



Standard Test Method for Measuring Total-Radiance Temperature of Heated Surfaces Using a Radiation Pyrometer¹

This standard is issued under the fixed designation E 639; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the measurement of the total-radiance temperature (see section 2.1.20) of surfaces using a radiation pyrometer that is not in contact with the surface. The measured total-radiance temperature is then converted to the “true” surface temperature using an assumed or measured value of the surface emittance.

1.2 This test method includes those pyrometers which respond to a wide band of radiant energy (heat), that is, total radiation pyrometers, as well as those which respond to a relatively narrow band of radiant energy, that is, monochromatic or pseudomonochromatic radiation pyrometers. The latter are often referred to as “optical” pyrometers. The visual optical pyrometer, sometimes referred to as a “disappearing-filament” or “brightness” pyrometer, is not covered by this test method.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Terminology

2.1 Definitions:

2.1.1 *band emissivity*—the weighted average spectral emissivity of a given surface at a given temperature and over a specified wavelength band, with the spectral radiance of a blackbody radiator at the given temperature as the weighting function. Expressed mathematically:

$$\epsilon_b = \frac{\int_{\lambda_1}^{\lambda_2} \epsilon_{\lambda} L_{e,\lambda} d\lambda}{\int_{\lambda_1}^{\lambda_2} L_{e,\lambda} d\lambda} \quad (1)$$

where:

ϵ_b = band emissivity of a surface at some known temperature,

ϵ_{λ} = spectral emissivity of that surface at the same temperature,

$L_{e,\lambda}$ = spectral radiance of a blackbody radiator at that temperature, and

λ_1 and λ_2 = limits of the spectral band involved.

For a pyrometer in which the spectral response varies over its wavelength range of sensitivity, the band emissivity should also be weighted by the relative spectral responsivity, $R(\lambda)$, of the pyrometer. The equation then becomes:

$$\epsilon_b = \frac{\int_{\lambda_1}^{\lambda_2} \epsilon_{\lambda} L_{e,\lambda} R(\lambda) d\lambda}{\int_{\lambda_1}^{\lambda_2} L_{e,\lambda} R(\lambda) d\lambda} \quad (2)$$

Eq 2 is required only when *both* the spectral emissivity, ϵ_{λ} , and the relative spectral responsivity, $R(\lambda)$, vary over the wavelength band of interest. If ϵ_{λ} is constant, its value is used, and neither equation is required. If $R(\lambda)$ is constant, but ϵ_{λ} varies, Eq 1 is used.

It should be noted that ϵ_b is a function of temperature even for those materials whose spectral emissivity is independent of temperature, since the relative distribution of $L_{e,\lambda}$ varies markedly with temperature.

2.1.2 *blackbody*—a thermal radiator that completely absorbs all incident radiation, whatever the wavelength or direction of incidence. This radiator has the maximum spectral concentration of radiant emittance at a given temperature **(1)**²; that is, blackbody is an ideal thermal radiator. Devices can be constructed which approximate an ideal blackbody by providing an opaque-walled heated cavity with a small opening (for example, **2, 3**) and are commonly called laboratory blackbodies.

2.1.3 *directional*—in a given direction from a surface. For isotropic surfaces this may be designated by the polar angle, θ , from the normal to the surface to the given direction. For nonisometric surfaces, the azimuth angle, ϕ , measured from a fiducial mark on the sample to the plane of incidence, must also be given. Directional is indicated in the general case by the symbol (θ) or (θ, ϕ) following the symbol for the quantity or property, as $L(\theta, \phi)$ or $\epsilon(\theta)$. For a specific case the angle in degrees is substituted for θ and ϕ .

¹ This test method is under the jurisdiction of ASTM Committee E21 on Space Simulation and Applications of Space Technology and is the direct responsibility of Subcommittee E 21.08 on Thermal Protection.

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² The boldface numbers in parentheses refer to the list of references appended to this test method.