



A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with CS 60 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 CS 60 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
CS60	5.07	0.428	0.145	0.125	0.492	0.132	0.117	0.88	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.**

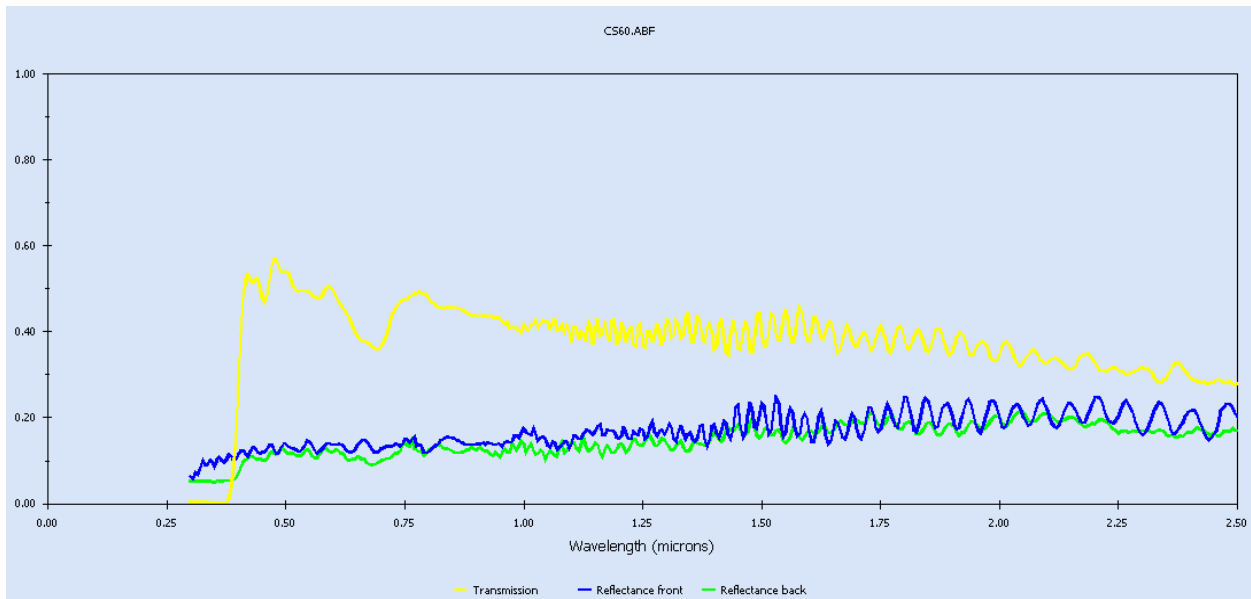
**Table 2: Thermal and optical properties of single glazing unit**

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
CS60	1	5.94	5.39	0.56	0.65	0.49	454	0.003	0.170	0.350

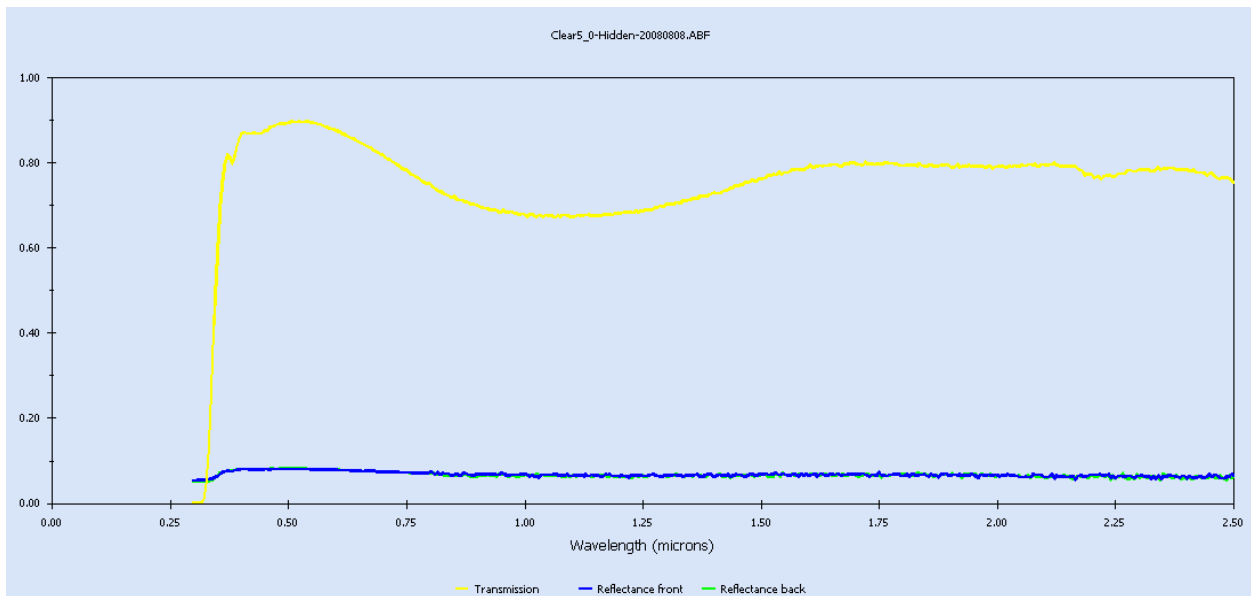
The NFRC standard boundary conditions given below were used for the calculations in Table 2:

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: CS 60**



**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  
14:07:54

ID : 18  
Name : CS60  
Tilt : 90.0  
Glazings: 1  
KEFF : 0.1000  
Width : 5.065  
Uvalue : 5.94  
SHGCc : 0.56  
SCc : 0.65  
Vtc : 0.49  
RHG : 453.63

Glass and Gas Data for Glazing System '18 CS60'

ID	Name	D(mm)	Tsol	1	Rsol	2	Tvis	1	Rvis	2	Tir	1	Emis	2	Keff
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Outside															
	30022FCS60.ABF	#	5.1	.428	.125	.145	.492	.117	.132	.000	.840	.880	.913		
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 '18 CS60'

Angle	0	10	20	30	40	50	60	70	80	90	Hemis
Vtc	: 0.492	0.495	0.489	0.481	0.472	0.455	0.418	0.340	0.205	0.000	0.430
Rf	: 0.117	0.110	0.109	0.112	0.121	0.138	0.171	0.256	0.483	0.999	0.164
Rb	: 0.132	0.125	0.123	0.126	0.136	0.152	0.184	0.268	0.492	0.999	0.177
Tsol	: 0.428	0.431	0.426	0.419	0.411	0.397	0.364	0.296	0.178	0.000	0.374
Rf	: 0.125	0.118	0.117	0.120	0.129	0.146	0.178	0.263	0.488	0.999	0.171
Rb	: 0.145	0.138	0.136	0.139	0.149	0.165	0.196	0.279	0.499	0.999	0.189
Abs1	: 0.446	0.451	0.458	0.462	0.460	0.457	0.458	0.441	0.334	0.001	0.444
SHGCc	: 0.562	0.566	0.563	0.558	0.549	0.534	0.501	0.429	0.277	0.000	0.508
Tdw-K	: 0.170										
Tdw-ISO	: 0.350										
Tuv	: 0.003										

Temperature Distribution (degrees C)

	Winter		Summer	
	Out	In	Out	In
Lay1	-10.1	-8.8	41.5	41.6