Technical Protocol

CCPR Key Comparison of Spectral Diffuse Reflectance

Samples

Each participating national metrology institute will receive a package containing six (6) samples to be measured – three (3) of Spectralon and three (3) of matte white ceramic tile. The Spectralon samples are mounted in a black anodized aluminum frame, while the matte ceramic tile samples are encased in a plastic frame. The dimensions of the samples are shown in the accompanying drawings. Each sample has a permanent identifying serial number on the back of the frame.

Logistics

The designated person for each participating institute will be contacted prior to shipping the samples to verify that the institute is ready to receive and measure the samples.

Upon receipt of the package, if there is an accompanying ATA Carnet document, keep it attached to the package, as it will be needed when the samples are returned to NIST. The samples should first be inspected for damage. The samples will be face-down in their containers, with the serial numbers visible. Always wear gloves when handling the samples to prevent contamination of the front surface. Remove the samples from the package, and inspect the front surfaces for damage, such as dents or scratches. Dirt can be removed by blowing with air or a clean gas. Report receipt of the samples and any damage to the comparison coordinator. If a sample is damaged, a replacement will be sent to the participating institute.

Upon completion of the measurements, repackage the samples as they were upon arrival and send the package, along with the ATA Carnet document, if applicable, back to NIST. Each participating institute is responsible for the shipping costs to return the samples to NIST.

The comparison coordinator and shipping address is

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National Institute of Standards and Technology
100 Bureau Dr. Stop 8441
Gaithersburg, MD 20899-8441

Phone (301) 975-2343
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Additional samples, supplied by the participating institute, can also be included in the comparison as a supplement to the key comparison. These samples, measured under the same conditions as those of the key comparison detailed below, could serve as artifacts residing at the participating institute at the conclusion of the key comparison. They would be sent to NIST at the same time as the key comparison samples are returned, NIST would measure them along with the key comparison samples, and then they would be returned to the participating institute. Arrangements for these additional samples must be made by contacting the comparison coordinator prior to their arrival at NIST.

Finally, one sample of each type may be returned to a participating institute after completion of the comparison, if so desired for future checks and tests. Again, contact the comparison coordinator at NIST to request these samples. Every effort will be made to send the same samples to the participating institute as they measured for the comparison.

Measurements

The samples will be mounted for measurement using the normal practice for each participating institute. The exterior dimensions of the samples are similar so that the two types are easily interchangeable on the sample port of an integrating sphere. Therefore, the frames of the Spectralon samples should normally not be removed. The samples can be modified to accommodate the requirements of an instrument, provided these modifications are done in consultation with NIST. If the samples must be permanently modified (e.g. corners removed or dimensions reduced), consult with NIST and the modifications will be performed at NIST before they are measured and sent to the participating institute. If the frame of the Spectralon sample must be removed, place a black surface at the back of the sample since Spectralon is translucent. Any mounts or frames used with modified samples are to be sent to NIST along with the returned samples so that their effect on the measured reflectance can be evaluated.

The spectral diffuse reflectance of each sample will be measured using the d/0 (or 0/d) geometry from 360 nm to 820 nm. Note that the directional angle should truly be 0º, not ±10º as allowed in the CIE standard. At a minimum, one sample of each type (Spectralon and matte white ceramic tile) will be measured three (3) times on three (3) separate days, and the other two samples of each type will be measured once each. The samples measured three times should be removed from the instrument between each measurement, so that the reproducibility of the measurements can be assessed. The purpose of including three samples of each type is redundancy in case of a problem with one of the samples. Therefore, it is not strictly necessary to measure all six samples three times each, but this is permissible if the institute so desires. The measurement conditions and results to report to NIST are given in the next section.

Reporting

The measurement results will be reported to NIST when the samples are returned, and items are enclosed with the samples for this purpose. Two tables on sheets of paper are to be filled out, the measurement results are to be placed on the floppy disk, and all are to be returned with the samples. Additionally, the results should be e-mailed to NIST if at all possible. Note that failure to return all the requested information and results will cause the institute to be excluded from the report on the comparison.

The accompanying Tables 1 and 2, detailing the measurement parameters and uncertainties, respectively, must be completed. Indicate the parameters and uncertainties that are not applicable to the measurement, and include any additional ones that are relevant. The uncertainties can be broken down by wavelength region, if needed, and should be reported with a coverage factor $k = 1$. Additional communication between NIST and the participating institute may be required to obtain all the necessary information.

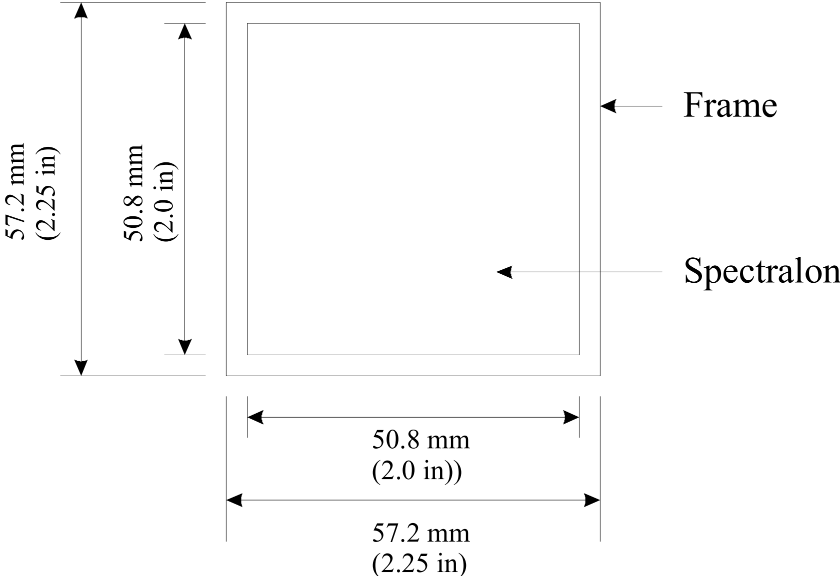
The results for each sample and measurement are to be reported as a separate ASCII tab-delimited file. The file name will be of the form IIII_SSS_N_WW.txt, where

> IIII is the institute (e.g. NIST, PTB),
> SSS is the sample serial number (e.g. S09, C15),
> N is the measurement index (1, 2, or 3), and
> WW is the wavelength increment (20 required, others optional, e.g. 25, V).

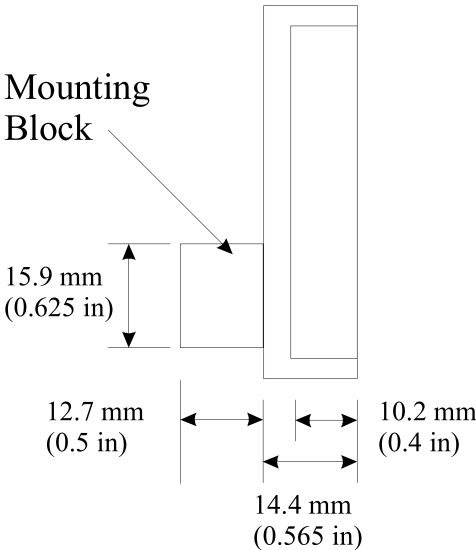
The file will contain two columns of tab-delimited numbers; first the wavelength and second the reflectance factor. The reflectance factor must be reported for wavelengths from 360 nm to 820 nm every 20 nm. At a minimum, two samples will each be measured three times and four samples will each be measured once, so there will be a minimum of 10 files of the form IIII_SSS_N_20.txt, where N = 1, 2, or 3. If the institute measures all six samples three times each, there will be 18 files. For those instruments that do not measure with a 20 nm wavelength increment, the results at the measured wavelengths are also to be reported, resulting in additional files. Use the actual wavelength increment in the file name if it is regular (e.g. 25), and use a “V” in the file name if the increment is variable. Also, include in the returned package a description of the technique used to convert the reflectance factors measured at the instrument wavelengths to reflectance factors at every 20 nm.

Spectralon

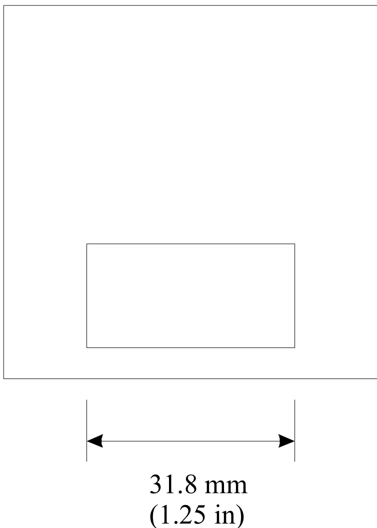
Front View



Side View

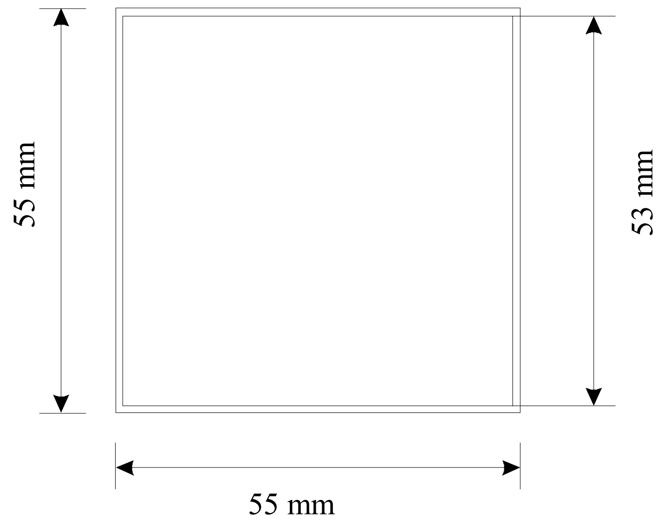


Back View



Matte Ceramic Tile

Front View



Side View

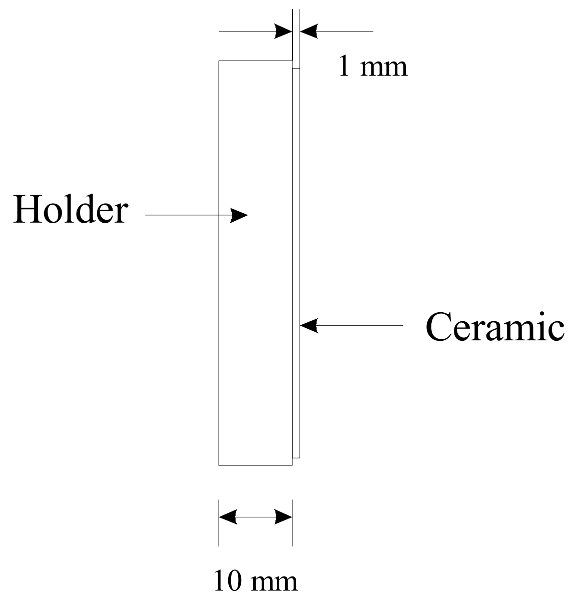


Table 1. Measurement Parameters

Parameter	Value or Description
Geometry (0/d or d/0)	
Directional Angle	
Sphere Diameter	
Sphere Coating	
Diameter of Entrance Port	
Diameter of Sample Port	
Diameter of Viewing Port	
Beam Diameter	
Beam f/# (f/∞ for collimated)	
Beam Polarization	
Spectral Bandwidth	
Wavelength Range and Increment	
Calibration Standard Traceability	

Table 1 Example for NIST

Parameter	Value or Description
Geometry (0/d or d/0)	0/d
Directional Angle	0 degrees
Sphere Diameter	30 cm
Sphere Coating	PTFE
Diameter of Entrance Port	3.8 cm
Diameter of Sample Port	5 cm
Diameter of Viewing Port	NA
Beam Diameter	25 mm
Beam f/# (f/∞ for collimated)	f/80
Beam Polarization	Unpolarized
Spectral Bandwidth	15 nm
Wavelength Range and Increment	360 to 820 by 20 nm
Calibration Standard Traceability	Van den Akker Method

Table 2. Uncertainties

Source of Uncertainty	Type (A or B)	Standard Uncertainty	Uncertainty in Reflectance Factor
Signal Noise			
Instrument Stability			
Wavelength			
Detector Linearity			
Van den Akker Method			
Calibration Standard			
Sharp-Little Method			
Calibration Standard			
Korte Method			
Port Correction			
Irradiance Uniformity			
Wall Correlation			

Table 2 Example for NIST

Source of Uncertainty	Type (A or B)	Standard Uncertainty	Uncertainty in Reflectance Factor
Signal Noise	A	0.06 %	0.06 %
Instrument Stability	A	0.04 %	0.04 %
Wavelength	B	1.0 nm	< 0.01 %
Detector Linearity	B	< 0.01 %	< 0.01 %
Van den Akker Method			
Calibration Standard	B	0.2 %	0.2 %
Sharp-Little Method			
Calibration Standard		NA	
Korte Method			
Port Correction		NA	
Irradiance Uniformity		NA	
Wall Correlation		NA	