Designation: C1549 – 16

# Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer[1]

This standard is issued under the fixed designation C1549; 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 a technique for determining the solar reflectance of flat opaque materials in a laboratory or in the field using a commercial portable solar reflectometer. The purpose of the test method is to provide solar reflectance data required to evaluate temperatures and heat flows across surfaces exposed to solar radiation.

1.2 This test method does not supplant Test Method E903 which measures solar reflectance over the wavelength range 250 to 2500 nm using integrating spheres. The portable solar reflectometer is calibrated using specimens of known solar reflectance to determine solar reflectance from measurements at four wavelengths in the solar spectrum: 380 nm, 500 nm, 650 nm, and 1220 nm. This technique is supported by comparison of reflectometer measurements with measurements obtained using Test Method E903. This test method is applicable to specimens of materials having both specular and diffuse optical properties. It is particularly suited to the measurement of the solar reflectance of opaque materials.

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

1.4 *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. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

E1980 Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

2.2 *ANSI/CRRC Standard:*[3]

ANSI/CRRC S100 Standard Test Methods for Determining Radiative Properties of Materials

## 3. Terminology

3.1 *Definitions*—For definitions of some terms used in the test method, refer to Terminology C168.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air mass*—air mass is related to the path length of solar radiation through the Earth's atmosphere to the site of interest. Air mass 1 is for a path of normal solar radiation at the Earth's equator while air mass 2 indicates two times this path length.

3.2.2 *solar reflectance*—the fraction of incident solar radiation upon a surface that is reflected from the surface.

3.3 *Symbols:*

3.3.1 $A$—area normal to incident radiation, m$^2$.

3.3.2 $Q_{abs}$—rate at which radiant heat is absorbed per m$^2$ of area, W.

3.3.3 $q_{solar}$—solar flux, W/m$^2$.

3.3.4 $r$—solar reflectance, dimensionless.

## 4. Summary of Test Method

4.1 This test method employs a diffuse tungsten halogen lamp to illuminate a flat specimen for two seconds out of a ten-second measurement cycle. Reflected light is measured at an angle of 20° from the incident angle with four detectors. Each detector is equipped with color filters to tailor its electrical response to a range of wavelengths in the solar spectrum. Software in the instrument combines the outputs of the four detectors in appropriate proportions to approximate the response for incident solar radiation through air mass 0, 1, 1.5,

---

[1] This test method is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.30 on Thermal Measurement.

Current edition approved Nov. 1, 2016. Published November 2016. Originally approved in 2002. Last previous edition approved in 2014 as C1549 – 09 (2014). DOI: 10.1520/C1549-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Cool Roof Rating Council (CRRC), 449 15th Street, Suite 400, Oakland, CA 94612, http://www.coolroofs.org.

or 2. The solar reflectance for the desired air mass is selectable from the instrument's keypad. The reflectances measured by the individual detectors are also available from the keypad and digital readout. The instrument is calibrated using a black body cavity for a reflectance of zero and one or more surfaces of known solar reflectance provided by the manufacturer. A surface to be evaluated is placed firmly against the 2.5 cm diameter opening on the measurement head and maintained in this position until constant readings are displayed by the digital readout. A comparison of techniques for measuring solar reflectance is available.[4]

## 5. Significance and Use

5.1 The temperatures of opaque surfaces exposed to solar radiation are generally higher than the adjacent air temperatures. In the case of roofs or walls enclosing conditioned spaces, increased inward heat flows result. In the case of equipment or storage containers exposed to the sun, increased operating temperatures usually result. The extent to which solar radiation affects surface temperatures depends on the solar reflectance of the exposed surface. A solar reflectance of 1.0 (100 % reflected) would mean no effect on surface temperature while a solar reflectance of 0 (none reflected, all absorbed) would result in the maximum effect. Coatings of specific solar reflectance are used to change the temperature of surfaces exposed to sunlight. Coatings and surface finishes are commonly specified in terms of solar reflectance. The initial (clean) solar reflectance must be maintained during the life of the coating or finish to have the expected thermal performance.

5.2 The test method provides a means for periodic testing of surfaces in the field or in the laboratory. Monitor changes in solar reflectance due to aging and exposure, or both, with this test method.

5.3 This test method is used to measure the solar reflectance of a flat opaque surface. The precision of the average of several measurements is usually governed by the variability of reflectances on the surface being tested.

5.4 Use the solar reflectance that is determined by this method to calculate the solar energy absorbed by an opaque surface as shown in Eq 1.

$$Q_{abs} = A \cdot q_{solar} \cdot (1 - r) \tag{1}$$

5.4.1 Combine the absorbed solar energy with conductive, convective and other radiative terms to construct a heat balance around an element or calculate a Solar Reflectance Index such as that discussed in Practice E1980.

## 6. Apparatus

6.1 This test method applies to solar reflectance tests conducted with a portable reflectometer. The instrument consists of three major parts.

6.1.1 *Measurement Head*—The measurement head contains a tungsten halogen lamp used as the radiation source, the filters used to tailor the reflected radiation to specific wavelength ranges, and detectors for each of the four wavelength ranges. A 2.5 cm diameter circular opening on the top of the measurement head serves as a port through which incident and reflected radiation are transmitted to and from the test surface.

6.1.2 *Connecting Cable*—A connecting cable, connects the measurement head to the readout module. The connecting cable transmits electrical signals from the four detectors to the readout module.

6.1.3 *Readout Module*—The readout module that is connected to the measurement head includes a keypad for controlling the functions of the software, software for interpreting the signals from the measurement head, and a digital readout for solar reflectivity or the display of input parameters or calibration information. The resolution of the digital readout is 0.001. Detailed instructions for use of the keypad to communicate with the software are provided by the manufacturer of the apparatus.

6.1.4 *Reference Standards*—The calibration of the solar reflectometer is accomplished with a black body cavity that is supplied by the manufacturer and at least one high-reflectance standard. The solar reflectance of the high-reflectance standard or standards are programmed into the software to facilitate calibration. The apparatus accommodates up to eight solar reflectance standards.

6.1.5 *Test Specimens*—Specimens to be tested for solar reflectance shall be relatively flat and shall have a minimum dimension greater than 2.5 cm in order for the specimen to completely cover the measurement head opening. Test specimens of sufficient size are placed on top of the measurement head. Position the measurement head against a surface for in-situ or large area solar reflectance measurements.

## 7. Procedure

7.1 *Set-up*—The instrument requires 110 volt AC power. Take into account necessary safety precautions when using the instrument outside of conditioned spaces. Before power is applied and the instrument is turned on, either end of the cable must be connected to the socket on the measurement head. The other end must be connected to the socket on the readout and control module. The instrument powers up, ready to estimate the total solar reflectance through air mass 2. The instrument is designed to provide solar reflectances for air mass values of 0, 1, 1.5, or 2.0. The instrument shall be calibrated after at least 30 min. of warm-up time to avoid drift from the calibration. Leaving the instrument on for extended periods of time with a cover over the measurement head opening does not cause damage.

7.2 *Calibration (gain)*—At the end of the warm-up period, check and adjust the zero and gain. A zero reflectance blackbody cavity and various high reflectance standard specimens are provided to check zero and gain. If the blackbody cavity covers the opening of the measurement head and a non-zero reading is noted, then depress calibration/zero key. The instrument detects the presence of the zero reflectance cavity and resets the output reflectance to zero.

7.2.1 The gain or calibration adjustment requires that the reflectance of a known standard be coded into the instrument.

[4] Petrie, T. W., Desjarlais, A. O., Robertson, R. H., and Parker, D. S., "Comparison of Techniques for In Situ Nondamaging Measurement of Solar Reflectances of Low-Slope Roof Membranes," *International Journal of Thermophysics*, Vol 22, No. 5 , 2001, pp. 1613-1628.