Calibration of Heat Flux Calorimeters

Historical Review

Boeing Commercial Airplanes

Daniel B. Slaton

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Heat Flux Gage Calibration

General Observations

- Historical data indicates that calibration levels have departed from the historical reference.
- The variation between original calibration levels and the higher levels today (based on the NIST calibration) are not crucial.
- Historical data provides support for a baseline calibration of a local “gold standard.”

Heat Flux Gage Calibration

Situation:

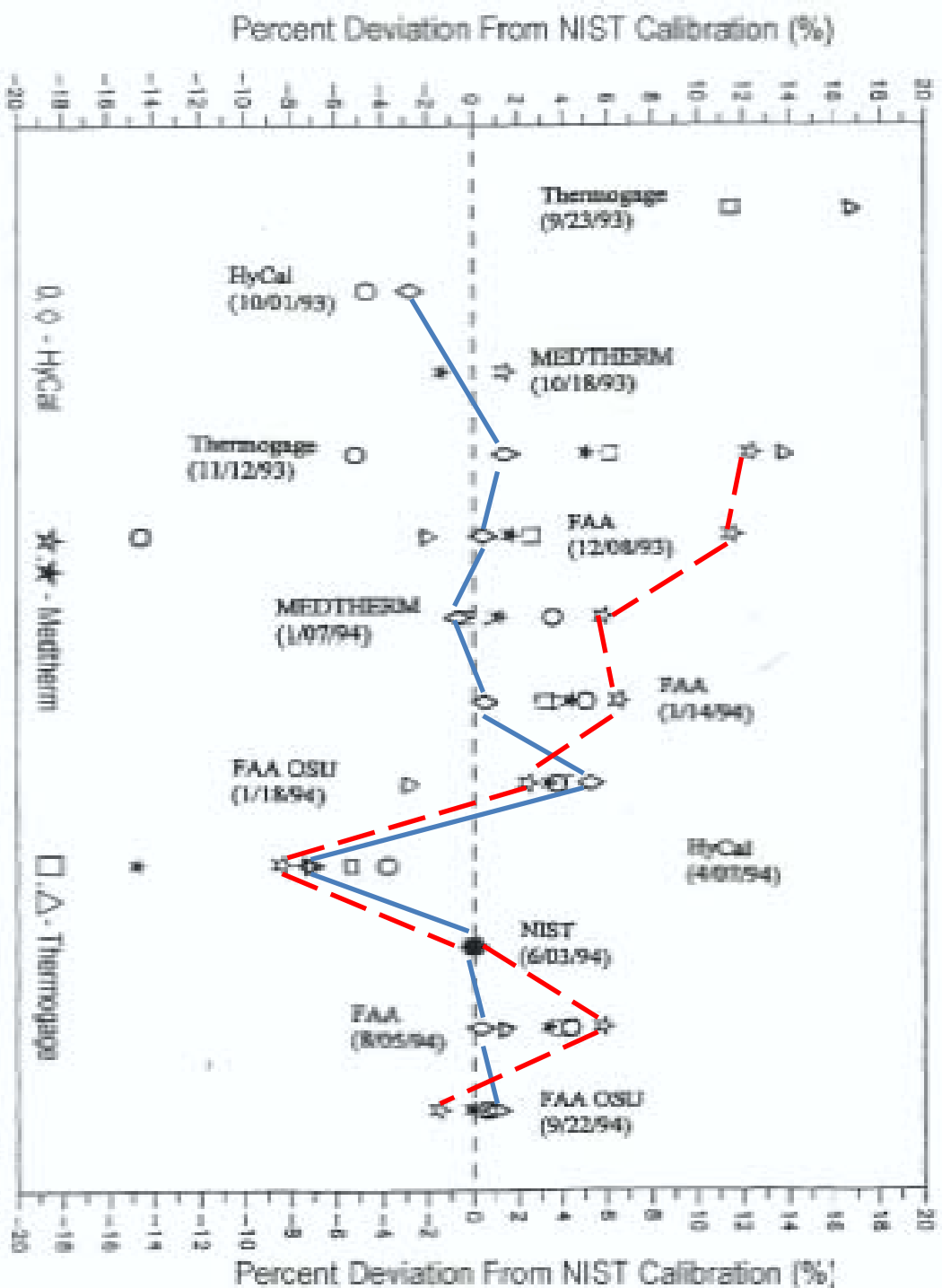
- The definition of 3.5 watts/cm^2 is uncertain.
  - Depends on type of calorimeter, calibration method, and calibration facility.
- Calorimeter manufacturers use different calibration methods.
- Calorimeter manufacturers calibration methods are accepted by the FAA.
  - Vatell calibration widely accepted as a standard.
- Calibrations traceable to a NIST standard are accomplished using different accepted procedures, yet different calibration levels are established.
- Historical information appears to indicate variation can be due to both calorimeter construction and calibration methods.
- Calibration procedures are specified differently in 14 CFR

Heat Flux Gage Calibration

Situation: (continued)

- FAA Calibration Round Robin in 1993/1994;
  - Variation between the different calibration methods .
  - Individual calorimeters show variation during subsequent calibrations by the same lab/method.
  - Labs demonstrated a range in % difference when compared to NIST calibration.
- NIST Calibration Round Robin in 2004;
  - Variation between the different calibration methods.
  - Individual calorimeters show very little variation during subsequent calibrations by the same lab/method.
  - Gardon gauges show ~10% variation across labs.

FAA 1993/1994 Calibration Round Robin Results



NIST Calibration Round Robin Report, 2004

10 mV Method:

121.2 kW/m2 ± 11.0 kW/m2 for the Gardon gauges. The variation correspond to about ± 9.1 %

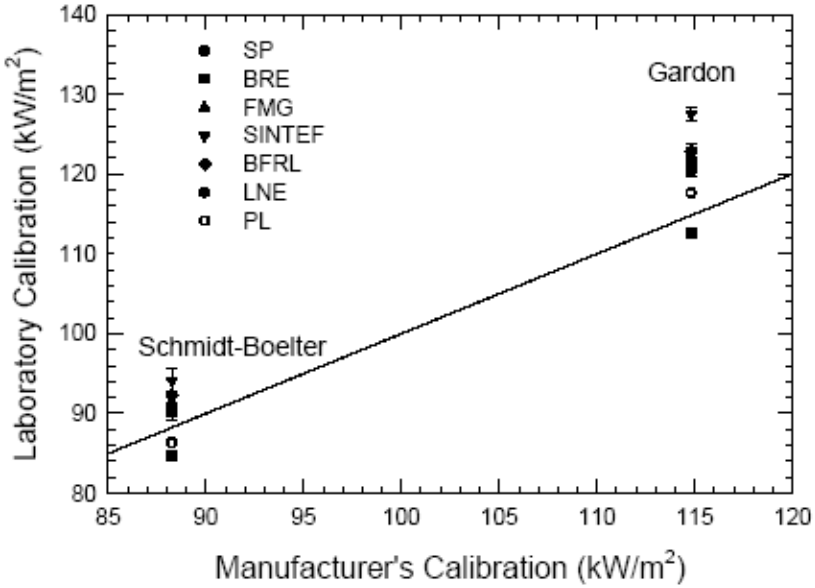


Figure 16. Calibration results for the five fire laboratories and two measurement laboratories are compared for the two gauges used during the first round robin by plotting the predicted full scale responses (i.e., the heat flux corresponding to a 10 mV gauge output) versus the manufacturer's results (line). Uncertainties based on experimental results and determined as described in the text are indicated for the results from the fire laboratories.

The averages and scatter (2σ) for the results from the five fire laboratories are 90.4 kW/m2 ± 7.2 kW/m2 and **121.2 kW/m2 ± 11.0 kW/m2** for the Schmidt-Boelter and Gardon gauges, respectively. The variations correspond to about ± 8.0 % and ± **9.1 %** of the two averaged values, respectively. The averages can be compared to the corresponding results based on the manufacturer's calibrations of 88.3 kW/m2 and 114.8 kW/m2. The averaged values from the fire laboratory calibrations are 2.4 % and 5.5 % higher than those based on the manufacturer's calibration for the Schmidt-Boelter and Gardon gauges, respectively.

Heat Flux Gage Calibration

Goals:

- Maintain heat flux levels established by original historical baseline.
- 3.5 watts/cm^2 to remain at the same levels that have always been used.
- Currently accepted calibration methods to remain acceptable.
- Continue to develop an understanding of acceptable calibration variation.
- If required, propose plans to reduce variability in calibration methods.

Heat Flux Gage Calibration

Proposals:

- Identify current acceptable calibration procedures.
- Define acceptable heat flux level based on historical reference.
- Define acceptable levels of variation based on industry round robin results.
- Develop approach for local “gold standard” calorimeter to verify new calibrations have not drifted.
  - Boeing – HyCal Calorimeter calibration history provides supporting data for a “baseline”
  - Vatell calibrations are generally consistent with historical baseline values (*within historical operational variation)*

Boeing HYCAL Calorimeter History