SWM

Application Guide

Argotec™ Interlayer Film

Laminated Glass Applications for Argotec™ ST-6050 TPU Interlayer Film

Optical interlayers have been used to laminate layers of glass into clear composites since the 1930s. Typically made from Polyvinyl Butyral (PVB), these interlayers have performed well in a wide variety of glass-to-glass applications, particularly curved automotive windshields. With the evolution of security glass, like glass-to-polycarbonate used in today's bullet-resistant constructions – a NEW interlayer material was needed that could adapt to the varying rates of thermal expansion and contraction between such dissimilar substrates.

In the 1970s, interlayer films made from Thermoplastic Polyurethane (TPU) were introduced to bond these dissimilar materials. SWM has been producing Argotec™ TPU optical interlayers since the early 1980s.

There are a wide variety of end uses for optical interlayers, PVB or TPU, wherever high strength and impact resistance are required:

- Architectural exterior & interior wall safety glass
- Security glass in banks, embassies, correctional facilities & retail store fronts
- Bullet-resistant glass
- Armored vehicles, both commercial & military
- Aerospace canopies & windows
- Hurricane resistant glazing

TPU interlayers possess the most desirable characteristics of both thermoset rubber and a thermoplastic. These characteristics make it ideal for laminating composites that combine dissimilar substrates like glass, polycarbonate, acrylic and other engineered plastics, whether flat or bent.

Laminated glass composites bonded together using optical interlayers can be constructed in a variety of flat and bent configurations. This application guide will cover common options.

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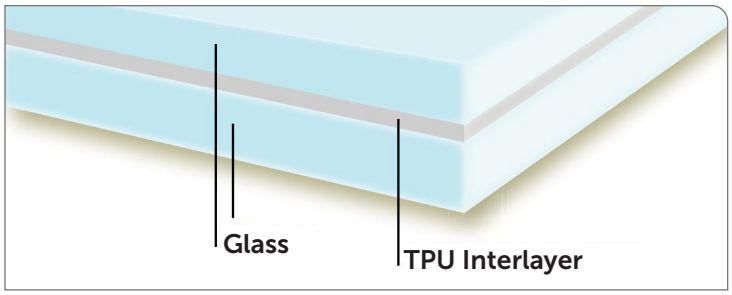
Application Bulletin - Laminate Designs & Constructions

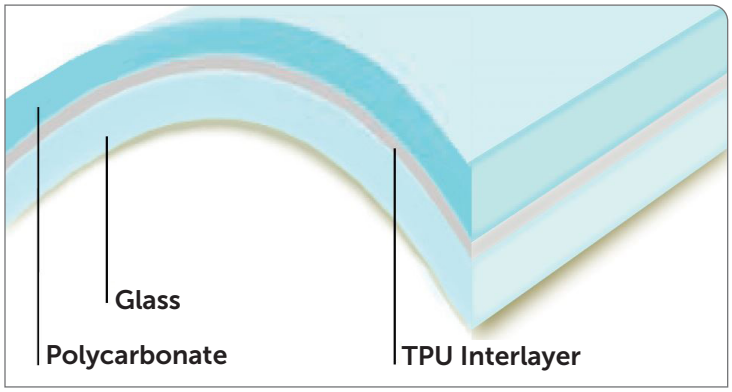
Laminated glass composites bonded together using optical interlayers can be constructed in a variety of flat and bent configurations as highlighted below:



Flat: Glass | TPU Interlayer | Glass

Flat symmetrical compositions are the easiest to laminate.

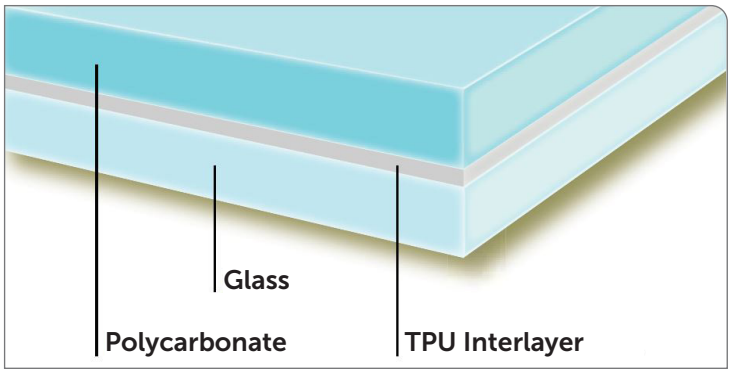
Recommendations:
- Use a minimum of 0.050" (1.25 mm) TPU interlayer between the glass layers
- There are no substrate min/max thickness requirements



Bent: Glass | TPU Interlayer | Polycarbonate

A flat ballistic composition uses polycarbonate as the anti-spall mechanism. As with asymmetric flat glass, stress is induced into the polycarbonate during lamination that can cause breakage of the glass.

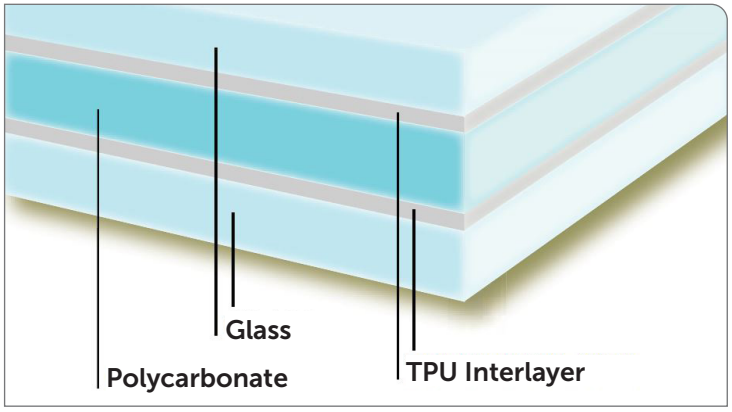
Recommendations:
- Use a minimum of 0.075" (1.9 mm) TPU interlayer between the inboard surface and glass
- Preforming the polycarbonate is recommended to reduce stress, including sheet that is coated one side with a scratch/abrasion-resistant coating; however, the coating must be designed to be formed
- Note that a laminated glass/TPU interlayer/ polycarbonate composition cannot be formed following lamination
- Thin polycarbonate sheet, such as 1/8" (3 mm or less) can be formed during lamination. The polycarbonate is not really "formed;" it is pulled into shape by the vacuum bag and held in place by the adhesion of the TPU interlayer



Flat: Glass | TPU Interlayer | Polycarbonate

Asymmetrical compositions are difficult to laminate. Ballistic compositions use polycarbonate as the anti-spall mechanism. A great deal of stress is induced into the polycarbonate during lamination that can cause breakage of the glass unless the glass is thick enough to withstand the stress. Typically, multiple layers of glass are used to overcome the stress in the polycarbonate.

Recommendations:
- Use a minimum of 0.075" (1.9 mm) TPU interlayer between the polycarbonate and facing glass surface
- Preforming the polycarbonate is recommended to reduce stress



Flat: Glass | TPU Interlayer | Polycarbonate | TPU Interlayer | Glass

Symmetrical compositions are easier to laminate than asymmetrical substrates.

Recommendations:
- Use a minimum of 0.050" (1.25 mm) TPU interlayer between the glass and polycarbonate
- There are no substrate min/max thickness requirements

Additional factors can impact an optical interlayer's ability to bond to a substrate. For instance, there are different types of glass (chemically strengthened, tempered, float, etc.). These may also have additives or coatings that can affect adhesion and performance of the interlayer. Engineered plastic sheet, like polycarbonate, can have varying coatings (i.e., UV-absorbers, coated one or both sides) that can impact interlayer performance.

Interlayer Selection

Interlayer materials should be matched to the specific application requirements which could include:

- Adhesion
- Coefficient of thermal expansion & contraction
- Light transmission
- Ultraviolet resistance
- Color (clear, non-yellowing)
- Haze
- Impact resistance
- Strength
- Operating temperature range

Interlayer Material Selection

PVB: Traditional PVB works well in glass-to-glass and curved interlayer applications. However, it contains plasticizers that can migrate, embrittle and cause fogging around the edges of the composite. Plasticizers can cause variability in optical properties and adhesion. Because they are sensitive to water and other chemicals, PVB interlayers may require an edge seal to preserve the integrity of the laminate. PVB also requires refrigerated storage to prevent blocking. It does not bond well to plastic substrates. Finally, PVB interlayers can de-gas and cause bubbles between the substrates.

TPU: The base TPU polymer is 100% solids and contains no plasticizers. TPU interlayers exhibit excellent adhesion to glass, polycarbonate and polyester (up to 150 pli/26.3 kN/m), as well as the thermal expansion/contraction properties needed for bonding dissimilar materials to glass. TPU has good light transmission, low haze, and possesses high tensile strength (up to 6000 psi/41.4 MPa) for high-impact applications. No distortion (birefringence) is observed on bent-glass laminations. TPU interlayers are interleafed, so no refrigeration is needed during storage or processing.

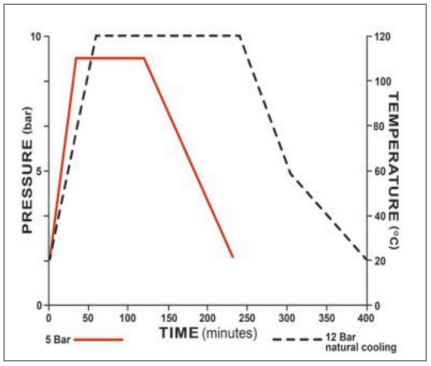
Lamination Processes

A number of processes are employed to create laminated glass composites:

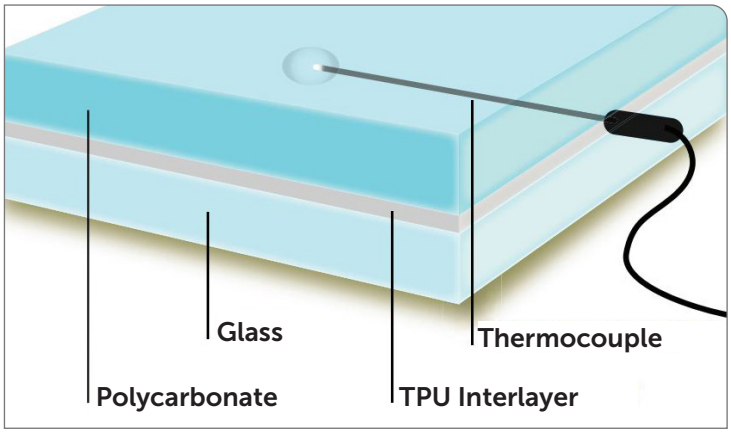
- Autoclave
- Vacuum lamination
- Nip rolls
- Bladder presses

In each of these processes, the substrate preparation is critical to the successful bonding of the layers into a single composite, as is careful control of the process conditions:

- Layup (stacking of the layers)
- Preheat temperature ramp-up
- Pressure
- Press-time, temperature and pressure
- Ramp-down time down (reduction of temperature and pressure) - reference graph to the right and the Autoclave Cycles chart on page 4.



Note: The key temperature reading is at the core of the interlayer and needs to be tracked throughout each cycle.



Core Temperature Readings

A core coupon is a laminate of the same configuration that is placed centrally in the laminating chamber. It has a thermocouple placed in the center of the thickest configuration in the core of the laminate, with the thermocouple passed through the wall of the laminating chamber to a device that will allow constant monitoring of the core temperature. When connected to a recorder it will display the temperature of the TPU interlayer throughout the entire lamination cycle.

Application Bulletin - Product Overview — Argotec ST-6050

Argotec ST-6050 optical interlayer film has been in service for over 25 years. It is a great choice for security glazing applications that combine glass and polycarbonate or other engineered plastic substrates into an impact-resistant composite.

Optically clear ST-6050 is extruded in a clean environment, an 8000 square foot atmospherically controlled, hard-walled white room with each extrusion line housed in its own ISO Class-7 soft-walled clean room.

Camera systems provide 100% inline inspection of films that can detect contamination or inclusions, pin holes, voids, gels, wrinkles and streaks as small as 0.3 mm (0.012"). The result is the cleanest, most optically clear TPU interlayer film in the industry.

General Temperature, Pressure and Time

- Temperature/pressure/time are composition dependent
- As glass thickness increases, the lamination cycle time is increased
- As the number of layers increases, the lamination cycle time is increased
- As polycarbonate thickness increases, the lamination cycle time is increased
- TPU interlayers should not be laminated to a coated polycarbonate surface because delamination may occur

The laminator should perform tests to ensure there is adequate adhesion/cohesion for their application.

Interlayer Sizes

Roll lengths (by gauge & width):

- 0.025"x 40-60"x 40' (0.635x1016-1524mmx12.2m)
- 0.050"x 40-60"x 120' (1.27x1016-3048mmx36.6m)
- 0.075"x 40-60"x 80' (0.635x1016-1524mmx24.4m)

Note: 80" (2032mm) width available upon request.

Available thicknesses:

- 0.015" (0.38mm)
- 0.025" (0.64 mm)
- 0.030" (0.76 mm)
- 0.050" (1.27 mm)
- 0.075" (1.91 mm)

Interlayer Handling Conditions

- Rolls are typically suspended on end plates and individually boxed, then palletized, nine rolls per pallet
- Widths up to 80 inches depending on gauge
- It is best to unwind by pulling the polyethylene interleafing
- Contact the local waste management company for disposal of the interleaf
- Store unused material suspended in the original packaging
- Keep in a cool and dry environment

For more information on Argotec Interlayer Films email us at ams@swmintl.com or visit www.swmintl.com.

Typical Autoclave Lamination Cycles for TPU Interlayers

Note: All of the parameters below are composition and process dependent.

	Time (minutes)	Temperature (F°/C°)	Pressure (psi)
Pull Vacuum	30 minutes prior to application of heat and throughout cycle	72°F (21°C)	Atmospheric = 14.72 psi (1 bar)
Ramp Up	TBD core temperature	72°F to 239°F (21°C to 115°C)	30–180 psi (2-12 bars) composition dependent
Melting Time	15 minutes for every 1/4" (6 mm) of composition thickness	Maximum desired temperature 239°F (115°C)	30–180 psi (2-12 bars) composition dependent
Cool Down	1°F (-17°C) per min at the core if using polycarbonate	Core temperature must be reduced below 125°F (52°C) before pressure is released	30-180 psi (2-12 bars) composition dependent

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