

## ArgoBond®

# SE-381 EVA Interlayer

## For Laminated Switchable and Decorative Glass Applications

### INTRODUCTION

Optical interlayers have been employed to laminate layers of glass into clear composites since the 1930's. Typically made from polyvinyl butyral (PVB), these interlayers have performed well in a wide variety of glass-to-glass applications, particularly curved automotive windshields. Through the evolution of security glass – like glass-to-polycarbonate used in today's bullet resistant constructions, thermoplastic polyurethane (TPU) interlayer materials evolved as the material of choice for those applications due to its ability to accommodate the varying rates of thermal expansion and contraction between such dissimilar substrates.

Now with the growth of decorative and switchable glass markets over the past several years, thermoset ethylene vinyl acetate (EVA) interlayers have gained importance based on their key properties, including high transparency, good strength, long term reliability (heat, humidity and UV durability), low temperature lamination and broad compatibility with other materials and decorative media.

In the late 1970's, interlayers made from thermoset ethylene vinyl acetate (EVA) were introduced as encapsulants to laminate photovoltaic panels, comprising glass laminates containing solar cells. SWM International (formerly Argotec) has been producing ArgoBond® thermoset EVA optical interlayers since 2007.

The purpose of this application bulletin is to provide the prospective user with guidelines on selection, handling and design considerations for **ArgoBond SE-381** thermoset EVA optical interlayer film.

### END USES

Thermoset EVA optical interlayers find applications wherever high transparency, good strength, long term reliability (heat, humidity and UV durability), low temperature lamination and broad compatibility with other materials and decorative media are required, like:

- Switchable glass laminates
- Decorative glass laminates

The low melting point allows the thermoset EVA interlayers to be laminated and simultaneously cured at temperatures which accommodate the low temperature limitations of the switchable film laminates. Uncured or thermoplastic EVA can undergo creep/cold flow in a laminated glass structure at temperatures as low as 35 to 40°C, depending on the vinyl acetate content. Creep/Cold Flow is noted by movement of one glass substrate in respect to the other due to outside forces, i.e. gravity. Thermoset EVA, properly cured during lamination, will not suffer from creep/cold flow at elevated use temperatures.

### LAMINATE DESIGNS/ CONSTRUCTIONS

The following constructions are recommended for switchable and decorative laminated glass configurations:

### Switchable Glass Laminate: Glass/Thermoset EVA Interlayer/Switchable Film/Thermoset EVA Interlayer/Glass (see fig. 1)



Fig. 1. Switchable glass laminate structure

**Recommendations:** Use a minimum of 0.015" (0.38 mm) thermoset EVA interlayer between the glass and switchable film on both the front and back. There are no substrate min/max thickness requirements.

### Decorative Glass Laminate: Glass/Thermoset EVA Interlayer/Decorative Media/Thermoset EVA Interlayer/Glass (see fig. 2)

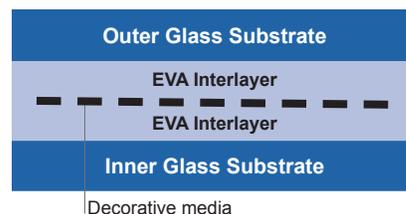


Fig. 2. Decorative glass laminate structure

**Recommendations:** Use a minimum of 0.015" (0.38 mm) thermoset EVA interlayer between the glass and decorative media interfaces. If using a thick decorative media that exceeds 0.015" (0.38 mm) thickness but less than 0.030" (0.76 mm), then the 0.030" (0.76 mm) should be used. In all cases, the EVA layer thickness should be greater than the decorative media being encapsulated or laminated.

## OTHER DESIGN CONSIDERATIONS

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 can have varying coatings (i.e., UV-absorbers, coated one or both sides) that can also impact interlayer performance.

## INTERLAYER SELECTION

Interlayer materials should be matched to the specific application based on:

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

## INTERLAYER MATERIAL COMPARISON

**PVB:** Polyvinyl butyral 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 degas 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 interleaved, so no refrigeration is needed during storage or processing.

**EVA:** Thermoset EVA works well in low temperature lamination applications with low melt viscosity and contains no plasticizers. The high vinyl acetate content of EVA copolymer resins afford a combination of beneficial properties including: good optical clarity and no distortion, low haze, and low melting points. The low melting point allows the thermoset EVA interlayers to be laminated and cured (crosslinked) as low 105°C (221°F), which accommodates the low processing temperature limitations of the switchable film laminates. The low melt viscosity allows for ease of bubble-free or void-free lamination of complex decorative media. The thermoset EVA interlayers bond aggressively to glass, PET and many other substrates. Roll storage is at room temperature; however, direct sunlight should be avoided.

## LAMINATION PROCESSES

Lamination is typically carried out by vacuum bag / autoclave or by vacuum lamination. During lamination, 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)
- Deaeration or evacuation of air lamination is typically carried out by vacuum bag / autoclave or by vacuum lamination. During lamination, the substrate preparation is critical to the successful bonding of the layers into a single composite, as is careful control of the process conditions:
- Preheat temperature ramp-up
- Pressure
- Cure time, temperature and pressure
- Ramp-down time (reduction of temperature and pressure)

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

A core coupon (see fig. 3) 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.

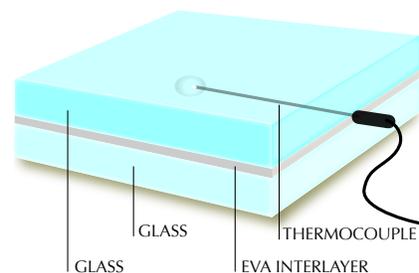


Fig. 3. Core coupon

## GENERAL TEMPERATURE/PRESSURE/TIME GUIDELINES

- Temperature/pressure/time are composition dependent.
- As glass thickness increases, the lamination cycle time is increased.
- The lamination cycle should be verified by adhesion testing to ensure that proper cure has been achieved. Poor adhesion is an indication of insufficient cure during lamination.
- EVA interlayers should be quenched cooled as rapidly as possible to minimize haze formation. Although the EVA cannot be remelted, haze levels can be reduced by heating the laminate to 90°C (194°F) and then cooling the laminate rapidly.
- The lamination cycle should be verified by adhesion testing to ensure that proper cure has been achieved. Poor adhesion is an indication of insufficient cure during lamination.

## SILICONE SEALANT COMPATIBILITY WITH ARGOBOND® SE-381 THERMOSET EVA INTERLAYER

Silicone sealants are frequently used on glass laminates constructed with ArgoBond SE-381 thermoset EVA interlayer. Certain types of silicone sealants can react with the EVA interlayer and cause the interlayer to rapidly discolor. Typically, neutral cure or platinum cure silicone sealants are found to be compatible. Acetoxy cure silicone sealants in general react with the EVA causing rapid discoloration of the interlayer. Verification of a silicone sealant's compatibility with the EVA interlayer is recommended.

## SWM'S ARGOBOND® SE-381 THERMOSET EVA INTERLAYER

ArgoBond SE-381 thermoset EVA interlayer is a great choice for switchable glass and decorative glass laminates. SE-381 is

## RECOMMENDED STARTING POINT LAMINATION CYCLES FOR EVA GLASS INTERLAYERS

### Switchable Glass Lamination

Starting Point Parameters – Vacuum Bag and Autoclave Lamination: Interlayer Temperature and Autoclave Pressure Vs. Time

Process	Time Interval	Temperature	Pressure
Pull vacuum	15 minutes	Room temperature	Atmospheric
Ramp temperature	30 minutes	Room temp to 90°C / 194°F	Pressurize to 10.5 bars
Melt EVA	90 minutes	90°C / 194°F	10.5 bars
Ramp temperature	15 minutes	110°C / 230°F	10.5 bars
Cure EVA	250 minutes	110°C / 230°F	10.5 bars
Cool EVA	Quench cool	110°C / 230°F to ambient	10.5 bars

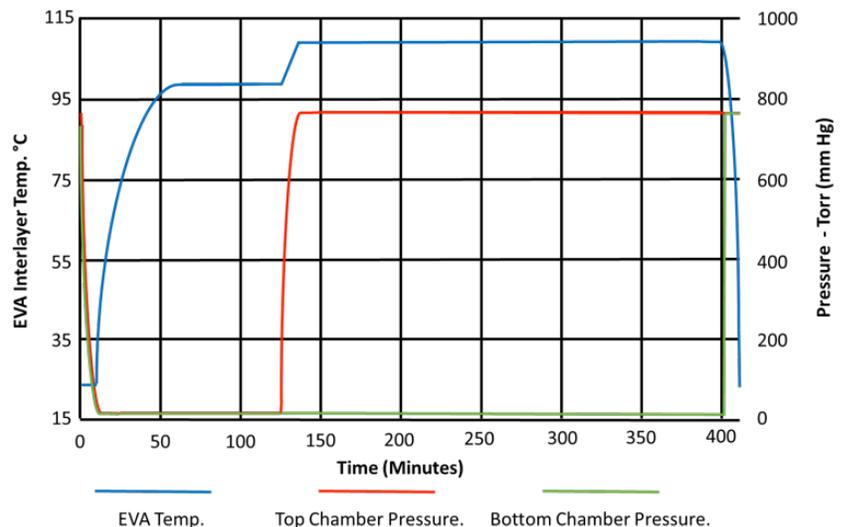
### Decorative Glass Lamination

Starting Point Parameters – Vacuum Bag and Autoclave Lamination: Interlayer Temperature and Autoclave Pressure Vs. Time

Process	Time Interval	Temperature	Pressure
Pull vacuum	15 minutes	Room temperature	Atmospheric
Ramp temperature	30 minutes	Room temp to 90°C / 194°F	Pressurize to 2 bars
Melt EVA	90 minutes	90°C / 194°F	2 bars
Ramp temperature	15 minutes	130°C / 266°F	2 bars
Cure EVA	50 minutes	130°C / 266°F	2 bars
Cool EVA	Quench cool	130°C / 266°F to ambient	2 bars

### Switchable Glass Lamination

Starting Point Parameters – Dual Chamber Vacuum Lamination: Interlayer Temperature and Chamber Pressure Vs. Time



Time	Description
0 minutes	Deaerate the laminate by loading it to the bottom chamber of the laminator, then evacuate the air from the top and bottom chambers at room temperature.
15 minutes	Initiate temperature ramp to 90°C / 194°F while maintaining full vacuum in both chambers.
60 minutes	Melt the EVA under vacuum to remove any volatiles while equilibrating the EVA/laminate temperature to 90°C / 194°F.

Table continues on next page.

extruded in a clean environment with each extrusion line housed in its own ISO Class-7 soft-walled clean room.

Camera systems provide 100% in-line inspection of SE-381 that can detect contamination or inclusions, pin holes, voids, gels, wrinkles and streaks as small as 0.3 mm (0.012 in.). The result is the cleanest, most optically clear EVA interlayer film in the industry.

### INTERLAYER SIZES

- Roll lengths (by gauge & width):

- 0.015" (0.38 mm) x 40-80" (1016-2032 mm) x 400' (122 M) roll

- 0.030" (0.76 mm) x 40-80" (1016-2032 mm) x 200' (61 M) roll

- Available thicknesses:

- 0.150" (0.38 mm)

- 0.030" (0.76 mm)

### INTERLAYER HANDLING CONSIDERATIONS

Rolls are typically hermetically sealed in a foil-lined pouch, suspended on end plates and individually boxed, then palletized, nine rolls per pallet.

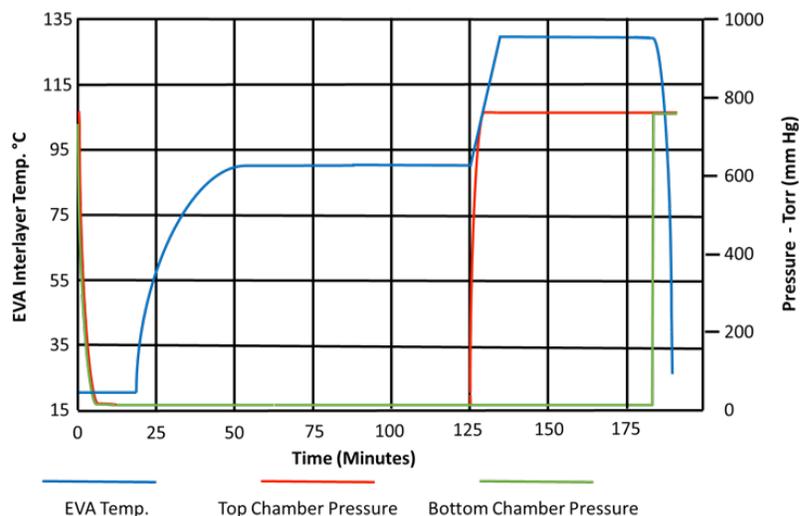
- Widths up to 80-inches (2 meters) depending on gauge.
- It is best to unwind by pulling the polyethylene interleaving.
- Contact the local waste management company for disposal of the interleaf.
- Store unused material in the original packaging, resealed.
- Keep in a cool and dry warehouse.
- Shelf-life is 6 months from the date of manufacture, provided the material remains uncompromised in its original packaging.

For more information on **SE-381**, please visit our web site, [www.swmintl.com](http://www.swmintl.com).

125 minutes	Ramp the EVA/laminate temperature to 110°C / 230°F while simultaneously releasing the top chamber's vacuum returning to 760 mm/1 atmosphere pressure.
135 minutes	Begin the crosslinking/curing of the EVA at 110°C / 230°F for 215 minutes under full vacuum in the bottom chamber, the top chamber remains pressurized.
400 minutes	Cure is complete, begin quench cooling the laminate to room temperature, simultaneously releasing the top chamber's vacuum returning to 760 mm/1 atmosphere pressure.
Note:	The laminate may be removed hot from the laminator to facilitate quench cooling. Rapid/quench cooling is necessary to reduce haze formation. Be sure to handle the laminate with care to avoid disrupting the bonded surfaces.

### Decorative Glass Lamination

Starting Point Parameters – Dual Chamber Vacuum Lamination:  
Interlayer Temperature and Chamber Pressure Vs. Time



Time	Description
0 minutes	Deaerate the laminate by loading it to the bottom chamber of the laminator, then evacuate the air from the top and bottom chambers at room temperature.
15 minutes	Initiate temperature ramp to 90°C / 194° while maintaining full vacuum in both chambers.
60 minutes	Melt the EVA under vacuum to remove any volatiles while equilibrating the EVA/laminate temperature to 90°C / 194°.
125 minutes	Ramp the EVA/laminate temperature to 130°C / 266°F while simultaneously releasing the top chamber's vacuum returning to 760 mm/1 atmosphere pressure.
135 minutes	Begin the crosslinking/curing of the EVA at 130°C / 266°F for 50 minutes under full vacuum in the bottom chamber, top chamber remains pressurized.
185 minutes	Cure is complete, begin quench cooling the laminate to room temperature, simultaneously releasing the top chamber's vacuum returning to 760 mm/1 atmosphere pressure.
Note:	The laminate may be removed hot from the laminator to facilitate quench cooling. Rapid/quench cooling is necessary to reduce haze formation. Be sure to handle the laminate with care to avoid disrupting the bonded surfaces.

**Important:** It should be noted that there can be considerable variability from one lamination device to another. The above processing parameters serve only as a guidance for designing the parameters that are best suited for your laminate configuration and equipment. It is important to understand that the temperature parameters are designed around the EVA interlayer temperature

*Notes continue on next page.*

and not the lamination device's temperature. Validation of the lamination profile is recommended using the core coupon configuration as previously depicted in Figure 3.

The most critical factors for ensuring high quality laminates are deaeration, interlayer cure time, interlayer cure temperature and cooling rate. As you dial in your optimal processing parameters it is critical to ensure that the thermoset EVA interlayer is fully cured. The time and temperature relationship is a logarithmic relationship and must be maintained in accordance with the time and temperatures presented in Table 1 below.

**Table 1** Minimum Soak Time as a Function of EVA Interlayer Cure Temperature

EVA Temperature	Minimum Soak Time @ Temperature
221°F/105°C	330 minutes
230°F/110°C	190 minutes
239°F/115°C	115 minutes
248°F/120°C	65 minutes
257°F/125°C	40 minutes
266°F/130°C	25 minutes
275°F/135°C	15 minutes
284°F/140°C	9 minutes
293°F/145°C	6.5 minutes
302°F/150°C	3.5 minutes

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