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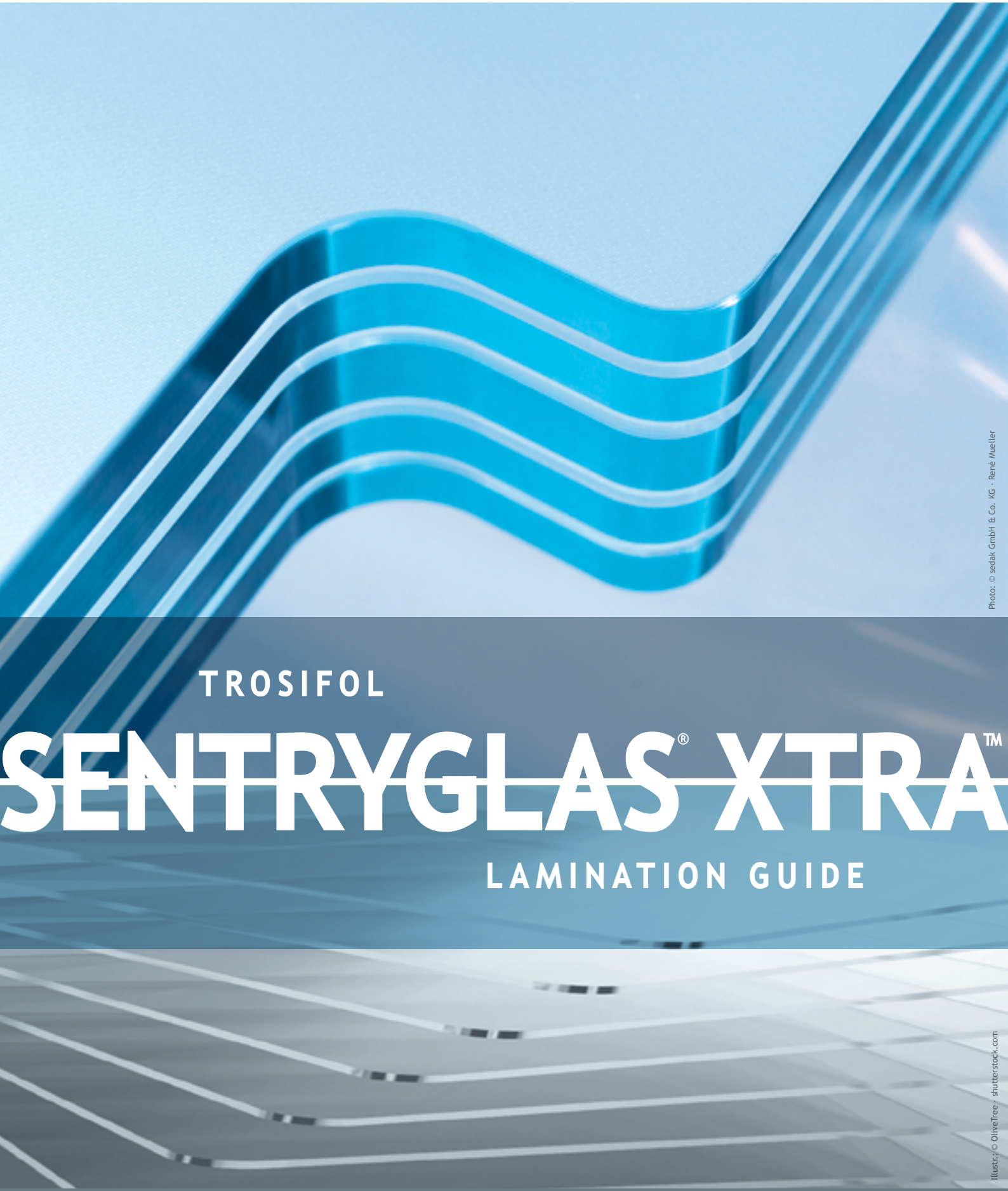

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TROSIFOL

SENTRYGLAS® XTRA™

LAMINATION GUIDE

Illustr.: © OliveTree / shutterstock.com

English

PROCESSING INSTRUCTION

Photo: © Eckersley O'Callaghan

Steve Jobs Theater Pavilion, Cupertino, USA

TROSIFOL™ – YOUR GLOBAL PARTNER FOR LAMINATED SAFETY GLASS

Kuraray's Trosifol™ business is a leading global specialist in the development, manufacture and supply of PVB and ionoplast interlayers for laminated safety glass applications in the architectural, automotive and photovoltaic industries. Following the acquisition of DuPont's Glass Laminating Solutions by Kuraray in 2014, Trosifol®, Sentryglas® and Butacite® product brands are being consolidated into a single brand: the new Trosifol™.

SentryGlas® Xtra™ (SGX™)is the next generation of SentryGlas®. SGX™ has all of the same properties of SentryGlas® but provides increased adhesion to the air side of glass eliminating the need to use a primer. This will make multi-ply lamination easier and less labor intensive. The haze formation is much less sensitive to the autoclave cooling rate reducing the need to re-autoclave laminates when cooling is insufficient. SGX™ is ideal for very thick laminates when achieving adequate cooling rates are a challenge.

This reference guide documents the proper handling methods and processing conditions for SentryGlas® Xtra™ ionoplast interlayer for laminated glass fabrication. The SentryGlas® Xtra™ Interlayer can be laminated using the same equipment traditionally used in the fabrication of PVB laminates. Process changes and equipment modifications beyond the scope of this guide may be needed depending on the capabilities of each individual laminator. For more detailed information on the fabrication of glass laminates with SentryGlas® Xtra™ interlayer, contact your Kuraray account manager or technical representative.

CONTENTS

1.

PRODUCT OFFERING SENTRYGLAS® XTRA™

The table below lists the current (July 2018) Kuraray product offering for SentryGlas® Xtra™ ionoplast interlayer. Please note that SentryGlas® Xtra™ is currently only available in sheet form. The target date for rolls to be available is December 2019.

SentryGlas® Xtra™ Product Offerings

Product	Caliper [mm]	Caliper [mil]	Width [mm]	Width [in]	Length [m]	Length [ft]
SentryGlas® Xtra™	0.89	35	610-2160*	24-85	6	19
SentryGlas® Xtra™	1.52	60	610-2160*	24-85	6	19
SentryGlas® Xtra™	2.28	90	610-2160*	24-85	6	19
SentryGlas® Xtra™	2.53	100	610-2160*	24-85	6	19

* Oversize shipment possible up to 2530 mm (99 inches)

Sheet form

2.

PACKAGING

SentryGlas® Xtra™ is currently only offered in sheet form. The sheets are shipped on a pallet (Figure 1) in hermetically sealed foil bags to protect the interlayer from moisture and contamination. The foil package is encased in cardboard to prevent damage that can occur during shipping.

Figure 1: SentryGlas® interlayer Sheet Package on Pallet

HANDLING & STORAGE

3.

Unopened sheeting require no temperature control for storage because SentryGlas® Xtra™ does not “block” like PVB does. SentryGlas® Xtra™ interlayer sheeting maintains its properties and overall quality consistency for many years under moisture proof storage conditions. Since moisture pick up over time can lead to deterioration in glass adhesion performance, it is recommended that SentryGlas® Xtra™ interlayer sheets in unopened packages be tested for moisture level and post-lamination adhesion performance if the product is stored beyond three years from its original manufacturing date.

SentryGlas® Xtra™ will however, absorb water when *opened* packages are exposed to ambient conditions. While the water absorption rate is very slow compared to PVB, water absorption of SentryGlas® Xtra™ will adversely affect adhesion. It is recommended that the interlayer not be used if the moisture exceeds 0.2% (when measured by Karl Fischer titration). Figure 2, 3 and 4 are the graphs showing water absorption rate our three calipers exposed to 27%, 50% and 75% relative humidities respectively. Upon opening, all packages of SentryGlas® Xtra™ need to be properly resealed.

SentryGlas® Xtra™ KF Moisture Uptake at 27% RH

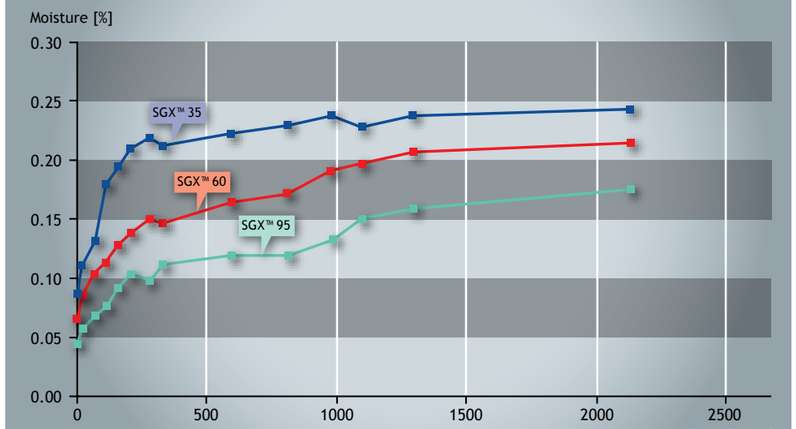


Figure 2

SentryGlas® Xtra™ KF Moisture Uptake at 50% RH

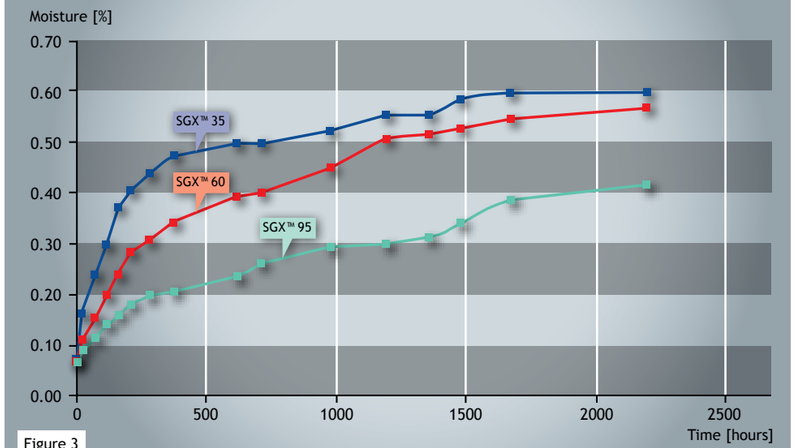


Figure 3

SentryGlas® Xtra™ KF Moisture Uptake at 75% RH

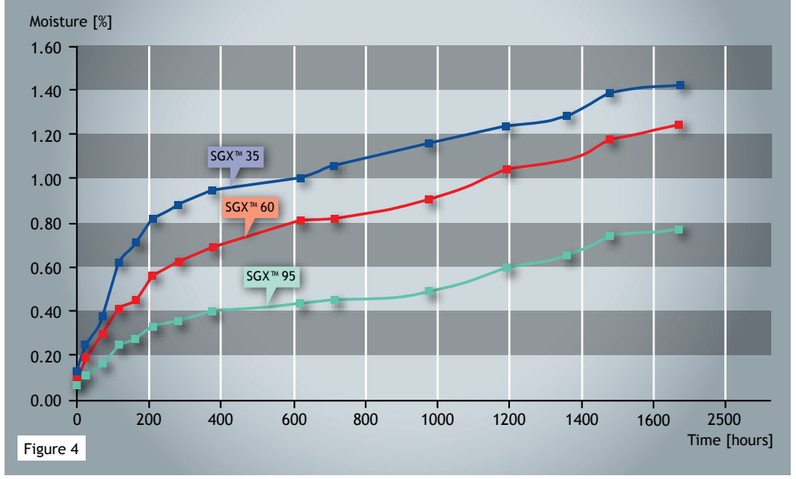


Figure 4

The recommended procedures for storing and handling of SentryGlas® Xtra™ interlayer differ for sheets. SentryGlas® Xtra™ interlayer sheets are packaged horizontally in stacks that are wrapped in a moisture resistant foil packaging film and shipped on pallets. Cardboard is used to both support the package and minimize sheet deformation. The packages should be stored so that the sheets do not become deformed which could impact lamination. Heavy loads placed on SentryGlas® Xtra™ interlayer sheet stacks can deform the sheets through the packaging foil. The protective cardboard top layer should always be as the barrier between stacks. Product pallets can be double stacked on one another, up to 5 pallets, provided that the stack top surfaces are supported with the cardboard flat to prevent pallet runner boards from imprinting product sheets through the foil packaging.

The use of overhead racks (see Figure 5) is a good alternative to stacking pallets on the floor since it minimizes sheet deformation while reducing the overall storage footprint. The recommend procedure for opening the foil packaging, removing sheets and then resealing it is:

- 1. Use a utility knife or scissors to trim off the excess foil just inside the heat sealed line (see red arrow in figure 6) leaving as much excess foil as possible for resealing.
- 2. Using lint free gloves, remove the top sheet by lightly “wafting” it once prior to pulling it out of the bag. This process forces air underneath the sheet allowing for easy removal.
- 3. Close the bag and fold over the excess foil. Seal the entire seam to the bulk of the package using either a medium tack tape (see Figure 7) or a heat gun.

Resealed packages can be stored in either a humidity-controlled environment or under ambient conditions. If there is a concern regarding the moisture level of an opened package please contact your Kuraray sales or technical representative prior to use.

Figure 5: Overhead Storage Racks

Figure 6: Heat Sealed Line in Foil Packaging

Figure 7: SentryGlas® interlayer Package – Properly Resealed with Tape

CUTTING & TRIMMING

The SentryGlas® Xtra™ interlayer sheeting needs to be properly sized prior to lay-up if not purchased cut-to-size. The recommended methods for sizing involve using a shear cutter or an automated table cutter, since these minimize the cutting debris compared to other methods such as sawing. Since the sheeting has excellent dimensional stability, it can be cut to nominal glass dimensions and post-assembly trimming may not be required.

Six typical methods used to cut SentryGlas® Xtra™

- 1. Shear type guillotine
- 2. Static automated table cutters (e. g. Eastman)
- 3. Utility knife: Score → Fold over → Tear
- 4. Die cut
- 5. Machine score then snap out
- 6. Size with a Rosenthal or similar sheeter (35-mil sheeting only)

For initial trials, the most straightforward and economical method to cut SentryGlas® Xtra™ is to use a utility knife. The recommended procedure for this method is detailed below.

- 1. Use a template to ensure the interlayer is cut to the proper dimensions. If laminating a curved or irregular shape surface (like a sidelite) an unbent sidelite or glass lite works very well. Trace the template with a utility knife or a razor cutter leaving a light score mark (Figure 8).
- 2. Fold the sheet along the entire scored perimeter.
- 3. Tear/snap-out along the scored boundary (figure 9).
- 4. Remove any debris using a Tek Nek roller or a lintless wipe.

The use of a saw is not a recommended method for sizing the interlayer unless the cuts can be made with little or no edge debris.

Figure 8: Cutting SentryGlas® Xtra™: Score Pattern Using a Utility Knife

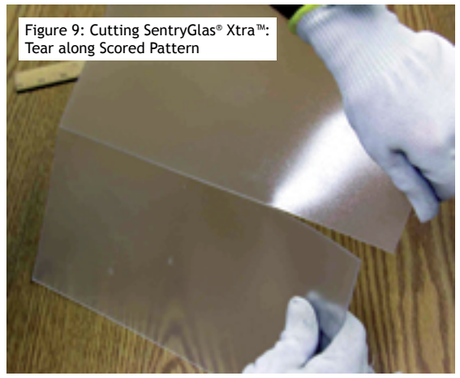


Figure 9: Cutting SentryGlas® Xtra™: Tear along Scored Pattern

CLEANING

SentryGlas® Xtra™ interlayer sheets are delivered clean but they are electrostatic. This can result in surface contamination if not cleaned during lay-up. Prior to assembly a final cleaning step is recommended especially if the sheets are cut or trimmed. Cleaning can be done by using one of the following methods:

- 1. Contact tacky roller (e.g. Tek Nek or SDI (see Figure 10). Ensure that when purchasing the tacky rollers and cleaning pads that they are silicone free.
- 2. Ionized air
- 3. Lintless wipes

Use of a glass washer for cleaning SentryGlas® Xtra™ is not recommended.
If the interlayer is cut using a saw (not recommended), it may be necessary to remove sheet shavings using a glass washer. If a glass washer is necessary, the following details are suggested:

- Do not use detergent.
- Use de-ionized (DI) water.
- Ensure water temperature is kept below 100 °F (38 °C). The use of hot water increases the potential for sheets to get caught in the glass washer.

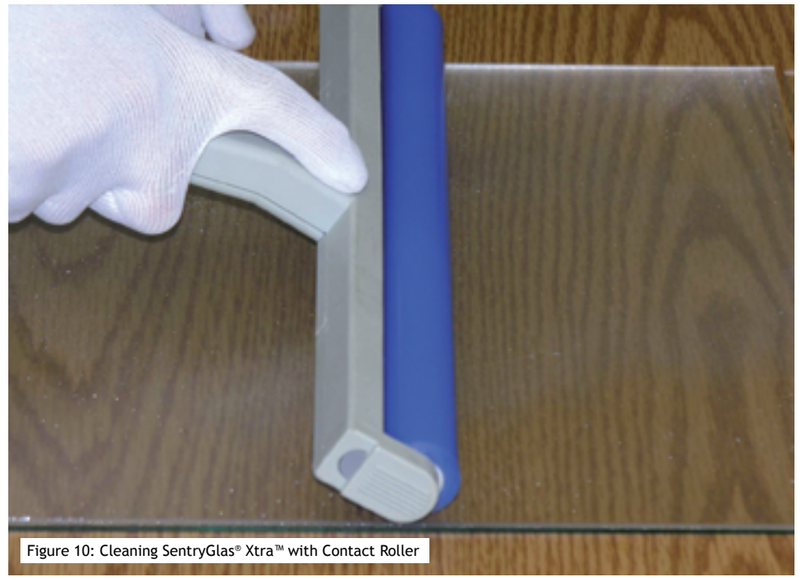


Figure 10: Cleaning SentryGlas® Xtra™ with Contact Roller

6. GLASS WASHING

The recommended method for cleaning the glass is to wash with detergent and rinse the lites with de-mineralized or de-ionized water. The use of unfiltered (hard) water or simple ion exchange (soft) water to clean the glass is not recommended since it may lower the laminate's adhesion. Excellent results have been obtained using various commercial grade detergents such as Basic H; however, the effect of specific detergents on the adhesion of SentryGlas® Xtra™ has not been detailed. Each detergent should be evaluated prior to routine production. Good adhesion can also be obtained without the use of detergent but the temperature of the wash water should be > 130°F to ensure the best results.

7. ASSEMBLY

Before assembly, ensure that the glass is dry. SentryGlas® Xtra™ can be laminated with high adhesion to either the tinside or the airside of the glass. No adhesion promoter is needed and one should not be used. SentryGlas® Xtra™ does not tack to the glass at lay-up. This makes glass repositioning easy; however, there is an increased potential for glass slippage.

8. ROLLER PROCESS

Glass lamination requires a de-airing step to remove the air at the glass/interlayer interface. De-airing can be accomplished with either a roller press (single or double nip) or using a vacuum process. The embossed sandblasted surface pattern of the SentryGlas® Xtra™ facilitates the de- airing process before adherence to the glass occurs.

Due to variations in equipment, the optimum temperatures and nip roll settings can be different for each laminator. Line speeds will depend on the temperature of the laminates during the process and the laminate appearance upon exiting the furnace. The laminate temperature will depend on many factors such as glass thickness, glass coating, oven type, and oven settings. Line conditions, such as power output and wavelength, can vary greatly for an IR furnace compared to a convective furnace. Although wavelength dependant, SentryGlas® Xtra™ interlayer absorbs IR radiation much better than glass (see Figure 11???) thus line speeds are faster than processing using a convective line. The following guidelines are recommended for the initial lamination of SentryGlas® Xtra™.

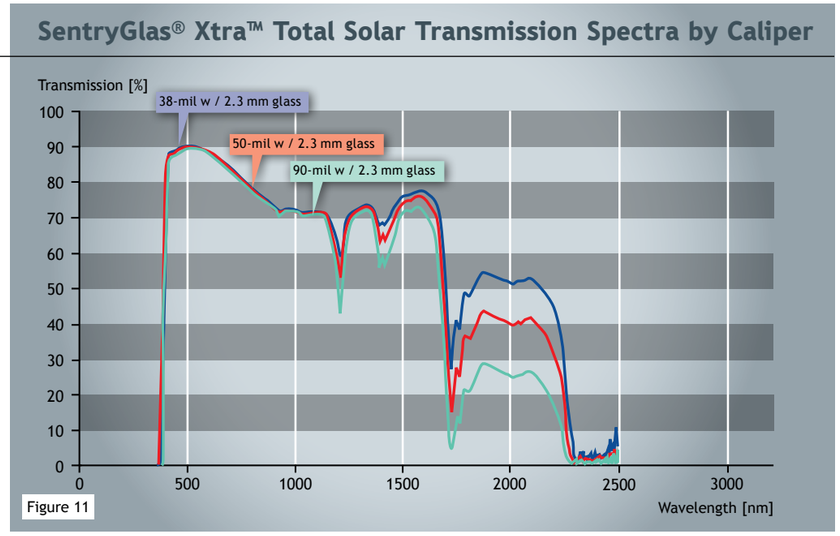


Figure 11

Adjustments to these parameters may be needed to attain the highest quality pre-press::

- Laminate temperature exiting last roller: 145 ± 15°F (63 ± 8°C). Speed should be set to obtain the desired last roller exit temperature, which is based on prepress appearance. The optimum prepress should have a well-defined edge seal (clear along the entire perimeter).
- The prepress appearance for laminates made with IR nip roll lines should have a minimum of 0.75" clear edge seal around the entire perimeter (2 cm). While the outside of edge of the laminate should be clear the interior will likely still be hazy (translucent) after prepressing due to residual surface pattern (see Figure 12). The optimum prepress temperature will be at the lower end of the recommended range.
- Convective furnaces tend to operate from the middle to upper range for the recommended glass temperature. The overall appearance will be mostly clear (see Figure 13).
- If a line of trapped air bubbles can be seen at the trailing edge of the prepress made on either a convective or IR line the laminate was most likely made at too high of a temperature resulting in a premature edge seal (see Figure 14).
- Roller pressure and opening:
  - 0.125" (3-mm) less than total laminate thickness for annealed glass.
  - Decreasing the nip gap maybe necessary if using heat strengthened glass that contains roller wave.
  - Air pressure to the nip rolls should be 75-psi or greater.
  - Open up first nips if any glass slippage occurs.

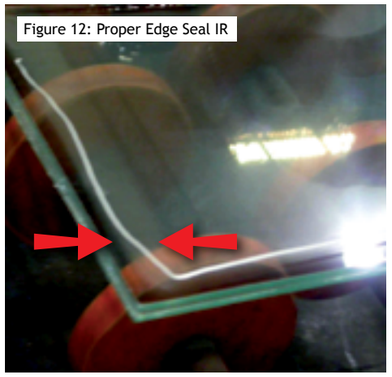


Figure 12: Proper Edge Seal IR

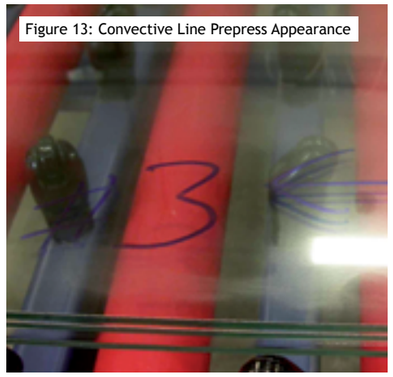


Figure 13: Convective Line Prepress Appearance

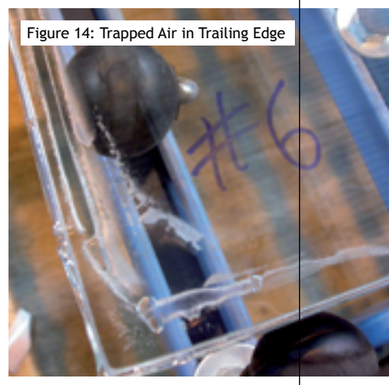


Figure 14: Trapped Air in Trailing Edge

VACUUM BAG/RING PROCESS

Although using a vacuum ring or vacuum bag process is slower and more labor intensive than nip rolling it typically has better post autoclaving yields with respect to air related defects. It is the recommended process for making very large tempered laminates or multi-laminates. Disposable or re-usable systems can be used for vacuum bagging. Disposable types are hand constructed to the dimension of the laminate (Figure 15). It is necessary to use a porous strip along the edge of the laminate inside the plastic bag to allow complete de-airing of the laminate. To keep the edge of the interlayer smooth for open edge applications a gas permeable tape can be inserted around the perimeter of the laminate between the interlayer and the porous strip. If sticking occurs between the strip and the interlayer use of a perforated release film between the two is recommended. Any material used in vacuum processing a laminate with heat should be rated for this application.

Figure 15: Disposable Vacuum Bag

Re-useable systems include silicone rubber envelope bags (see figure 16) and clamshell assemblies (see figure 17).

The cold vacuum time should be a minimum of 10-minutes. The hot vacuum temperature should be set based on the prepress appearance of the laminate. However, if desired, laminates can be made without the prepress operation by applying vacuum directly during the autoclave cycle, thus reducing handling and cycle time.

Figure 16: Silicone Rubber Envelope Bag (Reusable Vacuum Bag)

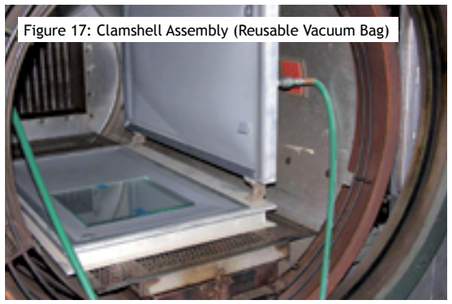


Figure 17: Clamshell Assembly (Reusable Vacuum Bag)

AUTOCLAVING

Control and monitoring of the autoclaving variables are essential to making quality laminates with SentryGlas® Xtra™ interlayer. Autoclave parameters including, prepress racking, soak time, soak temperature and cooling rate will influence both the optical and physical properties of the finished laminates. The laminates should be placed on the autoclave racks with ≥ 1/2“ (12- mm) spacing between pre-presses. Localized high stress areas need to be minimized by dispersing the load over a large area. Setting the laminate directly against the vertical rack supports should be avoided. Figure 18 is a photograph of laminates that have been racked improperly.

Areas of uneven stresses (caused by placing laminates directly against some autoclave racks) can result in non-uniform interlayer thickness. This differential thickness can result in areas of high residual stress within the laminate and possible optical distortion. Figure 19 is a photograph taken with a polarized lens showing a laminate with optical distortion (iridescence), as a direct result of the autoclave racking conditions. Figure 20 is a photograph of the proper technique for racking prepresses. The laminates are properly spaced with no airflow restrictions between the laminates.

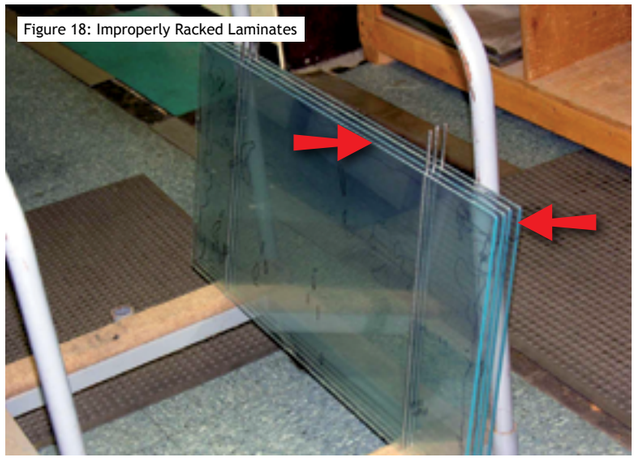


Figure 18: Improperly Racked Laminates

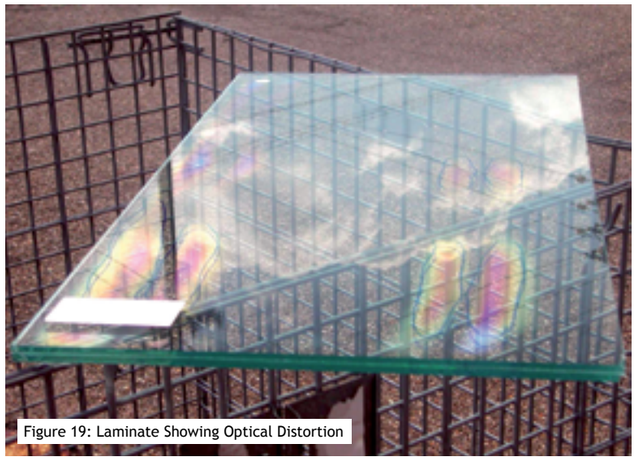


Figure 19: Laminate Showing Optical Distortion

Figure 20: Properly Racked Laminates

Autoclaves vary greatly with respect to size, heating, cooling rate and overall efficiency. The recommended soak temperature range is 250-267 °F (120-130 °C). It is imperative that the autoclave soak time be long enough so that the interlayer reaches the desired temperature for the required time to ensure adequate adhesion. The minimum recommended hold time is 45-mins. Laminates that do not receive the required time can look good optically but can have low adhesion due to incomplete bonding between the glass and the interlayer. Thicker laminate constructions (> 16-mm) will require a longer soak time. Imbedding a thermocouple in the exact construction to be laminated will give the most precise time versus temperature relationship.

The amount of haze in the final laminate is directly related to the autoclave cycle cooling rate. The faster the cooling rate the lower the haze. To ensure adequate cooling that the following recommendations apply:

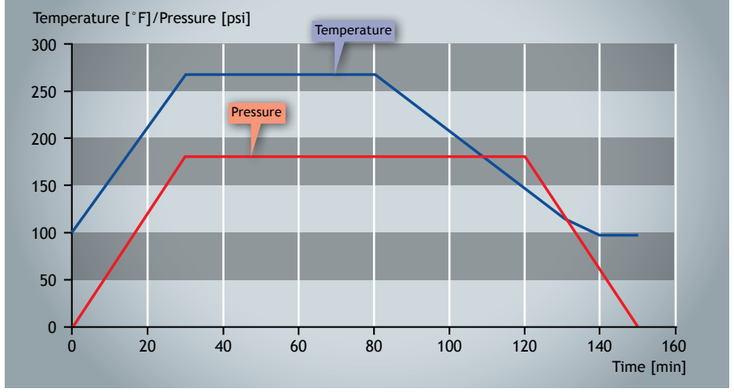
- 1. Use a properly sized fan.
- 2. Use cold or cool water with sufficient flow to maximize heat exchange.
- 3. Flush the radiator on a routine basis. Laminates with high haze can be re-autoclaved to reduce the haze level provided the cooling rate meets the recommended requirements.

The recommended autoclave parameters are:

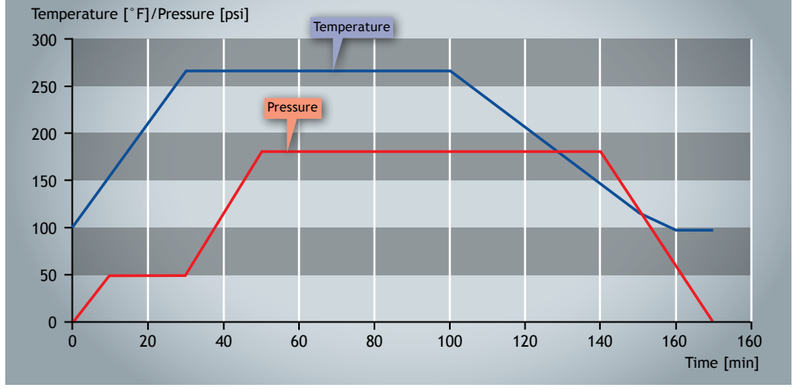
- Temperature: 250 - 267 °F (120 - 130 °C) nominally 257 °F (125 °C)
- Pressure: 150 -200-psi (10 -14 bar). Note: Lower autoclave soak pressures can be used however, the susceptibility of air bubbles forming in a laminate may increase with decreasing pressure.
- Hold: 45 minutes (or greater depending upon laminate thickness, autoclave size, load and airflow).
- Cooling rate: A minimum of 2 °F/min (1 °C/min). The cooling rate can impact haze formation in the laminates. It is recommended that the laminates be near ambient temperature prior to shutting off both the fan and cooling water.

To reduce the possibility of interlayer flow the maximum recommended autoclave temperature should not exceed 270 °F.

Typical Autoclave Cycle — Figure 21



Low Pressure Hold Autoclave Cycle — Figure 22



PROCESSING THIN 35-MIL SHEETING

Thin (35-mil) SentryGlas® Xtra™ requires some slight differences in processing versus 60 and 90 SentryGlas® Xtra™. Laminating with heat-strengthened or tempered glass requires the lites to have good flatness with minimal roller wave and edge kink.

The following are recommendations for processing thin SentryGlas® Xtra™ versus the thicker calipers:

- 1. Storage & Handling: Due to the increased surface area versus bulk thin sheeting absorbs moisture at a faster rate. Cutting & Trimming: Unlike the thicker calipers 35-mil sheeting can be easily trimmed at lay-up with a hook knife. For lamination with heat-strengthened or tempered glass it is recommended that 1/8 - ¼" excess material be left at lay-up. Any residual interlayer should be trimmed after autoclaving.
- 2. Cleaning: A tacky roller is the best method to clean the sheeting. Using a glass washer to clean the sheeting is not recommended since it will likely get caught in the washer's brushes.
- 3. Heated Treated Glass: Heat strengthened or tempered glass needs to be flat with minimal roller and edge kink.
- 4. Roller Processing: The prepress appearance of a nip rolled 35-mil laminate should be similar to a 90-mil laminate. However, due to the less mass a slightly higher line speed maybe required.
- 5. Autoclaving: Same as the thicker calipers.

12.

SENTRYGLAS® INTERLAYER MULTI-PLY SHEET LAMINATION

Achieving the desired laminate strength or projectile resistant properties may require laminating 2 or more sheets of interlayer together between two lites of glass. While any multi-ply sheet laminate can be vacuum bagged the nip rolling process window is limited.

NIP ROLL PROCESS

Laminating two sheets of SentryGlas® Xtra™ together can readily be done using a standard nip roll process. Each sheet surface should be cleaned e.g. tacky rolled prior to lay-up to minimize contamination. Line speed should be set so that there is a well defined clear edge seal without trapping air in the trailing edge of the prepress.

Laminating more than 2 sheets together between 2 lites of glass can be successfully done provided the total interlayer thickness does not exceed 200-mils. Nip rolling more than 2 sheets together when the total interlayer thickness exceeds 200-mils can result in:

- 1. The internal SentryGlas® Xtra™ interlayer interfaces not getting enough heat to create a sufficient prepress bond resulting in pressurized air breaking the seal during autoclaving (see Figure 24).
- 2. Trapped air between the glass and the outermost interlayer ply when the prepress temperature is increased to improve the prepress bond between the internal SentryGlas® Xtra™ interlayer interfaces.

In addition to the flatness of the glass, successfully laminating more than two 90-mil sheets of SentryGlas® Xtra™ together is dependent upon the type of line (IR versus convective), the parameters selected to run the line and the uniformity of heating within the prepress ovens.

VACUUM PROCESS

Vacuum lamination, if done correctly, will result in laminates without trapped air defects and is the preferred method for laminating more than 2 sheets of SentryGlas® Xtra™ together. The vacuum processing procedures remain the same regardless of the total interlayer thickness except for:

- 1. Cold de-airing time may need to be increased as the number of sheets increases. Since the required time is dependent upon process conditions (vacuum level, size of vacuum pumps, laminate size, etc.) it is recommended that optimum cold de-airing time be determined empirically.
- 2. As the size and thickness of both the interlayer and laminates increases the autoclave soak time should also increase proportionally. Please consult your Kuraray technical representative if there are questions regarding lamination of SentryGlas® Xtra™ .

13.

SENTRYGLAS® XTRA™ INTERLAYER LAMINATED TO MORE THAN 2 LITES OF GLASS (MULTI-LAMS)

Nip rolling SentryGlas® Xtra™ requires no special orientation or primer when laminating to three lites of glass. It is however, not recommended for applications that exceed three lites of glass and 2 sheets of interlayer.

14.

LAMINATING WITH POINT FIXATED GLASS (HOLES)

SentryGlas® Xtra™ does work well for point fixated systems i.e., laminates with holes provided the laminates are made correctly. Nip rolling versus vacuum bag processing is dependent upon the size, thickness and total amount of glass and/or interlayer plies required.

NIP ROLL

SentryGlas® Xtra™ interlayer with holes can be processed with high yields using a nip roll process without the use of clamps. In addition, success can be achieved by either removing the interlayer from the holes before or after autoclaving.

The most common problem for yield loss after autoclaving in point fixated laminates with SentryGlas® Xtra™ is trapped air adjacent to the holes (see figure 23).

This is most often caused not by trapping air in during prepressing but by pressurized air breaking the edge seal during autoclaving. Autoclave “blow-ins” occurs due to insufficient edge seal around the hole. A high amount of uniform haze (residual surface pattern) around the hole is a result prepressing too cold (see figure 24).

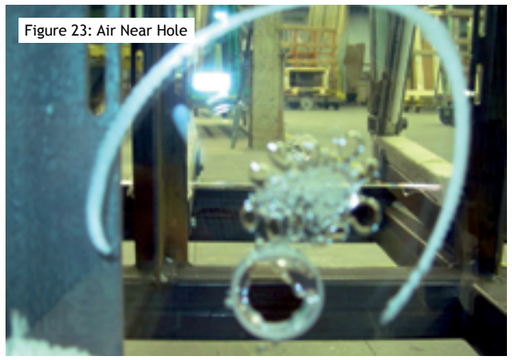


Figure 23: Air Near Hole

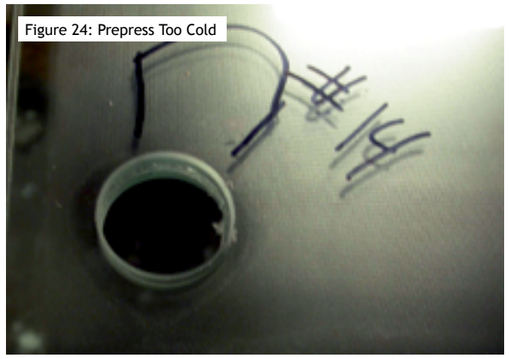


Figure 24: Prepress Too Cold

This can be corrected by running the prepress at a lower line speed. Non-uniform prepress haze around the hole is typified by having areas around the perimeter that are both clear and hazy (see figure 25). This is more difficult to rectify since it can be related to lack of flatness in the glass or variable heating across the laminate.

Figure 26 shows the desired appearance of a prepress with a clear edge seal around the entire perimeter of the hole.

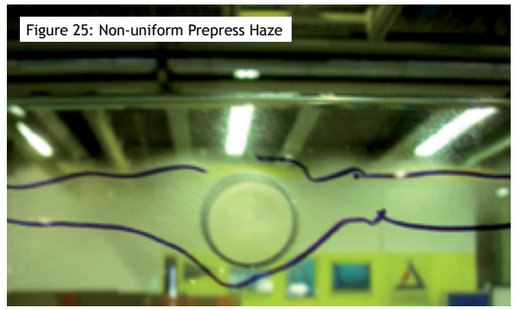


Figure 25: Non-uniform Prepress Haze

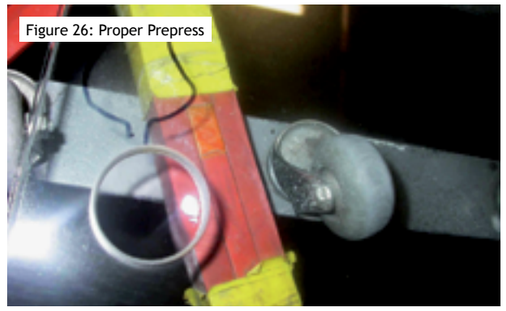


Figure 26: Proper Prepress

Removing the interlayer from the hole can be done either after prepressing or after auto¬claving. While there are a number of methods for doing this one of the quickest and easiest methods is using a core or hole bit to drill out the SentryGlas® Xtra™ (see figure 27). The drill bit diameter should be slightly less than the hole diameter to minimize contact with the glass.


Figure 27: Core Drill Bit

Figure 28 shows a hole drilled after prepressing. Since the interlayer is hot coming directly from the oven it is best to allow some cooling to prevent sticking of the interlayer to the drill bit. After drilling, the remaining interlayer will need to be removed with either an exacto blade or a hot knife (model ZTS 20 for example). The advantage of trimming the SentryGlas® Xtra™ interlayer flush after prepressing is that it is easier to remove since it is less stiff.

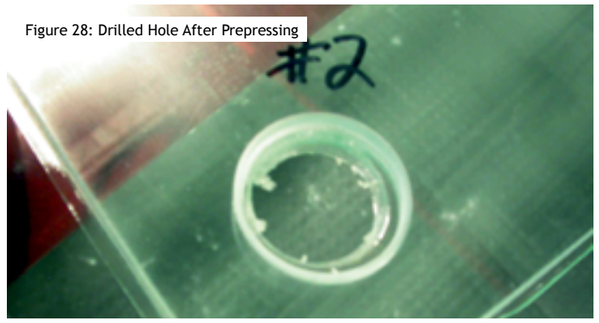


Figure 28: Drilled Hole After Prepressing

Good quality prepresses require no clamps during autoclaving. In addition, on precut holes there should be no flow of the interlayer from the hole during autoclaving thus no additional hole trimming should be required. Outward flow results in thinning of the interlayer which can result in delamination. To help prevent this ensure the soak temperature does not exceed 275 °F/270 °F (135 °C / 132 °C) and there are no high stress areas pressing on the laminates. Minimizing distortion (roller wave, edge kink, etc.) is important. If there is flow of the SentryGlas® Xtra™ into the laminate leading to "short vinyl" around the hole perimeter this is typically a result of: a) excessive void space due to tempering distortion or b) thinning caused by pulling too hard on the soft interlayer during trimming. If this is observed post autoclaving hole drilling should rectify the problem.

The process for hole drilling and trimming before versus after autoclaving is the same. However, after autoclaving more force is required for trimming due to the increased stiffness. Figure 29 shows a properly drilled and trimmed that was done after autoclaving.

Nip Roll Process Summary

- 1. Core drilling out the SentryGlas® Xtra™ works well either before or after autoclaving.
- 2. Core drilling after prepressing works best if the interlayer is allowed to cool partially before drilling.
- 3. Trimming the holes flush to the glass should be done using either an exacto knife or a hot knife after core drilling is completed. Use of a torch is not recommended.
- 4. Clamps should not be used.
- 5. No flow of the interlayer out of the holes should occur during autoclaving thus inserting tape or other substances into the hole restrict flow of the interlayer should not be needed.
- 6. If the interlayer becomes recessed into the glass consider trimming after autoclaving.

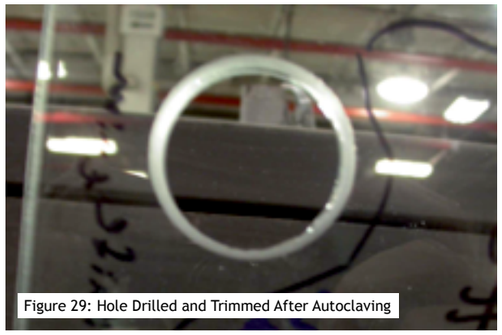


Figure 29: Hole Drilled and Trimmed After Autoclaving

VACUUM BAGGING

For large thick tempered laminates or multi-ply glass panels vacuum bagging the laminates with SentryGlas® Xtra™ with holes is recommended to maximize yields. The vacuum bag process for laminates with holes is similar to that of standard laminates (no holes) except for the addition of a few extra steps.

It is recommended that in a vacuum process the interlayer not be removed from the holes until after autoclaving to minimize flow into the laminate i.e. "suck-in". The porous breather material to promote de-airing should be placed over each hole on the top and bottom of each prepress and taped in place (see figure 30) to prevent getting sucked into the hole. After autoclaving the interlayer can be removed from the holes using a core drill and a knife. The remaining steps are the same as processing laminates without holes. An outline of the best practices of laminating SentryGlas® Xtra™ with holes in a vacuum bag process is listed below.

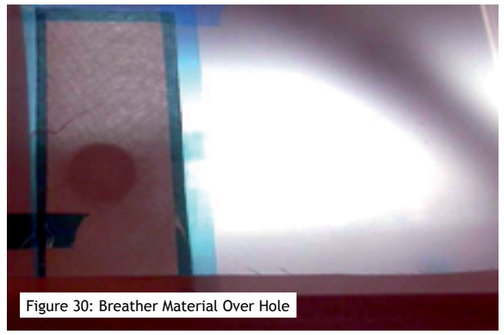


Figure 30: Breather Material Over Hole

Vacuum Bag Process Outline

- 1. To minimize distortion and trapped air defects orient or nest heat treated the glass.
- 2. Depending on the size of the laminates, the amount of distortion in the glass and the thickness of the SentryGlas® Xtra™ the interlayer may need to be cut up to 5-mm oversized in length and width to allow for flow-in during autoclaving.
- 3. To maximize de-airing channels a porous breather material is needed along the entire glass/interlayer interface including holes. It is strongly suggested that the breather material be securely adhered to the outside of the glass using a high temperature rated tape. This will prevent the breather material from recessing into the laminate when under vacuum.
- 4. For large laminates maximizing the number of vacuum connections will improve de-airing efficiency.
- 5. To properly de-air the prepress it is important to maximize the vacuum level. It is recommended that the vacuum be ≥ 28" Hg (93 % vacuum or 948 mbar).
- 6. Cold de-airing in the autoclave should be at least 30 minutes for large multi-ply laminates.
- 7. Autoclave soak time should be increased from 45 to 75-mins (or longer depending upon total laminate thickness).
- 8. The interlayer should be removed from the holes after autoclaving with a core drill and then trimmed flush using an exacto or hot knife. Use of a torch is not recommended.

COMPATIBILITY OF SENTRYGLAS® XTRA™ WITH COATED GLASS OR FRITS

Typically, SentryGlas® Xtra™ has very good adhesion to coated glass or ceramic frits. Contact your Kuraray account manager for an updated list of coatings that have been evaluated or check our website: www.trosifol.com (SentryGlas® Xtra™ hyperlink: https://www.trosifol.com/products/architecture/trosifolr-structural-security/sentryglas-xtra/). It is recommended that any low-e coating or frit not on the list be tested for adhesion and compatibility.

16.

NON-AUTOCLAVE PROCESSING

Since SentryGlas® Xtra™ does not contain a plasticizer and has a very low as made moisture it is more easily laminated without trapped air defects than other interlayers using a non-autoclave process. Due to the increasing number and type of non-autoclave laminating lines that are now available specifying the proper conditions for each in this guide is not practical. Contact your Kuraray technical representative for assistance in optimizing non-autoclave process parameters to produce defect free laminates while minimizing process time.

17.

QUALITY ASSURANCE TESTING

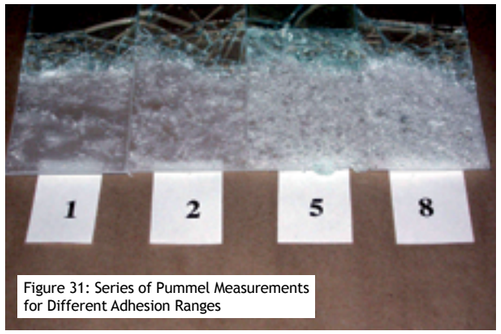


Figure 31: Series of Pummel Measurements for Different Adhesion Ranges

It is strongly recommended that routine Quality Assurance (QA) testing be conducted. Testing should include, as a minimum, measurements of pummel adhesion and optical properties such as haze and transmission. SentryGlas® Xtra™ interlayer pummel adhesion measurements are done at room temperature (nominally 70 °F / 21 °C) using PVB standards. Figure 31 shows a series of pummelled laminates with SentryGlas® Xtra™ with a range of adhesion from poor (1-2 pummels) to excellent (8 pummel).

Haze and transmission measurements should be made using a haze meter or direct comparison using visual standards.

18.

PERFORMANCE MONITORING TESTING

All customers are strongly encouraged to submit samples with SentryGlas® Xtra™ for testing to Kuraray on a regular basis for Performance Monitoring (PM) Testing. Kuraray will measure glass construction, pummel adhesion, haze, caliper and interlayer moisture. The results are sent to the customer to monitor quality as a function of time.

The following are the recommended PM submission guidelines:

- 1. One Laminate should be submitted with a TATA construction using 6-mm annealed glass. However, since the number of laminates and the frequency of submissions may vary by location please consult your Kuraray account manager or technical representative for more information.
- 2. Include the SentryGlas® Xtra™ lot number and the lamination date on the label.
- 3. If available include the laminator's QA test results.

19.

TROUBLESHOOTING GUIDE

Troubleshooting Guide

Problem	Potential Cause	Solution
Low Adhesion	High moisture in sheeting	Use low moisture sheeting and check storage and handling methods.
Low Adhesion	Interlayer not getting to required temp for the required time	Check autoclave soak time and temperature. Ensure adequate spacing and good airflow. Increase soak time if needed. Use an internal thermocouple within the laminate to verify proper control.
Low Adhesion	Incorrect pummel testing	Ensure the pummel test is done at room temperature.
Trapped Air	Premature edge seal (most noticeable in trailing edge and does not extend to laminate edge)	Increase belt speed or lower furnace temperature.
Trapped Air	Trapped air is randomly distributed in small areas due to excessive line (> 15 ft/min) speed (rolling over air pockets)	Decrease belt speed (may require lowering furnace temperature).
Trapped Air	Roller nip gap too wide	Nip gap needs to be a minimum 0.1“ less than the total laminate thickness.
Trapped Air	Insufficient edge seal (autoclave ”blow-in“) Trapped air extends to laminate edge(s)	Decrease belt speed or raise furnace temperature.
Trapped Air	Unequal heating causes air pockets to form on side of the interlayer	Adjust top and bottom furnace heaters so that the temperatures are equal.
Trapped Air	Lines of air pockets are routinely distributed across the laminate due to roller wave distortion or exessive bowing	Check glass heat strengthening/tempering process. Nest laminates to reduce bowing
Iridescence	Laminate has high stress areas during autoclaving	Eliminate any uneven stresses on the laminate and ensure the proper laminate separators are used.
High Haze	Autoclave cooling rate too slow or non-uniform	Ensure cooling rate is at least 4 °F/min with good unobstructed airflow.

20.

ADDITIONAL INFORMATION

If there are questions regarding lamination of SentryGlas® Xtra™ for processing requests that fall outside of this laminating guide, please contact your Kuraray representative. Product safety information is available upon request. It is the user's responsibility to determine the level of risk and the proper protective equipment needed for the user's particular purposes.

The information provided herein corresponds to our knowledge on the subject of the date of its publication. This information may be subject to revision as new knowledge and experience becomes available. The data provided falls within the normal range of product properties and relate only to the specific material designated; this data may not be valid for such material used in combination with any other materials or additives or in any process, unless expressly indicated otherwise. The data provided should not be used to establish specification limits or used alone as the basis of design; they are not intended to substitute for any testing you may need to conduct to determine for yourself the suitability of a specific material for your particular purposes.

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