



A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with DS 12 GN 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 DS 12 GN 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
DS 12 GN	5.06	0.112	0.461	0.361	0.150	0.396	0.388	0.76	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
DS 12 GN	1	5.59	5.02	0.26	0.31	0.15	234	0.001	0.045	0.100

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.

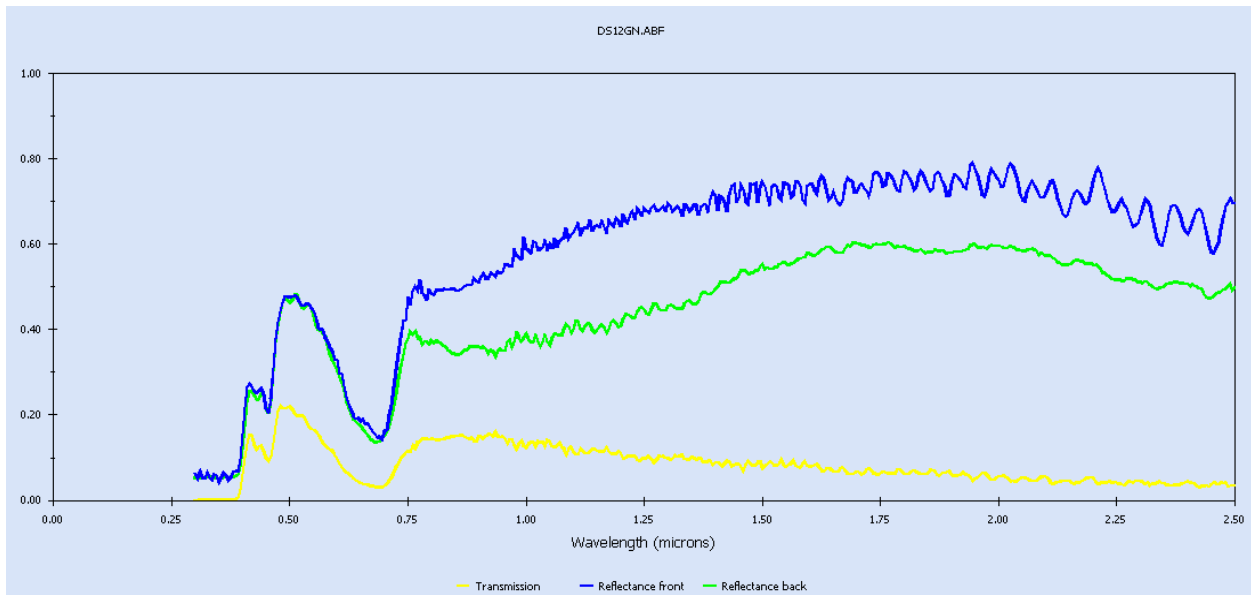


Figure 1: Spectral properties: DS 12 GN

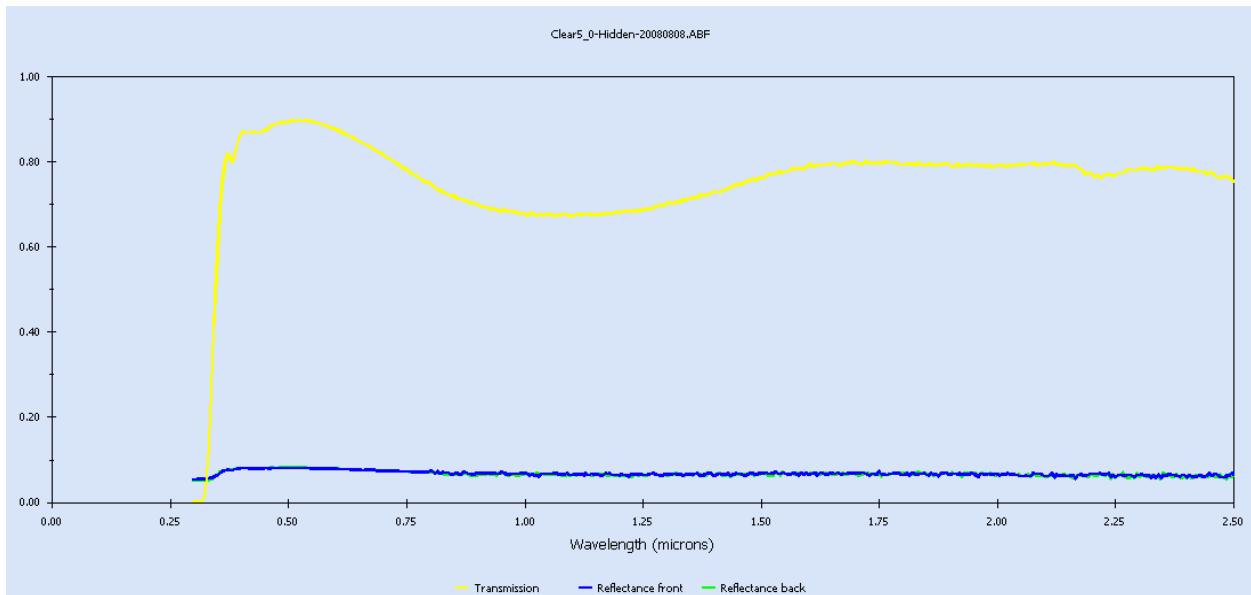


Figure 2: Spectral properties: Reference Glass sample (Substrate)

**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  
14:41:17

ID : 21  
 Name : DS 12 GN  
 Tilt : 90.0  
 Glazings: 1  
 KEFF : 0.1000  
 Width : 5.063  
 Uvalue : 5.59  
 SHGCc : 0.26  
 SCc : 0.31  
 Vtc : 0.15  
 RHG : 233.57

Glass and Gas Data for Glazing System '21 DS 12 GN'

ID	Name	D(mm)	Tsol	1 Rsol	2 Tvis	1 Rvis	2 Tir	1 Emis	2 Keff
Outside									
	30019FDS12GN.ABF	# 5.1	.112	.361	.461	.150	.388	.396	.000
Inside									
			.840	.760	.914				

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 '21 DS 12 GN'

Angle	0	10	20	30	40	50	60	70	80	90	Hemis
Vtc	: 0.150	0.151	0.149	0.147	0.144	0.139	0.127	0.104	0.062	0.000	0.131
Rf	: 0.388	0.383	0.382	0.384	0.391	0.403	0.425	0.485	0.642	0.999	0.417
Rb	: 0.396	0.391	0.390	0.392	0.399	0.411	0.433	0.491	0.647	0.999	0.425
Tsol	: 0.112	0.113	0.111	0.109	0.107	0.104	0.095	0.077	0.047	0.000	0.098
Rf	: 0.361	0.356	0.355	0.357	0.364	0.376	0.400	0.462	0.626	0.999	0.392
Rb	: 0.461	0.457	0.456	0.458	0.464	0.474	0.494	0.546	0.685	0.999	0.485
Abs1	: 0.527	0.532	0.534	0.534	0.529	0.520	0.505	0.461	0.328	0.001	0.500
SHGCc	: 0.262	0.264	0.263	0.262	0.258	0.252	0.239	0.208	0.137	0.000	0.240
Tdw-K	: 0.045										
Tdw-ISO	: 0.100										
Tuv	: 0.001										

Temperature Distribution (degrees C)

	Winter		Summer	
	Out	In	Out	In
Lay1	-10.6	-9.4	43.9	44.2