



A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with Crystal Green 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<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 Crystal Green 50 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 |
| Crystal Green 50 | 4.87       | 0.431 | 0.170              | 0.144              | 0.575   | 0.150              | 0.152              | 0.86       | 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 |
| Crystal Green 50 | 1                | 5.90               | 5.35               | 0.56 | 0.65 | 0.58 | 449                | 0.002      | 0.181 | 0.391   |

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.

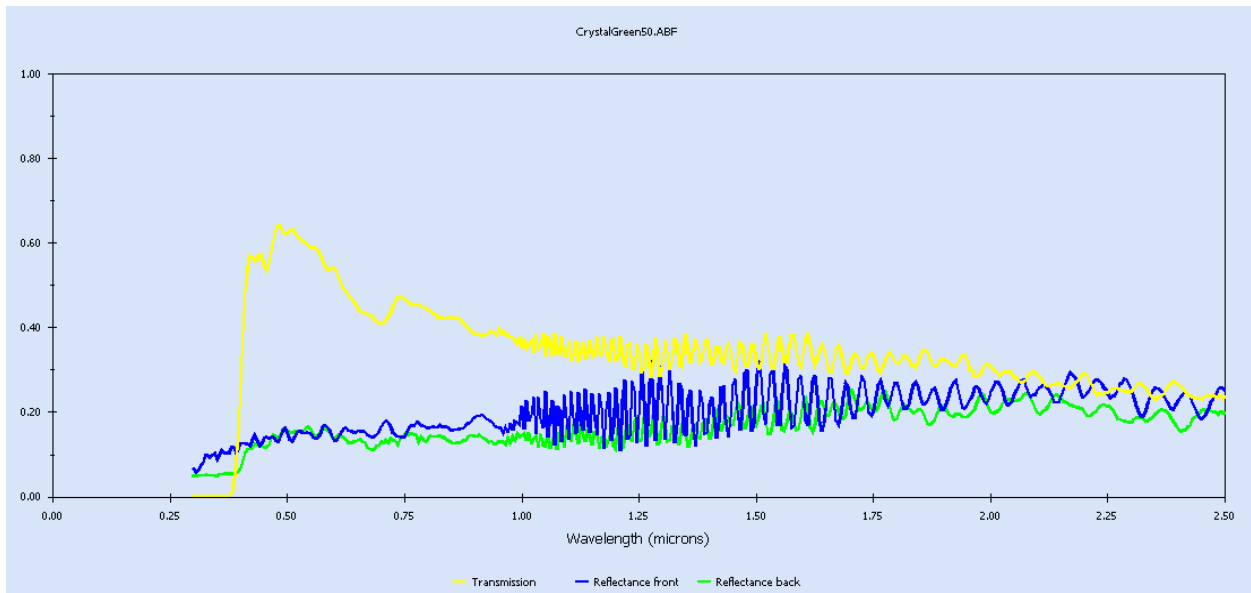


Figure 1: Spectral properties: Crystal Green 50

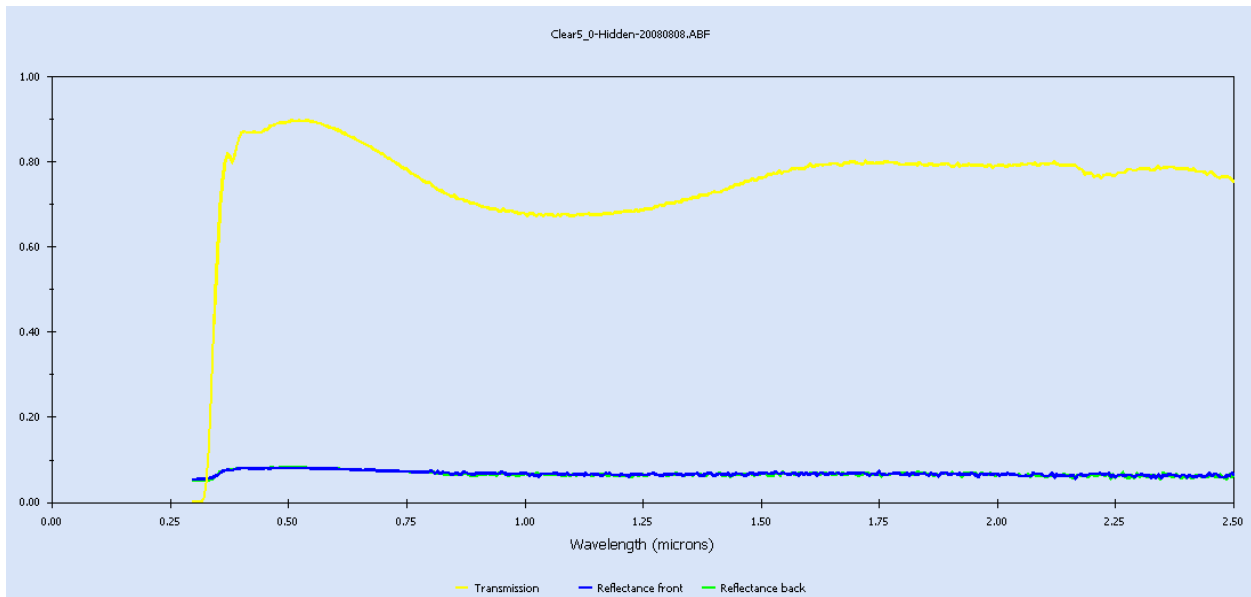


Figure 2: Spectral properties: Reference Glass sample (Substrate)

**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  
11:53:01

ID : 5  
 Name : Crystal Green 50  
 Tilt : 90.0  
 Glazings: 1  
 KEFF : 0.1000  
 Width : 4.871  
 Uvalue : 5.90  
 SHGCc : 0.56  
 SCc : 0.65  
 Vtc : 0.58  
 RHG : 449.27

Glass and Gas Data for Glazing System '5 Crystal Green 50'

| ID      | Name                   | D(mm) | Tsol | 1    | Rsol | 2    | Tvis | 1    | Rvis | 2    | Tir  | 1    | Emis | 2 | Keff |
|---------|------------------------|-------|------|------|------|------|------|------|------|------|------|------|------|---|------|
| -----   |                        |       |      |      |      |      |      |      |      |      |      |      |      |   |      |
| Outside |                        |       |      |      |      |      |      |      |      |      |      |      |      |   |      |
|         | 30023FCrystalGreen50.# | 4.9   | .431 | .144 | .170 | .575 | .152 | .150 | .000 | .840 | .860 | .983 |      |   |      |
| Inside  |                        |       |      |      |      |      |      |      |      |      |      |      |      |   |      |

Environmental Conditions: 1 NFRC 100-2002

|        | Tout<br>(C) | Tin<br>(C) | WndSpd<br>(m/s) | Wnd Dir  | Solar<br>(W/m2) | Tsky<br>(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 '5 Crystal Green 5'

| Angle   | 0       | 10    | 20    | 30    | 40    | 50    | 60    | 70    | 80    | 90    | Hemis |
|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Vtc     | : 0.575 | 0.579 | 0.572 | 0.563 | 0.552 | 0.533 | 0.489 | 0.398 | 0.239 | 0.000 | 0.503 |
| Rf      | : 0.152 | 0.145 | 0.143 | 0.146 | 0.156 | 0.172 | 0.203 | 0.285 | 0.503 | 0.999 | 0.196 |
| Rb      | : 0.150 | 0.143 | 0.141 | 0.144 | 0.154 | 0.170 | 0.201 | 0.284 | 0.502 | 0.999 | 0.194 |
| Tsol    | : 0.431 | 0.434 | 0.428 | 0.422 | 0.414 | 0.399 | 0.366 | 0.298 | 0.179 | 0.000 | 0.377 |
| Rf      | : 0.144 | 0.137 | 0.135 | 0.138 | 0.148 | 0.164 | 0.195 | 0.278 | 0.499 | 0.999 | 0.188 |
| Rb      | : 0.170 | 0.163 | 0.162 | 0.164 | 0.174 | 0.190 | 0.220 | 0.301 | 0.514 | 0.999 | 0.213 |
| Abs1    | : 0.425 | 0.430 | 0.437 | 0.440 | 0.439 | 0.437 | 0.438 | 0.423 | 0.322 | 0.001 | 0.425 |
| SHGCc   | : 0.557 | 0.561 | 0.558 | 0.552 | 0.544 | 0.529 | 0.496 | 0.424 | 0.273 | 0.000 | 0.503 |
| Tdw-K   | : 0.181 |       |       |       |       |       |       |       |       |       |       |
| Tdw-ISO | : 0.391 |       |       |       |       |       |       |       |       |       |       |
| Tuv     | : 0.002 |       |       |       |       |       |       |       |       |       |       |

Temperature Distribution (degrees C)

|      | Winter |      | Summer |      |
|------|--------|------|--------|------|
|      | Out    | In   | Out    | In   |
| Lay1 | -10.1  | -9.0 | 41.0   | 41.1 |