# Analysis of the Direct or Indirect Measurement of Solar Reflectivity Using Various "Non-Standard" Instruments

The purpose of this paper is to outline the results of testing, either directly or indirectly, the solar reflectivity of a coated roof surface as defined by ASTM C1549 using instrumentation that is not currently recognized by ASTM Subcommittee C16.30 for testing reflective roof coatings.

**Background**

The current instrument recognized by ASTM Subcommittee C16.30 as the "sole source of supply" for testing reflectance in accordance with the ASTM C1549 test method is the Solar Spectrum Reflectometer (SSR) manufactured by Devices & Services (D&S), located in Dallas, TX. It should be noted that a caveat in the ASTM test method states that the subcommittee would give any alternative suppliers "careful consideration" for approval.

The SSR employs a diffuse tungsten halogen lamp to illuminate the coated flat surface, the reflected light of which is detected by four detectors, each of which is equipped with color filters targeted to identify four wavelengths in the solar spectrum: 380 nm (ultraviolet [UV]), 500 nm (blue), 650 nm (red), and 1220 nm (infrared [IR]). The measurement spectrum is calculated by collecting the weighted sum of the response spectra from each detector. The extensive mathematics governing the data collection process of the SSR can be found in D&S literature, easily accessible from their website at www.devicesandservices.com.

The Cool Roof Rating Council's CRRC-1 Method #1 outlines a technique for estimating the mean solar reflectance of a flat, opaque, and heterogeneous test surface of asphalt roofing shingle "in accordance with ASTM C1549." Therefore, unless a CRRC-accredited testing facility has a D&S SSR in its possession, ASTM C1549 cannot be performed to the standards of ASTM Subcommittee C16.30. Furthermore, a roof coating or coatings system manufacturer who wishes to perform in-house testing of ASTM C1549 reflectance for the purposes of data gathering must either send samples out to a laboratory that uses a D&S reflectometer or must purchase the instrument. The SSR consists of two separate units which hinder its portability; although the machine can be transported to a testing site, the SSR will still require an electrical outlet to function and therefore extension cords or portable generators are necessary to power the machine.

It was the goal of this Roof Coatings Manufacturers Association (RCMA) study to explore alternative forms of reflectance measurement using three different pieces of optics equipment chosen from the following companies:

| Minolta | BYK | Surface Optics |
|---|---|---|
| CM700D | G836 | 410-Solar |

Three credentials were identified as desirable in justifying the use of alternative equipment to the D&S SSR.

1. The equipment should allow the user to obtain either a direct or indirect *repeatable* measurement of reflectivity of a surface.
2. The equipment should be portable, and preferably battery operated.
3. The equipment should be multi-purpose, allowing the user to also analyze Lab for color group determination or gloss.

The test specimens analyzed were chosen from a variety of available roofing surfaces and included: aluminized asphaltic coating over metal, commercial roofing shingles, fresh ethylene propylene diene terpolymer (EPDM), and white thermoplastic polyolefin (TPO). Since the SSR is the industry standard and identified by ASTM Committee C16.30 as the current "source of supply," all measurements collected during this testing on alternate instruments were compared simultaneously to data collected by the SSR. The testing was performed by Andre Desjarlais' group at Oak Ridge National Laboratories in the presence of each optics instrument's trained sales representative to ensure the machine was being used properly.

**Procedure**

For each specimen, the measurements were taken in accordance with each manufacturer's recommended procedure. At least three separate measurements were taken and the average reflectance (or correlating value) was calculated for each substrate. Each instrument's benefits and drawbacks were listed as well.

**Results and Discussion**

The table below shows the average reflectance numbers obtained in testing followed by a summary of how the alternate equipment met (or fell short of) the credentials listed in the background section.

*Reflectance*

| Substrate | SSR (D&S) | CM700D (Minolta) | G836 (BYK) | 410-Solar (Surface Optics) |
|---|---|---|---|---|
| Aluminum | 74% | 79% | 85% | 76% |
| Residential Shingle | 16% | 18% | 18% | 16% |
| EPDM | 17.5% | 15% | 15% | 19% |
| White TPO | 63% | 62% | 60% | 64% |

Because the instruments' function involves shining a light source onto a surface and measuring what reflects from the surface, it was not difficult for the technicians to configure their equipment to measure some kind of reflective value. Of the machines used in this test to compare to the SSR, only the 410-Solar had a comparable wavelength range that includes UV, IR, Near IR, Blue and Red. The Minolta and BYK instruments, on the other hand, have narrower wavelength views, scanning only in the visible range. In spite of this fact, the reflectance values across each substrate were surprisingly similar to one another, with the aluminum having the widest variance at +/- 4.8%. The remaining substrates vary only by, at most, +/-2%, which is much narrower a variation than was originally expected.

*Portability*

All of the alternate instruments fit the portability requirement. They were handheld and battery operated and involved a simple "point-and-click" operation. The Surface Optics instrument could be held like a power drill. Data readings for each piece of equipment were easily stored in the machine until downloaded; the SSR, on the other hands, requires that a computer interface accompany the equipment.

*Repeatability*

Measured values of the raw data showed near zero variance when measured with the D&S SSR and +/- 0.1% with the Surface Optics 410-Solar. Minolta's CM700D and BYK's G832 instrument each had a +/- 3% variance in reflectance for the groups of areas tested on each substrate.

*Multi-Purpose Use*

The Minolta and BYK instruments used can also be configured to read Lab color space values, which may prove useful as CRRC is currently discussing using Lab color space measurements for color families of pigmented shingles and color coated metals.

**Conclusions**

This test showed that using instruments other than the D&S SSR reflectometer did yield similar reflectance values over some typical roofing surfaces, even if those instruments do not have as wide a wavelength field of view. Variance in measurement was wider in the Minolta and BYK instruments, which are set up more for gloss readings; in spite of this variance, the reflectance values were very close to the D&S and 410-Solar readings, which scanned a wider wavelength range. Where this narrower field of vision in the Minolta and BYK instruments could be a detriment is when measuring newer "cool colors" on the market, as more of the reflected light coming from these coatings may be on either side of the visible spectrum and therefore outside the instrument's range of detection. Of the instruments tested, the 410-Solar from Surface Optics yielded reflectance values closest to the D&S SSR.

A more comprehensive study could show in greater detail the exact variances across equipment, however this qualitative evaluation did show that at least there was some agreement in the reflectivities measured using alternative optics equipment.