Use of a Furnace for a Thermal Radiation Source

FLUKE® Calibration

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Learning Objectives
- Learn about IR thermometer calibration
- Be informed about available calibration sources for radiation thermometer
- Learn about attributes of a blackbody cavity

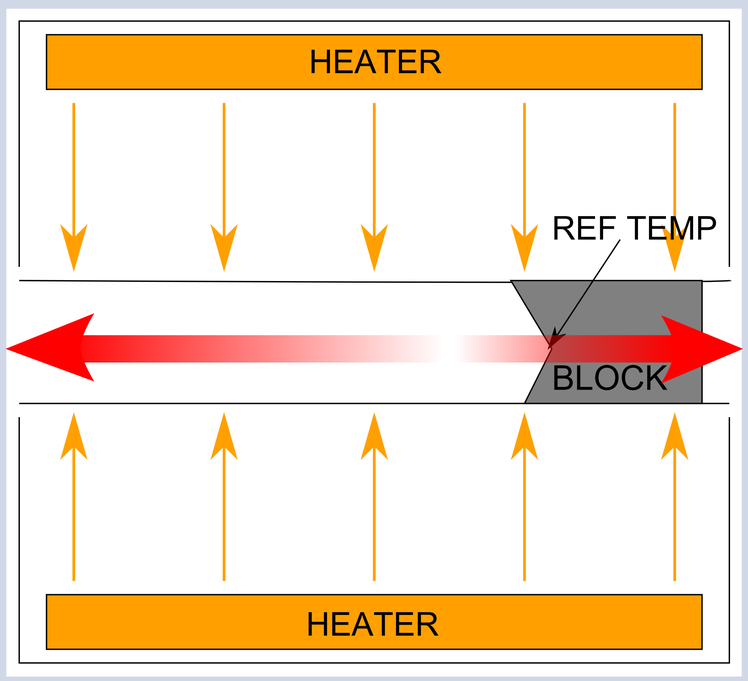
1. Introduction
- Flat plate calibrator range: -15 to 500 °C
- Increased demand for higher range: up to 1000 °C

2. Background
RT Calibration Sources
- Flat plate above 500 °C
  - Infrastructure would need to be devoloped
  - Large power requirements
- Cavity source
  - Contact probe as reference
  - Use of furnace

Schemes of Traceability
- Scheme I (contact)
  - source emissivity error
  - radiant heat-exchange error
- Scheme II (non-contact)
  - Scheme I errors reduced
  - Spectral emissivity not accounted for

Size-of-source
- Similar to emissivity errors
- Accounted for by two color thermometry

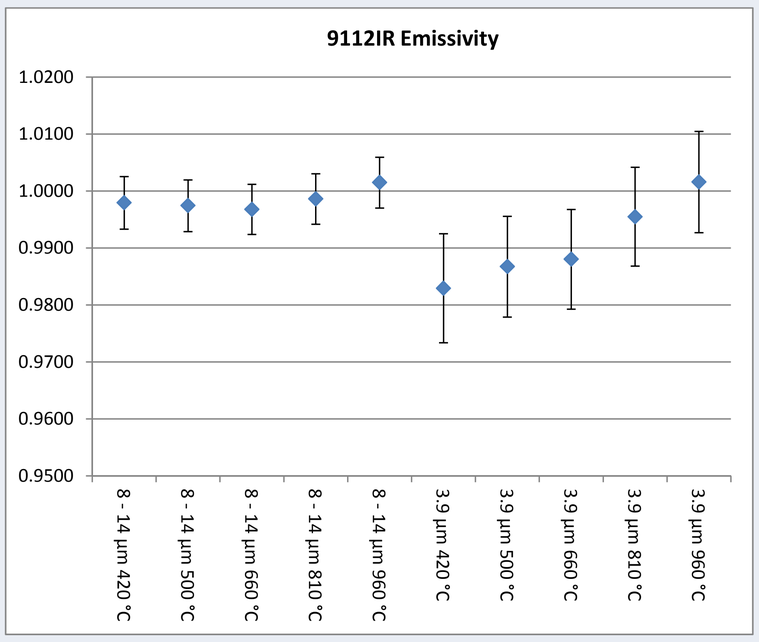
3. Blackbody Attributes
- Uncertainty analysis as a tool
- BIPM suggested structure
- Uncertainties of concern
  - Emissivity
  - Traceable temperature
  - Cavity bottom heat exchange
  - Cavity bottom uniformity



4. Measurements of a Blackbody
- Fluke 9112 used as furnace
  - Concerns with temperature uniformity
- Cavity inserted

4.1 Measurements Made

$$\varepsilon_{EFF} = 1 + \frac{\partial \varepsilon}{\partial T}(T_{RT} - T_{REF})$$ *Effective Emissivity*



$$\varepsilon_{EFF} = \frac{exp\left(\frac{-c_2}{\lambda_1 T_{MEAS1}}\right)}{exp\left(\frac{-c_2}{\lambda_1 (T_{REF}+\Delta T)}\right)} = \frac{exp\left(\frac{-c_2}{\lambda_2 T_{MEAS2}}\right)}{exp\left(\frac{-c_2}{\lambda_2 (T_{REF}+\Delta T)}\right)}$$ *Graybody Comparison*

T / °C	ε	U(ε)	ΔT / K	U(ΔT) / K
420	0.9901	0.0116	3.51	2.64
500	0.9935	0.0119	3.19	3.24
660	0.9948	0.0123	3.96	4.58
810	0.9981	0.0128	1.98	6.06
960	0.9987	0.0134	-0.09	7.75

4.2 Modeling of Cavity

3.9 µm

	ε	Δε			
Temp / °C	Base	#1	#2	#3	#4
Isothermal	0.9998	-0.0006	NA	NA	NA
420	0.9996	-0.0014	0.0078	-0.0019	-0.0026
500	0.9996	-0.0014	0.0063	-0.0015	-0.0021
660	0.9996	-0.0014	0.0044	-0.0011	-0.0015
810	0.9996	-0.0013	0.0033	-0.0008	-0.0011
960	0.9996	-0.0013	0.0026	-0.0006	-0.0009

9 µm

	ε	Δε			
Temp / °C	Base	#1	#2	#3	#4
Isothermal	0.9998	-0.0006	NA	NA	NA
420	0.9996	-0.0011	0.0038	-0.0009	-0.0012
500	0.9996	-0.0011	0.0032	-0.0007	-0.0010
660	0.9996	-0.0011	0.0023	-0.0005	-0.0007
810	0.9996	-0.0011	0.0019	-0.0004	-0.0005
960	0.9996	-0.0011	0.0015	-0.0003	-0.0004

Model Variaitons
Model 1:
Δε walls 0.95 to 0.80
Model 2:
reference ΔT 1 K
Model 3:
mid-point wall
ΔT 50 K
Model 4:
cavity corner ΔT 1 K

5. Conclusion
- Radiometric traceability - take great care
  - Bandwidth concerns
- Temperature uniformity
  - Cavity bottom
  - Cavity walls