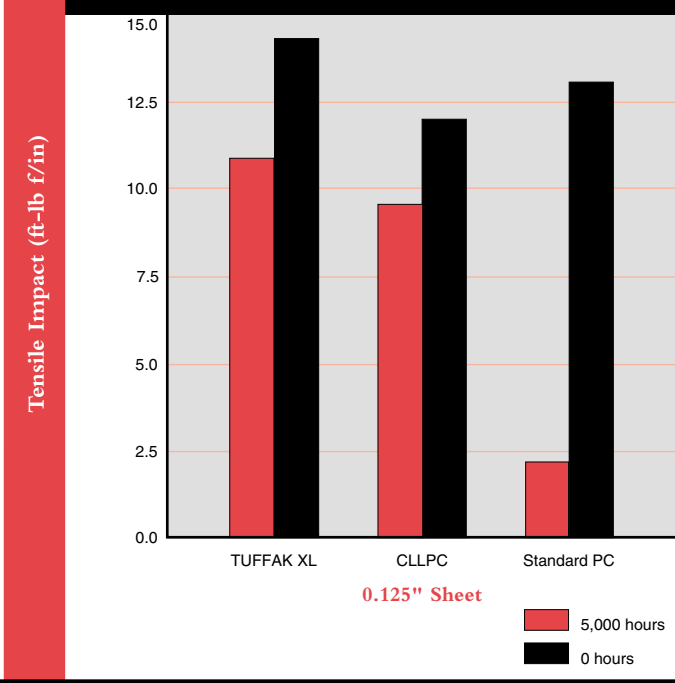


TUFFAK® XL Weatherable Polycarbonate Sheet

FIGURE 1 – TUFFAK XL

Tensile Impact of Aged Sheet – 5,000 hrs Xenon Weather-O-Meter



ARTIFICIAL WEATHERING STUDIES

IMPACT RESISTANCE

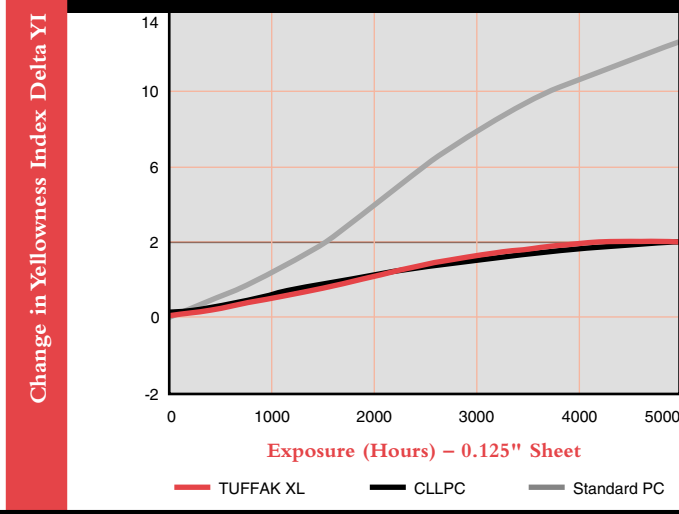
Polycarbonate sheet has long been the material of choice in applications demanding a high degree of impact resistance, such as vandal-resistant glazing and sign faces in high-traffic, high-vandalism areas.

However, the degradative effects of weather and the sun (especially ultraviolet radiation) reduce important impact-resistance properties that prompted the decision to use polycarbonate in the first place.

To evaluate the toughness of Tuffak XL polycarbonate sheet compared with other materials, Atoglas employed *Tensile Impact Testing*. Samples of Tuffak XL polycarbonate, general-purpose polycarbonate and a competitor’s coated UV-resistant polycarbonate sheet were exposed to UV radiation via a Xenon Weather-O-Meter device for 5,000 hours and then subjected to tensile impact testing. Tuffak XL sheet proved to have greater impact-resistance properties than the other materials both before and after the test (Figure 1).

FIGURE 2 – TUFFAK XL

Yellowness Index – Xenon Weather-O-Meter



RESISTANCE TO YELLOWING

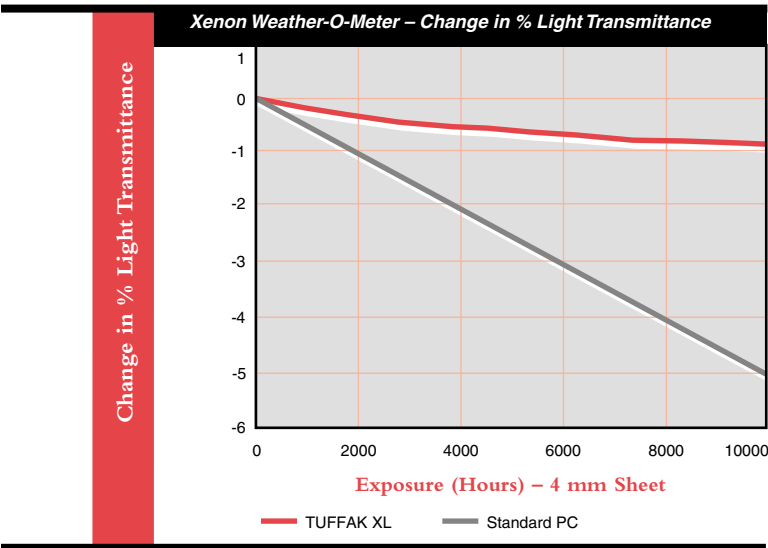
The Xenon Weather-O-Meter’s accelerated weathering effect also shows the changes in a material’s optical properties as it ages under the influence of “weather.”

Increased yellowness in relation to the length of exposure time is a result of the degradative effects of UV radiation. Yellowness Index (YI) is a term used to quantify the perceived yellowness of a material. Generally, the higher the Yellowness Index, the yellower the sample. Yellowness, an undesirable property in most transparent plastic sheet applications, is a particularly severe problem with general-purpose polycarbonate, as shown in Figure 2.

Tuffak XL polycarbonate sheet provides excellent protection against UV-induced yellowing.



FIGURE 3 – TUFFAK XL



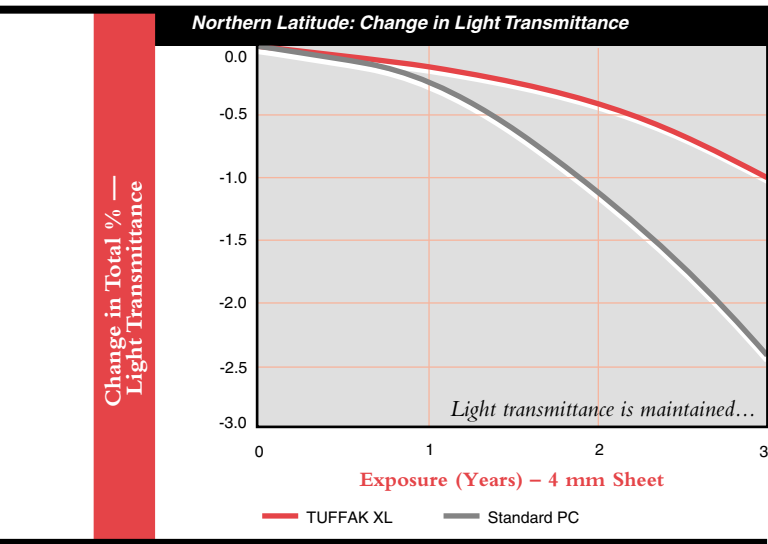
HAZE DEVELOPMENT

(DECREASE IN LIGHT TRANSMITTANCE)

In addition to Yellowness Index, another parameter used to evaluate the weatherability properties of a material is light transmittance. Light transmittance is affected by surface haze and yellowness, which combine to reduce the amount of incident light that can be transmitted through the thickness of the sheet.

As shown in Figure 3, there is a significant reduction in the level of light transmitted through a sheet of standard polycarbonate after it has been exposed to UV radiation. But Tuffak XL polycarbonate sheet maintains its clarity, since surface haze (i.e., “dullness”) and yellowing are held in check by the UV-protective structure.

FIGURE 4 – TUFFAK XL

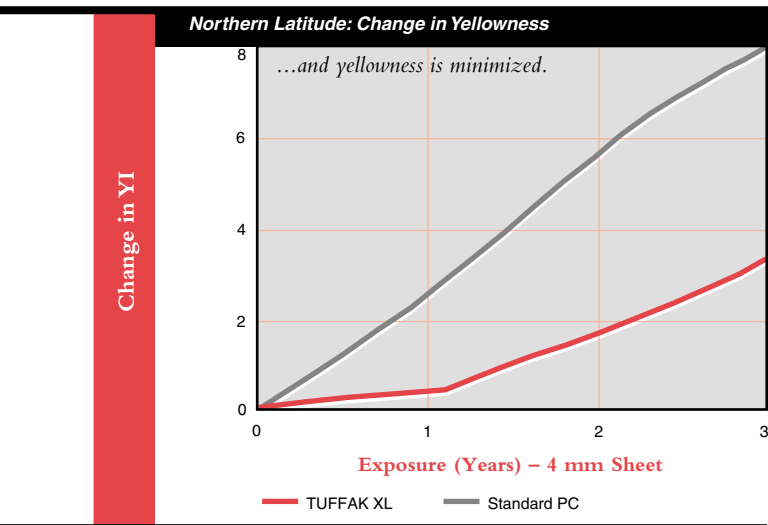


ACTUAL OUTDOOR WEATHERING

YELLOWNESS AND LIGHT TRANSMITTANCE

While accelerated artificial weathering studies provide one means of evaluating the weathering performance of plastics, actual outdoor weathering exposures are, of course, also an important, if slower, source of information. The results of the real-world/real-time weathering studies, as shown in Figures 4 and 5, support the conclusions drawn from the accelerated artificial studies: Tuffak XL polycarbonate exhibits improved UV-resistance performance over general-purpose polycarbonate.

FIGURE 5 – TUFFAK XL

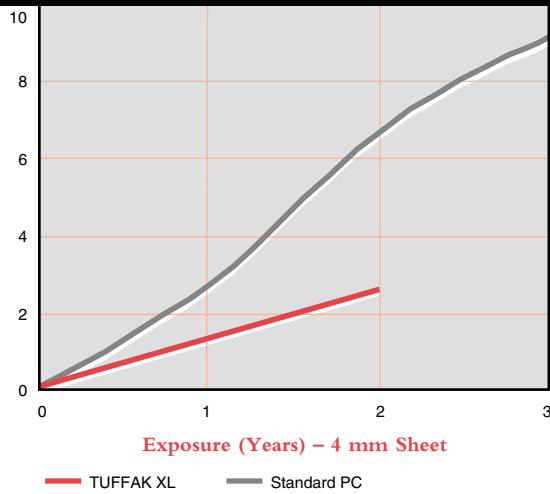


The superior weatherability of Tuffak XL polycarbonate sheet is once again illustrated in these exposure studies conducted in Florida, as depicted in Figures 6 and 7.

FIGURE 6 – OUTDOOR WEATHERING

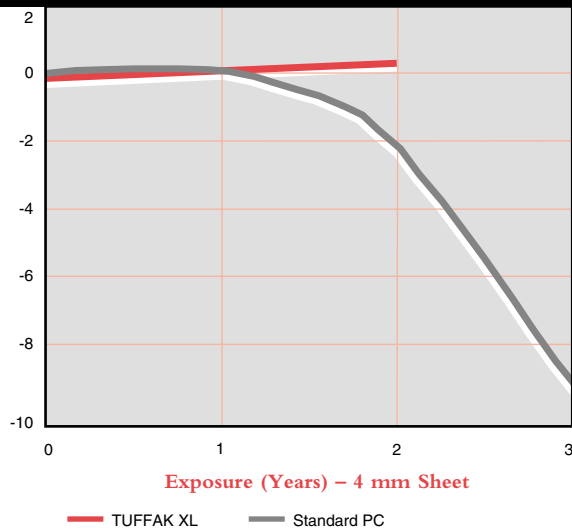
Florida: Change in Yellowness Index

Change in Yellowness Index Delta YI

**FIGURE 7 – OUTDOOR WEATHERING**

Florida: Change in Light Transmittance

Change in % Light Transmittance

**FORMING AND FABRICATING**

Tuffak XL polycarbonate sheet can be thermoformed, cold formed, and brake formed under the same conditions and using the same molds fabricated for use with standard-grade polycarbonate sheet. No special mold surfaces or surface preparations are needed, in contrast to systems required for UV-coated polycarbonate products.

High-temperature (from 370°F to 415°F) thermoforming is required for deep draws or sharp detail. It is critical that Tuffak XL sheet be dried to a moisture level of less than 0.04% before high-temperature forming to avoid formation of moisture bubbles. The sheet should be dried in a 250°F circulating air oven with the time dependent upon sheet thickness. See the Tuffak Forming and Fabrication Manual (ADV980496) for complete details.

Low-temperature (300°F to 350°F) thermoforming is sufficient for simple drape-forming Tuffak XL polycarbonate parts, and pre-drying is not necessary.

Cold forming is used when a retainer frame can be used to hold the Tuffak XL sheet to a shape. To ensure that stresses will not cause crazing, the minimum radius of curvature when cold forming must be $100t$ (where t equals sheet thickness).

Other fabrication and machining techniques, described in the general Tuffak A manuals, fully apply to Tuffak XL polycarbonate sheet applications.

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