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**NFRC**  
**“TG Diffuse Glazing”**

**INTER-LABORATORY COMPARISON (ILC) OF  
TRANSMITTANCE AND REFLECTANCE  
MEASUREMENTS  
OF LIGHT-SCATTERING AND PATTERNED GLASS**

**Instructions**

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## 1 BACKGROUND

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For light-scattering glazing used in architectural applications, knowledge of at least the normal-hemispherical transmittance and reflectance is needed. Similar considerations apply to patterned glass, whereby the transmittance is of greater significance than the reflectance in its common application as a cover to photovoltaic modules or solar-thermal collectors.

The TG “Diffuse Glazing” has recently introduced modifications to the NFRC documents 100, 200, 300, 301 and 302 to take account of the special precautions needed to determine the optical, solar and thermal properties of glazing with a diffusing layer. The modifications to the documents reflect the fact that suitable integrating spheres for the optical measurements have recently become commercially available.

In the current measurement inter-laboratory comparison (ILC), one aim is to apply the recently modified measurement procedures for the transmittance and reflectance of light-scattering glass, using commercially available integrating spheres and spectrophotometers, which are as accurate as is practically feasible. Patterned glass samples, where the embossed pattern is not much smaller than the illuminated area, are also included to see if the methods are valid for such samples as well.

The measurement results will be compared and analysed, and should provide a benchmark for future reference. If the variation in results for some samples should prove to be greater than the currently specified tolerances, the data will form a basis for identifying further modifications of procedures and/or instruments, should this be necessary.

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## 2 TEST SAMPLES AND CODING

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Seven types of light-diffusing glazing have been selected as samples, and are presented in the Table below. The glazing suppliers were also responsible for preparing 28 specimens of each of the sample types 1 to 6, namely 23 @ 125 mm x 125 mm, 3 @ 198 mm x 298 mm and 2 @ 400 mm x 400 mm. Only 3 specimens were required for sample type 7, namely 3 @ 198 mm x 298 mm.

Sample	Description	Supplier	“front” surface
1 – Diffuse interlayer	Eastman 0.030” Saflex Arctic Snow between two 6 mm low iron glass substrates	Eastman	Labelled surface
2 – Coated fritted glass	Viracon V1086 frit with triple silver coating on 12 mm glass substrate	Viracon	Uncoated glass surface
3 – Acid-etched	Guardian Satin Deco surface treatment on one surface of 12 mm glass substrate.	Guardian	Smooth glass surface
4 – Applied film	Eastman NRM PS2 applied film on Starphire 6mm glass substrate	Eastman	Glass surface
5 – Small inverted pyramid pattern	Pilkington SM patterned glass with small inverted pyramidal structure	NSG EU	Smooth glass surface
6 – Coated patterned glass	Guardian P-516 patterned glass coated with neutral silver color coating with emissivity ~0.2	Guardian	Patterned, uncoated glass surface
7 – Inverted pyramid pattern	Saint Gobain Albarino S patterned glass – <b>(only for LBNL and Fraunhofer ISE)</b>	Saint Gobain	Smooth glass surface

The sample are numbered on the format Y-ZZ, where:

Y = sample type number (1 to 7 inclusive)

ZZ = tracking number (01 to 28 inclusive)

The sample type number (Y) is as indicated in the Table above and is the first number inscribed onto each sample. The sample tracking number (ZZ) is the second number inscribed onto each sample, we tried to keep the tracking number the same as the box number for as many boxes as possible, however, a few (less than 5 among the over 100 samples) were identified as outliers and were replaced with samples that had a higher tracking number.

The surface reported as “front” for each sample is defined in the table above.

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### 3 INTER-LABORATORY COMPARISON DESCRIPTION

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The task of **preliminary characterisation** to check homogeneity among a given sample type and at different positions of each specimen was shared out among four laboratories (Eastman, LBNL, Guardian and NSG EU).

**Description of sample position.**

- "default" orientation is with the "front" surface facing the light source
- "default" angle of rotation =  $0^\circ$  is with the label/inscription upper right viewed from light source when the front surface faces the light source. Angles of rotation are clockwise (as viewed from the light source).
- The "default flipped" orientation is with the "front" surface away from the light source.
- The "default flipped" angle of rotation =  $0^\circ$  is with the label/inscription upper left viewed from light source when the "front" surface is away from light source. Angles of rotation are still clockwise (as viewed from the light source).

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## 4 MEASUREMENTS TO BE PERFORMED

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### 4.1 SPECTROPHOTOMETERS WITH INTEGRATING SPHERES

In general, these spectrophotometers allow the user to define a variety of measurement parameters. In stage 1, each participant is to measure and report one set of normal-normal and normal-diffuse transmittance and reflectance spectra for each sample surface using the method and measurement parameters described in NFRC 300-2017\_E0A2 and NFRC 301-2017\_E0A2. The reported spectra may be obtained by averaging several spectra measured e.g. for different angles of rotation of the sample, if the participant considers that this method is appropriate. The results for stage 1 of the inter-laboratory comparison should be reported with the measurement number MN=01 (see Section 5.1.1).

The method and measurement parameters to be used in stage 2 will be defined after analysis of the results from stage 1.

Participants are strongly recommended to determine the instrument parameters before embarking on the measurements, as this investigation may be useful in optimising these parameters.

The following measurement and instrument parameters shall be reported for each sphere and spectrometer combination using the Excel workbook provided:

Instrument parameters:

- manufacturer and model
- diameter of integrating sphere,
- shape of transmittance sample port (circular/rectangular),
- dimensions of transmittance sample port (diameter in mm or height in mm and width in mm),
- shape of beam at 550 nm at transmittance sample port (circular/rectangular),
- dimensions of beam at 550 nm at transmittance sample port (diameter in mm or height in mm and width in mm),
- shape of reflectance sample port (circular/rectangular),
- dimensions of reflectance sample port (diameter in mm or height in mm and width in mm),
- shape of beam at 550 nm at reflectance sample port (circular/rectangular),
- dimensions of beam at 550 nm at reflectance sample port (diameter in mm or height in mm and width in mm)
- shape and dimensions of exit port for directly transmitted radiation (circular/rectangular, diameter in mm or height in mm and width in mm),
- shape and dimensions of beam at 550 nm at exit port for directly transmitted radiation (circular/rectangular, diameter in mm or height in mm and width in mm),
- dimensions of exit port for specularly reflected radiation (gloss trap) (circular/rectangular, diameter in mm or height in mm and width in mm),
- shape and dimensions of beam at 550 nm at exit port for specularly reflected radiation (gloss trap) (circular/rectangular, diameter in mm or height in mm and width in mm),

Measurement parameters:

- UV/Vis slit mode (fix or servo),
- UV/Vis slit width or gain,

- scan speed in UV/vis
- integration time in UV/vis
- NIR slit mode (fix or servo),
- NIR slit width or gain,
- scan speed in NIR
- integration time in NIR
- data recording interval
- detector change wavelength
- common beam mask setting
- common beam depolariser (yes or no)
- polariser (yes or no)

#### Spectral data processing

- number of spectra averaged to obtain result spectrum
- angle of rotation of sample for each measured spectrum that is included in average
- specify any other parameter which has been varied for the measured spectra that are included in the average (N.B. the measurement and instrument parameters listed above should not be varied)

For all asymmetric samples (sample 2 to 7), normal-normal and normal-diffuse transmittance and reflectance from both sides (i.e. “default” and “flipped” orientations) should be measured.

For the matt laminate sample (sample 1), normal-normal and normal-diffuse transmittance and reflectance should be measured only with the “front” surface facing the light beam (in “default” orientation, i.e. “front” surface toward light source for transmittance, “front” surface toward sphere for reflectance).

Measured data shall be reported using the *CGDB interim textfile* format. These instructions are intended to be distributed together with a pdf that has the definition of how this format differs from the IGDB text file format, as well as an example file. Please note that **in stage 1, each participant is requested to provide only one set of results for each sample and spectrophotometer/sphere combination, using the method and measurement parameters which he/she considers to be the best possible with the equipment available.**

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## 5 DATA REPORTING

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### 5.1 DESCRIPTION OF THE EXCEL DATA WORKBOOKS

All data, results and details of the measurement procedure are to be reported to LBNL and Fraunhofer ISE by completing the appropriate sheets of the Excel Workbooks provided for this purpose

#### 5.1.1 MEASUREMENTS WITH A SPECTROPHOTOMETER WITH AN INTEGRATING SPHERE

The workbook “ILC\_DGSS\_XX\_n\_MN\_191121.xls” shall be used for reporting data from measurements on Diffuse Glazing made with a Spectrophotometer with an integrating Sphere.

In each EXCEL workbook, one sheet requests information describing the instrument and measurement procedure and parameters.

In the filename:

XX – is the participant number, this is equal to box number, i.e. the number on the outside of the box containing the samples (this number has been allocated by LBNL)

n - is the instrument number assigned by the participant, starting with 1

MN - is the two-digit Measurement Number. For the set of results from stage 1, MN=01.

Each participant should name their data files by substituting the “XX” component of the filename with the two-digit participant number, e.g. 04, 14 etc, by replacing “n” with the single-digit instrument number assigned by the participant, starting with 1, and by replacing “MN” by a two-digit measurement number, starting with 01 for the results from stage 1.

In the case of participants wishing to report results from more than one combination of commercial laboratory spectrophotometer with integrating sphere, the instrument number “n” will be “1” for the measurement made with commercial spectrophotometer/sphere combination 1, “2” for the measurement made with commercial spectrophotometer/sphere combination 2 etc.

The Measurement Number “MN” will be 01 for the set of spectra obtained with the commercial spectrophotometer/sphere combination that is submitted in stage 1. The result spectra can either be 1) the result of single measurements or 2) averages of repeated measurements with the same sample measurement and instrument parameters or 3) averages of measurements with different combinations of sample parameters (e.g. rotation angle or beam position) but the same measurement and instrument parameters. It is thus important that the sheet describing the sample, instrument and measurement parameters be correctly filled out in each work sheet. Please observe that **in stage 1, each participant is requested to provide only one set of results for each sample and spectrophotometer/sphere combination, using the method and measurement parameters which he/she considers to be the best possible with the equipment available.**

Thus the instrument information from participant 04 with a spectrophotometer/sphere combination 1 in stage 1 would be entered into the Excel Workbook and given the filename “ILC\_DGSS\_04\_1\_01\_191121.xlsx”



If a set of data is obtained from participant 04 with a second spectrophotometer/sphere combination, the filename for the information about that configuration using this second device in stage 1 will be “ILC\_DGSS\_04\_2\_01\_191121.xlsx”

#### 5.1.1.1 *Description sheet for commercial laboratory spectrophotometer and integrating sphere*

This sheet is intended to describe the laboratory and instrumentation used for measurements. The participant should complete the section “Information on commercial laboratory spectrophotometer and integrating sphere”.

#### 5.1.1.2 *Textfiles for each sample*

The measured data for each sample shall be reported in an individual text file as if the sample it was being submitted to the CGDB. The file format used is the CGDB interim text file format.

Each file should be names according to the format ILC\_DGSS\_NN\_n\_MN\_SN.txt. The definition of NN, n, and MN are the same as above, the number SN stands for sample number and should be a number from 1 to 6 (7 for LBNL and Fraunhofer) corresponding to the sample number in the box.

The spectral data shall be **corrected** for the calibration standard used.

Note that the file format specifies that normal-direct and normal-diffuse values are reported. A common integrating sphere design results in measurement in normal-hemispherical and normal-diffuse data, and if that is the case the calculated normal-direct value shall be reported rather than the measured normal-hemispherical value.

The spectral values should be given as a decimal figure between 0 and 1 e.g. 0.625, and **NOT as a percentage**.

All values should be given to at least 3 significant figures. Do not use scientific notation (such as 3E-2)

Spectral data (minimum 300 to 2500 nm with a 5 nm wavelength interval) shall be reported. Higher resolution data will be interpolated to 5 nm for the comparison activity and data outside the stated spectral range will be ignored.

#### 5.1.1.3 *Data in the Thermal IR range*

Emissometer vs spectral IR data, both are allowed.

Single-value results measured with emissometer are reported in the header of the textfiles.

Spectral results measured using IR integrating sphere is reported the same way as the rest of the spectral data. E.g.

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...
2.490 0.5260 0.2330 0.5300 0.2420 0.0000 0.0980 0.0000 0.0960
2.495 0.5150 0.2410 0.5170 0.2490 0.0000 0.0980 0.0000 0.0940
2.500 0.5200 0.2380 0.5280 0.2400 0.0000 0.0970 0.0000 0.0940
5.000 0.5260 0.2330 0.5300 0.2420 0.0000 0.0980 0.0000 0.0960
5.500 0.5150 0.2410 0.5170 0.2490 0.0000 0.0980 0.0000 0.0940
6.000 0.5200 0.2380 0.5280 0.2400 0.0000 0.0970 0.0000 0.0940
...

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Please send the completed worksheets to Jacob Jonsson and Helen Rose Wilson (contact details in Section 6) by December 1st.

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## 6 FURTHER INFORMATION AND CONTACT DETAILS

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### ENQUIRIES

**All enquiries** concerning further information and participation in the NFRC intercomparison of transmittance and reflectance measurements on light-scattering and patterned glass should be addressed to the TG Chairperson:

Jacob Jonsson  
LBNL  
Mailstop 90-3145  
Berkeley CA 94720  
USA  
Tel: + 1 510 486-7329  
Email: [jjonsson@lbl.gov](mailto:jjonsson@lbl.gov)

### DATA SUBMISSION

**All measured data for the light-scattering glazing** and queries on the measurement procedures/instructions should be submitted to

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