



A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with Crystal Green 30 applied film. The films were mounted on a 5 mm clear reference glass sample.

## **Test Methods and Procedures**

### **Optical data Measurements**

#### **UV-Vis-NIR Measurements:**

Total transmittance and total reflectance factor measurements were performed with ODA's Varian™ Cary 500E™ UV-Vis-NIR Double Beam Spectrophotometer equipped with a 150 mm diameter Labsphere™ Spectralon™ reference standard. Baselines are measured before and after the sample measurements, a zeroline is measured after the sample measurements and a didymia transmittance standard is measured during each set of measurements to verify the wavelength scale. For transmittance and reflectance factor, the angle of incidence is 0° and 7°, respectively. The typical wavelength interval is 5nm.

#### **IR Measurements:**

Specular transmittance and specular reflectance factor measurements are performed with ODA's Perking-Elmer™ 9836 G IR Double-Beam IR Spectrophotometer equipped with Perking-Elmer™ Specular Reflectance Accessory. The wavelength range is 2 to 56 μm. In reflectance, measurements are made with respect to a protected aluminum specular reflectance reference standard from National Physical Laboratory™ [NPL] in the United Kingdom. Baselines are measured before and after the sample measurements, a zeroline is measured after the sample measurements, and a polystyrene transmittance standard is measured during each set of measurements to verify the wavelength scale. For transmittance and reflectance factor, the angle of incidence is 0° and 7°, respectively. The wavelength interval is 10cm<sup>-1</sup>. This is the method adopted by the Lawrence Berkeley National Laboratory [LBNL].

The optical properties of glasses with films are summarized in Table 1 and the graphical details are shown in Appendix 1.

**Table 1: Optical properties of the glass with Crystal Green 30 applied film**

Product Name	Thick-ness	Solar			Visible			Emissivity	
	mm	Tsol	R <sub>f</sub> sol	R <sub>b</sub> sol	Tvis	R <sub>f</sub> vis	R <sub>b</sub> vis	Front	Back
Crystal Green 30	5.07	0.256	0.404	0.295	0.363	0.348	0.308	0.77	0.84

*Note: Subscript f and b represent front and back respectively. Films are applied at the front side. T and R denote transmittance and reflectance respectively.*

### Optical Data Calculations

The centre of glass U factor, SHGC (Solar Heat Gain Coefficient), Shading Coefficient, Visible Transmittance and Relative heat gains of the glass with applied film, assuming it as a single glazed unit, was calculated using WINDOW5 and the values are given in Table 2 below: **The film side of the glass faces the indoor environment.**

**Table 2: Thermal and optical properties of single glazing unit**

Product Name	# of glass layer	Winter U-Factor	Summer U-Factor	SHGC	SC	Tvis	Relative Heat Gain	UV Indices		
		W/m <sup>2</sup> K	W/m <sup>2</sup> K				W/m <sup>2</sup>	Tuv	Tdw-K	Tdw-ISO
Crystal Green 30	1	5.62	5.05	0.38	0.45	0.36	321	0.002	0.129	0.266

The NFRC standard boundary conditions given below were used for the calculations in Table 2:

ID	Name	U-factor Tin	U-factor Tout	SHGC Tin	SHGC Tout	SHGC Solar
		C	C	C	C	W/m <sup>2</sup>
1	NFRC 100-2002	21.0	-18.0	24.0	32.0	783

### Appendix 1.: Spectral properties of the glass sample with film.

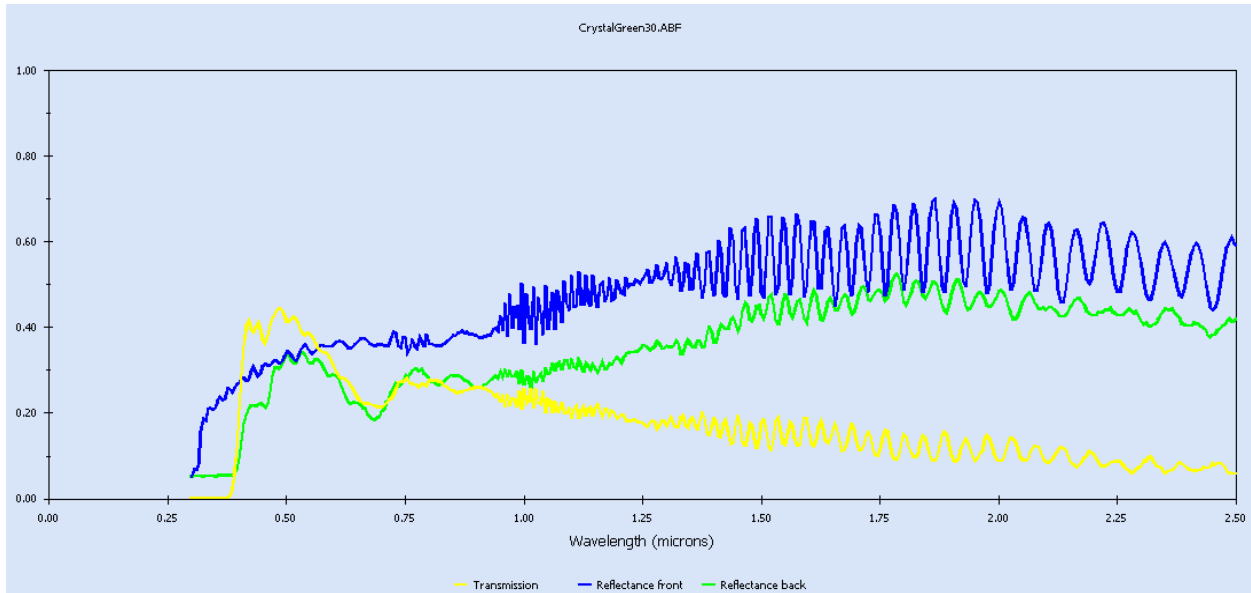


Figure 1: Spectral properties: Crystal Green 30

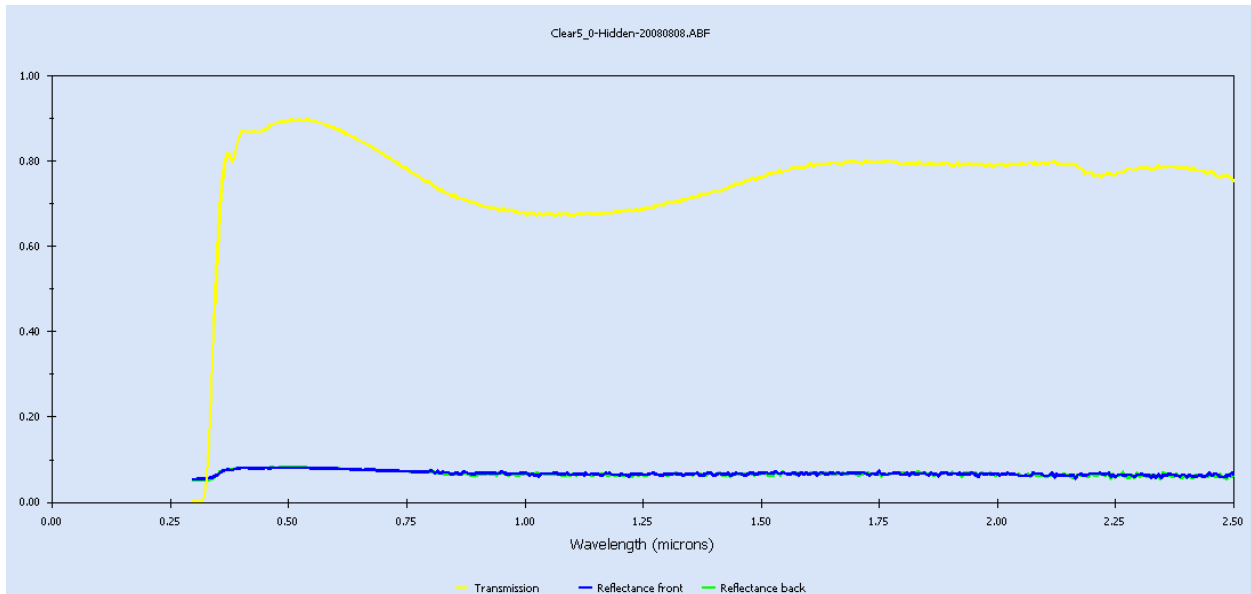


Figure 2: Spectral properties: Reference Glass sample (Substrate)

**Appendix 2.: Detailed glazing data of a single glazed unit with film**

Window 5.2a v5.2.17a Glazing System Thermal and Optical Properties 08/12/08  
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ID : 4  
 Name : Crystal Green 30  
 Tilt : 90.0  
 Glazings: 1  
 KEFF : 0.1000  
 Width : 5.071  
 Uvalue : 5.62  
 SHGCc : 0.38  
 SCc : 0.45  
 Vtc : 0.36  
 RHG : 321.11

Glass and Gas Data for Glazing System '4 Crystal Green 30'

ID	Name	D(mm)	Tsol	1	Rsol	2	Tvis	1	Rvis	2	Tir	1	Emis	2	Keff
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Outside															
	30024FCrystalGreen30.#	5.1	.256	.295	.404	.363	.308	.348	.000	.840	.770	.912			
Inside															

Environmental Conditions: 1 NFRC 100-2002

	Tout (C)	Tin (C)	WndSpd (m/s)	Wnd Dir	Solar (W/m2)	Tsky (C)	Esky
Uvalue	-18.0	21.0	5.50	Windward	0.0	-18.0	1.00
Solar	32.0	24.0	2.80	Windward	783.0	32.0	1.00

Optical Properties for Glazing System '4 Crystal Green 3'

Angle	0	10	20	30	40	50	60	70	80	90	Hemis
Vtc	: 0.363	0.366	0.361	0.355	0.349	0.336	0.309	0.251	0.151	0.000	0.318
Rf	: 0.308	0.302	0.301	0.303	0.311	0.324	0.350	0.417	0.595	0.999	0.342
Rb	: 0.348	0.343	0.342	0.344	0.351	0.364	0.388	0.451	0.618	0.999	0.380
Tsol	: 0.256	0.257	0.254	0.250	0.245	0.237	0.217	0.177	0.106	0.000	0.223
Rf	: 0.295	0.289	0.288	0.290	0.298	0.312	0.338	0.406	0.587	0.999	0.330
Rb	: 0.404	0.399	0.398	0.400	0.407	0.418	0.440	0.498	0.651	0.999	0.432
Abs1	: 0.449	0.454	0.458	0.460	0.456	0.452	0.445	0.417	0.306	0.001	0.436
SHGCc	: 0.383	0.386	0.384	0.381	0.375	0.365	0.343	0.295	0.191	0.000	0.347
Tdw-K	: 0.129										
Tdw-ISO	: 0.266										
Tuv	: 0.002										

Temperature Distribution (degrees C)

	Winter		Summer	
	Out	In	Out	In
Lay1	-10.5	-9.3	41.9	42.1