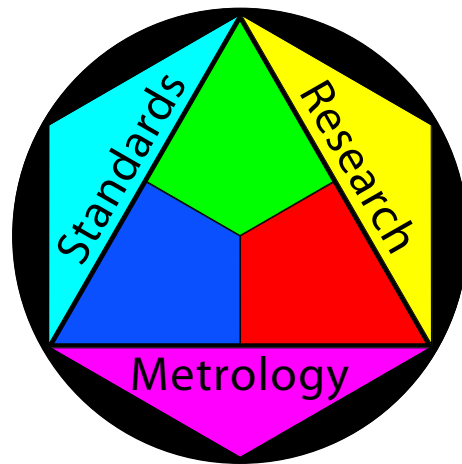
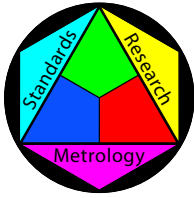


# Mt. Baker Research LLC



Measurement Services  
& Calibration Certificates



## Mt. Baker Research LLC

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Bellingham, Washington 98228-0370  
360-650-0771

# Certificate of Traceable Calibration

Customer: SICPA SA

Contact: Maarten Krupers      Tel: +41 21 627 5555

P.O. No.: 20091110-02      Date: 09.12.14

CAL No.: MBR-SCI-091214-03

### Laboratory Conditions

Mean T: 23.0 ± 0.2 °C

Humidity: 40%

Certified by: John W. Root, Ph.D.

### Measurement Parameters

Instrument: X-Rite ColorEye 7000A (2008) NUV-VIS spectrophotometer; S/N 37132651108

Geometry: (t/8°) SCI total w/ 8° viewing; LAV aperture plate & LAV lens setting

Sample Port: Circular w/ 25.4 mm diameter (illuminated) & 23.4 mm diameter (viewed) areas

Wavelength Pitch: 10 nm

Wavelength Range: 360 - 750 nm

No. Spectra per Measurement: 9 (3 repeated measurements w/ each averaging 3 consecutive spectra)

Delay between Spectra: 10 seconds

No. Averaged Measurements: 4 independent measurements per tile w/ replacement & re-calibration

Traceable Reference Standard: X-Rite CERAM white Tile; NIST #2020c S/N 27073, 844/259504-98R (99.05.14)

Data Media: 5 Excel charts (attached) & CD Disk (certified data)

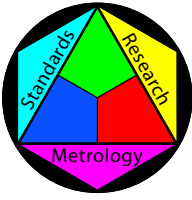
Samples Measured: Diagnostic Tile Set; 16 ceramic transfer standards

### Procedure

Spectral reflectance factors ("SRF") were measured at ambient temperature and humidity with an X-Rite ColorEye 7000A ("CE7000A") NUV-VIS spectrophotometer. The instrument was operated in the (t/8°) total hemispherical specular-included ("SCI") geometry. SRF data were measured from 360 - 750 nm in 10 nm intervals. CyberChrome OnColor QC Premium® software was used to control the spectrophotometer, to average the replicate spectra obtained during each measurement series, and to perform colorimetric analysis. The statistical analysis was based on proprietary algorithms developed at Mt. Baker Research L.L.C.

SRF values were measured for 16 diagnostic test tiles relative to the calibrated NIST traceable CERAM white reference tile supplied with the instrument. [REF: NIST #2020c S/N 27073, 844/259504-98R (99.05.14).] The metrological SRF scaling procedure monitored and corrected for instrument drift and optimized the statistical quality of the results. This was accomplished by bracketing 3 consecutive measurements of each tile with 2 measurements of the calibrated white reference tile.

Each data series consisted of 12 measurements performed using the following sequence: **C R R T1 T1 T1 R R T2 T2 T2 R R**. Here, **C**, **R**, **T1** and **T2** denote re-calibration followed by measurements of the white reference tile, the 1st test tile, and the 2nd test tile. For each pair of test tiles this sequence was repeated 4 times with sample replacement and re-calibration of the instrument between each series. [REF: Diagnostic Tile Set Instruction Manual.]



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Procedure -- Continued

**Synopsis:** The present study consisted of 3 parts, as follows: Part A: Traceable SRF calibrations were measured for 16 diagnostic test tiles. [REF: Charts #1 to #4.] Part B: A new procedure was developed to characterize the statistical noise levels of the CE7000A instrument during Part A. [REF: Chart #5.] Part C: A new procedure was developed to test the 16 diagnostic tiles for translucency. These results are described in a companion certificate. [REF: Mt. Baker Research L.L.C. Calibration Certificate No. MBR-SCITR-091214-04. NOTE: The error bars shown on the charts in this report represent  $2\sigma$  standard errors of estimate (95% confidence level).]

For Parts A - C each measurement averaged the data from 3 consecutive spectra measured at a 10 second delay interval. As described below, independent repeatability measurements were performed during each set of tests.

**Accuracy Studies:** In an independent study the absolute accuracy of a Konica-Minolta CM2500c ( $45^\circ/0^\circ$ ) bi-directional instrument was measured using 9 ceramic transfer standards calibrated at NRC. Based on traceability to NRC/NIST and the standard metrological procedures described herein, the  $2\sigma$  absolute accuracy of the Konica-Minolta CM2500c instrument was  $99.2\% \pm 1.6\%$ . This result is statistically equivalent to the  $99.1\% \pm 0.4\%$  accuracy value obtained for this instrument using our standard statistical analysis. Accordingly, the accuracy results reported below are estimates based on this same statistical procedure. [REF: NRC Calibration Report No. PAR-2008-2594. Mt. Baker Research L.L.C. Calibration Report No. MBR-(45/0)-091214-01.]

For the #D01 UltraWhite tile the measured average  $2\sigma$  standard error of estimate was 0.55, and the corresponding relative standard error was 0.0059. For the #D09 Light Grey 60% tile the corresponding errors were 0.35 and 0.0059. For the #D20 Deep Green and #D21 Mid-Green tiles the respective errors were 0.18, 0.0089, 0.19, and 0.0062.

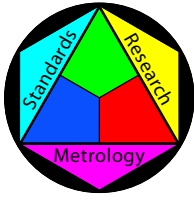
For all 16 diagnostic tiles the grand average  $2\sigma$  relative standard error of estimate was  $0.0073 \pm 0.0015$ . On this basis, with traceability to NRC/NIST the estimated  $2\sigma$  absolute accuracy of the certified SRF values is  $99.3\% \pm 0.3\%$ .

X-Rite specifies an inter-instrument agreement for the CE7000A within  $\Delta E^*_{ab} = 0.08$ . [NOTE: For this test the average inter-instrument agreement is measured for 12 CERAM BCRA Series II tiles.]

**Repeatability Studies:** For the CE7000A instrument X-Rite specifies a repeatability within  $\Delta E^*_{ab} = 0.010$ . [NOTE: This specification is based on 20 replicate measurements of the X-Rite CERAM white reference tile at 10 second intervals without replacement or re-calibration.]

In the present study repeatability measurements were based on the CERAM white reference tile. During Part A, based on 45 measurements of the CERAM white tile without replacement or re-calibration, the repeatability of the spectrophotometer was  $\Delta E^*_{ab} = 0.0030 \pm 0.0017$ . Based on 100 measurements with replacement but without re-calibration, the repeatability was  $\Delta E^*_{ab} = 0.0036 \pm 0.0015$ . [NOTE: The cited measurement uncertainties are standard deviations.]

**Noise Studies:** In Chart #5 (Part B) the statistical noise levels are compared for the SRF measurements performed during Part A. The wavelength-dependent noise data shown in Chart #5 represent the precision-based random error contributions to the average relative standard error of estimate values.



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# *Certificate of Traceable Calibration*

### Notes – Certified Data

1. The attached graphs of SRF data are provided for informational purposes only. The accompanying CD-R disk contains the certified SRF & colorimetric data for the calibrated tiles.

### Notes – Basis for Traceability

1. NRC Calibration Report No. PAR-2007-2528, 2007, "0°:45° Radiance Factors of Two Ceramic Tiles, S/N: P-6-Light-Green, B-5-White," National Research Council Canada, Institute for National Measurement Standards, Ottawa, Canada, [www.nrc-cnrc.gc.ca](http://www.nrc-cnrc.gc.ca).
2. ASTM E1349-06, 2006, "Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45:0 or 0:45) Geometry," ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).
3. ASTM E1345-98, 1998 (2003), "Standard Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements," ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).

### Technical References

1. ASTM E275-01, 2001, "Standard Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near-Infrared Spectrophotometers," ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).
2. ASTM E2214-02, 2002, "Standard Practice for Specifying and Verifying the Performance of Color-Measuring Instruments," ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).
3. ASTM E1164-07, 2007, "Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation," ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).
4. ASTM E308-06, 2006, "Standard Practice for Computing the Colors of Objects by Using the CIE System," ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).
5. CIE 15:2004, "CIE Technical Report: Colorimetry," 3rd edition, International Commission on Illumination (Commission Internationale de l'Eclairage), Vienna, Austria, ISBN: 3-901-906-33-9, [www.cie-usnc.org](http://www.cie-usnc.org).
6. D.R. Wyble, D.C. Rich, "Evaluation of Methods for Verifying the Performance of Color-Measuring Instruments. Part I: Repeatability," *Color Research and Application*, 32(3), 166(10), 2007.
7. D.R. Wyble, D.C. Rich, "Evaluation of Methods for Verifying the Performance of Color-Measuring Instruments. Part II: Inter-Instrument Reproducibility," *Color Research and Application*, 32(3), 176(19), 2007.
8. J.W. Root, "Diagnostic Tile Set Instruction Manual," v. 2.1, Mt. Baker Research L.L.C., Bellingham, Washington, October 1, 2009.

### General References

1. ISCC Technical Report 2003-1, 2003, J. Ladson, A.W. Springsteen, J. Sefl, H.S. Fairman, M.H. Brill, and J. Zwinkels, "Guide to Material Standards and Their Use in Color Measurement," Inter-Society Color Council, Reston, VA, [www.iscc.org](http://www.iscc.org).
2. R.S. Berns, "Billmeyer and Saltzman's Principles of Color Technology," 3rd edition, John Wiley & Sons, Inc., New York, 2000, ISBN: 978-0-471-19459-0, [www.wiley.com](http://www.wiley.com).
3. M.D. Fairchild, "Color Appearance Models," 2nd edition, John Wiley & Sons, Ltd., Chichester, England, 2005, ISBN: 0-470-01216-1, [www.wiley.com](http://www.wiley.com).
4. "Spectrophotometer CM-2500c Instruction Manual," Konica-Minolta Sensing Americas, Inc., Ramsey, NJ, [www.se.konicaminolta](http://www.se.konicaminolta).

Chart 1. Traceable SCI Spectral Reflectance Factors for Diagnostic Tile Set #4A

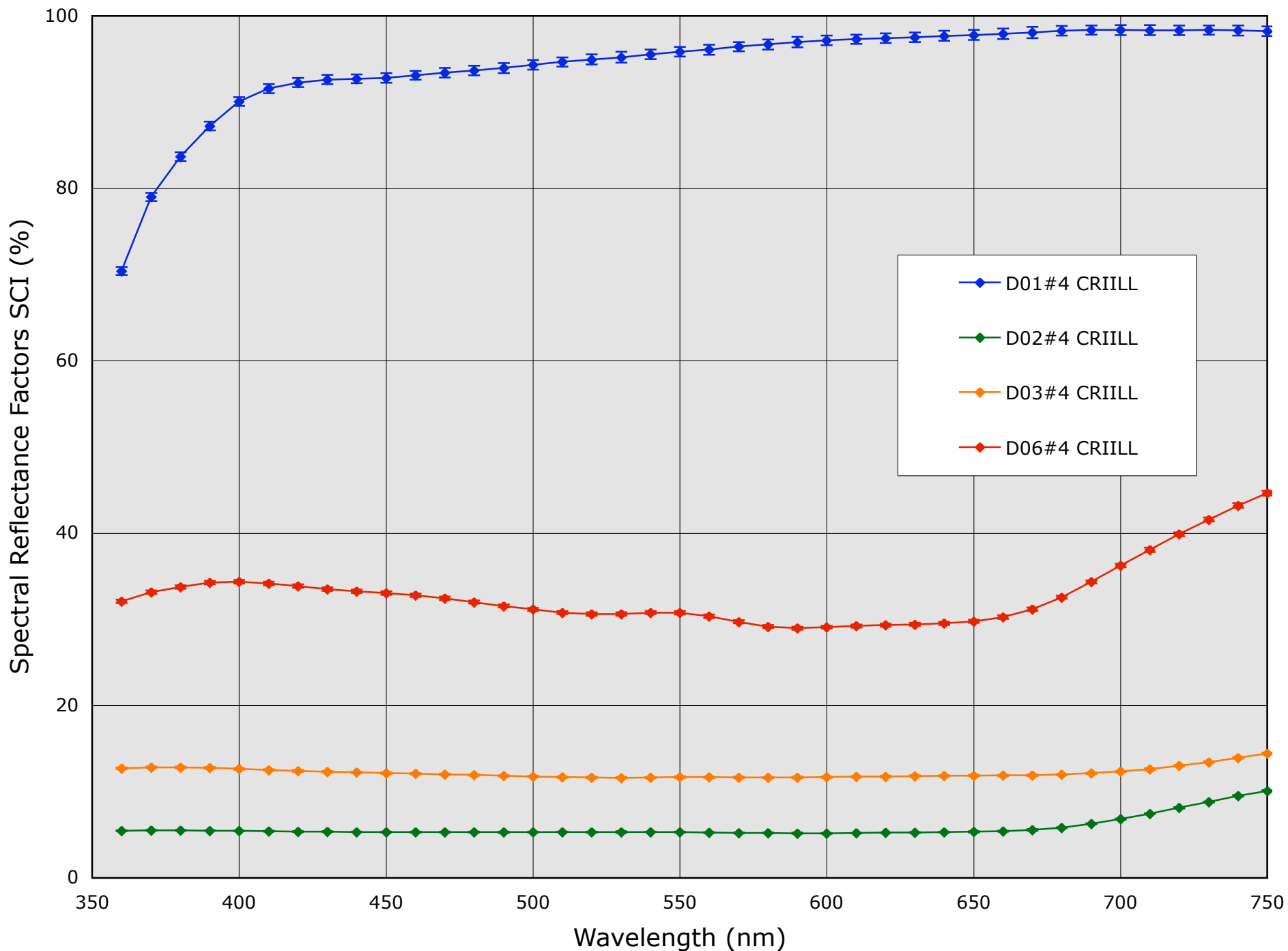


Chart 2. Traceable SCI Spectral Reflectance Factors for Diagnostic Tile Set #4A

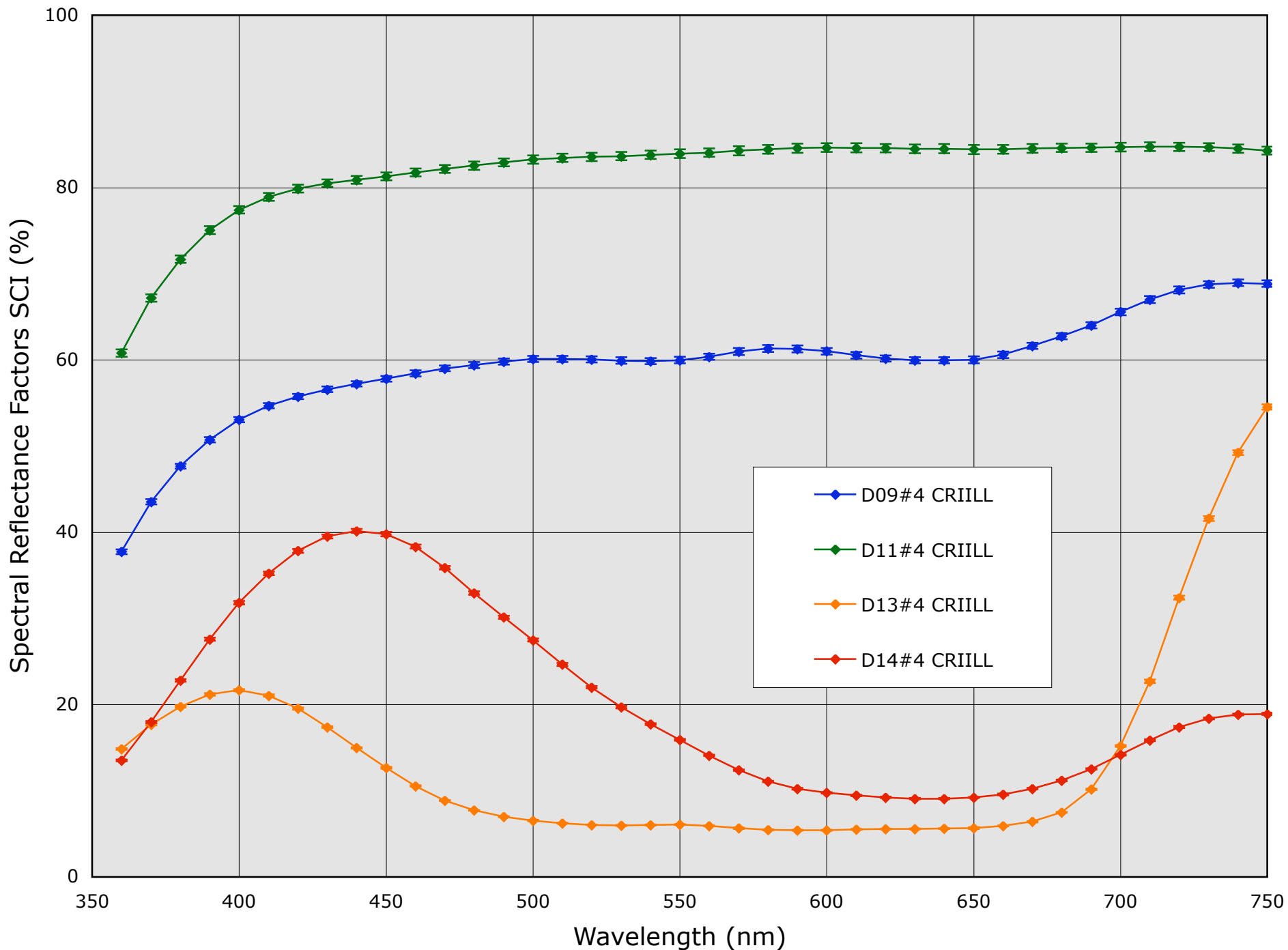


Chart 3. Traceable SCI Spectral Reflectance Factors for Diagnostic Tile Set #4A

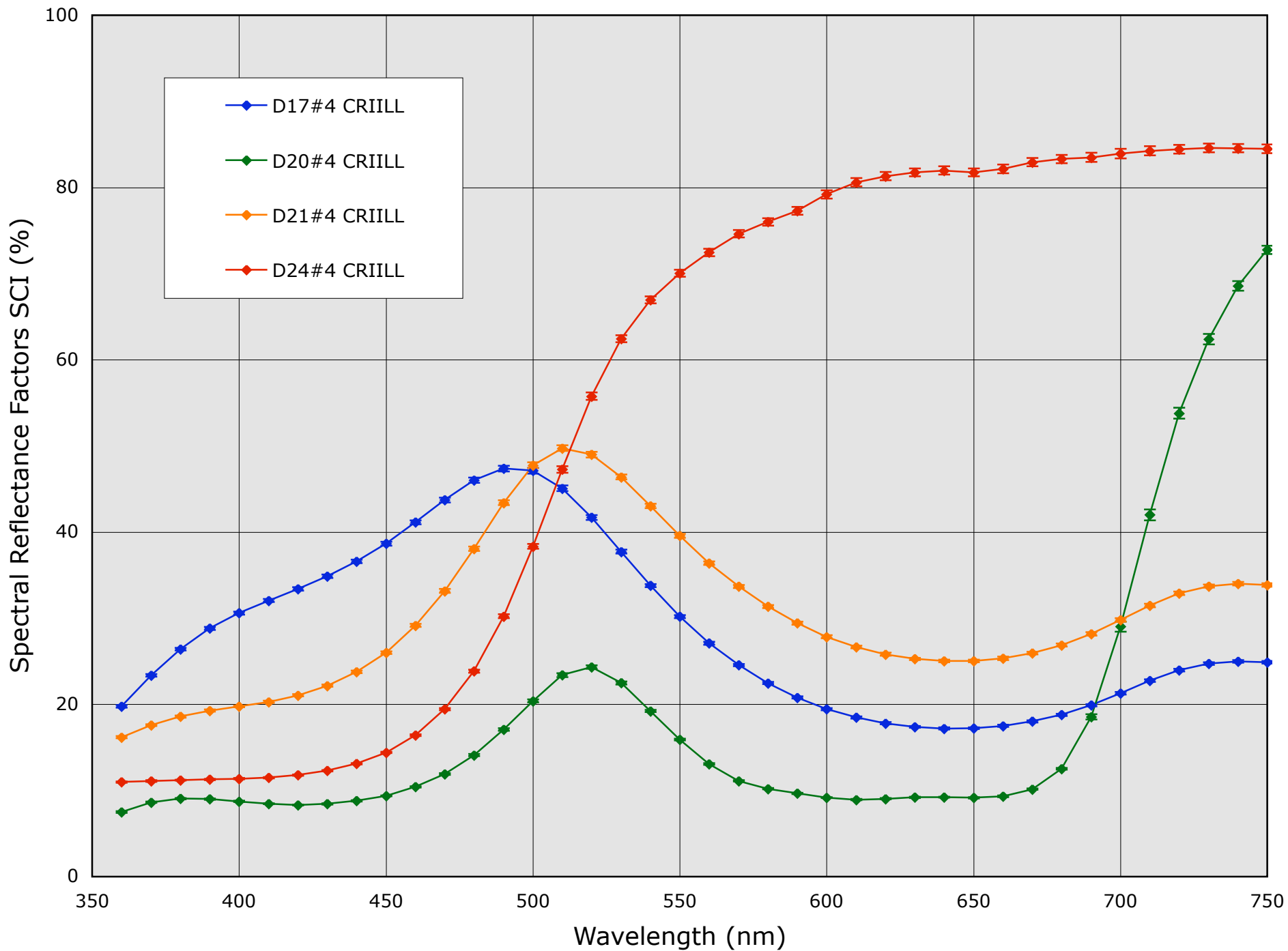


Chart 4. Traceable SCI Spectral Reflectance Factors for Diagnostic Tile Set #4A

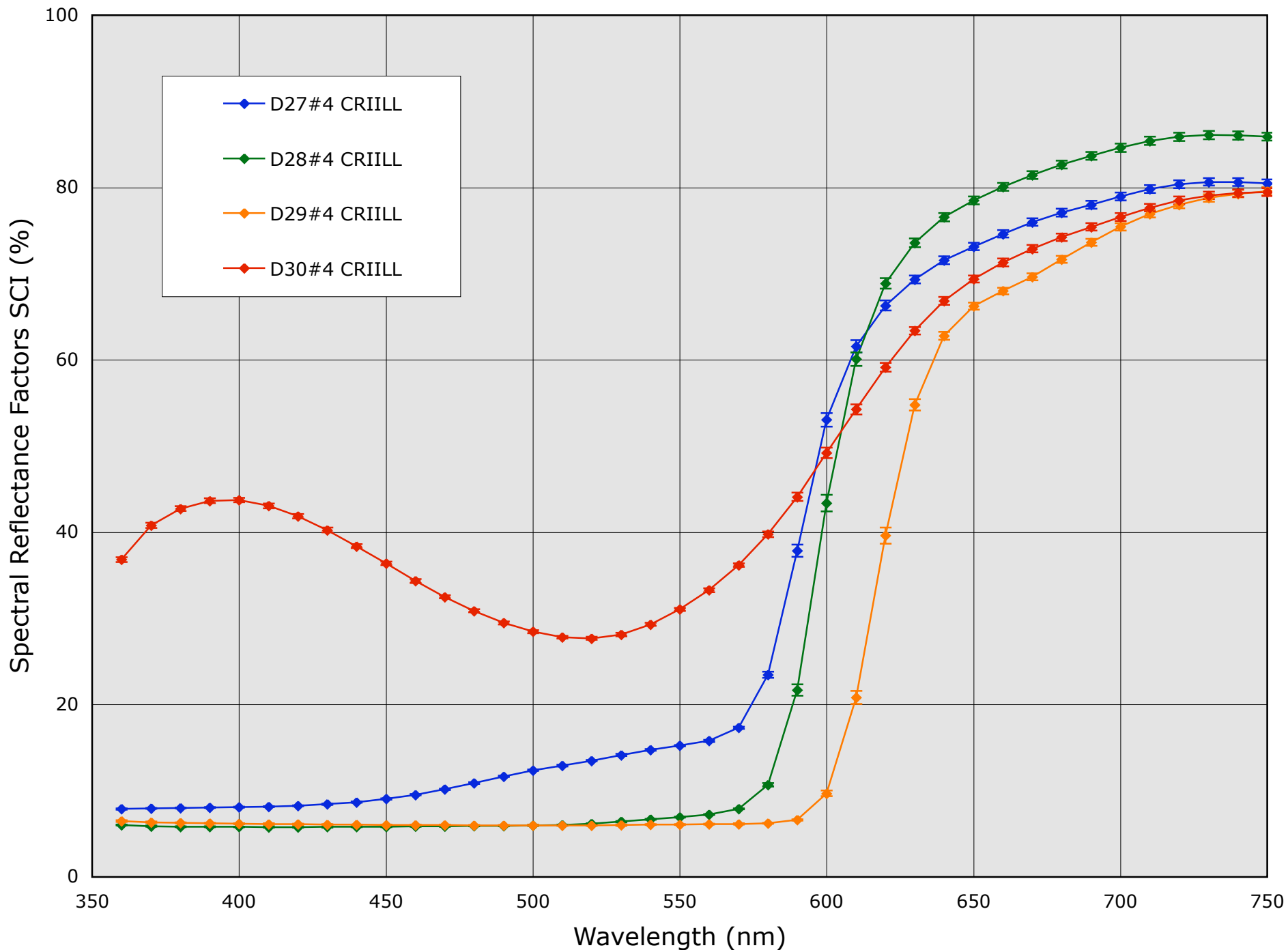
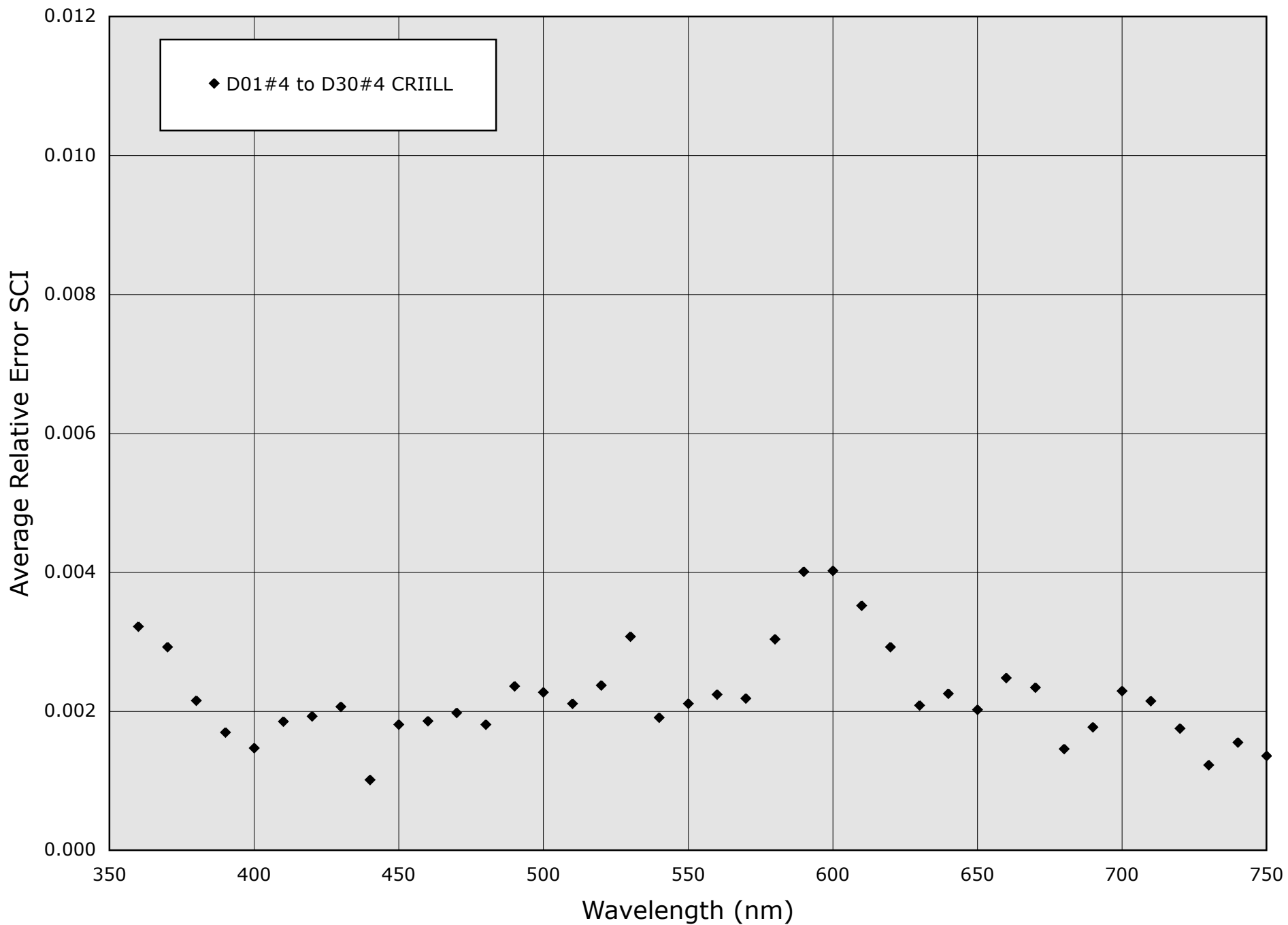
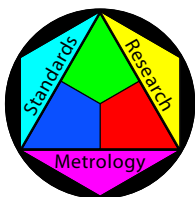


Chart 5. Precision-Based Errors Measured using CE7000A S/N 37132651108  
(CRIILL Status with 3 Flashes per Measurement & 10-Second Delay)





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