

Variations in Calibration of Radiometers using Cut-on Optical Filters

The spectral bandpass of infrared radiometers using thermopile detectors are often controlled with a $6\mu\text{m}$ cut-on filter. These filters normally have a cut-on tolerance of $\pm 1\mu\text{m}$ and the cut-off wavelengths are determined by the substrate transmission, which is usually germanium or silicon. This variation of cut-on wavelength effects the radiometer's calibration against a linearizing network in a manner that cannot be corrected by a single gain adjustment.

The following analysis is based on integrating the Planck function. The calculations will be for a radiometer that measures temperatures from 0°C to 200°C and has been temperature compensated for ambient temperature effects. We will also assume that the filter has a square bandpass ending at $15.5\mu\text{m}$ and a transmission of 1.0 throughout the pass band (typical average transmission is in the range of 60-80%). Additionally, we will assume the specimen to be an ideal blackbody emitter. The results of these calculations are presented in Table 1.

Temp. $^\circ\text{C}$	Transmitted Energy from Cut-on to $15.5\mu\text{m}$ ($\text{mW}/\text{cm}^2\text{sr}$)		
	Cut-on Wavelength: $5\mu\text{m}$	$6\mu\text{m}$	$7\mu\text{m}$
0	5.16	5.00	4.69
25	8.11	7.74	7.14
50	12.05	11.34	10.26
100	23.44	21.32	18.61
200	62.59	53.25	43.68

Table 1. Calculated Energy for Three Spectral Bandpasses Ending at $15.5\mu\text{m}$.

Table 2 shows the results when each column is normalized to its value at 200°C .

Temp. $^\circ\text{C}$	Normalized Transmitted Energy from Cut-on to $15.5\mu\text{m}$		
	Cut-on Wavelength: $5\mu\text{m}$	$6\mu\text{m}$	$7\mu\text{m}$
0	0.0824	0.0939	0.1074
25	0.1296	0.1454	0.1635
50	0.1925	0.2130	0.2349
100	0.3745	0.4004	0.4261
200	1.0	1.0	1.0

Table 2. Energy Normalized to 1.0 at 200°C for Each Cut-on Wavelength.

The normalization procedure is equivalent to calibrating the radiometer against a 200°C blackbody.

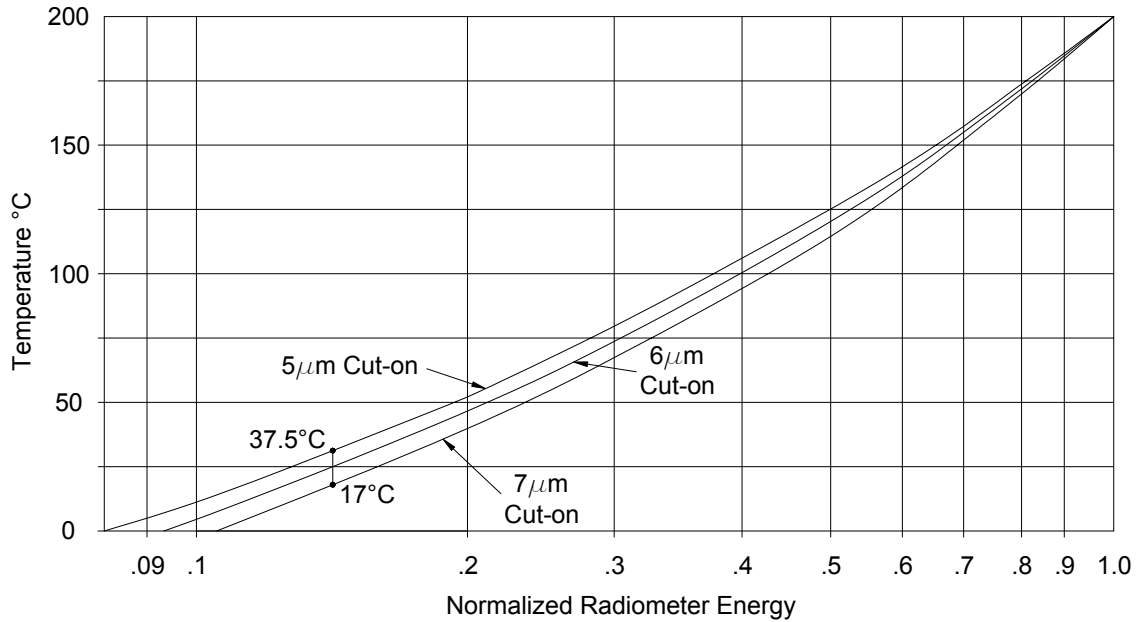


Fig. 1. Graphical Illustration of Variations in Radiometer Calibration.

The graph in Fig. 1. may be used to develop a meter scale that would be divided into °C for the temperature range from 0°C to 200°C. If the meter scale were based on the 6µm filter cut-on wavelength and radiometer was calibrated at 200°C, the temperature indication with a 5µm and 7µm filter cut-on would be 37.5°C and 17°C, respectively.

This application brief has shown the non-linearities that may be encountered when calibrating a radiometer that uses a cut-on filter to limit the spectral bandwidth of sensed thermal radiation.