HEAT FLUX CALIBRATION STUDY

2010 Triennial International Fire & Cabin Safety Research Conference

Atlantic City, NJ

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Federal Aviation Administration

AGENDA

- History
- “Interim” Aviation Heat Flux Calibration Standard
  - Specification, Method & Procedures
  - Tentative Calibration Facilities
  - Transition Target Date
- Radiant Panel Validation Study
  - Painted Surface Area Data
- Next Steps

BRIEF HISTORY

06/08 – Discovery of Heat Flux Gage Calibration Discrepancy

Visit to Manufacturers / NIST

06/09 – International Heat Flux Gage Calibration Study

Industry Submitted Gages To FAA Technical Center For Calibration Comparison

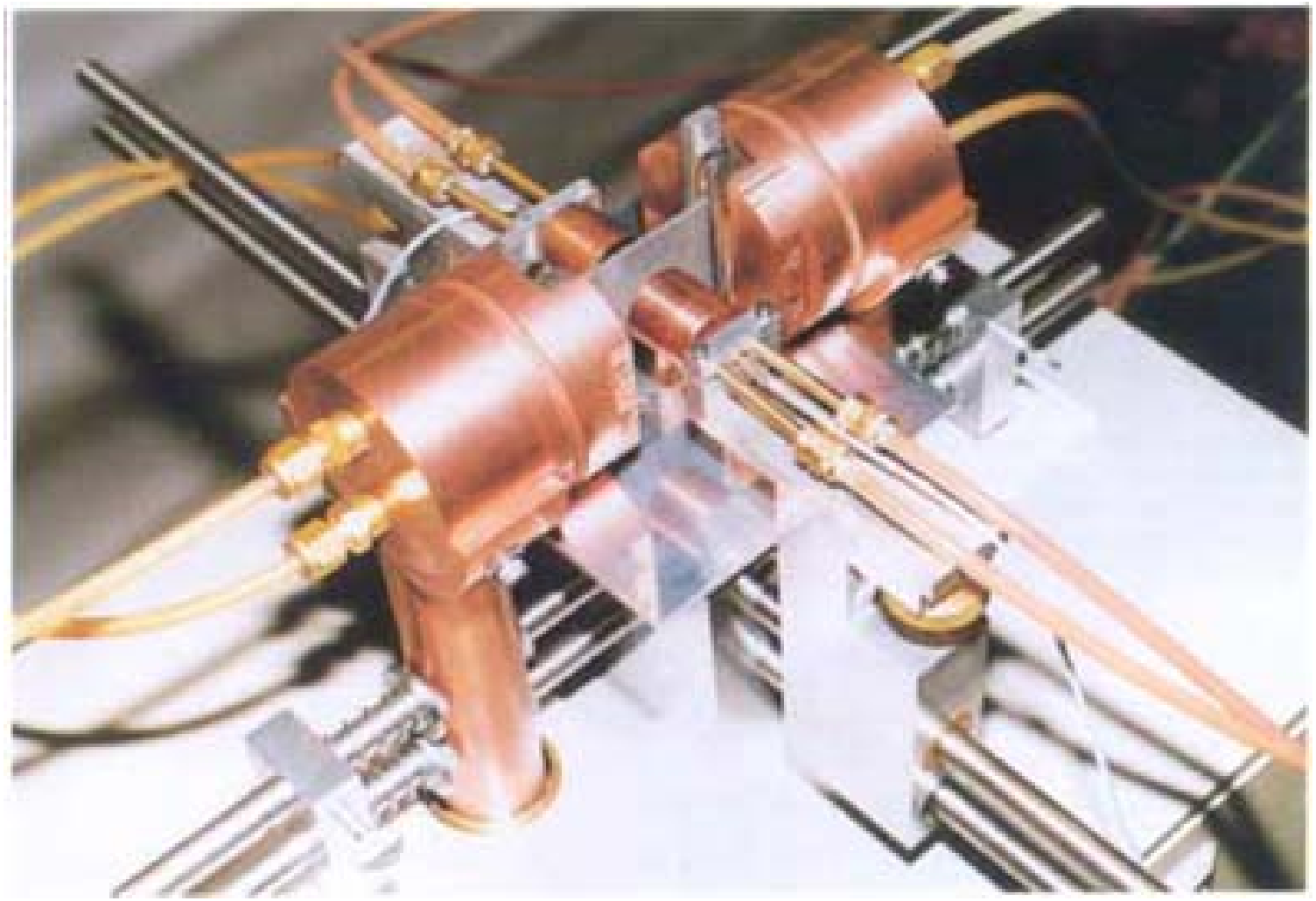
07/09 – Heat Flux Sensitivity Study Using Gages Installed In Test Apparatus (HRR, NBS Smoke Density & Radiant Panel tester)

10/09 – Sensitivity Study

Effect On Data By Varying Heat Flux Levels

10/10 – Development Of Interim Aviation Heat Flux Gage Calibration Standard

Interim Aviation Heat Flux Calibration Standard



Interim Aviation Heat Flux Calibration Standard

CALORIMETER SPECIFICATION, CALIBRATION METHOD AND PROCEDURE.

Calorimeter Specification: 0 – 5 W/cm^2 Sensor (See Note #1).
(Required for use in chapter 5,6,9,19,23 and 24 of the FAA Fire Test Handbook)

- One inch (25 mm) diameter, cylindrical, water-cooled, Gardon Gauge (See Note #2).
- The Heat Flux Gauge (HFG) must measure the temperature difference between the center and the circumference of a thin Constantan circular foil disk mounted in a copper heat sink body.
- The entire front sensing surface of the HFG must be evenly coated with flat black paint having an emissivity of 0.96 or greater (See Note #3).

Definitions:

- *Heat Flux*
  - Heat flux density is the intensity of the thermal environment to which a sample is exposed when burned.
- *Emissivity*
  - Emissivity is the measure of an object's ability to emit infrared energy.
- *HFG*
  - Heat Flux Gauge used in determining heat flux levels.

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- *NIST*
  - National Institute of Standards and Technology (USA).
- *Calibration Factor (Scale Factor)*
  - A constant multiplier which converts a HFG signal to a measured value in standard units.
  - Derived from Incident Flux [W/cm^2] / Sensor Output [mV].
  - The Sensitivity is the reciprocal of the Calibration factor.
- *Secondary Standard HFG*
  - Must be calibrated at NIST using the Heat Flux Scale.
  - Used to transfer NIST calibration values to a Transfer Standard HFG.
- *Transfer Standard HFG*
  - Must be calibrated by a Secondary Standard HFG.
  - Used to transfer NIST calibration values to a Working HFG.
- *Working HFG*
  - A HFG received from a testing facility to be calibrated.
  - Used for setting heat flux levels in day to day flammability testing.

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NIST Calibration Factor:

- The full range NIST calibration factor for the Secondary Standard HFG must not be used during transfer of calibration rather the single point calibration factor nearest the heat flux range for the flammability test method the HFG will be used to calibrate [See Chart].
- It may be possible for a Transfer Standard HFG to have more than one calibration factor correlating to separate FAA heat flux requirements or there may be a designated Transfer Standard HFG for each test method range.

NIST Calibration Report – Full Range, 10 Point Calibration Data

Range [W/cm^2]	Blackbody Temperature [K]	Incident Flux [W/cm^2]	Sensor Output [mV]	Single Point Cal. Factor [W/cm^2/mV]	Single Point Sensitivity [mV/W/cm^2]	FAA Flammability Chapter
	297	0.000	0.000			
	1573	0.764	1.641			
	1923	1.508	3.229			
0 - 2.0	2093	2.014	4.293	0.469	2.132	23
0 - 2.5	2228	2.515	5.323	0.472	2.117	9,24,6,19
	2348	3.033	6.399			
0 - 3.5	2453	3.540	7.397	0.479	2.090	5
	2543	4.029	8.361			
	2623	4.503	9.270			
	2703	5.017	10.266			
	Full Range Cal. Factor			0.4889	2.0456	

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Chapter	Description	Req'd Heat Flux Level	Range (W/cm^2)
23	Test Method to Determine the Flammability and Flame Propagation Characteristics of Thermal/Acoustic Insulation Materials.	1.7 W/cm^2	0 - 2.0 W/cm^2
9	Radiant Heat Testing of Evacuation Slider, Ramps, and Rafts.	2.3 W/cm^2	0 - 2.5 W/cm^2
24	Test Method to Determine the Burn-Through Resistance of Thermal/Acoustic Insulation (See Note #5).	2.3 W/cm^2	0 - 2.5 W/cm^2
6	Smoke Test for Cabin Materials.	2.5 W/cm^2	0 - 2.5 W/cm^2
19	Smoke test for Insulated Aircraft Wire.	2.5 W/cm^2	0 - 2.5 W/cm^2
5	Heat Release Rate Test for Cabin Materials.	3.5 W/cm^2	0 - 3.5 W/cm^2

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Calibration Interim:

Secondary Standard HFG

- Must be calibrated at NIST using the Heat Flux Scale.
- Must be calibrated once ever 5 years.

Transfer Standard HFG

- Must be calibrated by a Secondary Standard HFG.
- Must be calibrated once ever year.

Working HFG

- Must be calibrated by a Secondary Standard HFG or a Transfer Standard HFG.
- Must be calibrated once ever year.

Data Acquisition System

- Calibrated to NIST traceable voltage sources(±0.01 mV).
- Must be calibrated once ever year.

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Calibration Method:

- The transfer calibration must be by comparison to a like standardized HFG in the same:
  - Range
  - Manufacturer
  - Foil material, diameter, thickness
  - Painted surface area
  - Construction (with the exception of mounting flange, cooling water tubes & signal wire length)
- The HFG must be calibrated for incident heat flux.
- The HFG calibration transfer must be accomplished by placing a calibrated HFG and a like HFG an equal distance from a uniform radiant heat source.
- Suggested ambient conditions surrounding the calibration apparatus:
  - Draught Free (stagnant) air.
  - Non-condensing ambient air at 73 +/- 5 deg F (23 +/- 3 deg C).
  - Relative humidity less than 70%.
  - Dew Point less than 68 deg F (20 deg C).
- Calibrations must be performed by simultaneously applying radiant heat to each HFG, discontinuing heat and without disturbing sensors, record signal data as they cool.
- Suggested cool down rate from 5 W/cm^2 to zero should occur over an approximate time period of two (2) minutes.
- The recording device used must record the two (2) transducers simultaneously or at least within one tenth of a second of each other.

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Calibration Procedure:

- It is recommended clamping on the cylindrical one inch (25 mm) body of the instrument not interfering with the front surface area.
- The HFG holding fixtures for each sensor must be identical in construction (See Figure 1).
- Mount the standardized HFG and the unit to be calibrated an equal distance and perpendicular to a uniform radiant heat source.
- Ensure there is proper water flow to each sensor before exposing to radiant heat.
- The suggested water inlet temperature to each HFG shall be 73 +/- 5 deg F (23 +/- 3 deg C) at the start of calibration ensuring there is no condensation that occurs on either sensor face prior to or during the calibration procedure.
- Water pressure should not exceed 200 psig.
- Connect the signal wire's of each HFG to the data acquisition system or other approved recording device ensuring polarity is set correctly (an increase in heat flux corresponds to an increase in millivolt signal).
- Apply radiant heat to both sensors.
- Discontinue heating when the highest reading HFG reaches full scale (Approx. 10 mV) and start the recording device within five (5) seconds.
- Record data as the sensor's cool over the suggested time period of two (2) minutes.

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Requirements:

- It must be shown that if the location of the two (2) HFG's remains the same and the calibration is repeated, the difference in calibration factors must be less than 2.0%.
- It must be shown that if the location of the two (2) HFG's are interchanged and the calibration is repeated, the difference in calibration factors must be less than 2.0% (See Note #6).

Commonly Used HFG'S:

Vatell Corporation

RANGE	TYPE	P/N
0 – 5 W/cm^2	Gardon	T1000-0B (with flange)
0 – 5 W/cm^2	Gardon	T1000-1B (without flange)

Medtherm Corporation

RANGE	TYPE	P/N
0 – 5 W/cm^2	Gardon	64-5-20 (with flange)
0 – 5 W/cm^2	Gardon	64-5-18 (without flange)

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Suggested Reporting Parameters:

- Facility conducting calibration.
- Customer (Lab providing Working HFG).
- Calibration date.
- Transfer Standard HFG / Working HFG .
  - Part number.
  - Serial number.
  - Calibration factor (Sensitivity) – BTU/ft^2 *sec or W/cm^2.
  - Sensor Type.
  - Manufacturer.
  - Sensor Ohm reading between signal leads.
  - Calibration date of Transfer Standard HFG.
- HFG cooling water temperature / pressure / flow rate.
- XY Plot (Millivolt vs. BTU/ft^2*sec or W/cm^2).
- Linearity of HFG mV signals during calibration (both sensors).
- Calibration expiration date.
- Sensor coating material.
- Previous Calibration Data.
  - Date.
  - Calibration factor (sensitivity) – BTU/ft^2 *sec or W/cm^2.
  - Facility where calibration was conducted.
  - % Change in calibration factor.

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General:

- If using a closed loop system to cool the HFG's during calibration, it is suggested to change the water frequently or chlorinate and filter the water to eliminate the potential buildup of contaminates within the system.
- Use extreme caution when setting the gap distance from the radiant heat source (When possible, avoid contact with sensor face).
- The HFG coating must be removed and replaced prior to calibration if it is observed to be chipped, scratched, damaged, faded or in otherwise poor condition (See 1.C.).

NOTES:

Note #1 - Based on a sensor having an approximate 10 mV output at 5 W/cm^2.
Note #2 - Also known as: Circular Foil Gauge, Calorimeter or Radiometer
Note #3 - Historically "3M Black Velvet" paint has been used for this application.
Note #4 – The majority of heat flux sensors are used in chapters 5 (Heat Release Rate), 6 (Smoke Density) and 23 (Radiant Panel test chamber).
Note #5 – This HFG is used to measure heat flux levels and not for calibrating a heat source to a certain level.
Note #6 – Historically 3/8" (9.5 mm) gap separation has been used to achieve the interchange tolerance. This gap distance may require adjustment due to variations in radiant heat sources or other anomalies.

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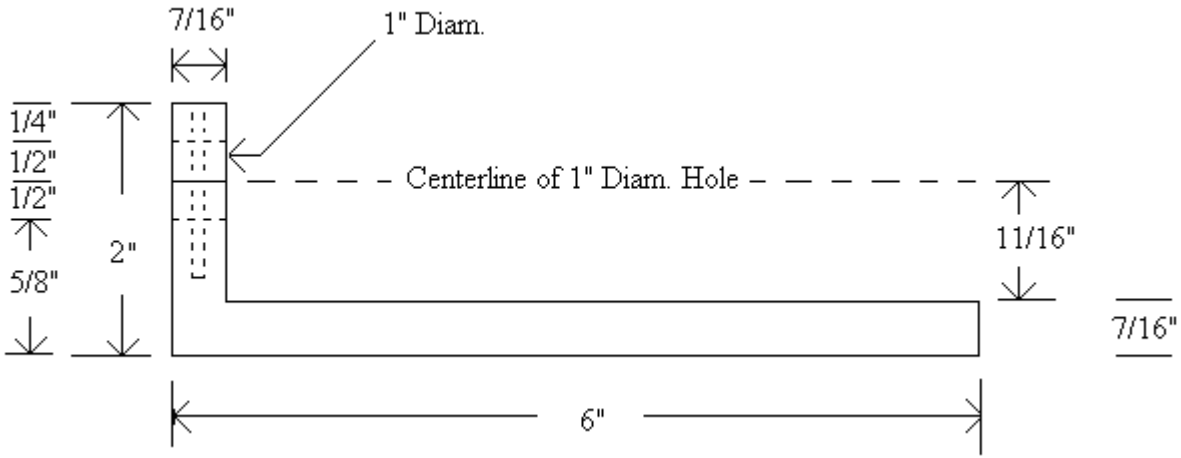

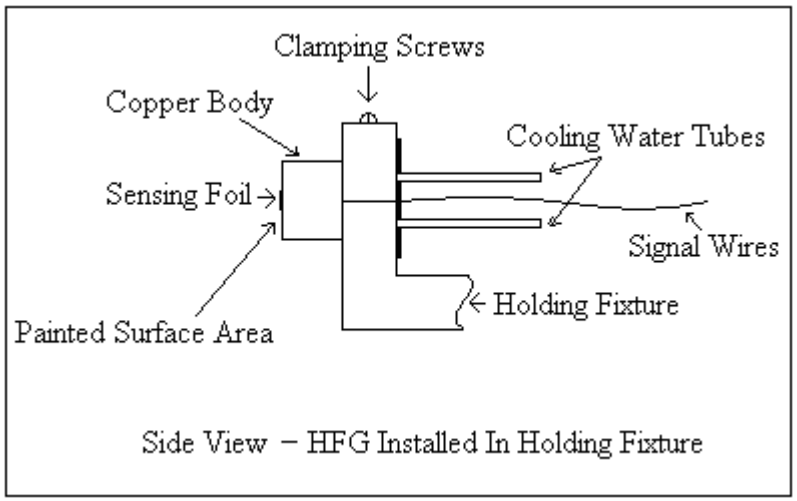

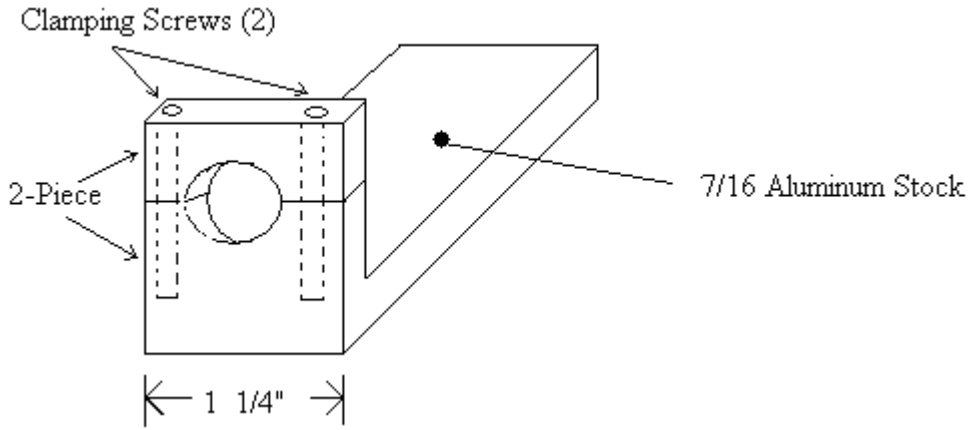

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Tentative Calibration Facilities

- Vatell Corporation (Larry Langley)

  Christiansburg, VA

- Marlin Engineering, Inc. (Martin Spencer)

  Bellingham, WA

- Thermo Gage Instruments (Chris Liller)

  Fort Ashby, WV

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Work To Do

- Secondary Standard Gages Calibrated Via NIST Calibration Services.

- Once Facilities Acquire Necessary Equipment A Round Robin And Conformity Inspection Will Be Arranged With Tech Center.

- Implementation Target Date 06/01/11.

Radiant Panel Validation Study

Vatell / Medtherm HFG - Differences In Painted Surface Area

- A Vatell and Medtherm HFG Was Sent To Vatell Corp. To Be repainted using 3M Black Velvet Paint (Full Face)
- Once Returned, Tech Center Conducted Calibration Using NIST Secondary Standard HFG & Graphite Plate Transfer Method
- Radiant Panel Tester Set To 1.5 BTU/ft^2*sec Using Vatell Gage
- Interchanged Vatell Gage with Medtherm Gage
- Variation In HFG Readings Improved From >15% To <2%

NEXT

- Interim Aviation Heat Flux Calibration Standard
  - Calibration Facility Conformity Inspection
  - Transition Date Target 06/01/11
- Awaiting Return of Alternative Type (Schmidt-Boelter [*Thermopile]*) Heat Flux Gage From NIST
  - Once Returned, Install Calibrated Gages Into OSU / RP & NBS For Validation Study

Questions / Comments?

“If I agreed with you we’d both be wrong”.

Unknown Author