OSU & NBS
March Materials Meeting

Federal Aviation Administration

Materials Working Group

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Background

- **International research community conducts tests to determine heat release and smoke generating characteristics of airplane cabin interiors**
  - Compliance with FAR 25.853
- **Ohio State University (OSU) Heat Release Rate and National Bureau of Standards (NBS) Smoke Chamber Testing**
  - Principal Investigator – Historically, The Boeing Company
  - Apparatus (OSU & NBS) and method (along with round robin) are industry standard
  - International partners serve as participating laboratories

The Problem is…

- **Test results from past years have raised concern**
  - Unexpected/unexplained variability in results
  - Validity and reliable under question

Agenda

- **Discuss 2006 OSU / NBS Smoke Chamber Round Robin Tests**
  - FAA examined results and procedures of most recent Int'l study (2006)
- **Present initial findings of 2007 'Mini-Study'**
  - FAA conducting independent follow-on work
- **Request for all participating laboratories…**
- **Next steps**

Review of 2006 Round Robin

- **27 laboratories participated in the Round Robin Test from North America, Europe, and Asia**
- **Some Labs were not specific as to whether they followed the Handbook or the FAA Rule**
- **Each lab tested 9 samples (3 samples of 3 materials)**
  - Material labeled 5300, 5400, 5500

Review of 2006 Round Robin

- **Good news…**
  - All 27 labs completed the test and reported data
- **Bad news…**
  - Data is inconsistent
- **Suspect test equipment and/or procedures were compromised**
  - Fully detailed results can be found on the FAA web site @ http://www.fire.tc.faa.gov/pdf/materials/March07Meeting/burns-0307-osunbsrr.pdf

2007 Independent Mini-Study

- **Follow-on 'Mini-Study' being conducted to investigate why results were so variable**
- **One international and 6 domestic laboratories participating**
  - Comprehensive site visits to identify process errors and apparatus deficiencies, review use of procedures and compliance (*complete*)
  - Conduct sample testing (*in progress*)
  - Goal is to improve and ensure validity and reliability of future results

2007 Mini-Study Initial Findings

- **Site inspections uncovered several issues that may have affected the outcome of past tests**
  - OSU ‘Cold inspection’ issues
  - OSU ‘Hot inspection’ issues
  - NBS ‘Cold inspection’ issues
  - NBS ‘Hot inspection’ issues
  - Furnace defects
  - Equipment altering
- **Next few slides will show a consolidated list (random order) of discrepancies found from the labs that were visited**

OSU Cold Inspection Issues

- **Very poor insulation surrounding the OSU as recommended by the FAA handbook.**
- **Upper Thermopiles shorted prior to bead (4 out of 5).**
- **Upper Thermopiles found out of position (5 out of 5).**
- **Not having ability to ensure proper location of upper thermopiles.**
- **Missing 1” x 3” baffle plate in chimney section.**
- **Found inner cone of chimney section distorted and having a large hole (approx. 2” in diameter).**
- **Found cooling manifold of chimney section corroded and having a large hole (approx. ½” wide x 2” in length).**
- **Found outer cone of chimney section to be the incorrect thickness (.049” instead of .031”).**

OSU Cold Inspection Issues…continued

- **Secondary plate was found covered with debris and having the incorrect diameter holes (120 #28 drill holes - .140” diam.).**
- **Flow straightening tube for orifice plate found installed in reverse position (28” before orifice plate and 11” after).**
- **No calibration sheet available for purity of methane**
- **Radiation doors found extremely warped, missing insulation and bolts that keep the doors together.**
- **Could not verify the proper value is used in the equation to calculate the calibration factor. The handbook states 23.55 (5.6.6), however the correct value should be 25.31.**
- **Missing radiant door shield washer on injection rod.**

OSU Cold Inspection Issues…continued

- **Rear deflector plate (behind glow bars) found to be extremely warped and very close to touching the glow bars.**
- **Flow straightening tube for orifice plate found having a crack near the orifice connection.**
- **Flow straightening tube for the orifice downstream fitting found to be 1” rather than ¾” as described in the handbook.**
- **Difficulties in getting to the thermopile - cause for extremely dirty thermopiles as well as inner cone, chimney and baffle plate caked with soot build up (approaching 1”).**
- **[Advised making access hole on lower left side of OSU to facilitate maintenance / cleaning]**
- **[Advised fabricating a stool of some sort to assist in cleaning the thermopiles more frequently (after each set of 3 tests as a minimum)]**

OSU Cold Inspection Issues…continued

- **Upper pilot found out of position (3/4” above and behind the sample face, holes facing glow bars).**
- **Lower pilot tube found incorrectly aligned to sample face (too high)**
- **Radiant door mechanism for opening and closing requires adjustment to keep doors closed tightly.**
- **Alignment tool for thermopiles does not fit in chimney correctly. [Suggested fabricating a new template which fits correctly and has points instead of flat areas to set thermocouple location]**
- **Found exhaust temperature probe (separate from the 5 thermopiles required) located adjacent to center probe. [Suggested relocating to a remote location so as not interfere with the center thermopile reading]**
- **Thermopile support bracket (on chimney) found warped and able to rock or move back and forth.**

OSU Cold Inspection Issues…continued

- **Operator unaware of proper procedures for filling wet test meter with distilled water (should be filled to pointer tip with no flow etc.)**
- **No procedure in place or unable to set sample face the correct distance from the radiation doors once inserted (100mm)**
- **No procedure in place or unable to set heat flux gage the correct distance from the radiation doors once inserted (100mm) [Same location as sample face when inserted]**
- **Found thermopile alignment tool extremely eroded**
- **Excessive play in sample holder injection rod (bad bushings).**
- **For calibration, the software does not let equipment stabilize for 2 minutes then capture and average 10 seconds of data.**

OSU Cold Inspection Issues…continued

- **Found secondary plate having incorrect number of holes as well as incorrect diameter of holes.**
  - There should be 120 #28 drill holes (.140 diam.) and there were 124 #27 drill holes.
- **Found wet test meter filled with sewing machine oil and not distilled water as described in the handbook.**
  - Operator claims the manufacturer recommends this, however, documentation must support this. There must also be testing to verify that there is no difference in flow readings between the two fluids.
- **Found mass flow controller used during calibration to achieve set points 1 Liter, 4 Liter, 6 Liter & 8 Liter. Only the 4 Liter set point was used as a calibration reference point and not each flow.**
  - Operator states that it is a linear calibration but documentation must prove this. Wet test meter must be installed in line for calibration and each flow verified prior to each calibration.

OSU Cold Inspection Issues…continued

- **Water temperature, barometric pressure and water vapor pressure are used in the calculation for the calibration factor, however, found software having no input for this information.**
- **A calibrated millivolt signal was sent to the Data Acquisition System (DAS). Four set points were observed as follows:**

Calibrated millivolt signal	Software reading
28.0 mv	**27.3 mv**
36.0 mv	**35.3 mv**
42.0 mv	**41.1 mv**
50.0 mv	**49.1 mv**

- ❖ It is recommended to have the DAS calibrated to obtain correct millivolt readings

OSU Cold Inspection Issues…continued

- **A simulated calibration was conducted using a millivolt generator. The data should have yielded a calibration factor of .187 kW/m^2/mv. The software calculated a .194 kW/m^2/mv. Since the voltage signals received were lower than the calibration source the calibration factor should have been lower as well, however, it was higher. This leads to the possibility of having incorrect calculations within the software.**
- **Malfunctioning mass flow controller caused very large flow spikes and difficulties in trying to conduct a calibration**
- **Wet test meter was found to have improper backpressure gage (0"- 6"water) instead a 0-100 psig gage was installed in its place.**
  - This must be approved by the manufacturer as an acceptable change to the equipment.
- **Sewing machine oil was found contaminating the line going to the lower pilot from the wet test meter.**

OSU Cold Inspection Issues…continued

- **On the flow straightening tube for the orifice plate a “T” fitting is installed at the orifice fitting upstream location. This “T” fitting provided air to the pilots. This must be relocated so as not to compromise the pressure differential reading across the orifice place.**

OSU Hot Inspection Issues

- **Operator not familiar with proper calibration procedures.**
- **Plumbing for heat flux gage holder plate found to be incorrect. Center gage was set on an angle and not parallel to sample face. The corner gage was found recessed too much.**
- **No water drain or air/oil separator installed in air supply line.**
- **Operator unaware of requirements for the number of pilots allowed out at any given time.**
- **Center heat flux gage found to be damaged.**
- **Operator unaware of which side to burn on Schneller standard core panels (the side with writing should be exposed to the heat).**
  - Panels with adhesive film (white film on sample face) should be used only in the NBS chamber.
  - This is only true for Schneller standard core panels.

OSU Hot Inspection Issues…continued

- **Flame length too long on lower pilot**
- **One of the upper pilots found clogged with soot.**
- **Problem with rheostat maintaining constant heat flux on glow bars**
  - ❖ Suggested replacing old rheostat.
- **Found stop on heat flux calibration plate to be set to the incorrect position. This could result in a heat flux setting greater than 3.5 W/cm2.**
- **Due to equipment being in such poor condition, unable to complete the inspection or measure the following:**
  - ➢ Upper pilot location and flame direction
  - ➢ Upper and lower pilot flame lengths
  - ➢ Sample holders
  - ➢ Measure sample position when injected into the OSU (100mm from inner wall)

OSU Hot Inspection Issues…continued

- Measure heat flux gage position (100mm from inner wall) when setting heat flux
- Proper procedures for setting heat flux (center and four corners)
- Proper position of lower pilot
- Proper procedures for wrapping sample with aluminum foil and installing into sample holder
- Procedures for cleaning thermopile
- Procedures for conducting a test
- Measure diameter of calibration “T” bar holes and location
- Wet test meter water temperature
- Wet test meter barometric pressure
- Wet test meter water vapor pressure
- Unable to read calibrated millivolt signal on Data Acquisition System

OSU Hot Inspection Issues…continued

- **Items needing to be replaced or repaired**
  - Replace Thermopile (upper and lower)
  - Replace outer cone with one of the correct thickness
  - Replace inner cone
  - Replace 1” x 3” baffle plate and wires connecting it to the chimney
  - Replace outer insulation
  - Replace gaskets between inner and outer cones and cooling manifold
  - Replace cooling manifold
  - Fabricate template (100 mm) to ensure sample holder is in correct position relative to radiation doors
  - Replace broken sealing washer on sample injection rod

OSU Hot Inspection Issues…continued

- Replace sample injection rod guides on holding chamber door
- Replace upper and lower radiant heat doors including insulation between skins of doors
- Replace gasket around door seal on holding chamber
- Replace secondary 18 gage stainless steel plate (120 holes .140 in diameter)
- Fabricate thermopile alignment tool to fit into chimney
- Reroute air line to OSU to accommodate an air/oil separator
- Reverse flow direction of cooling water to heat exchanger on air supply
- Verify computer program is reading millivolts accurately
- Replace inspection window on side of OSU

NBS Cold Inspection Issues

- No means of measuring pressure within the chamber
- Furnace coil found in 3:00 position and not the 12:00 position as illustrated in the handbook
- No means of relighting the pilot flames should they go out during a test
- Pilot tubes found incorrectly aligned to sample face
- Two center pilots (45 degrees) on burner were found to be oblong and not the correct #54 drill size diameter
- Found sample holder .020 stainless steel wires made of 2 pieces and not the recommended 1 piece construction
- Found sample holders with no .020” stainless steel wires installed
- Upper guides on the sample holders (relative to each other) were found out of alignment
- Debris/Soot buildup found on inside face of sample holders

NBS Cold Inspection Issues…continued

- **Soot found on lower glass lens (internally) of photomultiplier tube assembly**
- **Poor means of removing chamber contents (smoke) after testing that could be toxic to personnel**
- **Water filled pressure regulator not vented to a suitable exhaust system**
- **Found chambers that failed the leakage rate check of 2” of water in 2 minutes**
- **Wall thermocouple found suspended in air and not actually mounted to wall surface**
- **Black “eye” observed in the center of the coil (entire coil not heating evenly)**
- **Flickering of electronics on control panel**
- **Furnace coil found to close to the sample face (internal dimension set to 1 ¼” and not the recommended 1 ½”)**

NBS Cold Inspection Issues…continued

- **Found insulation around furnace coil cracked and missing in places.**
- **Found the distance between the sample holder and the furnace to be too close (less than 1 ½”)**
- **Found misaligned stops (for left/right adjustment) on upper guides used to center the sample in front of and parallel to the furnace**
- **Furnace set too low relative to sample holder**
- **Debris found inside furnace near coil**

NBS Hot Inspection Issues

- Operator unaware of proper procedures to check chamber for leaks or maximum leakage rate allowable (not more than 2” water in 2 minutes)
- Operator unaware of proper procedures to set pilot flame length
- Water level in pressure regulator set to values less than the 4” recommended in the handbook
- An increase in light signal was observed when the chamber door was closed for testing
- Operator unaware of requirements for the number of pilot flamelets allowed out at any given time and for how long
- Improper procedures for inserting sample into chamber (sealed chamber after sample begins to burn)
- Light source not functioning properly
- Operator removes the pilot burner prior to setting heat flux

NBS Hot Inspection Issues…continued

- **Problem with heat flux controller holding a stable heat flux (range from 4.1 millivolts to 5.0 millivolts). This fluctuation is out of specification for the required heat flux setting of 2.5 +/- .05 W/cm^2**
- **Improper aluminum foil wrapping techniques of samples prior to installing in the sample holder**
- **Operators not removing entire aluminum foil from sample face prior to testing**
- **Operator unaware of pilot flamelets going out during test**
- **Unable to close doors tightly during calibration of heat flux due to water lines/calorimeter signal wire passing through the door**
- **Poor handling / care of calorimeter**

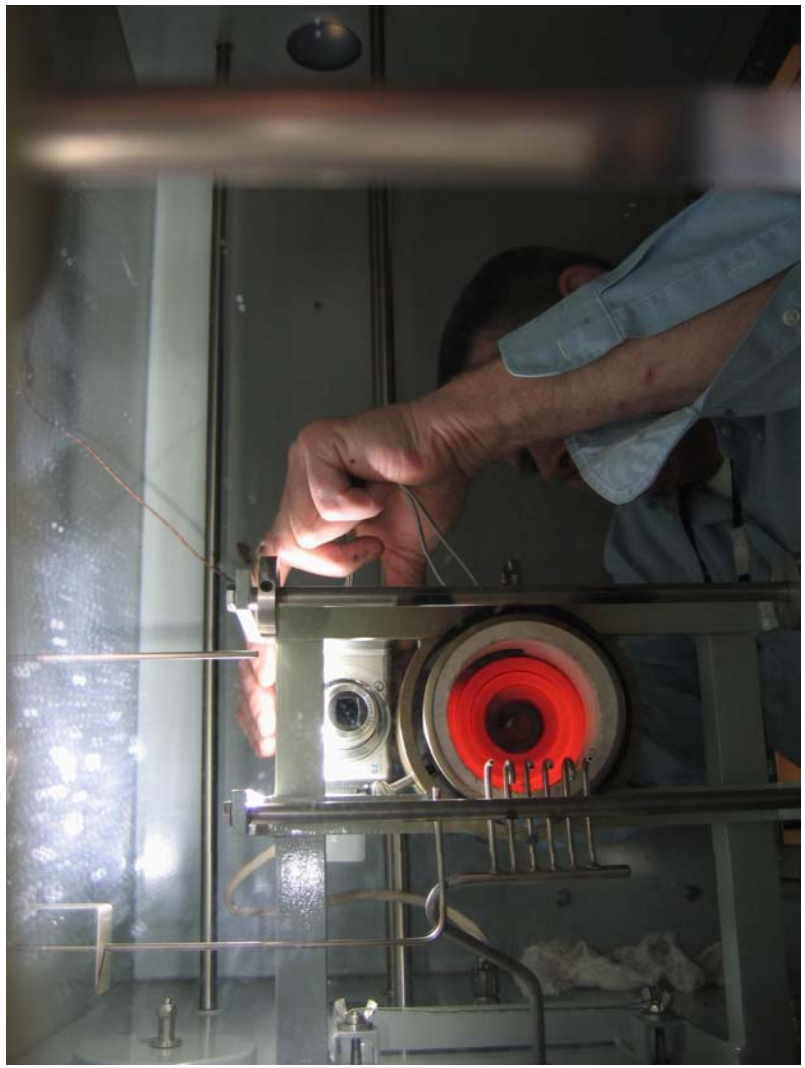
Furnace Defect

- **A problem with replacement furnaces of the NBS Smoke chamber has recently been observed**
  - A dark “eye” in the center of the furnace has been observed on some coils even after being calibrated to the 2.5 W/cm^2 value

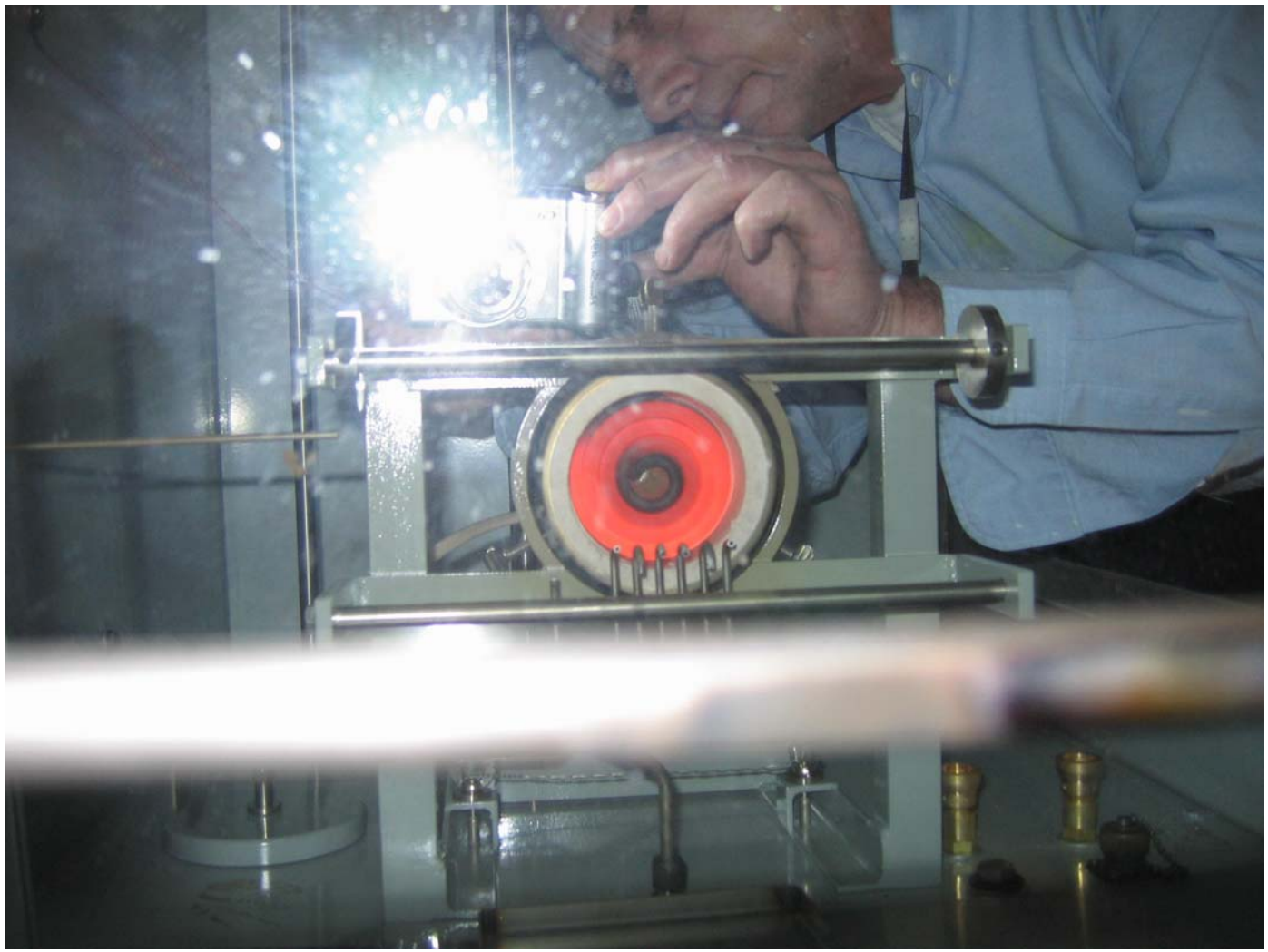
Furnace Defect

- **Drawing 40A132880 (NIST report NISTIR 4917, New Heater and Flux Guage for the NBS Smoke Box)**
  - Thought to be the most recent authoritative document, however, original designer did not specify tolerances
  - Original designer/manufacturer of furnace no longer in business
  - The current manufacturer is actively working with the FAA to resolve this issue

Furnace Defect

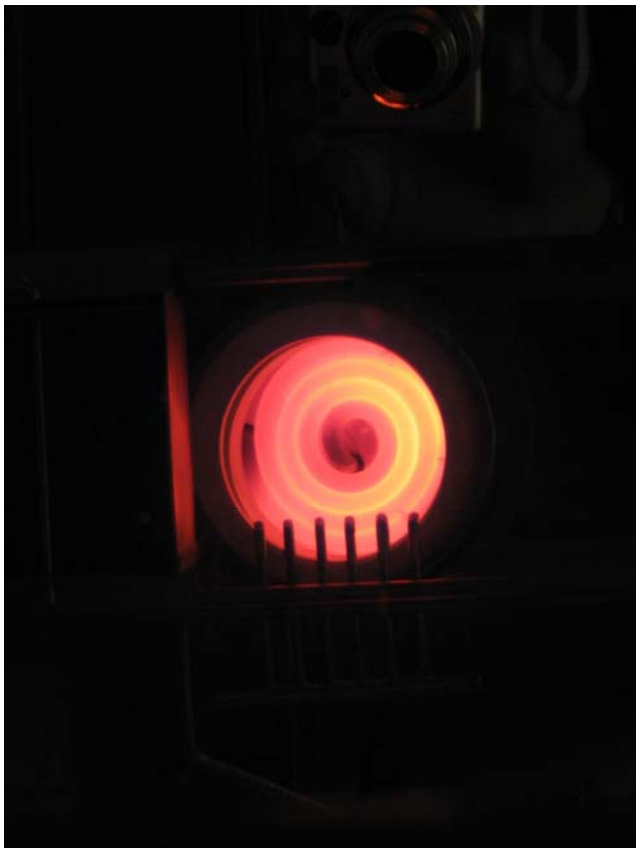


Furnace Defect

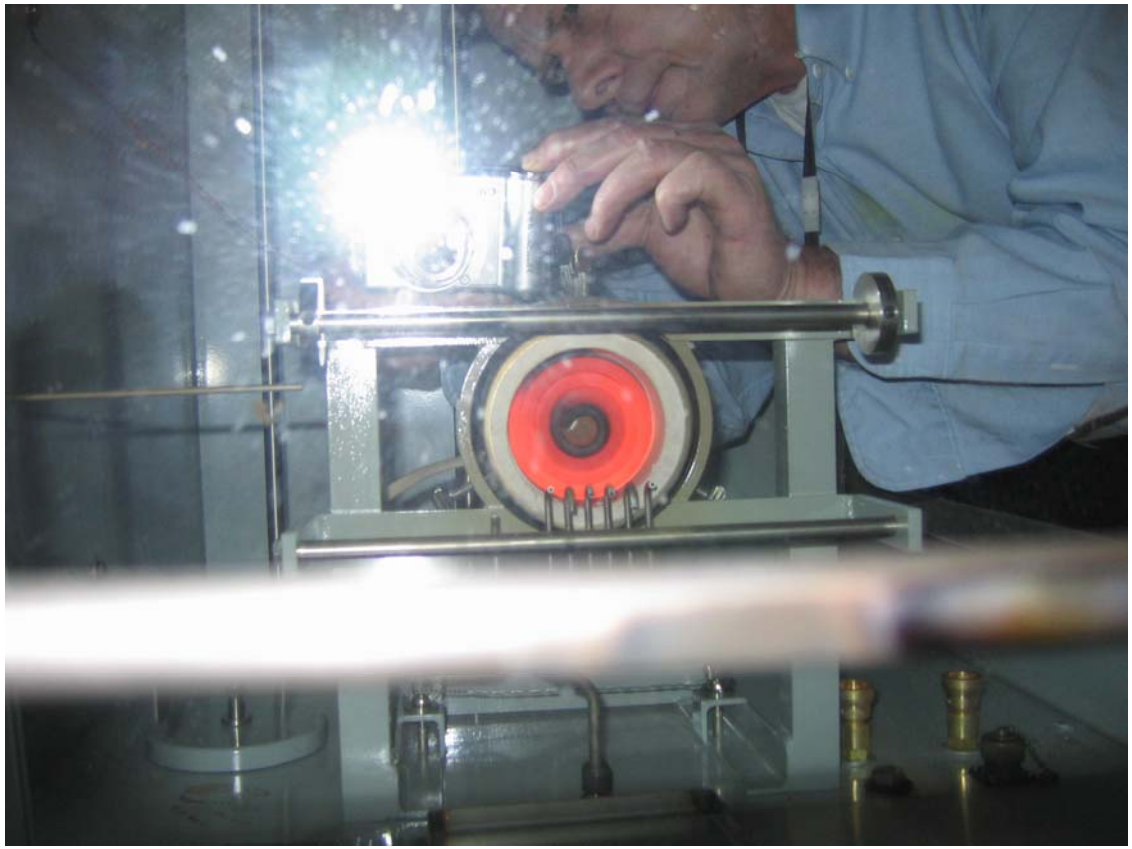


Furnace Defect

properly functioning furnace



defective replacement furnace



Alternate Equipment

- **Use of alternate equipment by manufactures in some NBS Smoke Chambers may be reason for erroneous data found in Round Robins**
  - Some known alterations include:
    - Changes to Furnace
    - Use of various Heat Flux measuring devices
    - IL 1700 Research Radiometer from International Light (USA)
    - SED033 / WBS465 or SED038 / WBS465 system (Photo multiplier tube replacement)

FAA Request For All Participating Labs

- **Review mini-study findings**
  - Do you have similar problems (OSU & NBS)?
- **<u>Conduct thorough internal review of equipment and procedures</u>**
- **Review must address the following issues:**
  - List discrepancies found during inspection
  - Course of action
  - Estimated completion date for all necessary repairs
- **Notify FAA once review is complete and submit findings no later than 6/1/2008**

Conclusions and Recommendations

- **Mini-Study still in progress.**
- **<u>Many</u> equipment and process infractions discovered.**
  - Most can be easily resolved now!
- **A check list of items can be provided upon request.**

Next Steps

- **FAA will be the Principal Investigator for next International Round Robin (date on hold)**
- **FAA will begin to address maintenance practices / schedules on both the OSU and NBS chamber**

Next Steps

- **FAA is in the process of updating Chapter 6 of the FAA Handbook (NBS)**
  - Main focus will address such issues as furnace specification, Heat flux gage/Radiometer use and photometric system
  - Comments on Chapter 6 will be accepted through 7/15/2008
  - Chapter 5 (OSU) to follow
- **FAA Contact Information:**

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QUESTION & ANSWER

ANY QUESTIONS, COMMENTS OR SUGGESTIONS?