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# Solar Reflectance FOR WALLS

## New green requirements have been established for vertical surfaces.

Solar reflectance has garnered attention due to requirements under the U.S. Green Building Council's (USGBC) LEED credits for reduction of urban heat-island effect. The LEED credits related to solar reflectance, or rather the solar reflectance index (SRI), apply only to roof and hardscape surfaces. The first edition of the ANSI/ASHRAE/USGBC/IES Standard 189.1—which was developed jointly by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), Atlanta; the USGBC; and the Illuminating Engineering Society (IES), Philadelphia—is the first U.S. standard written in code-intended language on the topic of green construction. It also is the first green standard or guide including SRI requirements for walls.

### SRI

SRI is a composite value accounting for a surface's solar reflectance and emittance. Reflectance and emittance are so-called radiometric properties (see **Terminology**, for more definitions). These are properties that vary with the direction of incident or exitant radiation flux, or both, and with the relative spectral distribution of the incident flux and the spectral response of the detector for the exitant flux. For reflectance, the direction and geometric extent of both the incident beam and exitant beam must be specified. For emittance, only the exitant beam needs specification (Ref. 1). The calculation procedure for solar reflectance index is described in ASTM E1980, Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

Nonmetallic opaque building materials, such as masonry, concrete, and wood, have an emittance of 0.90 (Ref. 2). Using ASTM E1980 and an emittance of 0.90, concrete needs to have a solar reflectance of at least 0.28 to meet the LEED-NC SS 7.1 requirement of an SRI of at least 29. Concrete needs to have a solar reflectance of at least 0.64 to meet the LEED-NC SS 7.2 requirement of an SRI of at least 78 for low-sloped roofs and at least 0.28

**Solar reflectance has garnered attention due to requirements under the U.S. Green Building Council's Leadership in Energy and Environmental Development credits for reduction of urban heat-island effect.** PHOTOS: CTLGROUP

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to meet the LEED-NC SS 7.2 requirements of an SRI of at least 29 for steep-sloped roofs. The LEED-NC Reference Guide provides a default value for concrete emittance of 0.9. The same source provides default solar reflectance and SRI values for "new typical gray concrete" and "new typical white concrete." Solar reflectance measurements on 45 concrete mix designs performed at CTLGroup, Skokie, Ill., support the values in the LEED-NC Reference Guide (Ref. 3).

## ASHRAE 189.1

In ASHRAE 189.1, "Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings," the requirements included cover five broad areas: site sustainability; water use efficiency; energy efficiency; indoor environmental quality; and the building's impact on the atmosphere, materials, and resources. Every project also must comply with construction and plans for operation.

The first two sections in every chapter—general and compliance paths—include general information and an explanation of the possible compliance paths, respectively. Mandatory provisions contain requirements that must be met on all projects. Each chapter then contains prescriptive and performance options (the two compliance paths), and the project must meet requirements in one or the other of these sections. In general, the prescriptive option allows for simpler showing of compliance, and the performance option is more involved.

SRI requirements for walls are contained in section 5.3.2, Mitigation of Heat Island Effect. In addition to hardscape requirements, section 5.3.2.2 contains the requirements for abovegrade building walls and retaining walls. To comply with this section, the surfaces can either be shaded or 75% of the opaque wall surface area (east and west walls) must have a minimum SRI of 29. The goal of this section is to reduce heat island effects near buildings.

Although the title and scope of ASTM E1980 refer to horizontal and low-sloped surfaces, SRI is allowed to be calculated using this method because no standard exists for the SRI of vertical surfaces. The SRI is calculated in E1980 based on the solar reflectance, thermal emittance, wind speed, and other factors. The difference between the SRI of a vertical and horizontal surface is primarily in the surface film resistances. The 189.1 standard was written with full knowledge of these differences. Therefore, SRI values for horizontal surfaces calculated in compliance with E1980 are allowed to be used to meet this requirement for walls (vertical surfaces).

## Sample preparation

The requirements related to solar reflectance should not seem daunting to any concrete professional. Concrete mixes are easily tested to determine if they conform to the SRI requirements. All that is needed is about a week and some properly prepared samples.

**Contact a testing firm.** When choosing a firm, be sure they are reputable and have the proper equipment to conduct the testing. The firm also should be familiar with the ASTM standards required to perform the tests (ASTM C1549–09, Standard Test Method for Determination of Solar Reflectance Near

Ambient Temperature Using a Portable Solar Reflectometer) and calculate the SRI (ASTM E1980).

**Create the samples.** To ensure that the SRI value of the samples to be tested is representative of the intended end product, there are a few best practices for sample preparation. They include:

1. *Finish like in the field.* One of the most important criterion for specimens is that the surface-to-be-tested should be finished as close as possible to field conditions. This means if the concrete will have a broom finish in the field, the top surface (the surface to be tested) of each specimen should have an identical broom finish. Surface smoothness affects test results—with rougher surfaces generally having lower SRI values.
2. *Keep them level.* Be sure to keep the surface of each specimen as flat and level as possible while still meeting the requirements of the step above. Testing is conducted by placing the 1-inch opening of the testing apparatus on the surface of the sample, so if the surface is uneven (that is, not flat or level), less of the light reflected from each specimen's surface will be measured by the testing apparatus. In other words, the sample set will be reported as having a lower-than-actual solar reflectance (and SRI).
3. *Plan ahead.* Concrete's color changes as it cures and hardens. To ensure the color is what it will be in the field, preparing specimens at least 28 days before testing is recommended. Additionally, it is not recommended to heat concrete to an equivalent age of 28 days since this will not likely be done in the field.
4. *Label specimens.* When sending samples to a testing firm, it is important to label each specimen with its corresponding name, mix design, etc. However, it is very important to not write on the surface to be tested. Markings on the surface of the specimen will adversely affect the solar reflectance measurements (and SRI) of the specimen.
5. *Sample size.* For testing, a 3-inch-minimum dimension per specimen is required (e.g. a 3-inch diameter cylinder), and a minimum of three specimens per sample set are required. Larger specimens (such as a 12-inch-square paver) can be divided into three specimens, which constitutes one sample set.

**Submit the report.** Once you have a report for a given sample submission, it is likely that it can meet the submission requirements for multiple projects. Keep in mind, however, that if any of the proportions of the mixture change, or the surface finish is changed, the testing will need to be performed again and another report generated. It is recommended that you retest every three years.

## Conclusions

New SRI wall requirements do not have to be just "another thing to do" for contractors. The ASHRAE 189.1 criteria do not change best practices for sample preparation. Knowing how to best prepare—and test—your samples will ensure that you are ready when asked for this information. **CC**

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## References

1. ASTM E772-05. Standard Terminology Relating to Solar Energy Conversion, ASTM International, West Conshohocken, Pa., 2006, 8 pages.
2. ASHRAE, 2009 ASHRAE Handbook Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta.
3. Marceau, Medgar L. and VanGeem, Martha G., Solar Reflectance of Concretes for LEED Sustainable Site Credit: Heat Island Effect, SN2982, Portland Cement Association, Skokie, Ill., 2007, 94 pages.

## Terminology

These terms refer to measures of electromagnetic flux, which is the amount of electromagnetic radiation (including visible light) in a given place at a given time.

### Solar reflectance

Solar reflectance is a surface property of opaque materials. Solar reflectance is measured on a scale of 0 to 1: from not reflective (0) to 100% reflective (1.0). Generally, materials that appear to be light colored in the visible spectrum have higher solar reflectance values and those that appear dark colored have lower solar reflectance values. However, color is not always a reliable indicator of solar reflectance because color only represents 47% of the energy in the solar spectrum.

### Emittance

Emittance for a sample at a given temperature is the ratio of the radiant flux emitted by the sample to that emitted by a blackbody radiator at the same temperature, under the same spectral and geometric conditions of measurement (ASTM E772). A blackbody radiator is a hypothetical object that completely absorbs all incident radiant energy, independent of wavelength and direction (ASTM E772).

Emittance can be thought of as a measure of how well a surface emits (or releases) heat. It is a value between 0 and 1. Highly polished aluminum has an emittance less than 0.1, and a black nonmetallic surface has an emittance greater then 0.9. However, most nonmetallic opaque materials at temperatures encountered in the built environment have an emittance between 0.85 and 0.95 (ASHRAE 2009). Emissivity is a property of a material, and emittance is a surface property.

### Solar reflectance index (SRI)

Solar reflectance index (SRI) is a measure of a constructed surface's ability to reflect solar heat, as shown by a small temperature rise. A standard black surface (solar reflectance 0.05, emittance 0.90) has an SRI of 0 and a standard white surface (solar reflectance 0.80, emittance 0.90) has an SRI of 100. SRI is generally between 0 and 100 but can be greater than 100 or less than 0. (As opposed to solar reflectance which is always between 0 and 1.0).