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# **UV/VIS/NIR SPECTROPHOTOMETRIC NEAR-NORMAL SPECULAR TRANSMITTANCE AND REFLECTANCE MEASUREMENT INTERCOMPARISON**

## **RESULTS**

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## 1 INTRODUCTION

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WinDat is a European RTD Thematic Network (2001-2004) which aims to make available and freely distribute a European software tool for the calculation of the thermal and solar properties of commercial and innovative window systems on the basis of known component properties and thermal and solar/optical interactions between the components. It is intended that this tool will be collectively supported and used in research, industry, standardisation, education and design throughout Europe. It will be used to compare, select and promote innovative windows and window components for the optimum use of renewable energy and maximised energy savings and indoor comfort. One of the unique elements in the software tool is the combination of glazings and shading devices. This makes the tool particularly suited to calculate the thermal and solar performance of complex windows and active facades. One of the early achievements (Spring 2002) was the agreement on a draft European procedure and format for the collation of optical properties of non-scattering glazings. It will be ensured that the European database is compatible with the existing database in USA (Optics5) with the long-term aim of creating a single international glazing library for worldwide application.

The WinDat inter-laboratory comparison forms part of the procedure to assure the quality of spectral transmittance and reflectance data in the range 2500 –300 nm held in the WIS database [2,3]. Participants include European manufacturers who submit data for inclusion in the WIS database and other European laboratories with the capability for accurate measurement of spectral optical properties. This is the first such exercise undertaken within WinDat. It is intended that this activity be repeated regularly with a frequency of no less than once in every 5 years.

Oxford Brookes University has responsibility for coordination of the WinDat inter-laboratory comparison. This report presents the results of this round-robin exercise.

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## 2 OVERVIEW OF THE WINDAT UV/VIS/NIR TRANSMITTANCE AND REFLECTANCE MEASUREMENT INTERCOMPARISON

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For the WinDat UV/Vis/NIR spectrophotometric near-normal specular transmittance and reflectance measurement intercomparison, 15 sets of samples have been prepared.

Each set contains 4 commercially available glass samples. The samples were measured and evaluated by the coordinating laboratory (Brookes) before despatch to the participants [ 5].

The 4 glass samples used in the intercomparison are:

Planitherm Std (Single Ag based, low emissivity)

SS-108 (Stainless steel/Silicon nitride based, medium emissivity)

Ecologique (SnO<sub>2</sub>:F, low emissivity)

SKN-165B (Double Ag based low emissivity)

The dimension of all samples is 100 mm x 100 mm. All samples were procured from St Gobain Recherche, Aubervilliers, France.

Each participant in the measurement intercomparison received an individual set (Box) containing the 4 test samples.

A written set of instructions was prepared [4] and distributed to each participant together with a purpose designed data workbook prepared in Excel format for the return of the measured data to the coordinating laboratory (Brookes). The instructions define the measurement procedures and the required data-reporting format.

For each sample the following measurements were to be carried out:

Spectral transmittance 300 – 2500 nm

Spectral reflectance 300 – 2500 nm

Measurements were to be made for near-normal incidence only. The spectral transmittance and spectral reflectance (the latter for both the “Back “ (Coated) side and “Front”(Uncoated) sides) of the samples were to be measured.

The participants were required to use their own traceable reference standards and the spectral data were to be supplied corrected\_for the optical properties of the standard used where necessary.

Each participant was also required to calculate and report the integrated solar and visible optical properties using the procedures defined in the European standard EN410 [ 1] and to submit both the measured spectral data and the integrated results according to the specified data format.

### 2.1 SAMPLE CODING

The samples are coded as follows (xx = Box number 01 –15 inclusive):

WD04\_BOX XX\_ S01: Planitherm Std (Single Ag based, low emissivity)

WD04\_BOX XX\_ S02: SS-108 (Stainless steel/Silicon nitride based, medium emissivity)

WD04\_BOX XX\_ S04: Ecologique (SnO<sub>2</sub>:F, low emissivity)

WD04\_BOX XX\_ S05: SKN-165B (Double Ag based low emissivity)

Thus Sample “WD04\_BOX 06\_ S05” is the SKN-165B sample contained in Box No. 06.

Each sample is labelled according to this coding. The labelled side of the samples is “Front” (Uncoated) side.

N.B. There is no sample numbered S03. This derives and is consistent with earlier labelling from an infrared interlaboratory comparison undertaken within the Thermes FP5 project where the same samples were measured.

## **2.2 ESSENTIAL EXPERIMENTAL INFORMATION**

Each participating laboratory provided the essential details of the measurement procedures, details of all reference materials used and certificates of calibration by completing the “Measurement Information Page” of the data workbook.

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### 3 SPECTRAL REFLECTANCE AND TRANSMITTANCE DATA SUMMARY

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#### 3.1 MEASUREMENT SETUP

Twelve laboratories took part in the WinDat intercomparison exercise and in total submitted 14 measurement data sets. Two laboratories shared the same set of samples (the same box, Box 05).

Table 1 presents details of the participating laboratories and the number of complete sets of data (files) submitted.


Table 2 shows details of the measurement apparatus used by the laboratories. The first column “Box Measurement ” identifies the box number followed by the sequence number, e.g. 02\_1, first measurement for samples in Box 02 or the data set submitted from the laboratories sharing the same box e.g. 05\_1, 05\_2.

Table 1. List of the WinDat WP2.1 laboratory intercomparison participating laboratories.

<b>Box No</b>	<b>Organisation</b>	<b>Country</b>	<b>Number Files</b>
01	Belgian Building Research Institute (BBRI)	Belgium	1
02_1 02_2	Centre Scientifique et Technique du Batiment (CSTB)	France	2
04	GLAVERBEL S.A.	Belgium	1
05_1	Interpane	Germany	1
05_2, 05_3	Fraunhofer Institute for Solar Energy Systems	Germany	2
06	Instituto Elettrotecnico Nazionale Galileo Ferraris	Italy	1
08	Netherlands Organization for Applied Scientific Research (TNO TPD)	The Netherlands	1
09	Pilkington	United Kingdom	1
11	Schott Glas	Germany	1
12	Stazione Sperimentale del Vetro (SSV)	Italy	1
13	Uppsala University	Sweden	1
14	Velux A/S	Denmark	1
	<i>Total Countries: 8</i>		
	<i>Total Laboratories:12</i>	<b>Total Files</b>	<b>14</b>

Table 2. Details of the measurement apparatus used by the laboratories.

Box Measurement	Name of Organisation	Instrument	Detector(s)	Resolution	Special Features	Other
01	BBRI	Perkin-Elmer Lambda 900	[REDACTED] <sup>[1]</sup>	UV-VIS : 2 nm NIR : servo		
02_1	Centre Scientifique et Technique du Bâtiment	Perkin Elmer Lambda 19	Integrating sphere (PMT and PbS)	step 5 nm		
02_2	Centre Scientifique et Technique du Bâtiment	Perkin Elmer Lambda 19	Integrating sphere (PMT and PbS)	step 5 nm		
04	GLAVERBEL-B	Perkin-Elmer 900	PbS and photomultiplier tube (PMT)	[REDACTED] <sup>[2]</sup>	Integrating sphere PELA 1000 (diam.: 150mm)	
05_1	INTERPANE GLAS INDUSTRIE AG	Perkin-Elmer Lambda-900	Photomultiplier, PbS	2 nm	Spectrometer maintained externally every six months, most recently Jan 2004	Relative specular reflectance measurement, aluminium mirror as standard
05_2	Fraunhofer ISE	Perkin-Elmer Lambda 900	Photomultiplier, PbS in 220 mm diameter, PTFE-coated integrating sphere	3 nm	220 mm diameter PTFE-coated integrating sphere constructed jointly by ISE and Perkin-Elmer	Transmittance and reflectance sample port diameter: 25 mm
05_3	Fraunhofer ISE	Perkin-Elmer Lambda 9	Photomultiplier, PbS in 150 mm diameter integrating sphere	2 nm		
06	Istituto Elettrotecnico Nazionale G. Ferraris	Perkin Elmer Lambda 900	Photomultiplier for UV/vis range and Peltier-cooled PbS for NIR range	In the range 2500-1700nm: 10nm; 1700-900 nm:5nm; 900-860,8:10nm; 860,7-300nm: 2,5nm		Measurements performed with integrating sphere

Box Measurement	Name of Organisation	Instrument	Detector(s)	Resolution	Special Features	Other
08	TNO TPD	Perkin Elmer Lambda 900 with 150 nm integrating sphere	PMT (UV/Vis) + Peltier cooled PbS cell (NIR)	5 nm		
09	Pilkington Research, Lathom, UK	Cary 5	150mm Integrating Sphere (Labsphere DRA-CA-50)	SBW = 2nm (visible), Fixed Energy IR (SBW <= 20nm)		UKAS Testing Laboratory 2584
11	Schott Glas	Perkin Elmer Lambda 900	Photomultiplier/ PbS	1 nm	T measurement with integrating sphere	
12	Stazione Sperimentale del Vetro	Perkin Elmer Lambda 900	Photomultiplier for UV/vis range and Peltier-cooled PbS for NIR range	2 nm	Integrating Sphere	
13	Uppsala University	Optical bench spectrophotometer, single beam	Silicon + PbS		Integrating sphere detector	Absolute T and R
14	VELUX	Perkin Elmer Lambda 35 UV/VIS Spectrophotometer	Photodiodes	1		Internal references from Pilkington; Opti White, Opti Float, Kappa Sol Bronze, K Glass Used for both Transmittance and Reflectance

### 3.2 SPECTRAL TRANSMITTANCE AND REFLECTANCE DATA

The measured spectral transmittance and spectral reflectance (for both Back and Front sides) in the range 300 – 2500 nm of all participants are presented for Sample 01 in Figure 1 , for Sample 02 in Figure 2, for Sample 04 in Figure 3, and for Sample 05 in Figure 4.

From the figures it is evident that the measurements performed by most of the participating laboratories appear in good agreement. However, there are a small number of measurements (outliers), which deviate from the majority.

### 3.3 CALCULATED INTEGRATED OPTICAL PROPERTIES. INTERLABORATORY COMPARISON.

The integrated solar and photopic optical properties obtained from the individual measurement are compared with the values calculated by Brookes for each sample in turn.

The calculated difference between an integrated value of the laboratory measured sample and the value obtained by Brookes for the same sample is:

For the solar integrated values:

$$\begin{aligned} \text{Dif } T_S &= T_{S\_lab} - T_{S\_Brookes} \\ \text{Dif } Rf_S &= Rf_{S\_lab} - Rf_{S\_Brookes} \\ \text{Dif } Rb_S &= Rb_{S\_lab} - Rb_{S\_Brookes} \end{aligned}$$

For the Photopic integrated values :

$$\begin{aligned} \text{Dif } T_{Ph} &= T_{Ph\_lab} - T_{Ph\_Brookes} \\ \text{Dif } Rf_{Ph} &= Rf_{Ph\_lab} - Rf_{Ph\_Brookes} \\ \text{Dif } Rb_{Ph} &= Rb_{Ph\_lab} - Rb_{Ph\_Brookes} \end{aligned}$$

The respective integrated solar and photopic optical properties of all samples and the differences between the laboratory and Brookes values for each sample are shown in Table 4.

The interlaboratory comparison of the differences between the laboratory and Brookes values by participant (Box Number) are shown for Sample 01 in Figure 5, for Sample 02 in Figure 6, for Sample 04 in Figure 7 , and for Sample 05 in Figure 8 respectively.

One laboratory presented measurements, for the UV/Vis part of the spectral range. The spectral reflectance data as reported do not agree well with the reference values and these data have been considered as outliers.

The calculated integrated optical properties considered as outliers are shown in . Table 3.

Table 3. Integrated optical properties Outliers.

Sample Measurement (Box No)	Brookes	Lab		Brookes	Lab	
	Br_Rf_S	Rf_Solar	Diff	Br_Rf_Ph	Rf_Photoptic	Diff
S02_11	0.347	0.118	-0.23	0.406	0.142	-0.26

The Mean and Standard Deviation of the differences in the integrated optical properties between the calculated laboratory and Brookes values averaged for all measurements for each sample are shown on Figure 9 and Figure 10 . The outliers are excluded

Table 4 The integrated solar and photopic optical properties and the differences between the laboratory and Brookes values for each sample.

Sample Measurement (Box No)	Integrated Values - Brookes						Integrated Values - Laboratory						Differences Laboratory-Brookes					
	Br_T_S	Br_Rf_S	Br_Rb_S	Br_T_Ph	Br_Rf_Ph	Br_Rb_Ph	T_Solar	Rf_Solar	Rb_Solar	T_Phopic	Rf_Phopic	Rb_Phopic	Dif T_S	Dif Rf_S	Dif Rb_S	Dif T_Ph	Dif Rf_Ph	Dif Rb_Ph
S01_01	0.601	0.154	0.214	0.822	0.050	0.053	0.605	0.154	0.210	0.825	0.052	0.051	0.004	0.000	-0.004	0.003	0.002	-0.002
S01_02_1	0.602	0.154	0.212	0.823	0.051	0.052	0.602	0.158	0.218	0.833	0.053	0.055	0.000	0.004	0.005	0.011	0.003	0.003
S01_02_2	0.602	0.154	0.212	0.823	0.051	0.052	0.601	0.158	0.218	0.832	0.053	0.055	-0.001	0.004	0.005	0.009	0.003	0.003
S01_04	0.601	0.153	0.213	0.822	0.050	0.053	0.600	0.153	0.213	0.820	0.050	0.053	-0.001	0.000	0.000	-0.002	0.000	0.000
S01_05_2	0.602	0.153	0.213	0.822	0.051	0.053	0.598	0.154	0.214	0.819	0.051	0.054	-0.004	0.000	0.001	-0.003	0.001	0.001
S01_05_3	0.602	0.153	0.213	0.822	0.051	0.053	0.598	0.154	0.214	0.819	0.051	0.054	-0.004	0.000	0.001	-0.003	0.001	0.001
S01_05_1	0.602	0.153	0.213	0.822	0.051	0.053	0.600	0.150	0.220	0.820	0.050	0.050	-0.002	-0.003	0.007	-0.002	-0.001	-0.003
S01_06	0.601	0.153	0.213	0.822	0.051	0.053	0.600	0.153	0.213	0.820	0.050	0.052	-0.001	0.000	0.000	-0.002	-0.001	-0.001
S01_08	0.602	0.153	0.211	0.821	0.051	0.053	0.601	0.152	0.210	0.821	0.049	0.051	-0.001	-0.001	0.000	-0.001	-0.002	-0.001
S01_09	0.601	0.153	0.212	0.820	0.051	0.053	0.601	0.154	0.213	0.821	0.052	0.054	0.000	0.001	0.001	0.001	0.001	0.001
S01_11	0.605	0.152	0.210	0.824	0.051	0.052	0.600	0.154	0.219	0.819	0.052	0.055	-0.004	0.002	0.009	-0.005	0.001	0.003
S01_12	0.603	0.153	0.211	0.824	0.051	0.052	0.601	0.154	0.211	0.821	0.051	0.051	-0.002	0.001	0.000	-0.003	0.000	-0.001
S01_13	0.603	0.153	0.210	0.823	0.051	0.052	0.601	0.152	0.209	0.816	0.051	0.051	-0.002	-0.001	-0.001	-0.007	0.000	-0.001
S01_14	0.604	0.152	0.209	0.823	0.051	0.052				0.823	0.067	0.067				0.000	0.016	0.015
S02_01	0.072	0.344	0.429	0.093	0.400	0.331	0.073	0.345	0.431	0.093	0.401	0.333	0.001	0.001	0.002	0.000	0.001	0.002
S02_02_1	0.072	0.344	0.428	0.093	0.401	0.329	0.072	0.352	0.439	0.093	0.411	0.339	0.000	0.008	0.011	0.000	0.010	0.010
S02_02_2	0.072	0.344	0.428	0.093	0.401	0.329	0.072	0.352	0.439	0.092	0.411	0.339	0.000	0.008	0.011	0.000	0.010	0.010
S02_04	0.072	0.343	0.431	0.093	0.400	0.334	0.072	0.343	0.430	0.093	0.399	0.333	0.000	0.000	-0.001	0.000	-0.001	-0.001

Sample Measurement (Box No)	Integrated Values - Brookes						Integrated Values - Laboratory						Differences Laboratory-Brookes					
	Br_T_S	Br_Rf_S	Br_Rb_S	Br_T_Ph	Br_Rf_Ph	Br_Rb_Ph	T_Solar	Rf_Solar	Rb_Solar	T_Photoptic	Rf_Photoptic	Rb_Photoptic	Dif T_S	Dif Rf_S	Dif Rb_S	Dif T_Ph	Dif Rf_Ph	Dif Rb_Ph
S02_05_2	0.072	0.344	0.427	0.093	0.401	0.328	0.072	0.347	0.431	0.093	0.404	0.332	-0.001	0.003	0.004	0.000	0.003	0.004
S02_05_3	0.072	0.344	0.427	0.093	0.401	0.328	0.072	0.347	0.431	0.093	0.404	0.332	-0.001	0.003	0.004	0.000	0.003	0.004
S02_05_1	0.072	0.344	0.427	0.093	0.401	0.328	0.070	0.350	0.440	0.090	0.410	0.340	-0.002	0.006	0.013	-0.003	0.009	0.012
S02_06	0.070	0.347	0.428	0.090	0.406	0.327	0.071	0.351	0.432	0.090	0.411	0.331	0.001	0.004	0.004	0.000	0.005	0.004
S02_08	0.072	0.345	0.428	0.092	0.402	0.330	0.073	0.344	0.429	0.093	0.400	0.330	0.001	0.000	0.001	0.000	-0.001	0.000
S02_09	0.072	0.345	0.429	0.093	0.402	0.331	0.072	0.346	0.431	0.093	0.404	0.333	0.000	0.001	0.002	0.000	0.002	0.002
S02_11	0.071	0.347	0.423	0.091	0.406	0.321	0.071	0.118	0.442	0.091	0.142	0.335	0.000	-0.229	0.019	0.000	-0.263	0.014
S02_12	0.073	0.343	0.428	0.094	0.400	0.331	0.073	0.347	0.437	0.093	0.410	0.340	0.000	0.004	0.009	-0.001	0.010	0.009
S02_13	0.072	0.344	0.427	0.093	0.401	0.328	0.072	0.346	0.429	0.092	0.404	0.329	0.000	0.002	0.002	-0.001	0.003	0.001
S02_14	0.073	0.344	0.427	0.094	0.401	0.329				0.094	0.522	0.443				0.000	0.121	0.114
S04_01	0.615	0.110	0.124	0.757	0.105	0.118	0.616	0.111	0.125	0.757	0.106	0.119	0.001	0.001	0.001	0.000	0.001	0.001
S04_02_1	0.616	0.110	0.123	0.758	0.105	0.118	0.618	0.114	0.128	0.760	0.109	0.122	0.002	0.004	0.004	0.002	0.004	0.004
S04_02_2	0.616	0.110	0.123	0.758	0.105	0.118	0.617	0.115	0.128	0.758	0.109	0.122	0.001	0.005	0.004	0.000	0.004	0.004
S04_04	0.617	0.110	0.123	0.758	0.106	0.119	0.616	0.111	0.124	0.757	0.106	0.118	-0.001	0.001	0.001	-0.001	0.000	-0.001
S04_05_2	0.615	0.110	0.124	0.757	0.105	0.117	0.614	0.111	0.125	0.757	0.106	0.120	-0.001	0.001	0.002	-0.001	0.002	0.002
S04_05_3	0.615	0.110	0.124	0.757	0.105	0.117	0.614	0.111	0.125	0.757	0.106	0.120	-0.001	0.001	0.002	-0.001	0.002	0.002
S04_05_1	0.615	0.110	0.124	0.757	0.105	0.117	0.610	0.110	0.130	0.750	0.100	0.120	-0.005	0.000	0.006	-0.007	-0.005	0.003
S04_06	0.616	0.110	0.124	0.758	0.106	0.119	0.615	0.110	0.124	0.756	0.107	0.119	-0.001	0.000	0.000	-0.002	0.001	0.000
S04_08	0.614	0.110	0.124	0.756	0.106	0.119	0.616	0.109	0.122	0.757	0.105	0.117	0.001	-0.001	-0.001	0.001	-0.002	-0.002
S04_09	0.617	0.110	0.124	0.759	0.106	0.119	0.616	0.112	0.125	0.758	0.107	0.120	-0.001	0.002	0.001	-0.001	0.001	0.001

Sample Measurement (Box No)	Integrated Values - Brookes						Integrated Values - Laboratory						Differences Laboratory-Brookes					
	Br_T_S	Br_Rf_S	Br_Rb_S	Br_T_Ph	Br_Rf_Ph	Br_Rb_Ph	T_Solar	Rf_Solar	Rb_Solar	T_Photoptic	Rf_Photoptic	Rb_Photoptic	Dif T_S	Dif Rf_S	Dif Rb_S	Dif T_Ph	Dif Rf_Ph	Dif Rb_Ph
S04_11	0.615	0.110	0.123	0.756	0.107	0.120	0.610	0.107	0.131	0.749	0.103	0.115	-0.005	-0.002	0.007	-0.007	-0.003	-0.004
S04_12	0.619	0.110	0.123	0.760	0.106	0.118	0.615	0.110	0.124	0.757	0.107	0.120	-0.004	0.000	0.001	-0.003	0.001	0.002
S04_13	0.616	0.110	0.124	0.758	0.106	0.119	0.609	0.106	0.120	0.744	0.099	0.114	-0.007	-0.004	-0.004	-0.014	-0.007	-0.005
S04_14	0.616	0.110	0.123	0.757	0.107	0.120				0.753	0.137	0.155				-0.004	0.030	0.035
S05_01	0.338	0.276	0.414	0.637	0.111	0.102	0.339	0.277	0.414	0.639	0.111	0.102	0.001	0.001	0.000	0.002	0.000	0.000
S05_02_1	0.336	0.279	0.420	0.636	0.109	0.105	0.337	0.286	0.429	0.638	0.114	0.109	0.001	0.007	0.009	0.002	0.004	0.004
S05_02_2	0.336	0.279	0.420	0.636	0.109	0.105	0.336	0.285	0.428	0.637	0.113	0.109	0.001	0.006	0.008	0.001	0.004	0.004
S05_04	0.337	0.278	0.417	0.638	0.110	0.103	0.337	0.277	0.416	0.637	0.111	0.103	0.000	-0.001	-0.001	-0.001	0.001	0.000
S05_05_2	0.336	0.278	0.419	0.638	0.109	0.104	0.336	0.279	0.421	0.637	0.110	0.105	-0.001	0.001	0.002	0.000	0.001	0.001
S05_05_3	0.336	0.278	0.419	0.638	0.109	0.104	0.336	0.279	0.421	0.637	0.110	0.105	-0.001	0.001	0.002	0.000	0.001	0.001
S05_05_1	0.336	0.278	0.419	0.638	0.109	0.104	0.340	0.270	0.420	0.640	0.110	0.100	0.004	-0.008	0.001	0.002	0.001	-0.004
S05_06	0.334	0.280	0.422	0.635	0.108	0.105	0.333	0.281	0.423	0.635	0.107	0.103	-0.001	0.001	0.001	0.000	-0.001	-0.002
S05_08	0.334	0.280	0.422	0.635	0.108	0.104	0.333	0.279	0.420	0.633	0.107	0.104	0.000	-0.001	-0.002	-0.001	-0.001	0.000
S05_09	0.335	0.278	0.419	0.636	0.109	0.103	0.336	0.280	0.420	0.636	0.111	0.105	0.001	0.002	0.001	0.000	0.002	0.002
S05_11	0.338	0.276	0.416	0.638	0.110	0.102	0.336	0.275	0.426	0.636	0.110	0.102	-0.001	-0.001	0.010	-0.002	0.000	0.000
S05_12	0.337	0.277	0.417	0.637	0.110	0.104	0.337	0.283	0.424	0.635	0.112	0.106	0.000	0.006	0.007	-0.002	0.002	0.002
S05_13	0.338	0.275	0.413	0.637	0.114	0.102	0.337	0.273	0.410	0.637	0.113	0.100	-0.001	-0.002	-0.003	0.000	-0.001	-0.002
S05_14	0.337	0.277	0.417	0.637	0.109	0.103				0.639	0.143	0.132				0.002	0.034	0.029

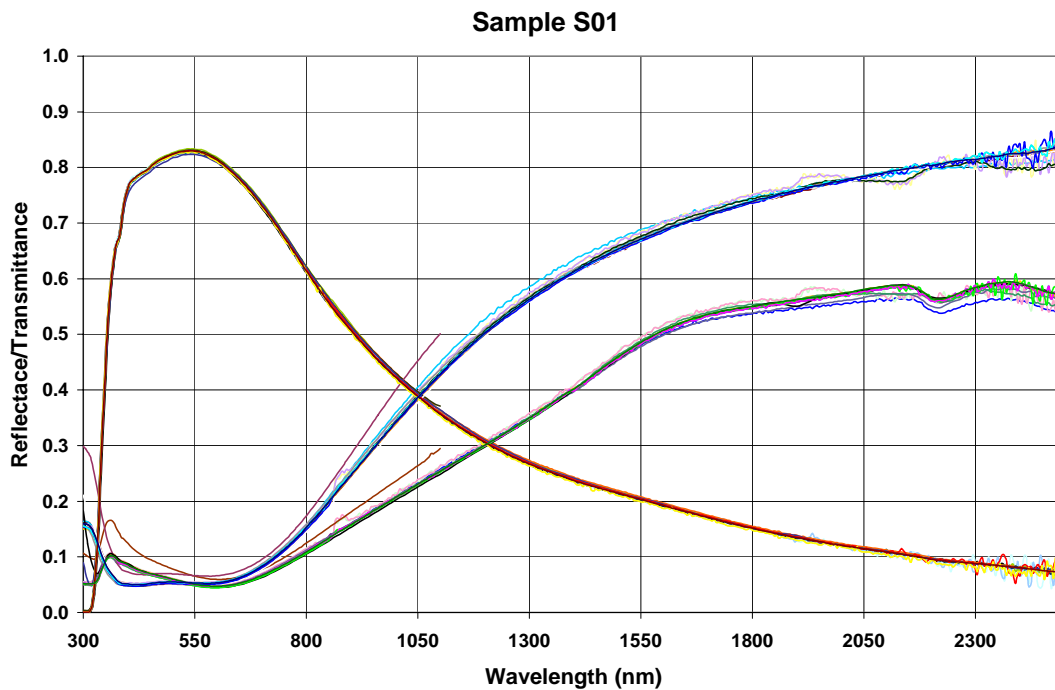


Figure 1. Measured spectral reflectance and transmittance data submitted by the laboratories for Sample S01.

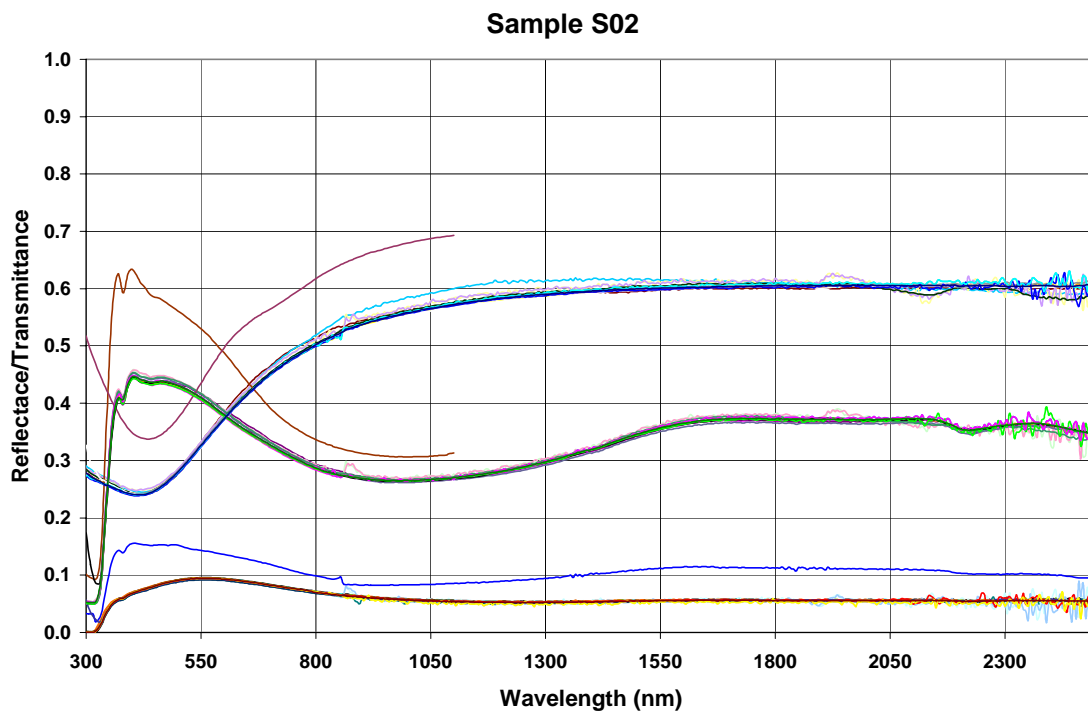


Figure 2. Measured spectral reflectance and transmittance data submitted by the laboratories for Sample S02.

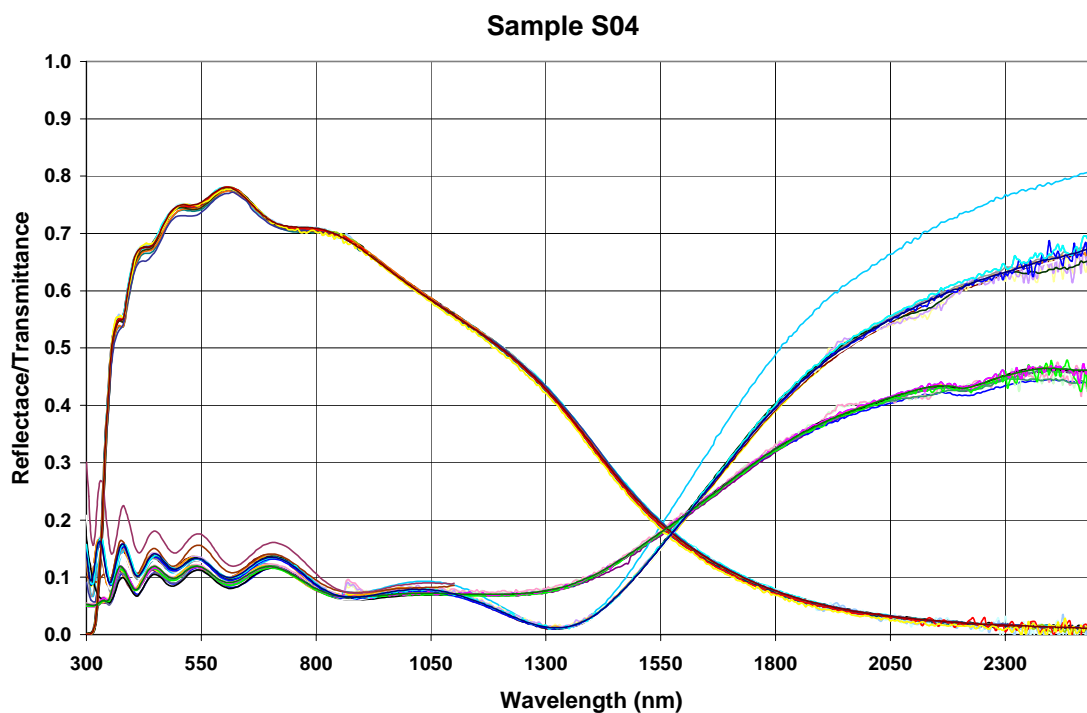


Figure 3. Measured spectral reflectance and transmittance data submitted by the laboratories for Sample S04.

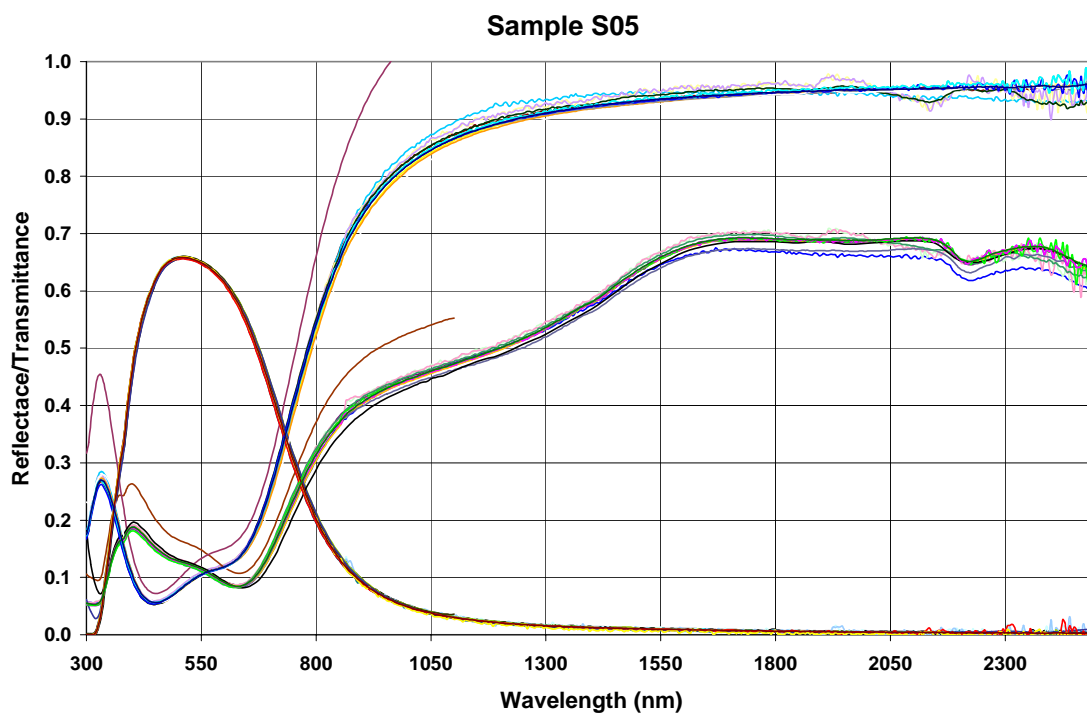


Figure 4. Measured spectral reflectance and transmittance data submitted by the laboratories for Sample S05.

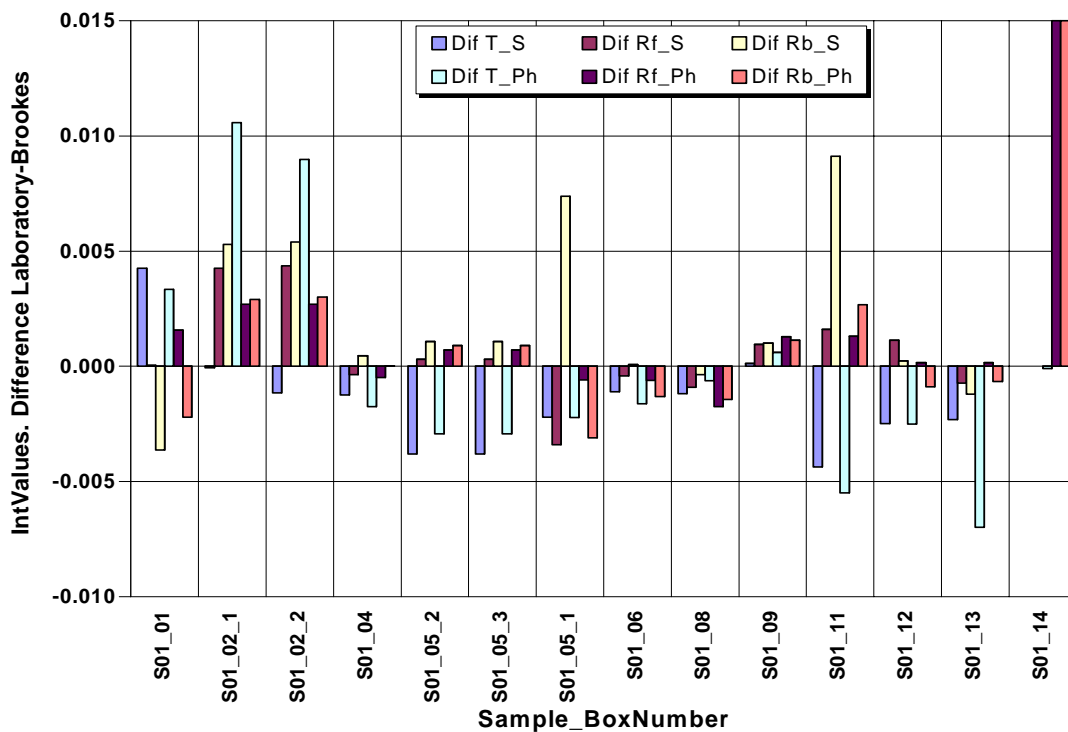


Figure 5. Interlaboratory comparison of the differences between the laboratory and Brookes integrated optical properties values by Participant (Box Number): Sample S01.

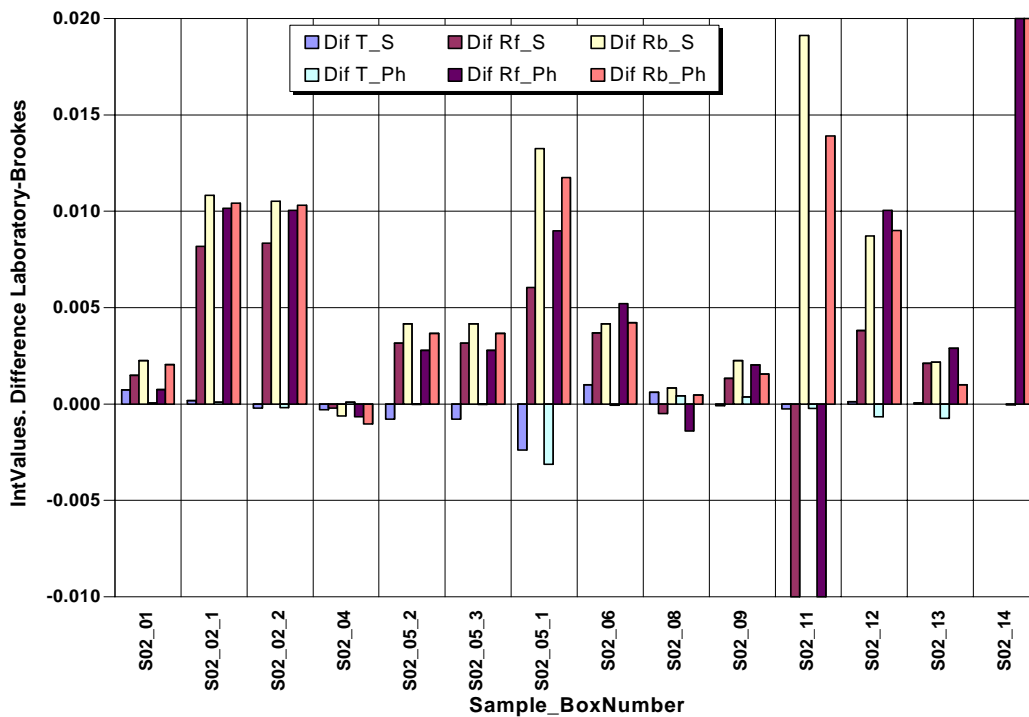


Figure 6. Interlaboratory comparison of the differences between the laboratory and Brookes integrated optical properties values by Participant (Box Number): Sample S02.

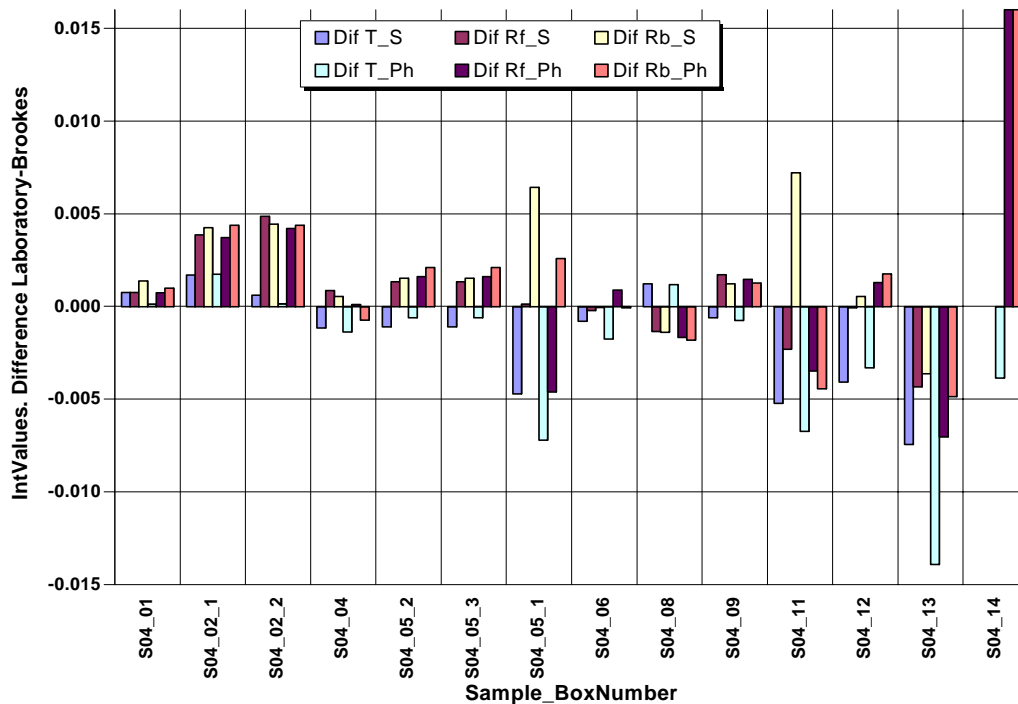


Figure 7. Interlaboratory comparison of the differences between the laboratory and Brookes integrated optical properties values by Participant (Box Number): Sample S04.

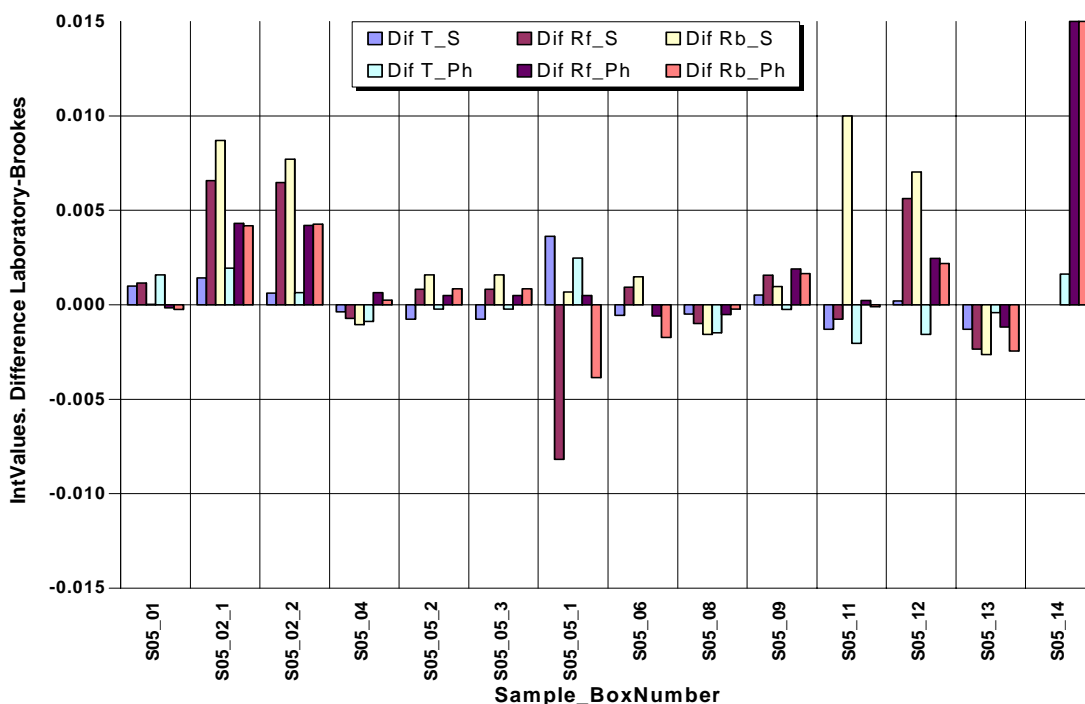


Figure 8. Interlaboratory comparison of the differences between the laboratory and Brookes integrated optical properties values by Participant (Box Number): Sample S05.

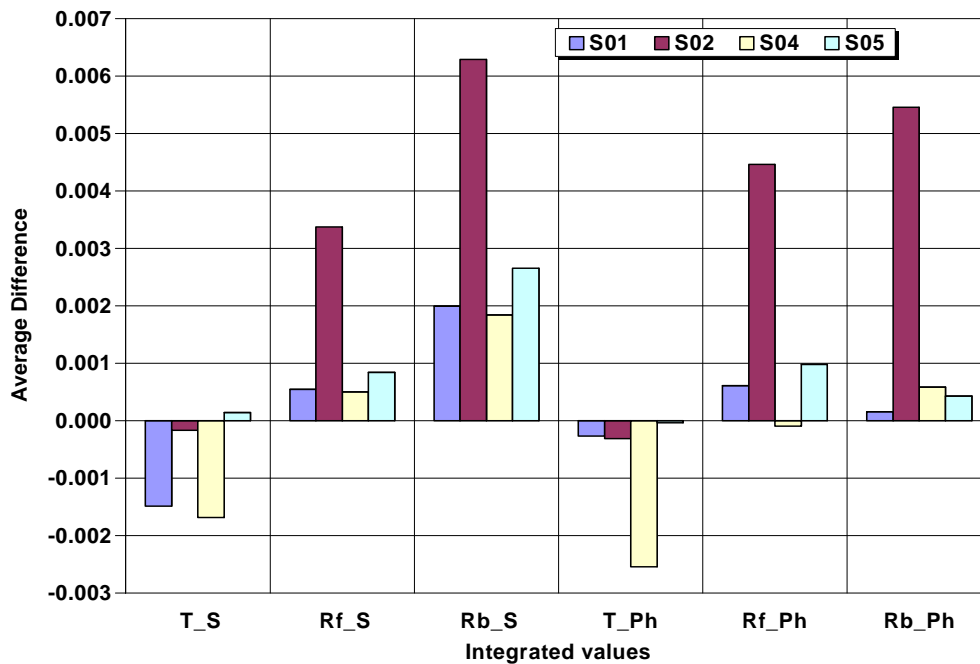


Figure 9 Mean Deviation of the differences between the laboratory and Brookes integrated optical properties values averaged for all measurements for each sample. The outliers are excluded.

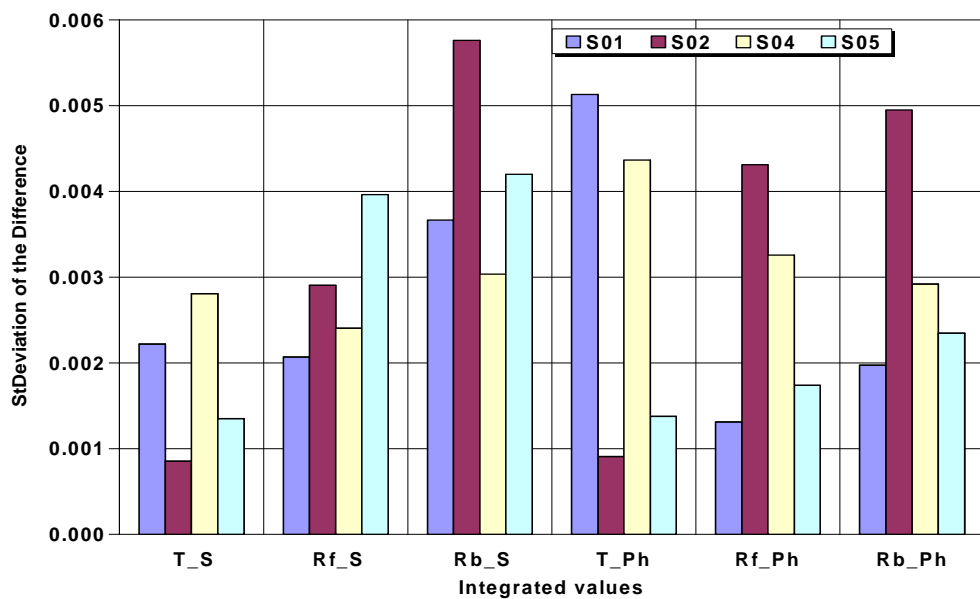


Figure 10 Standard Deviation of the differences between the laboratory and Brookes integrated optical properties values for all measurements for each sample. The outliers are excluded.

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#### 4 SUMMARY

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The overall outcomes of the WinDat UV/Vis/NIR spectral transmittance and reflectance measurement intercomparison exercise is very encouraging.

Participants have performed the work using a range of instruments, detectors and measurement standards and have adhered to the instructions.

The measurements performed by most of the participating laboratories are in very good agreement, however, there are small number of measurements (outliers), which deviate from the majority.

The Mean deviation of the differences between the laboratory and Brookes integrated optical properties values averaged for all measurements for each sample is less than  $\pm 0.006$ . The Standard deviation of the differences between the laboratory and Brookes integrated optical properties values for all measurements for each sample is less than 0.006 .

The biggest differences in the Mean and Standard deviations are observed for Sample S02.

It is concluded that the participants have performed the measurements accurately. This underpins the quality of the spectral optical properties data held in the WIS database for non-scattering glass and glazing products.

#### ACKNOWLEDGEMENTS

The WinDat partners are grateful to all laboratories and persons who participated in this measurement inter-comparison and for the prompt submission of their completed work in good time.

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**5 REFERENCES**

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- 1 EN 410 Glass in building – Determination of luminous and solar characteristics of glazing, April 1998.
- 2 WIS Database, Data Submission Procedure for Glass and Coatings (non –scattering) glazing products, Version 1.0, May 2004 (**WinDat\_N2.01**)
- 3 WIS Database, Verification Procedure for Glass and Coatings (non –scattering) Glazing Products Data, Version 1.0, May 2004 (**WinDat\_N2.02**).
- 4 WinDat -Brookes-2004-02-11 WP21.1Measurement Intercomparison\_ Glass and Coatings (non-scattering) Instructions, Oxford Brookes University, February 2004 (**WinDat\_N2.05**).
- 5 WinDat -Brookes-2004-05-11 WP21.1Measurement Intercomparison\_ Glass and Coatings (non-scattering) Initial Sample Characterisation, Oxford Brookes University, February 2004 (**WinDat\_N2.04**).

Page: 8  
[MGH1] These are the lamp sources in the spectrophotometer not the detectors!

Page: 8  
[MGH2] Find resolution from the data submitted ?

Page: 9  
[MGH3] As for Comment 2 above