Next Generation Fire Test Burner for Powerplant Fire Testing Applications

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Steve Summer
Federal Aviation Administration
Fire Safety Branch
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

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**
  - Propane and jet fuel flames, despite having similar measured temperatures and heat flux, are fundamentally different
  - Propane will provide a less severe flame than a jet fuel flame, due to the transparency of the propane flame vs. the opacity of the jet fuel 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 jet fuel flame
  - Intent of regulations is to provide protection against an *engine* fire, which is a jet fuel flame, not a propane flame
- **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**

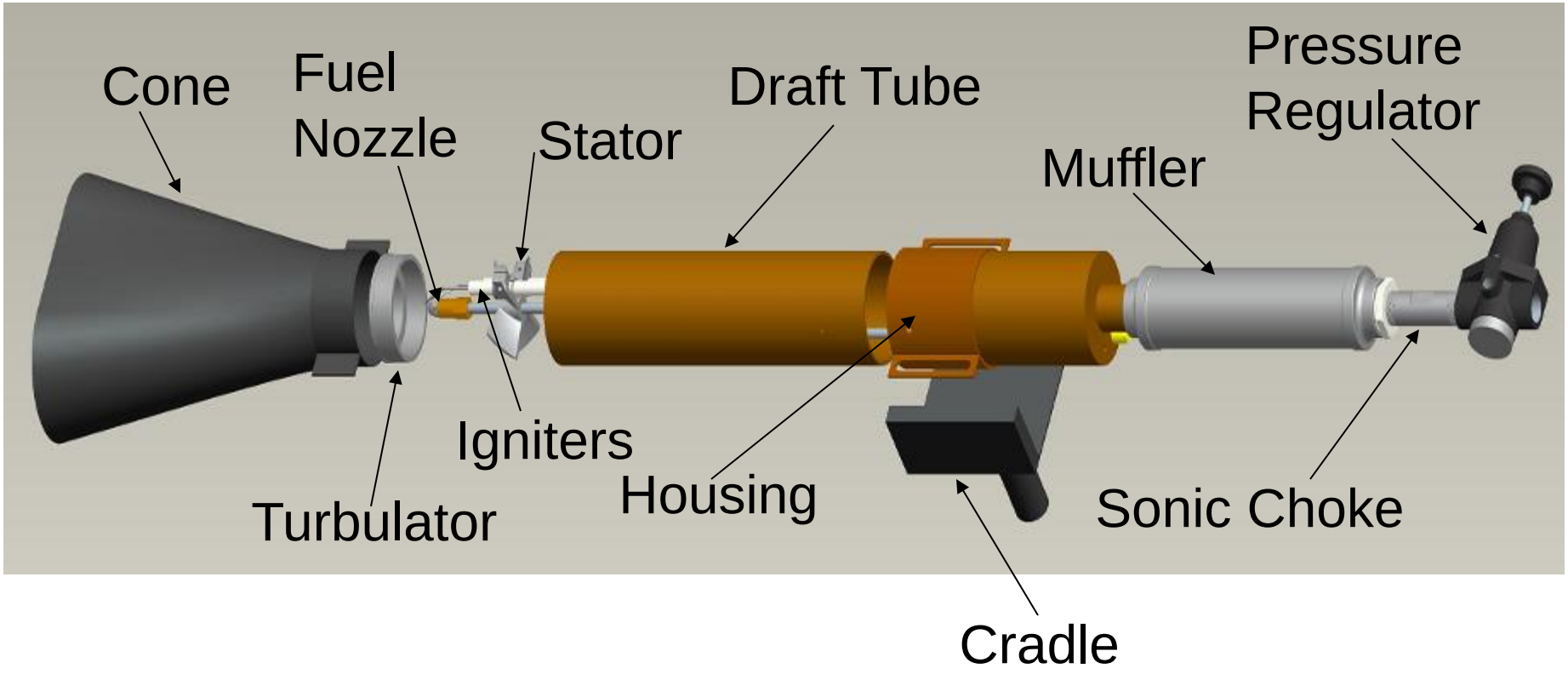
What is a NexGen Burner?

- **The next generation (NexGen) burner was designed by the FAA Technical Center to be used as an equivalent burner to the Park DPL 3400 which is no longer in production**
- **The NexGen burner relies on the same operating principles as the Park DPL 3400, which was designed for home heating purposes**
- **The NexGen burner uses compressed air and fuel to supply the burner, whereas the Park DPL 3400 uses an electric motor to spin a blower fan and mechanical fuel pump**
  - Air Flow Metering:
    - Park uses a butterfly throttle valve
    - NexGen uses a sonic orifice
  - Fuel Pressure
    - Park uses pressure regulator on pump
    - NexGen uses fuel tank head pressure
  - Both air and fuel temperature are restricted to a 20°F range by using an ice bath heat exchanger
- **Major advantages of a NexGen burner:**
  - Precise metering of inlet parameters
  - Can be constructed in-house with easily obtainable materials
  - Can be easily modified for future upgrades (as a result of FAATC research)

NexGen Burner Calibration

- **For the NexGen burner, the heat flux measurement is not as important to the calibration procedure**
  - Since all inlet parameters and burner dimensions are fixed, no adjustments can be made to achieve a specified heat flux
  - It has yet to be determined whether to completely eliminate the need for heat flux measurement, or to utilize it as a periodic check of burner performance
- **Flame temperature is measured and used to determine proper burner output**
  - 1/8” S.S. exposed bead K-type thermocouples
  - 7 TC’s, 4” from burner exit plane and 1” above exit cone centerline

NexGen Burner Components



NexGen Drawings

- **Drawings are available online at**

http://www.fire.tc.faa.gov

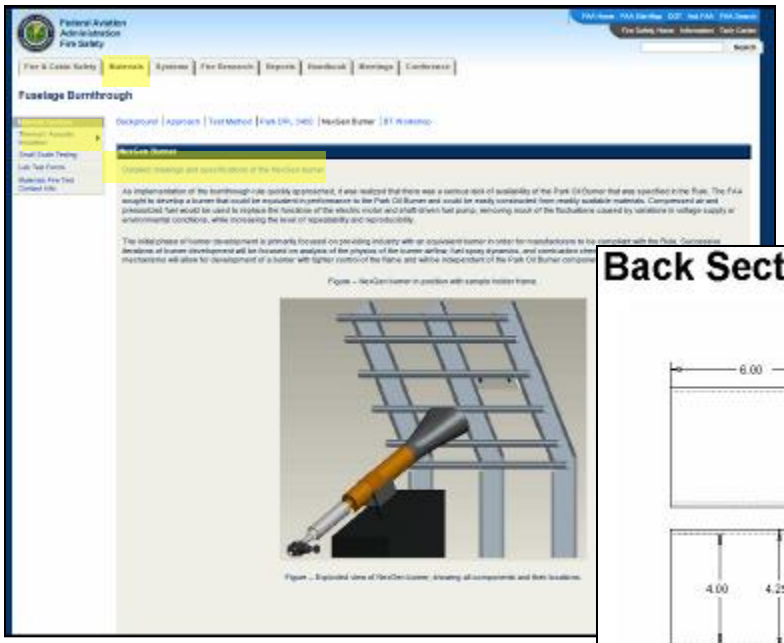
➢ ***Home***

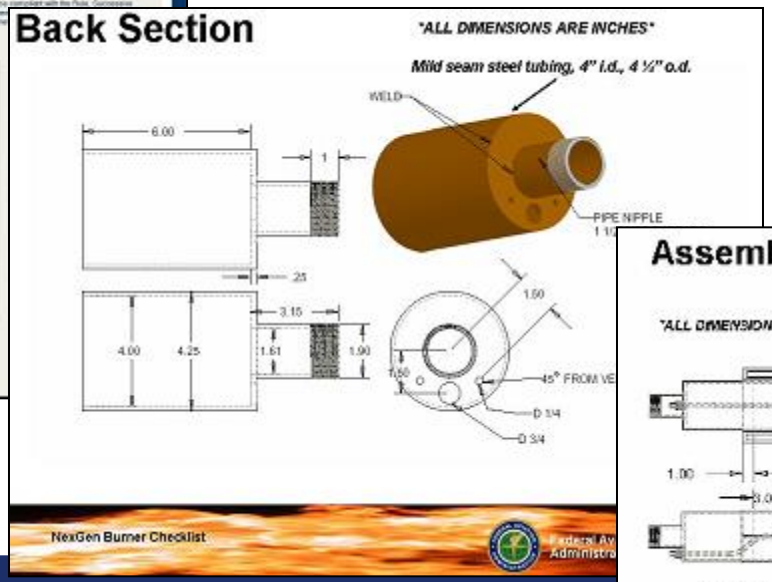
➢ ***Materials***

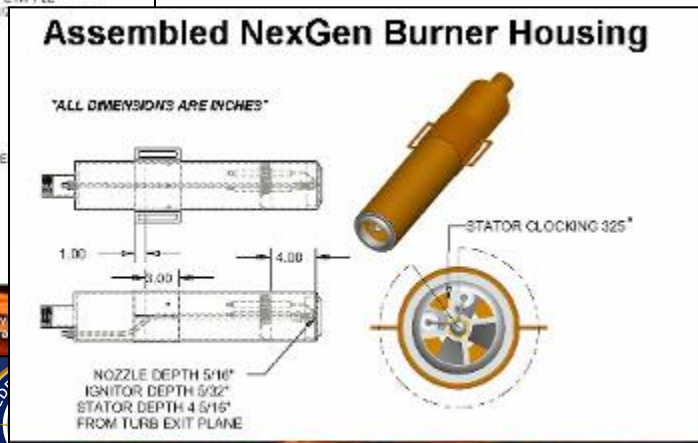
➢ ***Thermal/Acoustic Insulation***

➢ ***Burnthrough***

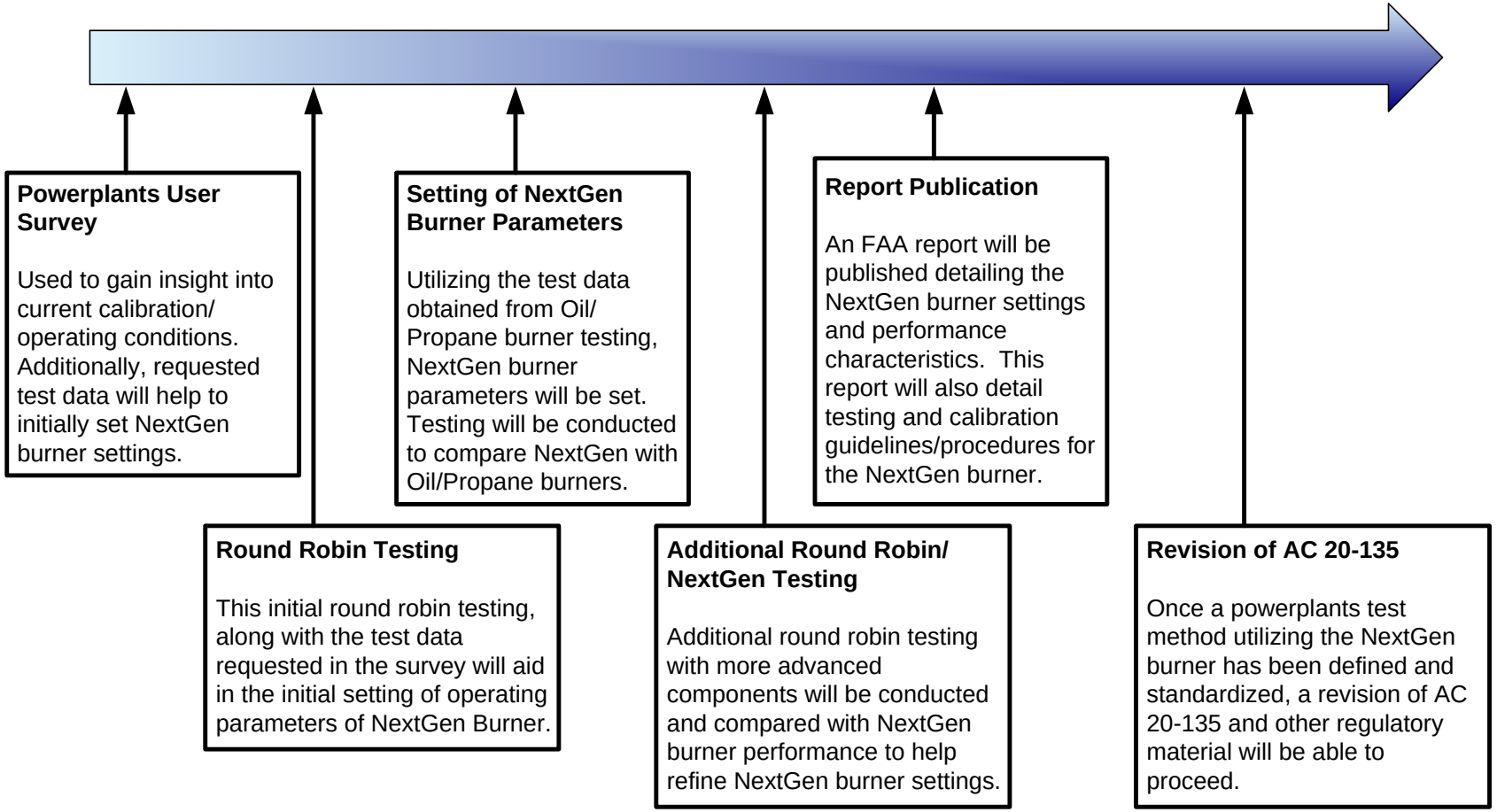
➢ ***NexGen Burner***



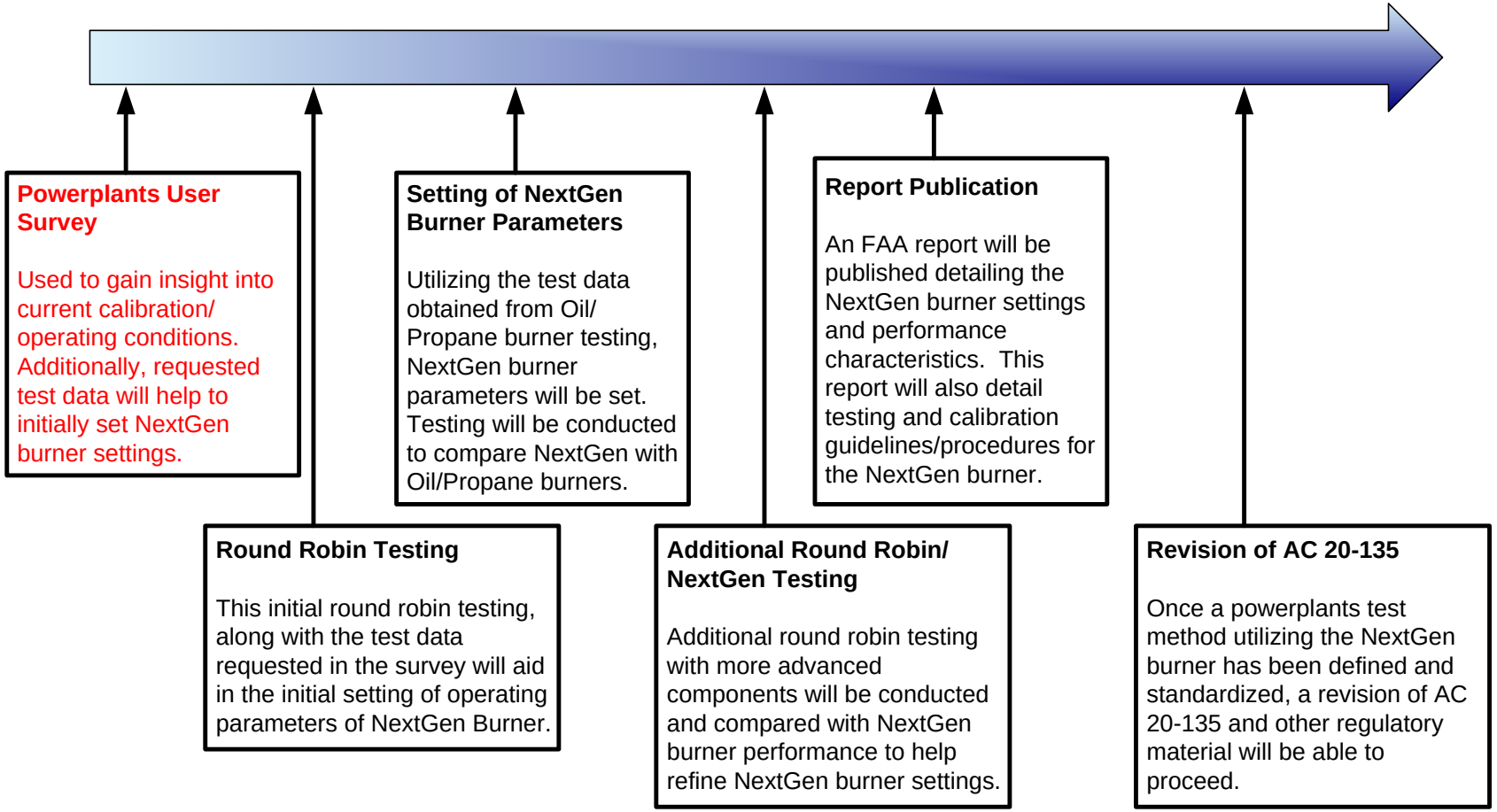




A Roadmap to NextGen Burner Implementation for Powerplant Testing

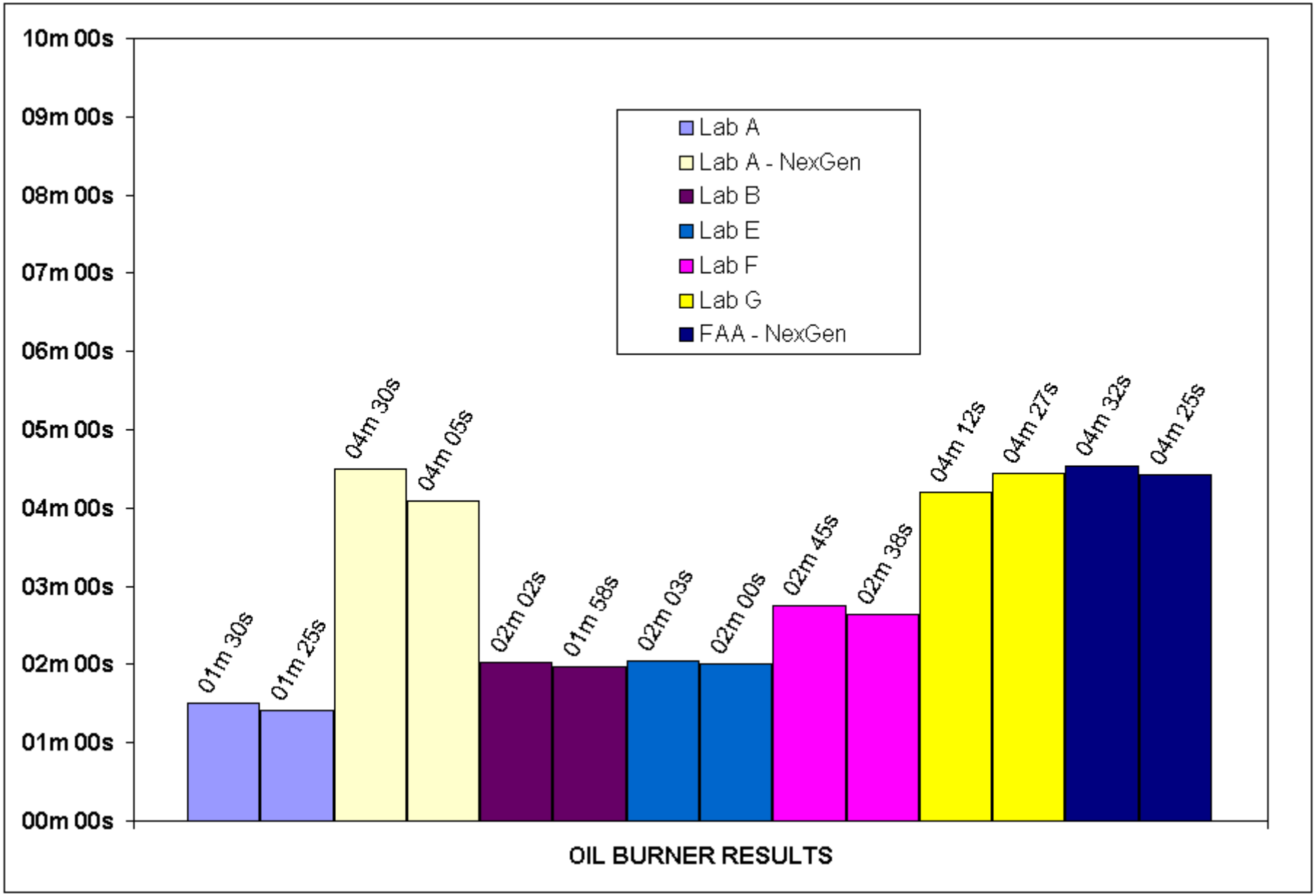


Previous Work



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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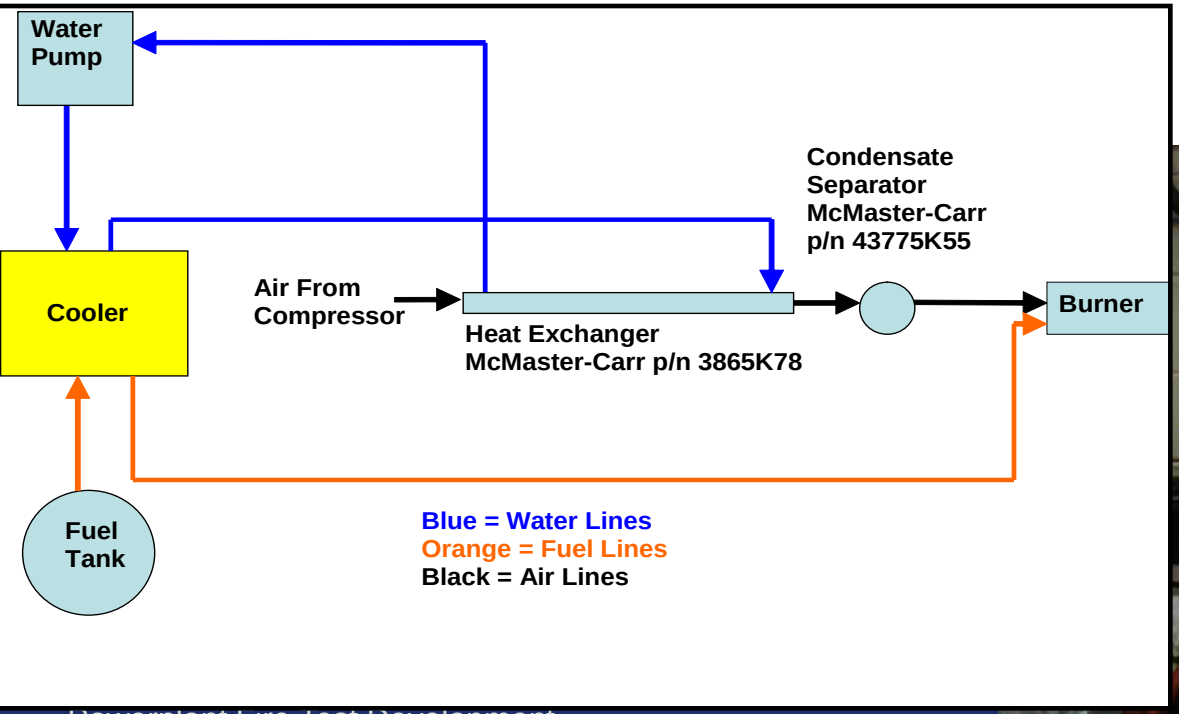
Lab A
Lab A - NexGen
Lab B
Lab E
Lab F
Lab G
FAA - NexGen
01m 30s
01m 25s
04m 30s
04m 05s
02m 02s
01m 58s
02m 03s
02m 00s
02m 45s
02m 38s
04m 12s
04m 27s
04m 32s
04m 25s
OIL BURNER RESULTS

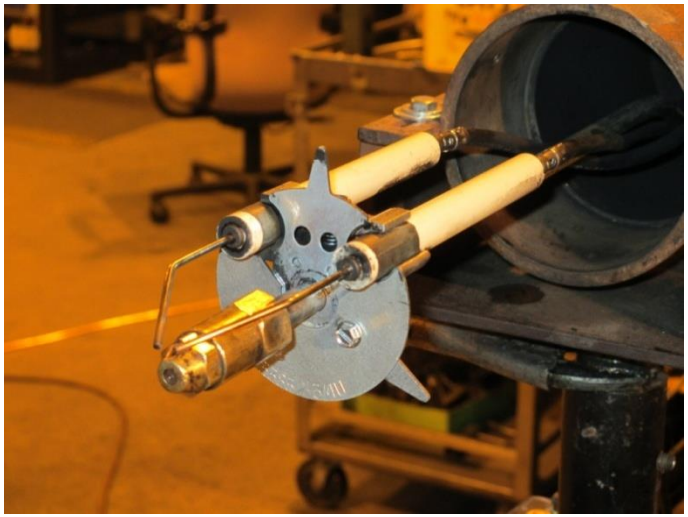
Update on Burner Configuration

- **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.



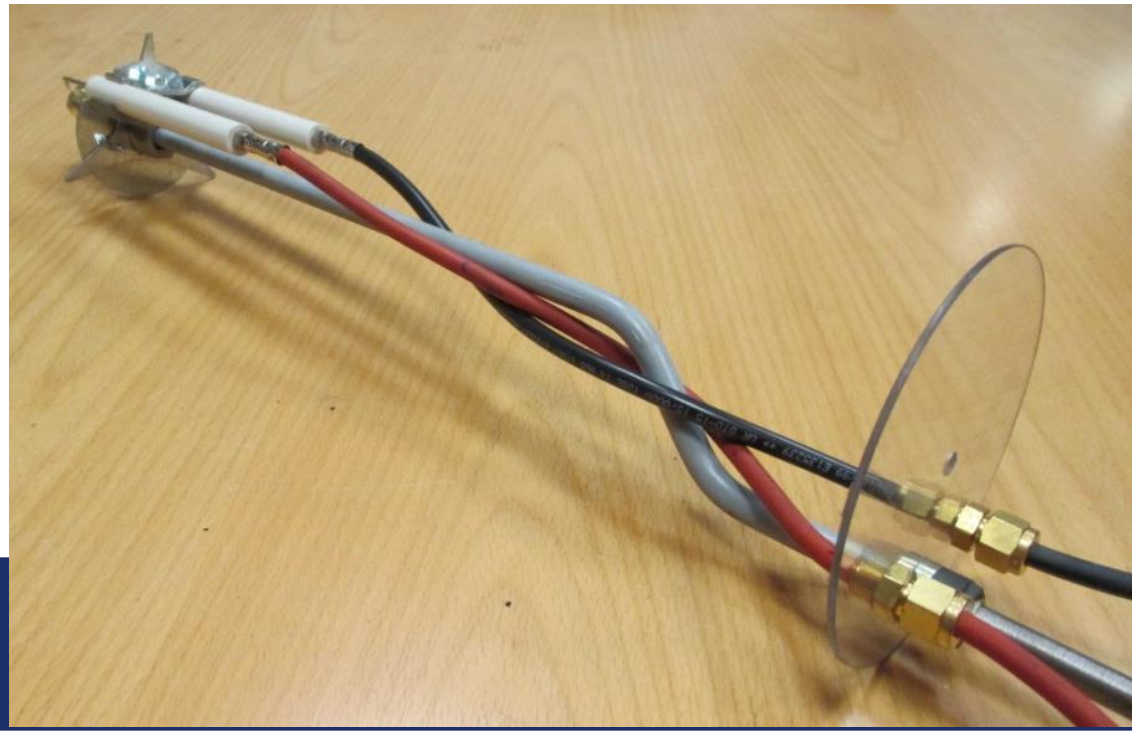
Update on Burner Configuration

- **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.**



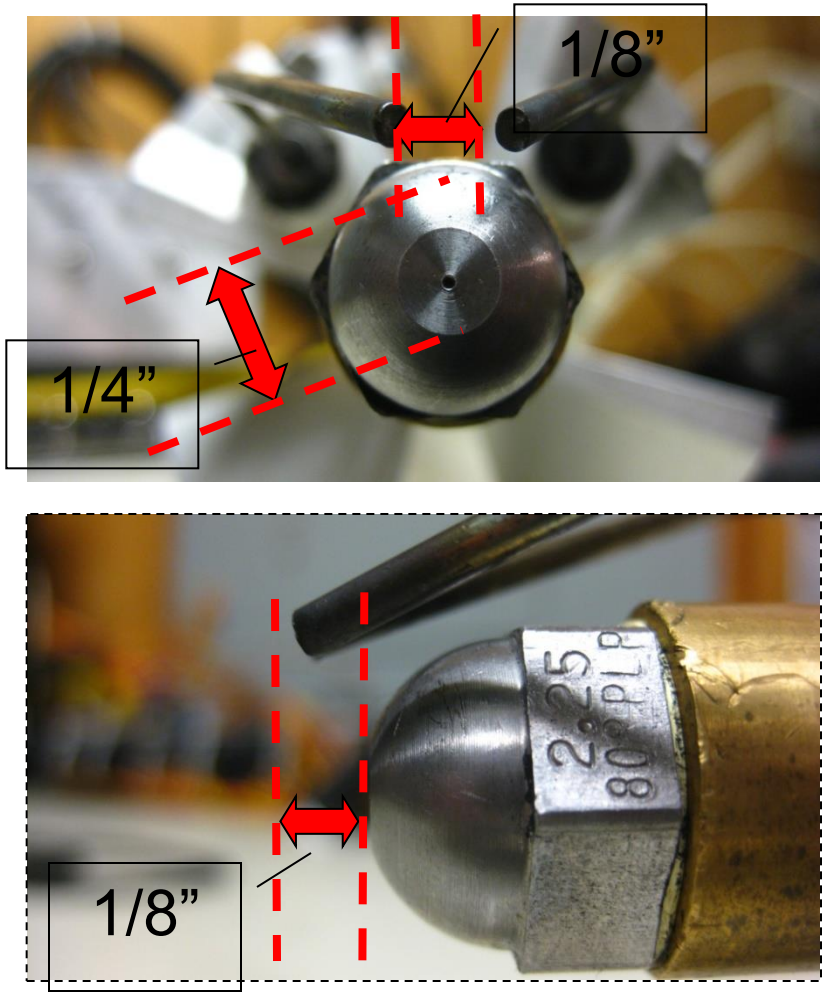
Update on Burner Configuration – Ignition Wires

- **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

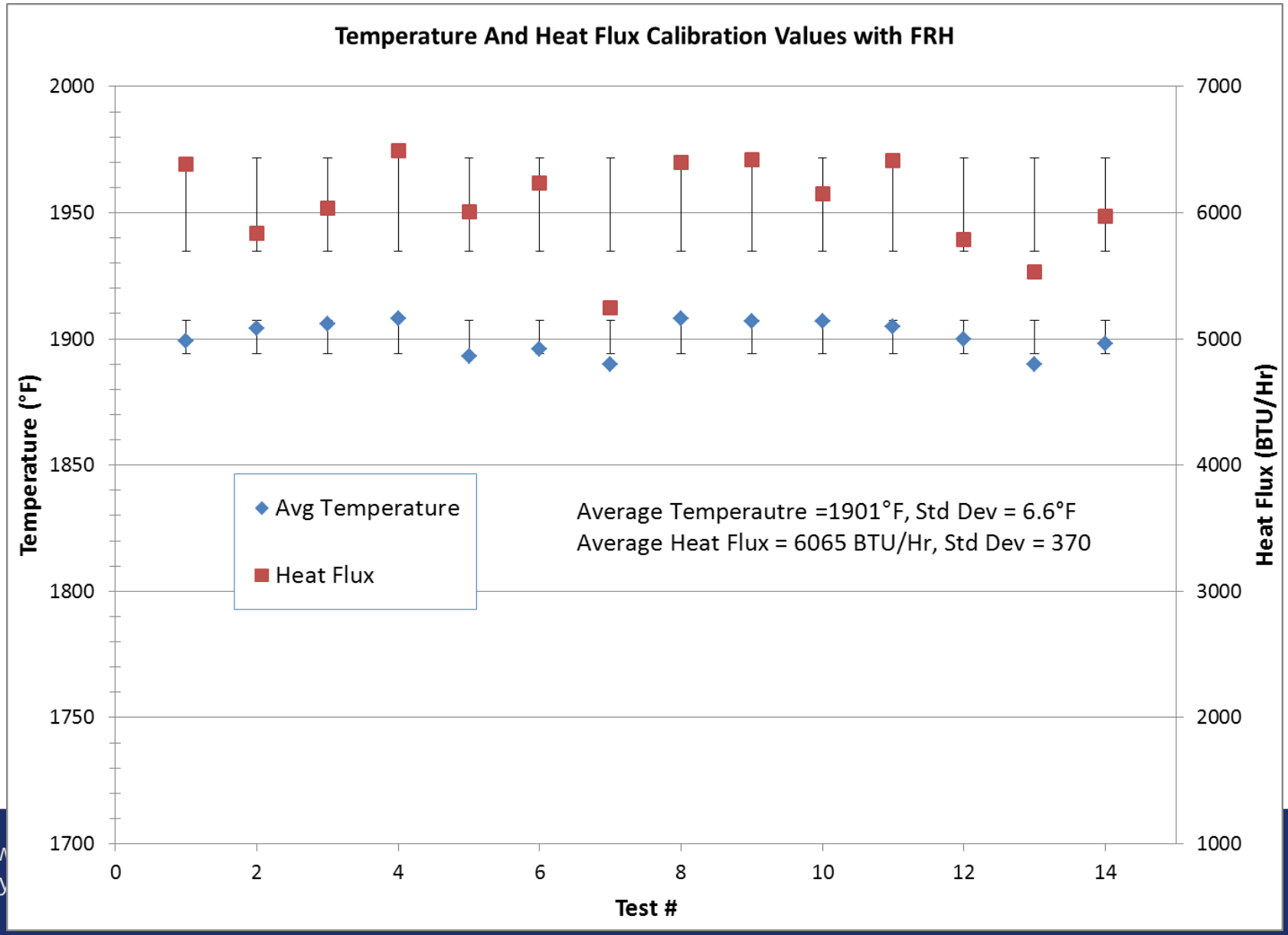
- **Standardized igniter positions**
- **Gap between igniters**
  - 1/8”
- **Nozzle center to igniter**
  - 1/4"
- **Nozzle face to igniter**
  - 1/8”



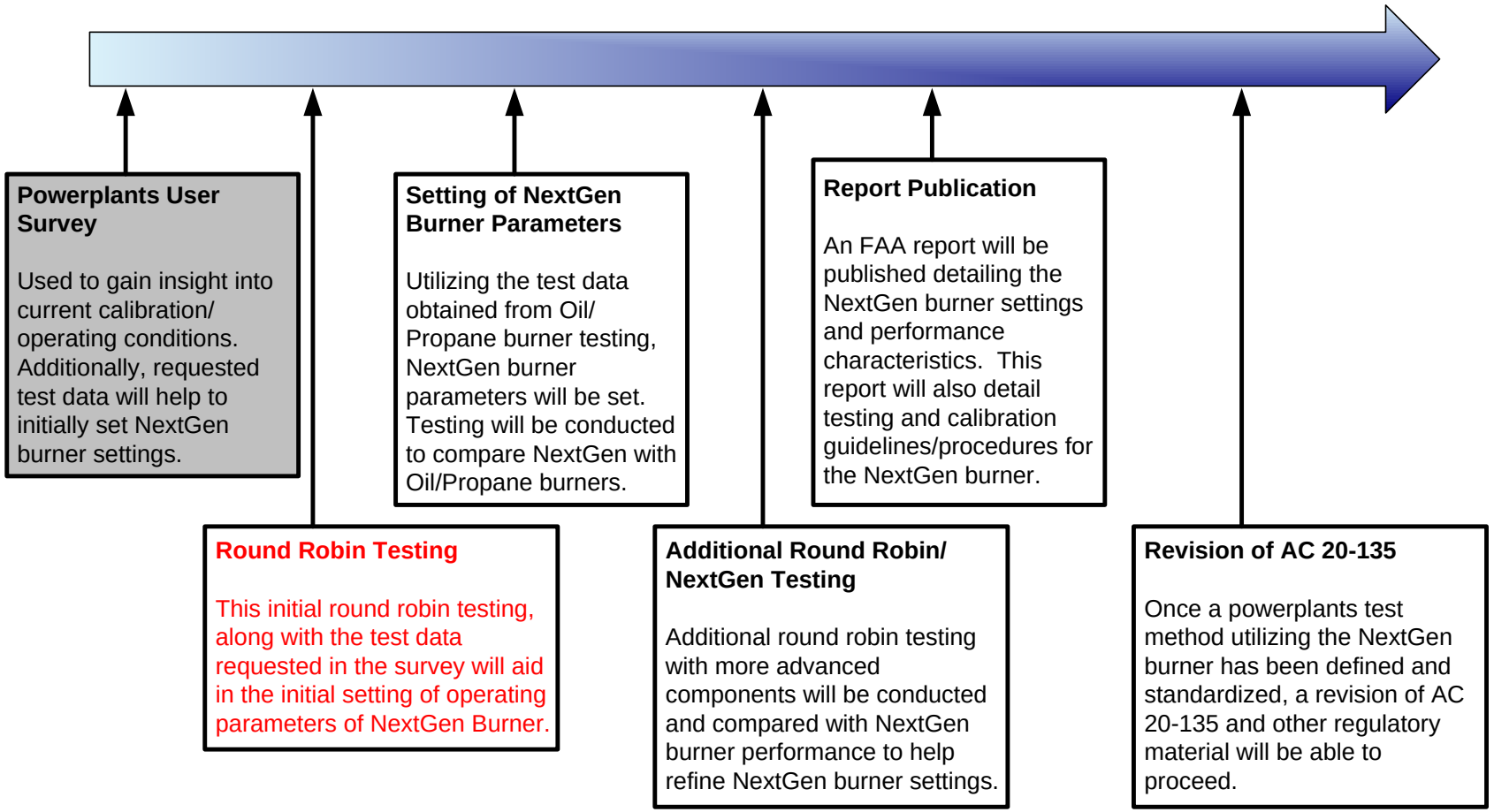
Current Burner Settings with FRH

- **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



Current Status



Current Status – Round Robin Testing

- **Round Robin testing to be 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
  - 8611R Polyacrylonitrile (PAN)

- **Initial testing is currently being conducted with FAA NexGen burner with FRH to ensure consistency in results prior to initiating round robin.**
  - Results with slug calorimeter and 2024 aluminum show very repeatable results.
  - Testing with PAN material is under way.