

A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with Ornyx Steel 5 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⁻¹. 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 Ornyx Steel 5 applied film

Product Name	Thick-ness	Solar			Visible			Emissivity	
	mm	Tsol	R _f sol	R _b sol	Tvis	R _f vis	R _b vis	Front	Back
Ornyx Steel 5	4.87	0.068	0.243	0.173	0.078	0.227	0.156	0.78	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 ² K	W/m ² K				W/m ²	Tuv	Tdw-K	Tdw-ISO
Ornyx Steel 5	1	5.67	5.10	0.29	0.34	0.08	257	0.000	0.028	0.057

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 ²
1	NFRC 100-2002	21.0	-18.0	24.0	32.0	783

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

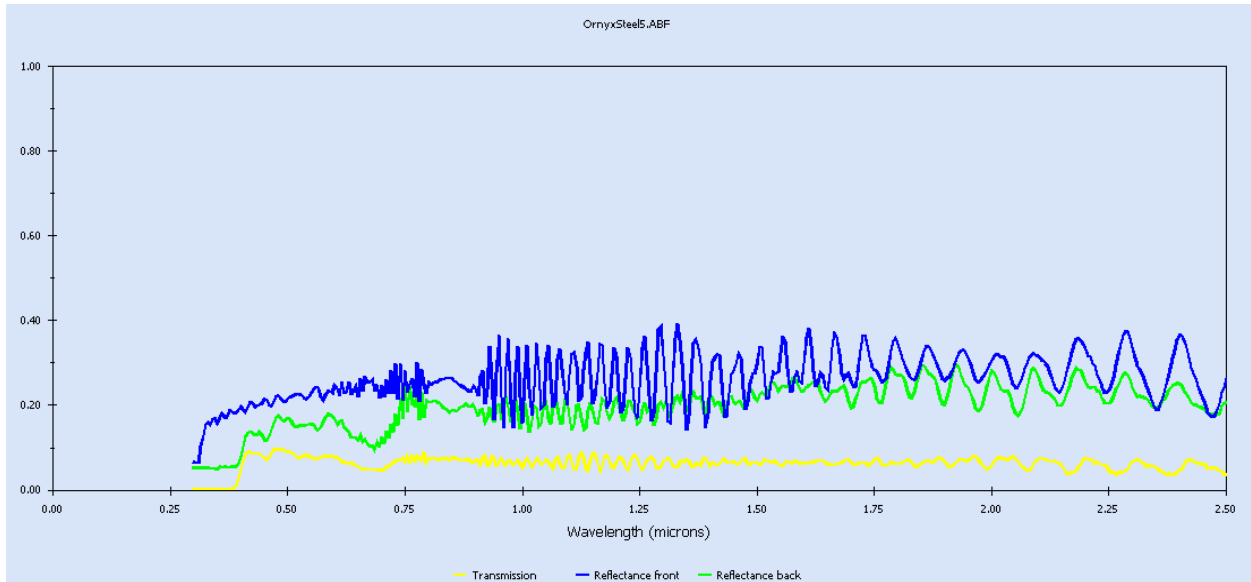


Figure 1: Spectral properties: Ornyx Steel 5

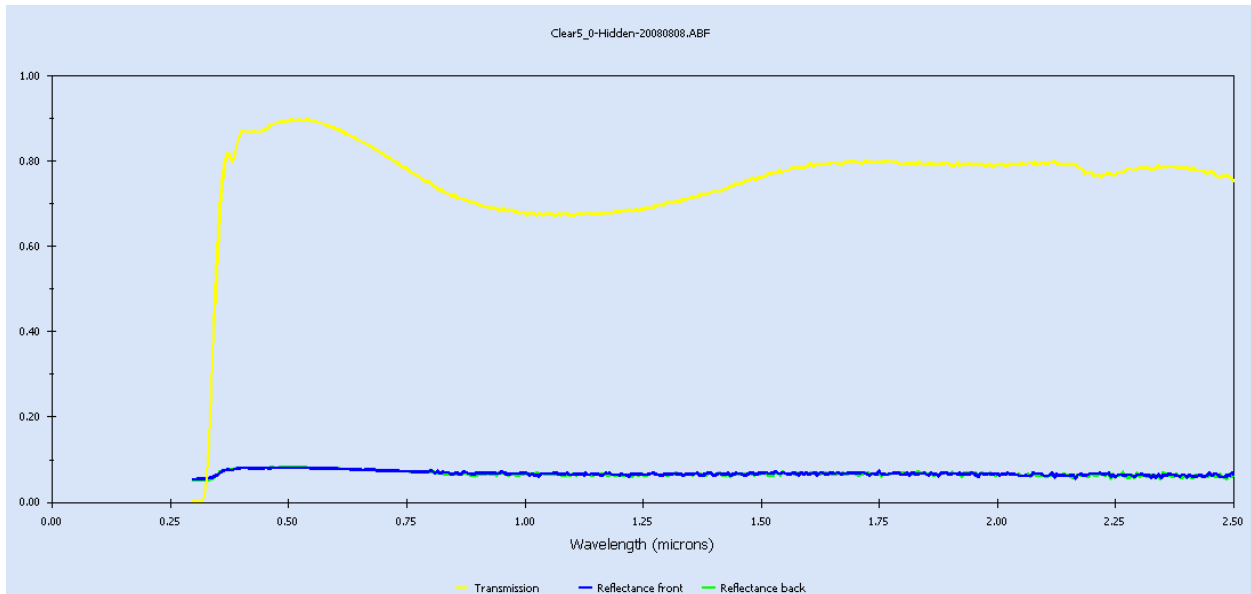


Figure 2: Spectral properties: Reference Glass sample (Substrate)

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 : 15
 Name : Ornyx Steel 5
 Tilt : 90.0
 Glazings: 1
 KEFF : 0.1000
 Width : 4.874
 Uvalue : 5.67
 SHGCc : 0.29
 SCc : 0.34
 Vtc : 0.08
 RHG : 257.05

Glass and Gas Data for Glazing System '15 Ornyx Steel 5'

ID	Name	D(mm)	Tsol	1 Rsol	2 Tvis	1 Rvis	2 Tir	1 Emis	2 Keff			

Outside												
	30006FOrnyxSteel5.ABF#	4.9	.068	.173	.243	.078	.156	.227	.000	.840	.780	.981
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 '15 Ornyx Steel 5'

Angle	0	10	20	30	40	50	60	70	80	90	Hemis
Vtc	: 0.078	0.079	0.078	0.076	0.075	0.072	0.066	0.054	0.033	0.000	0.068
Rf	: 0.156	0.149	0.147	0.150	0.160	0.176	0.207	0.288	0.506	0.999	0.199
Rb	: 0.227	0.221	0.219	0.222	0.231	0.246	0.274	0.349	0.548	0.999	0.266
Tsol	: 0.068	0.069	0.068	0.067	0.066	0.063	0.058	0.047	0.028	0.000	0.060
Rf	: 0.173	0.166	0.164	0.167	0.176	0.192	0.223	0.303	0.516	0.999	0.215
Rb	: 0.243	0.237	0.235	0.238	0.247	0.261	0.289	0.362	0.557	0.999	0.281
Abs1	: 0.759	0.766	0.768	0.766	0.758	0.745	0.719	0.650	0.456	0.001	0.715
SHGCc	: 0.292	0.294	0.294	0.292	0.288	0.282	0.269	0.236	0.158	0.000	0.269
Tdw-K	: 0.028										
Tdw-ISO	: 0.057										
Tuv	: 0.000										

Temperature Distribution (degrees C)

	Winter		Summer	
	Out	In	Out	In
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Lay1	-10.5	-9.4	49.6	50.0