

# National Bureau of Standards Smoke Chamber Testing

## International Fire & Cabin Safety Conference

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Federal Aviation  
Administration



# Background

- **International research community conducts tests to determine smoke generating characteristics of airplane cabin interior**
  - Compliance with FAR 25.853
- **National Bureau of Standards (NBS) Smoke Chamber Testing**
  - Principal Investigator - The Boeing Company
  - Apparatus (smoke chamber) 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 reliability under question

# Agenda

- **Review 2006 NBS Smoke Chamber ‘Round Robin’ Test**
  - 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
- **Conclusions and recommendations**
- **Next steps**

# Review of 2006 NBS Smoke Chamber Test

- **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

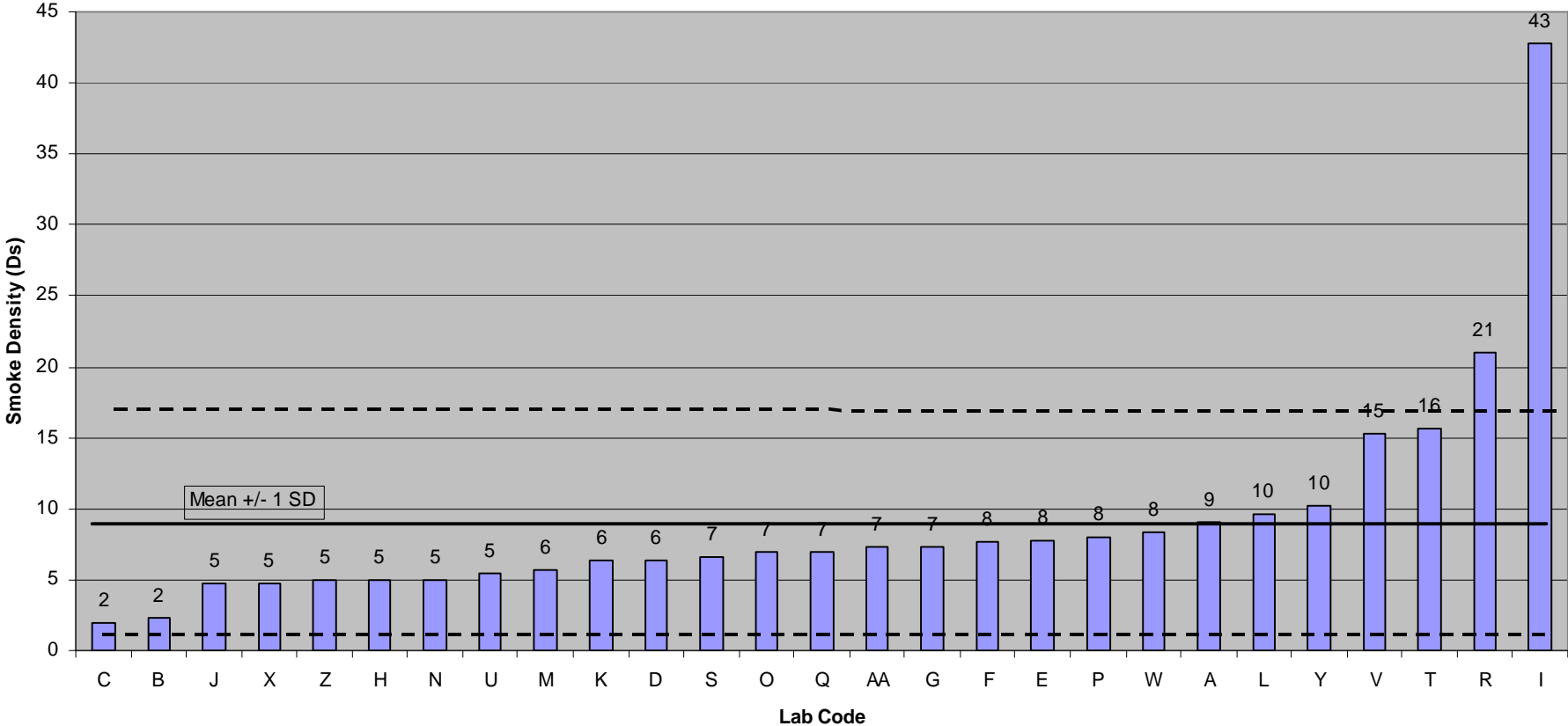
# Review of 2006 NBS Smoke Chamber Test

- **Good news...**
  - All 27 labs completed the test and reported data
- **Bad news...**
  - Data is inconsistent
- **Suspect test equipment and/or procedures were compromised.**
  - For example, data may have been improperly reported
  - Test calls for reporting the Maximum Smoke Density observed during 4 minute test
  - Suspect some labs mistakenly reported the Observed Smoke Density at 4 minute mark
- **Next 3 figures illustrate the data obtained**
  - Fully detailed results can be found on the FAA web site @ <http://www.fire.tc.faa.gov/pdf/materials/March07Meeting/burns-0307-osunbsrr.pdf>

# 2006 NBS Test Results – 5300 material

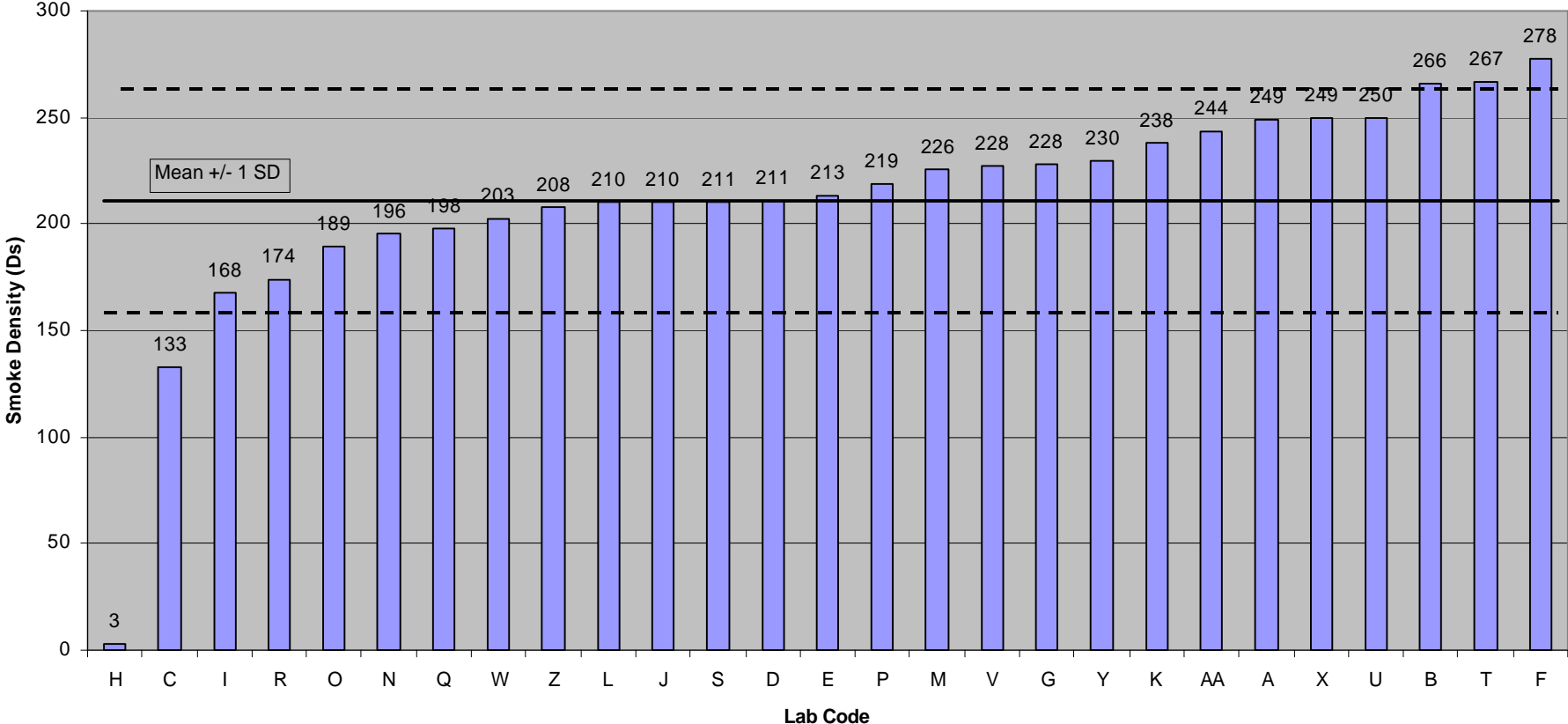
## SAMPLE 5300 - MAX. SMOKE DENSITY DURING 4 MINUTES

Mean = 9 SD = 8



# 2006 NBS Test Results – 5400 material

**SAMPLE 5400 - MAX. SMOKE DENSITY DURING 4 MINUTES**  
Mean = 211 SD = 53

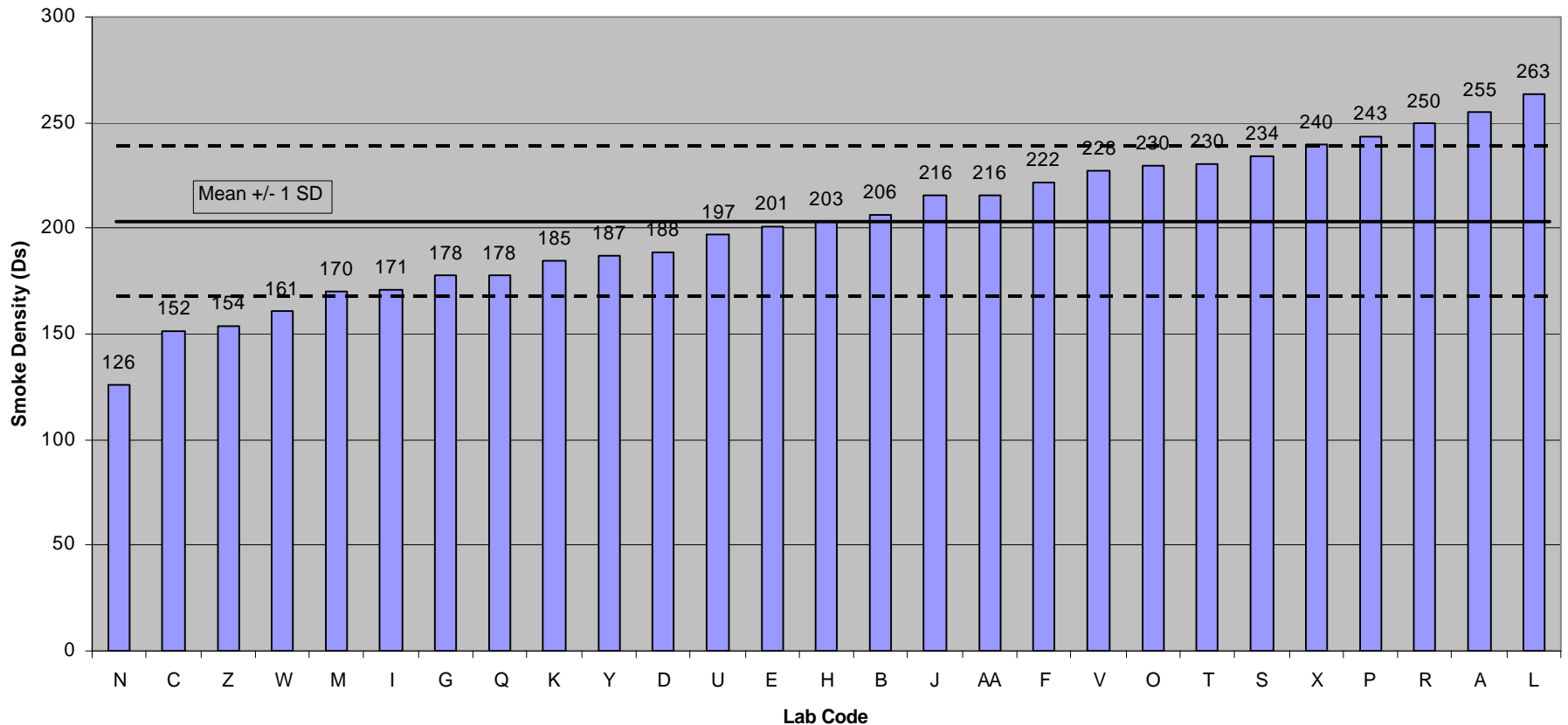




# 2006 NBS Test Results – 5500 material

## SAMPLE 5500 - MAX. SMOKE DENSITY DURING 4 MINUTES

Mean = 203 SD = 35

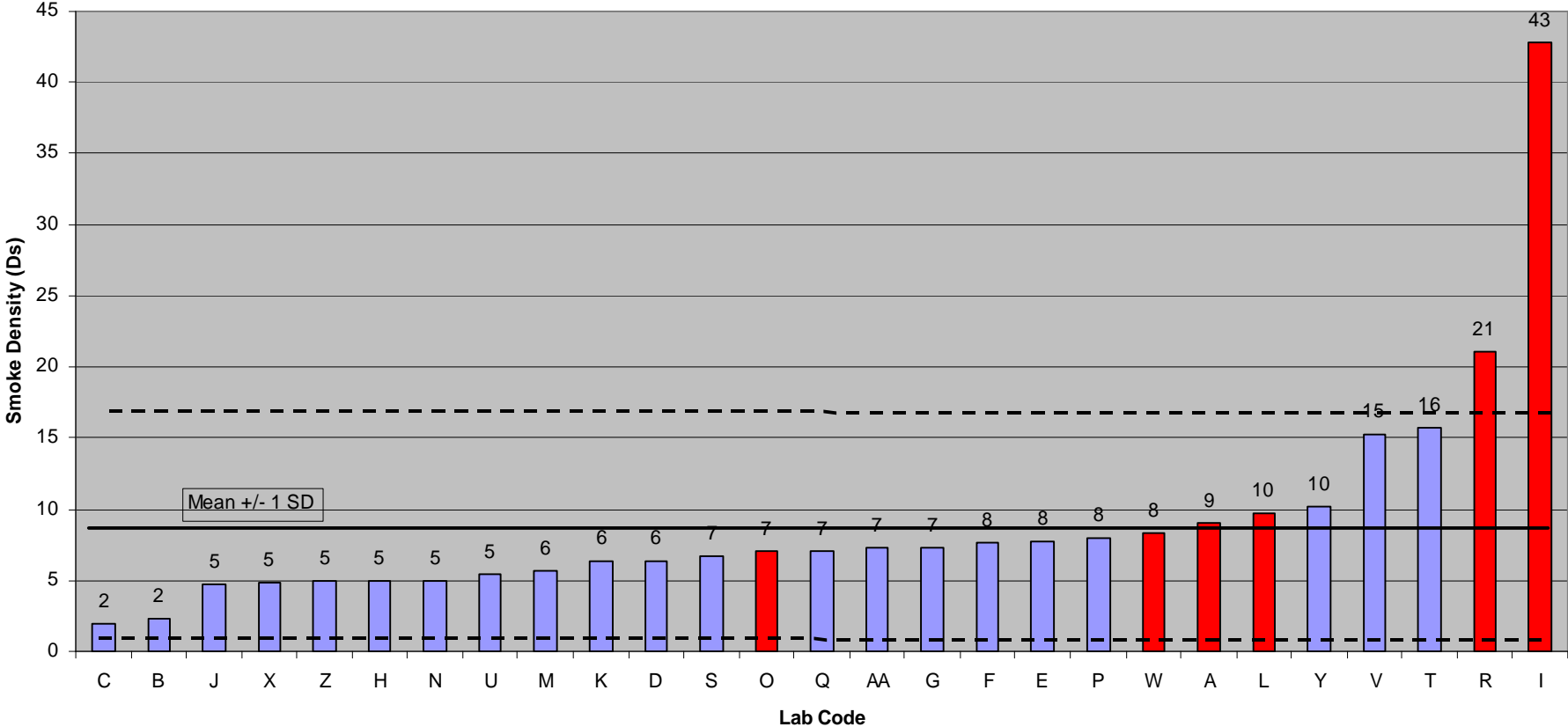


# 2007 Independent Mini-Study

- **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
- **Next 3 figures highlight the labs that were included**

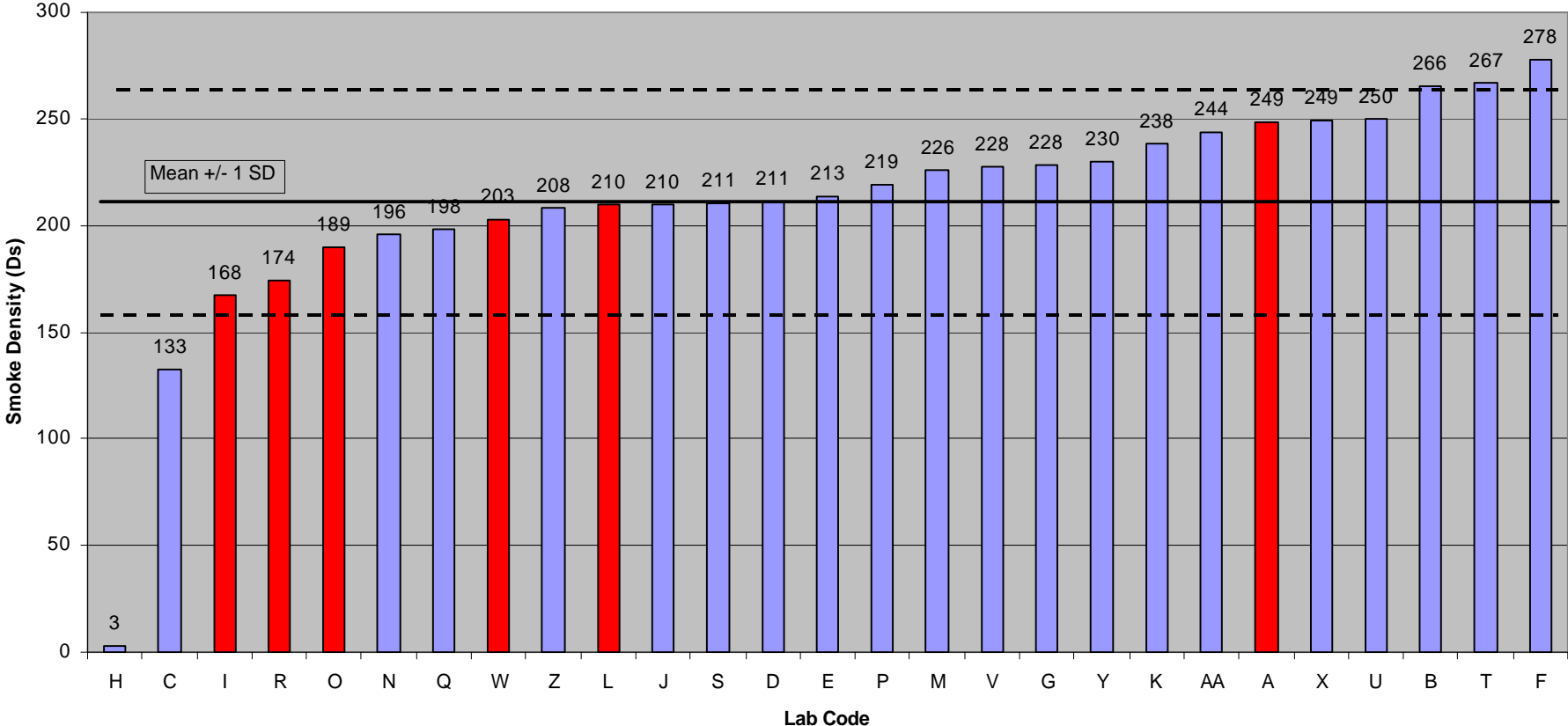
# 2006 NBS Test Results – 5300 material

**SAMPLE 5300 - MAX. SMOKE DENSITY DURING 4 MINUTES**  
 Mean = 9 SD = 8



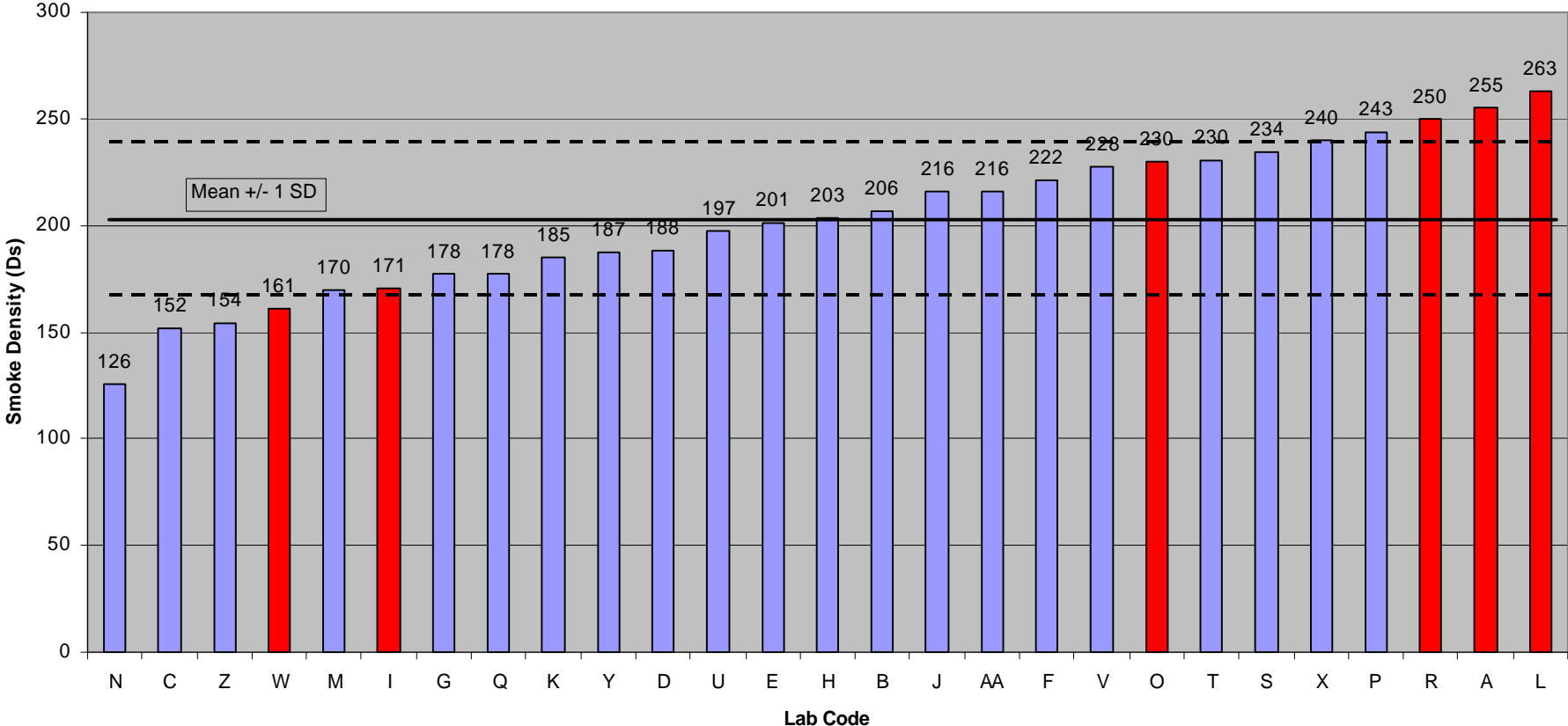
# 2006 NBS Test Results – 5400 material

**SAMPLE 5400 - MAX. SMOKE DENSITY DURING 4 MINUTES**  
 Mean = 211 SD = 53



# 2006 NBS Test Results – 5500 material

**SAMPLE 5500 - MAX. SMOKE DENSITY DURING 4 MINUTES**  
 Mean = 203 SD = 35



# 2007 Mini-Study Initial Findings

- **Site inspections uncovered several issues that may have affected the outcome of past tests**
  - ‘Cold inspection’ issues
  - ‘Hot inspection’ issues
  - Furnace defects
  - Equipment altering
- **More potential issues upon completion of Round Robin sample analyses**

# 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
- The sample holder .020 stainless steel wires were 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
- 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

# Cold Inspection Issues

- 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")
- 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



# 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**

# Hot Inspection Issues

- **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<sup>2</sup>**
- **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**

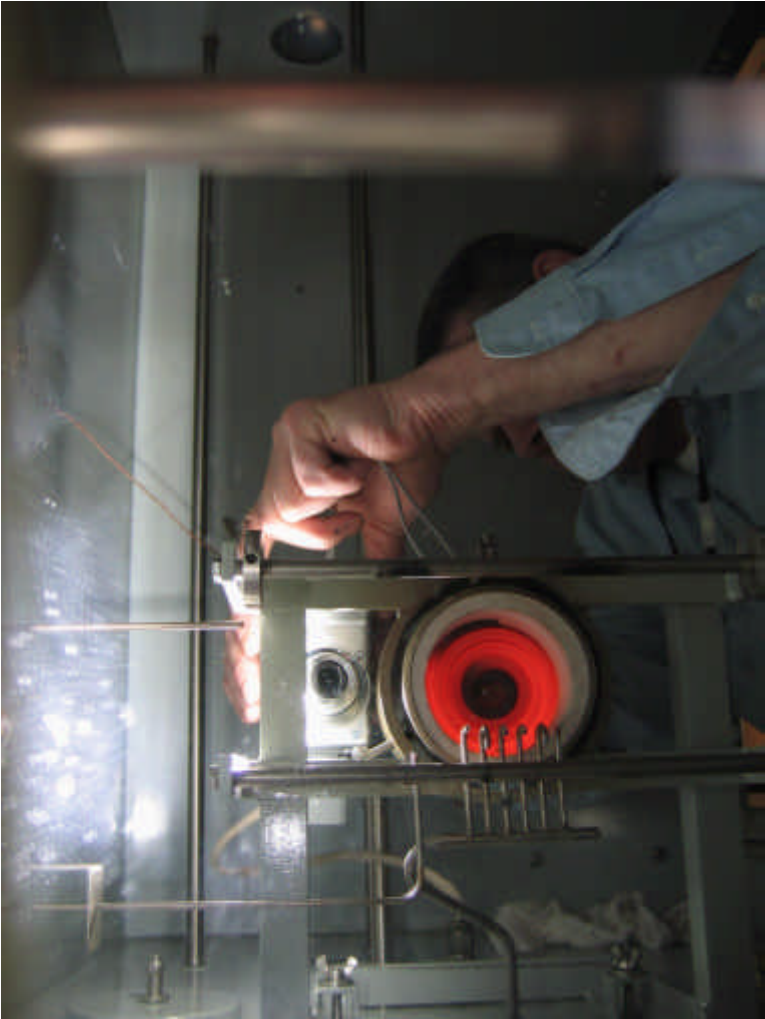
# Furnace Defect

- **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<sup>2</sup> value**

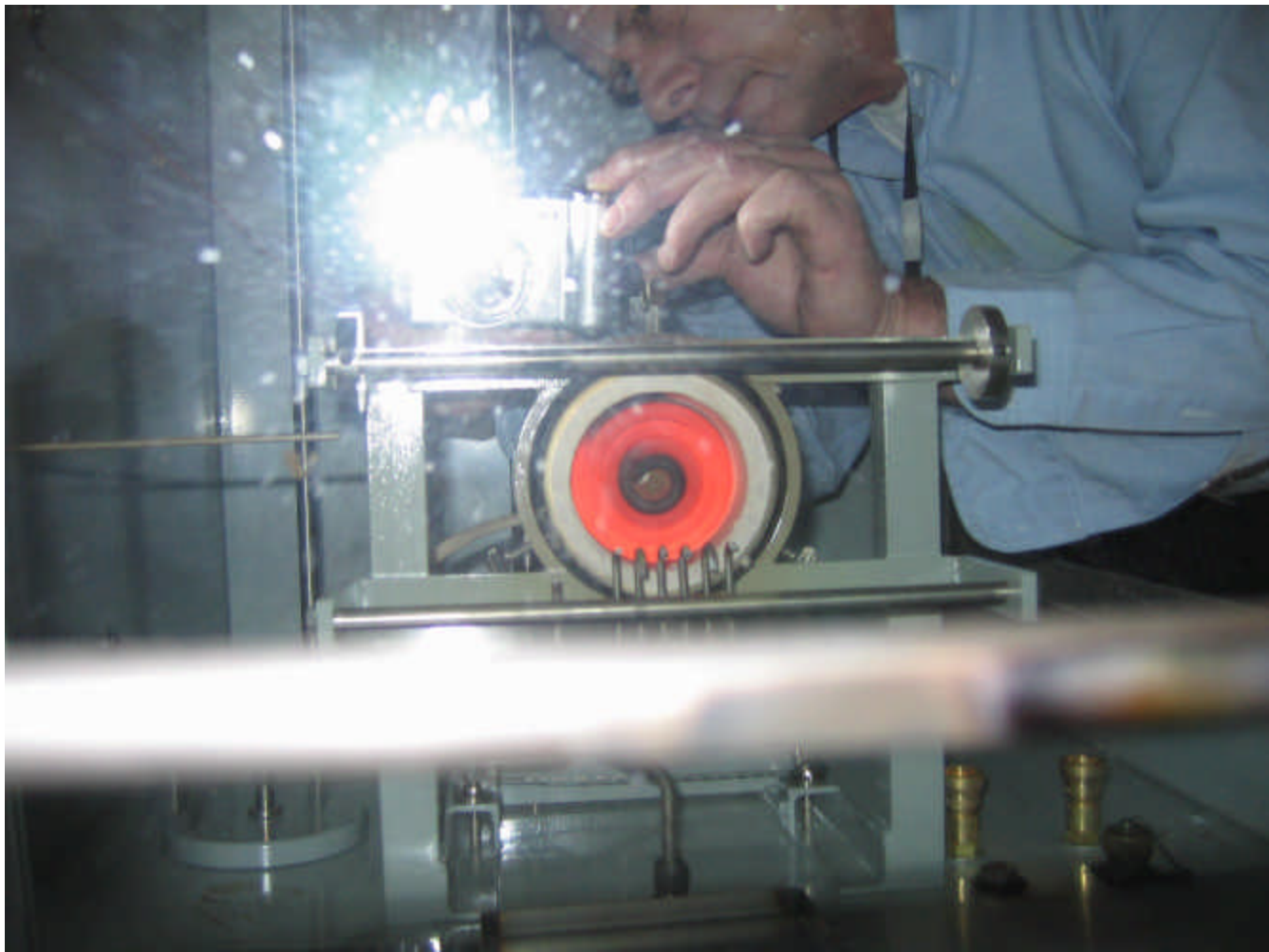
# Furnace Defect

- **Drawing 40A132880 (NIST report NISTIR 4917, New Heater and Flux Guage for the NBS Smoke Box) is thought to be the most recent authoritative document, however, original designer did not specify tolerances**
- **The manufacturer is actively working to attempt to reduce this dark area.**

# Furnace Defect

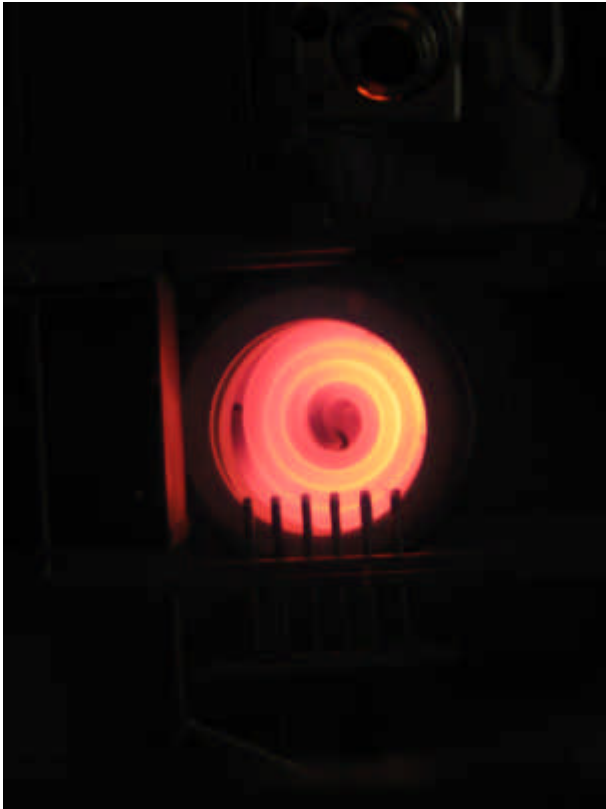


# Furnace Defect

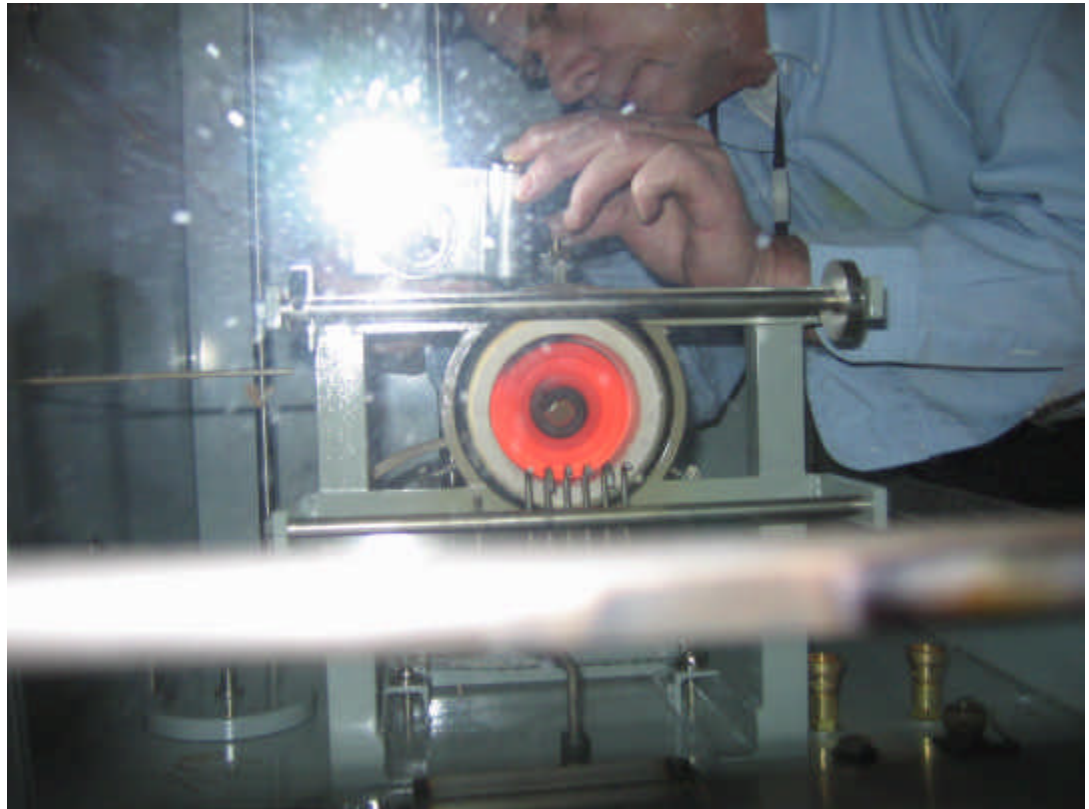


# Furnace Defect

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 in recent 'Round Robin'**
- **Some known alterations include**
  - IL 1700 Research Radiometer from International Light (USA)
  - SED033 / WBS465 or SED038 / WBS465 system (Photo multiplier tube replacement)
- **FAA will evaluate these alterations to assure compliance with the Rule**



# Conclusions and Recommendations

- **Mini-Study still in progress but...**
- **Many equipment and process infractions discovered**
  - Most can be easily resolved now!
- **Request all participating laboratories...**
  - Review mini-study findings (do you have similar problems?)
  - Conduct thorough internal review of equipment and procedures before 2008 test commences
  - Strive to ensure 100% compliance
- **Remember – our work saves lives!**

# Next Steps

- **Mini-Study will be completed and results published**
- **FAA will be the Principal Investigator for next International Round Robin (early 2008)**
- **FAA will address the tolerance issue for the furnace coil specification**
- **Please contact Mike Burns to participate and obtain your lab codes and samples**

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# QUESTION & ANSWER

**ANY QUESTIONS, COMMENTS OR  
SUGGESTIONS?**

