

GUARDIAN CLARITY™ ANTI-REFLECTIVE GLASS IN ARCHITECTURAL APPLICATIONS

HANDLING AND FABRICATING GUIDELINES

INTRODUCTION

Guardian Clarity™ Anti-Reflective glass is a high quality anti-reflective coated glass product (single side- and double-side coated) that provides minimal reflectance and maximum transmission in the visible range. The Guardian Clarity coating has chemical and mechanical durability characteristics that make it suitable for use in a range of exposed and protected surface applications. However, in order to facilitate the processing of the coated glass, single-sided and double-sided Guardian Clarity is provided with a temporary protective film (TPF). The TPF protects the coated surface from mechanical damage often experienced during general processing, thereby significantly increasing processing yields.

The TPF is a full coverage, polyethylene-based, low adhesive tape that can be easily removed from the glass prior to heat treatment. The TPF can be processed on most standard glass processing equipment, and can be disposed of in a variety of ways after removal from the glass. The TPF is recyclable.

In order to maximize the benefits provided by the TPF, a couple of points need to be considered when processing Guardian Clarity glass. This document provides specific instructions with respect to storage, handling and processing of coated products with TPF. Noncompliance with these processing guidelines may lead to poor product quality including damage of the glass or the coating, and will invalidate any claims.

In addition to single-sided and double-sided Clarity, Guardian is also offering combined coated glass; with Clarity anti-reflective coating on one side of the glass and ClimaGuard Premium2 Low-E coating on the other. This combined product is referred to as "Guardian Clarity / ClimaGuard Premium2" in this document and must be applied in hermetically sealed insulating glass units with the ClimaGuard Premium2 Low-E coating facing the sealed gas space of the unit. Guardian Clarity / ClimaGuard Premium2 is not covered by TPF on any of the sides and is not heat-treatable. As the more sensitive side of this product is the ClimaGuard Premium2, during processing the sections of the "Architectural Coated Glass - General Processing Guidelines" relevant to ClimaGuard Premium2 are to be adhered to.

CHARACTERISTICS OF TPF

The TPF is a polyethylene (PE) polymer sheet that is applied directly to the coated surface by Guardian during the manufacturing process. The adhesive used in the TPF is low tack and can be easily removed from the coated surfaces. The TPF preserves the coating by sealing it from contamination and protecting it from mechanical damage during processing before the glass is heat-treated.

It is important that the TPF is removed completely before the product is heat-treated.

The TPF should never be allowed into the furnace, as this would irreparably damage the coating.

The TPF could be applied to one or both coated surfaces. In the case of the single-sided Guardian Clarity, it is recommended to process the glass the same as other TPF-covered products.

The TPF is recyclable and can be disposed of in a variety of ways, for efficient recycling it may be desirable to collect it separately from other waste products. In case the TPF is not removed from glass trims, Guardian recommends to throw it away together with the laminated glass waste. Please refer to local waste collection guidelines. According to the European List of Waste Products (Eural) the code for TPF is 20.01.39.

STORAGE AND UNPACKING

Guardian recommends that glass be unloaded under dry, indoor conditions. If outdoor unloading is required, care should be taken to avoid exposure to rain and snow, and glass should be moved indoors as soon as it is practical. Glass should be stored in a dry and clean place and be kept away from glass washers, external doors and corrosive chemicals.

Relative humidity in the warehouse should not exceed 70% and a minimum temperature of 15°C should be

maintained in order to prevent condensation which may damage the coating surfaces. If a pack has become particularly cold during transportation, do not open the pack until the glass has reached the ambient temperature in the warehouse, to avoid condensation forming on the coating. The warehouse should be well ventilated and all of the glass rotated (first in, first out).

Do not mark the coated surface with adhesive labels or wax crayons, and do not drag suction cups or metal objects across the surface. The coating is resistant to damage by such materials, but handling practices that are more aggressive than those used with uncoated glass must be avoided. Case tags should remain with the original packaging and case tag numbers should be traceable to work-in process, and finished goods.

Although the coated surface of Guardian Clarity glass is resistant to staining and chemical degradation, Guardian's customer assumes responsibility for as-coated inventory that is held beyond 12 months from the original date of receipt from Guardian.

As far as the storage and unpacking of the combined Guardian Clarity / ClimaGuard Premium2 is concerned, the recommendations of the "Architectural Coated Glass - General Processing Guidelines" relevant to ClimaGuard Premium2 are to be followed.

SURFACE IDENTIFICATION

The type of packaging and the arrangement of the coating on the panes are indicated on a label attached to the first pane in each pack. The label should be retained for reference until the whole pack has been satisfactorily processed. In addition, the location of the TPF may help to determine the coated side of the glass. Note: there is never TPF on an uncoated surface.

The Image Method (Fig.1) can be used for detection of the coated surface of the single-sided Clarity glass. Remove the TPF and place a pencil or similar pointed object against the surface of the glass. When contact is made with the Clarity coated surface, the reflected image appears in the depth of the glass thickness. But against the uncoated surface, a single, well-defined reflected image is produced immediately at the place of contact.

A special separator powder is placed between the panes to ensure good separation and prevent damage during transportation.



Fig.1

In case of the combined Guardian Clarity / ClimaGuard Premium2, the ClimaGuard Premium2 coated side is electrically conductive (unlike the Clarity coating), so may be easily identified with a commercial coating detector or ohmmeter. Use these detectors within 12mm of the edges whenever possible to prevent damage to the coated surface.

HANDLING

Do not open the glass pack until all the people responsible for handling and processing the glass have been properly trained on the correct handling, storage and processing of the particular type of glass. If the Guardian Clarity coating is not protected by TPF, then always wear suitable clean, dry, lint-free cotton gloves when handling the glass.

If suction cups are used, contact with the coating should be avoided, since it will always present an additional

risk of surface damage. If contact is unavoidable (double-sided Guardian Clarity glass), cups should be cleaned frequently, be free of any lubricants, and they should also have suitable, clean, protective covers.

In order to prevent damage of the coating, avoid contact with hard objects such as glass splinters, glass edges, metallic parts, abrasive particles, etc. Always use separator material between individual panes of glass; adhesive-free cork pads or acid-free paper (contact supplier for confirmation of acid content) should be used. Glass to glass contact must be avoided. Do not stick, glue or write anything on the coated side.

After certain steps of processing, manual cleaning might become necessary. See separate Cleaning Guidelines on www.eu.en.sunguardglass.com for the recommended cleaning agents and tools.

INSPECTION

Upon receipt and after each processing step, Guardian Clarity must be inspected both in reflected and in transmitted light.

CUTTING

Do not start the processing until all the people responsible for processing the glass have been properly trained on the correct handling and processing of this particular type of glass.

Despite the fact that the coating is protected by TPF, Guardian Clarity needs special care when metal tape measures, straight edges or cutting bars come into contact with the coated surface as abrasion or marking may occur. Multi-lite stacking should also be avoided to minimize abrasion or marking of the coated surface.

In case of single-side coated Guardian Clarity, the glass must be placed on the cutting table with the coated surface facing upward.

The combined Guardian Clarity / ClimaGuard Premium2 is not covered by TPF on any of the sides. This product must be placed on the cutting table with the ClimaGuard Premium2 coated surface facing upward.

The cutting table has to be cleaned with vacuum-cleaner before the start of the cutting process and after cutting each lite in order to avoid scratches of the coating caused by glass chips. Furthermore, it is crucial that the air cushion pressure is sufficient to support the Guardian Clarity glass.

Manual adjustment of positioning sensors may be necessary for cutting tables controlled on the principle of visible light reflection since Guardian Clarity glass has very low reflectance in the visible range.

The cut glass should be washed or processed immediately. In between steps of processing, the glass should be stored in clean and dry conditions.

Guardian Clarity with TPF must be cut through the foil. In case of double-sided Clarity with TPF on both of the coated surfaces, optimal cutting can only be performed with a cutting table designed for cutting laminated glass.

Guardian recommends the following changes with respect to the cutting parameters of coated glass of the same thickness without protective film:

- Only very small amounts of cutting fluid are required and recommended when cutting through the TPF surface. Guardian recommends slowly evaporating cutting fluids like Acecut 6000 to avoid shrinking of the TPF.
- Results from Guardian research indicate that pre-facetted cutting wheels are optimal for cutting the TPF and scoring the glass consistently with a clean edge (for example: MDI Penett SC 060/130 or Bohle Cutmaster Platinum BO 03AP130P for 4 to 6mm glass, and MDI Penett SC 060/140 or Bohle Cutmaster Platinum BO 03AP140P for 8 and 10mm glass).
- The optimal angle for cutting depends on the thickness of glass and both the make and model of the cutting wheel.
- It is recommended to increase the cutting pressure until a clean break across the whole length and width of a Jumbo is achieved. It may be necessary to increase the tool pressure by a substantial amount. It is possible

that stress lines are visible after the break.

- The cutting speed may need to be reduced in order to optimize the quality of the score. Cutting speed and pressure affect each other and some fine-tuning may be required to achieve the best possible result.

Cutting quality is considered satisfactory if the TPF foil is not ripped or delaminated at the edges. This is crucial in order to avoid problems during further processing steps (edgework, washing, etc.)

In case of Laminated double sided Guardian Clarity with double sided TPF, Guardian recommends to use a cutting table designed for cutting laminated glass with automatic separation of the glass and adjustable heating time for PVB melting. Unnecessarily long heating time might damage the bottom TPF foil.

WASHING AND CLEANING

Do not start the processing until all the people responsible for processing the glass have been properly trained on the correct handling and processing of the particular type of glass.

Automatic washing machines using de-ionized ($< 30 \mu\text{S}$) water can be used with Guardian Clarity glass. The diameter of the bristles of the brushes can be max. 0.20 mm. The water must not contain any cleaning agents or non-dissolved particles (such as lime). During the washing process the panes must not remain stationary in the washing machine with the brushes revolving, as excessive brushing may damage the TPF protected surface. The glass panes must exit the washing machine completely dry in order to prevent water droplets from drying onto the coating. Air used for drying must be clean and free of dust or any particles.

The washing machine must be checked, cleaned and maintained at regular intervals in order to ensure proper operation. The brushes, in particular, must be checked for cleanliness, alignment, and ample supply of water. The brushes must not operate dry, as this could damage the TPF. TPF must remain on the surface during post-washing transport when the washer is not directly in line with the furnace entry conveyor.

It is crucial to avoid water drying to the coated surface, as watermarks will later be difficult to remove. To keep the optical cleanness, manual cleaning might become necessary with a clean, soft cloth. See separate Cleaning Guidelines for the recommended cleaning agents and tools.

Cerium oxide is not allowed for cleaning Guardian Clarity glass.

Razor blades and steel wool must not be used on the coated surface.

EDGEWORK

Do not remove the TPF foil from the glass surface prior to the edgework operation, including CNC milling. The glass should be washed immediately after the edgework operation is completed. In between steps of processing, the glass should be stored in clean and dry conditions.

PROCESSING TO LAMINATED GLASS

Single-sided Guardian Clarity can be processed to laminated glass for safety and sound control requirements. It is not recommended to laminate double-sided Clarity or the combined Guardian Clarity / ClimaGuard Premium2 due to potential discoloration. Special care must be taken during fabrication to maintain aesthetics and to ensure superior performance.

- The TPF foil must be removed before lamination, as the removal may become more difficult after the process.
- The anti-reflective function of the coating diminishes if it is in contact with the interlayer foil. Therefore, the coating should be turned away from the interlayer foil. Identification of the coated side is necessary.
- Special attention needs to be paid if the coating is exposed to mechanical contact - especially if nip rolls are

used for the pre-lamination process. If vacuum bags are used, then acid free paper interlayer is necessary between the glass and the inside of the vacuum bag to avoid marking.

- Different types of PVB and EVA foil may result in different color appearance of the final Laminated Clarity product. It is therefore strongly recommended to carry out tests to verify appearance.
- Separate the lites in the autoclave with suitable, non-marking material.
- The coated surface requires quality inspection after each step under suitable light conditions.

If single-sided Guardian Clarity is laminated in combination with ClimaGuard low-emissivity or SunGuard multifunctional coated glass, then the guidelines for processing and lamination of those glass types must be respected as well*.

In general it is advisable to keep the more sensitive ClimaGuard or SunGuard coated surface away from conveyors during the lamination process. The coated surfaces require a quality control after each fabrication step under suitable light conditions.

BONDING, GLUING FOR INTERIOR APPLICATIONS

Transparent, glass-to-glass bonding of Clarity for interior applications is approved with neutral silicones and UV-glues only. Regardless of the material used, it needs to be ensured, that excess material is removed from the Clarity coating immediately and without causing mechanical damages. Isopropyl alcohol or acetone may be used for this purpose, however, an additional cleaning step with the recommended cleaner must follow immediately after - see the separate "Guardian Clarity Cleaning Guidelines" for more information.

ENAMELING, SILK-SCREEN PRINTING

Clarity can be painted for decorative purposes or to cover up certain fixing/hardware elements behind the glass. Ceramic frits - requiring firing -, as well as organic paints - requiring drying only - may be used under certain conditions, after compatibility and suitability tests. Side-by-side installation of heat treated and annealed Clarity is not recommended. It is advisable to carry out tests to verify the color appearance of the painted area. A certain color difference in the residual reflection between the painted and the non-painted areas of the glass is to be expected. If this color difference is deemed disturbing, it can be minimized by laminating 2 sheets of Single Sided Clarity with painting on one of the uncoated sides facing the interlayer. For projects with painted Double Sided Clarity it is recommended to use glass out of the same batch.

Paint should be applied to the air side of the glass for optimal color appearance. Single Sided Clarity should be ordered from Guardian accordingly, with the Clarity coating either on the air or on the tin side depending on the application. In case of Double Sided Clarity, paint should be applied to the coating on the air side of the glass. Guardian delivers Double Sided Clarity with the tin side marked.

In case of ceramic fritting, the settings for firing the enamel must be adjusted compared to regular clear float glass. Excess heating may lead to enamel discoloration and may damage the Clarity coating as well. Please see chapter Heat-treatment for more information.

HEAT-TREATMENT

Side-by-side installation of heat-treated and annealed Clarity is not recommended. The TPF must be removed before the glass is indexed into the furnace for heat treatment. The best location for removing the TPF is the loading table of the tempering furnace.

The removal of the TPF is facilitated by the film's "easy-peel" effect. It is recommended to peel back about 20 to 30 cm of the TPF in a first step, and then in a second step hold the TPF tightly and pull swiftly. This fast pull substantially reduces the force required to remove the film from the coated glass. For the removal of the TPF,

* Please refer to the documents "Processing Guidelines Architectural Coated Glass" and "Processing SunGuard to Laminated Glass", available at www.eu.en.sunguardglass.com or from your Guardian representative.

it is recommended to start in a corner of the glass. If it proves difficult to get a good grip of the corner of the TPF, a strip of strongly adhesive tape applied to the TPF can help lift the protective film off the coated glass.

In the unlikely event that spot cleaning is required after TPF removal, please refer to the separate Cleaning Guidelines.

The outstanding optical characteristics of Guardian Clarity may require some process adjustments to the furnace profile for heat-treatment in good quality. As a rule, furnace temperatures should be decreased compared to clear float glass of the same thickness, and the furnace dip time increased proportionately.

SO₂ (sulphur dioxide) must not be used at any time during the heat treatment. The SO₂ flow must be discontinued at least 2 hours prior to starting heat-treatment of Guardian Clarity glass. In order to obtain good optical quality of heat-treated Guardian Clarity coated glass, attention to the uniform heating and cooling of the glass is critical. Non-uniform heating and cooling of glass can lead to permanent deformations.

In order to limit potential risk of spontaneous breakage of tempered glass, Guardian strongly recommends Heat-Soak process to be carried out.

Guardian does not warrant glass against breakage or failure of any kind as well as any consequences that can occur or result from such breakage or failure.

INSULATING GLASS ASSEMBLY, INSTALLATION

Single-sided and double-sided Guardian Clarity may be used in monolithic applications or in insulated glass units. The combined Guardian Clarity / ClimaGuard Premium2 coated glass may only be used in hermetically sealed insulating glass units with the ClimaGuard Premium2 coating facing the sealed gas space of the unit. Edge deletion of the ClimaGuard Premium2 coating is mandatory. During processing the sections of the "Architectural Coated Glass - General Processing Guidelines" relevant to ClimaGuard Premium2 are to be adhered to. For the best possible aesthetics in double glazing, it is recommended to apply the ClimaGuard Premium2 coating in position #3, and the Guardian Clarity coatings in positions #1, #2 and #4.

Guardian Clarity requires special attention related to the following assembling steps:

- The rollers in the washing machine at the IG unit line must be clean and uncorrupted.
- Before IG unit assembly the intended sealant material must be tested – adhesion and compatibility tests have to be done. Extensive testing by Guardian indicated potential adhesion issues with Guardian Clarity in combination with polysulfide secondary sealants if the coating is to be assembled into IG units without heat-treatment (due to residual adhesive from the TPF). In such cases Guardian recommend one of the following options:
 - To use silicone or polyurethane secondary sealant instead of polysulfide
 - To clean the perimeter area (up to the line of the spacer bar) with isopropyl alcohol and lint-free tissue prior to the glass entering into the glass washing machine.

For further information please contact Guardian's Technical Advisory.

- Always use separator material between individual IG units such as adhesive-free cork pads or acid-free paper (contact supplier for confirmation of acid content).

The primary function of the TPF foil is to protect the coated surface from mechanical damage during general glass processing. It is the processor's decision to select at which step of the processing the TPF is removed, e.g. for quality inspection. It is also important to note that TPF-covered glass should not be exposed to sunlight for more than 2 to 3 weeks – depending on the intensity of sunlight – as the foil may leave some residues behind that could be difficult to clean.

PACKING

When packing Guardian Clarity glass for shipping with the coating exposed, it is preferable to use a slot-racking system that prevents glass-to-glass contact. It is acceptable to stack individual lites of Guardian Clarity; however, care must be taken to ensure proper interleaving is used to minimize the potential for abrasion to the coated and uncoated surfaces.

Recommended	Not Recommended
Lucite powder Acid-free paper (contact supplier for confirmation of acid content) Adhesive-free cork pads	Newsprint Cardboard and other hard papers Powder separators containing acid Nut powders

QUALITY FEATURES OF COATED GLASS

The European Standard EN 1096-1 characterizes defects on coated glass.

When the glass is inspected in reflection, the observer must view the glazing from outside the building. Examination in transmission is effected when looking through the glass from the inside of the building. It is necessary to maintain a minimum distance of 3m between the observer and the coated glass (see fig. 2) in order to characterize the potential defects.

Daylight (evenly covered sky without direct sunlight) should be used as the light source.

Stains and defects in homogeneity

These defects are acceptable if an unbiased observer does not regard coating variations as disturbing.

Spot-shaped defects

All defects larger than 3mm are inadmissible. Separate defects measuring between 2 and 3mm are acceptable provided the number of defects does not exceed one per square meter. The concentration of small defects is only admissible in areas outside the normal field of vision.

Line-shaped defects

Scratches longer than 75mm are inadmissible in the center of a lite. Scratches in the edge area (10% of length and width) are acceptable if located 50mm distant from each other. If an unbiased observer does not feel disturbed by the local accumulation, then scratches smaller than 75mm are allowable.

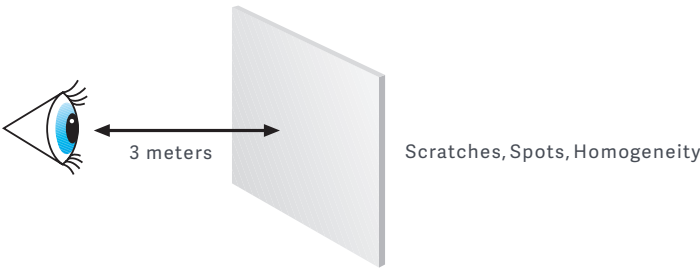


Fig. 2

Important advice:

Double-sided Guardian Clarity provides a residual reflection of less than 1% (exact number depends on glass configuration and/or thickness) and provides a viewing experience through the glass that is virtually distortion free. However, under specific natural and artificial lighting conditions and in some specific viewing angles, a slight reflection may be seen by the naked eye, which cannot be considered as a reason for complaint or claim. It is recommended that a sample is viewed in the actual location to understand which of these factors may be present in your particular application.

The use of Guardian Clarity is NOT recommended and not covered by Guardian's warranty in the following applications:

- Outside surface (position #1) of roof or skylight glazing, including greenhouses
- Outside surface (position #1) of vehicle glazing, windshields
- Solar power applications (e.g. photovoltaic panels)
- Applications where the Guardian Clarity coating may come into direct, regular contact with seawater.

WARRANTY

The processing guidelines contained herein are for information purposes only and Guardian does not assume any responsibility for the accuracy or completeness hereof, unless otherwise stipulated by applicable law. It is the sole responsibility of the user to adequately inspect the Clarity products before each step of fabrication and prior to installation. Failure to apply professional standards, customary instructions and these processing guidelines will automatically void any warranty given by Guardian regarding Guardian Clarity™ products and no claim in relation to Guardian Clarity™ products will be admissible against Guardian if 1) the user's processing capabilities have not been certified by Guardian and 2) Guardian Clarity™ products are damaged in fabrication, handling or due to improper storage, installation or maintenance.

Guardian reserves the right to inspect any product claimed to be defective.

Sales by Guardian are subject to the latest Guardian Conditions of Sale and Guardian AR Glass Limited Warranty.

VERIFICATION

The signature below verifies that the customer has read and understood the full content of these processing directives. Handling and Fabricating Guidelines / Guardian Clarity™_PG_EN_0319

Name/Signature: _____

Title: _____

Company/Stamp: _____

Date: _____

Please return this page signed by mail: information@guardian.com

For additional information regarding storage, handling, fabrication, limited warranty coverage or use of any Guardian glass product, please contact the Guardian Technical Advisory Center.

The products in this publication are sold subject to Guardian's standard terms and conditions of sale and any applicable written warranties. It is the responsibility of the purchaser to confirm that the products are suitable for their intended application in compliance with the applicable laws and regulations. Please contact your local Guardian representative to obtain any applicable handling and fabrication guides and for the most current product information.



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