Designation: D7897 – 18 (Reapproved 2023)

Standard Practice for Laboratory Soiling and Weathering of Roofing Materials to Simulate Effects of Natural Exposure on Solar Reflectance and Thermal Emittance[1]

This standard is issued under the fixed designation D7897; 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 Practice D7897 applies to simulation of the effects of field exposure on the solar reflectance and thermal emittance of roof surface materials including but not limited to field-applied coatings, factory-applied coatings, single-ply membranes, modified bitumen products, shingles, tiles, and metal products. The solar reflectance and thermal emittance of roof surfacing materials can be changed by exposure to the outdoor environment. These changes are caused by three factors: deposition and retention of airborne pollutants, microbiological growth, and changes in physical or chemical properties. This practice applies to simulation of changes in solar reflectance and thermal emittance induced by deposition and retention of airborne pollutants and, to a limited extent, changes caused by microbiological growth.

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]

C1371 Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

C1549 Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

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

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

2.2 *Other Standards:*

ANSI/CRRC S100 Standard Test Methods for Determining Radiative Properties of Materials[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *solar energy*—the radiant energy originating from the sun.

3.1.1.1 *Discussion*—Approximately 99 % of terrestrial solar radiation lies between the wavelengths of 0.3 and 2.5 µm, with peak radiation near 0.5 µm. This spectrum includes ultraviolet, visible, and near-infrared radiation.

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

3.1.3 *thermal emittance*—efficiency with which a surface emits thermal radiation, measured on a scale from 0 to 1, where a value of 1 indicates perfect emission (that is, equal to that of a black body).

3.1.4 *thermal radiation*—the radiant energy originating from a 300 K (about 27 °C) black body.

3.1.4.1 *Discussion*—Approximately 99 % of thermal radiation lies between the wavelengths of 4 and 80 µm, with peak radiation near 10 µm.

4. Summary of Practice

4.1 This practice presents a rapid laboratory method for weathering and soiling, which simulates natural changes in solar reflectance and thermal emittance of materials in the field.

[1] This practice 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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

The practice describes a simulated field exposure protocol that consists of spraying an aqueous mixture of soot and other soluble soiling constituents, including salts and organic matter, onto a specimen of roof surfacing material. The specimen is exposed in a weathering apparatus before soiling, to provide UV conditioning; and after soiling, to simulate the cleaning effect of moisture (**1**).[4]

5. Significance and Use

5.1 The solar reflectance of a building envelope surface affects surface temperature and near-surface ambient air temperature. Surfaces with low solar reflectance absorb a high fraction of the incoming solar energy. Sunlight absorbed by a roof or by other building envelope surfaces can be conducted into the building, increasing cooling load and decreasing heating load in a conditioned building, or raising indoor temperature in an unconditioned building. It can also warm the outside air by convection. Determination of solar reflectance can help designers and consumers choose appropriate materials for their buildings and communities.

5.1.1 The solar reflectance of a new building envelope surface often changes within one to two years through deposition and retention of soot and dust; microbiological growth; exposure to sunlight, precipitation, and dew; and other processes of soiling and weathering. For example, light-colored "cool" envelope surfaces with high initial reflectance can experience substantial reflectance loss as they are covered with dark soiling agents. Current product rating programs require roofing manufacturers to report values of solar reflectance and thermal emittance measured after three years of natural exposure (**2**, **3**). A rapid laboratory process for soiling and weathering that simulates the three-year-aged radiative properties of roof and other building envelope surface materials expedites the development, testing, and introduction to market of such products.

5.2 Thermal emittance describes the efficiency with which a surface exchanges thermal radiation with its environment. High thermal emittance enhances the ability of a surface to stay cool in the sun. The thermal emittance of a bare metal surface is initially low, and often increases as it is soiled or oxidized (**4**). The thermal emittance of a typical non-metal surface is initially high, and remains high after soiling (**5**).

5.3 This practice allows measurement of the solar reflectance and thermal emittance of a roofing specimen after the application of the simulated field exposure.

5.4 This practice is intended to be referenced by another standard, such as ANSI/CRRC S100, that specifies practices for specimen selection and methods for radiative measurement.

6. Standard Practice Method and Apparatus

6.1 *Soiling Agents*—Atmospheric particles originate from windblown dust, forest and grassland fires, living vegetation, and sea spray, as well as from human activities, such as the burning of fossil and biomass fuels. Most particles either scatter or weakly absorb sunlight. A notable exception is black carbon soot emitted from the burning of fossil and biomass fuels and from fires. Because of its strong mass absorption efficiency, small amounts of black soot appreciably contribute to the soiling of building surfaces. An aqueous mixture of four soiling agents (as described below) is used for the simulated field exposure. The soiling agents and their concentrations were chosen based on their respective contributions to changes in the solar reflectance spectra of soiled surfaces, as determined in the laboratory. These four soiling agents have been shown to accumulate on surfaces exposed in natural outdoor settings (**6**).

6.1.1 *Dust*—A mixture of iron oxide (Fe_2O_3) powder (color: red-brown, particle size <5 µm, purity ≥99 %, CAS: 1309-37-1; example: SKU 310050 Sigma Aldrich) and two natural clays ((*1*) montmorillonite K10 powder (color: yellowish-gray, surface area: 220 to 270 m^2/g, CAS: 1318-93-0; example: SKU 281522 Sigma Aldrich) and (*2*) nanoclay, hydrophilic bentonite (particle size ≤25 µm, CAS: 1302-78-9; example: SKU 682659 Sigma Aldrich)) is used as a surrogate for dust. (Similar chemicals can be procured from other vendors.)

6.1.1.1 A mass of 0.3 ± 0.02 g of Fe_2O_3 powder is mixed with 1.0 ± 0.05 g of montmorillonite and 1.0 ± 0.05 g of bentonite. The mixture is transferred into 1 L of distilled water and stirred for about 1 h to prepare a stable dust suspension of 2.3 ± 0.1 g/L. To prevent sedimentation, the suspension is stirred again before use if more than 1 h has elapsed since it was previously stirred.

6.1.2 *Salts*—A solution containing a mixture of inorganic salts is prepared by dissolving 0.3 ± 0.03 g of sodium chloride (NaCl, CAS: 7647-14-5), 0.3 ± 0.03 g of sodium nitrate ($NaNO_3$, CAS: 7631-99-4) and 0.4 ± 0.03 g of calcium sulfate dihydrate ($CaSO_4{\cdot}2H_2O$, CAS: 10101-41-4) into 1 L of distilled water. The solution is stirred to ensure that all salts are dissolved. The total salt concentration of the solution is 1.0 ± 0.1 g/L.

6.1.3 *Particulate Organic Matter (POM)*—1.4 ± 0.05 g of humic acid (CAS: 1415-93-6) is dissolved in 1 L of distilled water to produce a solution of 1.4 ± 0.05 g/L.

6.1.4 *Soot*—A commercially available self-dispersible carbon black (Aqua-Black 001: Tokai Carbon Co., Ltd[5]), is used as surrogate for soot. 1.37 ± 0.05 g (equivalent volume: 1.25 ± 0.05 mL) of Aqua-Black 001 aqueous dispersion (19 % m/m carbon black) is diluted into 1 L of distilled water and shaken for 3 to 5 min to produce a stable soot (carbon black) suspension of 0.26 ± 0.01 g/L.

6.1.5 *Composition of Soiling Mixture*—A separate solution or suspension is prepared for each soiling agent. Once prepared, the four soiling solutions/suspensions described above are combined in various ratios depending upon the climate to be simulated. Each soiling mixture below has the same total mass concentration of soiling agents.

6.1.5.1 Composition of soiling mixture for average U.S. conditions (average of three exposure sites: Phoenix, Arizona;

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[5] The sole source of supply of the material known to the committee at this time is Tokai Carbon Co., Ltd. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.