



Report:

Optical Data measurement and performance indices calculation of a glass samples with Ornyx Steel 50 applied film

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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 50 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 50 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 50 | 4.87 | 0.440 | 0.110 | 0.109 | 0.532 | 0.105 | 0.125 | 0.91 | 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 50 | 1 | 6.05 | 5.50 | 0.58 | 0.67 | 0.53 | 465 | 0.002 | 0.162 | 0.355 |

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.

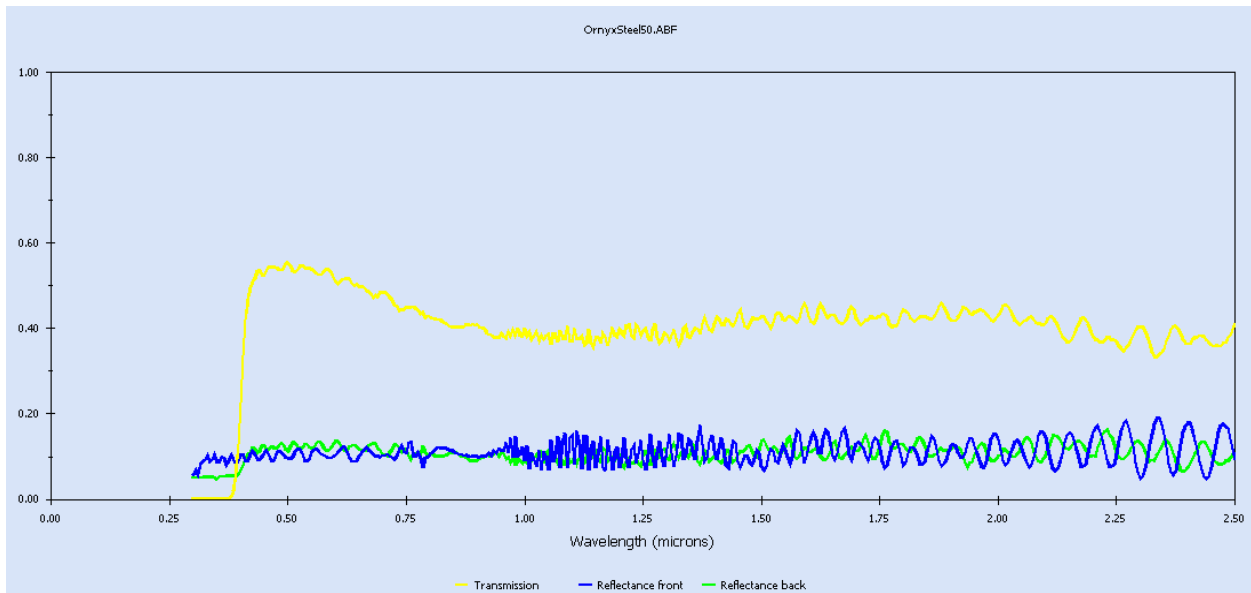


Figure 1: Spectral properties: Ornyx Steel 50

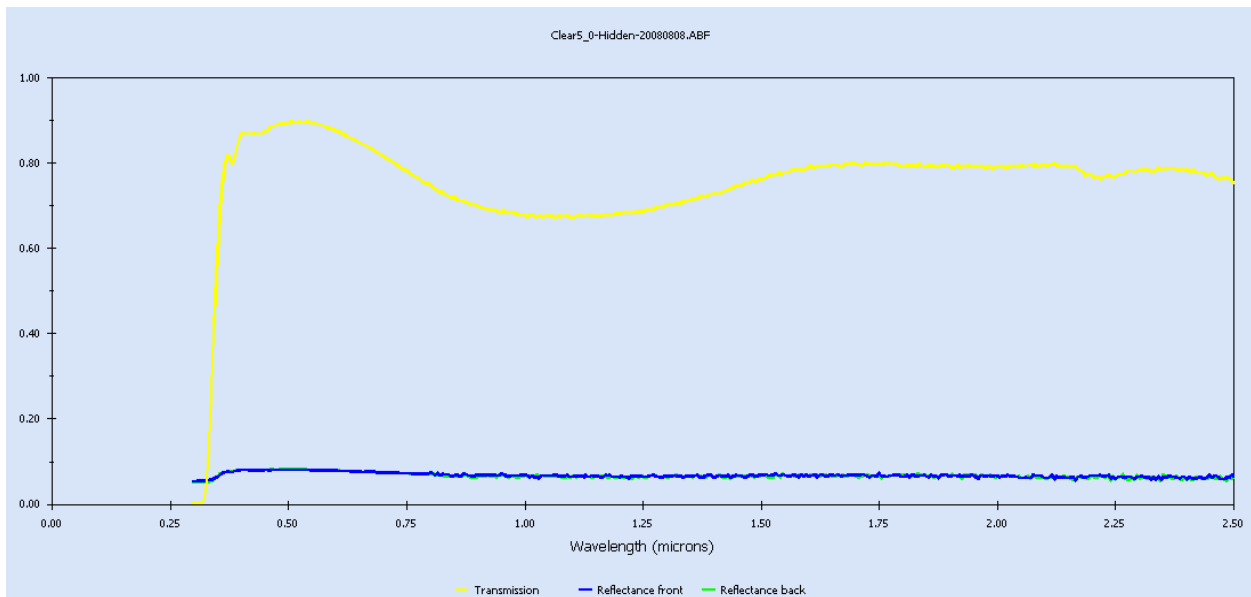


Figure 2: Spectral properties: Reference Glass sample (Substrate)

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
13:45:48

ID : 16
 Name : Ornyx Steel 50
 Tilt : 90.0
 Glazings: 1
 KEFF : 0.1000
 Width : 4.871
 Uvalue : 6.05
 SHGCc : 0.58
 SCc : 0.67
 Vtc : 0.53
 RHG : 465.26

Glass and Gas Data for Glazing System '16 Ornyx Steel 50'

| ID | Name | D(mm) | Tsol | 1 Rsol | 2 Tvis | 1 Rvis | 2 Tir | 1 Emis | 2 Keff | | | |
|---------|------------------------|-------|------|--------|--------|--------|-------|--------|--------|------|------|------|
| Outside | 30005FOrnyxSteel50.AB# | 4.9 | .440 | .109 | .110 | .532 | .125 | .105 | .000 | .840 | .910 | .983 |
| 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 '16 Ornyx Steel 50'

| Angle | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | Hemis |
|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Vtc | : 0.532 | 0.531 | 0.528 | 0.522 | 0.512 | 0.495 | 0.463 | 0.394 | 0.238 | 0.000 | 0.471 |
| Rf | : 0.125 | 0.125 | 0.125 | 0.126 | 0.130 | 0.142 | 0.173 | 0.255 | 0.463 | 1.000 | 0.169 |
| Rb | : 0.105 | 0.125 | 0.125 | 0.126 | 0.130 | 0.142 | 0.173 | 0.255 | 0.463 | 1.000 | 0.169 |
| Tsol | : 0.440 | 0.439 | 0.435 | 0.428 | 0.418 | 0.401 | 0.372 | 0.313 | 0.186 | 0.000 | 0.383 |
| Rf | : 0.109 | 0.112 | 0.112 | 0.113 | 0.117 | 0.129 | 0.161 | 0.242 | 0.449 | 1.000 | 0.157 |
| Rb | : 0.110 | 0.112 | 0.112 | 0.113 | 0.117 | 0.129 | 0.161 | 0.242 | 0.449 | 1.000 | 0.157 |
| Abs1 | : 0.451 | 0.450 | 0.453 | 0.459 | 0.465 | 0.470 | 0.467 | 0.444 | 0.365 | 0.000 | 0.450 |
| SHGCc | : 0.577 | 0.575 | 0.573 | 0.568 | 0.559 | 0.544 | 0.514 | 0.448 | 0.296 | 0.000 | 0.520 |
| Tdw-K | : 0.162 | | | | | | | | | | |
| Tdw-ISO | : 0.355 | | | | | | | | | | |
| Tuv | : 0.002 | | | | | | | | | | |

Temperature Distribution (degrees C)

| | Winter | | Summer | |
|------|--------|------|--------|------|
| | Out | In | Out | In |
| Lay1 | -10.0 | -8.8 | 41.5 | 41.6 |