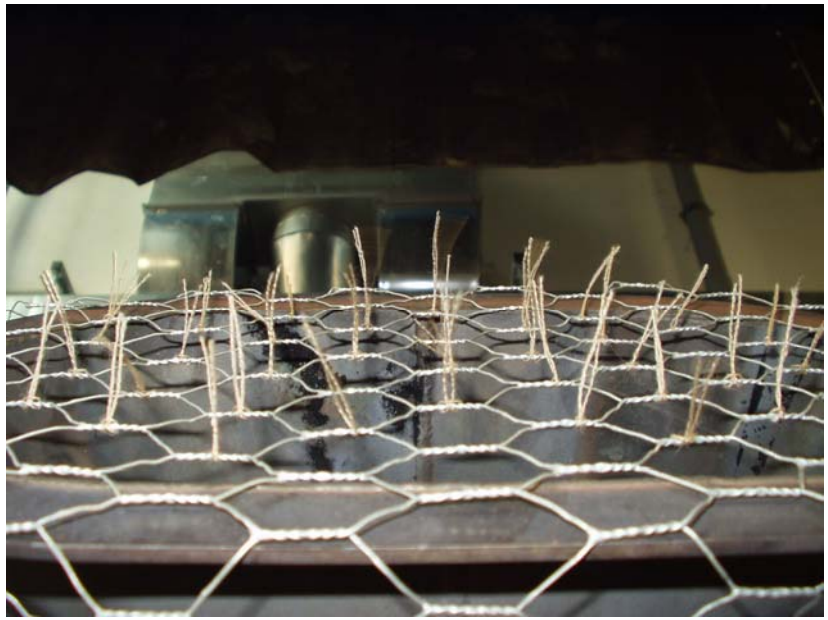
- The results of the development with the Park Oil Burner and first experience with the Küppersbusch Burner shows us:
  - The fuel rate shall be fixed at 6 gal/h
  - The air outlet at the burner opening shall be > 5,85 m/s in a 100 mm tube.
  - The distance, burner cone opening to the calorimeter and thermocouples shall be fixed at 102 mm.





Air flow distribution





Light weight fibres attached to a mash to demonstrate the air stream distribution

The intensive study of the air outlet distribution shows:

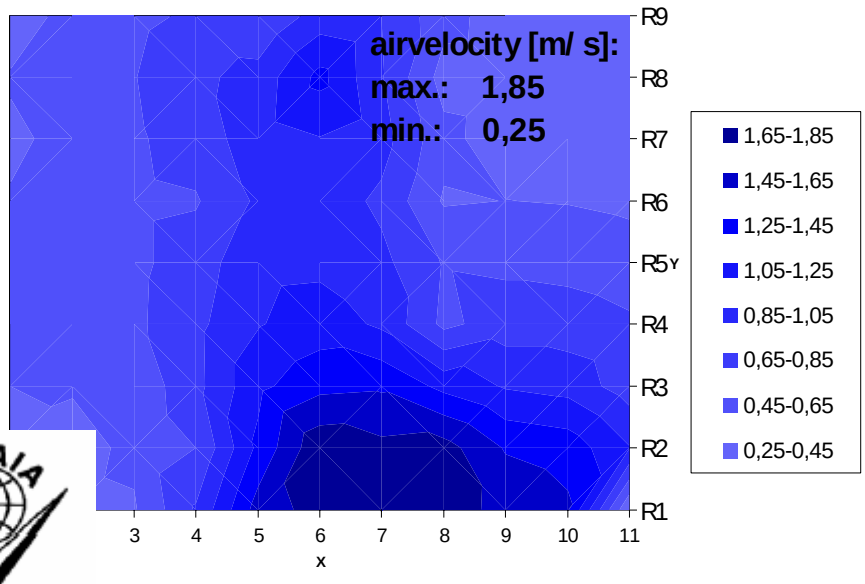
Small variations in cone geometries => big variation in air flow distribution

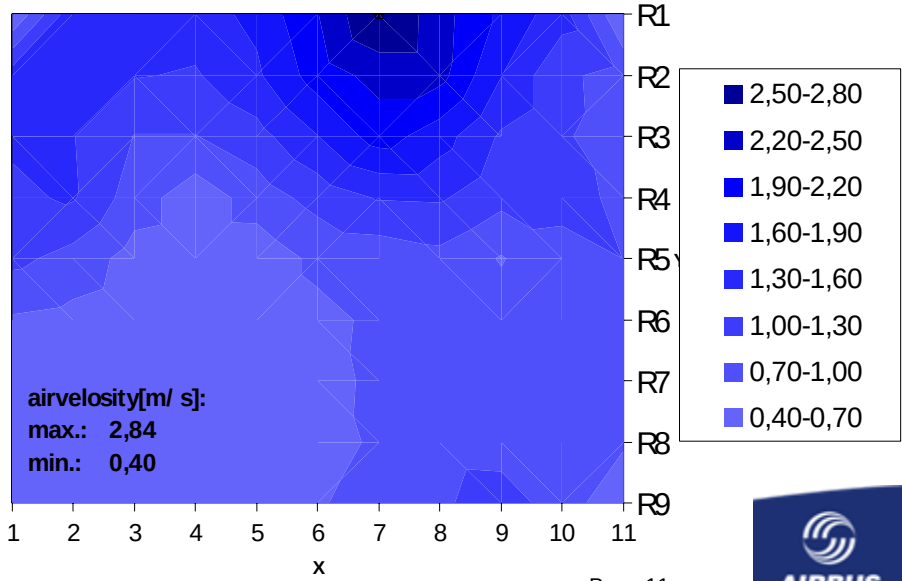
Variation in air flow

View into the burner cone

To demonstrate the influence of small changes in geometry air flow measurement before and after the cone was turned around 180°.

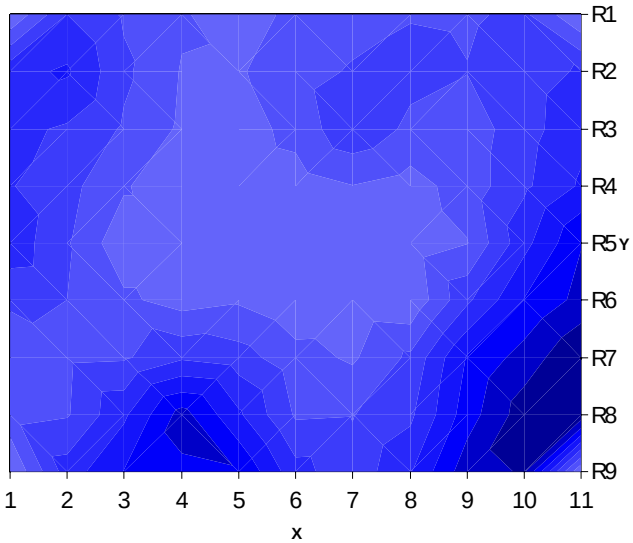
All other parameter fixed



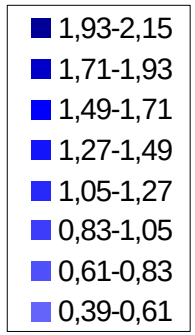


Air distribution Küppersbusch with FAA cone

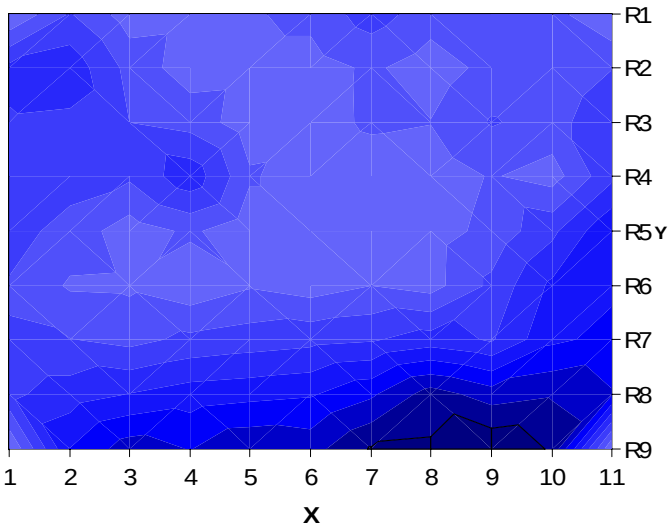
0° Position



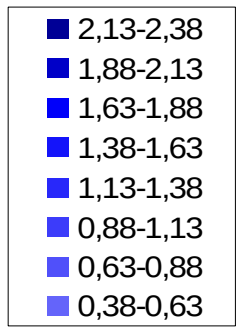
Air velocity[m/s]:
max.: 2,15
min.: 0,39



180° Position



Air velocity[m/s]:
max.: 2,60
min.: 0,38



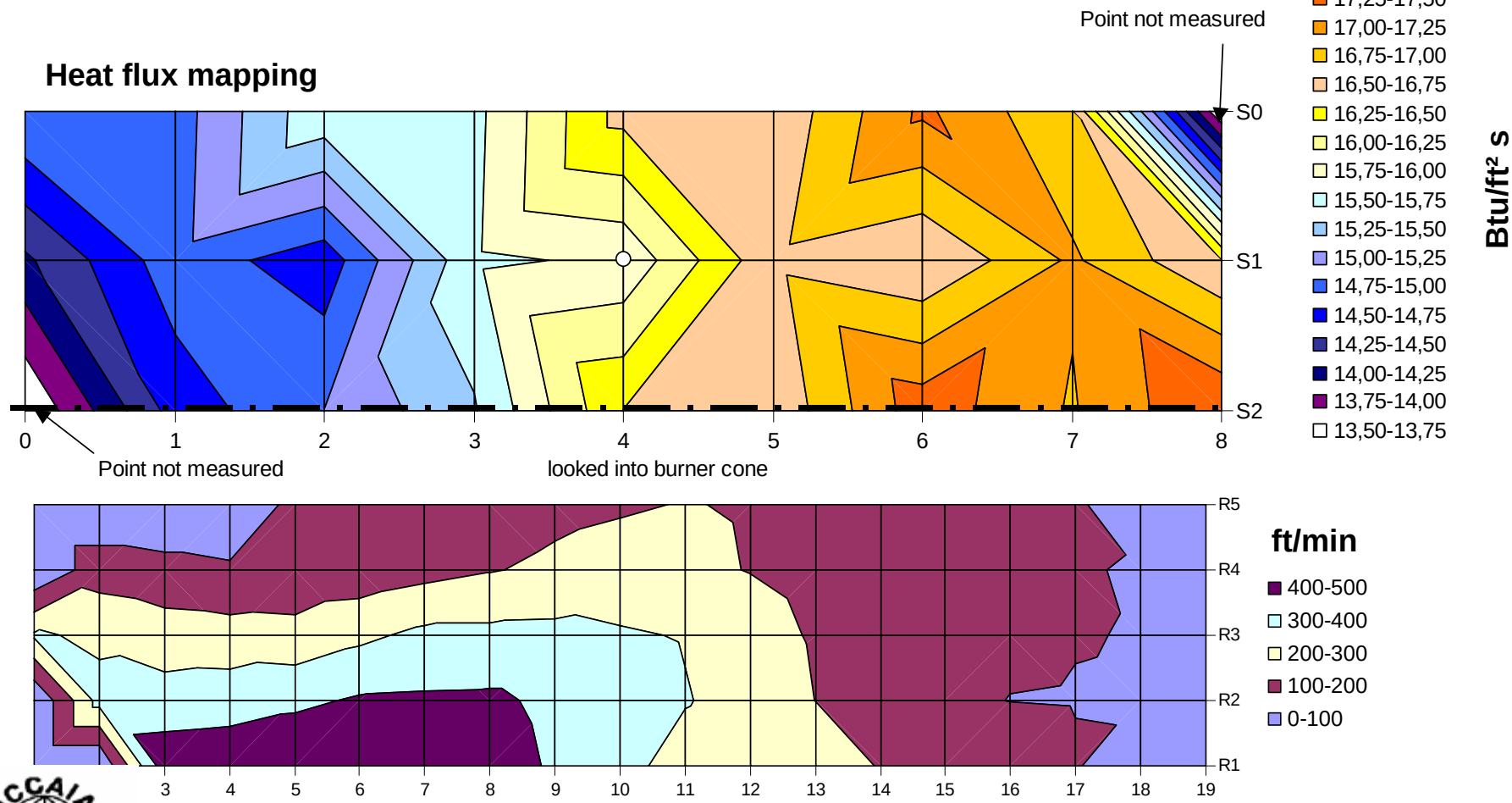
Correlation: Air distribution – Heat flux ?

Point S1 - 4: Calibration Point

Line S2: Burner Cone Center Line

Line S0: Additional measured line

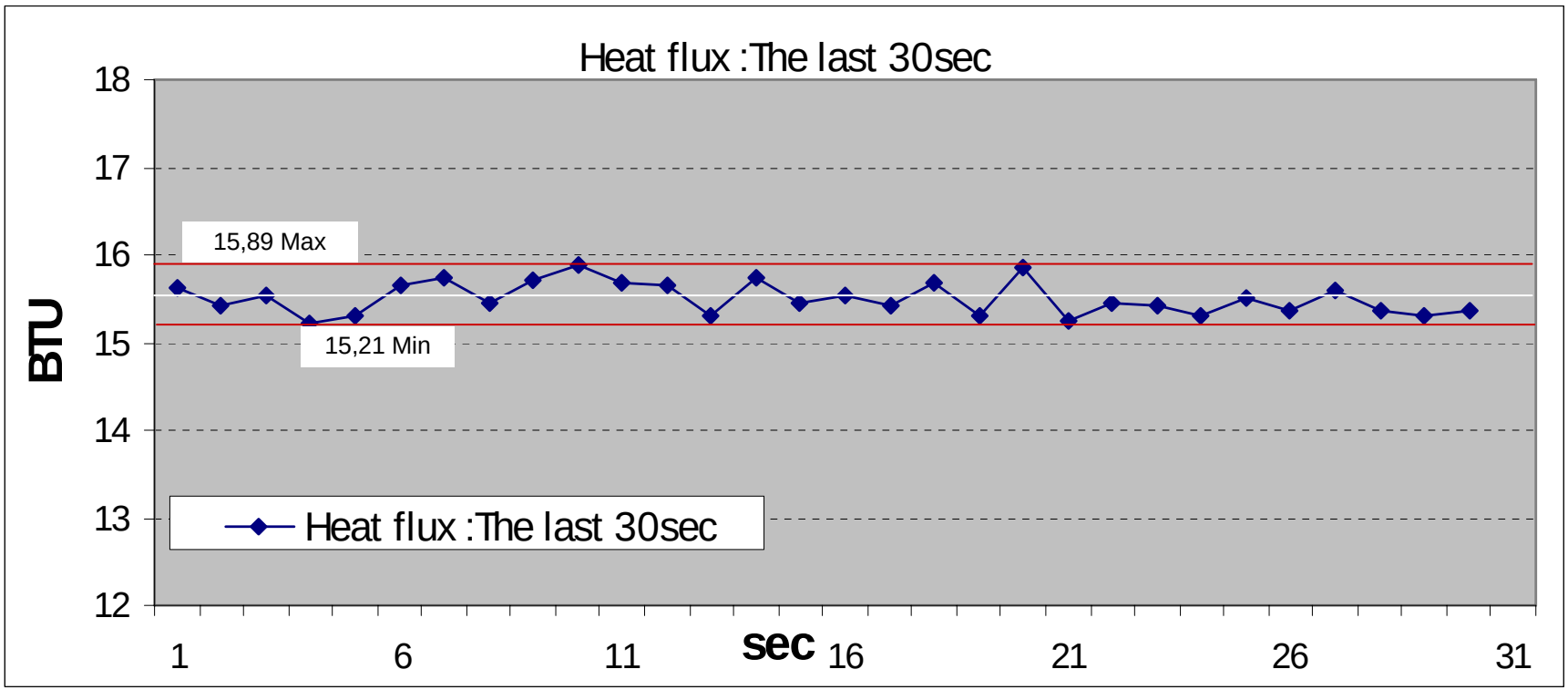
Mapping done after testing



Airbus Evaluation of Fire Performance Parameters

Heat Flux Calibration

Results with new Airbus-Küppersbusch burner



Objectives

- Find a solution that is economically viable, reliable, repeatable and available, and equipment and process definition that can be used for testing to show compliance to the “burnthrough” rule … acceptable to Aircraft Certification Offices

- Identify a commercially available industrial burner that…
  - is readily available to all participants
  - is economical
  - is designed for the amount of expected flame output
  - is developed by specialists in ignition, calibration, and combustion
  - has repeatable performance based on SQC tools (3 sigma) (using statistical control experts to validate)

Burner in Operation

Improved Equipment with Stable Flame

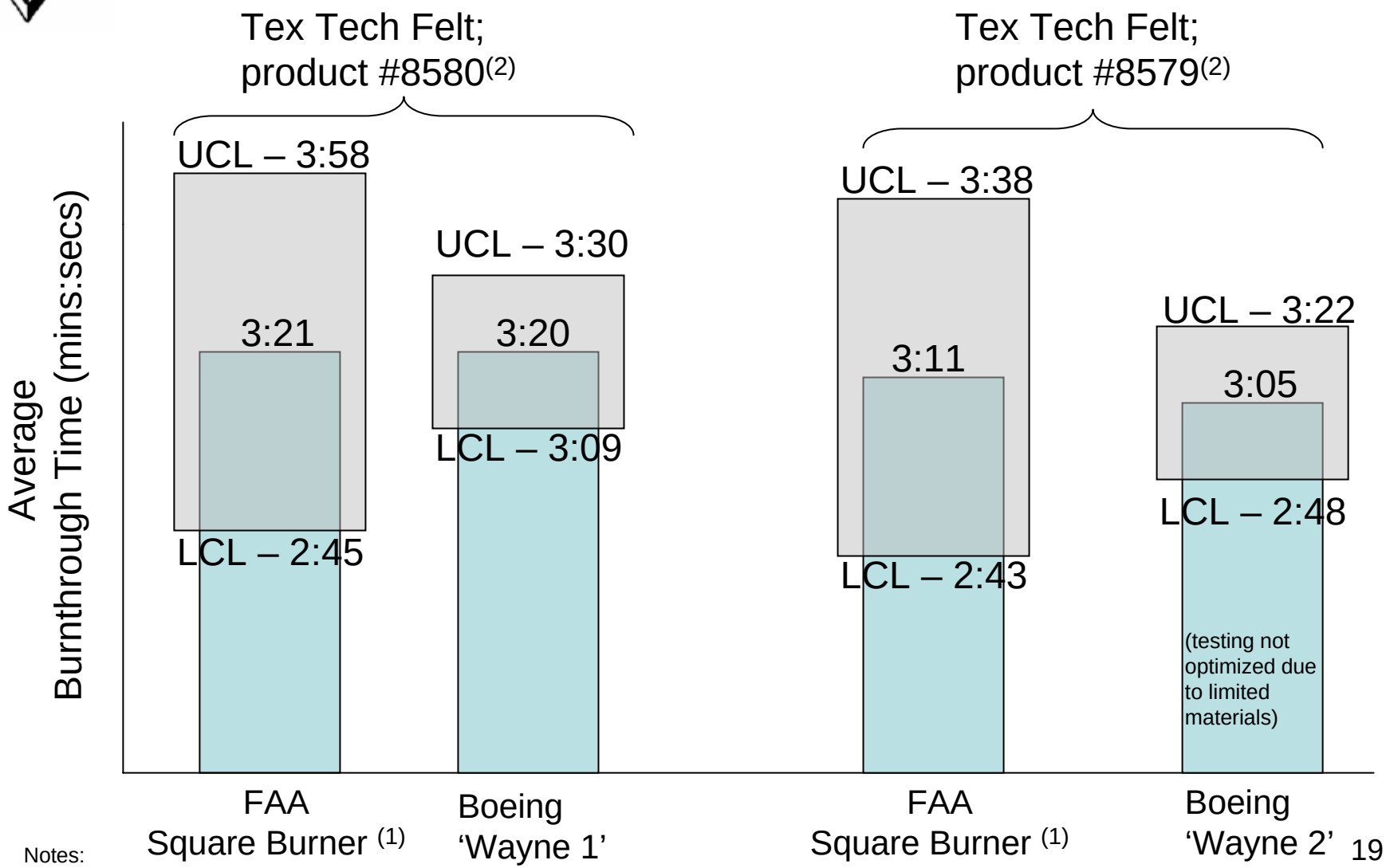
‘Sierra’ Hot Wire Anemometer

- Precisely measure airflow to adjust for repeatable burner results

Summary of Results

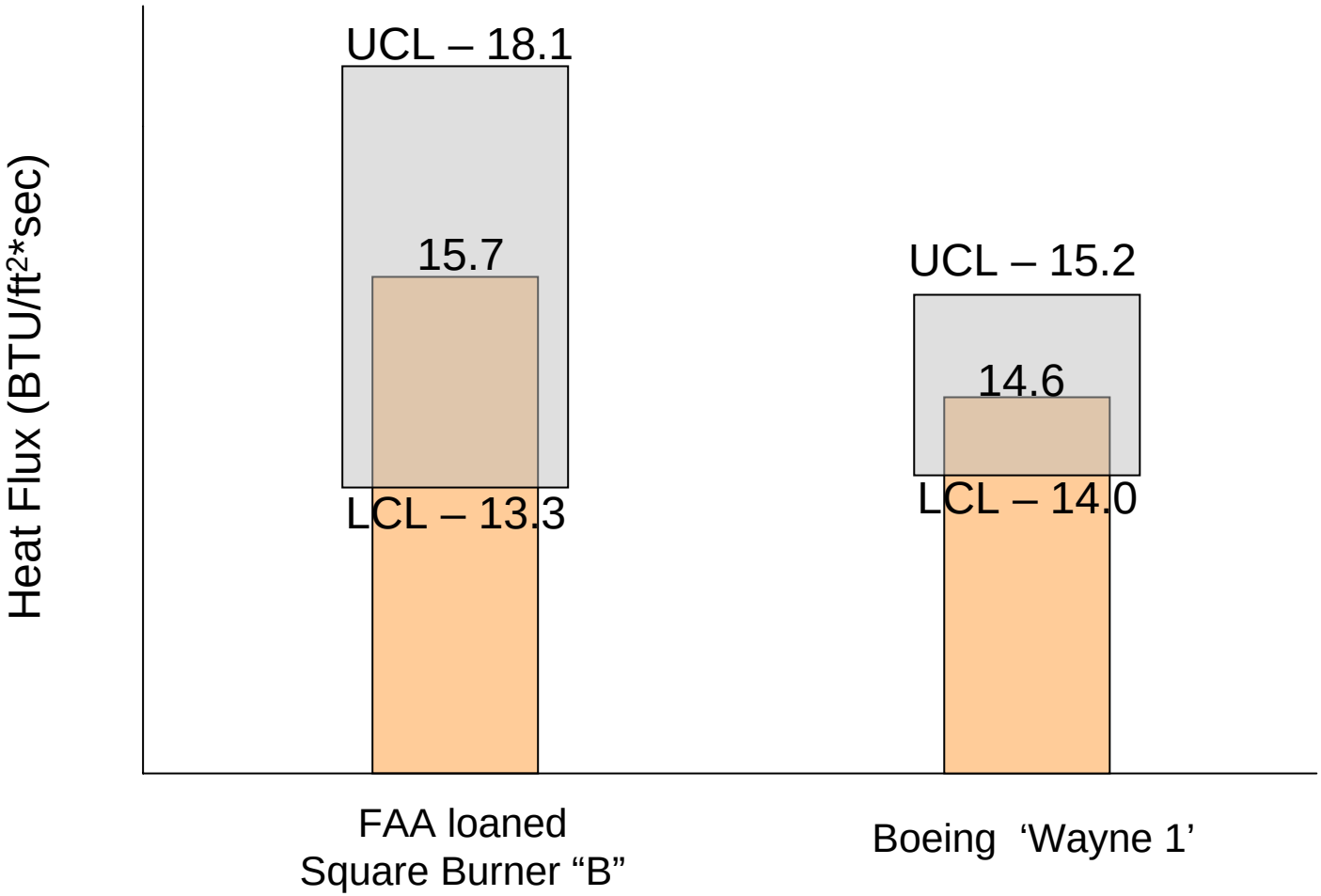
- Similar burnthrough times achievable when comparing to Tech Center's burner with a common felt material
- To date, the 'Wayne' burners (first and second units) have been set-up and have been shown to have matching, consistent and repeatable performance within desired variation (less than +/- 5 percent)
- One 'Carlin' burner has been tested and has been demonstrated to perform (also within +/- 5 percent) near the average of FAA burner on felt materials with consistent performance
- The burners have shown …
  - to match FAA TC Square Flange burner average burnthrough times of the available standard felt within a few seconds
  - to perform with substantially less variation in burnthrough times for the TEXTECH felt
  - that the heat flux is within statistical control (no trend over time, stable) as compared to the Park burners for this operating range

Similar BT times achieved



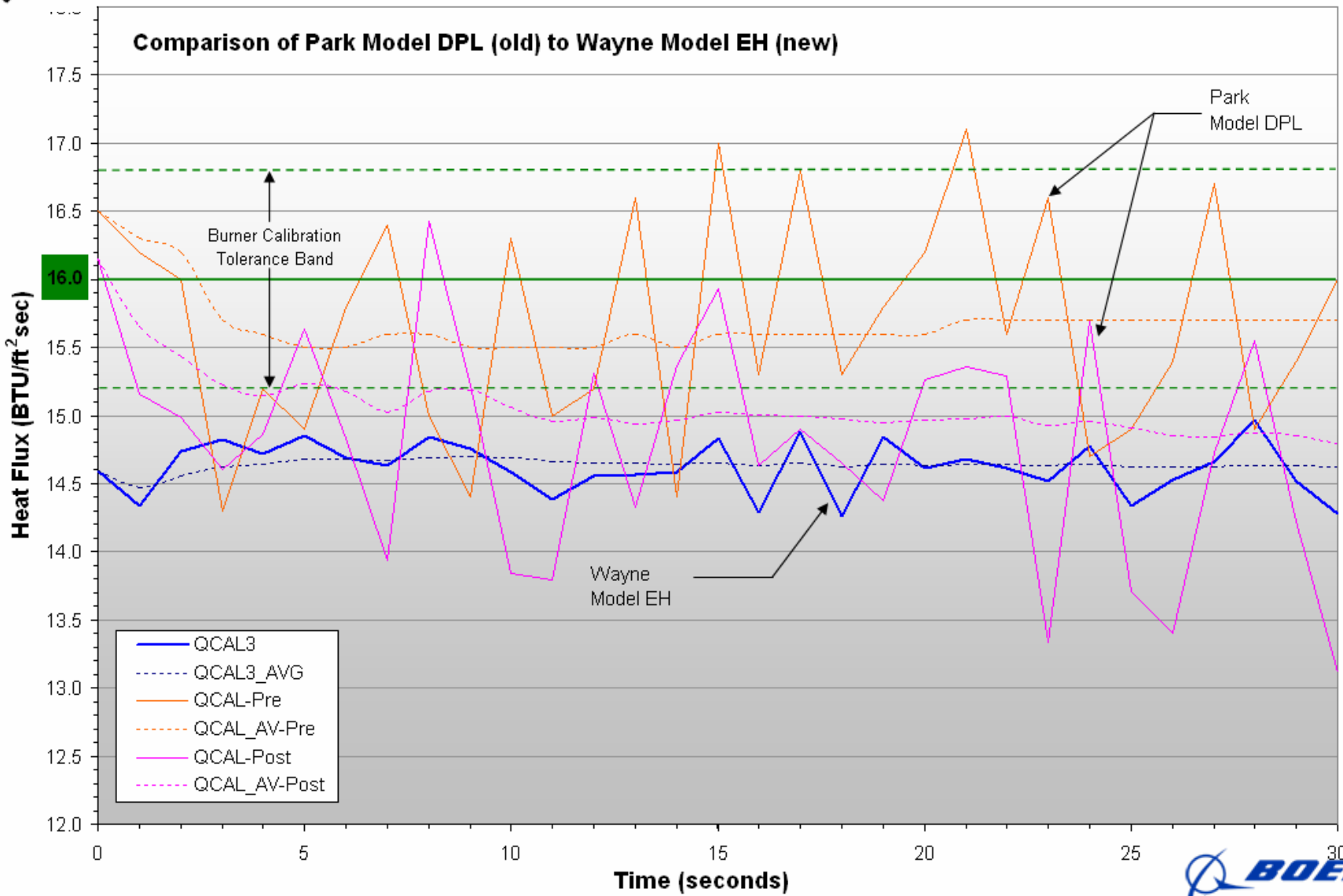
Notes:
(1) Data as obtained and compiled from International Aircraft Materials Fire Test Working Group, July 2006
(2) Tested on Pre-calibration felts in August, prior to Hot Wire Anemometer

Improved Heat Flux Variation



Boeing Evaluation Commercially Available Burners

Heat Flux Calibration Comparison



Boeing DOE Parameters

- The purpose of the experiment was to determine which variables have a large influence on the Burnthrough time consistency
- Factors considered:
  - Intake air temperature (~40 degrees F; ~70 degrees F)
  - Exhaust hood volume rate (~1200 CFM, ~5000 CFM)
  - Nozzle depth (Min/max of burner)
  - Nozzle copy ((2) qty. Delevan 6GPH, 80°, Solid spray pattern nozzles)
  - Fuel Pressure (95 PSI, 105 PSI)

Boeing DOE Results

- Major influences:
  - Fuel Nozzle reproducibility (up to 3.5 minute range (+/- 3 std dev) influence)
    - Variable causing the most significant impact on burn-through times
    - Unexpected since same quality nozzle would theoretically yield consistent results
- Minor influences:
  - Nozzle Depth (up to 48 second range (+/- 3 std dev) influence)
    - Amount of air being processed through burner changed by nozzle depth.
  - Unknowns (up to 50 second range (+/- 3 std dev) influence)

    Potential sources (Refine with future DOE?):
    - Felt quality
    - Fuel temperature
    - Other?
  - Exhaust Hood
  - Fuel Pressure
  - Air flow (however can be used to compensate for major influences)

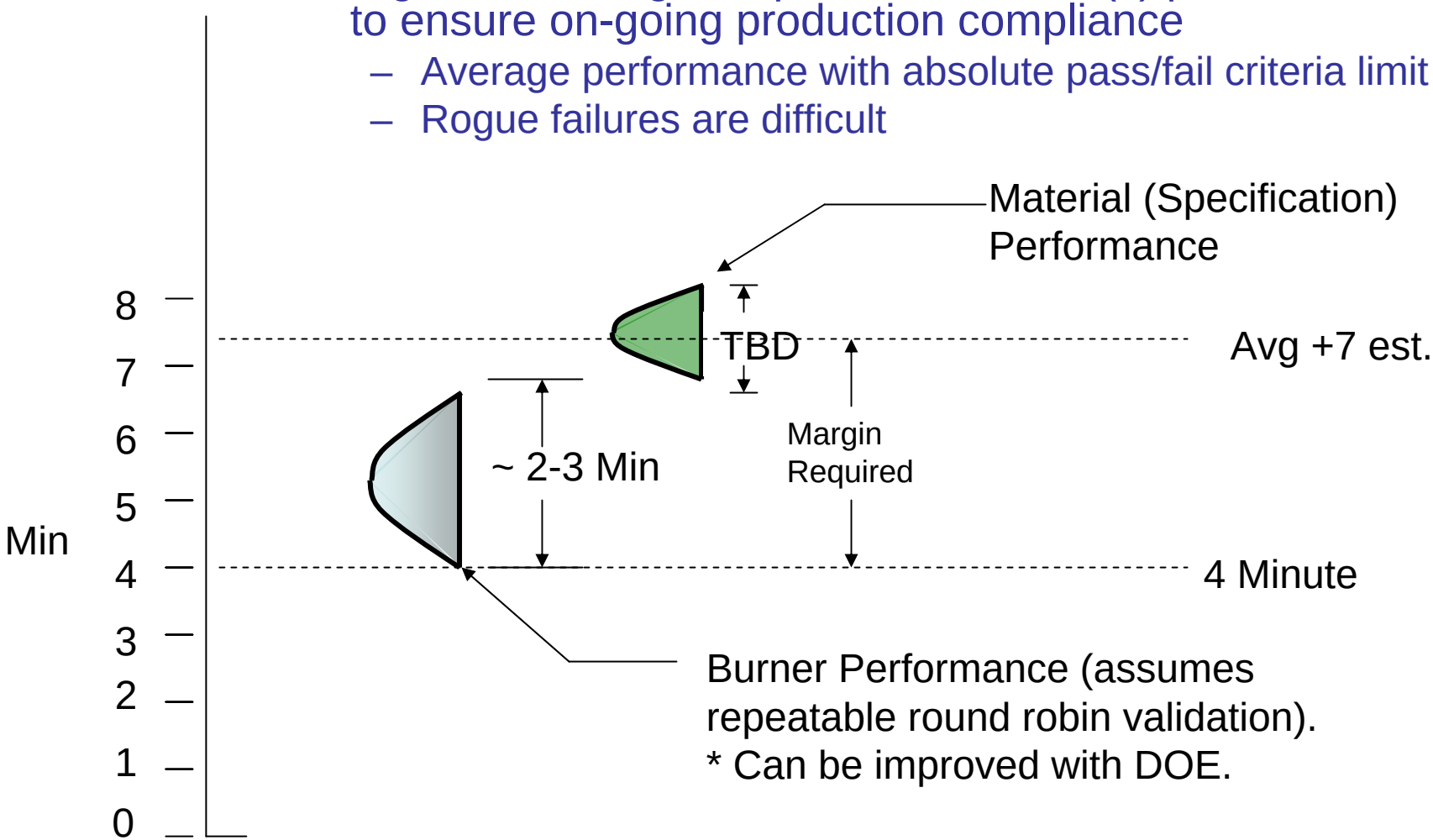
  - Intake Air Temperature/barometric condition

Common Learning's and Issues

- Heat flux and temperature calibration methods not adequate to define flame. More precision required.
  - Heat flux and temperature only good to approximate performance
  - 'Forcefulness' of output flame, slight mfg differences in equipment/nozzles and airflow believed to cause differences in results; these are not controllable features nor defined performance parameters
  - Alternate calibration methods being pursued: Felt(s), Paper(s) and new methods (frangible conductor). Awaiting confirmation of plans/schedules.
  - Calibration of existing FAA TC burner performance does not transfer across material types due to variation of its performance
- Precise airflow control required to compensate for small changes in fuel nozzles, air quality, settings, internal differences, etc.
- Design of Experiment isolates high influence test equipment, methods and process variables
  - Needed to better interpret and control variation of test results.
  - Necessary to minimize test result failures due to test equipment variation.
  - Necessary to minimize test result failures due to material variation.

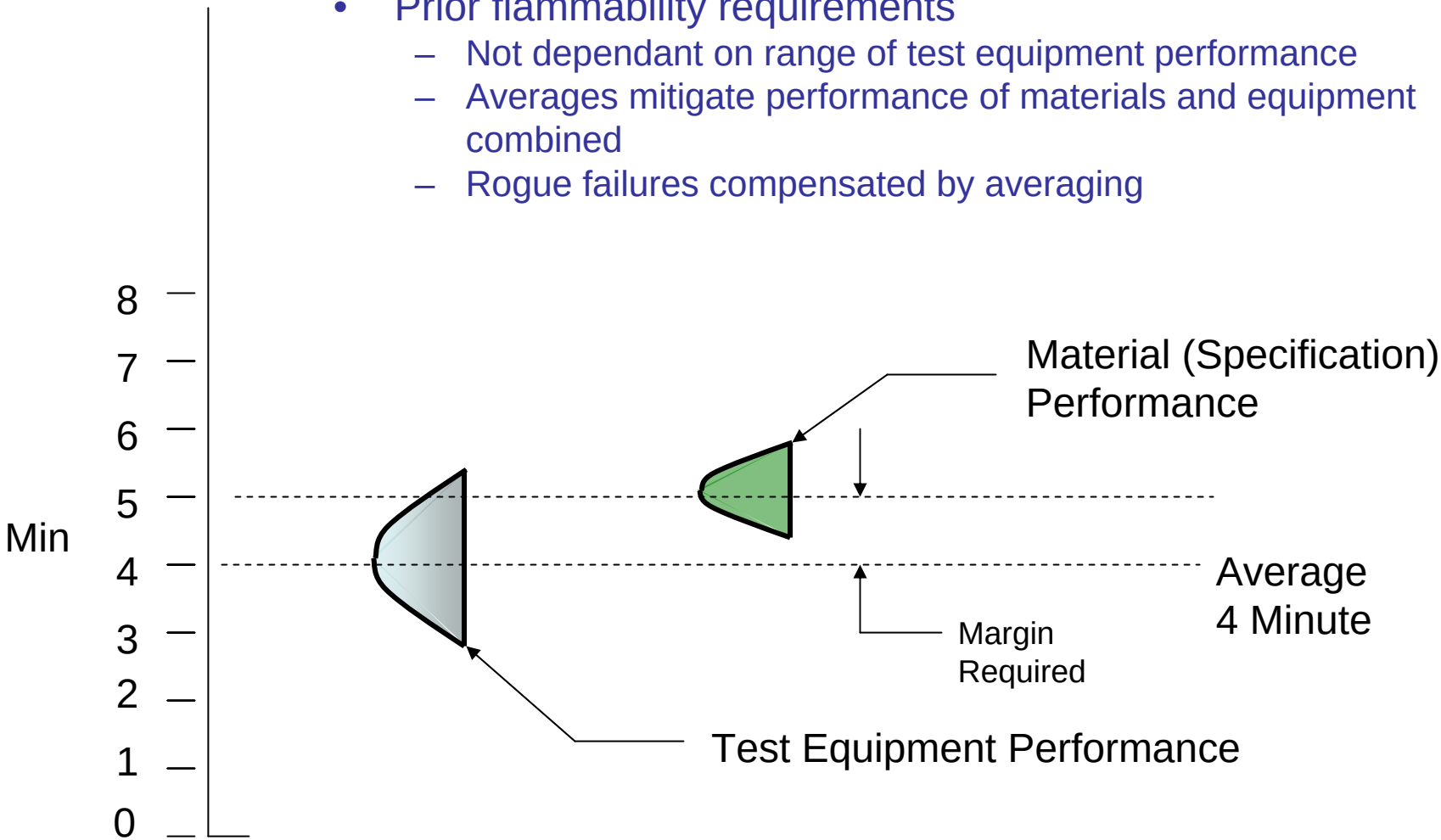
Common Learning's and Issues

- Significant margin required in material(s) performance to ensure on-going production compliance
  - Average performance with absolute pass/fail criteria limit
  - Rogue failures are difficult



Common Learning's and Issues

- Prior flammability requirements
  - Not dependant on range of test equipment performance
  - Averages mitigate performance of materials and equipment combined
  - Rogue failures compensated by averaging

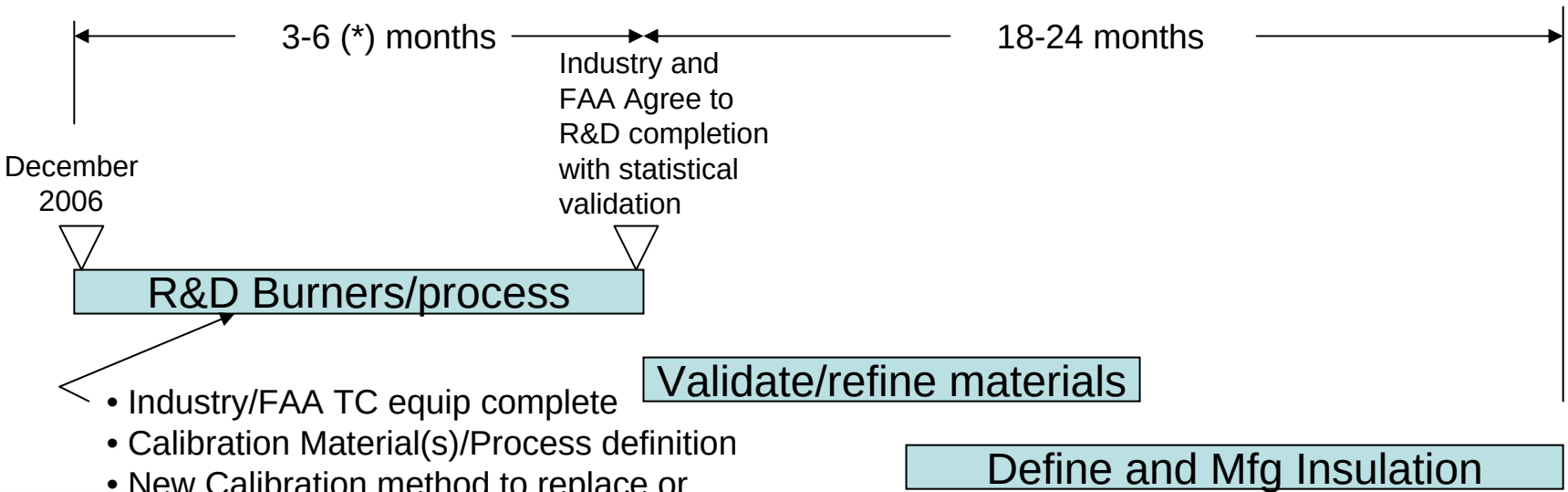


Schedule Risks

- Awaiting completion of following R&D tasks:
  - Validated repeatable and reproducible performance of the sonic nozzle burners in various test labs
    - Guidance needed for calibration methods and objectives to correlate performance including average performance and performance within a range across materials
  - Documentation of sonic burner test equipment setup, validation, maintenance, and required alterations (fuel supply) … for ACO acceptance
  - Improved pass/fail and rogue specimen criteria better correlating to past fire testing process and known randomness of material fire test results

Summary

- **Industry is supporting R&D to provide burners acceptable (to industry) for production (QC) and potentially for FAA certification purposes**
- **Several R&D issues are yet to be fully resolved: fuel nozzle, calibration methods, materials and documented processes.**
- **Solutions must be validated by statistical methods with round robins to ensure performance.**
- **Need agreement that R&D is complete.**
- **Insulation solutions can be validated after burners are accepted and available**
- **18-24 months are required after burners are accepted and available to support production incorporation of 25.856 (b) insulation materials**



(*) May be improved with successful sonic burner validation