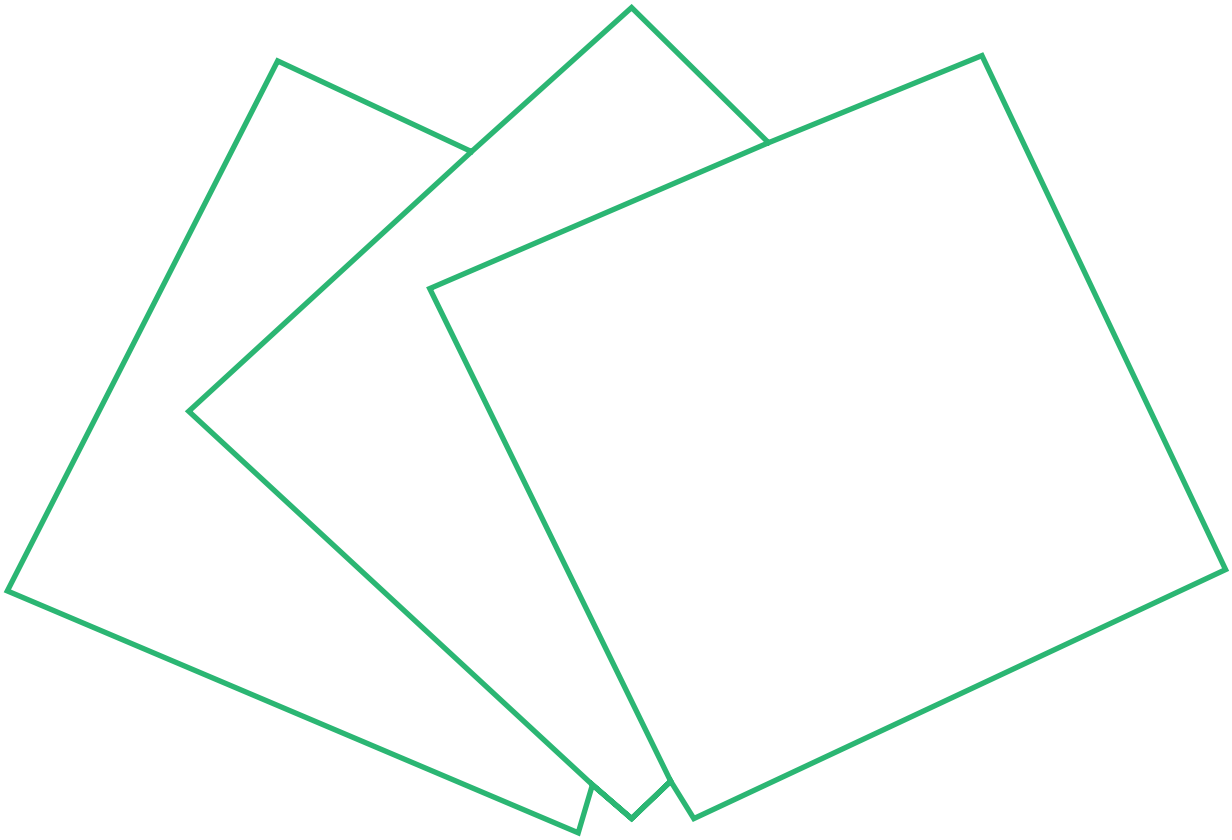
PILKINGTON



# Pilkington Suncool® and Pilkington Optitherm®
# Glass processing, transportation and storage manual

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## 1. Introduction

Pilkington Suncool® and Pilkington Optitherm® are «soft» glass coatings applied by magnetron sputtering.

This manual contains general instructions as to storage, transportation and processing of soft-coated glass.

As a rule, recommendations mentioned in this guide will be sufficient for successful processing of Pilkington Suncool® and Pilkington Optitherm® coatings. In rare cases, depending on the specific conditions at the facility, and type of the equipment, additional measures are to be taken to mitigate the risk of damaging or destroying the soft coating.

Breach of the above-mentioned requirements and recommendations increases the risk of damaging the coating and can invalidate any further claims. Pilkington Glass LLC recommends to avoid manipulations, which are not mentioned in this processing guide. In case of non-standard manipulations with the coating we recommend to address the technical support service for information on the risks and additional measures to be taken to perform such manipulations.

Pilkington Glass LLC insists that glass with Pilkington Suncool® and Optitherm® coating is to be handled and processed only by trained and familiar with this guide personnel. It is recommended to do the first processing trial under supervision of Pilkington Glass representatives.

In case when basic training on soft-coated glass processing technique is necessary we recommend to address your regional Pilkington Glass representative. Our technical team will be pleased to assist you.

## 2. Product range

Pilkington Suncool® - is a series of glass with high-selective coatings, combining excellent sun-control and heat insulating properties:

- Pilkington Suncool® - family of glass coatings with a neutral tint, to be processed without any heat treating. Toughening is prohibited;
- Pilkington Suncool® ProT – family of glass coatings with a neutral or coloured tint to be used after heat treating only. Use of this glass without heat treating is prohibited;
- Pilkington Suncool® One – family of glass coatings of neutral tint which can be used with or without heat treating.

Pilkington Optitherm® - family of glass with LowE coatings with exceptional thermal insulating properties:

- Pilkington Optitherm® S3 is glass with neutral-coloured coating to be used without heat treating only. Toughening is prohibited;

- Pilkington Optitherm® S3 ProT is glass with neutral-coloured coating, to be used after heat treating only. Use of this glass without heat treating is prohibited.

As a routine practice, Suncool® and Optitherm® coatings are applied to the standard float glass Pilkington Optifloat® thickness ranging from 4 to 12 mm of the following sizes:

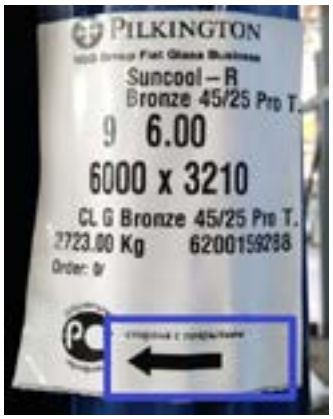
- LES (3210x2250mm);
- LES+ (3210x2550mm);
- Jumbo (3210x6000mm).

For detailed information on the product range please contact your Pilkington representative.

Pilkington Suncool® coated glass is produced to specific order. Pilkington Glass LLC recommends during placing the order for Pilkington Suncool® glass to point out the project name, necessary volume, and duration of the project to provide for the minimal product stock.

Contact list of Pilkington Glass LLC representatives is located on our web site: www.firstinglass.ru

## 3. Delivery and storage




Immediately after delivery and unloading of the glass to the warehouse it is necessary to inspect the packing and glass to make sure there are no signs of damage and traces of moisture. In case there is any breach of package or signs of moisture, please immediately inform Pilkington Glass LLC.

Before unpacking check the position of the coated side, and, if necessary, turn the pack around. Pilkington Suncool® and Optitherm® glass should be positioned on the storage racks with the coated side facing the frame. To avoid damaging the coating on the last pane in the pack, each glass pack contains an uncoated 4mm pane for protection. The coated side of glass is indicated by the arrow on the package tag.

Options regarding a different coated side orientation on the rack are to be discussed with the representative of Pilkington Glass LLC before placing the order.

Glass with Pilkington Suncool® and Optitherm® coating is to be stored on steady, reliable racks padded with soft material to avoid damaging the glass. Storage area should be dry, well-ventilated and protected from atmospheric precipitation. Storage of glass outside is strictly prohibited.

Soft coatings are sensitive to moisture, each pack with Pilkington Suncool® and Optitherm® coated glass is delivered with the edges sealed by an adhesive tape to

protect the coating. To avoid adverse effect of moisture appearing on the coated glass, a desiccant is placed under the adhesive tape. Please make sure that all personnel responsible for glass unpacking and handling has been properly trained. It is necessary to comply with all safety regulations, and use equipment, gear, and racks, excluding rubbing of glass panes against each other and preventing the glass from falling.

To prevent condensate formation on the glass, it is prohibited to unseal the adhesive tape on the glass edges after delivery at the cold time of the year or after night delivery, until temperature of the glass reaches the warehouse ambient temperature.

After unsealing the glass should be stored in a dry well-ventilated warehouse with relative air humidity not more than 65% and a minimum temperature of 15°C to avoid forming of any condensation and subsequent coating damage. When a glass pack is not fully utilized and will be stored for a long time, it is recommended to seal the edges with the adhesive tape, while keeping the desiccant in place.

Soft coatings are sensitive to mechanical damage, so special separating powder is always placed between all panes of Pilkington Suncool® and Optitherm® coated glass.

Glass delivered in wooden boxes in addition to ordinary sealing with an adhesive tape is wrapped in a plastic film. If any moisture condensation is detected on the plastic film or outer glass panes in the pack, it is necessary to remove this plastic film after placing the glass inside the warehouse. Please make sure that hermetic sealing on the glass edges is not damaged.

The outer plastic bag, if there is one, must be removed immediately after unloading the glass into the warehouse.

Pilkington Suncool® and Optitherm® coated glass with the original undamaged sealing has a shelf life of 6 (six) months, starting from the loading date from the Pilkington warehouse. Shelf life of packs with opened hermetic sealing is 1 (one) month, provided normal storage and warehouse conditions mentioned above are maintained.

The warehouse glass rotation should be done according to «FIFO» principle (First In First Out). Identification tags should be retained for reference until the glass pack is fully processed. Pilkington Glass LLC will ask to refer this tag in case of lodging a claim. Pilkington Glass LLC will ask for the tag data should any questions regarding quality of glass arise. It is recommended to build the production logistics based on the individual number of the pack which is being processed (indicated on the tag).

Pilkington Glass LLC does not recommend to use mixed packs of coated glass. However, should such a situation occur due to customer's order, the glass producer may reject claims connected with mechanical damage of the coating, including cases when such damage becomes evident only after the toughening. Assembling of mixed packs requires moving individual glass panes which causes protective powder shedding and higher risk of damaging the coating during handling and transportation.

## 4. Handling Pilkington Suncool® and Optitherm® coated glass

Soft coatings are sensitive to different manipulations that may lead to irreversible

defects of the coating which become evident after toughening only, so it is paramount during processing of Suncool® and Optitherm® coated glass to comply with the following rules:

- All personnel responsible for glass handling and processing should be familiarized with the current processing directives;
- It is necessary to always wear clean gloves made of materials not damaging the coating, not leaving any prints, and compatible with the glass cutting liquid;
- The coating can be easily damaged due to mishandling, so the personnel should take all the necessary measures not to rub the glass panes against each other during removing them from the rack or loading/unloading them onto the processing equipment;
- Individual glass panes should be moved, if possible, using automatic equipment with suction cups or other gear. Coated side of the glass should not be touched;
- If suction cups come in contact with the coating, the risk of damaging the coating is very high. To reduce it, the suction cups should have special protection covers. Special care should be taken to keep the protection covers and suction cups absolutely clean, frequent inspection and cleaning is necessary. We recommend to clean the suction cups surface with a spirit solution before starting manipulations with the coated glass;
- Any contact with the coating should be avoided. The cut glass should be moved touching its edges only, in a manner that will prevent any contact with the coating;
- No organic substances (fingerprints, beads of perspiration, saliva, etc..) should remain on the coating during heat treating of the glass (tempering, toughening, bending). For instance, a fingerprint left after touching the coating without gloves will irreversibly destroy the coating during heat treating;
- It is prohibited to write or stick any tags or leave any other temporary marks on the coated side;
- For spot cleaning it is allowed to use clean, soft, lint-free wipes moistened with solution containing 50% of isopropyl or ethyl alcohol and 50% of distilled water In this case the processor is to make sure that the solution and wipe does not leave any marks or streaks and the coating is not damaged in any way. Household glass cleaning products are not to be used;
- To prevent damage to the coating and appearance of scratches it is necessary to avoid contact of the coating with any hard objects (e.g. glass splinters or edges, metal tools, buttons, tip of the tape-measure, etc...). Operators have to know that any contact of the coated side with hard or sharp objects will damage the coating;

During moving or installation of individual cut pieces, glass-to-glass contact or contact with rack and pyramid parts with the coated side should be avoided. During packing of the individual glass pieces, it is necessary to use soft cork-type separators, placing them close to the edges. Using paper as a separation material is not

recommended. It is solely the processor's responsibility to make sure that the separators do not leave any marks and do not damage the coating.

During processing it is recommended to plan the production chain in such a manner that individual pieces of coated glass are not left for long-term storage. It is recommended that they are assembled in the IG units within one production shift.

If this is not possible, the following maximum storage time for coated cut glass should not be exceeded:

**[Cutting]**
Storage 8 hours maximum
↓
**[Edge working]**
Storage prohibited
↓
**[Washing after processing]**
Storage 6 hours maximum
↓
**[Tempering]**
Storage 24 hours maximum
↓
**[IG unit assembly]**

## 5. Glass cutting

Pilkington Suncool® and Optitherm® coated glass should always be placed on the cutting table with the coating facing upward, it is prohibited to turn the glass so that the coated side is facing the table surface.

Use of automatic glass cutting tables with fast-evaporating cutting fluids is preferable. Some types of gloves have polymer coatings dissolvable with glass cutting fluids, which will lead to prints on the glass and damaging of the coating. It is solely the processor's responsibility to make sure that the glass cutting fluid is compatible with the type of gloves used, and the soft coating remains intact.

During automatic glass breaking and moving of the cut glass, contact of equipment elements (breaking bars or rollers, suction cups) with the coated side is possible. It is solely the processor's responsibility to make sure that the automatic glass breaking, conveyor, or clamping system does not damage the coating. The equipment should be timely checked, cleaned, and maintained to make sure it is operating correctly.

During cutting the glass manually (for instance, using templates), extreme precautions should be taken. Metal tape-measures, triangles, rulers and other tools ruin the coating during contact.

All personnel must wear clean gloves to avoid leaving prints on the coating. Gloves should always be clean, and changed regularly.

## 6. Soft coating edge-deletion

To ensure reliable adhesion of the sealants to the glass and avoid damaging the coating in the long term, the coating of any Pilkington Suncool® and Optitherm® cut size pane has to be removed completely along the perimeter. Depth of edge-deletion depends on the depth of sealing. The coating is to be deleted according to the depth of sealing regardless of the sealant type, because any sealant can change the coating colour or destroy it in the long term. If it is not possible to avoid contact of the sealant with the soft coating, the processor has to test the compatibility of the sealant and the coating on its own and bear the full responsibility.

It is recommended to use automatic systems to remove the soft coating along the perimeter. The processor has to adjust the equipment settings so that the coating is removed completely. To improve the quality of coating removal, it is recommended to do tests with different grinding wheels and equipment settings (disk rotation speed, linear speed, and pressure force). In some cases, double pass along the same trajectory (double-pass edge deletion) might be needed. The edge-deletion device should be equipped with an aspirating unit.

During manual edge-deletion extreme precautions must be taken, as manual processing always entails a high risk of damaging the coating.

## 7. Edge working

Edge processing (dulling, grinding, polishing) is necessary prior to heat treating of Pilkington Suncool® and Optitherm® coated glass. Any mechanical glass processing produces a lot of abrasive waste that may damage the soft coating.

It is recommended to always use automatic equipment for edge working. Any contact of equipment parts (drive belts and shafts, curtains, brushes, etc...) with the soft coating must be avoided. If such contact is unavoidable, make sure that the soft coating does not get damaged in any way, and abrasive dust is not accumulating on parts of the equipment that may come in touch with the coating.

Use of semi-automatic equipment for edge-working is possible (for example, cross-belt machines of wet type). Extreme precautions must be taken during this kind of processing, as any manual operations involve great risk of damaging the coating.

The glass must be washed immediately after mechanical processing. Drying of any abrasive waste on the glass surface during or after the processing is strictly prohibited. However, in case of slow processing of the glass edge, some machines may require additional supply of water onto the coated side.

To remove abrasive dust from the coated side it is strongly recommended to additionally rinse the glass with plenty of clean water immediately after processing. Rinsing the glass in this case is a separate operation.

Special attention should be paid not to damage the coating and to avoid drying of the abrasive waste on the coated side when glass is moved to the washing machine after the mechanical processing.

## 8. Washing

Washing the glass after mechanical treatment is the most important part of the production chain during processing of the soft-coated glass. Only special equipment intended for soft-coated glass is suitable for washing of Pilkington Suncool® and Optitherm® coatings. The washing machine has to satisfy the following requirements:

- The washing machine must have a multi-step washing system with a separate water reservoir for every washing phase;
- The washing machine design must not allow the conveyor to stop with coated glass remaining stationary inside the washing section with the brushes rotating, otherwise the coating may be damaged;
- The coating must not face the rollers during washing;
- The brushes touching the coating should have soft bristles, which will not damage the coating. It is recommended to use special brushes for soft coatings with bristles diameter of 0,15mm maximum;
- Standard hard brushes, various curtains at the entrance and exit of the washing machine or between the machine sections, squeeze rollers, etc., should be drawn up or tuned in such a way that they do not touch the coating;
- The washing machine should have quick-setup and tuning capabilities to quickly adjust for washing the glass of different thickness (moving the washing brushes and driving shafts);
- Washing brushes, driving shafts and rinsing nozzles are to be cleaned timely;
- Washing and rinsing should be done with cleaned, de-ionized, pH-neutral water. Initial rinsing and washing are to be done with 40°C water with specific conductivity of <30 µS/cm. Additional final rinsing is recommended with clean de-ionized water with specific conductivity of <15 µS/cm;
- The water used for washing should not contain any cleaning agents or biocides (e.g. hydrogen peroxide, salt, acid, etc...).

Additional functions of washing machines that can reduce risk of damaging the soft coatings:

- powerful system of preliminary water rinsing to remove main abrasive waste;
- adjustable brushes rotation speed and conveyor system with possibility to change glass transportation speed.

After washing and drying it is necessary to visually assess the glass surface for cleanliness and presence of any defects in transmitted and reflected lighting. Impurities, streaks, etc., may cause damage to the coating during thermal treating.

In case if any damage to the coating is visible, it is recommended to perform an urgent maintenance of the washing machine:

- clean all brushes;
- clean all parts that may come in touch with the coating;

- check the washing nozzles;
- check pressing force of the brushes, rotation speed of the brushes and glass conveyor speed in the washing machine;
- change water.

During washing machine maintenance works it is recommended to follow instructions of the washing machine producer.

In some cases, the only way to clean the glass may be washing in rinsing mode (with brushes fully withdrawn).

If necessary, for spot cleaning it is allowed to use clean, soft, lint-free wipes moistened with solution containing 50% of isopropyl or ethyl alcohol and 50% of distilled water. In this case the processor is to make sure that the solution and wipe does not leave any marks or streaks and the coating is not damaged in any way.

## 9. Thermal treating

Pilkington Suncool® and Optitherm® coated glass with designation ProT is specially designed for toughening, it is prohibited to use it without thermal treating.

Pilkington Suncool® coated glass with designation One, if necessary, can be thermally treated, following the processor's or customer's requirements.

During toughening process, the coating should always face upward to avoid touching the rollers and damaging the coating in the furnace.

It is recommended to use furnaces with convection heating. Non-uniform, excessive heating or cooling of the glass may result in flatness deviation, optical distortions, and high anisotropy. Thus, a sufficient number of tempering tests may be necessary to get the best settings for thermal treatment. In case of poor test results please address the technical support department of Pilkington Glass LLC to get help on the right settings.

During visual assessment of glass please follow the instructions for lighting and visual examination set out in chapter 10 of this manual.

During thermal treating it is recommended to take into account the orientation of the glass panes on the façade. It is advised to position the glass in the furnace so that possible roller waves will be installed on the façade horizontally.

During thermal treatment $SO_2$ (Sulphur Dioxide) is not to be used. The $SO_2$ supply must be stopped at least 24 hours prior to the heat treating.

It is recommended to do the first heat treating test of Pilkington Suncool® и Optitherm® coated glass together with the Pilkington technical staff.

## 10. External appearance

The processor should inspect visually the incoming Pilkington Suncool® and Optitherm® glass for any damage and breaches of the pack prior to acceptance and inform the Pilkington Glass LLC representative immediately in case if any defects are found.

Examination of the Pilkington Suncool® and Optitherm® coated glass quality between the production stages and in the final product should be done according to the following rules:

- Examination is done visually in transmitted or reflected diffused daylight or similar to it artificial light (without direct lighting). Lighting intensity should be within range of 300 to 600 lx.
- The observer should maintain a distance of 0,6 to 1 meter from the glass surface;
- During visual inspection the angle between the surface normal and the viewing point should be no more than 30°;
- Sizes and amount of the defects is defined according to the glass regulatory documentation.

Sometimes iridescence phenomena visible in a form of slight stripes or spot patterns of different colour may appear over the surface of tempered glass, especially noticeable at a sharp angle or in polarized light. They are caused by a nonhomogeneous distribution of the impressed prestressing of the glass panes due to uneven cooling. This phenomenon is called anisotropy and is not a defect. It is possible to control it by changing the tempering settings. Pilkington Glass LLC recommends to assess and control the anisotropy phenomenon appearance in the tempered glass.

During glass selection for a project it is strongly recommended to visually assess the appearance by installing full-size mock-ups from Pilkington Suncool® and Optitherm® glass on the façade. It is advised to repeat the assessment in different lighting conditions (in the morning, at midday, in the evening) and with different conditions inside the room (light-coloured room, dark-coloured room, lights on/off, etc…).

## 11. Heat Soak Test

Pilkington company recommends to do with tempered glass a heat soak test according to standard GOST EN 14179 – 1 - 2015 “Heat soaked thermally toughened glass. Technical requirements” using calibrated special equipment.

Heat Soak Test (HST) is done to minimize the probability of spontaneous breakage of tempered glass.

During heat soak test most of the glass contaminated with NiS inclusions is breaking inside the HST chamber.

There are additional risks of damaging the coating and glass during heat soak test:

- Mechanical damage to the equipment;
- Chips;
- Glass breakage.

To separate individual glass panes, it is necessary to select and use a material not leaving any traces on the glass and coating.

Recommendations during heat soak test:

- Individual glass panes should be placed in order from the biggest one to the smallest;
- Uncoated side of a glass pane should face the operator;
- The distance between the glass panes should allow for free uniform circulation of hot air;
- Minimal distance between the glass panes is 20mm;
- There should be no contact between the glass panes;
- Temperature sensors should be placed on uncoated side;
- HST should be done, if possible, on the same day as tempering;

Please take into account that additional washing before/after the test may be necessary;

Pilkington Glass LLC informs you that existing production technologies cannot exclude completely NiS contaminations in the glass, and, therefore the risk of spontaneous glass breakage is not excluded completely after the heat soak test.

## 12. Bending

Pilkington Suncool® and Optitherm® glass with ProT and One designation were designed to withstand a wide range of high temperatures. Nevertheless, the processor should do his own tests with minimal bending radius using full-size panes of glass to make sure that the coating does not get damaged in any way.

Glass bending is connected with risk of damaging the coating due to stretching or compression, that is why testing is necessary for each project and each coating type to define possible minimal bending radius.

## 13. Laminated glass production

Pilkington Suncool® and Optitherm® glass can be laminated. Remember that the coated side should always face outside the laminated glass (in position #4).

The polymer materials used in laminated glass can influence the colour, light transmittance and transparency of the final product, so it is recommended to pay attention to possible changes in the appearance.

Damaging of the coating by the vacuum bags or pressure rollers is possible during the production laminated glass.

Pilkington Glass LLC recommends to produce full-size mock-ups with the chosen materials with the chosen equipment for assessment of the final product appearance.

During Pilkington Suncool® and Optitherm® coatings development, the possibility of using them facing the interlayer (in position #2 or #3) was not researched, and

Pilkington does not recommend to use Suncool® and Optitherm® coatings in this manner.

If the processing company takes a decision to produce laminated glass with the coating facing the interlayer, it bears entire responsibility for this kind of application and should consider all possible negative consequences. The processor must on its own do all necessary tests regarding materials compatibility, longevity and durability of the laminated glass according to the local national standards. The laminated glass mount system should be designed in a way that prevents the coating corrosion and delamination. It is important to know that during laminated glass production with the coating facing the interlayer, thermal and physical characteristics are changing and colour shift is possible.

## 14. Enameling / silk screening

Pilkington Glass LLC does not recommend to put any paint on the coated side without prior coating removal.

If the processor has taken a decision to put a paint on the coating, precautions must be taken, as during thermal treatment the paint can react with the coating which may lead to the colour shift, partial or full coating destruction.

It is recommended to test compatibility of the paint and coating on full-size mock-ups using the actual production furnace and real temperature settings.

The processor is fully responsible for any consequences of such application of the coated glass and should do all necessary tests according to the local national standards and regulations. It is important to know that such applications will change thermal and physical characteristics of the coating and colour shift is possible.

## 15. Transportation

Any transportation of Pilkington Suncool® and Optitherm® soft-coated glass outside the production premises is connected with high risk of damaging the coating. Pilkington Glass LLC does not recommend to move soft-coated glass outside the production site.

If the processor decides to move the glass outside the production premises, the processor bears the fully responsibility for any consequences and should take all precautions to exclude damage of the coating on his own.

## 16. IG units production

Pilkington Suncool® and Optitherm® soft coating should always face the inner part of the IG unit.

During washing the glass prior to the IG units assembly, the processor must take precautions mentioned in a separate chapter above.

The coating edge-deletion instructions are also represented in a separate chapter

above.

After proper coating removal along the glass perimeter, most sealants' adhesion to the edge-deleted areas will be the same as the adhesion the ordinary non-coated glass. Quality of the coating removal should be checked both visually and by the adhesion tests, applicable to the sealants.

IG units should be hermetically sealed without interruptions, and reliably keep the gas and dried air inside the IG unit. Interruptions in the sealing will lead to the service life decrease and coating damage.

IG units design and assembly should be done according to the local national standards.

## 17. Confirmation

By signing this document, I confirm that this processing, transportation and storage manual has been fully read and understood. All items of the aforementioned manual are sufficiently clarified. All additional questions are properly replied.

# Coated glass processing

| | Emissivity $\varepsilon_n$ | Edge deleting | Heat treatment | Bending |
|---|---|---|---|---|
| **Suncool® series** | | | | |
| **Pilkington Suncool® 70/40** | 0.03 | △ | ⊗ | ⊗ |
| **Pilkington Suncool® 70/40** PRO T | 0.03 | △ | △ | nt |
| **Pilkington Suncool® 70/35** | 0.01 | △ | ⊗ | ⊗ |
| **Pilkington Suncool® 70/35** PRO T | 0.01 | △ | △ | nt |
| **Pilkington Suncool® 66/33** | 0.01 | △ | ⊗ | ⊗ |
| **Pilkington Suncool® 66/33** PRO T | 0.01 | △ | △ | nt |
| **Pilkington Suncool® 50/25** | 0.01 | △ | ⊗ | ⊗ |
| **Pilkington Suncool® 50/25** PRO T | 0.01 | △ | △ | nt |
| **Pilkington Suncool® 40/22** | 0.02 | △ | ⊗ | ⊗ |
| **Pilkington Suncool® 40/22** PRO T | 0.02 | △ | △ | nt |
| **Pilkington Suncool® 30/17** | 0.01 | △ | ⊗ | ⊗ |
| **Pilkington Suncool® 30/16** PRO T | 0.01 | △ | △ | nt |
| **Suncool®-R series** | | | | |
| **Pilkington Suncool®–R Silver 50/27** PRO T | 0.01 | △ | △ | nt |
| **Pilkington Suncool®–R Blue 50/25** PRO T | 0.01 | △ | △ | nt |
| **Pilkington Suncool®–R Bronze 45/25** PRO T | 0.01 | △ | △ | nt |
| **Pilkington Suncool®–R Green 45/25** PRO T | 0.01 | △ | △ | nt |
| **Suncool® One series** | | | | |
| **Pilkington Suncool® One 30/21** | 0.01 | △ | □ | nt |
| **Pilkington Suncool® One 60/40** | 0.01 | △ | □ | nt |
| **Optitherm® series** | | | | |
| **Pilkington Optitherm® S3** | 0.03 | △ | ⊗ | ⊗ |
| **Pilkington Optitherm® S3** PRO T | 0.03 | △ | △ | nt |

△ operation required
⊗ operation is prohibited
□ operation is possible
nt operation is possible, preliminary testing is required

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