



Standard Test Method for Measuring Heat Transfer Rate Using a Thin-Skin Calorimeter¹

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1. Scope

1.1 This test method covers the design and use of a thin metallic calorimeter for measuring heat transfer rate (also called heat flux). Thermocouples are attached to the unexposed surface of the calorimeter. A one-dimensional heat flow analysis is used for calculating the heat transfer rate from the temperature measurements. Applications include aerodynamic heating, laser and radiation power measurements, and fire safety testing.

1.2 Advantages:

1.2.1 *Simplicity of Construction*—The calorimeter may be constructed from a number of materials. The size and shape can often be made to match the actual application. Thermocouples may be attached to the metal by spot, electron beam, or laser welding.

1.2.2 Heat transfer rate distributions may be obtained if metals with low thermal conductivity, such as some stainless steels, are used.

1.2.3 The calorimeters can be fabricated with smooth surfaces, without insulators or plugs and the attendant temperature discontinuities, to provide more realistic flow conditions for aerodynamic heating measurements.

1.2.4 The calorimeters described in this test method are relatively inexpensive. If necessary, they may be operated to burn-out to obtain heat transfer information.

1.3 Limitations:

1.3.1 At higher heat flux levels, short test times are necessary to ensure calorimeter survival.

1.3.2 For applications in wind tunnels or arc-jet facilities, the calorimeter must be operated at pressures and temperatures such that the thin-skin does not distort under pressure loads. Distortion of the surface will introduce measurement errors.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4.1 *Exception*—The values given in parentheses are for information only.

1.5 *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. Summary of Test Method

2.1 This test method for measuring the heat transfer rate to a metal calorimeter of finite thickness is based on the assumption of one-dimensional heat flow, known metal properties (density and specific heat), known metal thickness, and measurement of the rate of temperature rise of the back (or unexposed) surface of the calorimeter.

2.2 After an initial transient, the response of the calorimeter is approximated by a lumped parameter analysis:

$$q = \rho C_p \delta \frac{dT}{d\tau} \quad (1)$$

where:

q = heat transfer rate, W/m²,
 ρ = metal density, kg/m³,
 δ = metal thickness, m,
 C_p = metal specific heat, J/kg·K, and
 $dT/d\tau$ = back surface temperature rise rate, K/s.

3. Significance and Use

3.1 This test method may be used to measure the heat transfer rate to a metallic or coated metallic surface for a variety of applications, including:

3.1.1 Measurements of aerodynamic heating when the calorimeter is placed into a flow environment, such as a wind tunnel or an arc jet; the calorimeters can be designed to have the same size and shape as the actual test specimens to minimize heat transfer corrections;

3.1.2 Heat transfer measurements in fires and fire safety testing;

3.1.3 Laser power and laser absorption measurements; as well as,

3.1.4 X-ray and particle beam (electrons or ions) dosimetry measurements.

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 E21.08 on Thermal Protection.

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