Next Generation Fire Test Burner for Powerplant Fire Testing Applications

International Aircraft Systems Fire Protection Working Group
Atlantic City, NJ
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http://www.fire.tc.faa.gov

Background

- **Numerous FAR's mandate fire protection in aircraft powerplant fire zones**
  - Parts 23, 25, 27, 29, 33…
  - FAR Part 1 Section 1.1 – Definitions and Abbreviations
    - Fireproof--
      - (1) With respect to materials and parts used to confine fire in a designated fire zone, means the capacity to withstand at least as well as steel in dimensions appropriate for the purpose for which they are used, the heat produced when there is a severe fire of extended duration in that zone;
      - (2) With respect to other materials and parts, means the capacity to withstand the heat associated with fire at least as well as steel in dimensions appropriate for the purpose for which they are used.
    - Fire resistant--
      - (1) With respect to sheet or structural members means the capacity to withstand the heat associated with fire at least as well as aluminum alloy in dimensions appropriate for the purpose for which they are used; and
      - (2) With respect to fluid-carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls, means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.
  - No definition of test method, apparatus, or criteria
  - Advisory material has been used to define these test parameters

Background

- **Advisory Circulars and FAA Reports:**
  - Power Plant Engineering Report No. 3A, Standard Fire Test Apparatus and Procedure (For Flexible Hose Assemblies), Revised March 1978
    - Acceptable fire test burners listed in Appendix III:
      - Lennox OB-32 (not available)
      - Carlin 200 CRD (not available)
      - Stewart-Warner HPR 250 (not available)
      - Stewart-Warner FR-600 (not available)
  - AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria, 2/6/90
    - Acceptable fire test burners listed in sec. 6c:
      - Those listed in Appendix III of Powerplant Report 3A
      - SAE 401 Burner adjusted to 9.3 BTU/ft^{2}s (propane fueled burner)
      - Propane and oxy-acetylene torch-standard and diverging nozzles (for small components)

Background

- **Advisory Circulars and FAA Reports (cont.):**
  - FAA Aircraft Materials Fire Test Handbook (4/2000)
    - Chapter 11 specifies the oil burners listed above, plus
      - Park DPL 3400 (not available)
    - Chapter 12 specifies the oil burners above, including the Park DPL 3400
      - Chapter 12 Supplement, section 12.3.1 states:
        - » SAE AS401B Propane Burner is also acceptable provided the temperature profile and heat flux density conform to the specified requirements
  - AC 33.17-1A, Engine Fire Protection, 8/3/09
    - References Powerplant Report 3A and AC 20-135 for acceptable burners

- **All of these specified oil burners are no longer commercially available**

Background

- **Industry is left with the propane burner, which can be obtained and is typically preferred due to it’s consistency and ease of use**
  - Intent of regulations is to provide protection against an *engine* fire, with flames from aviation flammable fluids such as oil, jet fuel and hydraulic, not a propane flame
  - Propane and engine flammable fluid flames, despite having similar measured temperatures and heat flux, are fundamentally different
  - Propane will provide a less severe flame than an engine flammable fluid flame, due to the transparency of the propane flame vs. the opacity of engine flammable fluid flame
    - As test components approach the flame temperature, they begin to re-radiate due to the high surface temperature
    - Heat is lost readily from the hot surface through the transparent propane flame
    - Heat is not lost through the opaque engine flammable fluid flame

Background (cont.)

- **This difference has been recognized by the authorities**
- **FAA Tech Center Fire Safety Branch has been tasked by Transport Airplane Directorate to develop burner performance standards for the next-generation fire test burner for powerplant fire testing**
  - New burner should be much easier to calibrate, provide more consistent results, and be readily available for industry use.

A Roadmap to NextGen Burner Implementation for Powerplant Testing

Powerplants User Survey

Used to gain insight into current calibration/operating conditions. Additionally, requested test data will help to initially set NextGen burner settings.

Round Robin Testing

This initial round robin testing, along with the test data requested in the survey will aid in the initial setting of operating parameters of NextGen Burner.

Setting of NextGen Burner Parameters

Utilizing the test data obtained from Oil/Propane burner testing, NextGen burner parameters will be set. Testing will be conducted to compare NextGen with Oil/Propane burners.

Additional Round Robin/ NextGen Testing

Additional round robin testing with more advanced components will be conducted and compared with NextGen burner performance to help refine NextGen burner settings.

Report Publication

An FAA report will be published detailing the NextGen burner settings and performance characteristics. This report will also detail testing and calibration guidelines/procedures for the NextGen burner.

Revision of AC 20-135

Once a powerplants test method utilizing the NextGen burner has been defined and standardized, a revision of AC 20-135 and other regulatory material will be able to proceed.

Previous Work

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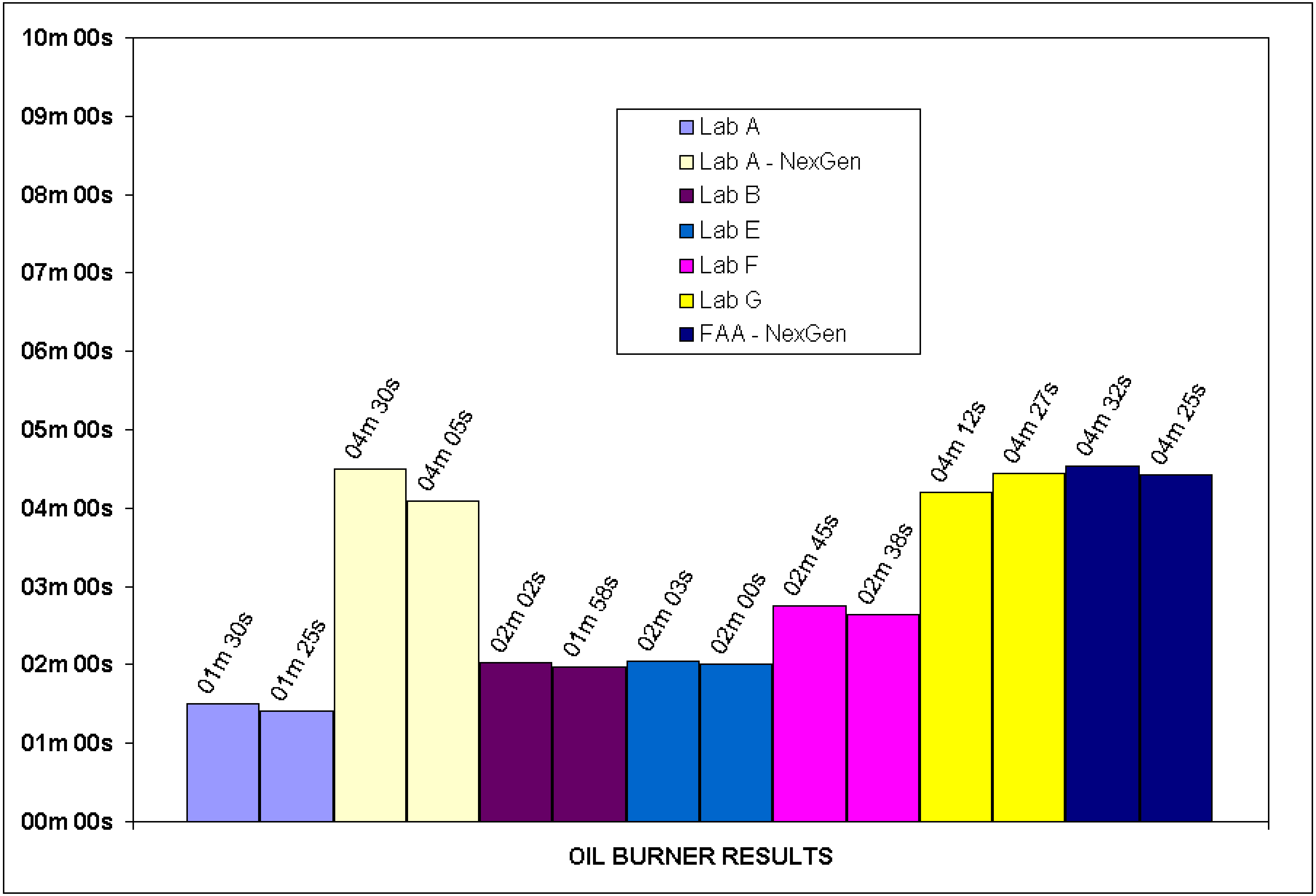
Previous Work

- **Round robin testing as part of the Powerplants User Survey resulted in initial burner configuration:**
  - 2.25 gph Delavan, Solid-Cone nozzle
  - Fuel pressure: 100-110 psi (pressure matched to obtain proper flow based on nozzle being used)
  - Fuel Temperature: 42º ± 10ºF
  - Air pressure: 40 psi
  - Air Temperature: 50º ± 10ºF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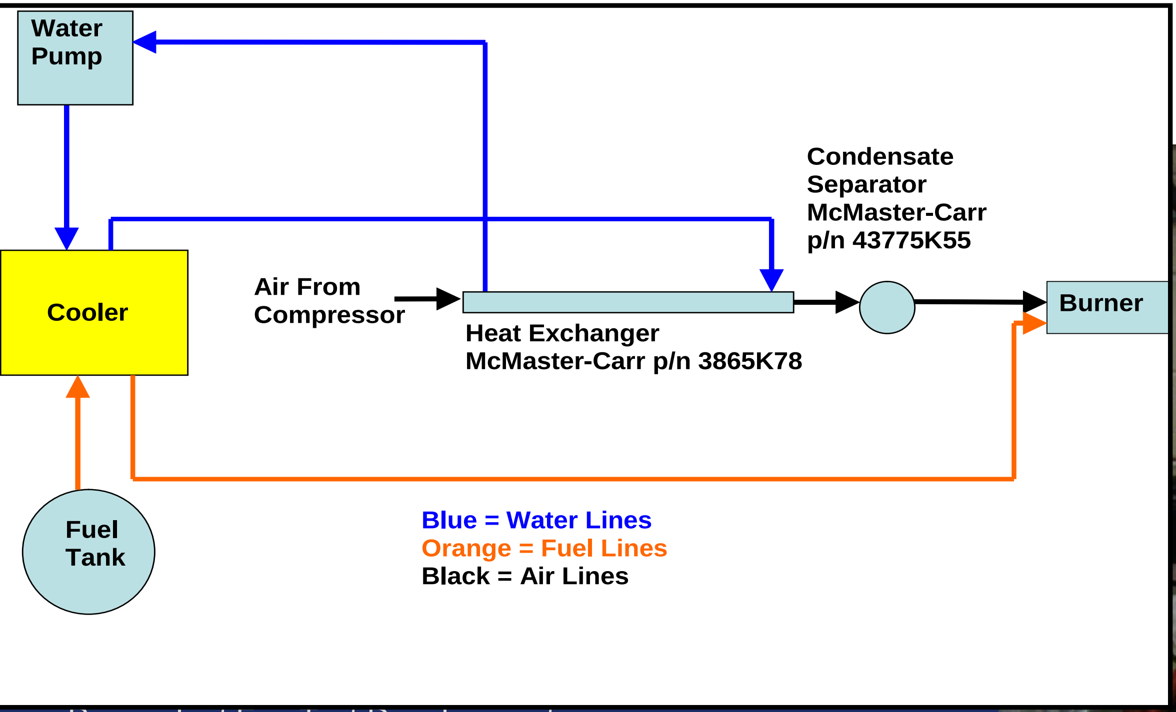
01m 58s
02m 03s
02m 00s
02m 45s
02m 38s
04m 12s
04m 27s
04m 32s
04m 25s
OIL BURNER RESULTS

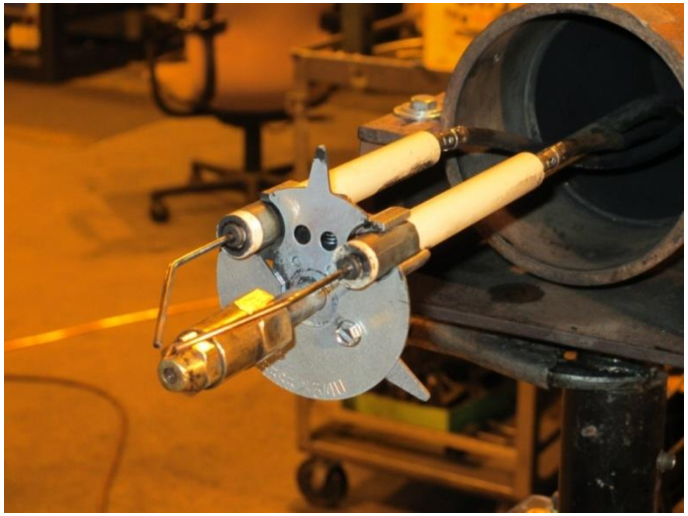
Update on Burner Configuration

- **Cooler/ice water bath has been replaced with a small (5.1 cu. ft.) freezer filled with a 50/50 mixture of antifreeze and distilled water.**
  - This eliminates the need for ice/water replenishment and provides consistent cooling for both the fuel/air lines.



Update on Burner Configuration

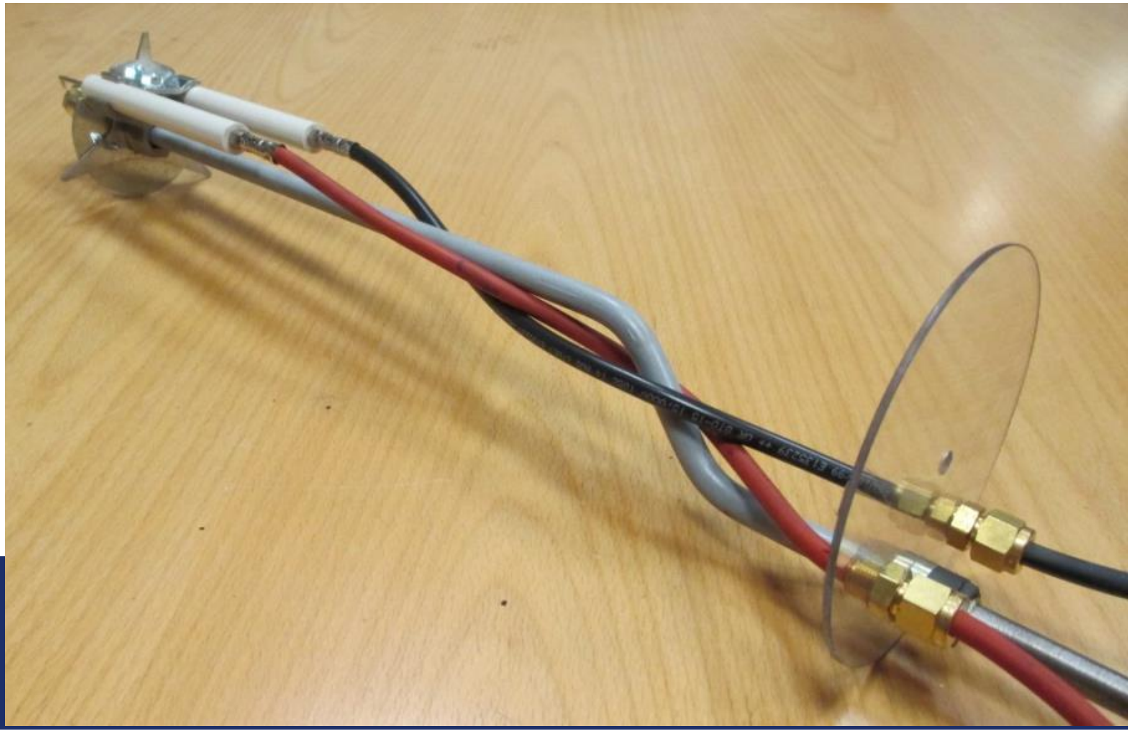
- **Flame Retention Head (FRH)**
  - **Eliminates the need for a stator and turbulator**
  - **Fits on end of burner draft tube with minimal modification**
  - **Parts purchased from local heating supply store for less than $50**
  - **Testing conducted for some of the materials fire tests has shown potential for improved test result repeatability as compared to stator and turbulator configuration**
  - **Initial testing on FAA Powerplants burner shows dramatic increase in uniformity of flame.**



Update on Burner Configuration – Ignition Wires

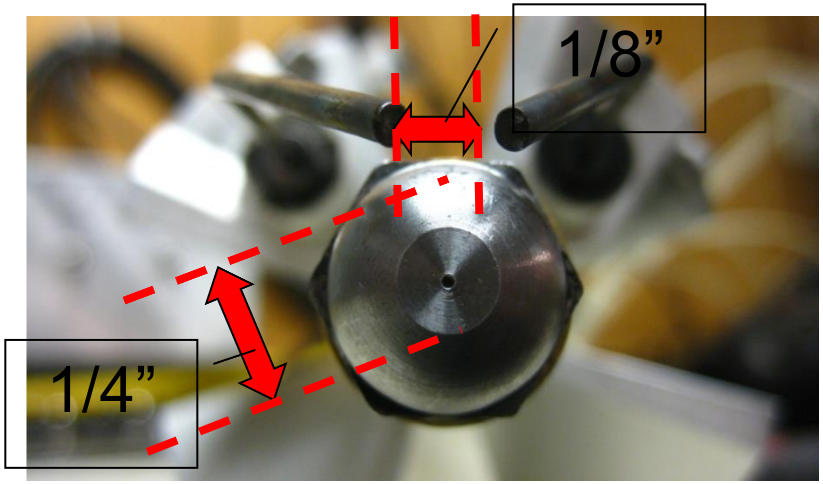
- **Standardized wire length and positions minimize airflow disturbance**

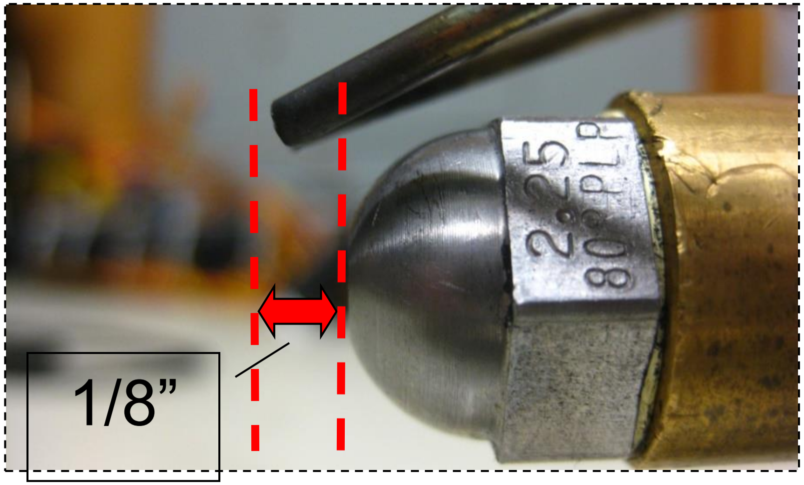
- **Standardized wire positions to minimize variability in burner performance and data results**



Update on Burner Configuration - Igniter Positions

- **Standardized igniter positions**
- **Gap between igniters**
  - 1/8”
- **Nozzle center to igniter**
  - 1/4"
- **Nozzle face to igniter**
  - 1/8”

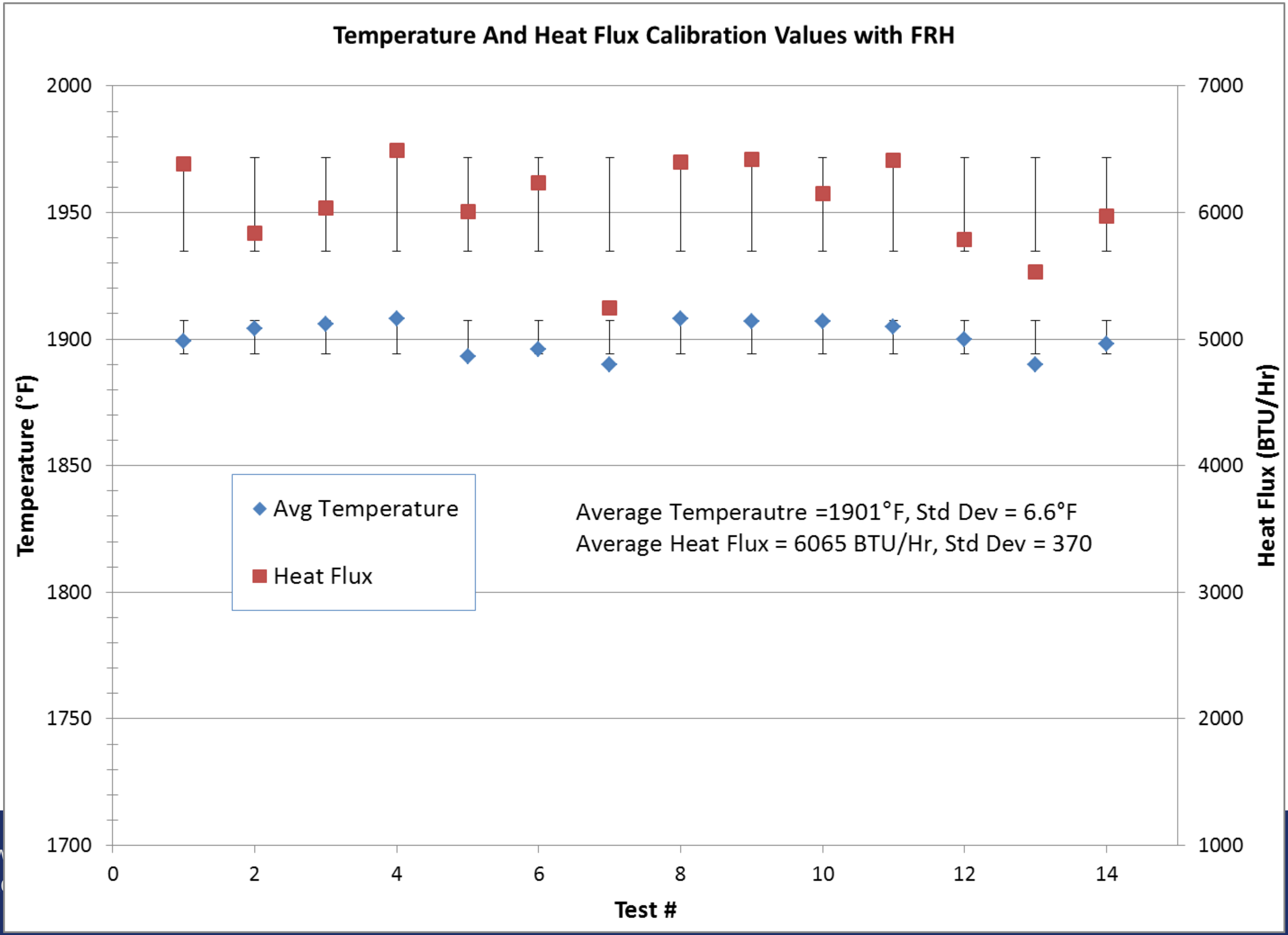




Current Burner Settings with FRH

- 2.5 gph Delavan, W (All-Purpose) nozzle
- Fuel pressure: 90-100 psi (pressure matched to obtain proper flow based on nozzle being used)
- Fuel Temperature: 42º ± 10ºF
- Air pressure: 50 psi
- Air Temperature: 50º ± 10ºF

Performance of Burner with Current Settings



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Current Status – Round Robin Testing

- **Round Robin testing is currently being initiated with various labs and burners (Park DPL 3400, NexGen, and other oil burners). Materials to be tested include:**
  - Slug Calorimeter
    - Sheet of copper with thermal absorptive coating, and thermocouple(s) on back face to determine heat flux
  - 2024 Aluminum Sheet
  - Double layer of 8611R Polyacrylonitrile (PAN)
- **Initial testing with FAA NexGen burner with FRH has shown consistent results with all three test materials.**
- **9 test labs participating in testing, 12 sets of material sent out**
  - 1 lab is conducting tests with Park and Nexgen, both under different lab conditions
- **Waiting for results from 5 test labs**
- **Once full results are received, data will be compared to FAA data, and burner settings will be adjusted as needed.**

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Current Status – AC 20-135

- **A sub-group had been formed with the goal of developing proposed rewording of AC20-135 in a parallel effort with NexGen burner development.**
  - Testing requirements (i.e. when/how to vibrate sample, orientation of sample, etc) and testing equipment (i.e. thermocouple type, heat transfer calibration device, etc) will be addressed.
  - Actual burner operation and calibration will be left open subject to burner development.
- **After initial sub-group meetings, it became evident that a more formal involvement from FAA was required and it was suggested that a proposal be submitted to the FAA from industry with the request that a formal group chartered for this task.**

Current Status – AC 20-135 (cont.)

- Dirk Kearsley (BAE Systems) has drafted this request and has submitted to FAA (6/2014).
- Work is currently underway to form an internal FAA group of experts and interested parties to develop a plan of action.
- Resulting chartered group will likely be managed through the existing Systems Fire Protection Working Group and Powerplants Fire Test Task Group

Questions

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