SOLAR & THERMAL 1D ULTRAVIOLET

This Technical Guidance Document outlines the properties and performance of various glass types with regards to the transmittance of incident ultraviolet radiation.

ULTRAVIOLET RADIATION

The region of the electromagnetic spectrum which is covered by ultraviolet (UV) light is divided into 3 bands, UV-C (100 – 280 nm), UV-B (280 – 315 nm) and UV-A (315 – 400 nm). The below chart shows the relative spectral distribution of the UV portion of global solar radiation, incident at the Earth's surface, as per EN 410:2011 [1]. UV-C is absorbed by the atmosphere and the ozone layer, which leaves UV-A and UV-B as the regions of the electromagnetic spectrum under consideration.

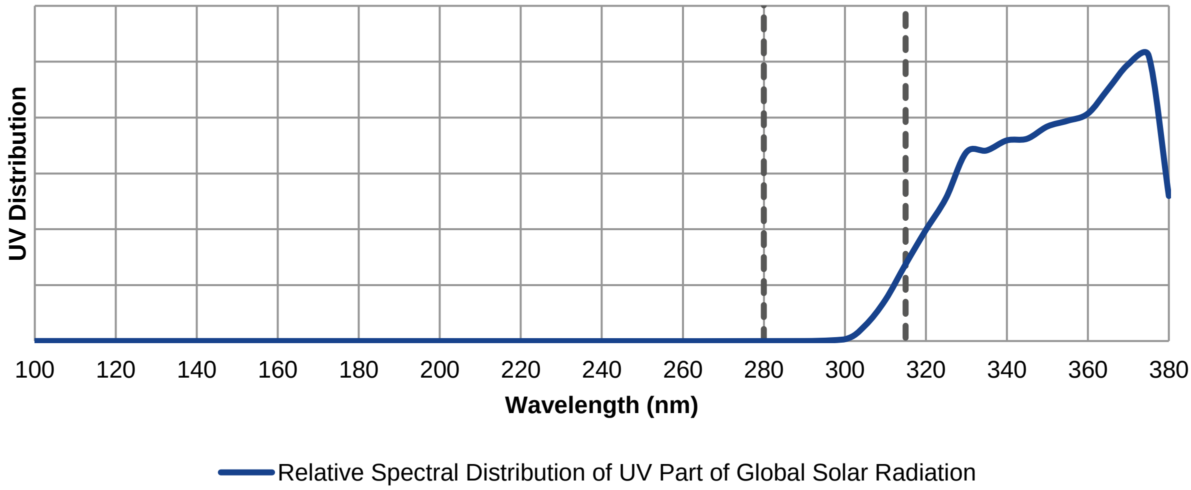


Figure 1 - UV Radiation Distribution

MEASUREMENT OF UV RELATED PERFORMANCE CHARACTERISTICS

Within the EU, measurements of the solar and thermal properties are typically carried out in accordance with EN 410:2011, as required when declaring relevant performance characteristics for the purposes of CE marking.

UV TRANSMITTANCE (EN 410:2011)

Within EN 410:2011, the region between 300 – 380 nm is considered for the assessment of UV transmittance, and based on laboratory measurements of transmittance using UV-vis spectrophotometry, and the distribution of the UV portion of global solar radiation, the UV transmittance can be determined through calculation with the relative spectral distribution of the UV portion of global solar radiation.

SKIN DAMAGE FACTOR

The skin damage factor (SDF) considers the UV portion of global solar radiation which may contribute to solar radiation damage of skin, as well as the erythemal effectiveness spectrum, which is a measure of the response of skin to different wavelengths [2]. Combining the erythemal action spectrum with the distribution of the UV portion of global solar radiation gives the relative spectral distribution factor, as illustrated below.

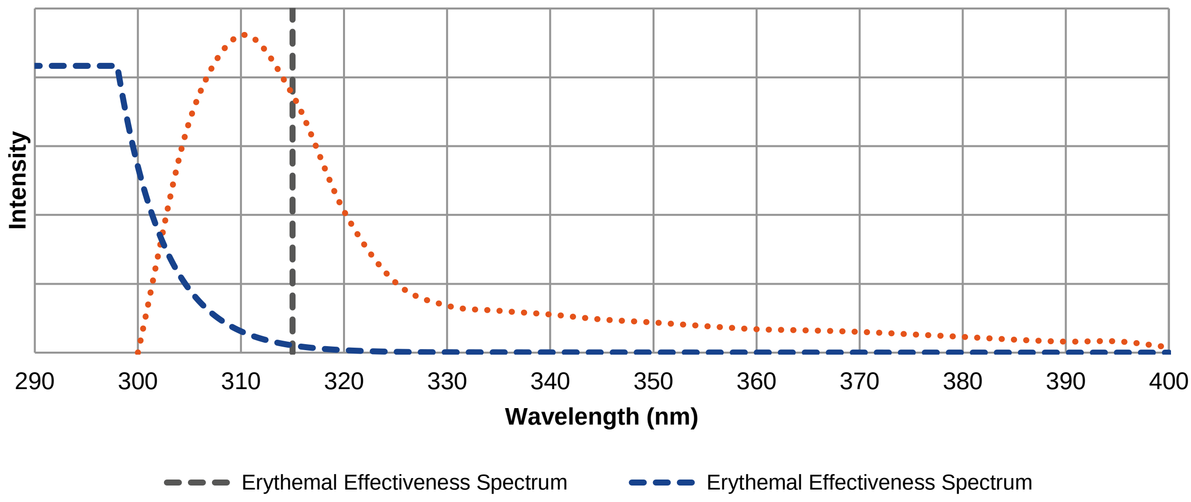
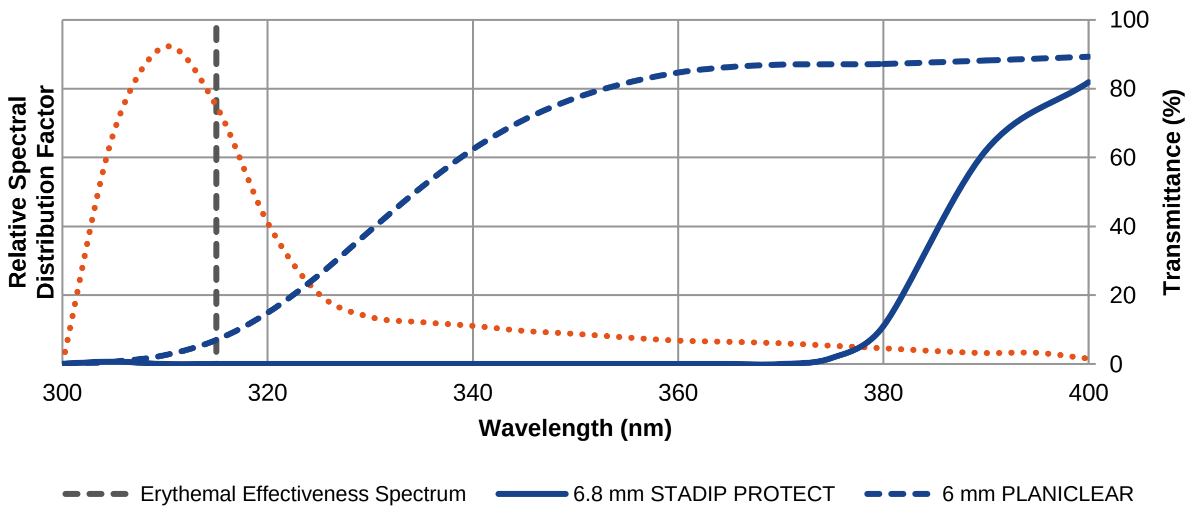


Figure 2 - Erythemal Effectiveness Spectrum

SDF is a single value factor determined through measurement of UV transmittance, with UV-vis spectrophotometry, followed by calculation, as per ISO 9050 [3], to incorporate the CIE erythemal effectiveness spectrum. Spectral data for 6 mm PLANICLEAR and 6.8 mm STADIP PROTECT is shown below;

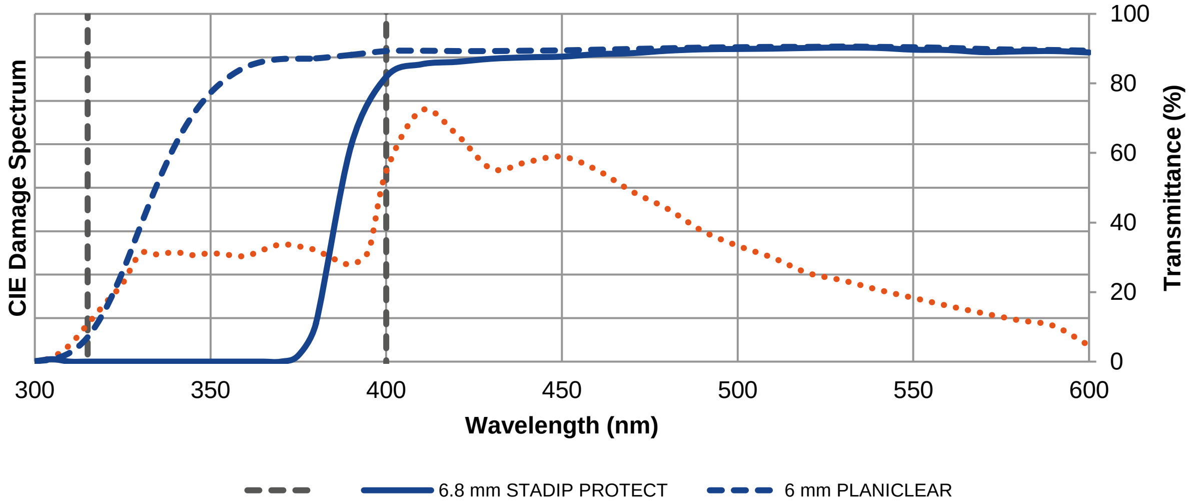


Construction	ISO 9050	
	UV Transmittance (%)	Skin Damage Factor (%)
6 mm PLANICLEAR	70.3	23.4
6.8 mm STADIP PROTECT	0.9	2.2

Figure 3 - Glass Transmittance and Spectral Distribution

CIE DAMAGE FACTOR

The CIE damage factor expands on the UV transmittance by incorporating the regions of the solar radiation spectrum to incorporate wavelengths that can damage materials. This region extends from 300 – 600 nm, and so includes a significant portion of the visible spectrum. Spectral data for 6 mm PLANICLEAR and 6.8 mm STADIP PROTECT is shown below;



Construction	ISO 9050	
	UV Transmittance (%)	CIE Damage Factor (%)
6 mm PLANICLEAR	70.3	82.1
6.8 mm STADIP PROTECT	0.9	57.6

Figure 4 - Glass Transmittance and Spectral Distribution

MUSEUM SPECIFICATIONS

Museums and galleries understandably place an emphasis on the performance of materials with a view to limiting damage to objects and artefacts from incident natural and artificial light.

Commonly, a value of microWatts per lumen (μW/lm) is used to provide a limit of the amount of UV energy from incident visible light. For sensitive materials, this is typically restricted to less than 75 μW/lm, or ideally below 30 μW/lm.

In terms of spectral performance, as measured for EN 410:2011 and ISO 9050:2003, the flowing guidance is often provided [4, 5]; "*For a curve normalised to 100 % at 550 nm, transmission of UV radiation should be less than 1% between 320 – 380 nm and less than 50% at 400 nm.*" Based on these requirements, with high light transmittance glasses, this is more difficult to achieve. The below charts show selected materials, with the red points indicating that transmission at 400 nm is above 50% of transmission at 550 nm, or between 320 – 380 nm, above the 1% relative requirement.

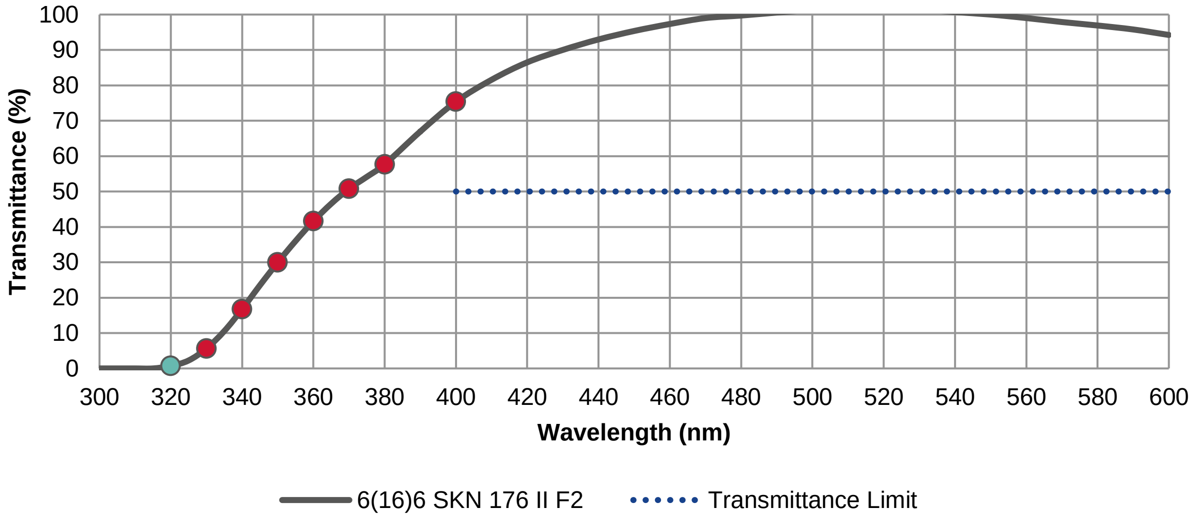


Figure 5 - SKN 176 II Monolithic-Monolithic Configuration & Museum Limits

With the above, the addition of coatings within a double glazed unit makes some difference, albeit relatively insignificant. As many solar control and thermally insulating coatings are typically designed to allow light transmission, reflect solar height and maintain neutrality with regards transmitted and reflected light, the transmittance at lower wavelengths within the visible range can remain relatively high.

The below uses a 6.8 mm SGG STADIP PROTECT in place of the 6 mm SGG PLANICLEAR inner pane, which significantly reduces the UV transmittance, although not sufficiently to meet the above requirements.

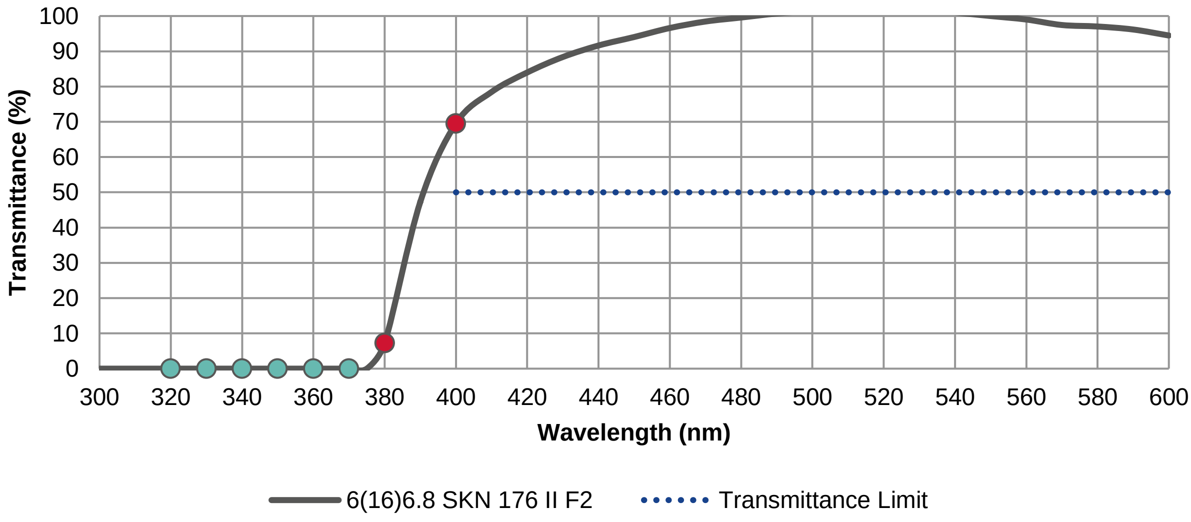


Figure 6 - SKN 176 II Monolithic-Laminated Configuration & Museum Limits

Acrylic materials are sometimes considered as a suitable material for the reduction of incident UV radiation; however, the indicative performance for standard acrylic, shown below, performs in a similar manner to 6.8 mm SGG STADIP PROTECT.

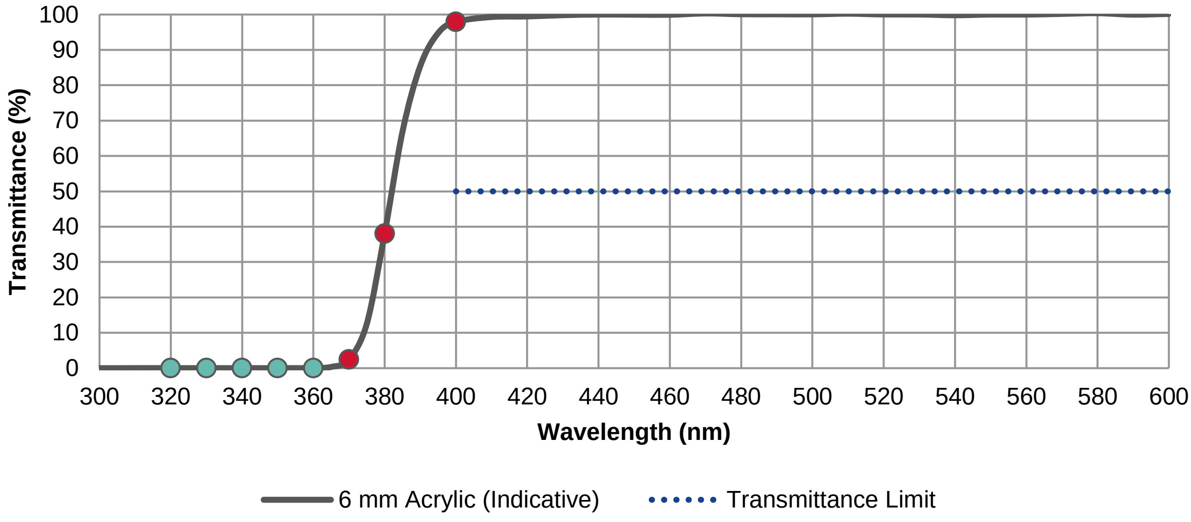


Figure 7 - Acrylic Configuration & Museum Limits

In order to reach the limit, multiple interlayers can be used, alongside solar control coatings, the below configuration using SGG COOL-LITE SKN 176, with a 7.5 mm (33.4) SGG STADIP PROTECT outer pane and a 8.3 mm (33.6) SGG STADIP PROTECT inner pane, will give the following;

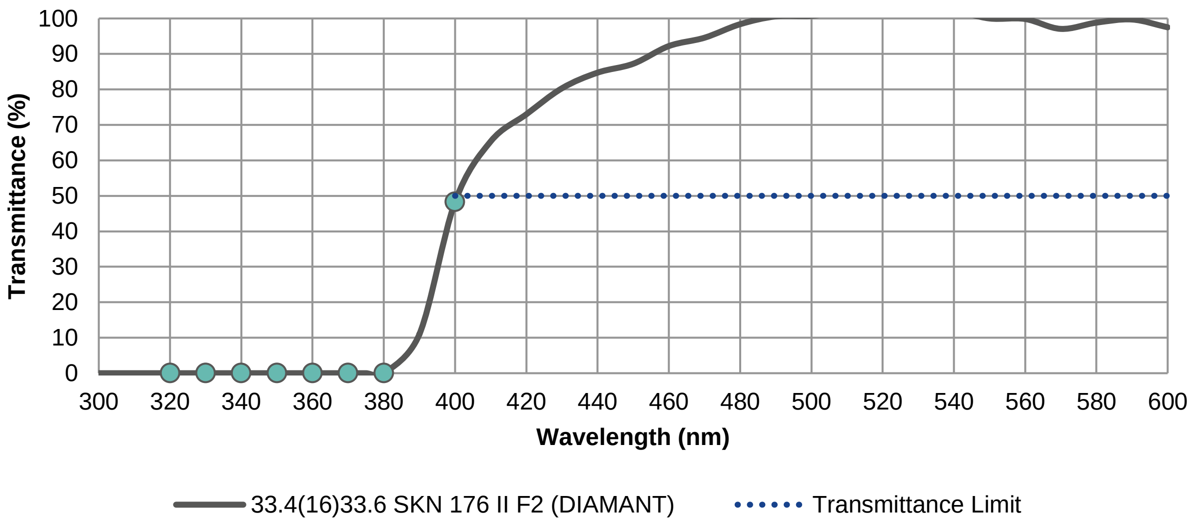


Figure 8 - SKN 176 Laminated-Laminated Configuration & Museum Limits

OTHER CONSIDERATIONS

Alongside the UV limits, colour rendering should also be considered. For naturally lit spaces, the light through the glazing should retain as much neutrality as possible, which makes the applicability of body tinted glasses, coloured interlayers or tinted coatings less certain. Taking the previous example, the following performance criteria are calculated;

Table 1 - SKN 176 Laminated-Laminated Configuration Single Figure Performance Values

Construction	ISO 9050			
	Light Transmittance (%)	UV Transmittance (%)	CIE Damage Factor (%)	Colour Rendering Index
7.5(16)8.3 SKN 176 F2	67.5	0.0	37.2	93.6

REFERENCES

[1] European Committee for Standardization, EN 410:2011 - Glass in building. Determination of luminous and solar characteristics of glazing, CEN, 2011.

[2] A. F. McKinlay and B. L. Diffey, "A reference action spectrum for ultraviolet induced erythema in human skin," *CIE Research Note,* vol. 6, no. 1, pp. 17-22, 1987.

[3] International Organization for Standardization, ISO 9050:2003 - Glass in building - Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors, ISO, 2003.

[4] G. Thomson, The Museum Environment, Elsevier, 2013.

[5] M. Cassar, Environmental Management: Guidelines for Museums and Galleries, Routledge, 2013.