EFFECTOR

# TECHNICAL CONDITIONS

OF INSULATING GLASS UNITS
AND SPECIAL GLASS
OFFERED BY EFFECTOR S.A.

**ISSUE No. 1**
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## 1. Subject of the criteria

The subject of these criteria are insulating glass units and special glass offered by Effector S.A. used in construction: installed in windows, doors, curtain and partition walls, in which there are protections of the edges against direct ultraviolet radiation and occurring in structural and semi-structural glazing.

Insulating glazing unit (IGU) is a unit consisting of at least two sheets of glass, separated by one or more spacers, hermetically sealed along the edge, mechanically stable and durable.

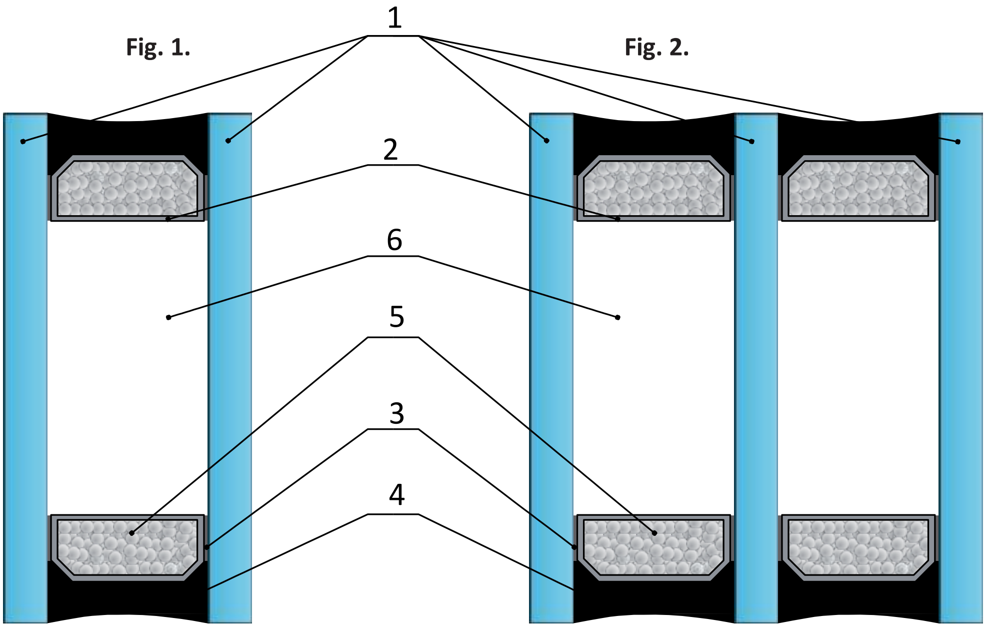



**Table 1 - List of components of the glazing unit (Fig. 1 and Fig. 2)**

| Element no. | Element name |
|---|---|
| **1** | Glass e.g.:<br>- float,<br>- float with low-emission coatings<br>- body tinted glass<br>- glass with reflective coatings<br>- laminated glass<br>- toughened glass<br>- toughened enamelled glass<br>- patterned glass<br>- wired glass<br>- matt glass |
| **2** | Spacer |
| **3** | Primary sealing: butyl |
| **4** | Secondary seal: polysulfide (thiocol), polyurethane, silicone |
| **5** | Molecular sieve (water vapour absorbent) |
| **6** | Gas filling in the inter-pane space (e.g. air, argon, krypton) |

### 1.1 Production capability

In accordance with Annex 1 - Production capabilities

## 2. Dimensional shapes and tolerances of insulating glass units

### 2.1 IGU thickness tolerances

The actual thickness is measured on the outer surfaces of the composite glass, at each corner and close to the centre points of the edges. The measurement should be made with an accuracy of 0.1 mm.

The thickness measurement should not differ from the nominal thickness (the sum of the thicknesses of the individual panes and frames) by more than the tolerances given in Table 2.

When using laminated glass (VSG) in IGU, it should be considered that the thickness of the VSG depends on the thickness of the component glass and the number of layers of film (a single layer of film is 0.38 mm thick).

**Examples:**

- VSG 33.1 is 6.38 mm thick
- VSG 33.2 is 6.76 mm thick
- VSG 44.2 is 8.76 mm thick
- VSG 44.4 is 9.52 mm thick

- IGU with a composition of 44.4/10/4 has a nominal thickness of 9.52+10+4= 23.52mm
- IGU with a composition of 44.2/12/4 has a nominal thickness of 8.76+12+4= 24.76mm
- IGU with a composition 33.2/12/33.2 has a nominal thickness of 6.76+12+6.76=25.52 mm

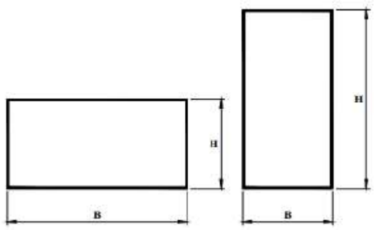
**Table 2 - Thickness tolerances of insulating glazing units**

| Glazing | Pane | IGU - thickness tolerance |
|---|---|---|
| double glazing (double glass unit) | All panes are annealed float glass | ± 1.0 mm |
| | At least one pane is laminated, patterned or not annealed glass | ± 1.5 mm |
| triple glazing (triple glass unit) | All sheets are annealed float glass | ± 1.4 mm |
| | At least one pane is laminated, patterned or not annealed glass | + 2.8 mm / -1.4 mm |
| *if one glass component has a nominal thickness greater than 12mm in the case of annealed or toughened glass, or 20mm in the case of laminated glass, the insulating glass unit manufacturer should be consulted. | | |

***Source: EN 1279-1:2018***

### 2.2 shapes and tolerances of IGU height and width

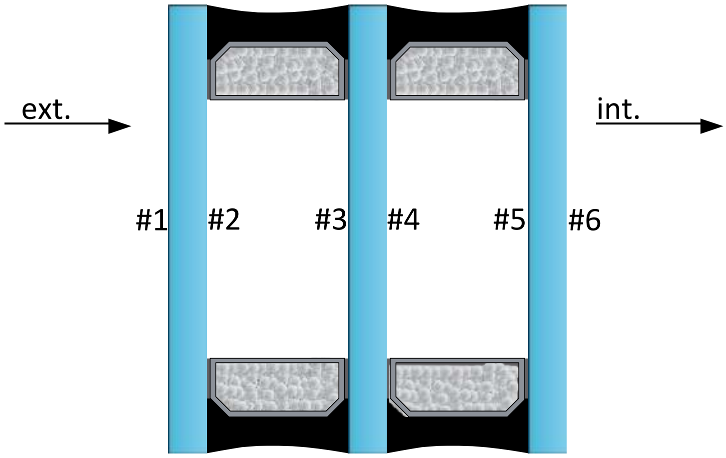
In the case of insulating dimensions of rectangular glass units, the order should first specify the dimension of width B, and then the dimension of height H, as shown in Fig. 3 (this is related to the position of the glass installation). The dimensions are given in millimetres.




Unless otherwise specified in the order, in the case of patterned glass with a clear directionality of the pattern, the direction of the pattern is taken along the height of pane H and item #2 (double glazing unit) or item #4 (triple glazing units).

When specifying the composition of the insulating glazing unit in the order, the pane located outside the room should always be defined first, and then the next components of the insulating glazing unit, specifying the thickness and types of component glasses as well as the width and type of the spacer.

In the case of glass with reflective coatings, the order indicates where the coating should be located (position), starting from the outside of the room. If this is not stated, the panes will be made with the coating at position 2.

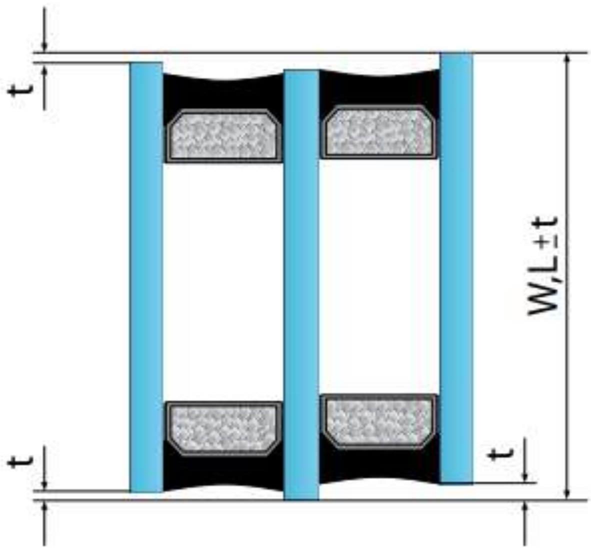



If there are no detailed arrangements between the IGU producer and the buyer, the maximum deviations of the width and height of rectangular glazing units are given in Table 3.

**Table 3 - Guidelines for dimension tolerances of insulating glass units**

| Double / Triple IGU | B and H tolerances | Edge offset [t] |
|---|---|---|
| all sheets ≤ 6 mm, and (B and H) ≤ 2000 mm | ± 2 mm | ≤ 2 mm |
| 6 mm < the thickest sheet ≤ 12 mm, or 2000 mm < (B or H) ≤ 3500 mm | ± 3 mm | ≤ 3 mm |
| 3500 mm < (B or H) ≤ 5000 mm and the thickest sheet ≤ 12 mm | ± 4 mm | ≤ 4 mm |
| 1 sheet > 12 mm, or (B and H)> 5000 mm | ± 5 mm | ≤ 5 mm |
| Thicknesses are nominal. | | |

***Source: EN 1279-1:2018***




In the case of IGUs with shapes other than rectangular, all dimensions must be specified in the order in accordance with the attached figures catalogue (Annex 2 - Figures catalogue).

In the case of IGUs with shapes other than those included in Annex 2 - Figures catalogue, contact the producer of insulating glass units.

If this is not indicated, it is assumed that the drawings on the order show the view of the figure from the room inside.

In justified cases, it is allowed to make glass units on the basis of the provided forms (using 1:1 scale) from plywood, board or hard cardboard. The accuracy of the glazing on the basis of the form is ±3 mm. It is mandatory to specify the view on the form.

The storage time of the forms is 2 weeks from the date of production. After this time, complaints about dimensions and shape will not be considered.

## 3. Spacersand sash bars in the inter-pane space

### 3.1 Spacers

Bent spacers (up to three connectors) and cut spacers (mounted with corners) are used. The permissible gap in the connection of the spacers must not be higher than 1mm.

For technological reasons, it is permissible to use manual gas filling sleeves in the spacer.

**Table 4 - Minimum bending radii for spacers**

| Type and width of spacer [mm] | Minimum bend radius [mm] |
|---|---|
| Aluminum, TGI, Chromatech Ultra, Chromatech Plus, Thermix | 115 |
| Swisspacer (SSP) | 200 |
| Steel | Not subject to bending |

### 3.2 Inter-panes muntins

a. inter-panes muntins can be used in glass with spacer widths of: 12, 14, 16, 18, 20 mm,
b. in the case of ordering glass with a muntin, when dimensioning the muntin mesh, the dimensions from the edge of the glass to the axis of the muntin and between the axes of the smuntin should be given,
c. the minimum distance from the edge of the glass to the axis of the muntin and between the axes of the muntin must be 80 mm,
d. if this is not indicated otherwise, it is assumed that the drawings on the order show the view of the figure from the room inside,
e. in the case of two-colour sash bar, if one side of the muntin is white, then, unless specified in the order, the white side is connected to the inside of the room,
f. in the case of Vienna muntin (duplex) in a triple glazing unit, the sash bar is mounted as standard in both chambers,
g. transparent spacers (teardrops, bumpons) are applied to the muntin to ensure:
   - the correct spacing between the muntin and the panes (at least 2 mm per side),
   - reduction of muntin vibration,
   - limiting the formation of the thermal bridge, with the proviso that it is not possible to completely eliminate the vibrations of the muntin and thus possible sound effects,
h. the number and arrangement of the teardrops can be subject to agreement between the IGU producer and the Recipient; if this is not specified in the order, the number and arrangement of the spacer teardrops are decided by the glass producer,
i. the visible raw material of the muntin within the cutting and milling is conditioned by the treatment and is acceptable,
j. the performance tolerance of the placement of muntin in the IGU is ± 2 mm,
k. it is not recommended to install sash bars in the panes if the windows are exposed to strong vibrations (e.g. from intensive car traffic), as this can cause increased vibrations of the muntin and the associated ringing effect.
l. the phenomenon of so-called "bell-ringing" is related to external factors, such as: weather conditions, wind pressure, pressure changes, building vibrations, traffic, etc. is a natural phenomenon and is not dependent on the technology of production of insulating glass units, thus it does not constitute a basis for the guarantee claims.

**Table 6 - Possibilities of connecting muntin of different widths**

| Basic muntin width [mm] | Possibility of connection with the muntin of different width |
|---|---|
| 8 | Impossible connection |
| 18 | 26 mm |
| 26 | 18 mm |
| 45* | 26mm |
| Blind muntin | Impossible connection |

* no possibility of cross connection of the 45mm muntin in renolite veneer

**Table 7 - Minimum bending radii for arch muntins**

| Muntin width [mm] | Minimum bend radius [ mm] |
| --- | --- |
| 8 | 70 |
| 18 | 180 |
| 26 | 200 |
| 45 | Not subject to bending |
| Blind muntin | Not subject to bending |

**4. Permissible dimensions of the glass units, depending on the thickness of the component glasses used and the width of the spacer.**

In accordance with Annex 3 – Permissible dimensions of glazing units

**5. Visual assessment of the quality of glass units**

In accordance with Annex 4 – Classification of defects of glass units

**6. Classification of defects of laminated glass**

In accordance with Annex 5 – Classification of defects of laminated glass

**7. Making holes, cuts and undercuts in glass**

In accordance with Annex 6 – Holes, cuts, undercuts

**8. Classification of defects of thermally toughened glass**

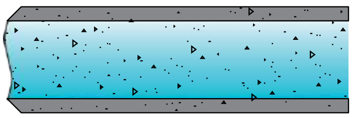
In accordance with Annex 7 – Classification of defects of laminated glass

**9. Classification of defects of enamelled glass.**

In accordance with Annex 8 – Classification of defects of enamelled glass

**10. Edge treatment.**

**Table 8 – Types of glass edge-work**

| of edge-work | Appearance of the | Description |
| --- | --- | --- |
| Arrised edge |  | The edges of the glass are blunted, without processing the corner and the front of the glass. Applies to: monolithic, laminated glass |
| Grinded edge |  | Head, smooth and matt edges with allowed glossy areas, without processing the corner. Applies to: monolithic, laminated glass |
| Polished edge |  | Head, smooth and glossy edges, without processing the corner. Applies to: monolithic, laminated glass |

Tolerances of edge working (tolerance of length of sides, diagonals) – as for glass after cutting

Quality of edge working – possible mutual differentiation of machined surfaces within the same type of processing, not subject to complaint

**11. Optical and visual quality of glass**

There can be some physical phenomena that are visible on the surface of the glass and should not be considered when assessing the visual quality of the glazing units. They are not considered as defects.

**1. Integral colour**

Differences in colour impression are possible due to: iron oxide content in the glass, the process of applying coatings, the coating itself, the change in glass thickness and the structure of the anastomosis, and they cannot be avoided.

**2. Difference in colour of insulating glass unit**

Façades made of insulating glass units containing coated glass can have different shades of the same colour; a phenomenon that can be amplified when viewed at an angle. Possible causes of colour differences include slight differences in the colour of the substrate on which the coating is applied, and slight differences in the thickness of the coating itself.

**3. Brewster rims (strips) – interference effect**

These are colour disturbances in the form of multi-coloured lines or stripes located in different places on the surface of the insulating glass unit. The phenomenon is perceived as a variation in the intensity of colour zones, which change when there is pressure on the glass. This phenomenon is most visible when viewing the glass at an angle. The reason for this phenomenon is the interference of light occurring due to the parallelism and very small difference in the thickness of the glass components of the insulating glass, made of high quality float glass. This phenomenon is not a defect; it is intrinsically linked to the insulating glass structure, occurs randomly and cannot be avoided.

**4. Anisotropy**

In the process of thermal tempering, in the cross-section of the glass, areas with different stresses are produced. Stress areas produce a birefringence effect in the glass, visible in polarized light. When viewed in polarized light of thermally tempered soda-lime-silicate safety glass, the stress areas appear as coloured zones, sometimes called 'leopard spots'. Polarization of light occurs in normal daylight. The degree of polarization of light depends on the weather and the angle of the rays of the sun. The birefringence effect is more visible when viewed at an angle or through polarized glasses. Anisotropy is not a defect, but a visible effect.

**5. External condensation**

External condensation on the surface of the glass unit can occur inside and outside the building. Condensation inside the building is mainly due to the high humidity in the room and the low temperature outside. Kitchens, bathrooms and other rooms with high humidity are particularly susceptible to this phenomenon.

Condensation outside the building is mainly caused by night heat loss by infrared radiation of the outer surface of the glass, with a cloudless sky and high air humidity.

This phenomenon is not a defect of the insulating glass unit.

**6. Wettability of insulating glass units**

The wettability of the outer insulating surfaces of the glass units can vary depending on the imprints of rollers, labels, vacuum suction cups, residues of sealing materials, etc. generated in the production process of the base glasses and glass units. With damp surfaces of the glass units (e.g. during rain), different wettability can be visible in the form of clear stains that disappear after the glass has dried. This phenomenon is not a defect of the insulating glass unit.

**7. Multiple reflections**

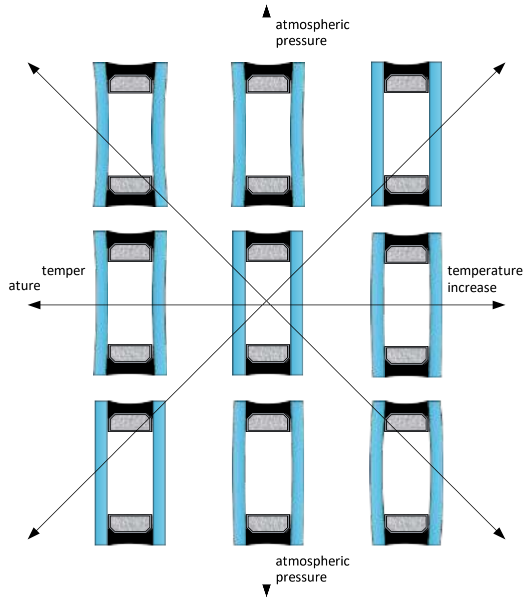
Multiple reflections of varying intensity can occur on the surface of the glass units. These reflections are particularly visible if the background viewed by the connection is dark. This phenomenon is a physical property of IGU.

**8. Glass deflection due to changes in temperature and atmospheric pressure**

Changes in temperature in the inter-pane space filled with air or gas and changes in atmospheric pressure and height affect the compression and expansion of air or gas in the inter-pane space, as a result of which the glass surfaces bend, causing distortions of the reflected images.

The size of the deflection depends on the stiffness and size of the glass sheets, as well as on the width of the inter-pane space. Small dimensions, thick panes and small inter-pane spaces significantly reduce deflections.

These deflections and the resulting distortions cannot be prevented because they change over time. They do not constitute a defect of the insulating glass unit, provided that the glass components are not in contact with each other.



**12. Types and causes of glass damage**

In accordance with Annex 9 – Types and causes of glass damage.

**13. Marking**

Insulating glass units produced by Effector S.A. have a permanent marking on the spacer containing at least:

- CE mark,
- name of the producer,
- production date.

**14. Storage and glazing**

- Insulating glass units should be stored in covered, dry, airy and weather-protected rooms, at a temperature not exceeding 40°C.
- The glass units should be placed on metal or wooden racks of type L, A or C. All metal parts of the rack that come into contact with the glass should be lined with rubber, felt or other shock-absorbing material. The panes should be placed at an angle of 5-6° from the vertical on a base perpendicular to the plane of the glass (the base of the stand must create a right angle with the support).
- Each pane should be separated by a spacer made of soft material, e.g. cork or cardboard. The panes should be protected against sliding.
- Glasses placed on racks on construction sites (during glazing) should be protected against direct sunlight by covering with tarpaulin, black foil, etc. This eliminates the risk of thermal breaks.
- Another way of storing the glass is permissible after agreement between the supplier and the recipient, provided that the protection of the glass is not inferior to the one described above.
- The supplier is not liable for defects resulting from improper storage.
- Glazing of insulating glass units should take place at a minimum temperature of 12°C and a maximum of 40°C, after at least one hour of glazing in this temperature range.

**15. Using and maintenance**

In accordance with Annex 10 – Using and maintenance

**16. General information**

Glazing units are produced in two production plants:

| | | |
|---|---|---|
| Zakład Produkcyjny<br>Szyby Zespolone i Obróbka Szkła ła<br>ul. Gen. Hauke-Bosaka 2,<br>25-214 Kielce | and | Zakład Produkcyjny<br>Szyby Zespolone i Obróbka Szkła<br>Wędkowy,<br>83-115 Swarożyn |

Both plants are equipped with connection lines with LISEC gas presses and produce in the same technology using the same component materials.

Declarations of Performance and held Test Certificates and are available on the website: www.effector.pl

# ANNEXES

# OF TECHNICAL CONDITIONS
# OF INSULATING GLASS UNITS AND SPECIAL GLASS
# PRODUCED BY EFFECTOR S.A.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ISSUE DATE: 04.2023

# Annex no. 1 to the TC

# PRODUCTION CAPABILITIES

| | INSULATING GLASS UNITS – DIMENSIONS | |
|---|---|---|
| 1 | Minimum dimension of the glass unit | 250 x 200 mm |
| 2 | Maximum size of a double glass unit: | |
| 3 | ESG6/16Ar/ESG6 | 2700 x 2590 mm or 3500 x 2000 mm |
| 4 | ESG8/16Ar/ESG8 | 3500 x 2800 mm or 5000 x 2000 mm |
| 5 | ESG10/16Ar/ESG10 | 5000 x 2400 mm or 4280 x 2800 mm |
| 6 | Maximum dimension of the double glass unit: | |
| 7 | ESG6/16Ar/ESG6/16Ar/ESG6 | 2700 x 2590 mm or 3500 x 2000 mm |
| 8 | ESG8/16Ar/ESG8/16Ar/ESG8 | 4000 x 2500 mm or 5000 x 2000 mm |
| 9 | ESG10/16Ar/ESG10/16Ar/ESG10 | 5000 x 2000 mm |
| 10 | Other combinations of connections with the change of any of the glasses to thicker ones | Individual consultations |

| | INSULATING GLASS UNITS AND SINGLE GLASS – THICKNESSES AND WEIGHTS | |
|---|---|---|
| 1 | Maximum weight of the glass unit | 750 kg |
| 2 | Maximum weight of the central and one lighter outer glass in the insulating glass unit | 100 kg/lm |
| 3 | Maximum weight of a single piece of glass to be insulated | 150 kg/lm |
| 4 | Maximum weight of the insulating glass unit | 250 kg/lm |
| 5 | Maximum thickness of the insulating glass unit | 100 mm |
| 6 | Maximum thickness of the triple glass unit | 80 mm |
| 7 | Maximum thickness of a single glass to be insulated | 26 mm |

| | TOUGHENED GLASS – DIMENSIONS AND WEIGHTS | |
|---|---|---|
| 1 | Minimum dimension of toughened glass | 350 x 180 mm |
| 2 | Maximum dimension of toughened glass/ maximum weight | 6000 x 2800 mm / 300 kg |
| 3 | Toughening of glass in thicknesses | 4 – 19 mm |

| | ENAMELLED TOUGHENED GLASS – DIMENSIONS AND WEIGHTS | |
|---|---|---|
| 1 | Minimum dimension of enamelled toughened glass | 350 x 180 mm |
| 2 | Maximum dimension of enamelled toughened glass / maximum weight | 3500 x 1780 mm / 130 kg |
| 3 | Enamelling of glass in thicknesses | 5 – 19 mm |

| | GLASS FOR EDGE WORKING – DIMENSIONS , THICKNESSES AND WEIGHTS | |
|---|---|---|
| 1 | Minimum dimension of glass for edge working | 350 x 180 mm |
| 2 | Maximum dimension of glass for edge working / maximum weight | 6000 x 3000 mm / 800 kg |
| 3 | Minimum dimension of glass for processing (holes, cuts, undercuts) | 550 x 200 mm |
| 4 | Maximum dimension of glass for processing (holes, cuts, undercuts) / maximum weight | 6000 x 3000 mm / 800 kg |
| 5 | Glass processing in thicknesses | 4 – 19 mm |
| 6 | Possibility to grind and grind with polishing of non-rectangular glass | Consultation necessary |
| 7 | Possibility of blunting of non-rectangular glass | Shapes from the LISEC catalogue |

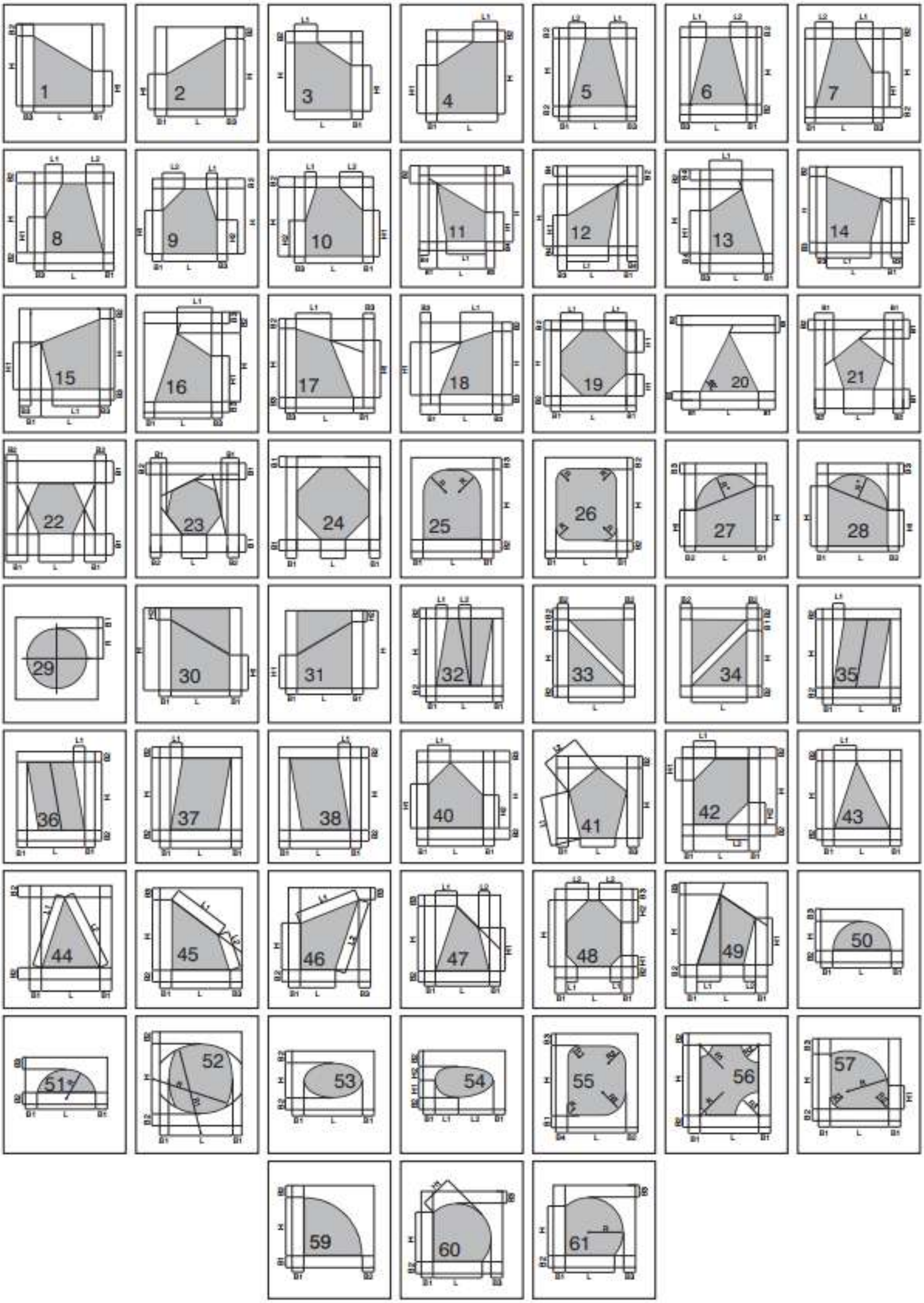
| | LAMINATED GLASS – THICKNESSES AND WEIGHTS | |
|---|---|---|
| 1 | Minimum dimension of laminated glass produced by Effector | 400 x 200 mm |
| 2 | Maximum dimension of laminated glass produced by Effector / maximum weight (at the thickness of laminate up to 70mm) | 5100 x 2600mm / 800kg |
| 3 | Maximum thickness of laminated glass produced by Effector | 100 mm |
| 4 | Maximum thickness of cut laminated glass | 18mm (88.4) |

| | HEAT-STRENGTHENED - THICKNESSES | |
|---|---|---|
| 2 | Thickness of semi-tempered heat-strengthened coated glass | 6 mm |

| | INSULATING GLASS UNITS (WHEEL SHAPE) - DIMENSIONS | |
|---|---|---|
| 1 | Maximum dimension of the wheel-shaped glazing unit | r = 600mm |
| 2 | Minimum dimension of the wheel-shaped glazing unit | see frame bending radii (table no. 4) |

# Annex no. 2 to the TC Shapes catalogue





# PERMISSIBLE DIMENSIONS OF INSULATING GLASS UNITS

**ISSUE DATE: 04.2023**

**Insulating glaSS units – double glaSS units (two sheets of glass)**

| Connection of glass/frame/glass | Maximum area (m²) | Maximum side length (mm) | Minimum distance between panes (mm) | Maximum ratio of the length of the sides | Maximum dimensions (mm x mm) | Maximum square dimensions (mm x mm) | Maximum dimensions for toughened glass (mm x mm) |
|---|---|---|---|---|---|---|---|
| 3/10-24/3 | 1.50 | 1500 | 10 | 1:6 | 1500 x 1000 | 1220 x 1220 | 1500 x 1000 |
| 4/10/4 | 2.50 | 2500 | 10 | 1:6 | 2500 x 1000 | 1700 x 1700 | 2500 x 1000 |
| 4/12-24/4 | 3.35 | 2500 | 12 | 1:6 | 2500 x 1340 | 1700 x 1700 | 2500 x 1340 |
| 5/10/5 | 3.50 | 3000 | 10 | 01:10 | 3000 x 1160 | 2000 x 2000 | 3000 x 1160 |
| 5/12-24/5 | 5.00 | 3300 | 12 | 01:10 | 3300 x 1510 | 2000 x 2000 | 3300 x 1510 |
| 6/10/6 | 4.50 | 3000 | 10 | 01:10 | 3000 x 1500 | 2400 x 2400 | 3000 x 1500 |
| 6/12-24/6 | 7.00 | 3500 | 12 | 01:10 | 3500 x 2000 | 2400 x 2400 | 3500 x 2000 |
| 8/10/8 | 6.00 | 3000 | 10 | 01:10 | 3000 x 2000 | | 3000 x 2000 |
| 8/12-15/8 | 8.75* | 3500 | 12 | 01:10 | 3500 x 2500 | | 3120 x 2800 |
| 8/16-24/8 | 10.00* | 5000 | 16 | 01:10 | 5000 x 2000 | | 3500 x 2800 |
| 10/16-24/10 | 12.00* | 5000 | 16 | 01:10 | 5000 x 2400 | | 4250 x 2800 |

**Insulating glass units – triple glass units (three sheets of glass)**

| Composition of glass/frame/glass/frame/glass | Maximum area (m²) | Maximum side length (mm) | Minimum distance between panes (mm) | Maximum ratio of the length of the sides | Maximum dimensions (mm x mm) | Maximum square dimensions (mm x mm) | Maximum dimensions for toughened glass |
|---|---|---|---|---|---|---|---|
| 3/10-24/3/10-24/3 | 1.50 | 1500 | 10 | 1:6 | 1500 x 1000 | 1220 x 1220 | 1500 x 1000 |
| 4/10/4/10/4 | 2.50 | 2500 | 10 | 1:6 | 2500 x 1000 | 1700 x 1700 | 2500 x 1000 |
| 4/12-24/4/12-24/4 | 3.35 | 2500 | 12 | 1:6 | 2500 x 1340 | 1700 x 1700 | 2500 x 1340 |
| 5/10/5/10/5 | 3.50 | 3000 | 10 | 01:10 | 3000 x 1160 | 2000 x 2000 | 3000 x 1160 |
| 5/12-24/5/12-24/5 | 5.00 | 3300 | 12 | 01:10 | 3300 x 1510 | 2000 x 2000 | 3300 x 1510 |
| 6/10/6/10/6 | 4.50 | 3000 | 10 | 01:10 | 3000 x 1500 | 2400 x 2400 | 3000 x 1500 |
| 6/12-24/6/12-24/6 | 7.00 | 3500 | 12 | 01:10 | 3500 x 2000 | 2400 x 2400 | 3500 x 2000 |
| 8/10/8/10/8 | 6.00 | 3000 | 10 | 01:10 | 3000 x 2000 | | 3000 x 2000 |
| 8/12-15/8/12-15/8 | 8.75* | 3500 | 12 | 01:10 | 3500 x 2500 | | 3120 x 2800 |
| 8/16-24/8/16-24/8 | 10.00* | 5000 | 16 | 01:10 | 5000 x 2000 | | 3500 x 2800 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10/16-24/10/16-24/10 | 10.00* | 5000 | 16 | 01:10 | 5000 x 2000 | | 3500 x 2800 |

**Notes to the table:**

1. The data contained in the table are given with the following assumptions:
   - wind load was adopted as the average typical load occurring in Poland,
   - vertical glazing,
   - wedging on four sides within the frame,
   - glazing height from 0 to 8 m above the ground surface; glazing above 700 m above sea level is not recommended.
   - does not apply to glazing the corners of the building.

2. When using component glass of different thicknesses in the glass unit, the permissible dimensions of the insulating glass are determined by the glass of a smaller thickness.

3. In the case of spacers wider than 16 mm, the permissible dimensions of glass units as in the case of glass units with spacers with a width of 16 mm are adopted.

4. In the case of spacers narrower than 10 mm, it is necessary to additionally consult the technical possibilities of manufacturing the insulating unit (possibilities conditioned by the dimensions of the glass unit and the thickness of the component glasses).

5. When converting the thickness of laminated glass to the thickness of float glass, a coefficient of 0.63 is used.

6. For insulating **glass units using glass of a thickness of 4 mm**, the maximum dimensions of a shape similar to a square is 1700 × 1700 or above both of these dimensions and the difference between the lengths of the sides is ≥ 100 mm.

7. For insulating **glass units using glass of a thickness of 6 mm**, the maximum dimensions of a shape similar to a square is 2400 × 2400 or above both of these dimensions and the difference between the lengths of the sides is ≥ 100 mm (for spacers from 12 to 24 mm).

8. **In the case of insulating glass units with a side length of more than 3500 mm and/or a total area of more than 7 m$^2$, it is necessary to use toughened glass (*mandatory toughening).**

If any of the above assumptions is not met, individual calculations are required to determine the thickness and type of glasses used.

**Selection of glass to be used**

Effector S.A. produces insulating glass units based on the guidelines of standards for the production of glass units, toughened and laminated glass:

- PN-EN 1279-1 “Glass in Building - Insulating glass units - Part 1: Generalities, system description, rules for substitution, tolerances and visual quality”
- PN-EN 12150-1 “Glass in building - Thermally toughened soda lime silicate safety glass - Part 1: Definition and description”
- PN-EN 14449 “Glass in building - Laminated glass and laminated safety glass - Evaluation of conformity/Product standard”

**Effector S.A. informs that each time the selection of the glazing for a given structure or facility is the responsibility of the ordering party and should result from the assumptions and calculations already adopted at the design stage, taking into account, among others: the location and the resulting wind load, the load on the structure, exposure to high temperatures and related thermal analyses, the size of the glazing, methods of installation, or the use of materials that are in the area or in direct contact with the glazing and can affect interactions through, for example, vapour migration.**

**Effector S.A. informs that each time on request it can provide information about the materials included in the insulating glass units, based on their safety data sheets.**

**Effector S.A. assumes that the ordering party has made all required calculations of the strength of the ordered products and verified information regarding material compatibility.**

**Effector S.A. is not responsible for the correct selection of the glass structure and its dimensions, thickness and type of glass used, to the place, conditions and method of use.**

# Annex no. 4 to the TC

## CLASSIFICATION OF DEFECTS OF INSULATING GLASS UNITS

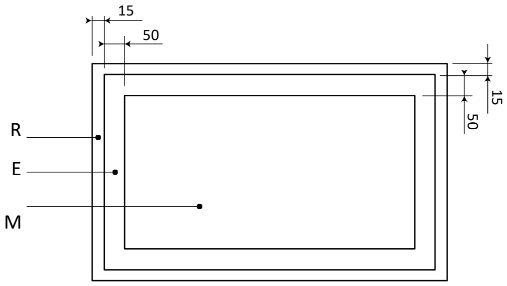
**ISSUE DATE: 04.2023**

The basis for the assessment of the quality of the glazing units are the provisions of the PN-EN 1279-1:2018 standard and internal documents of Effector S.A.

### 1. Observation conditions

The glazing should be assessed under passing light conditions and not under reflected light conditions.
Insulating glass units should be observed at a distance of not less than 3 m from the inside to the outside and at an observation angle as perpendicular to the glass surface as possible, for up to one minute per $m^2$.
The assessment is carried out under diffuse daylight conditions (e.g. cloudy skies), without direct sunlight or artificial lighting. Defects should not be marked on the pane.
Insulating glass units assessed from the outside should be assessed under installation conditions, considering a standard observation distance of at least 3 meters. The viewing angle of the observation should be as perpendicular as possible to the glass surface.

**The observation zones are defined in Figure 1.**




**Legend:**

**R** – 15mm edge zone, usually covered with a frame or corresponding to the sealing of the rim in the case of an unframed edge

**E** – edge zone, on the edge of the visible area width 50mm

**M** – main zone

**Insulating glass units made of two sheets of monolithic glass**

| PERMISSIBLE NUMBER OF SPOT DEFECTS (e.g. blisters, stones, "grains", lack of coating) | | | | | |
|---|---|---|---|---|---|
| ZONE | Defect dimension (no halo) Ø in mm | S-pane area ($m^2$) | | | |
| | | S ≤ 1 | 1 < S ≤ 2 | 2 < S ≤ 3 | 3 < S |
| R | All dimensions | No defects limit | | | |
| E | Ø ≤ 1 | Acceptable if less than 3 pcs. per each area Ø ≤ 20cm | | | |
| | 1 < Ø ≤ 3 | 4 pcs. | 1 pc. per each meter of perimeter | | |
| | Ø > 3 | Unacceptable | | | |
| L | Ø ≤ 1 | Acceptable if less than 3 pcs. per each area Ø ≤ 20cm | | | |
| | 1 < Ø ≤ 2 | 2 pcs. | 3 pcs. | 5 pcs. | 5 pcs. + |
| | Ø > 2 | Unacceptable | | | |

| PERMISSIBLE DIRT AND/OR STAINS (e.g. dirt, stains etc., after the production process) | | | |
|---|---|---|---|
| ZONE | Defect dimension and type Ø | S-pane area ($m^2$) | |
| | | S ≤ 1 | 1 < S |
| R | All dimensions | No defects limit | |
| E | Dots Ø ≤ 1 | No defects limit | |
| | Dots 1 < Ø ≤ 3 | 4 pcs. | 1 pc. per each meter of |
| | Stain Ø ≤ 17 | 1 pc. | |
| | Dots Ø > 3 and Spot Ø > 17 | Maximum 1 pc. | |
| L | Dots Ø ≤ 1 | Acceptable if less than 3 pcs. per each area Ø ≤ 20cm | |
| | Dots 1 < Ø ≤ 3 | Maximum 2 pcs. per each area Ø ≤ 20cm | |
| | Dots Ø > 3 and Spot Ø > 17 | Unacceptable | |

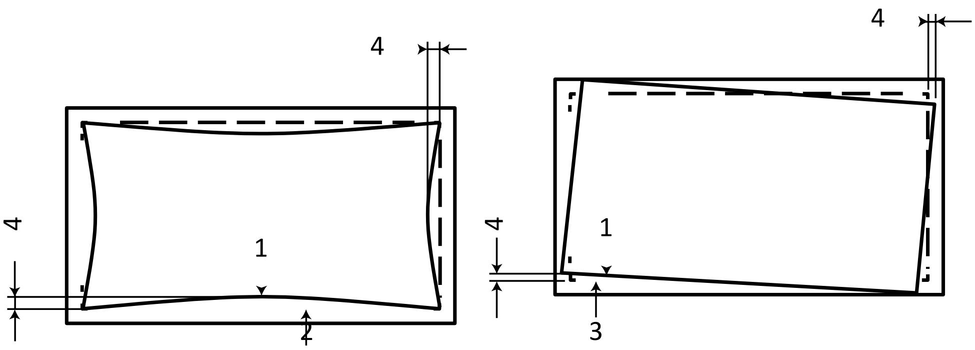
| PERMISSIBLE NUMBER OF LINEAR/EXTENDED DEFECTS (e.g. capillary scratches ≤ 0.15 mm thick; normal scratches) | | | |
|---|---|---|---|
| ZONE | Type of defect | Individual lengths (mm) | Sum of individual lengths (mm) |
| whole area | Capillary scratches ≤ 0.15 mm | Unlimited | |
| R | Other linear/elongated defects | Unlimited | |
| E | | ≤ 30 mm | ≤ 90 |
| L | | ≤ 15 mm | ≤ 45 |

**Insulating glass units other than of two sheets of monolithic glass**

The permissible number of defects is increased by 25% for each additional glass component (e.g. triple glass unit – x 1.25) Defects smaller than 0.5mm are not considered during the visual assessment (they are not visible from 3 lm)

## TOLERANCATION ON SPACER STRAIGHT LINE

In the case of double glass unit, the tolerance to the straightness of the spacer is 4 mm to 3.5 m long and 6 mm for larger lengths. The permissible deviation of the spacer in relation to the parallel straight edge of the glass or to other spacers (e.g. in triple connection) is 3 mm for edge lengths up to 2.5 m. For larger edge lengths, the permissible deviation is 6 mm.




**Definitions of defects:**

**Spot defect:** spherical or semi-spherical interference with visual transparency when viewed through glass.

**Halo:** locally distorted area, usually around the spot defect when the defect is in the glass sheet.

**Residue (dirt):** a residue is a material that remains on the surface of the glass, which can be in the form of a dot or stain.

**Stain:** a defect larger than a spot defect, often of irregular shape, partly with a mottled structure.

**Linear / longitudinal defects:** defects that can be on or in the glass, in the form of deposits, stains or scratches that cover a larger length or elongated area.

**Visual aspects of insulating glass units** - They are not considered when assessing the visual quality. They do not constitute a defect.

**Integral colour** - Differences in colour impression are possible due to: iron oxide content in the glass, the process of applying coatings, the coating itself, the change in glass thickness and the structure of the anastomosis, and they cannot be avoided.

**Difference in the colour of the insulating glass unit** - Façades made of insulating glass units containing coated glass can have different shades of the same colour; a phenomenon that can be amplified when viewed at an angle. Possible colour differences include slight differences in the colour of the substrate on which the coating is applied, and slight differences in the thickness of the coating itself, and are permissible if they meet the GEPVP criteria for measuring and assessing the colour of the glass.

**Interference effect** – In the case of insulating glazing units made of float glass, the phenomenon of interference can cause the appearance of spectral colours. Optical interference is caused by the superposition of two or more light waves at one point. The phenomenon is perceived as a variation in the intensity of colour zones, which change when there is pressure on the glass. This physical phenomenon is enhanced by the parallelism of the glass surface. The phenomenon of interference occurs randomly and cannot be avoided.

**Specific effect due to barometric conditions** – Insulating glass unit contains a volume of air or other gas, hermetically sealed by sealing the rim. The state of the gas is essentially determined by the altitude, barometric pressure and air temperature, at the time and place of production. If the insulating glass unit is installed at a different altitude or when the temperature or barometric pressure (higher or lower pressure) changes, the glazing units will deflect inwards or outwards, causing optical distortion.

**Anisotropy** - In the process of thermal tempering, in the cross-section of the glass, areas with different stresses are produced. Stress areas produce a birefringence effect in the glass, visible in polarized light. When viewed in polarized light of thermally tempered soda-lime-silicate safety glass, the stress areas appear as coloured zones, sometimes called 'leopard spots'.
Polarization of light occurs in normal daylight. The degree of polarization of light depends on the weather and the angle of the rays of the sun. The birefringence effect is more visible when viewed at an angle or through polarized glasses. Anisotropy is not a defect, but a visible effect.

**Condensation on the outer surface of the insulating glazing unit** – Condensation can occur on the outer glass surfaces when the glass surface is colder than the adjacent air. The intensity of condensation on the outer surfaces of the pane depends on the value of U, air humidity, air movement and internal and external temperature. When the relative humidity of the environment is high and the pane surface temperature falls below the ambient temperature, condensation occurs on the glass surface.

**Wettability of glass surfaces** – The appearance of glass surfaces can vary due to the influence of rollers, fingerprints, labels, suction cups, sealant residues, silicone compounds, smoothing agents, lubricants, environmental influences, etc. This can be seen when the glass surfaces are wet from condensation, rain or cleaning water.

**Thermal breaks** - Breaks caused by thermal stress appear in the case of sudden changes in the temperature of the glass. The risk of thermal breaks increases in installations where there is a large partial shading (e.g. through curtains, blinds, posters, furniture, stickers, etc.). Thermal breaks can also occur when glass units stored on racks are exposed to direct sunlight.

## Annex no. 5 to the TC

## CLASSIFICATION OF DEFECTS OF LAMINATED GLASS

**ISSUE DATE: 04.2023**

**PRINCIPLES FOR THE ASSESSMENT OF LAMINATED GLASS**

The basis for the assessment of the quality of the laminated panes are the provisions of PN- EN 12543-6:2022 standard and internal documents of Effector S.A.

The laminated glass to be tested shall be positioned vertically, opposite and parallel to the frosted grey screen and illuminated with diffuse or equivalent light.

The laminated glass is visually checked, in a direction perpendicular to the glass, with a matt screen on the other side of the glass.

**DEFECTS IN THE VISIBLE AREA (visible area – the main area of the glass, without the rim area)**

| TYPES OF DEFECTS | OCCURRENCE OF DEFECTS IN THE LAMINATED GLASS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Vent**<br>(sharply terminated gap or rupture from rim to glass) | unacceptable | | | | | | | |
| **Folds and streaks**<br>(distortion introduced into the interlayer in the form of a fold visible after | unacceptable | | | | | | | |
| **Point defects**<br>(defects involving opaque spots, bubbles and foreign matter) | dimension of the sheet ≤ 1 m² | | dimension of the sheet > 1 m² ≤ 2 m² | | dimension of the sheet > 2 m² ≤ 8 m² | | dimension of the sheet > 8 m² | |
| ≤ 0.5 mm | permissible | | permissible | | permissible | | permissible | |
| > 0.5mm ≤ 1.0mm | acceptable but not concentrated* | | acceptable but not concentrated* | | acceptable but not concentrated* | | acceptable but not concentrated* | |
| > 1.0mm ≤ 3.0mm | 2 sheets | 1 pc. | 2 | 2 pcs. | 2 | 1/m² | 2 | 1.2/m² |
| | 3 sheets | 2 pcs. | 3 | 3 pcs. | 3 | 1.5/m² | 3 | 1.8/m² |
| | 4 sheets | 3 pcs. | 4 | 4 pcs. | 4 | 2/m² | 4 | 2.4/m² |
| | ≥5 sheets | 4 pcs. | ≥5 | 5 pcs. | ≥5 | 2.5/m² | ≥5 | 3/m² |
| > 3.0 mm | unacceptable | | unacceptable | | unacceptable | | unacceptable | |

| **Linear defects**<br>(defects involving foreign matter and scratches or scrapes) | dimension of the sheet ≤ 5 m² | dimension of the sheet > 5 m2 ≤ 8 m² | dimension of the sheet > 8 m² |
|---|---|---|---|
| with length of ≤ 30 mm | permissible | permissible | permissible |
| with length of > 30 mm | unacceptable | 1 pc. | 2 pcs. |

**DEFECTS IN THE RIM AREA (the area that is usually located in the glazing system)**

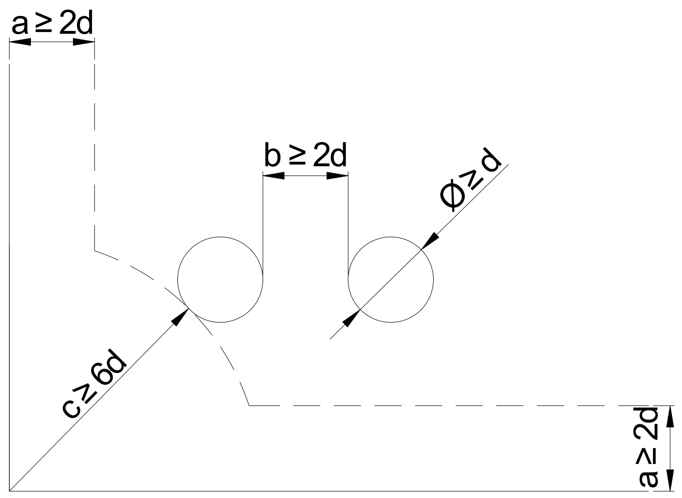
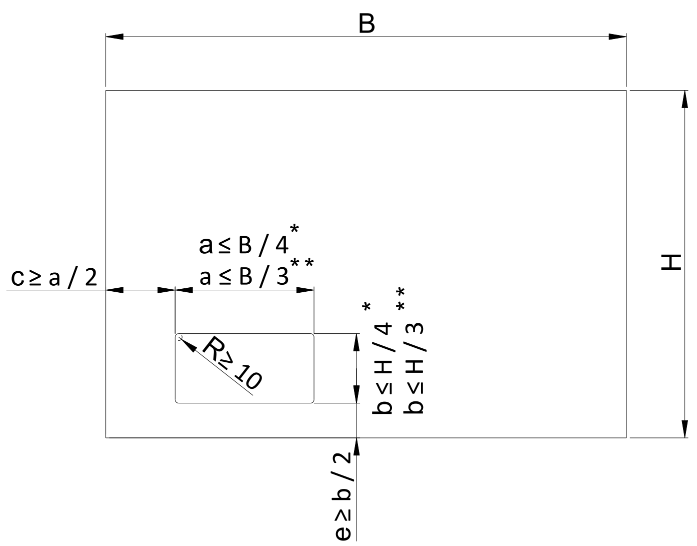
| **Rim width**<br>**For sheets ≤ 5 m2 – 15 mm rim**<br>**For sheets > 5 m2 – 20 mm rim** | Framed rim | Unframed rim |
|---|---|---|
| Diameter ≤ 5 mm or 5% of rim area | permissible | unacceptable |
| Chips and bubbles | permissible | permissible<br>if they do not catch your |
| Interlayer extrusions and retractions | permissible | permissible |

Legend[*]:

A defect concentration occurs when at least four defects are < 200mm apart. This distance is reduced to 180 mm for laminated glass consisting of three sheets, to 150 mm for laminated glass consisting of four sheets and to 100 mm for laminated glass consisting of five or more sheets.

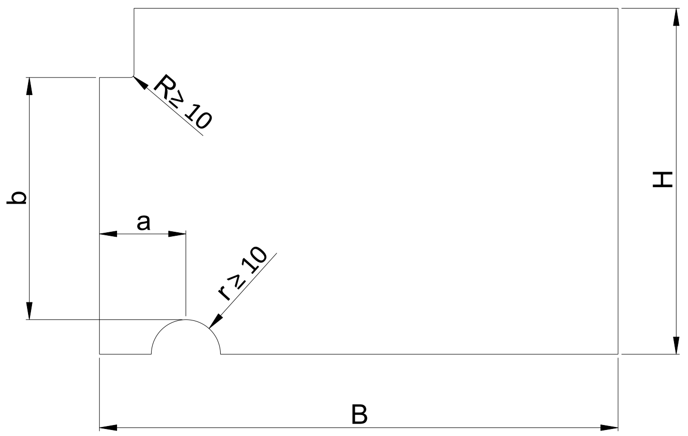
## Annex 6 to TC
# HOLES, CUTS, UNDERCUTS

**ISSUE DATE: 04.2023**

| LEGEND | REQUIREMENTS | DESCRIPTION |
|---|---|---|
| **Making round holes according to PN-EN 12150-1:2015** | | |
| **d** – nominal glass thickness<br>**Φ** – hole diameter<br>**a** – distance of the hole rim from the glass rim<br>**b** – distance between the rims of two holes<br>**c** – distance of the hole rim from the pane corner |  | The hole diameter, **Φ**, should be no less than the nominal glass thickness.<br><br>It is recommended that the distance, **a,** of the hole rim from the glass rim is not less than **2d**.<br><br>It is recommended that the distance, **b**, between the rims of two holes is not less than **2d**.<br><br>It is recommended that the distance, **c**, of the hole rim from the pane corner is not less than **6d**. |
| **Making other holes - cuts** | | |
| **B** – glass width<br>**H** – glass length<br>**a** – hole width<br>**b** – hole height<br>**c**, **e** – distance of the hole rim from the glass rim<br>**R** – hole rounding radius<br>**d** – nominal glass thickness |  | * for **d** < 8 mm<br>** for **d** ≥ 8 mm<br><br>The corner of cuts should be rounded off. |

## Making cuts, undercuts in edges

**B** – glass width
**H** – glass length
**R** – cut rounding radius
**r** – cut radius
**a** – distance of cu middle from the glass rim
**b** – distance between two opposite cuts




The corner of cuts, undercuts should be rounded off.

b : B = 1:10 max

| r [mm] | a [mm] |
|---|---|
| 20 | 90 |
| 25 | 95 |
| 30 | 100 |
| 35 | 110 |
| 40 | 120 |

## Diameter tolerances for round holes

| Nominal hole diameter Φ [mm] | Tolerances [mm] |
|---|---|
| 4 ≤ Φ ≤ 20 | ± 1.0 |
| Φ > 20 | ± 2.0 |

## Holes position tolerances

| Nominal glass thickness d [mm] | Tolerances [mm] |
|---|---|
| d ≤ 8 | ± 2.0 |
| d > 8 | ± 3.0 |

## Dimension tolerance

| Nominal dimension [mm] | Tolerance [mm] | |
|---|---|---|
| | Nominal glass thickness d ≤ 8 | Nominal glass thickness d > 8 |
| dimension ≤ 2000 | ± 2.0 | ± 3.0 |
| 2000 < dimension ≤ 3000 | ± 3.0 | ± 4.0 |
| dimension > 3000 | ± 4.0 | ± 5.0 |

# Annex no. 7 to the TC

# CLASSIFICATION OF DEFECTS OF THERMALLY TOUGHENED GLASS

**ISSUE DATE: 04.2023**

The basis for the assessment of the quality of the thermally toughened glass are the provisions of the PN-EN 12150-1 A1:2019 standard and internal documents of Effector S.A.

**1. Flatness**

The nature of the toughening process makes it impossible to obtain a product as flat as annealed glass. The difference in flatness depends on the type of glass, e.g. coated, etc., the dimensions of the glass, i.e. nominal thickness, dimensions and ratio between dimensions, and the tempering process used.

**There are six types of deformations:**

- **total convexity** - point 2
- **deformation in the form of corrugation made by rollers** (for horizontally tempered glass) - point 3
- deformation in the form of a wave from the air bag (for tempered glass on the air bag)
- **raised rim** (for horizontally tempered glass) – point 4
- rim deformation (for glass tempered on the air bag)
- local deformation (for vertically tempered glass)

**2. Total convexity**

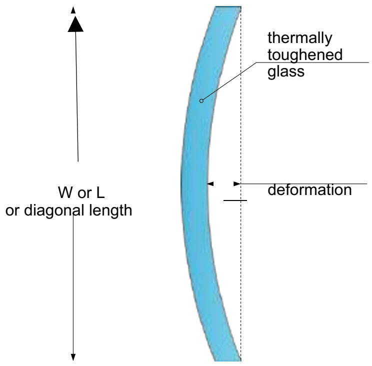
Deformation of the entire surface toughened glass caused by the heating and cooling process

**2.1. Total convexity measurement**

The pane should be placed in vertical position and its longer side should be supported on two load-bearing blocks placed at a distance of one quarter of the side length. For glass with a nominal thickness of less than 4 mm, the support will be at an angle between $3_{o}$ and $7_{o}$ to the vertical direction.

The deformation is measured along the glass rims and along the diagonals, as the maximum distance between a straight metal ruler or stretched wire and the concave surface of the glass.

The value of the convexity is therefore expressed, respectively, as a deformation, in millimetres, divided by the measured length of the edge of the glass or diagonal, in metres.




| Glass type | Maximum allowable deformation value |
|---|---|
| | Total convexity mm/m |
| Uncoated float glass according to EN 572-1 and EN 572- | 3.0 |
| Other* | 4.0 |

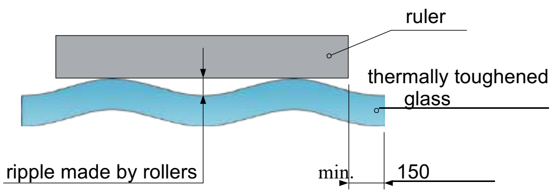
* For enamelled glass not coated with enamel on the entire surface, it is recommended to consult the producer

**3. Deformation in the form of ripple made by rollers**

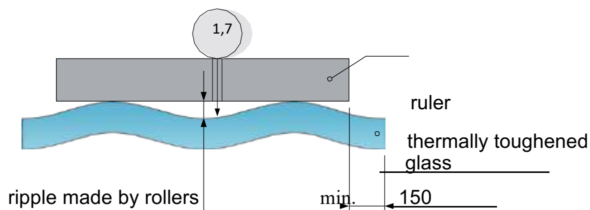
Deformation formed in toughened glass horizontally caused by contact of glass with rollers during the toughening process.

**3.1. Measurement of ripple and ripple made by rollers**

The ripple and ripple made by rollers is measured using a ruler and feeler gauge or an equivalent tool applied at right angles to the ripples or ripples made by rollers, connecting the ripple peaks with the bridge.




An alternative method of measuring the ripple made by rollers is to measure using an instrument with a centre-mounted deformation indicator - a clock/electronic sensor




The depth of ripple made by a roll is the difference between the zero point and the reading point.

Maximum admissible ripple value made by rollers:

| Glass type | Maximum allowable deformation value |
|---|---|
| | Ripple made by rollers mm |
| Uncoated float glass according to EN 572-1 and EN 572- | 0.3 |
| Other* | 0.5 |

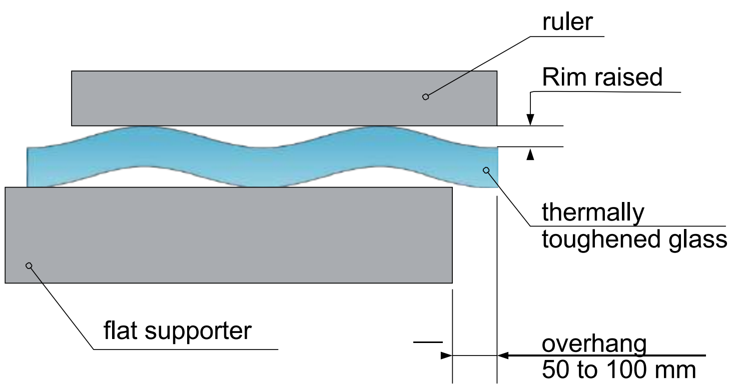
* For enamelled glass not coated with enamel on the entire surface, it is recommended to consult the producer

**4. Rim raised**

Deformation formed in horizontally-toughened glass, on the front and rear glass rim

**4.1. Raised rim measurement**

The glass should be placed on a flat support with the rim raised, protruding from 50mm to 100mm beyond the rim support. The ruler is placed on the peaks of ripple made by rollers, and the gap between the ruler and the glass is measured with a feeler gauge.




Maximum admissible deformation value in the form of raised rim:

| Glass type | Maximum allowable deformation value | |
|---|---|---|
| | Glass thickness in mm | Rim raised in mm |
| Uncoated float glass according to EN 572-1 and EN 572-2 | 3 | 0.5 |
| | 4 to 5 | 0.4 |
| | 6 to 25 | 0.3 |
| Other* | 3 to 19 | 0.5 |

* For enamelled glass not coated with enamel on the entire surface, it is recommended to consult the producer

**5. Optical deformation**

**5.1. Anisotropy (opalescence)**

In the process of thermal toughening, in the cross-section of the glass, areas with different stresses are produced. Stress areas produce a birefringence effect in the glass, visible in polarized light.

When viewed in polarized light of thermally tempered soda-lime-silicate safety glass, the stress areas appear as coloured zones, sometimes called ‘lampart spots’.

Polarization of light occurs in normal daylight. The degree of polarization of light depends on the weather and the angle of the rays of the sun. The birefringence effect is more visible when viewed at an angle or through polarized glasses.

Anisotropy is not a defect, but a visible effect.

**Annex no. 8 to the TC**

# CLASSIFICATION OF DEFECTS OF GLASS WITH ENAMEL

**ISSUE DATE: 04.2023**

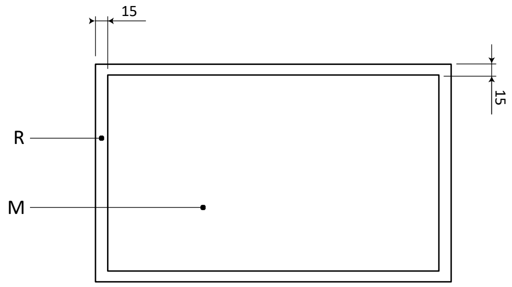
## 1. Observation conditions

The enamelled glass should be observed at a distance of not less than 3 m and at an observation angle as far as possible to the glass surface (the angle formed with a line perpendicular to the glass surface should be maximum 30°).

The assessment is carried out in daylight (or equivalent) conditions without direct sunlight or artificial lighting. The assessment is made on the front surface of the glass (without an enamel layer) on an opaque background.

Defects visible from a distance greater than 3 m are subject to assessment and qualification.

**The observation zones are defined in Figure 1.**




**Legend:**

**R** – 15 mm edge zone, usually covered with a frame or corresponding to the sealing of the rim in the case of an unframed edge

**M** – main zone

For glasses not intended to be grouped or framed, the requirements for zone R are the same as for zone M.

| PERMISSIBLE NUMBER OF SPOT DEFECTS (enamel defects) | | |
|---|---|---|
| **ZONE** | Defect dimensio | Tolerance |
| **R** | All dimensions | No defects limit |
| **L** | Ø ≤ 1 | Acceptable if less than 3 pcs. per each area Ø ≤ 20 cm |
| | 1 < Ø ≤ 5 | Acceptable if less than 3 pcs. per m², spaced ≥ 100 mm |
| | Ø > 5 | Unacceptable |

| PERMISSIBLE NUMBER OF LINEAR DEFECTS | | | |
|---|---|---|---|
| **ZONE** | Lengths in mm | Sum of lengths in | |
| | | Area ≤ 3 m² | Area > 3 m² |
| **R** | All dimensions | No defects limit | |
| **L** | ≤ 75 | ≤ 225 | 75/m² |
| | > 75 | Unacceptable | |

| PERMISSIBLE NUMBER OF STAINS AND STREAKS | | |
|---|---|---|
| **ZONE** | Stains | Streaks |
| **R** | All dimensions | No defects limit |
| **L** | Ø ≤ 17<br>1 pc./m² | Permissible if not visible under lighting conditions and at a distance specified as for panes control |

## COLOUR TOLERANCE

The final/actual colour of the enamel should be determined by looking at the heat-treated sample, looking through the glass.

Due to the existence of many factors affecting the visual reception of glass covered with enamel, it is possible that there are differences in colours selected on the basis of standard systems, e.g. RAL, which are not possible to eliminate.

Among the factors that influence the assessment of recognizable colour differences between two sheets of glass covered with ceramic enamel, we can mention, among others: the origin of the base glass float, the existence of low-emission coatings, the thickness of the glass sheet, the type of glass (body tinted, low iron).

The final effect of the enamel position, i.e. the colour, is also influenced by the method of application. Enamels produced by screen printing are characterized by thinner layers of enamel and are more permeable to light than enamels produced by the roller method, in which the layer is thicker.

Colour differences cannot also result from the same ceramic enamel, which is made of inorganic materials responsible for a specific colour, within which there can be slight deviations from the initial colour.

The perception of enamel glass in terms of colours is also influenced by lighting, which varies depending on the season, day or weather conditions. Light components in the visible spectrum (wavelengths of 400-700 nm), before they encounter ceramic enamel burned to varying degrees, pass through several centres (air, glass) and, depending on the angle of incidence, refract and reflect a part of the beam of light. This results in the possibility of different perception of the colour of the enamel depending on the prevailing lighting conditions.

The comparison and assessment of glass covered with ceramic enamel in terms of colour can only take place in the case of glass supplied by a single supplier, within a single production batch in which the treated glass is heat-treated.

The permissible colour difference can be 4E≤3 (C.I.E L*a*b) when measured on the surface of the glass.

## OTHER PHYSICAL PROPERTIES

**Anisotropy:**

In the process of thermal tempering, in the cross-section of the glass, areas with different stresses are produced.

Stress areas produce a birefringence effect in the glass, visible in polarized light.

When viewed in polarized light of thermally tempered soda-lime-silicate safety glass, the stress areas appear as coloured zones, sometimes called ‘lampart spots’.

Polarization of light occurs in normal daylight. The degree of polarization of light depends on the weather and the angle of the rays of the sun. The birefringence effect is more visible when viewed at an angle or through polarized glasses.

Anisotropy is not a defect, but a visible effect.

**Imprints made by rollers (print of rollers):**

Imprints formed in the process of applying enamel using a roller. This phenomenon is not the basis for a complaint.

**Ripple made by rollers:**

Deformation formed in tempered glass horizontally caused by contact of glass with rollers during the tempering process.

The permissible values for corrugation from rollers are included in Annex 7 "Classification of thermally toughened glass"

# Annex no. 9 to the TC

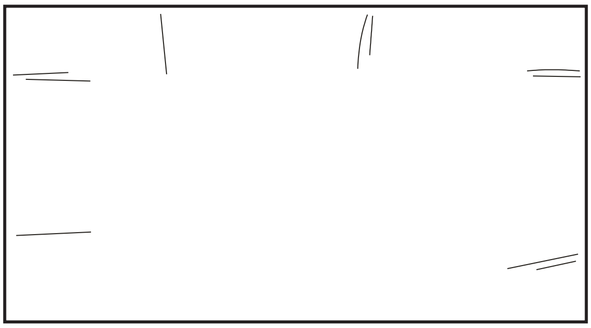
# TYPES AND CAUSES OF GLASS DAMAGE

**ISSUE DATE: 04.2023**

**MECHANICALLY DAMAGED GLASS SURFACE**

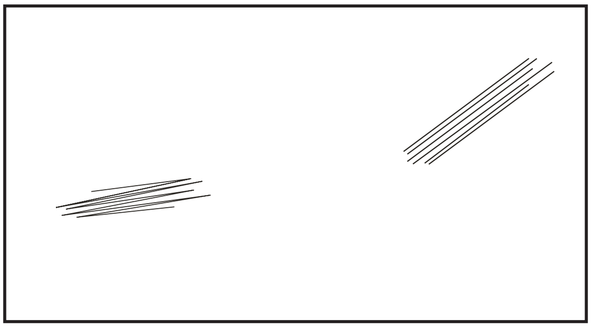
**Assembly scratches**

Typical scratches that occur when inserting a glazing strip or nailing glass nails when the glass sheet is not sufficiently protected. Scratches usually occur in front of the strip and follow the direction of operation of the hammer.



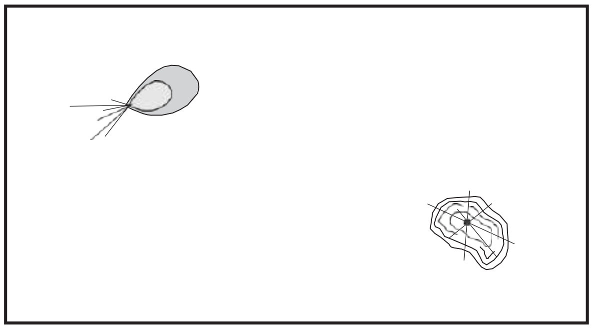
**Scratches engraved with a scraper (cyclin)**

When using scrapers to clean the glass surface, special care should be taken. An incorrectly-used scraper can damage (destroy) the glass surface, especially when the glass surface is contaminated with small grains of sand, as these grains collected under the scraper blade can cause a number of minor scratches.



**Chips from mechanical impacts**

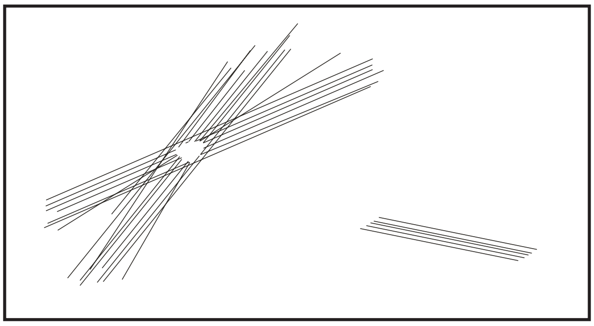
Conical chip can be caused by the impact of small stones on the surface of the glass, for example, during transport. Depending on the angle of impact, chips are round (perpendicular impact) or oval (oblique impact).



**Scratches from steel wool**

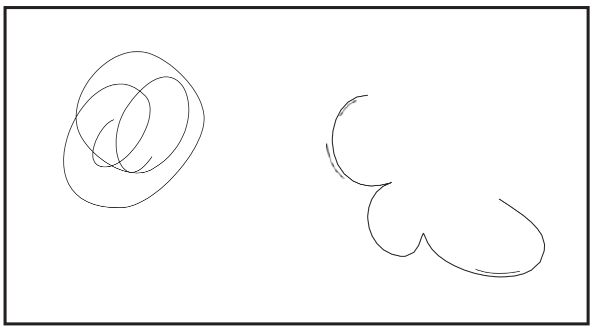
Scratches on the surface of horizontally positioned glass (e.g., glass tops, optical glasses) when removing dirt with steel wool or similar cleaning tools.

Such scratches are formed in accordance with the cleaning direction, usually in the middle of the surface there is an area with preserved transparency.



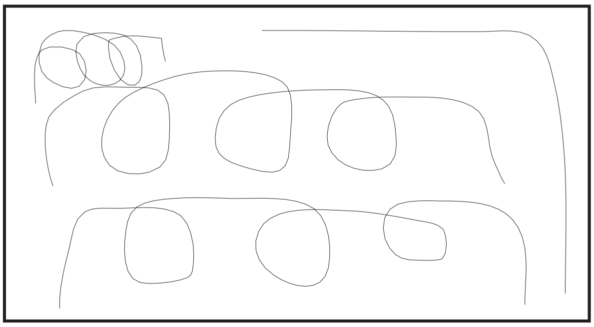
**Scratches from wiping**

They occur on the glass surface when stains on not yet hardened mortar or similar substance are incorrectly wiped. The scratch direction shows the wiping direction.



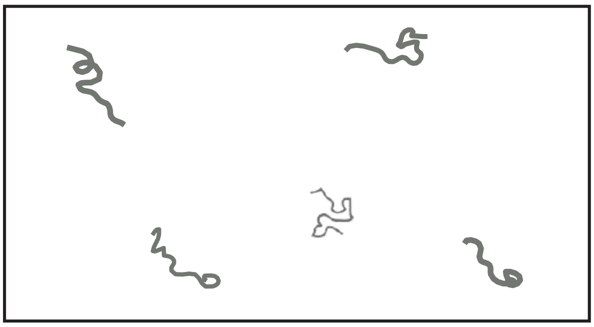
**Extensive surface scratches from cleaning**

Such scratches occur when glass surfaces are cleaned with insufficient water or when a dirty "cloth" is used for cleaning – long scratches appear mapping the movements of the hand during cleaning.



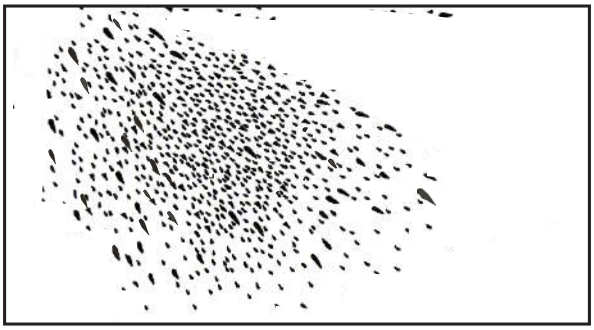
**Abrasions**

Vibration and jerks during transport can cause abrasions on the glass if the panes are not sufficiently separated by spacers. This is due to the effects of grains of sand or small pebbles that got between the glass sheets and caused abrasions.



**Chips marks made by angle grinder**

An angle grinder working near the glass pane (e.g. when cutting steel elements of the supporting structure) can damage the glass caused by sparks on the glass surface. The direction of sparks is clearly visible. Sparks with burning metal melt into the surface of the glass and after some time they can cause the appearance of rust on the glass, they also cause small chips and scratches.

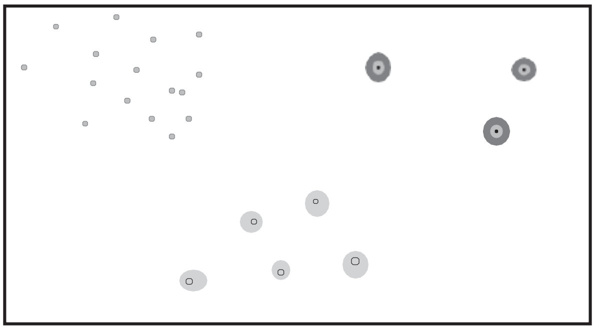


**Extensive leaching on the glass surface**

Matt areas of various shapes can appear, e.g. imitating fire flames or falling rain droplets, on the glass surface constantly exposed to cyclic soaking and drying, or to alkali (e.g. contained in the cement from masonry works performed nearby).

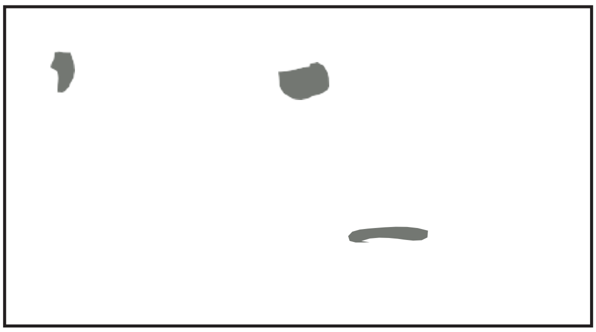
**Spot oxidation of the soft coating**

The spot oxidation of the low-emissivity coating applied on the glass sheet can occur as a result of the action of particles of impurities that have been applied to the surface of the coated glass (e.g. during the production of the glass unit). Over time, oxidation can spread to a larger area inside the insulating glass unit.



**Spot corrosion**

Acidic or alkaline substances, as well as masonry mortars and sealing materials during hardening, can cause spot damage if they are left on the glass for a long time. They do not have a specific shape and are matt.



**BREAKING OF GLASS CAUSED BY THERMAL STRESSES**

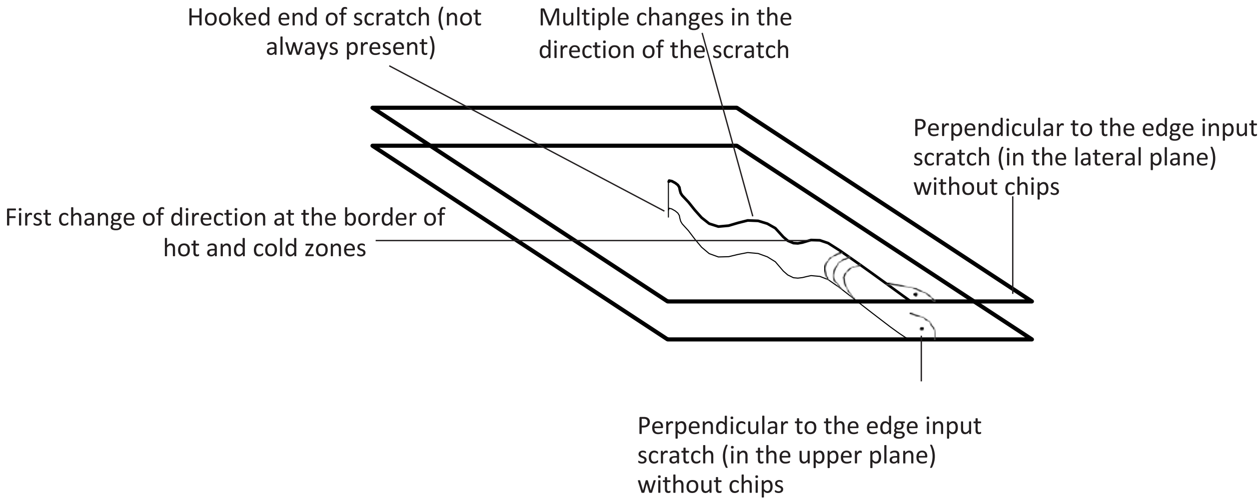
Glass breaks if the stresses acting in the glass are greater than the compressive or tensile strength of this material (depending on the loads acting). The reasons for such stresses are multiple.

Thermal breaks of glass caused by temperature differences can result from the local heating of a part of the glass sheet. This can occur, for example, when items of equipment are set too close to the pane and cast shadows, or when a composite image of dark colours has been painted on the pane.

In addition, the shading devices installed between the partitions (e.g. in a double-skin façade) and the shading devices located inside the glass unit can cause the glass to break, as well as the dark muntins located in the inter-pane space.

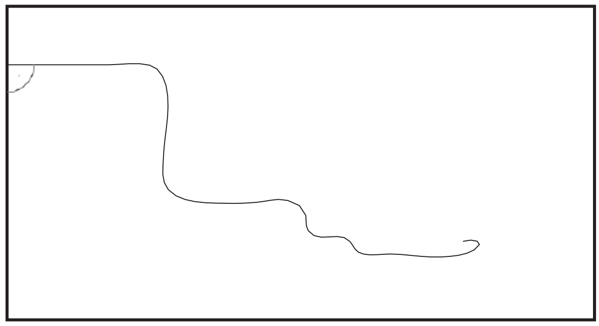
The scratches of thermally induced breaks, always starting from the glass edge, reflect the division into hot and cold zones on the glass sheet.
"Perfect" thermally induced scratches run along the line of the lowest strength, that is, the shortest route between the hot and cold zones, with clear changes in the direction of scratch line.

Here, there is typical and characteristic direction of the input scratch perpendicular to the glass sheet edges and the rectangular scratch system. Another peculiarity can involve chips, which often occur in the area of the first change in the direction of scratch line.



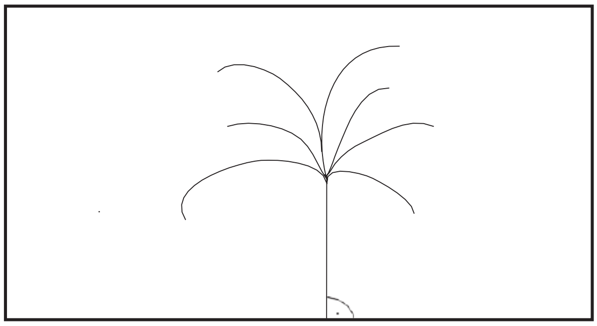

**Standard thermal scratches**

Their causes are as follows: too deep installation of the glazing and films applied on the glass. The glass units inserted into the profiles are exposed to direct sunlight. In addition, the sashes of folding or sliding doors, containing untoughened glass, interact with each other during closing. The features created in this case are the result of interaction with mechanical effects.



**Fan-shaped thermal breaks**

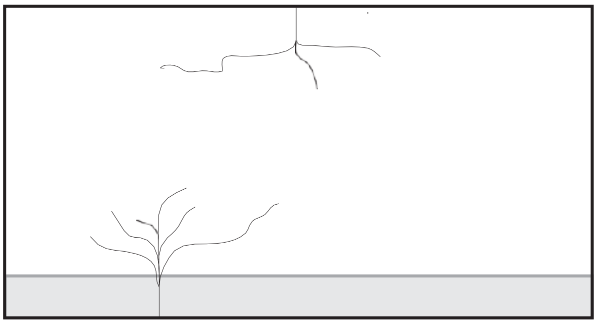
They are formed when part of the glazing is exposed to intense solar radiation or when the hot air heater is set too close to the pane.



**Thermal breaks at the border of light and shade**

Thermal breaks at the border of light and shade

Here, too, the angle of the input scratch, as well as the angles of further scratches, diverge at right angles. The input scratch reaches the border of the hot and cold zones, after passing just above the pressure (fixing) strip, the glazing in the window frame is divided into a keel of separate breaks. The formation of a hooked ending of a scratch is rare. Another feature of this type of breaks involves chips, which often occur at the point of change in the break direction. Causes: glazing very deep into the profile frame, local shading (e.g. stickers) when the pane is exposed to intense action of the sun radiation.



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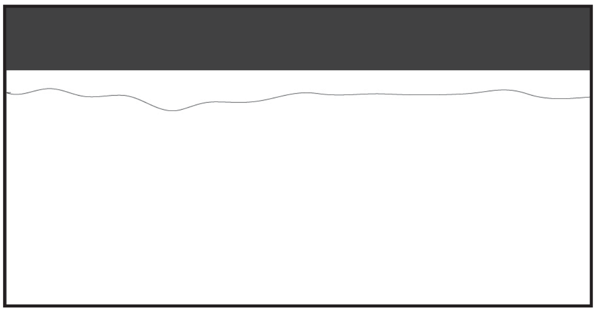
**Thermal breaks at the border of light and**

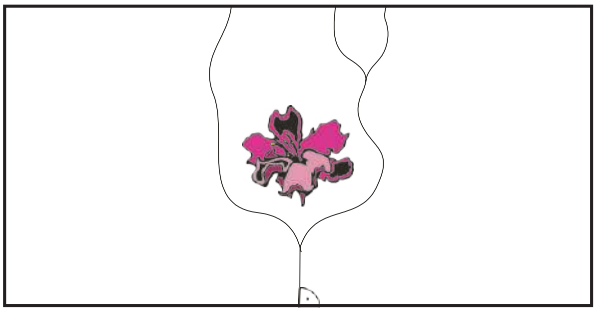
**shade Thermal extensive breaks of type A**

In the case of these breaks, the angle of the input breaks as well as the passing breaks are the same.
The scratches run along the border of the hot and cold zones, without major changes in directions. Chips appear infrequently, and Wallner lines are possible.



**Thermal extensive breaks of type B**

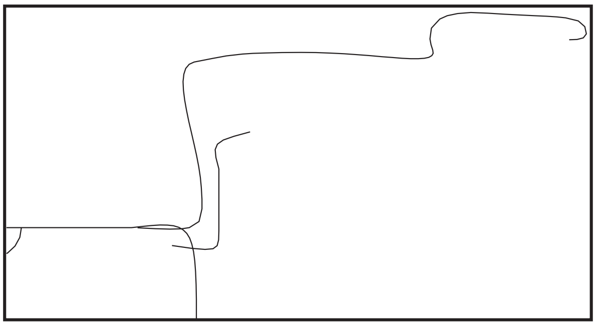
The angle of the input and output breaks is also perpendicular; however, changes in the direction of the hot and cold zones are more visible and it is possible to divide the break. Wallner lines and spatter in the scratch area are often present. The reasons for such scratches are, for example, only partially covered blind, the formation of a shadow boundary as a result of the protruding eaves of the roof and in other shaded places, resulting from the sticking of labels, film or the like on the pane.



**Strong thermal breaks**

In this type of breaks, both the input and output scratches run at right angles. If the input scratch is on the border of the hot and cold zones, it is divided into several scratches (clearly visible Wallner lines), which are strongly branched and run straight. The formation of a hooked ending of a scratch is rare. Another characteristic feature involve chips, which often occur in the zone of change in the direction of scratches.

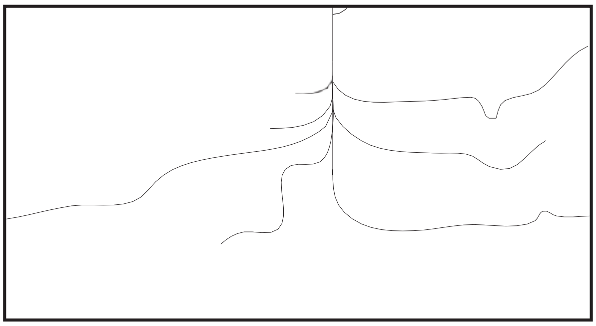
The reason for the formation of such breaks are strong thermal effects in the immediate vicinity of the pane (e.g. hot air blowing), folding or sliding doors made of untoughened glass, in which the sashes move one after the other. Such scratches occur when a part of the pane is exposed to intense solar radiation or films with high absorption of sun rays are glued on the glass sheet.



**Very strong thermal breaks**

In this case, both the input and output scratch are at right angles. When the input scratch reaches the border of the hot and cold zones, the scratch division occurs several times (clearly visible Wallner lines). The formation of a hooked ending of a scratch is rare.

Another peculiarity can involve chips, which often occur in the area of the first change in the direction of scratch line. Causes: laying hot cast asphalt too close to the pane without proper cover, partially shaded and hitting each other with a sliding door made of untoughened glass and hot air blowing in the immediate vicinity of the glass sheet.

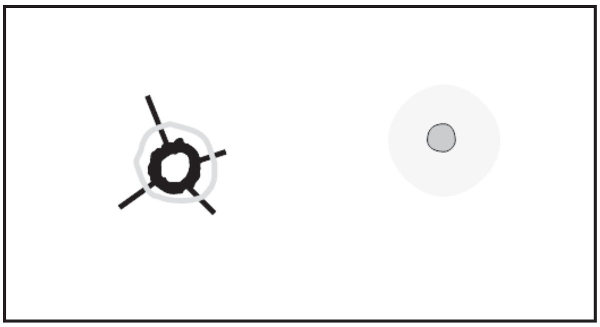


**MECHANICALLY DAMAGED GLASS**

**Ball hole in homogeneous, monolithic glass**

In homogeneous float glass, a single shot on the impact side creates a small inlet opening. The outlet opening, on the other side of the pane, has much larger dimensions.

When spheres fall with high kinetic energy in the glass, a hole in the shape of a steep cone with sharp edges is formed. The lower kinetic energy results in an opening in the shape of a flatter cone with irregular edges. On the hole rim, transverse breaks are possible; however, they occur very rarely.

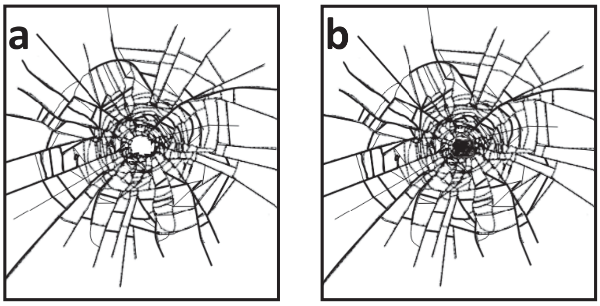


**Hole made by a ball in laminated glass VSG**

While laminated glass - VSG (glass/film/glass) is being shot, the projectile penetrates all layers of glass or is stopped. Depending on the case, the breaks mesh varies.

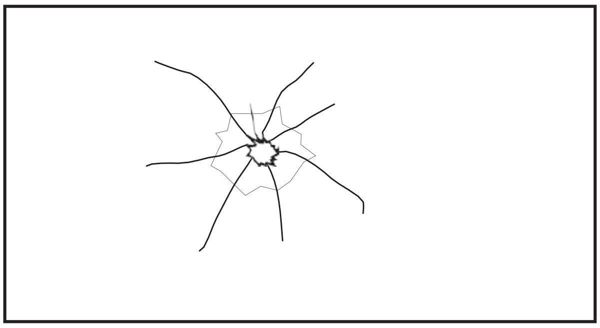
**Case (s):** If a ball with high energy passes through the VSG glass, an extensive break mesh is formed. There are broken pieces of glass around the input hole.

**Case (b):** If the ball is stopped by a glass pane, it falls to the ground in front of the pane, as are the remnants of glass crushed at the point of impact (glass chips can also appear on the other side of the glass pane). A break mesh is formed around the impact site.




**Shot from a slingshot in untoughened monolithic glass**

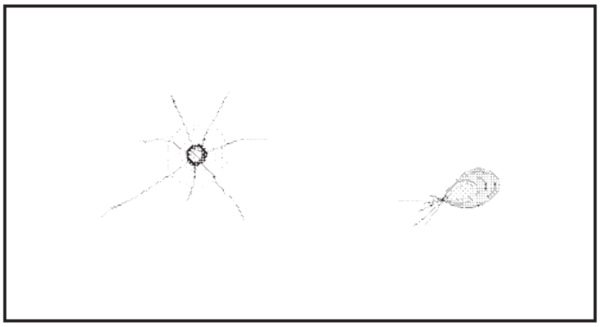
As a result of the shot from the slingshot into the float glass pane, round or oval holes with irregular jagged edges are formed in it. Most often, there is also a small break mesh.



**Shot from a slingshot in VSG laminated glass**

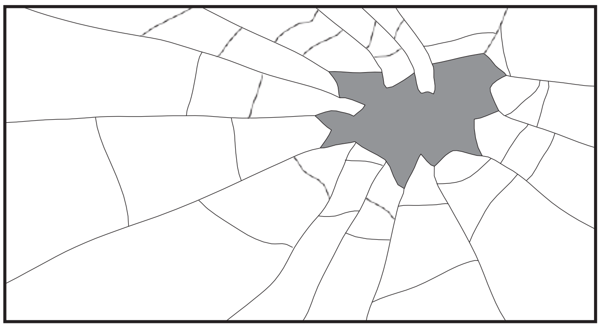
As a result of the shot from the slingshot into the VSG, no through holes are formed, because the stones, due to the low kinetic energy, are not able to pierce the laminated glass sheet.

The result is an irregular conical break and chips of small pieces of glass. The surface of the glass sheet away from the impact site usually remains undamaged



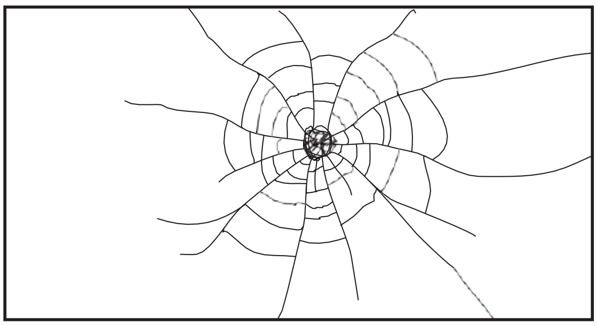
**Throwing a stone at untoughened monolithic glass**

The pattern of breaks resulting from throwing pieces of concrete or bricks into the glass sheet is similar to the case of attempted burglary by heavy objects. If the glass breaks in the middle, a jagged, irregular hole is formed, from which the "rare" break mesh leaves.



**Throwing a stone at VSG laminated glass**

If the attack on laminated glass occurs with pieces of concrete or bricks, a break mesh is formed around the impact site. Breaks away from the middle of impact often reach the edges of the glass sheet. Similar patterns of breaks are formed as a result of attacks with heavy objects or as a result of hitting with a hammer.



**SPONTANEOUS MECHANICAL BREAKS OF toughened GLASS ESG**

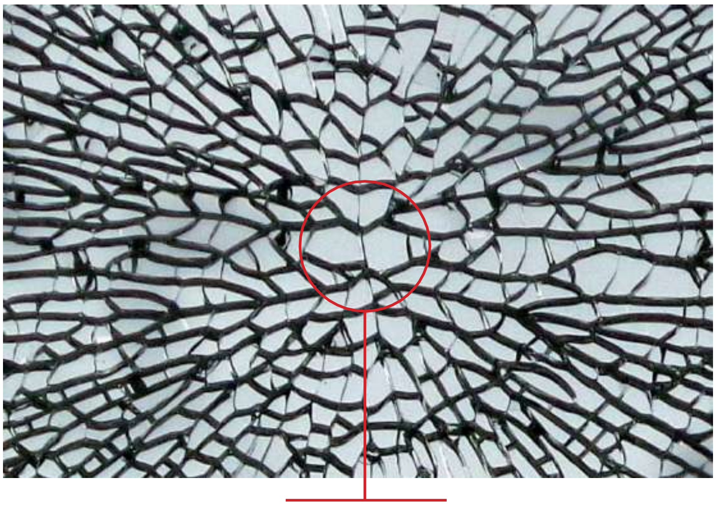
Glass breaks if the stresses acting on the glass are greater than the compressive or tensile strength of the material (depending on the operating NiS nickel sulphide molecule in ESG toughened glass).

NiS nickel sulphide inclusions belong to the so-called foreign solids, i.e. accidental impurities of glass mass. NiS inclusions are not dangerous if the glass sheets in which they occur are not intended for quenching, i.e. they will not be subjected to thermal treatment in order to create a characteristic stress system, causing an increase in the mechanical and thermal strength of the glass.

NiS inclusions in the toughened glass, changing its form, can increase its volume to 4%, thus leading to an increase in stress in the glass and, in the extreme case, to glass breakage. These breaks occur spontaneously, i.e. without the interference of mechanical external factors. The destruction of glass is caused "from the inside".

The breaks caused by NiS are recognized by the occurrence at the place of insertion, that is, in the middle of the break mesh, of pieces of glass with a characteristic shape – similar to the wings of a butterfly (which is visible if the cracked tempered glass does not break into separate pieces).

The Heat Soak Test (in accordance with EN 14179) is performed to exclude breaks caused by the inclusion of NiS nickel sulphide in ESG toughened glass. The Heat Soak Test (HST) consists in heating the toughened glass to a temperature of approx. 290°C and maintaining it for the time specified in the standard. Under such conditions, with a probability of 99%, a defect in the form of NiS inclusion is revealed and the glass breaks, thus eliminating it from circulation.

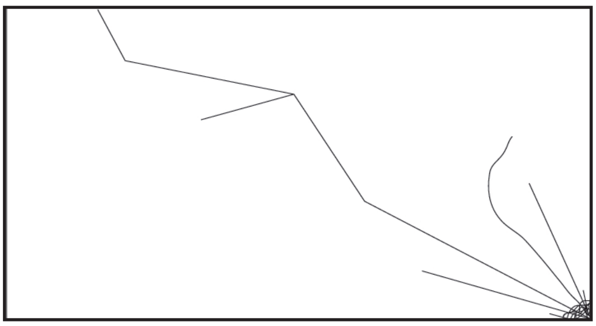


Fragmentation of glass pieces in the shape of a "butterfly", at the location of the NiS molecule

**BREAKS ON THE PANE EDGE**

**Breaks caused by impacts on the pane corner**

Improper handling of glass, e.g. placing a glass sheet directly without prior protection on concrete, stone or metal, often leads to damage to the glass edge, even breaking. The same risk applies to the impact of the glass edge on the metal part or to the rotation and tilting of the pane on the corner without the use of appropriate backing materials. The angle of the initial break and the angles of subsequent breaks diverge radially in all directions. In the place of the beginning of the break – a shell.



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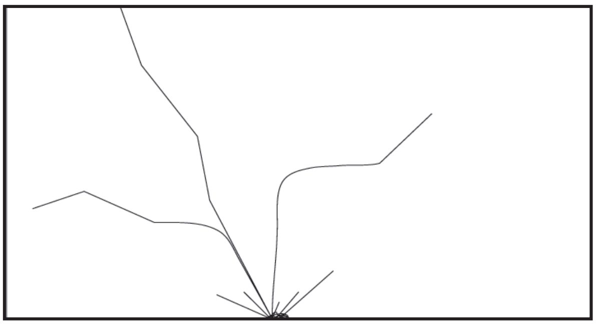
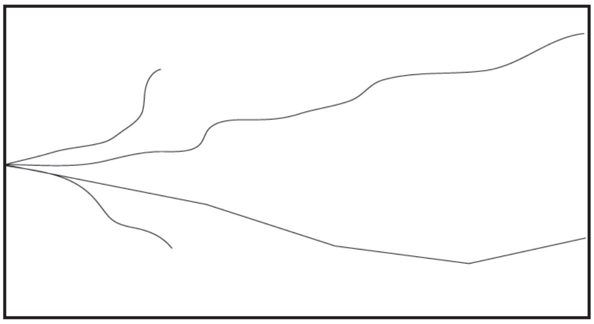
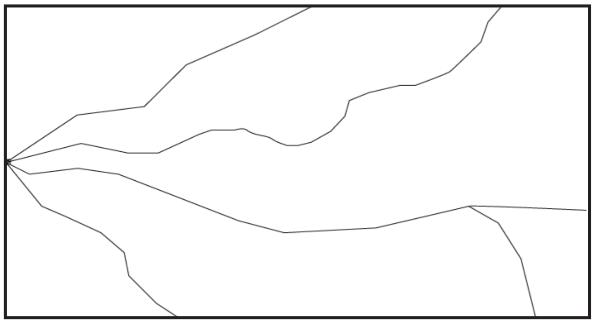


**Spot force application on the edge of the float glass**



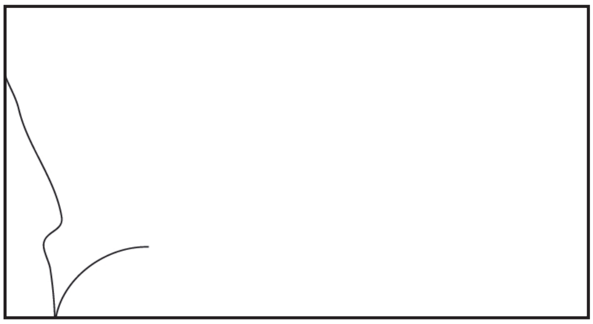
Incorrect use of spacers for the panes or relatively high pressure when screwing the glazing strips can cause breaks under the influence of too high a force applied to the pane edge. The angle of the input break and further angles of subsequent breaks diverge radially in all directions, with them running straight and with bevels, rarely reaching the pane edge. Shell-shaped damage occurs occasionally. If they do, they are small.

**Spot force application on the edge of the float glass**



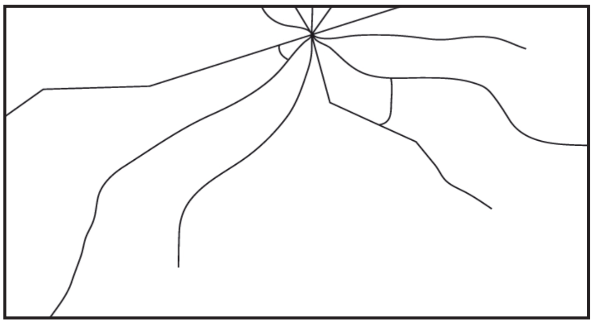
As in the case of float glass, the break is caused by applying too much force to the edge of the TVG glass with improper installation of the glazing strip. The angle of the input break and the additional angles of subsequent breaks diverge radially in all directions. Breaks lines always extend to the pane edge and rarely extend in a straight line.

**Break on the edge caused by an earlier impact**



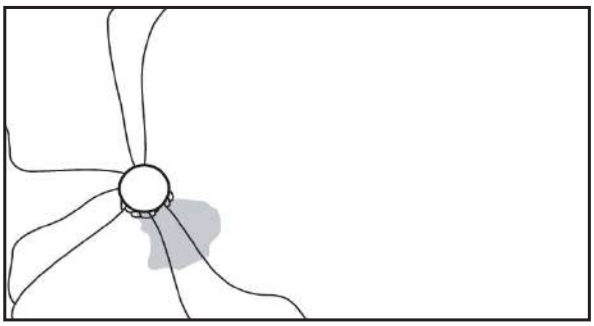
If the pane edge has already been pre-damaged, it can break under pressure in the next stage. The starting point is easy to locate. The angle of the input break and further angles of subsequent breaks diverge radially in all directions, with basically straight, rarely reaching the edge.

**Breaks in the area of the edge of the float and TVG pane**



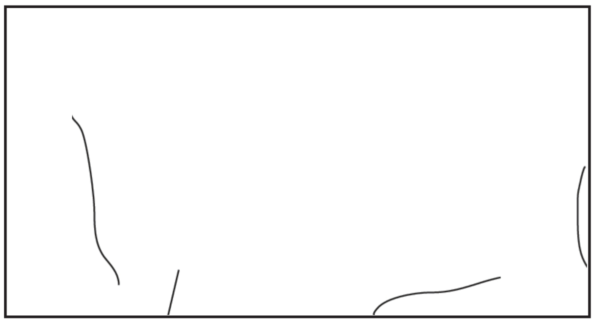
An impact with tools in the area of the pane edge or an impact directly on the edge itself, as well as an impact with a hammer when hammering a glazing strip, can cause a break near the pane edge. In the case of float glass, starting from the centre of impact, the break goes radially, in a linear manner towards the next pane edge. In the case of TVG, the break is meandered, in the form of a winding river, and always reaches the next edge.

**Break at point-fixed VSG made ofTVG**



Too tightly screwed to the glass elements of fittings in point fixing or not adhering exactly to the glass surface, can lead to exceeding the strength parameters of the glass and, as a consequence, to breaking. This kind of break begins at the point of the hole in the glass for fitting is drilled and where the centre of the greatest stress is located. The break is curved and almost parallel to the glass edge. Damages in the form of shells often occurs near the hole.

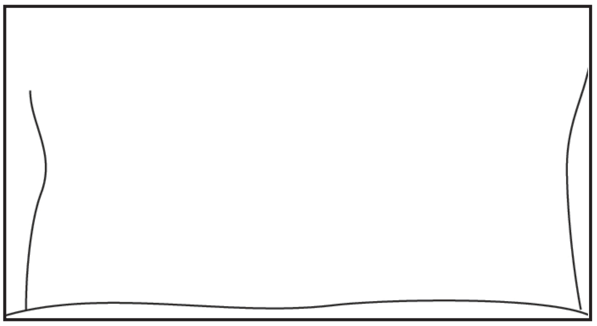
**Forced breaks**



The directions of breaks in this type of forced damage to the glass always start from the edge, are characterized by short breaks and can run in all directions. Such breaks can result in improper use of the glazing washer in the case of very heavy glazing. The same applies to the operation of short-term dynamic loads or long-term static loads on the pane.

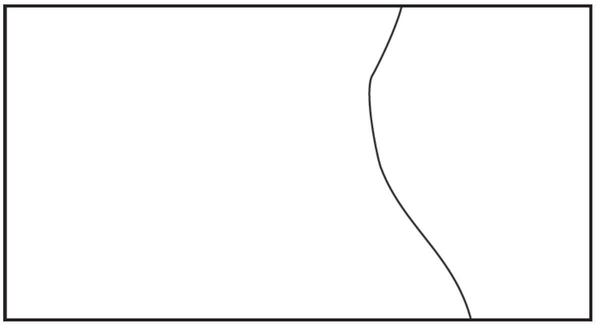
**Break in the laminated glass from the pressure on the edge**

Breaking on the edge under the influence of pressure on the laminated glass occurs mainly in the case of angled and very heavy panes, as well as in the case of excessive loads on the pane edge or in the case of excessive clamping of the pane edge. This type of break can occur especially in the panes with very thick layers between the panes, such as fire-resistant gel, thick PVB films, through which cold air can penetrate. The break often starts in the corner of the pane and runs parallel along the edge towards the next closest corner. The angle of the input break and the angles of subsequent breaks along the surface vary depending on the load.



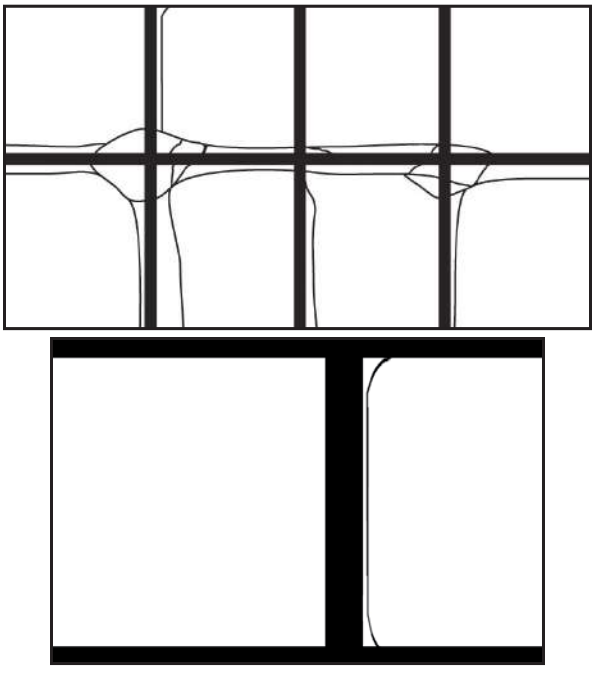
**Twisted breaks**

The type of break is slightly wavy, passes almost straight without additional outgoing breaks and often goes from edge to edge. The angle of the input break and further transition angles on the surface are arbitrary. Such a break is caused by insufficiently sized glass thickness, or incorrectly selected window sash too tightening the glazing. The twisted break can also result from the movement of the building structure, which causes additional loads on the pane.



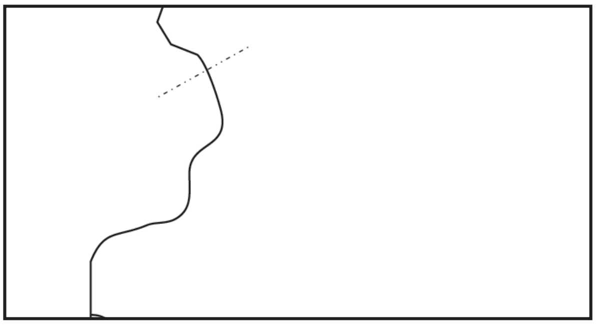
**Breaks in panes with muntins**

This type of break always runs along the muntin and goes from one edge of the glass to the other. The angle of the input break and the angles of subsequent breaks on the pane can diverge in all directions. The reason for the break in the pane with the muntin can involve too small space between the panes, as well as the loads associated with the effect of double glass in the glass unit, i.e. changes in temperature or atmospheric pressure cause a mutual change in the position of the panes. Another reason can be the bulging of the pane related to the production process. In the cross muntins, too hard spacing teardrops to the muntin, considering the conditions described above, can cause a similar break in the pane.



**Hybrid breaks**

We talk about a hybrid break when the thermal and mechanical loads overlap, causing the limit values to be exceeded and, as a consequence, the glass to break.



**Source: Glas Fachwissen, GLASWELT**

# Annex no. 10 to the TC

# USING AND MAINTENANCE

**ISSUE DATE: 04.2023**

This guideline applies to standard insulating applications of glass units mounted in building façades. Standard application means vertical installation with natural light, air and water flow and no direct exposure to aggressive chemical compounds, high temperatures, dust and vapours that can cause permanent raids on the glass or degradation of the glass surface and sealing compound. In the case of operation in non-standard conditions, Effector S.A. is not liable for damage to glass.

## 1. Glass storage

a) All products (flat glass, insulating glass units) should be stored in covered, dry and ventilated rooms.

b) The stored products should be protected against precipitation and direct sunlight or other thermal radiation that, as a result of the accumulation of heat in the glass units, can cause breaking.

c) The glass and glass units should be separated from each other by spacers made of moisture-resistant material, ensuring that the distance between individual glazing units is maintained.

d) In the case of storing products on the construction site, they should be protected against aggressive chemicals, residues of building materials or mechanical interactions that can lead to a decrease in performance or damage to glass.

e) During the storage of the panes, the clamping force of the safety elements (transport belts) should be reduced to ensure that it is possible to compensate for changes in the thickness of the panes during changes in temperature and pressure.

## 2 Glass transport

a) Panes should be transported on dedicated metal racks or wooden racks with a structure and load capacity adapted to the load on them.

b) The elements of the racks in direct contact with the glass should be lined with a cushioning material to eliminate possible damage to the glass.

c) The method of packing the glass on racks and racks for means of transport must meet the safety requirements during transport.

d) During the transport, the clamping force of the safety elements (transport belts) should be increased to protect the panes against displacement.

## 3. Glass cleaning

a) The panes should be washed regularly, depending on the dirt degree. It should be considered that over time, any dirt on the surface of the glass can become increasingly difficult to remove, thus increasing the risk of damage to the panes during cleaning.

b) The panes should be washed with water and generally available glass washing agents.

c) Any metal or ceramic scrapers, sharp sponges, pastes and abrasive solutions that can cause permanent scratches to the panes are excluded.

d) For the removal of dirt that cannot be removed in the manner described in point 2b, it is permissible to use soft brushes, rubber, lint, fine industrial steel wool during washing, after making sure that they do not cause scratches to the glass surface.

e) Spirits, acetone, isopropyl alcohol or gasoline should be used to remove dirt, e.g. from paint, tar, adhesive residues. It should be remembered that after using the aforementioned agents, the panes should be thoroughly washed with water and generally available glass washing agents and then thoroughly wiped dry.

f) ) Alkali and acid solutions as well as cleaning agents containing fluoride and chlorine should not be used to wash and clean the panes.
Such solutions can cause irreparable damage to the surface of the glass and PVB film.

g) Each time, in the case of using liquids, pastes, chemical mixtures to clean the panes, a test should be carried out on a small surface of the glass before starting work, in order to ensure that they do not cause damage to the glass, seals or joinery coatings.

## 4. Possible damage resulting from inadequate storage/use

a) Destructive etching of the glass surface
The surface of the glass is etched after contact of the glass with hydrofluoric acid, lyes and chemicals usually used in building materials (and cleaning agents). Chemicals such as alkali solutions, including but not limited to fresh concrete and plaster, acting for a long time lead to permanent etching of the glass surface.

b) Destructive leaching of the glass surface caused by water
It is possible to damage the glass surface due to the phenomenon of leaching as a result of prolonged exposure to precipitation water and condensation on the glass surface. Water causes hydrolysis of silicates contained in the glass with the formation of silica in the form of a gel (raid on the glass). In particular, the glass stored without spacers and exposed to long-term dirt is exposed to damage as a result of leaching.

c) Thermal cracks
Cracks caused by thermal stress appear in the case of sudden changes in the temperature of the glass. The risk of thermal cracks increases in installations where there is a large partial shading caused by objects or elements located both on the outside and inside of the glass (e.g. scaffolds, curtains, blinds, posters, furniture, stickers, etc.) and objects placed near the glass emitting heat (e.g. lamps, heaters, fans, kettles, etc.). Thermal cracking can also occur when glass units stored on racks are exposed to direct sunlight.

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