PROCEEDINGS

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Test Method Changes Impact on Roofing Solar Reflectance and Thermal Emittance

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Abstract

In this intermediate-level presentation, roofing professionals from all facets of the industry will learn how advancements in measurement devices and test procedures affect the rating of roofing products' thermal emittance and solar reflectance values. The presentation will discuss CRRC-conducted research around developing an alternative to ASTM C1371 and evaluating the differences between two versions of the solar spectrum reflectometer used with C1549.

Speaker

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JEFFREY STEUBEN is the technical liaison for the Cool Roof Rating Council (CRRC), an independent, nonprofit educational organization that promotes cool roofing and maintains a third-party rating system for the radiative properties of roof surfacing materials. Mr. Steuben's oversight includes conducting analysis of CRRC research studies and facilitation of its technical committee. Mr. Steuben received a BS degree from Humboldt State University in environmental science technology with a minor in geographic information systems.

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Test Method Changes Impact on Roofing Solar Reflectance and Thermal Emittance

INTRODUCTION

The Cool Roof Rating Council (CRRC) is a nonprofit organization established in 1998 to implement and promote a fair, accurate, and credible energy performance rating system for roof products. Additionally, the CRRC supports research of the radiative properties of roofing surfaces and provides education to parties interested in understanding roofing options. The CRRC's primary function is to provide objective information about the radiative properties of roofing products available to the marketplace and the public sector. These properties are tested through the CRRC Product Rating Program, and the program procedures (including test methods and guidelines for sample preparation) are freely available on the Internet (www.coolroofs.org). The CRRC rating protocol has been accredited as an ANSI standard.

The CRRC rates two surface radiative properties of roofing materials: solar reflectance and thermal emittance. Solar reflectance is the fraction of incident sunlight that is reflected off the surface of the product. Thermal emittance gauges the efficiency with which a warm surface can cool itself by emitting radiation; it is the ratio of thermal radiation emitted by a product to that emitted by a black-body radiator at the same temperature. Both properties are reported on a scale of 0 to 1, with a higher value signifying higher reflectance or emittance properties. Each property is measured for new product samples and for samples that have been weathered for three years in each of three U.S. representative climate zones. The CRRC posts these values as initial ratings and aged ratings in the Rated Products Directory.

The CRRC Product Rating Program specifies test methods for each roofing product type. To measure the radiative properties of roofing products, the current protocol allows a variety of test methods for solar reflectance: ASTM E1918, ASTM E903, ASTM C1549, and CRRC-1 Test Method #1 (a variant on ASTM C1549), as well as two tests for thermal emittance: ASTM C1371 and the Slide Method (a variant on ASTM C1371). Most products on the CRRC database are tested for solar reflectance using ASTM C1549, *Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer*; or its variation, CRRC-1 Test Method #1. Likewise, nearly all products are tested for thermal emittance using ASTM C1371, *Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers*.

The CRRC is guided by a board of directors and its committees. Scientific decisions relating to the rating program are evaluated by the Technical Committee, a group of board-appointed technical experts from the roofing industry, national laboratories, academia, and government agencies. The Technical Committee is responsible for reviewing and updating the CRRC rating program protocol, including but not limited to adopting test protocols for new product types, evaluating new measurement devices, and working with ASTM to perform precision and bias studies. In an effort to continually improve the CRRC Product Rating Program and ensure that the ratings are accurate, the Technical Committee recently considered two key studies: one regarding an upgrade to a device used to measure solar reflectance, and the other regarding how to accurately measure the thermal emittance of products with high thermal resistance.

Solar Spectrum Reflectometer Model SSR Upgrade Study

The solar reflectance of most roofing products is measured following ASTM Standard C1549 (or by following CRRC-1 Test Method #1, a variation of ASTM C1549). Method C1549 uses the Solar Spectrum Reflectometer Model SSR-ER, manufactured by Devices and Services Company (D&S). For the first 10 years of the CRRC program, the version of the Solar Spectrum Reflectometer in circulation was Version 5 (TN 86-1). In 2009, D&S produced an updated Version 6 model (TN 09-1). With the introduction of Version 6, the CRRC performed a study to compare solar reflectances measured with Version 6 to those measured with Version 5 and assess whether to adopt the latest version into the program. Of CRRC's seven Accredited Independent Testing Laboratories (AITLs), six possess Version 5 reflectometers and one has the Version 6 reflectometer. With this mix of versions used by the AITLs, and understanding that only Version 6 reflectometers would be available for future purchase, the CRRC also needed to determine if Version 6 could accurately emulate the Version 5 solar reflectance output specified by the CRRC Product Rating Program.

Reflectometer Background

A reflectometer displays the solar reflectance of the sample covering its measurement port. The reflectometer Version 5 measures solar reflectance by illuminating a sample with diffuse light from a tungsten lamp, then measuring near-normally reflected light at an angle of 20 degrees with four separate detectors. A spectral response shaped like a solar spectral irradiance is obtained by weighting the spectral responses of the four detectors. Three filtered silicon detectors collectively respond in the spectrum of about 0.3 to 1.1 μm, covering the ultraviolet, visible, and part of the near-infrared spectrum, while a filtered lead-sulfide detector responds in the spectrum of about 0.9 to 2.0 microns, covering most of the near-infrared spectrum. The spectral responses of the detectors overlap; however, they are designated ultraviolet (UV), blue, red, and infrared (IR). (D&S TN 79-16 and TN 86-1) See *Figure 1*.

The revised Version 6 reflectometer utilizes the same basic Version 5 model, with hardware and software modifications. This

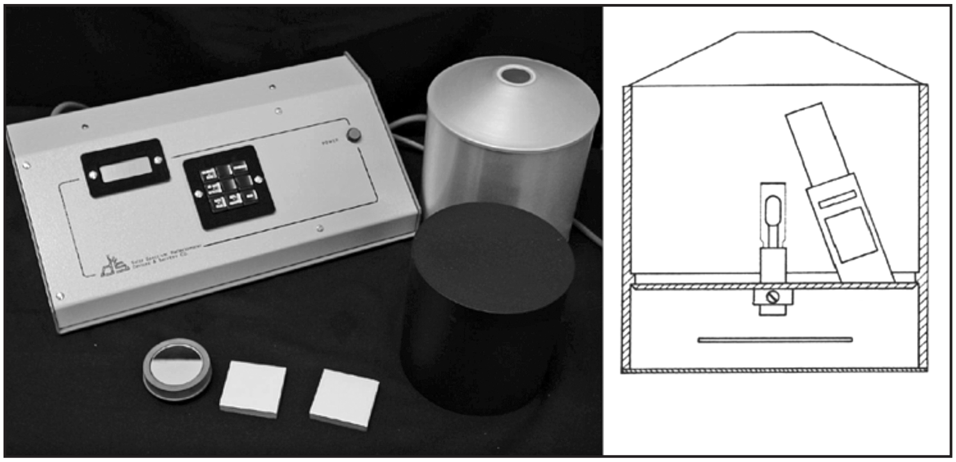

Figure 1 – The D&S Solar Spectrum Reflectometer Model SSR. Image courtesy of Devices and Services Company.

upgrade was proposed to improve the match between the reflectometer device and the spectrophotometer device, which is utilized by ASTM E903 to produce solar reflectance measurements using integrating spheres over the wavelength range of 250 to 2500 nm. When ASTM C1549 was originally developed, the accuracy of its measurements was confirmed through comparison against measurements obtained from ASTM E903. The air mass 1.5 solar reflectance output by the Version 5 reflectometer was designed to match the terrestrial solar reflectance specified in ASTM E903, which weights solar spectral irradiance with the beam-normal air mass 1.5 solar spectral irradiance under a hazy sky. As such, ASTM E903 has historically been used as a baseline for reflectance value accuracy. (ASTM C1549; D&S TN 09-1; Levinson *et al.*, 2010.)

To improve the match between the reflectometer and the spectrophotometer, D&S developed Version 6 by making the following modifications to Version 5 (D&S TN 09-1):

- Ten different irradiance options are available, whereas the original Version 5 allowed for only direct irradiance.
  - — G173 – ASTM G173 air mass 1.5 global irradiance
  - — b173 – ASTM G173 air mass 1.5 beam normal component
  - — G1 – Air mass 1 global irradiance on a horizontal surface
  - — b1 – Air mass 1 beam normal component
  - — d1 – Air mass 1 diffuse component
  - — b0 – Air mass 0 beam normal
  - — b891 – ASTM E891-87 air mass 1.5 beam normal
  - — 2E – Emulation of version 5 air mass 2 beam normal
  - — 1.5E – Emulation of version 5 air mass 1.5 beam normal
  - — 0E – Emulation of version 5 air mass 0 beam normal
  - — L1-L4 – IR, red, blue, and UV detector readings at ~3125 K lamp
  - — L5-L6 – IR and Red detector readings at ~2300 K lamp
- Two "virtual" detectors were added to generate a better match to the variety of solar irradiances. The red and IR detectors were resampled at a lower lamp color temperature to develop the "virtual" detectors.
- Each Version 6 instrument is spectrally calibrated against a set of 155 reflectance tiles that were measured using a spectrophotometer. This custom set of weightings results in a tighter match between the two devices.
- Four calibration tile standards were added to the original set of three to track the device's spectral calibration.
- Other changes were implemented, including a software update, lamp monitoring capability, and power supply modifications.

The CRRC program protocol for solar reflectance using ASTM C1549 specifies an air mass of 1.5, which is based on solar spectrum ASTM E891-82. Air mass is related to the path length of solar radiation through the earth's atmosphere to the site of interest. Air mass 1.5 was selected to represent the average solar radiation path through the atmosphere for the typical North American latitude (ASTM C1549, CRRC-1).

With the reflectometer Version 5, the air mass was set to 1.5 to perform CRRC solar reflectance measurements. However, with Version 6, due to the variety of irradiances now available, an air mass of 1.5 could be any one of the following options: G173, b173, b891, or 1.5E. D&S had created the irradiance option 1.5E for the purpose of emulating the Version 5 instruments at an air mass of 1.5. Consequently, 1.5E also emulated the inaccuracies from Version 5, which contribute to the disparity from spectrophotometer measurements. D&S recommended the use of the b891 selection to produce the most accurate solar reflectance

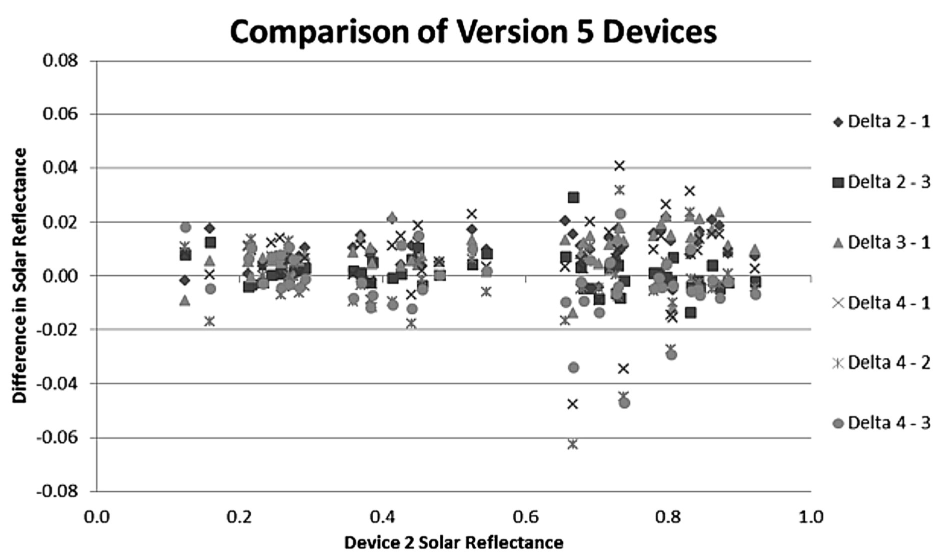

Figure 2 – Comparison of Version 5 instruments.

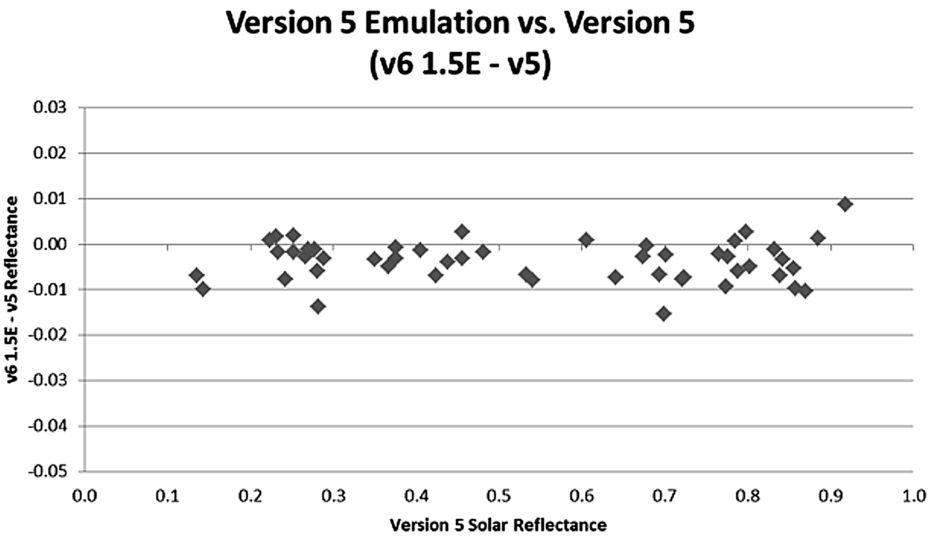

Figure 3 – Version 5 versus Version 5 in 1.5E mode: difference in reflectance.

readings for an air mass of 1.5 (D&S TN 09-1).

Round 1 Study Objective

The objective of Round 1 of the Reflectometer Upgrade study was to ascertain the quantitative difference between solar reflectance measurements made with a Version 5 reflectometer at air mass 1.5, a Version 6 reflectometer in b891 output, and a Version 6 reflectometer in 1.5E output for a wide range of types of roofing materials. A secondary goal of this study was to ensure that any quantitative differences that are found are consistent between different devices and different labs. The range of quantitative differences for the varying product types may provide an indication of whether upgrading a reflectometer is likely to result in significant deviation from previously measured and rated solar reflectance values for any given roofing product.

Round 1 Study Protocol

The study included a range of product types and colors aimed to represent the range of products rated in the CRRC program. Fifty-six products were tested, including built-up roofing (BUR) products, field-applied coatings, modified bitumen, single ply, shingles, tiles, and colored metal products. Three identical samples of each product were collected from the manufacturer or distributor. Oak Ridge National Laboratory (ORNL) and D&S participated in the study. Each lab was provided its own complete set of samples. Both labs measured the solar reflectance of each sample three times, in accordance with ASTM C1549, with each of the following device arrangements:

- D&S reflectometer Version 5, air mass 1.5 solar reflectance output (SSRv5 1.5)
- D&S reflectometer Version 6, b891 solar reflectance output (SSRv6 b891)
- D&S reflectometer Version 6, 1.5E solar reflectance output (SSRv6 1.5E)

Measurements were first taken with a Version 5.0 device (SSRv5 1.5), and then each device was upgraded by D&S to Version 6. Each upgraded Version 6 device was then used to measure SSRv6 b891 and SSRv6 1.5E solar reflectances. A total of four reflectometers were used in the study; however, only two reflectometers were upgraded to Version 6.

Round 1 Study Results

The four Version 5 reflectometer devices' values for 56 products were compared against each other as displayed in *Figure 2.* The variation among devices for measurements taken on the same sample demonstrated an absolute maximum of 0.063, with a mean absolute difference of 0.009. This testing shows that some variation can be expected from one Version 5 instrument to another.

Comparison of the measurements between Version 6 instruments running in selection 1.5E (emulation mode for Version 5) and Version 5 are displayed in *Figure 3.* While D&S ran its Version 6 device in 1.5E mode, ORNL did not; as a result, there is only one data set available for these measurements. For a given sample, the data demonstrated a maximum absolute difference between the two versions of 0.015, with a mean absolute difference of 0.004. The variation between these two versions (Version 5 and Version 6 in 1.5E mode) was significantly lower than the variation seen between the three different Version 5 instruments.

The last comparison demonstrated the variation between a Version 6 reflectometer running in b891 output and a Version 5 reflectometer. D&S and ORNL each upgraded one device, and all samples were measured before and after the upgrade. The D&S results show a maximum absolute difference of 0.020, while the ORNL results show a maximum absolute difference of 0.040. D&S data demonstrated larger absolute variations in products with a Version 5 solar reflectance between 0.45 and 0.60, while ORNL saw the largest absolute variation in products of higher solar reflectance, above 0.65. Both data sets are presented in *Figures 4* and *5*.

The difference in findings between D&S and ORNL is notable. In the case of D&S, the variation between Version 5 and Version 6 is less than the variation seen between multiple Version 5 instruments. However, the ORNL data shows variations up to a point higher than the largest variation seen between Version 5 instruments.

Round 1 Study Analysis

Round 1 provided data on three different measurements from the reflectometer: one in Version 5, one in Version 6 running in 1.5E mode, and the last in Version 6 running in b891 mode. The study noted the possible range of variation between Version 5 instruments, with a mean absolute difference of 0.009 and a maximum absolute difference of 0.063 among four devices. The study suggested that 1.5E replicated Version 5 fairly accurately. Version 6 measurements, however, were inconsistent between the two labs. The Reflectometer Upgrade Working Group attributed the inconsistency of the data to the following factors:

- Time delay between the testing of samples for the Version 5 and Version 6. D&S could modify its instruments immediately, while ORNL had a delay of months for transportation and upgrading. Certain roofing product

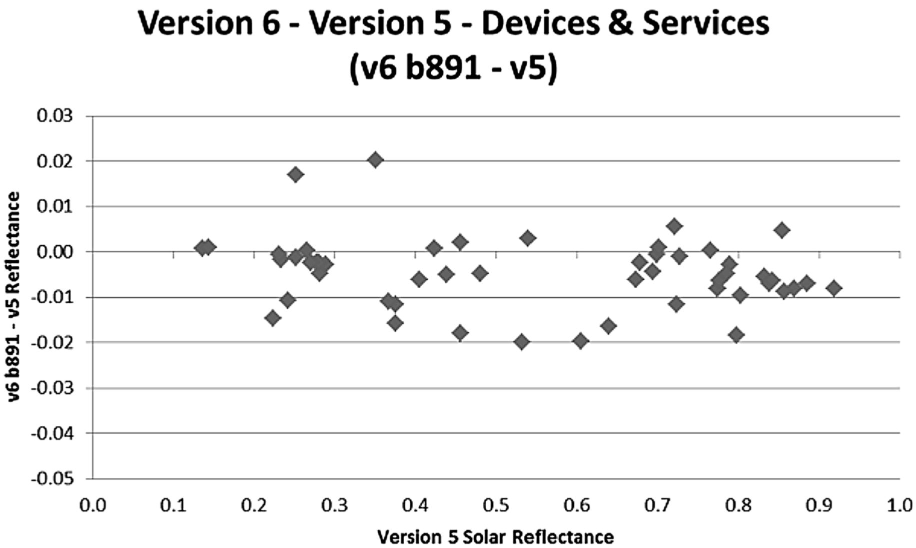

Figure 4 – Comparison of Version 5 and Version 6 (b891) – D&S data.

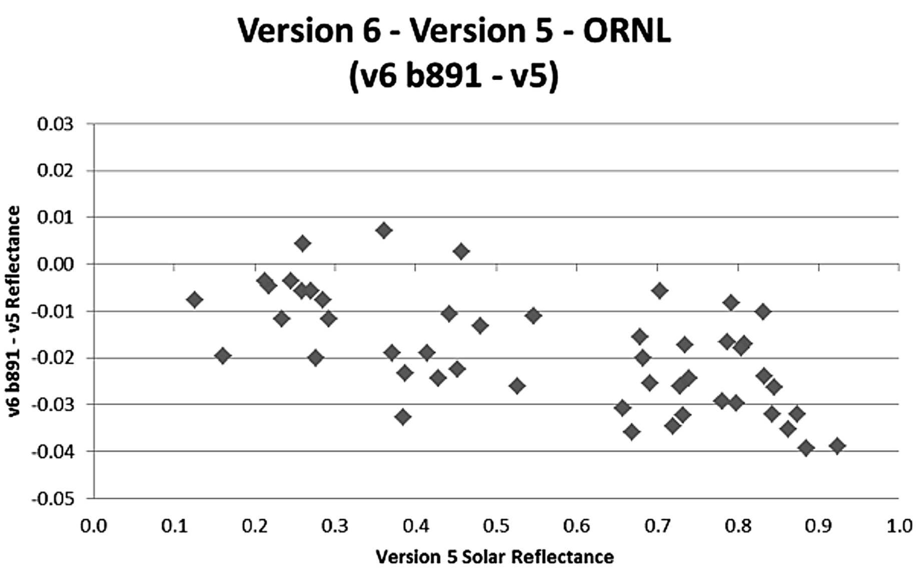

Figure 5 – Comparison of Version 5 and Version 6 (b891) – ORNL data.

Sample #	Avg Reflectance	Product Type	Color
1	0.781	Tile	White Buff Full
2	0.714	Factory-applied Coating	Cool White
3	0.673	Factory-applied Coating	Bone
4	0.448	Factory-applied Coating	Platinum
5	0.378	Factory-applied Coating	Brick Red
6	0.368	Tile	Traditional Flash
7	0.360	Factory-applied Coating	Banner Red
8	0.357	Factory-applied Coating	Maui Blue
9	0.276	Factory-applied Coating	Medium Bronze
10	0.257	Factory-applied Coating	Royal Blue
11	0.227	Factory-applied Coating	Cool Black

Table 1 – Round 2 sample set.

materials "age" from their initial production (for example, coatings that cure during the first year); thus reflectance values would be dependent on the timing of ORNL and D&S measurements.

- Sample variability in several product types, lending to potential measurement variations due to curvature or other material differences. Additionally, the samples potentially could have become contaminated over the study period.
- Limited data set, with testing being performed by only two laboratories.

Round 2 Study Objective

Round 1's inconsistent data resulted in an inability to draw conclusions regarding the impact on solar reflectance ratings from use of Version 5 versus Version 6 of the reflectometer. As a result, the CRRC developed a Round 2 study to address this comparison. The CRRC Technical Committee and Reflectometer Upgrade Working Group evaluated the Round 1 study to limit factors that might bias the data for Round 2.

Round 2 Study Protocol

The sample set for Round 2 was simplified to a set of 11 flat, homogeneous samples. The set included a variety of spectrally selective samples that were each at least one year old at the beginning of the round-robin to minimize errors due to the curing of coatings. Samples were stored in glassine paper envelopes to reduce contamination. See *Table 1*.

Six laboratories in possession of Version 6 reflectometers participated in the round-robin: D&S, ORNL, Lawrence Berkeley National Laboratory, PRI Construction Materials Technologies (PRI), Valspar Corporation, and Architectural Testing. Each lab recorded measurements from the Version 6 reflectometer in the following outputs: b891, 1.5E, L1, L2, L3, L4, L5, and L6. One measurement at the center of each sample was recorded. D&S contributed Version 5 measurements to the data set in addition to Version 6 data. D&S commenced the round-robin; the samples were then forwarded to each lab for their Version 6 reflectometer measurements. After all of the labs completed their tests, the samples were returned to D&S to repeat the measurements from the Version 5 and Version 6 devices, which checked for variations that may have resulted from soiling the samples in handling.

Round 2 Study Results

All six labs provided measurements comparing the solar reflectance difference between Version 6 b891 and Version 6 1.5E, which can be viewed in *Figure 6*. The mean absolute difference in reflectance demonstrated by all six labs' data for all samples came out to be 0.008. The maximum absolute value difference from all of the labs and all samples was 0.023.

The set of Version 6 b891 data was then compared against the D&S set of Version 5 measurements, as exhibited in *Figure 7*. Note, however, that the Version 5 measurements are a single set of data provided by D&S using a Version 5 device, whereas the Version 6 b891 data is obtained from all six labs. The mean absolute difference in solar reflectance between the lab Version 6 b891 and the D&S data for Version 5 was 0.008. The absolute maximum difference in reflectance from any of the Version 6 b891 lab readings from the Version 5 measurements was 0.023.

The set of Version 6 1.5E data was then compared against the D&S set of Version 5 measurements, as displayed in *Figure 8*. As noted above, the Version 5 measurements are a single set of data provided by D&S using a Version 5 device, whereas the Version 6 1.5E data is obtained from all six labs. The mean absolute difference in solar reflectance between the lab Version 6 1.5E and the D&S data for Version 5 was 0.004. The maximum absolute difference in reflectance from any of the Version 6 1.5E lab readings from the Version 5 measurements was 0.015.

Figure 9 takes all of the above data and averages the measurements from each of the six labs to lay out the difference in reflectance for the 11 samples.

Round 2 Study Analysis

Round 2 consisted of a comprehensive round-robin from data provided by six laboratories on two different measurements from the reflectometer: one in Version 6 in 1.5E output and the other in Version 6 in b891 output. Additionally, the D&S lab offered measurements from a Version 5 reflectometer for comparison. The study results revealed the following:

- For red samples (5, 6, and 7), the Version 6 b891 measurements trend lower than Version 5 or Version 6 1.5E. The absolute average change in reflectance for the three red samples was no more than 0.014. The maximum absolute difference in reflectance noted by any of the three red samples measurements was 0.023.
- For blue samples (8 and 10), the Version 6 b891 measurements trend higher than Version 5 or Version 6 1.5E. The absolute average change in reflectance for the two blue samples was no more than 0.015. The maxi-

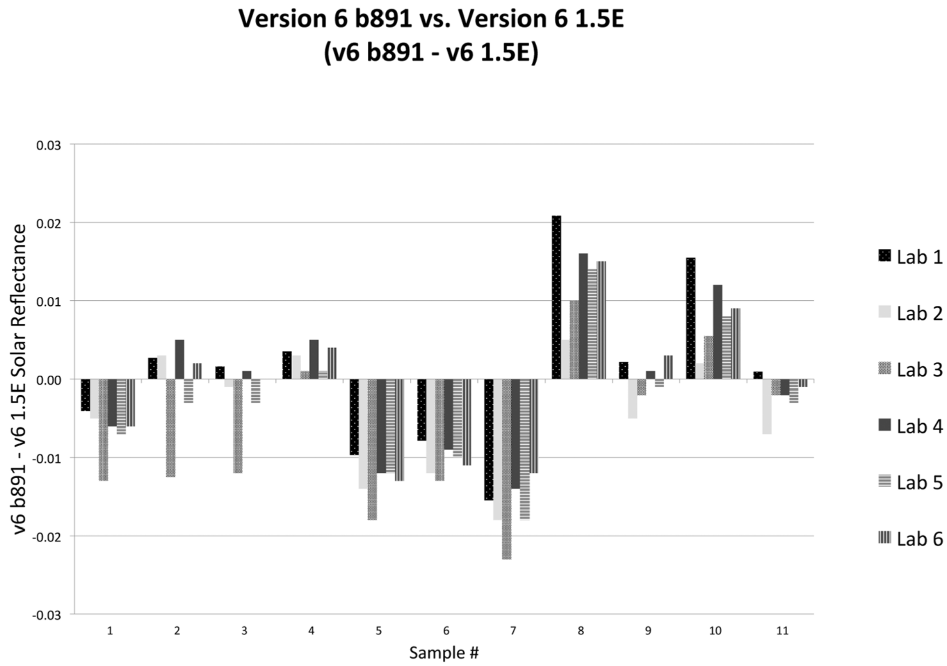

Figure 6 – Differences in solar reflectance between Version 6 b891 and Version 6 1.5E.

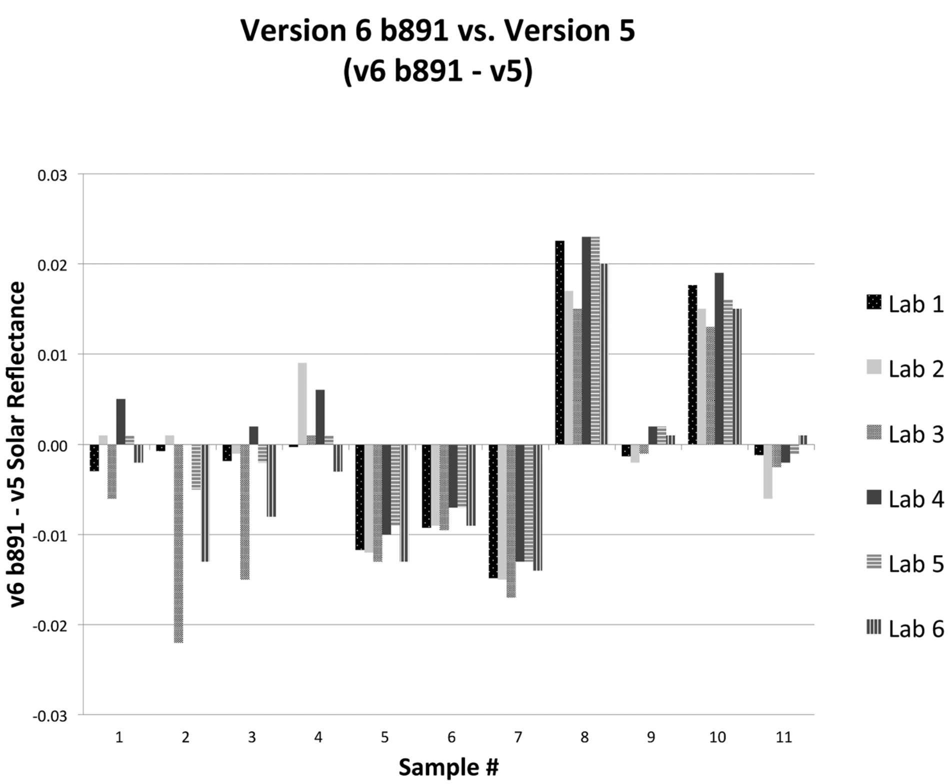

Figure 7 – Differences in solar reflectance between Version 6 b891 and Version 5.

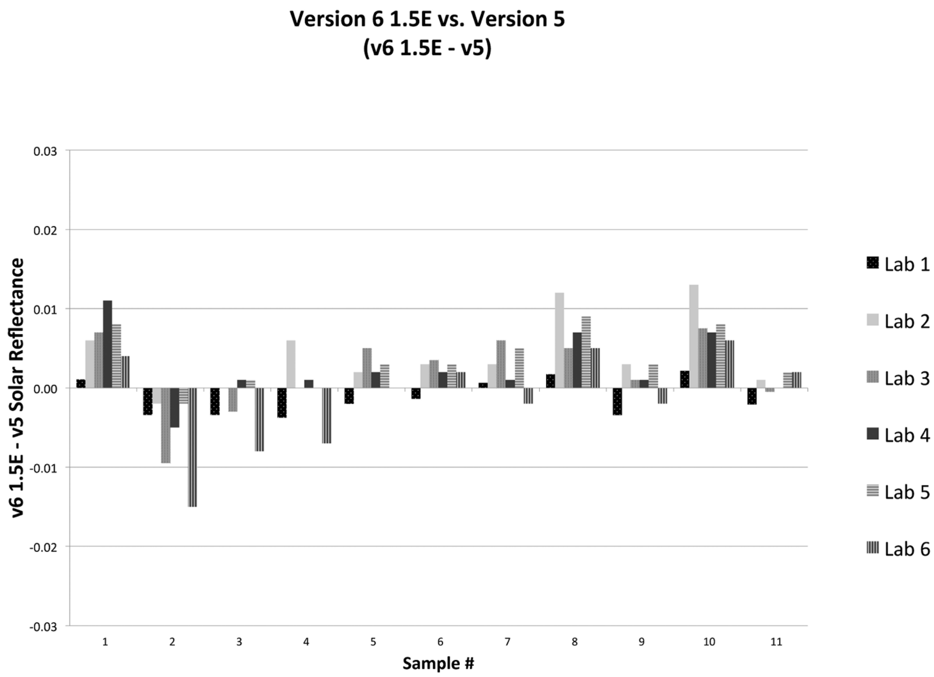

Figure 8 – Differences in solar reflectance between Version 6 1.5E and Version 5.

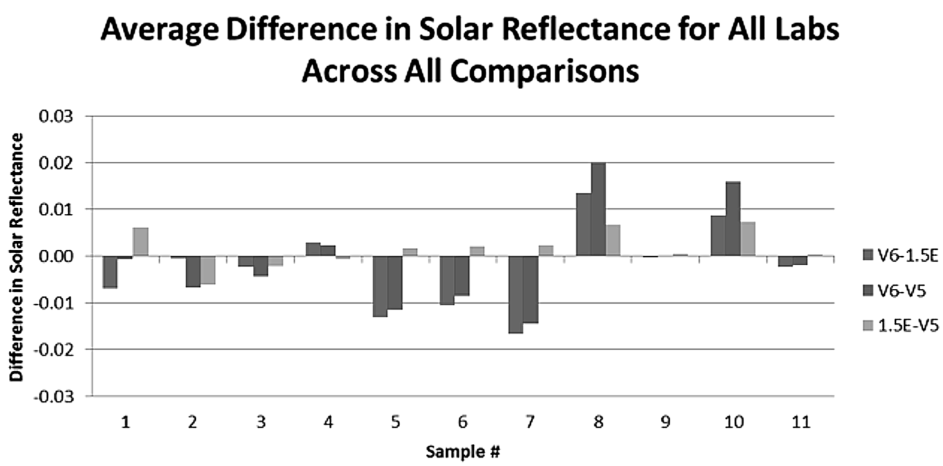

Figure 9 – Differences in solar reflectance from the average of all lab values.

mum absolute difference in reflectance noted by any of the two blue samples measurements was 0.023.

- All other samples demonstrated a 0.004 mean absolute difference in reflectance from Version 6 b891 to Version 5 or Version 6 1.5E. Version 6 tended to be slightly lower than the Version 5 or Version 6 1.5E measurements.
- Version 6 1.5E measurements tend to measure higher than Version 5; however, they were close in value to one another, with a mean absolute difference of no more than 0.004.

Thermal Emittance Slide Method Study

As a core component of its Product Rating Program, the CRRC uses ASTM C1371 to determine a product's thermal emittance. This standard, which uses the D&S Emissometer Model AE1, measures a sample's total hemispherical emittance. The device contains a heater that maintains the temperature of the detector. The detector is heated in order to provide the necessary temperature difference between the detector and the surface to be measured. A differential thermopile measures the temperature difference between black-coated, high-emittance areas and gold-plated, low-emittance areas on the detector surface. The instrument is calibrated using two standards—one with a high emittance and the other with a low emittance—that are placed on the flat surface of a heat sink. The emittance of the test specimen is quantified by comparison to the emittances of the standards (ASTM C1371).

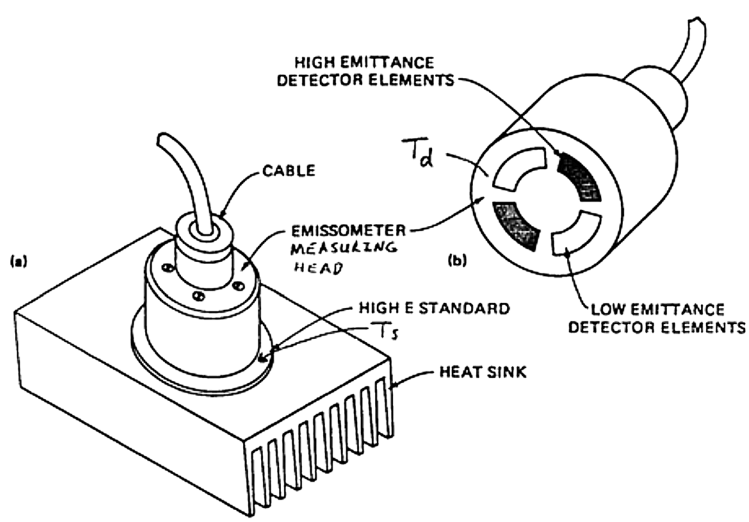

Figure 10 – Schematic of D&S AE1 Emissometer. Image courtesy of Devices and Services Company.

Emissometer Background

To conduct ASTM C1371, the operator first calibrates the instrument using a pair of high- and low-emittance standard discs provided by D&S. The emissometer head is placed on the high-emittance standard until the reading stabilizes, and then is placed on the specimen, waiting at least 90 seconds until the readings stabilize (ASTM C1371).

ASTM C1371 specifies that it can only be used for materials with a surface roughness less than 0.25 mm over an area the size of the emissometer head (a 50.8-mm diameter circle). Additionally, ASTM C1371 is applicable to materials with a thermal conductance of 1100 W m-2 K-1 or greater. Roofing products of high thermal resistance—including clay, concrete, asphalt shingles, wood, polymer, fleece-backed single-ply, and granule products—do not meet this threshold. As shown in *Figure 10*, a heat sink is used to keep the sample's surface at constant temperature. However, a heat sink will not operate effectively for samples that have high thermal resistance or cannot lie flat against the heat sink.

Figure 11 – D&S emissometer with port adaptor.

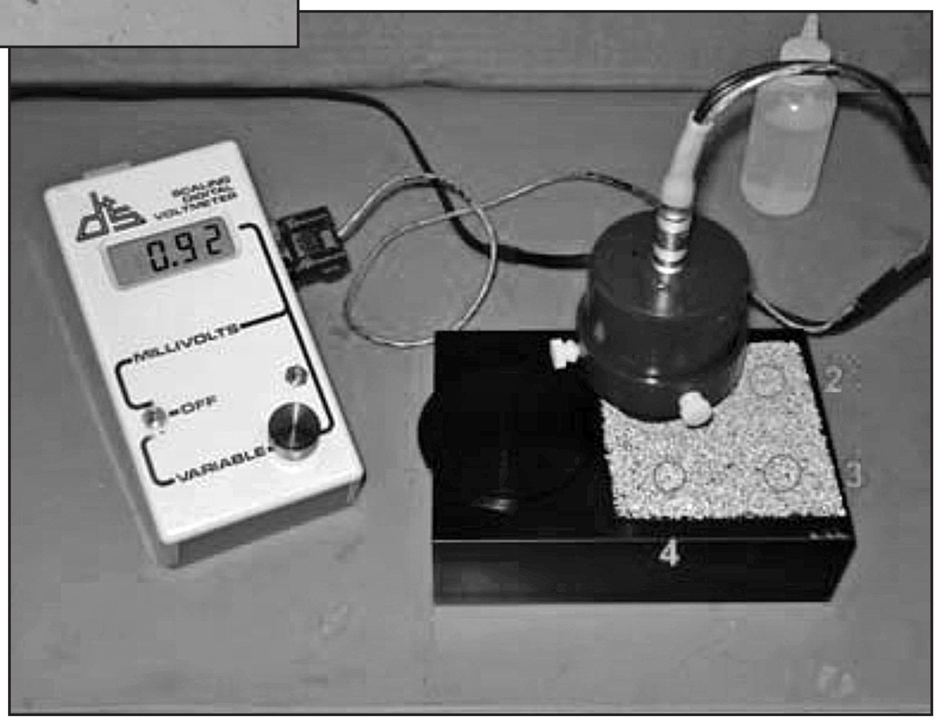

Figure 12 – Slide method diagram.

Study Objective

In order to overcome these challenges, D&S developed an alternative method for measuring emittance for products of high thermal resistance. The Slide Method, detailed in D&S technical notes TN10-2 and TN11-2, employs the port adaptor shown in *Figure 11* and requires the operator to slide the emissometer head across the sample during testing. The port adapter is a standard AE-ADP adapter with a highly reflective film that redirects radiation heat exchange. Under the Slide Method protocol, the measurement head is moved approximately every 15 seconds until the reading stabilizes (see *Figure 12*). The periodic movement prevents excess heat buildup that can skew results for materials with low thermal conductance. The port adaptor serves to decrease the heat load on the sample and minimize errors on nonflat samples by reducing the size of the measurement port (D&S TN 10-2 and TN 11-2).

Study Protocol

In 2011, the CRRC evaluated the Slide Method to determine the impact it would have on product ratings. The CRRC conducted a round-robin study comparing ASTM C1371 and the Slide Method among nine samples (see *Table 2*) and nine laboratories: LBNL; ORNL; Architectural Testing; PRI; R.I. Ogawa and Associates, Inc.; Momentum Technologies, Inc.; Underwriters Laboratories, Inc.; Intertek; and R&D Services, Inc. The study began with samples 1 through 5. Samples 6 through 9 were added midway through the study and were tested by six labs. These additional samples were added to the sample set to determine the relationship between the emittance of fleece-backed and nonfleece-backed

Sample #	Description
1	Gray modified bitumen capsheet
2	Flat tile with white coating
3	Metal panel with blue coating
4	Curved tan tile
5	White PVC field-applied coating
6	Single Ply - 50 mil non-fleeceback
7	Single Ply - 50 mil fleeceback
8	Single Ply - 60 mil non-fleeceback
9	Single Ply - 60 mil fleeceback

Table 2 – Slide method study samples.

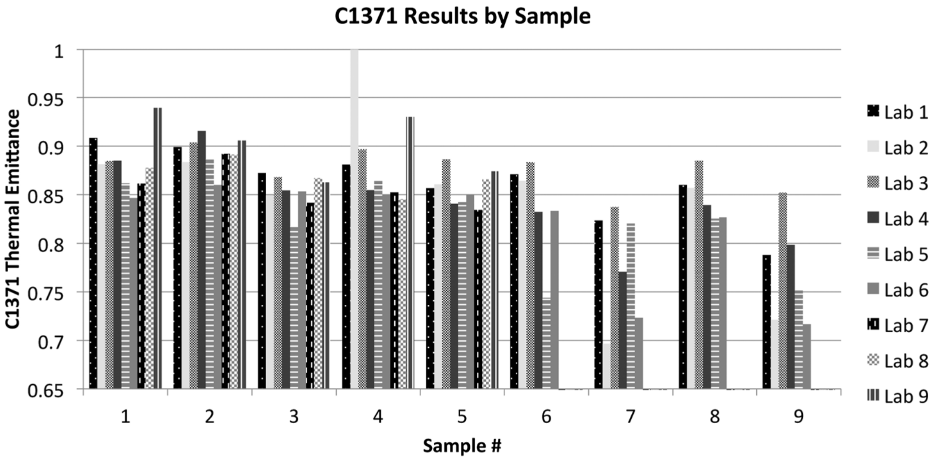

Figure 13 – C1371 emittance results.

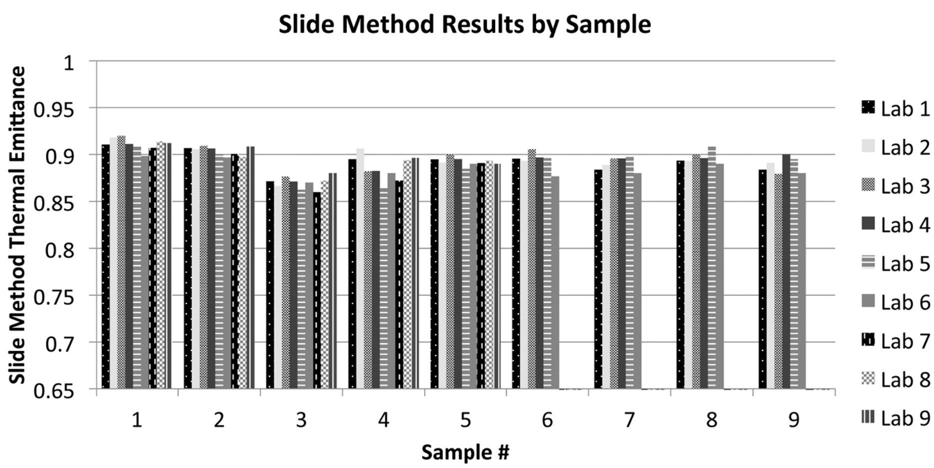

Figure 14 – Slide Method emittance results.

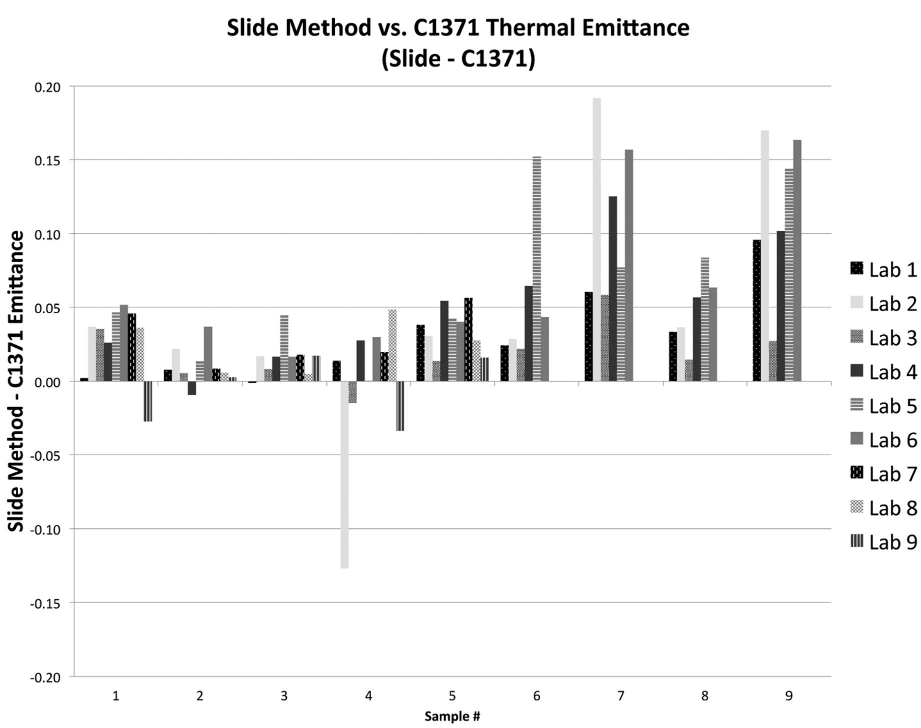

Figure 15 – Difference between C1371 and Slide Method results.

single-ply products.

As shown in *Table 2*, a variety of roofing products was included in the study to demonstrate results across different product types rated by the CRRC program. Each lab participating in the study tested each sample with ASTM C1371 and the Slide Method. Results for ASTM C1371 were the average of three separate readings measured after 90 seconds, while the Slide Method was the average of three readings taken after 60 seconds of sliding.

Study Results

The ASTM C1371 and Slide Method results from the study can be seen in *Figures 13* and *14*. For samples 1 through 5, nine data points are compared, while samples 6 through 9 each have six data points. The two sets of results are compared in *Figure 15*, demonstrating the difference between the two test methods. Over 90% of the Slide Method results were higher than their ASTM C1371 counterparts. The difference from the Slide Method minus ASTM C1371 measurements for all labs ranged from -0.13 to 0.19, with a mean absolute difference of 0.05. The largest decrease, -0.13, stems from lab two reporting an emittance value of 1.03 for the curved tile sample (sample four). This report treats that value as an incorrect outlier. Excluding this outlier value, the largest decrease drops from -0.13 down to -0.03.

Study Analysis

Two significant trends were seen in the results of the study. First, with the exception of sample four, all samples saw an increase in the average reported emittance when using the Slide Method (see *Figure 16*). The average emittance value for sample four, the curved tile, was the same for both ASTM C1371 and the Slide Method, as a result of the outlier data point discussed above. Due to the curvature of the sample, incorrect orientation of the emissometer head can cause inaccurate results. If the device head is oriented such that both pairs of sensors have a similar relationship to the surface of the sample, it can be measured with reasonable confidence. However, if the head is rotated 90 degrees from this position so that the high emittance sensors are in contact with the sample and the low emittance sensors are suspended with an air gap over the curvature of the sample (or vice-versa), the readings can be skewed.

The second significant trend observed through the round-robin is an increase in precision, or decrease in result variability, for all samples when using the Slide Method (see *Figure 17*). Variability was measured by taking the average of all the absolute differences between each lab result and the average of all labs. This reduction in variability was especially prominent in the fleece-backed, single-ply samples and the curved tile. If the sample four 1.03 outlier emittance reading is removed from the sample set, the variability of the C1371 curved tile results drops from 0.04 to 0.02.

Some samples displayed unexpected results from use of C1371, including the 50-mil noninsulated single ply (sample six), which had relatively high variability for a product of rather low thermal resistance; or the flat tile (sample two), which had relatively low variability for a product of high thermal resistance. These discrepancies are likely compounded by the small sample set (one product each) and could possibly be attributed to operator error. Additionally, sample four demonstrated higher variability with the Slide Method for a product of high thermal resistance. This increased variability was likely due to the curvature of the tile.

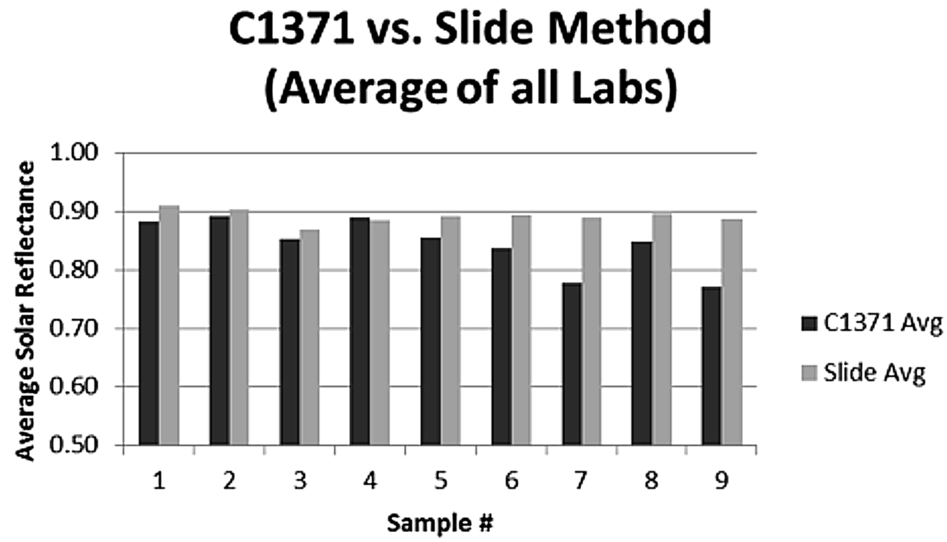

Figure 16 – CRRC round-robin study results.

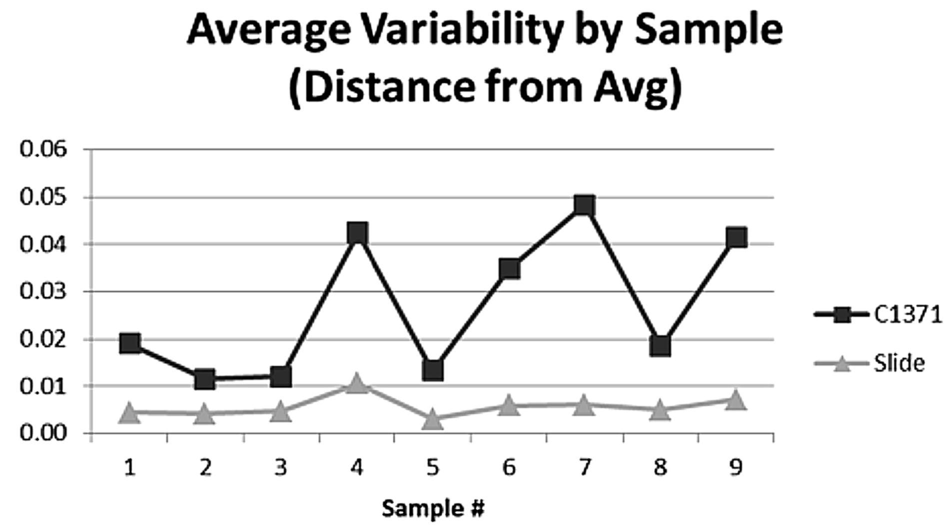

Figure 17 – Impact of Slide Method on result variability.

CONCLUSION

Solar Spectrum Reflectometer Model SSR Upgrade Study

The CRRC conducted two rounds to study the impact of upgrading the reflectometer from Version 5 to Version 6. Three measurements were taken and compared: Version 5, which represents the current device used for CRRC solar reflectance ratings; Version 6 in 1.5E output, which represents the upgraded reflectometer emulating the Version 5 device; and Version 6 in b891 output, which represents the upgraded device operating under ASTM C1549, corrected for the inaccuracies of Version 5.

Round 1 was a preliminary study, which assisted in developing a more robust methodology for Round 2. Round 1 suggested that Version 6 in 1.5E output (emulation mode for Version 5) was representative of Version 5 measurements. However, Round 1 comparisons of Version 6 to Version 5 did not yield conclusive results. Round 2 expanded the participating labs and decreased the number of product samples. Results from Round 2 indicated slight variations in measurement differences from Version 6 b891 when compared to Version 6 1.5E or Version 5—more notable for red products, which trended lower, and blue products, which trended higher from Version 6. However, all of the differences in values were low, with an average difference of 0.008 and a maximum difference of 0.023.

After analyzing the results of this study, the CRRC board and Technical Committee requested that AITLs in possession of a Version 6 device run it in 1.5E mode to ensure that their readings are consistent with the majority of AITLs who possess a Version 5 device. In March 2012, the Technical Committee determined the difference in reflectance from the Version 6 b891 device to be insignificant and did not vote to request that the CRRC AITLs upgrade Version 5 devices to Version 6 devices. The CRRC board has yet to consider the results from the reflectometer study in regard to adopting Version 6 b891.

Thermal Emittance Slide Method Study

The CRRC conducted a round-robin to study the impact of using the Slide Method to measure the thermal emittance for products of high thermal resistance. The results from the study demonstrated that the Slide Method produces consistent emittance readings for a variety of product types. Additionally, the results showed that all tested samples' values increased slightly, ranging from 0.01 to 0.12 (when disregarding the 1.03 outlier curved tile measurement).

There is always some natural variation between thermal emittance results due to different devices, operators, and operating conditions. However, the Slide Method reduction in measurement variability assists the CRRC in its ongoing effort to produce accurate and credible energy performance ratings for the Rated Products Directory. In November 2011, to address concerns with using ASTM C1371 for low thermal-conductance materials, the CRRC adopted use of the Slide Method for all samples except those on an uninsulated metal panel. Products on bare metal panels, such as field-applied coatings or factory-applied coatings, were determined to not require use of the Slide Method and could continue using ASTM C1371. However, as of May 2012, the Technical Committee began discussing whether field-applied coatings may not meet the thermal conductance criteria set in C1371 and may warrant use of the Slide Method. The Committee will be investigating this topic in more detail.

OTHER CRRC RESEARCH

Ongoing research is an integral part of the CRRC to keep up with the evolution of roofing products and test methods. Additional research projects currently being conducted by the CRRC include a precision-and-bias statement for ASTM E1918 and the development of a rating protocol for directionally reflective products.

The precision-and-bias study is being conducted in partnership with ASTM to evaluate the use of pyranometers for measuring solar reflectance. The results of this study will allow CRRC to determine ASTM E1918's repeatability and reproducibility, and generate a precision-and-bias statement for the standard. The study results may influence updates to ASTM E1918's language to correct any shortcomings identified through the study.

Directionally reflective roofing products, which display different reflectivity values depending on the angle of incidence, cannot be evaluated accurately by current CRRC testing protocol; therefore, a new rating method must be developed. The CRRC is working with Dr. Hashem Akbari of Concordia University to develop a new rating method for this emerging-technology product type.

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