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Report:

Optical Data measurement and performance indices calculation of a glass samples with Ornyx Steel 60 applied film

Report prepared for: ***A & B Films Pte Ltd***
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A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with Ornyx Steel 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 Spectrophometer 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^o and 7^o, 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^o and 7^o, 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 60 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 60	5.07	0.571	0.078	0.085	0.645	0.082	0.098	0.95	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^2K	W/m^2K				W/m^2	Tuv	Tdw-K	Tdw-ISO
Ornyx Steel 60	1	6.14	5.60	0.68	0.78	0.65	537	0.001	0.186	0.420

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/m2
	1	NFRC 100-2002	21.0	-18.0	24.0	32.0	783

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

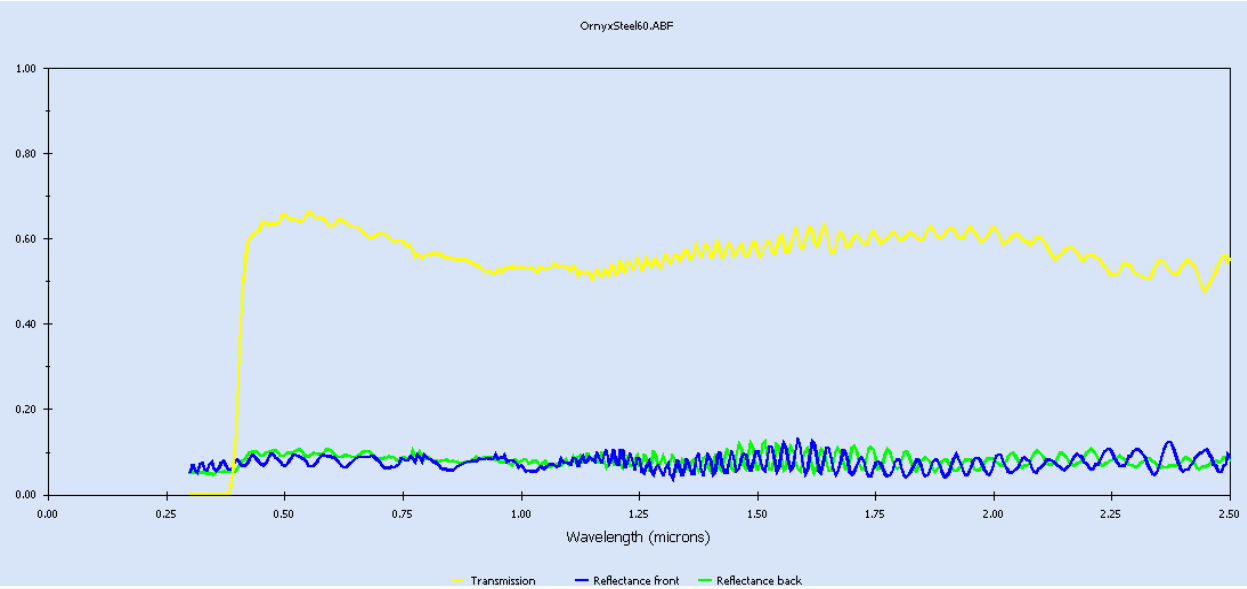

Figure 1: Spectral properties: Ornyx Steel 60

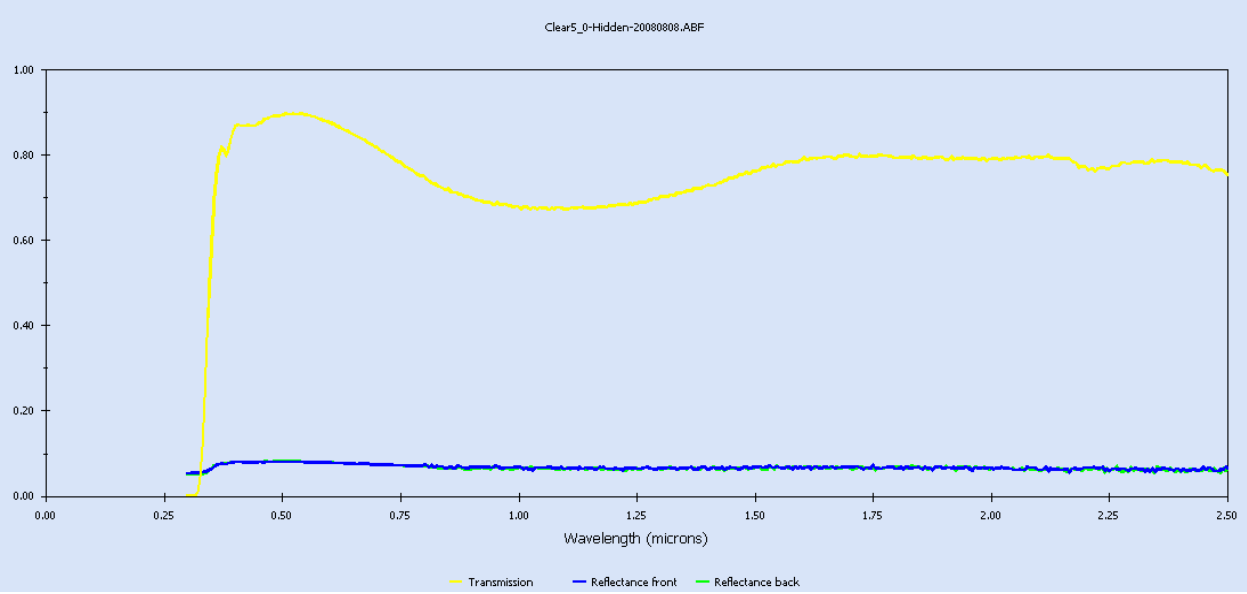

Figure 2: Spectral properties: Reference Glass sample (Substrate)

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

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Window 5.2a  v5.2.17a Glazing System Thermal and Optical Properties 08/12/08
14:03:45

ID      : 17
Name    : Ornyx Steel 60
Tilt    : 90.0
Glazings: 1
KEFF    : 0.1000
Width   : 5.068
Uvalue  : 6.14
SHGCc   : 0.68
SCc     : 0.78
Vtc     : 0.65
RHG     : 0.537.28

Glass and Gas Data for Glazing System '17 Ornyx Steel 60'

ID     Name             D(mm) Tsol  1 Rsol 2 Tvis  1 Rvis 2  Tir  1 Emis 2 Keff
------ ---------------- ----- ---- ---- ---- ---- ---- ---- ---- ---- ---- ----
Outside
 30004FOrnyxSteel60.AB#  5.1 .571 .085 .078 .645 .098 .082 .000 .840 .950 .913
Inside


Environmental Conditions: 1 NFRC 100-2002

          Tout   Tin  WndSpd   Wnd Dir   Solar  Tsky  Esky
          (C)    (C)   (m/s)            (W/m2)  (C)
         -----  ----  ------  --------  ------  ----  ----
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 '17 Ornyx Steel 60'

Angle      0    10    20    30    40    50    60    70    80    90 Hemis

Vtc  : 0.645 0.650 0.641 0.631 0.619 0.598 0.548 0.447 0.269 0.000 0.564
Rf   : 0.098 0.090 0.089 0.092 0.102 0.119 0.152 0.240 0.472 0.999 0.145
Rb   : 0.082 0.074 0.073 0.076 0.086 0.104 0.137 0.226 0.463 0.999 0.130

Tsol : 0.571 0.575 0.568 0.559 0.548 0.529 0.485 0.395 0.238 0.000 0.500
Rf   : 0.085 0.078 0.076 0.079 0.090 0.107 0.141 0.229 0.465 0.999 0.134
Rb   : 0.078 0.071 0.069 0.072 0.083 0.100 0.134 0.224 0.461 0.999 0.127

Abs1 : 0.343 0.347 0.356 0.362 0.362 0.364 0.374 0.375 0.298 0.001 0.356

SHGCc: 0.676 0.681 0.677 0.670 0.659 0.641 0.600 0.511 0.328 0.000 0.609

Tdw-K  :  0.186
Tdw-ISO:  0.420
Tuv    :  0.001


      Temperature Distribution (degrees C)
        Winter         Summer
       Out   In       Out   In
      ----  ----     ----  ----
Lay1  -9.8  -8.5     38.6  38.7
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