Designation: E1918 – 21

Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field[1]

This standard is issued under the fixed designation E1918; 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 solar reflectance of various horizontal and low-sloped surfaces and materials in the field, using an albedometer or pyranometer. The test method is intended for use when the sun angle to the normal from a surface is less than 45°.

1.2 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

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

3. Terminology

3.1 *Definitions:*

3.1.1 *albedometer*—an instrument consisting of two anti-parallel (back-to-back) pyranometers, where the upper pyranometer measures incoming solar radiation and the lower pyranometer measures solar radiation reflected from the test surface.

3.1.2 *inhomogeneous test site*—a test site of nonuniform solar reflectance.

3.1.3 *low-sloped surface*—a surface with a tilt angle not exceeding 9.5°. The roofing industry has widely accepted a slope of less than 2:12 (16.7 %) as characteristic of a low-sloped roof. This corresponds to a tilt angle of approximately 9.5°.

3.1.4 *pyranometer*—a radiometric instrument used to measure the hemispherical (beam plus diffuse) solar radiant energy incident upon a surface per unit time and unit surface area.

3.1.5 *solar energy*—the radiant energy originating from the sun. Approximately 99 % of terrestrial solar energy arrives at wavelengths between 0.3 and 2.5 µm.

3.1.6 *solar flux*—for these measurements, the beam and diffuse radiance (radiative power per unit area) from the sun received at ground level, expressed in watts per square meter.

3.1.7 *solar reflectance*—the fraction of solar flux reflected by a surface.

3.1.8 *test site*—a location that contains one or more test surfaces.

3.1.9 *test surface*—a surface whose solar reflectance is to be measured with a pyranometer.

4. Summary of Test Method

4.1 An albedometer or pyranometer is used to measure incoming and reflected solar radiation for a uniform horizontal or low-sloped surface. The solar reflectance is the ratio of the reflected radiation to the incoming radiation.

5. Significance and Use

5.1 Solar reflectance is an important factor affecting the temperature of a sunlit surface and that of the near-surface ambient air temperature. The test method described herein measures the solar reflectance of surfaces in natural sunlight.

6. Apparatus

6.1 *Sensor*—A precision spectral pyranometer (PSP) sensitive to radiant energy in the 0.28 to 2.8 µm band is recommended. A typical pyranometer yields a linear output of ±0.5 % between 0 and 1400 $W \cdot m^{-2}$ and a response time of 1 s.

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[1] This test method is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.20 on Roofing Membrane Systems.

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[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.

Specific characteristics can be obtained based on calibration by the manufacturer of the pyranometer. Other suitable pyranometers are discussed in Zerlaut.[3] The double-dome design of the PSP minimizes the effects of internal convection resulting from tilting the pyranometer at different angles. For this reason, the PSP is especially suitable for this test, since measurement of solar reflectivity requires the apparatus to alternatively face up and down.

6.2 *Readout Instrument*—The analog output from the pyranometer is converted to digital output with a readout meter (such as EPLAB Model 455 Instantaneous Solar Radiation Meter) that has an accuracy of better than ±0.5 % and a resolution of $1\ W \cdot m^{-2}$. The meter shall be scaled to the sensitivity of the specific PSP by the manufacturer of the pyranometer. Alternatively, a precision voltmeter can be used.

6.3 *Albedometer or Pyranometer Support*—The albedometer (Fig. 1) or pyranometer (Fig. 2) shall be mounted on an arm and a stand that centers the sensor at a height of 500 mm above the target surface to minimize the effects of sensor, arm, and stand shadows on measured reflected radiation. The horizontal distance from the center of the albedometer or pyranometer to the edge of the test surface shall be at least 2 m. The arm and stand shall be strong and cast the smallest possible shadow. If using a pyranometer, the support must allow the pyranometer to be turned upward and downward easily as shown in Fig. 2.

7. Sampling, Test Specimens, and Test Units

7.1 This test method applies to low-sloped test surfaces that are at least 4 m in diameter (if circular) or at least 4 m on each side (if rectangular). Examples of sites that may contain test surfaces include roofs, streets, and parking lots.

8. Calibration and Standardization

8.1 The albedometer or pyranometer shall be checked to ensure its accuracy. A radiometric instrument is usually precalibrated by its manufacturer. It is a good practice to recalibrate the instrument at the manufacturer-specified interval, typically once every year or two years. Recalibration is performed by the manufacturer.

9. Procedure

9.1 Cloud cover and haze significantly affect the measurements. The tests shall be conducted on a clear, sunny day with no cloud cover or haze during the individual measurements. See Annex A1 for guidelines on determination of the suitability of the atmospheric conditions for conducting the tests.

9.2 The test shall be done in conditions where the angle of the sun to the normal from the test surface of interest is less than 45° (cosine of solar incidence angle is greater than $\frac{1}{\sqrt{2}} \approx 0.707$). For horizontal and low-sloped surfaces, this generally limits the test to between the hours of 9 a.m. and 3 p.m. local standard time; this is when solar radiation is at least 70 % of the value obtained at solar noon for that day. In winter months (when solar incidence angle is low), perform the tests between hours of 10 a.m. and 2 p.m.

NOTE 1—Solar elevation angle, solar azimuth angle, and the cosine of the solar incidence angle based on time and location may be obtained from a tool such as the NREL Solar Position and Intensity Calculator (https://midcdmz.nrel.gov/solpos/solpos.html).

9.3 Align the support such that the arm points toward the sun; this eliminates the shadow of the people conducting the test and minimizes the effect of the shadow from equipment. There shall be no other shadow on the measurement area other than the minimal shadow cast by the pyranometer and its support. The pyranometer shall be parallel to the test surface where measurement is conducted. The horizontal distance from the pyranometer sensor to the nearest edge of the test surface must be at least 2 m.

9.4 The measurement practices for a dual-sensor albedometer (9.4.1) and a single-sensor pyranometer (9.4.2) are as follows:

9.4.1 Albedometers will read both the incoming solar radiation and the reflected solar radiation simultaneously. Make sure each reading is constant for at least 10 s before recording its value. The albedometer shall be parallel to the test surface. Measure at least three pairs of incoming and reflected radiation

[3] Zerlaut, G., "Solar Radiation Instrumentation," *Solar Resources*, R. L. Hulstrom, ed., MIT Press, Cambridge, MA, 1989, pp. 173–308.

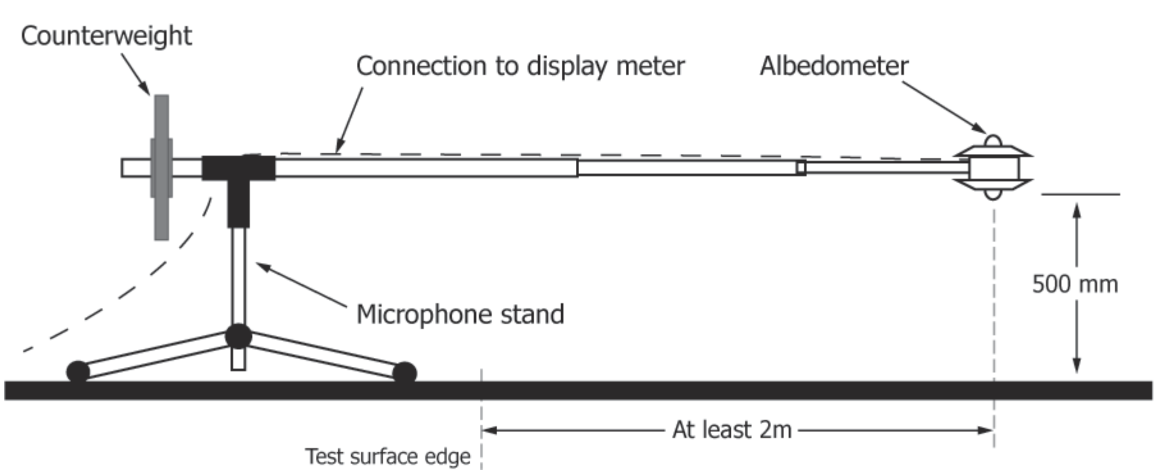

FIG. 1 Schematic of the Albedometer and Its Support

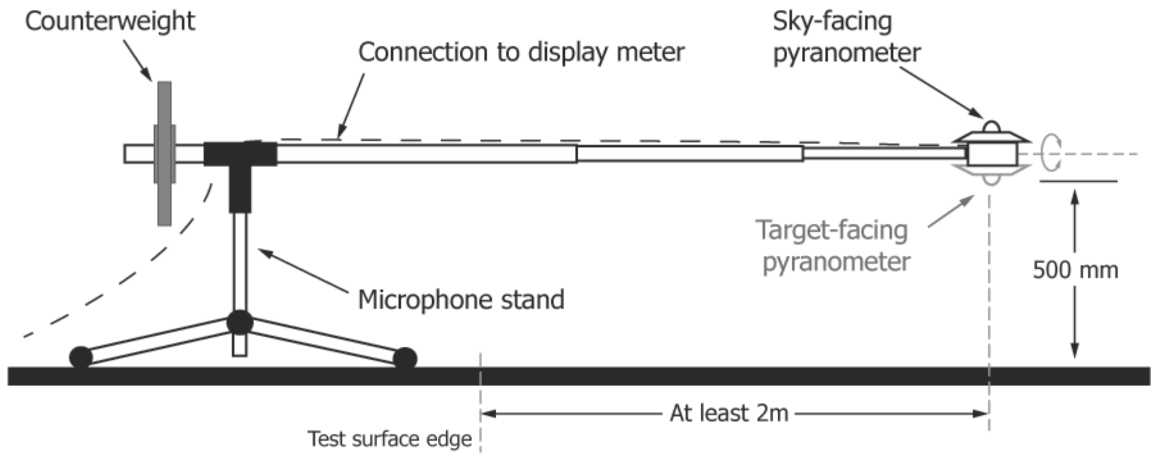

FIG. 2 Schematic of the Pyranometer and Its Support

within 2 min. The calculated solar reflectance (the ratio of the reflected radiation to incoming radiation) from all the measurements shall agree to within 0.01 in a reflectivity scale of 0.00 to 1.00.

NOTE 2—Since it is challenging to align the albedometer parallel to a tilted test surface, it is simpler and preferable to characterize a horizontal test surface.

9.4.2 To use a pyranometer, face the pyranometer upward and parallel to the test surface to read incoming solar radiation. Flip the pyranometer downward and parallel to the test surface to read reflected solar radiation. Make sure each reading is constant for at least 10 s before recording its value. Measure at least three pairs of incoming and reflected radiation within 10 min. The calculated solar reflectance (the ratio of the reflected radiation to incoming radiation) from all the measurements shall agree to within 0.01 in a reflectivity scale of 0.00 to 1.00.

NOTE 3—Since it is challenging to align the albedometer or pyranometer parallel to a tilted test surface, it is simpler and preferable to characterize a horizontal test surface.

9.5 To adequately represent the solar reflectance of an inhomogeneous site, the measurement practice specified in 9.3 and 9.4 shall be conducted at a minimum of three widely spaced test surfaces (locations separated by more that ten times the height of the sensor above the test surface being measured. The details (condition, location, and surroundings) of each test surface shall be recorded. For each test surface, follow the instructions in 9.3 and 9.4.

10. Report

10.1 The report shall include the following for each test surface:

10.1.1 The location (including latitude and longitude), date, and time of the test (indicating standard or daylight time).

10.1.2 General description of the test surface (for example, surface condition, presence of dirt, age).

10.1.3 A qualitative assessment of cloud cover or haze. (The measurements may need to be repeated if taken under cloudy or hazy conditions.)

10.1.4 The incoming solar radiation, the reflected solar radiation, and the calculated solar reflectance for all three pairs of acceptable measurements at each test surface.

10.1.5 The solar reflectance of each test surface, which is the average of the calculated solar reflectances at that surface.

NOTE 4—A tool to aid in reporting of results in 10.1 is available from Lawrence Berkeley National Laboratory (https://HeatIsland.LBL.gov/resources/technical-resources).

10.2 If the measurement site includes more than one test surface, the report shall also include the mean and standard deviation of the solar reflectances of the test surfaces.

11. Precision and Bias

11.1 *Precision*—The precision of this test method is based on an interlaboratory study of Test Method E1918 conducted in 2012. Each of seven laboratories tested three different smooth surfaced materials. Every "test result" represents the average of three determinations, and all participants were instructed to report four replicate test results. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. RR:D08-1018.[4] This precision statement is not applicable to materials whose surface is covered with mineral granules such as modified bitumen cap sheets. A new interlaboratory study is underway to determine the precision of this test method with such materials.

11.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

11.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D08-1018. Contact ASTM Customer Service at service@astm.org.