FIN TECNIC

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QUALITY ASSESSMENT CRITERIA FOR INSULATED GLASS UNITS

Fintecnic manufactures its insulated glass units (IGU) in compliance with EN 1279, a master governing standard which specifies the mandatory requirements for the production process, and in compliance with European Harmonised Standards which provide the visual inspection criteria for IGU and single panes (being the components of IGU):

- hEN 572 – float glass
- hEN 1096 – coated glass
- hEN 12150 – tempered glass
- hEN 12543 / 14449 – laminated safety glass

The assessment criteria for IGU are equivalent to or more stringent than the requirements of EN 1279 and its reference standards.

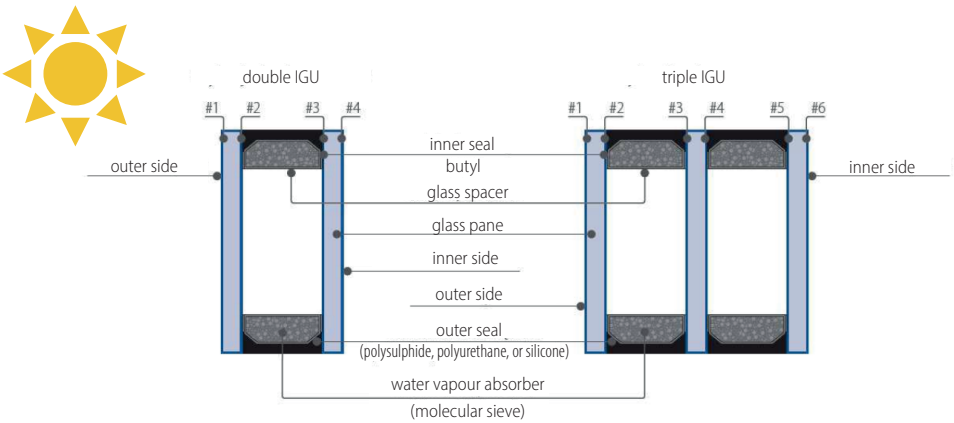
The assessment criteria provide the following information:
- the proper visual inspection process for IGU;
- the unacceptable defects and acceptable indications for IGU;
- the physical phenomena potentially occurring in the IGU structure;
- proper recording of a Non-Conformity Report.

An IGU Quality Assessment Form is appended hereto for reference.

DESIGN AND STRUCTURE OF IGU

An insulated glass unit (IGU) is a system comprising two or more (three to four) glass panes separated along their edges with one or more glass spacers which are in hermetic interface with each glass pane along its periphery.
The primary application of an IGU is glazing of structures which shield off the IGU sides from direct exposure to UV light. Whenever a specific application will not shield off the IGU sides from direct exposure to UV light, this shall be explicitly indicated in the purchase order, since the construction of IGU will require a different sealant (i.e. a silicone compound) to ensure the basic performance of the IGU.

Fig. 1. Structural design of a double IGU and a triple IGU with the explanation of components and glass pane arrangement



IGU thickness and size

The thickness of an IGU is the total thickness of all its glass panes and glass spacers. The maximum thickness tolerances are shown in Table 1.

Table 1. IGU thickness tolerance

Type	Thickness tolerance
2-pane IGU (annealed float glass)	± 1,0 mm
2-pane IGU with one or more HT or laminated glass panes	± 1,5 mm
3-pane IGU (annealed float glass)	± 1,4 mm
3-pane IGU with one or more HT or laminated glass panes	+ 2,8 mm / - 1,4 mm

Table 2. IGU size tolerance

Double and triple IGU	Tolerance in length and width of unit	Glass pane misalignment tolerance
Units with glass thickness < 6 mm, and width or height < 2000 mm	± 2,0 mm	≤ 2,0 mm
Units, where the thickest glass pane is between 6 mm and 12 mm, or the unit width or height is between 2000 mm and 3500 mm	± 3,0 mm	≤ 3,0 mm
Units, where the thickest glass pane is < 12 mm, or the unit width or height is between 3500 mm and 5000 mm	± 4,0 mm	≤ 4,0 mm
Units, where the thickest glass pane is > 12 mm, or the unit width or height is > 5000 mm	± 5,0 mm	≤ 5,0 mm

Unit width and length tolerance for modelled glass panes: ± 5.0 mm

Recommended applications of special glass panes

- Ornamental glass: the ornament texture shall be facing the inside of the IGU (not applicable to deeply textured ornamental glass, e.g. Niagara).

In directional ornament textures, the texture shall be oriented along the IGU height.

- Sun protection glass (coated): see the proper location of the coating in the IGU structure as shown in (2)
- If two coated glass panes (with one in the middle) are installed in a triple IGU, they should be tempered due to thermal loads in operation.

If high-energy absorption glass pane is used in an IGU, it should be tempered due to thermal loads in operation. Any cracks caused by normal thermal stress shall not be qualified as defects of the glass.

IGU marking

Each IGU is marked with a print visible on the glass spacer. The marking contents follow:
- CE marking / production date and time / manufacturer's designation [EO] / size / IGU structure type / order no / run number / position number

Safety tempered IGU features additional marking in the form of a print on the glass pane surface in the IGU corner or at the glass pane edge away from the corner, reading the manufacturer's designation and reference to EN 12150.

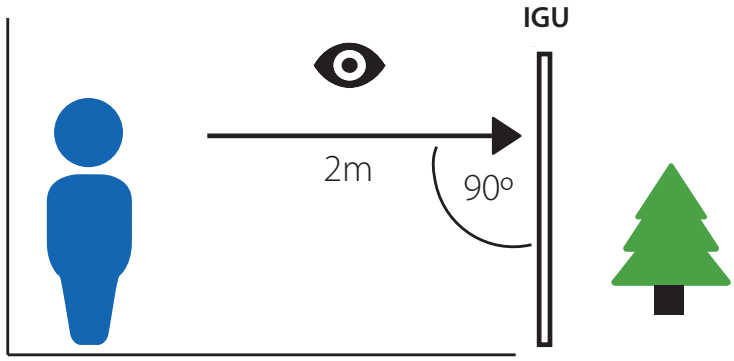
VISUAL INSPECTION

Procedure for the visual inspection of IGU glass quality and workmanship:

- Hold the IGU in a fixture 90° to the level and inspect the image seen through the IGU and not the IGU surfaces:
- from the inside of the inspection room;
- from a distance of 2 m;
- with the IGU perfectly dry;
- in natural (scattered) daylight: the IGU shall not be exposed to direct sunlight; do not use any magnifying aids or strong artificial light sources (e.g. torches or halogen lamps).

Visual inspection time: 20 s maximum.
If no defect is visible during the visual inspection performed within the time limit and per the procedure above, the defect is an indication without any effect on the product quality and shall not be qualified as IGU defects.
All identified indications of defects shall be measured and compared with the criterion guidelines in Table 3.

Fig. 2. Procedure for IGU VI



In the visual inspection of IGU, there are three areas of interest:

- The edge area: up to **15 mm** in width from the glass edge (the surface to be concealed within the frame);
- The boundary area: up to **50 mm** in width from the glass edge;
- The main area: the surface area inside the boundary area limits, or the glass pane centre.

Edge area, 15 mm from the glass pane edge (concealed by the frame)

Boundary area, 50 mm from the glass pane edge

Main area

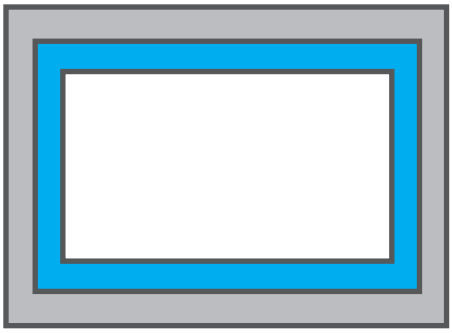


Table 3. Criterion guidelines for acceptable defect indications in IGU

Area of interest	Acceptable defects
EDGE AREA 15 mm from the glass pane edge: the glass surface to be concealed within the frame	Edge damage, shells, and nicks on the outside which do not affect the glass pane strength and do not extend beyond the glass seal width.
	Internal shells without loose splinters and filled with sealing compound.
	Localised and superficial impurities and scratches, and undulation of the butyl compound: no restrictions to acceptability.
BOUNDARY AREA 50 mm from the glass pane edge:	Inclusions and air bubbles: Glass pane area ≤ 1 m2: 4 defects maximum, ≤ Ø 2 mm each Glass pane area > 1 m2: 1 defect maximum, ≤ Ø 2 mm / linear metre along edge
	Superficial scratches Max length per single scratch line < 30 mm, total length of all scratches < 90 mm.
	Minor superficial scratches – hairline scratches – acceptable if not in clusters.
	Flat impurities / stains: white and grey or clear in appearance – 1 defect ≤ Ø 17mm
MAIN AREA	Localised defects (inclusions, air bubbles, specks, etc.): Defects ≤ Ø 1 mm are acceptable if not in clusters. Glass pane area ≤ 1m2: 2 defects maximum, ≤ Ø 2 mm each Glass pane area 1 < S ≤ 2 m2: 3 defects maximum, ≤ Ø 2 mm each Glass pane area ≥ 2 m2: 3 defects maximum + 2 defect per 1 m2 of the glass ≤ Ø 2 mm Flat impurities / stains: white and grey or clear in appearance – 1 defect ≤ Ø 17 mm
	Scratches: Max length per single scratch line < 15 mm, total length of all scratches ≤ 45 mm (applies to glass panes up to 5 m2). Hairline scratches: acceptable if not in clusters

NOTE:
- A hairline scratch is less than 0.15 mm wide.
- A cluster of defects contains a minimum of 4 singular defect indications within a diameter < 200 mm.
- Defect indications less than 0.5 mm in maximum dimension: to be ignored.

WORKMANSHIP ASSESSMENT OF GLASS SPACERS

Fintecnic applies two processes for the pretreatment of glass spacers:

- Glass spacers are formed by bending to shape in the corners and bonded at four locations along the circumference, along the sides (applies to each IGU hollow separately); the glass spacer is concave at the corners, due to the manufacturing process.

- The glass spacer is trimmed to shape and joined at the corners with corner pieced.

The visible gap in between the glass spacer joints (both on the sides and at the corners) shall not exceed 1 mm.
In modelled glass panes (and specifically, curved glass panes), the maximum gap in between the glass spacer joints shall be 2 mm; lateral undulation and concavity of the glass spacers are permitted (as caused by the glass spacer bending process).

Glass spacer misalignment in triple IGU:
- 2 mm maximum with square glass panes; 5 mm maximum with modelled glass panes.

Visible glass spacer surface location relative to the glass pane edge within 10-13 mm; maximum variation in distance from the edge along a single side:
3 mm maximum.
Maximum butyl compound flash: 2 mm along the glass spacer, 5 mm at the corners, provided that the basic performance of the IGU is not compromised (gas tightness and adhesion of glass spacers and glass panes).
Undulation of the butyl compound is acceptable (as caused by uneven application) within the tolerance limits of the butyl compound flash.

The butyl compound shall be uninterrupted along the entire IGU circumference.

Visually inspect the glass spacers by following the procedure for assembled IGU above; the inspection distance shall be 2 m.

- Impurities and localised inclusions: acceptable within Ø > 1 mm to Ø ≤ 3 mm and when no more than 1 indication per linear metre of the glass spacer.
- Impurities and localised inclusions sized Ø > 0.5 to Ø ≤ 1 mm (e.g. molecular sieve mesh): acceptable if not clustered and with no more than 4 indications per every 20 cm of the glass spacer (per each IGU hollow).
- Hairline scratches: acceptable.
- Scratches (wider than 0.15 mm): acceptable if not clustered, with the single scratch line length no more than 30 mm and the total length of all scratches no more than 90 mm per every linear metre of the glass spacer (per each IGU hollow).
- Stains / streaks up to Ø18 mm, acceptable if 1 indication only is present per the glass spacer circumference (per each IGU hollow).

Indications which appear as scratches, impurities, stains, finger marks, streaks, etc. and not visible by visual inspection from 2 m under the procedural VI conditions shall not be qualified as unacceptable defects.

WORKMANSHIP ASSESSMENT OF GBG (GRILLES BETWEEN THE GLASS)

The maximum workmanship tolerance for the GBG alignment shall be an offset from the nominal dimensions of no more than 2 mm in 90° unit joints and 5 mm in modelled unit joints.
The GBG are joined by superimposing the pre-milled GBG parts on a pole, followed by bracing with a strut. The minimum GBG to glass pane distance shall me 2 mm minimum per each side (this also applies to simulated (duplex) dividers).
The GBG length may vary with temperature, resulting in a slight deformation.

The GBG may rattle slightly from its vibration under the pressure of wind or the leaf closing action.
These phenomena shall not be qualified as IGU defects.
Application of bump-on plastic spacers may reduce the risk of IGU failure, GBG vibration and rattle, and cold bridges; however, none of the phenomena can be eliminated.
Water condensation may occur on the glass pane surface at the fixing locations of GBG and at the glass spacer along the whole IGU, if relative humidity is high and/or there are high temperature variations.

The locations of GBG trimming, milling and joints may reveal joining parts, the raw material, and slight discolouration (confined to the trimmed or milled surface), up to 1 mm in size.

Visually inspect the GBG by following the procedure for assembled IGU above; the inspection distance shall be 2 m.

- Impurities and localised inclusions: acceptable if Ø ≤ 2 mm.
- Hairline scratches: acceptable.
- Scratches (wider than 0.15 mm): acceptable if not clustered, with the single scratch line length no more than 15 mm and the total length of all scratches no more than 45 mm per the whole GBG of the IGU (per the inspected IGU side).
- Stains / streaks up to Ø18 mm: acceptable if 1 indication is present per the whole GBG of the IGU (per the inspected IGU side).

Indications which appear as scratches, impurities, stains, finger marks, streaks, etc. and not visible by visual inspection from 2 m under the procedural VI conditions shall not be qualified as unacceptable defects.

PHYSICAL PHENOMENA IN IGU (EXEMPT FROM THE QUALITY ASSESSMENT)

Light interference: Brewster fringes

A phenomenon of light interference called the Brewster fingers occurs in the IGU under the following conditions:

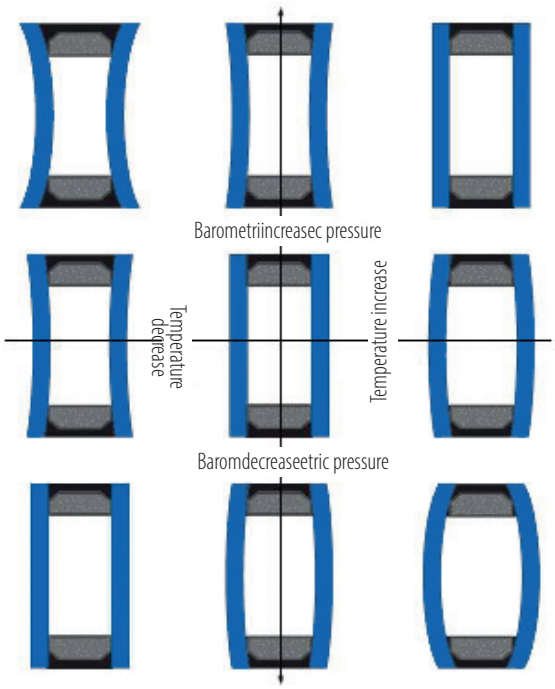
- The IGU is made from glass panes with an extremely low differential thickness (at 400-700 nm, which is equal to the visible (white) light wavelengths) and, at the same time, the differential parallelism of both glass panes is within 400-700 nm.

Under these conditions, white light interference becomes visible in the form of multi-coloured 'stains' or 'rings' on the IGU surface, especially with the line of sight at an angle away from the perpendicular to the IGU plane.
This phenomenon is beyond the control of the IGU manufacturer and a result of high quality and high performance of the glass panes. It shall not be qualified as an unacceptable defect or accepted as such on commercial warranty.reklamacji.

Glass deflection: distortion of reflected image

In the manufacturing process of an IGU, a specific volume of inert gas is sealed within the IGU hollow at specific barometric pressure, altitude, and ambient temperature. At the operating stage of an IGU, it is subject to continuous variations of barometric pressure and ambient temperature. The variations change the inert gas volume within the IGU hollow, resulting in relative displacement of the glass pane surfaces (by their concavity or convexity) and optical distortion of the image reflected by the IGU.

Fig. 3. Glass pane concavity / convexity vs. temperature and pressure variations



When installing an IGU at altitudes above 700 m (above sea level) or with a relative altitude difference of more than 500 m between the production plant and the installation site (or the shipping waypoint of the IGU), pressure compensation is recommended (by applying capillary tubes sealed with pliable diaphragms).
Pressure compensation helps reduce the prominence of concavity / convexity of the glass panes, and thereby reduce the risk of glass pane failure.
IGU also have an effect of 'multiplied reflection' or 'multiplied ghosting of images. This is a result of the IGU structure, which comprises more than one glass panes. The multiplied reflection effect is amplified in triple IGU and/or by coated glass panes and/or as the background becomes darker.

These phenomena are natural physical attributes of all IGUs and proved their gas-tightness. They are not unacceptable defects.

Water condensation on glass pane surfaces

Water condensation appears on the outer IGU surface when highly humid air touches the glass surface which is colder. The air in contact with the glass cools down and releases the surplus water vapour on the surface. With IGU, when the indoor room is warmer than the outdoor air, the outer glass pane will as cold as low is its Ug value (which means less heat escaping from the room). This phenomenon depends on the weather conditions and the IGU performance. It is also transient and shall not be qualified as a defect, since it cannot be eliminated.

Water condensation usually appears on the indoor side of the IGU when the room has a high relative humidity and it is poorly ventilated. Under extreme circumstances, which means extremely low outdoor temperatures and poor indoor heating, the indoor condensation may freeze at the edges of the IGU, at the glass spacer. The application of warm edge spacers in between the glass panes and glass panes with low Ug values reduces this phenomenon. It shall not be qualified as an IGU defect.

If water condensation appears within an IGU (on the inside surfaces of the glass panes), the IGU has lost its gas-tightness. This is a defect which qualifies the IGU for replacement.

Colour differences: specific colour

Variations in glass surface wettability originate during the manufacturing process due to e.g. contact with sealants, labels, handling suction cups, handling rollers, gloves, fingers, and the like.
When the glass surface of an IGU is wet due to water condensation, rain or other sources of water, the variations in glass surface wettability may manifest themselves as stains with an apparently higher clarity. This shall not be qualified as a defect of the glass pane; each IGU is visually inspected with all its surfaces dry.

Each float glass pane features its own specific colour and its tone depends on the input materials, melting process parameters, and other conditions. It is a natural property of glass and may vary between manufacturers or production lots / runs.
Low-emission coatings also change the glass pane tint.
The visible glass colour depends on the type of coating, glass thickness, and angle of observation (line of sight incidence).
Low-emission glass coatings may, under certain illumination conditions, appear like a layer of clear film, or 'fogging' of the glass pane. Objects near an IGU (like sheer curtains) may appear darker that they actually are.

Another cause of differences in the visual effect of glass panes (even those adjacent to one another) can be differences in the IGU structure (e.g. when different glass panes or panes of varying thickness have been assembled together), or different times of glass pane production (which means that the IGU panes come from different production lots).
In time, and due to accidental causes, the surfaces of an IGU may suffer slightly from weather and ambient conditions, which means reactions on the glass pane surface, which change the IGU appearance.
These phenomena shall not be qualified as IGU defects.

Glass breaks (failure)

Glass is an amorphic material which exhibits low internal stress. This makes glass easy to process and trim.
Glass breaks, or fails, most often due to mechanical or thermal inputs.
The most common causes of mechanical failure of glass include: impact against the glass surface (e.g. from a thrown object), impact to a glass edge or corner, application of pressure to a glass edge (when the glazing clearance within the frame is too tight or the glazed leaf strikes hard against the opening frame), jamming of glass with continued application of force, torsion of the glass surface, and wind pressure.

The most frequent causes of thermal failure of glass include: application of adhesive decorations, stickers, partial shading of the glass (e.g. with roller blinds, tree crowns, canopies, or fencing), proximity of heaters or A/C units, or leaving the IGU in its packaging and bound to a rack with high exposure to sunlight.
Glass can have its strength against mechanical and thermal loads improved by tempering.
No glass failure which occurs after delivery to the buyer shall be qualified as a defect and will not be accepted on warranty.
External defects, nicks, outer scratches, other forms of damage and stains (e.g. due to chemical reactions on the outer surfaces) which may originate downstream of the production plant are not covered by warranty.

Indications on tempered glass

Tempered glass features mechanical and thermal strength several times higher than annealed glass. When tempered glass fails, it usually breaks down into fine and usually blunt fragments. This is why it can be called 'safety glass'. Indications may result from the process of glass tempering. If present, they are not evidence of glass defects and shall not be rejected as such.

- Anisotropy, or 'the rainbow effect':
  During glass tempering, specific 'stress areas' emerge within the glass pane which result in double refraction of light. This is indicated under polarized light or visible light (white / daylight) by small, 'rainbow-coloured' stains, observable at a low line of sight angle.

- Roller undulation: a result of the contact of hot glass with the furnace rollers, evident by surface distortion and deviation of the glass surface from the straight line.
  It is recommended for the buyer to specify the orientation (direction) of the glazing. This will allow a proper orientation of the glass panes entering the tempering furnace (in the oriented tempering process).

- Roller marks: glass panes over 8 mm in thickness and/or with a large surface area may feature small roller marks, formed by the pressure of the rollers along the manufacturing line.

- Spontaneous tempered glass fracture:
  while completely harmless to annealed glass, residual traces of nickel sulphide may cause tempered glass to spontaneously burst and fail in operation.

Glass cleaning and washing

- The glass surfaces need to be periodically washed, as required by the amount of deposited dirt.
- Do not remove cured / solid dirt (e.g. masonry mortar) with dry cleaning methods.
- Do not remove dirt with putty knives, blades, razors, and the like to detach persistent dirt from the glass.
- Wet the dirt with plenty of water, leave to soak, and proceed with washing the glass clean.
- Use commercially available detergents. Greasy surfaces can be pre-treated with ethanol or isopropyl alcohol before washing.
- Do not use corrosives, alkalis (with fluoride or chlorine), scouring powders, abrasive tools or materials, or sharp cleaning tools.

Recording and reporting warranty claims

- The warranty claim form shall at least specify a detailed description of the claimed defect(s), the reference to the original purchase order, a photograph of the product label or the glass spacer marking.
- Append a photograph of the entire IGU.
- Append a photograph of the defects with a rule or tape measure shown next to it to assess the size.

PHOTOGRAPHY OF DEFECTS

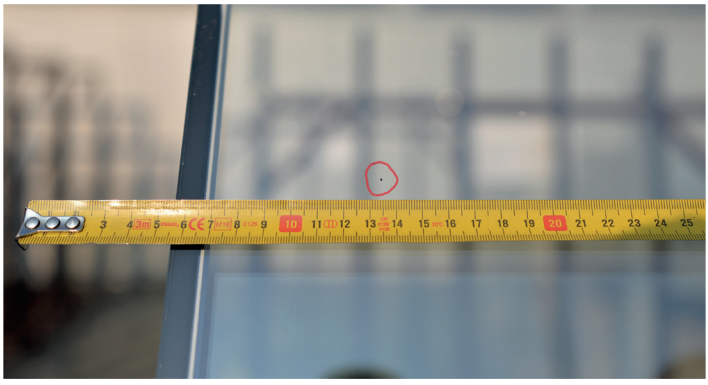
Taking photographs of defects on the glass is rather difficult and a suitable technique must be used as follows:

1. Tools required: a smartphone or other digital camera; a line rule.
2. Read the Quality Assessment Criteria for Insulated Glass Units.
3. Inspect the IGU from 2 m away. Is the defect visible per the Visual Inspection Procedure?

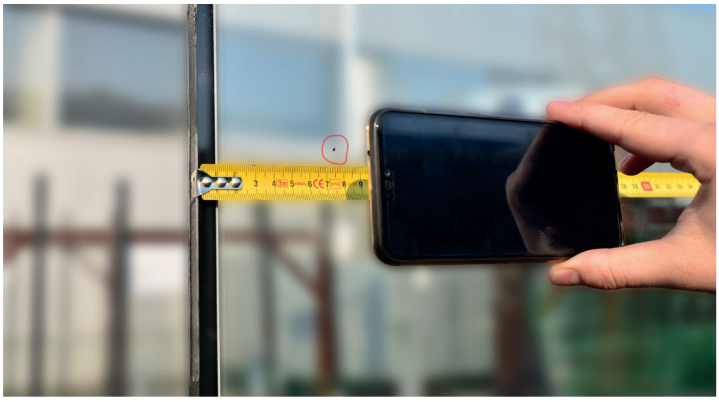
YES
See Section 4

NO
The IGU complies with PN-EN 1279

4. Place the line rule with its top edge approximately 5 mm below the defect.



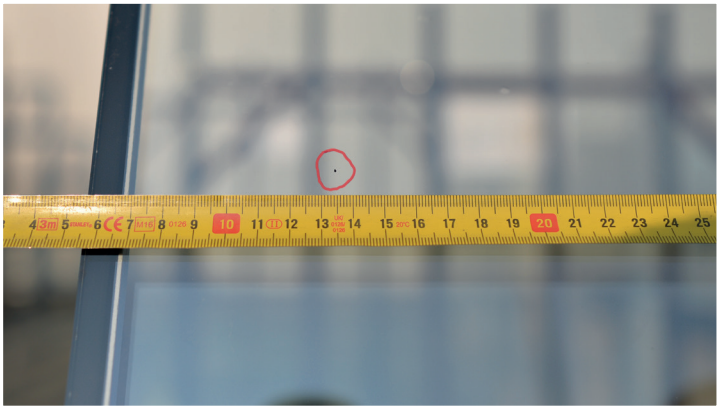
5. Hold the smartphone camera 10 cm away from the glass surface.



6. Attempt to photograph the defect.

7. If the image is blurry or out of focus:

8. Hold the smartphone steady – and tap the camera app's image centre on the screen. The camera should be in focus now.

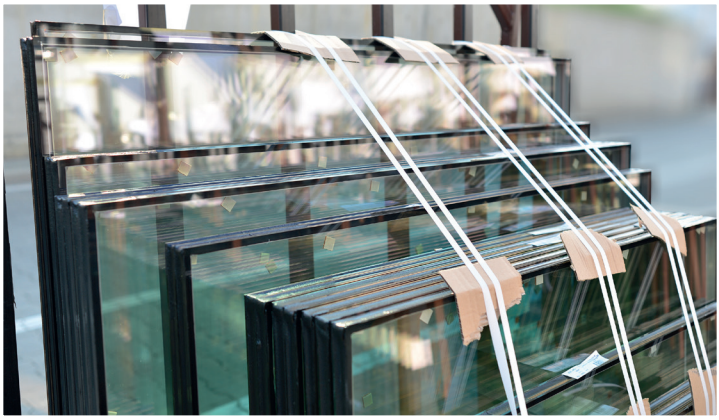


9. If you cannot produce the right focus on the image, try moving the smartphone camera closer and further from the glass surface within a distance of 5 to 20 cm and with a smooth motion. Monitor the camera app's screen and take the picture when the focus appears to be best.

PACKING ON A CLAIM RETURN RACK

Correct packing on a claim return rack: ensures IGU acceptance for warranty claim verification

- Secure the IGU on the rack as shown in the images below.
- Use cardboard spacers under the bands to prevent the glass from cutting the bands.
- Place rubber/cork spacers in between the IGU with a spacing of 25 cm minimum and at least in two rows per IGU.
- Place the IGU on the claim return rack with the largest IGU closest to the rack inside. All IGUs must be brought right to the inner stop on the rack and secured so.



Incorrect packing on a claim return rack: the IGU will be automatically rejected and scrapped upon delivery