COMPANY STANDARD

ML SYSTEM S.A.

POLSKI PRODUCENT

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1 INTRODUCTION

The quality of products made of flat glass is assessed against the requirements specified in the harmonised standards applicable to the relevant product. Where a standard does not regulate specific production tolerances, ML System S.A. defines its own standard tolerances that can be achieved during the normal production process. The harmonised standards currently in force remain applicable and form the basis for commercial cooperation and product quality assessment.

Each Customer may contact the manufacturer and agree production tolerances and product quality assessment criteria so that they meet the Customer's particular requirements and needs.

The product type and quality are agreed between the manufacturer and the customer before production of the order begins. The quality of the base glass supplied by the glass manufacturer shall comply at least with the Polish standards applicable to the relevant type of glass.

Any additional information contained in this Standard is presented as notes that clarify the requirements.

Note:
This Company Standard forms an integral part of the quotation, price list and cooperation agreement. Acceptance of an order for production also constitutes acceptance of the General Terms and Conditions (OWS), this Company Standard and the warranty terms.

2 DEFINITIONS AND STANDARDS

Table 1. Definitions, glass properties and quality requirements

Standard	Type of glass
Unprocessed glass (basic glass)	
PN-EN 572-2	Float glass
PN-EN 572-3	Polished wired glass
PN-EN 572-4	Drawn sheet glass
PN-EN 572-5	Rolled patterned glass
Processed glass	
PN-EN 12150-1	Thermally toughened soda-lime-silicate glass
PN-EN 12337-1	Chemically strengthened soda-lime-silicate glass
PN-EN 1863-1	Heat-strengthened soda-lime-silicate glass
PN-EN 14179-1	Heat-soaked thermally toughened soda-lime-silicate safety glass silicate
PN-EN 12543–1 PN-EN 12543–2 PN-EN 12543–3 PN-EN 12543–4 PN-EN 12543–5 PN-EN 12543–6	Laminated glass and laminated safety glass
PN-EN 1096-1	Coated glass
PN-EN 14449	Laminated glass and laminated safety glass - Evaluation of conformity/product standard
PN-EN 1279-1 PN-EN 1279-5	Insulating glass units
refer to the standard applicable to the base glass used for manufacture	ceramic-printed glass
	subsurface-engraved glass
	surface-engraved glass

3 MONOLITHIC GLASS

3.1 Base glass

Float glass is the basic flat glass used for most products. Depending on the intended application of the final product and the customer's preferences, ML System also offers compositions made with other types of glass, such as coated, body-tinted or patterned glass.

3.2 Cutting

The first production process is cutting the glass panes, which then proceed to the subsequent processing stages.

3.2.1 Width and length - dimensions and tolerances

Glass-pane dimensions are specified with reference to a rectangle. The first dimension shall be the width W and the second dimension the height L, in mm, as shown in the figures below (Fig. 1).

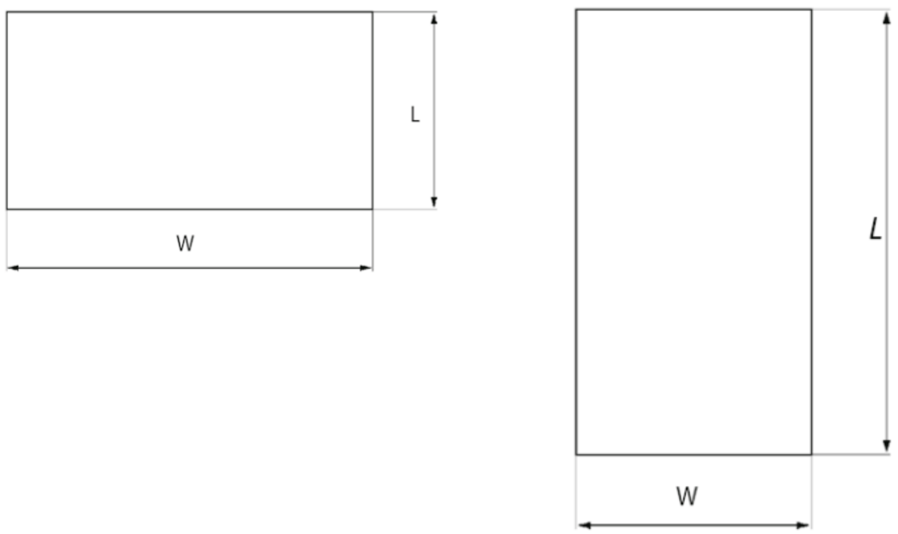


Fig. 1. Dimension designation.

Subject to agreement between the manufacturer and the customer, glass panes of shapes other than rectangular may be produced. In each case, the customer shall specify all non-standard dimensions and obtain the manufacturer's confirmation that the ordered solution can be produced.

Table 2. Dimensional tolerances for rectangular panes [mm]

Glass thickness [mm]	Tolerance, t		
	Dimensions (W - width, L - length)		
	(W, L) <= 1500	1500 < (W, L) <= 3000	(W, L) > 3000
3, 4, 5, 6	± 1,0	± 1,5	± 2,0
8, 10, 12	± 1,5	± 2,0	± 2,5
15	± 2,0	± 2,5	± 3,0
19, 25	± 2,5	± 3,0	± 3,5

For oversized panes, tolerances and differences between diagonals shall be consulted with the manufacturer.

Table 3. Permissible difference between the long diagonals of rectangular panes [mm]

Glass thickness [mm]	Difference between diagonals		
	Dimensions (W - width, L - length)		
	(W, L) <= 1500	1500 < (W, L) <= 3000	(W, L) > 3000
3, 4, 5, 6	3	4	5
8, 10, 12	4	5	6
15,19,25	5	6	8

If orders containing decorative glass (e.g. ceramic-printed, engraved, patterned, etc.) do not specify the orientation of the pattern, it is assumed as standard that the pattern will run along the dimension corresponding to glass height L in the order. Where reflective glass is used, the order shall specify the position of the reflective coating.

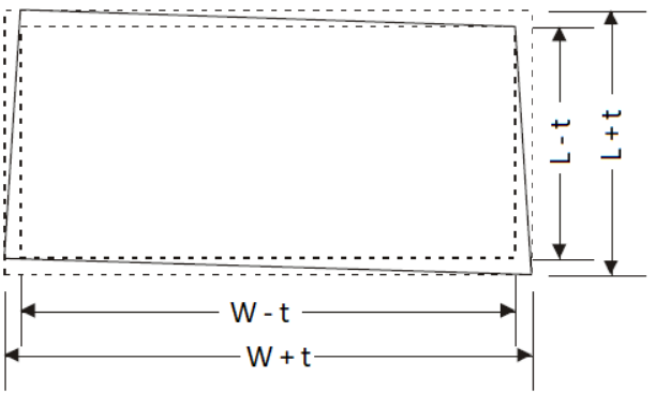


Fig. 2. Rectangle showing the tolerance limits.

The nominal width W and height L shall not be greater than the bounding rectangle resulting from increasing the nominal dimensions by the upper limit deviation t, nor smaller than the bounding rectangle resulting from decreasing them by the lower limit deviation t. The sides of the bounding rectangles are parallel and shall have a common centre.

3.3 Nominal thickness of monolithic glass

The thickness of a glass pane shall be calculated as the arithmetic mean of measurements taken at the mid-points of its four sides. Measurements shall be made with a calliper accurate to 0.01 mm, and their mean shall be rounded to 0.1 mm. Thickness deviations shall remain within the tolerances specified in the table.

Table 4. Thicknesses and tolerances

Nominal glass thickness [mm]	Tolerance [mm]
2	± 0,2
3	± 0,2
4	± 0,2
5	± 0,2
6	± 0,2
8	± 0,3
10	± 0,3
12	± 0,3
15	± 0,5
19	± 1,0
25	± 1,0

3.3.1 Edge breakouts

Breakouts in glass panes directly affect the final product and are therefore verified against the breakout tolerance table.

Table 5. Maximum permissible breakouts

Maximum breakouts [mm]	Glass thickness [mm]
1	3, 4, 5, 6
2	8, 10
3	12
4	15, 19

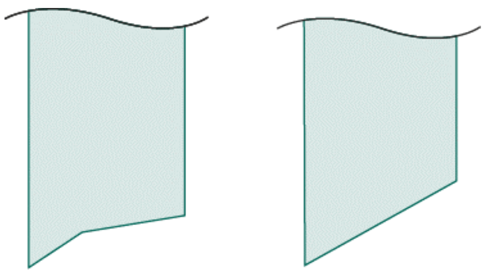


Fig. 3. Breakouts - monolithic glass

3.3.2 Defects in the form of edge chips, shelling and bevels

The glass edges and the relevant geometric dimensions are shown below.

e - glass thickness, d - chip length, h1 and p - shelling dimensions.

Table 6. Maximum size of chips or shelling at the glass edge

Geometric dimension	Tolerance
h1	< (e-1) mm
p	< (e/4) mm
d	< (e/4) mm

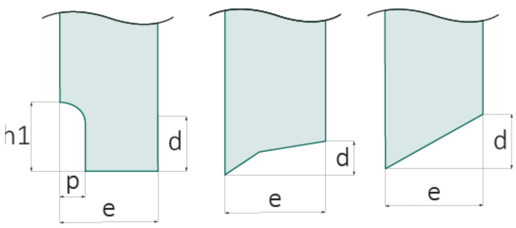


Fig. 4. Dimensions defining chips and shelling at the glass edge.

3.3.3 Area not subject to assessment

Table 7. Values of length a and the corresponding acute-angle values

Angle [deg]	Monolithic d < 8 [mm] / Laminated d < 66.x	Monolithic d ≥ 8 [mm] / Laminated d ≥ 66.x	Need for corner cutting
12,5≤α<15	90	180	YES
15≤α<20	75	149	YES
20≤α<35	55	110	NO
35≤α<45	29	57	NO

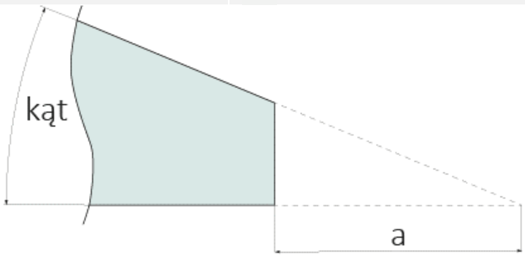


Fig. 5. Lengths of section a.

3.4 Edge finishing

Glass processing shall be carried out before processes that change its mechanical properties (tempering, strengthening). Once subjected to such a process, the glass must not subsequently be cut, drilled or edge-processed, because this may cause the glass to crack or break.

3.4.1 Tolerances

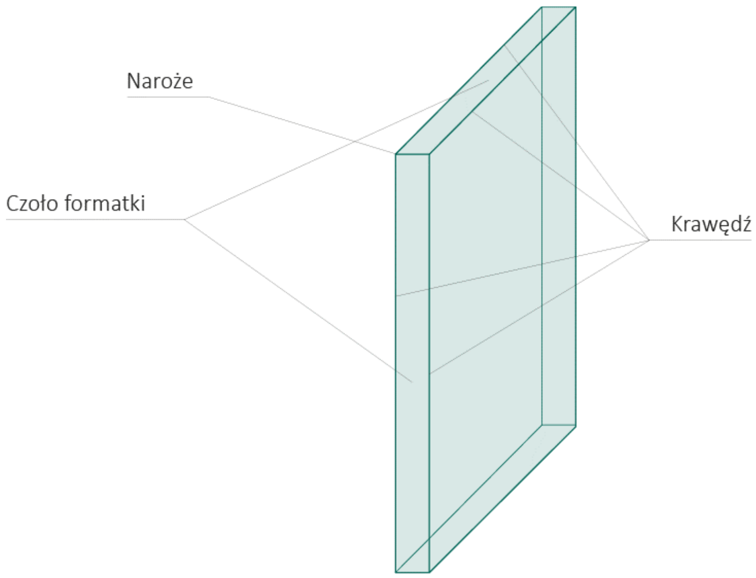


Fig. 6. Description of a glass pane.

The manufacturing tolerances for glass with this type of edge treatment, i.e. side lengths and diagonals, are the same as for cut glass.

3.4.2 Arrissing (seamed edge)

This is the simplest form of edge processing, intended to blunt the glass edge, and is used mainly before tempering. Arrissing is sufficient when the glass must be handled safely (to prevent cuts) and the pane will be installed so that its edges are not visible. The corners and the face of the pane are not processed. This treatment is available for panes 3-8 mm thick.

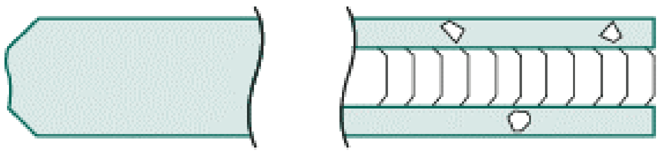


Fig. 7. Arrissed glass edge.

3.4.3 Grinding

Performed using diamond-coated wheels - a matt ground finish over the entire edge, smooth, with permitted glossy areas (small unprocessed spots may occur). Available profiles include trapezoidal and rounded grinding (C-edge). Applicable to panes 3-19 mm thick.

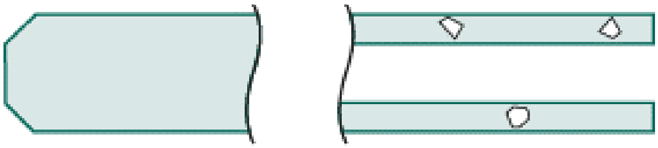


Fig. 8. Ground glass edge.

3.4.4 Polishing

Performed using diamond-coated wheels and polished with polishing wheels/discs - the face and edge have a glossy finish. This is a type of grinding followed by polishing. Applicable to panes 4-19 mm thick.

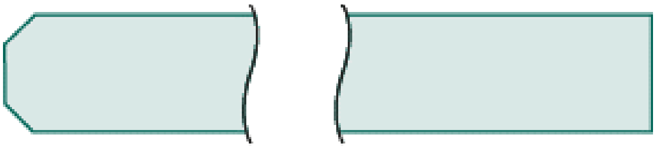


Fig. 9. Polished glass edge.

The appearance of processed surfaces may vary within the same type of treatment. This is not grounds for a complaint.

3.5 Holes and cut-outs

3.5.1 Round-hole diameter tolerances

The hole diameter (Ø) shall not be less than the nominal glass thickness (d). Any smaller diameter or hole tolerance not included in the table must be agreed with the customer and confirmed in the order.

NOTE 1: Hole-edge processing applies to diameters of 16 mm or more; holes of a smaller diameter may have minor chips.

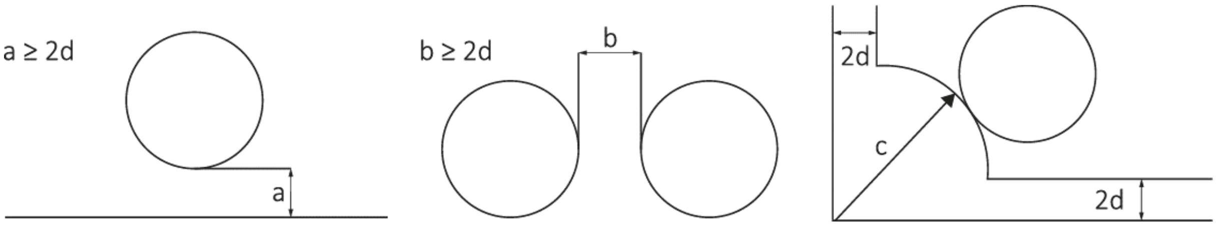
NOTE 2: Diameters smaller than Ø 11 mm and larger than Ø 40 mm must be agreed with the manufacturer.

Table 8. Round-hole diameter tolerances

Nominal diameter, Ø [mm]	Tolerances [mm]
Ø < 11	To be agreed with the manufacturer
11 ≤ Ø ≤ 20	± 1,0
20 < Ø ≤ 40	± 2,0
Ø > 40	To be agreed with the manufacturer

3.5.2 Round-hole positioning limitations

Due to technological constraints associated with strengthening processes, limitations apply to the position of holes relative to the glass edge, their distance from the glass corner and their position relative to one another. The most common hole-positioning limitations are listed below.



(d) - glass-pane thickness.

Fig. 10. Hole-positioning limitations.

a) Relative position of a hole and the glass edge (the distance shall not be less than 2d). b) Relative position of two holes (distance b shall not be less than 2d). c) Relative position of a hole and the glass corner (the distance shall not be less than 6d).

Table 9. Round-hole positioning tolerance [mm]

Glass dimension [mm]	Nominal glass thickness d ≤ 12	Nominal glass thickness d > 12
≤ 2000	± 2,5	± 3,0
2000 < B or H <= 3000	± 3,0	± 4,0
> 3000	± 4,0	± 5,0

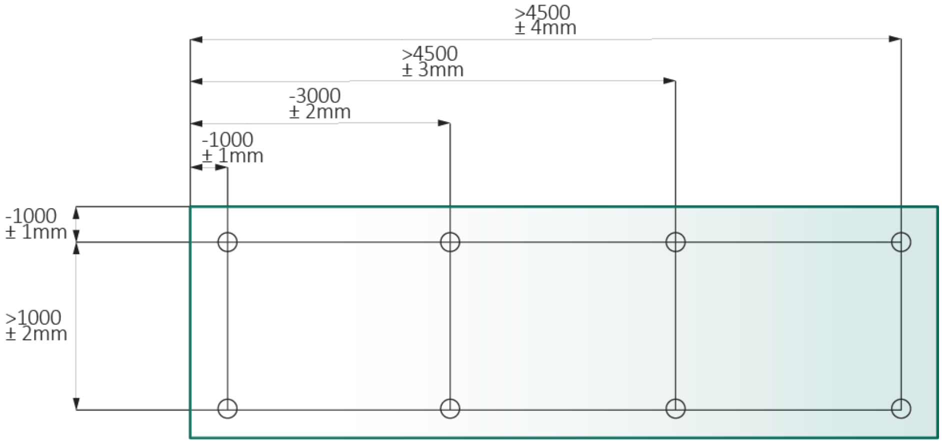


Fig. 11. Hole-positioning limitations in a glass pane

3.5.3 Positioning of edge cut-outs and applicable limitations

h1, h2, h3, h4 - cut-out lengths, c1, c2, c3, c4 - cut-out widths, L - pane height, W - pane length, r - cut-out radius,

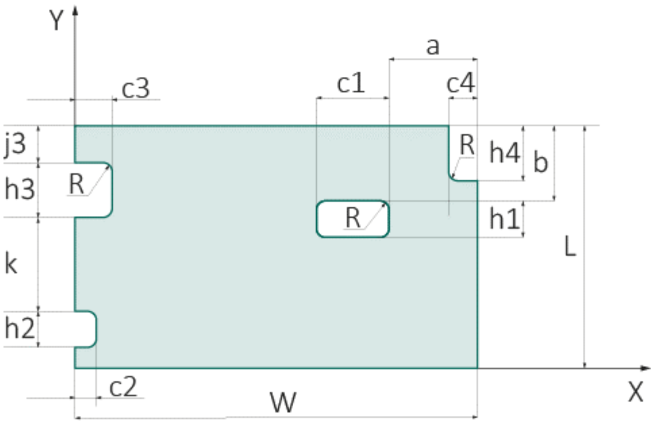


Fig. 12. Positioning of other holes and cut-outs.

- The lengths of cut-outs (h1, h2, h3, h4) shall not exceed 1/3 of dimension L.
- The widths (c1, c2, c3, c4) shall not exceed 1/3 of dimension W.
- Distance (a) to the edge of a rectangular hole shall not be less than 1/2 of the hole dimension
(c1), and distance (b) to the edge of a rectangular hole shall not be less than 1/2 of the hole dimension (h1).
- Distance (k) between cut-outs shall be greater than 1/2 of the length of the larger cut-out.
- The cut-out radius (r) shall be at least 7 mm.
- Cut-out distance (j3) shall be greater than 100 mm and at least half of dimension (h3).

3.5.4 Tolerances for other holes and cut-outs

Table 10. Hole and cut-out tolerances

Hole or cut-out [mm]	Tolerances [mm]
h or c	± 3,0

- Cut-out corners shall be rounded.
- Minimum internal corner radius R >= 5 mm.
- External corner radius: unrestricted.

NOTE: For radii smaller than 5 mm, the edge is not processed.

Table 11. Positioning tolerance for other holes and cut-outs [mm]

Glass dimension [mm]	Nominal glass thickness d ≤ 12	Nominal glass thickness d > 12
≤ 2000	± 2,5	± 3,0
2000 < B or H <= 3000	± 3,0	± 4,0
> 3000	± 4,0	± 5,0

The position of rectangular holes is measured in two perpendicular directions from the X and Y axes, which serve as reference axes (points), to the nearest edge of the rectangular hole.

3.6 Coating edge deletion

Coated glass intended for use as part of an insulating glass unit or laminate shall have the coating removed at the edge. Coating ablation ensures adhesion of the sealant to the glass surface. The deletion width depends on the calculated width of the sealant joint.

Table 12. Coating-deletion width tolerances [mm]

Tolerance	Coating-deletion width
± 1,0	for a coating-deletion width of up to 11 mm
+2,0/-1,0	for a coating-deletion width above 11 mm

The mechanical coating-deletion process may result in visible hairline scratches, streaks, spots or discolouration, which do not constitute glass defects. The appearance of the abraded coating may differ from edge to edge as a consequence of the process. The phenomena listed above are not grounds for a complaint.

3.7 Visual assessment of glass

Monolithic glass is assessed in diffuse daylight against a matt grey screen. The glass shall be positioned vertically and viewed from a distance of 2 metres. Visible defects are marked and measured, and then checked for compliance with the permissible values. Defects that are not visible under the conditions specified above are considered permissible.

Table 13. Defect categories for float glass

Category	Spot-defect dimensions [mm]
A	> 0.6 and <= 1.5
B	> 1.5 and <= 3.0
C	> 3.0 and <= 9.0
D	> 9,0

Table 14. Acceptance levels for spot defects in float glass of final cut sizes

S - glass area

Spot-defect category*	$S \leq 5m^2$	$5m^2 < S \leq 10m^2$	$10m^2 < S \leq 20m^2$
A	Permitted without limitation		
B**	1	2	4
C	Not permitted	1	1
D	Not permitted		

*As defined in PN-EN 572-2, a spot defect in float glass is a core, sometimes surrounded by a halo of distorted glass. Spot defects include solid inclusions, bubbles, etc.
**The minimum distance between category B defects shall be at least 500 mm.

Scratches on cut-size float-glass panes are permitted without limitation as to their number or length, provided that they are not visible from a distance of 2 metres.

4 GLASS TEMPERING

Tempered glass is glass that has undergone heat treatment by means of a controlled heating and cooling process (to substantially increase resistance to thermal and mechanical stresses and to obtain the required fragmentation characteristics), and is therefore classified as safety glass. The increased mechanical and thermal strength of tempered glass results from a specific distribution of thermal stresses in the glass plate. With symmetrical, uniform cooling, the outer layers form a zone of compressive stress, while the inner layers form a zone of tensile stress.

For glass to be tempered, the following minimum edge processing is required:
- arrissing for glass up to and including 8 mm thick,
- edge grinding for glass >= 10 mm thick.

These requirements are justified because substantial stresses arise in the glass during tempering and are concentrated at its edges. An improperly prepared edge may cause the pane to break in the furnace. All edge processing, drilling, cut-outs, etc. must be completed before tempering. It should also be remembered that holes and cut-outs increase the risk of glass breakage during the tempering process.

4.1 Dimensions and tolerances

Table 15. Width and length tolerances [mm]

Width or height (W or L) [mm]	Tolerance, t Nominal glass thickness, d <= 8	Tolerance, t Nominal glass thickness, d > 8
≤ 2000	± 2,0	± 3,0
2000 < W, L <= 3000	± 3,0	± 4,0
> 3000	± 4,0	± 5,0

Table 16. Limit deviations for the difference between diagonals [mm]

Width or height (W or L) [mm]	Nominal glass thickness, d <= 8	Nominal glass thickness, d > 8
≤ 2000	≤ 4	≤ 6
2000 < W, L <= 3000	≤ 6	≤ 8
> 3000	≤ 8	≤ 10

Colourless float glass, body-tinted glass, glass with hard coatings and certain types of glass with soft coatings may be thermally tempered (availability shall always be confirmed by the glass manufacturer).

The dimensions of tempered glass are determined by the technological capabilities of the edge-processing equipment and the tempering furnace.

Table 17. Dimensions of tempered glass

Glass thickness [mm]	Minimum dimension [mm]	Maximum dimension* [mm]
3	200 x 350	1000 x 1800
4 - 5	200 x 350	1500 x 2500
6	200 x 350	2500 x 4000
8-19	200 x 350	3200 x 6000
4 mm coated glass emissivity 1-0.1	200 x 350	1200 x 2000
>= 6 mm coated glass emissivity 1-0.1	200 x 350	2000 x 3000
4 mm coated glass Emissivity below 0.1	200 x 350	1200 x 2000
>= 6 mm coated glass emissivity below 0.1	200 x 350	1500 x 2500
*Larger glass dimensions may be tempered, but this requires confirmation by the manufacturer (maximum 2400 x 3600 mm).		

4.1.1 Overall bow

Overall bow is the deviation from straightness relative to annealed (non-tempered) glass. The deviation depends on the glass thickness, dimensions and aspect ratio. Distortion shall be measured along the glass edges and diagonals as the maximum distance between a straight metal rule or a tensioned wire and the concave surface of the glass. The bow is expressed as the distortion in [mm] divided by the length of the glass edge or diagonal in [m].

Table 18. Maximum permissible values of overall bow

Tolerance [mm/m]	Type of glass
3,0 mm	float
4,0 mm	other glass types

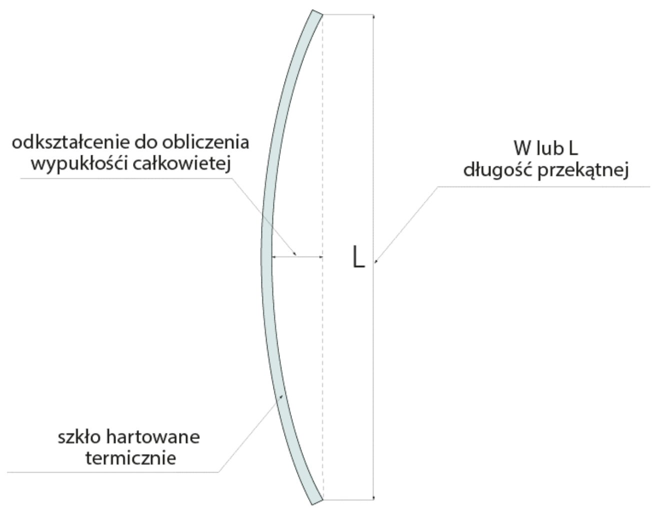


Fig. 13. Overall bow.

Overall-bow results for glass thinner than 4 mm may be inaccurate. For digitally printed glass that is not covered over its entire surface, consult the manufacturer. For vehicle glazing, the bow tolerance may be lower. The use of tighter tolerances requires additional agreement between the manufacturer and the customer.

4.1.2 Roller-wave distortion

Roller-wave distortion is measured using a straightedge or equivalent instrument (e.g. an aluminium profile with a dial gauge) placed perpendicular to the roller waves so that it bridges the wave peaks. The straightedge is positioned so that it bridges two adjacent wave peaks.

Table 19. Maximum permissible roller-wave distortion

Tolerance	Type of glass
0,3 mm	float glass
0,5 mm	other glass types

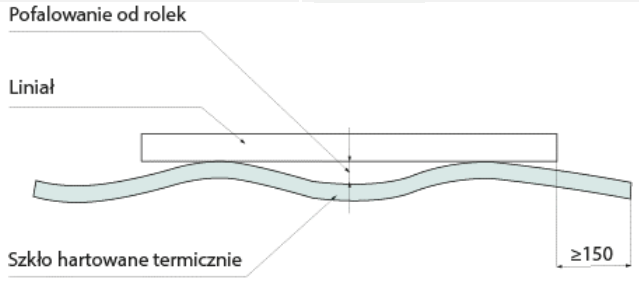


Fig. 14. Roller-wave distortion.

Measurement limitations:
- roller-wave distortion can be measured only on panes with a dimension greater than 600 mm,
measured perpendicular to the roller waves;
- roller-wave distortion cannot be measured within the excluded area extending 150 mm from
the edges of the pane;
- panes with overall bow shall be placed on a flat support. Gravity will then
flatten the overall bow and allow the roller-wave distortion to be measured correctly. For painted glass that is not coated over its entire surface, consult the manufacturer.

4.1.3 Edge lift

The glass shall be placed on a flat support with the edge projecting 50-100 mm beyond the support. A straightedge is placed on the peaks of the roller waves, and the gap between the straightedge and the glass is measured using a feeler gauge or another straightedge.

Table 20. Maximum permissible edge-lift values

Tolerance	Type of glass
0,4 mm	float 4-5 mm
0,3 mm	float 6-19 mm
0,5 mm	other glass types

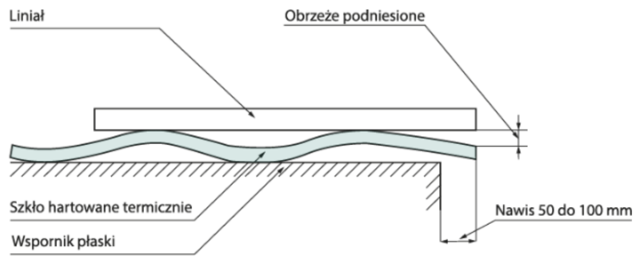


Fig. 15. Edge lift

4.2 Fragmentation test

The test determines whether the glass fractures in the manner required for thermally toughened safety glass. It consists of breaking the tempered pane in the manner specified in PN-EN 12150-1 and counting the fragments within a 50 x 50 mm square. For the relevant type of glass, the test result is satisfactory if the number of fragments in the sample is not lower than the value specified in the table.

Table 21. Minimum number of fragments counted

Type of glass	Glass thickness [mm]	Minimum number of fragments counted in the sample
Float, painted, surface-engraved glass	3	15
	4-12	40
	15-25	30

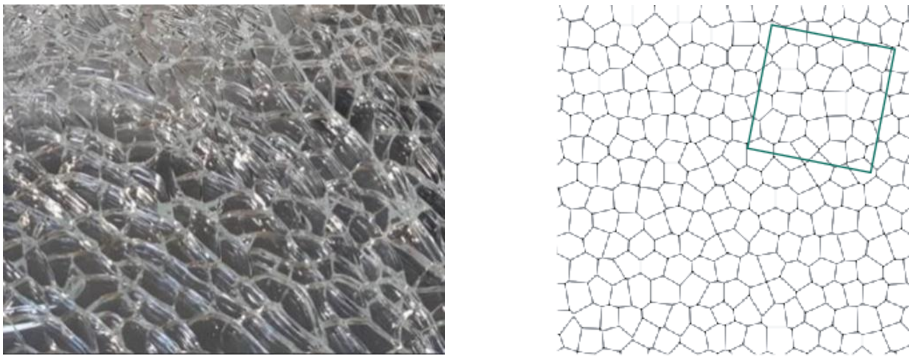


Fig. 16. Fragmentation pattern of tempered glass

4.3 Thermal resistance of tempered glass

The properties of thermally tempered glass remain unchanged at temperatures up to 250 °C (and also at temperatures below 0 °C). Thermally tempered glass can withstand thermal shocks of approximately 200 °C.

4.4 Limitations - directional tempering

Because roller-wave distortion occurs, a preferred tempering orientation may be selected - with the length of the pane perpendicular or parallel to the rollers in the tempering furnace. Directional tempering is not possible where dimension W or L, depending on the selected orientation, exceeds the furnace working width of 2400 mm. In such a case, the relevant pane may be tempered in a different direction from the other panes in the order. For directional tempering, the order must in each case specify the tempering orientation selected by the customer. If no orientation is specified, the glass may be tempered without taking orientation into account.

4.5 Marking of tempered glass

In accordance with PN-EN 12150-1, tempered glass must be marked. Differences in the location, application method, appearance or position of the glass marking are not grounds for a complaint, provided that they affect no more than 10% of the order.

NOTE: Any special Customer requirements concerning glass marking must be agreed and approved before the order is placed.

4.6 Heat soak testing of glass (HST)

In the interests of our Customers, we recommend an additional glass heat-soak test, known as HST (in accordance with EN 14179), because tempered glass may fracture spontaneously due to nickel-sulphide inclusions. This test reduces the risk of spontaneous glass breakage by as much as 99%. Any glass breakage caused by a nickel-sulphide inclusion, despite HST, is not subject to complaint. Tempered panes that have undergone HST are legibly and permanently marked with the company mark and the PN-EN 14179-1 standard number.

NOTE: If HST is selected, it must be included when the order is initially placed. The HST process requires additional order lead time.

4.7 Glass for other applications

An order for this type of glass shall state that the intended application is non-constructional, e.g. furniture. If no such information is provided, the glass will be treated as a construction product and permanently marked accordingly.

4.8 Surface assessment of tempered glass

4.8.1 Assessment method

Visual inspection is carried out with the unaided eye under natural lighting conditions, in transmitted and/or reflected light depending on the glass used and the corresponding technical specification. The observation shall not last longer than 30 seconds.
- The observer shall be 2 m from the glass.
- For coated glass, the distance shall be 3 m.

The assessment is carried out in accordance with the following guidelines:

Zone R (rebate zone) - equal to the frame width or the edge-seal width and not less than 15 mm; no limitations apply except for mechanical damage to the edge. The width of the rebate zone is 15 mm for panes with an area <= 5 m2 and 20 mm for panes > 5 m2.

Zone E (edge zone) - the zone at the edge of the visible area, equal to 5% of the edge length and not less than 50 mm.

Zone M - main/central zone

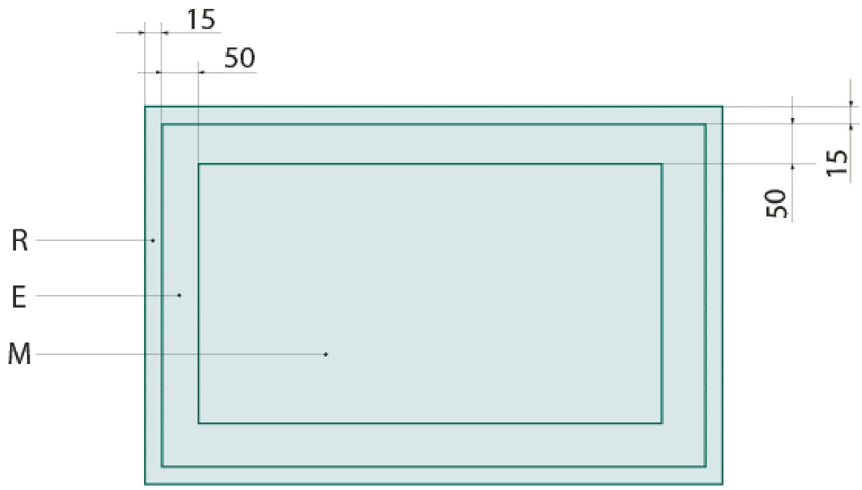


Fig. 17. Defect zones of glass panes

For glass not intended for installation in frames or for assembly into units, the requirements for zone R are the same as for zone E.

4.8.2 Definition of defects

spot defects spherical or hemispherical disturbances of visual transparency when viewed through the glass. These may be solid inclusions, gas inclusions or spot defects in the coating.

linear defects defects that may occur on or within the glass in the form of deposits, stains or scratches extending over a greater length or an elongated area.

streaks haze characteristic of heat-treated glass, visible under certain lighting conditions (e.g. direct sunlight or artificial light) and against a dark background. This phenomenon is associated with the production process and cannot be avoided.

stains defects larger than a spot defect, often irregular in shape and partly speckled in structure.

4.8.3 Possible defects

Table 22. Permissible spot defects

Assessment zone	Defect size Ø, [mm] (excluding the so-called "halo")*	Glass area S [m2]			
		S ≤ 1	1 < S ≤ 2	2 < S ≤ 3	3 < S
R	Any size	Unlimited			
E	Ø ≤ 1	Permitted if fewer than 3 occur in each area of Ø 200 mm			
	1 < Ø ≤ 3	4 pcs.	1 defect per linear metre of the glass perimeter		
	Ø > 3	Not permitted			
M	Ø ≤ 1	Permitted if fewer than 3 occur in each area of Ø 200 mm			
	1 < Ø ≤ 2	2 pcs.	3 pcs.	5 pcs.	7 pcs./m2
	2 < Ø ≤ 3	1 pc./m2			
	Ø > 3	Not permitted			
*Halo - a locally distorted area, usually around a spot defect where the defect is within the glass pane					

Table 23. Linear defects

Assessment zone	Individual lengths	Total length	
		Area <= 3 m2	Area > 3 m2
R	Unlimited		
E	≤ 75 mm	≤ 225 mm	75 mm/ m2
	> 75 mm		
M	≤ 75 mm	≤ 225 mm	75 mm/ m2
	> 75 mm	Not permitted	

Table 24. Streaks and stains

Assessment zone	Stains	Streaks
R	Unlimited	
E	Ø <= 17 mm - 1 pc./m2	Unlimited
M	Permitted if not visible from the distance specified for glass inspection under daylight conditions.	

Table 25. Edge defects

Location	Type of defect
Arrissing	Minor chips at the edge are permitted. Glossy areas are permitted.
Grinding	Edge chips are not permitted; unprocessed spots may occur unprocessed spots
Polishing	Matt areas and edge chips are not permitted

Anisotropy (iridescence) - the appearance of rainbow effects - is one of the characteristics of heat-treated glass. It is not a defect, but a visible effect of the heat-treatment process. The phenomenon is caused by local internal stresses resulting from rapid cooling of the glass during heat treatment. These stresses cause birefringence in the glass, which becomes visible in polarised light. Polarised light occurs naturally in normal daylight, but its intensity depends on factors such as atmospheric conditions and the angle of incidence of sunlight. Anisotropy resembles shadows and becomes more visible as the viewing angle changes, in the form of coloured areas known as polarisation fields. Polarisation fields are visible when the glass is viewed at a shallow angle, also in daylight (this phenomenon can easily be observed on tempered vehicle vehicle glass).

Roller imprints (roller marks) - during heat treatment of glass 8 mm thick or thicker, and of thinner but larger panes, small imprint marks may become apparent on the glass surface. Provided that they are not visible from the distance specified in the relevant glass standard under daylight conditions, they are considered permissible.

Roller-wave distortion - formed during thermal tempering of the glass, it creates optical distortion that is mainly visible in reflected light. It consists of surface distortion caused by contact between the hot glass (at a temperature close to the softening point) and the furnace rollers. This causes deviations from glass straightness. Permissible roller-wave values are specified in the section on glass tempering. When ordering glass for building façades, the customer is advised to take roller-wave distortion into account and specify the loading direction of the panes in the tempering furnace (see: directional tempering).

Nickel-sulphide inclusion - under the applicable PN-EN 12150-1 standard, nickel- sulphide (NiS) inclusions are a rare but naturally occurring glass contaminant. During service, tempered glass may fracture spontaneously as a result of the presence of nickel sulphide in the glass. During tempering, a nickel-sulphide particle undergoes a polymorphic transformation that changes its volume and introduces additional stresses into the glass pane. Tempered glass broken due to a nickel-sulphide inclusion shows a characteristic butterfly pattern formed by two pentagonal or hexagonal pieces of glass with the inclusion at their centre. Breakage of tempered glass caused by such an inclusion is not grounds for a complaint.

4.9 Thermally bent glass

Thermally bent glass is glass that is slowly heated until it exceeds its softening temperature and is then formed to the required shape.

4.9.1 Bending capabilities and tolerances

Table 26. Bending radius

Glass thickness [mm]	Minimum bending radius [mm]
4 mm	1200 mm
5-6 mm	700 mm
8-10 mm	1000 mm
12 mm	1500 mm
Maximum bending radius	10 000 mm

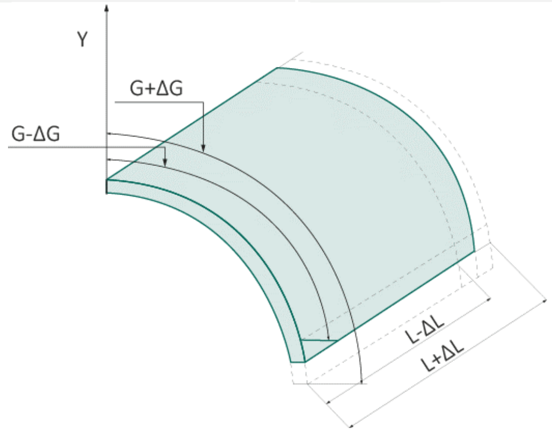


Fig. 18. Bent-glass tolerances

Table 27. Bent-glass tolerances

Tolerance of straight-side length ΔL and arc ΔG		Shape-deviation tolerance		Maximum offset of Offset is the deviation of one or two or more corners from the plane connecting the corners. L - length of the straight side	
4-8 mm thickness	2 mm/m	4-8 mm thickness	± 2/3 G	4 mm	L ≤ 1200
10-12 mm thickness	±3 mm/m	10-12 mm thickness	± 1/2 G	6 mm	1200 < L < 1500
Maximum permissible bow				6 mm	1500 < L < 2000
3 mm/m - measured at the glass edges				7 mm	2000 < L < 2400
4 mm/m - measured at the centre				8 mm	L > 2400

5 CERAMIC-PRINTED GLASS

The print (enamel) is a multicolour print applied to the glass surface using ceramic inks. During tempering, the ceramic print fuses into the glass surface and forms a durable coating. Printed glass must undergo tempering or heat-strengthening. The strength values of tempered or heat-strengthened enamelled glass are lower than those of non-enamelled glass.

NOTE: Processing of this glass after heat treatment is not possible.

Table 28. Thickness range and dimensions of tempered ceramic-printed glass

Glass thickness range [mm]	Minimum glass dimensions glass [mm]	Maximum glass dimensions glass [mm]	Print resolution [DPI]
3 - 19	150 × 350	2200 × 3600	1440
Printing on thinner glass is possible subject to agreement with the manufacturer.			

5.1 Printing limitations

Depending on the production process and enamel colour, the glass exhibits a higher or lower light transmission and is not transparent. Light colours always have higher light transmission than dark colours. Materials placed directly against the print, e.g. sealants, adhesives, panels, insulation or fixings, are visible through the glass. The enamelled side must always be positioned on the side not exposed to weather conditions. The print must not be exposed to weathering. The colour perceived is always influenced by the colour of the base glass. Colour differences may occur between the viewing side and the printed side. Minor lines in the printing direction are typical for this process, depending on colour, print density and application, as are occasional pinholes, shadows and isolated slightly blurred spots. These effects are particularly visible with full-surface printing.

NOTE: Applications in which the printed pane is visible from both sides must always be consulted with the manufacturer.

5.2 Assessment, defects and tolerances of printed glass

Assessment is carried out from the front of the pane under normal daylight (or equivalent) conditions against an opaque background, without direct sunlight or artificial illumination. Inspection is always performed through the glass, looking at the surface without the printed layer. Enamelled glass shall be assessed from a distance of at least 3 m, perpendicular to its surface. During inspection, the viewing angle measured from the line perpendicular to the assessed glass surface shall not exceed 30°. Glass visible from both sides is subject to the same assessment. Features visible only from a distance of less than 3 m are not classified as defects.

NOTE 1: Observed defects shall not be marked.
NOTE 2: Features visible only from a distance smaller than that specified in the standard applicable to the relevant type of glass are not classified as defects.

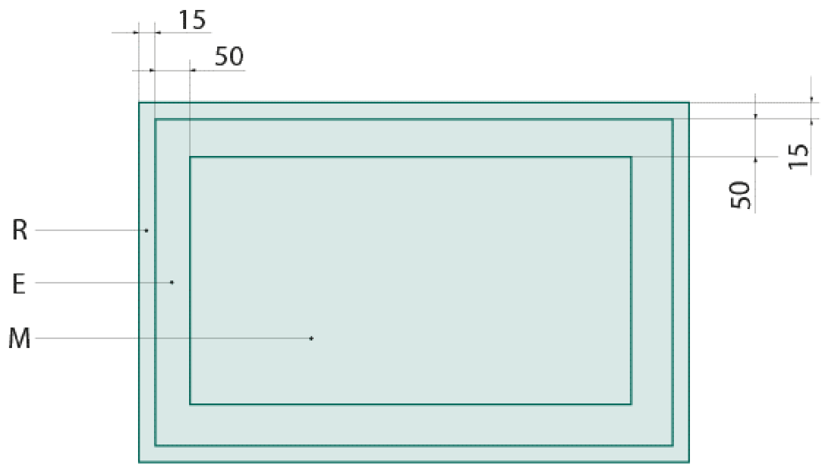


Fig. 19. Defect zones of glass panes

Zone R 15 mm rebate zone Zone E + M Main zone

For glass not intended for installation in frames or for assembly into units, the requirements for zone B are the same as for zones E + M.

5.2.1 Possible defects and tolerances

Table 29. Spot defects

Assessment zone	Dimension [mm]	Tolerances
R	Any size	Permitted without limitation
E + M	Ø ≤ 1	Permitted if fewer than 3 occur in each area of Ø 200 mm
	1 < Ø ≤ 5	Maximum 3 defects/m2, spaced at least 100 mm apart
	Ø > 5	Not permitted

If enamelled glass is used against a light-coloured substrate or is illuminated from the side opposite the observer, a starry-sky appearance may occur (or spots, stains and streaks may appear) as a consequence of the production technology. This is caused by the nature of the print, which is not completely opaque to light.

NOTE: This effect is not grounds for a complaint.

Table 30. Linear defects

Assessment zone	Dimension [mm]	Total length	
		Area <= 3 m2	Area > 3 m2
R	Unlimited	Unlimited	
E + M	Ø ≤ 1	≤ 225 mm	75 mm/m2
	≤ 75 mm	Maximum 3 defects/m2, spaced at least 100 mm apart	
	> 75 mm	Not permitted	

Slight stripes in both the longitudinal
and transverse directions, as well as isolated slightly blurred spots, are characteristic of enamelled glass.

Table 31. Streaks and stains

Assessment zone	Stains	Total length
R	Unlimited	Unlimited
E + M	Ø ≤ 17 mm 1 pc./m2	≤ 225 mm Permitted if not visible from the distance specified for glass inspection under daylight conditions

5.2.2 Surface assessment of printed glass

Table 32. Surface assessment of printed glass

Description	Main zone E + M		Rebate zone B
Enamel defects per pane	Max. 3 defects with an area not exceeding 25 mm2/ 1m2 Total of all defects: maximum area 25 mm2/ 1m2		Width: 3 mm Length: unrestricted
Excess enamel at the edge	Not applicable		Permitted
Depending on length:			
Tolerance for partial coverage with print/enamel*	Enamel length: ≤ 2000 mm > 2000 mm	Tolerance: ±3,0 mm ±5,0 mm	Not applicable
* The enamel-position tolerance is measured from the reference point. If the glass edge is embedded, the measurement is taken from the face of the glass. For arrissed, ground or polished edges, the measurement is taken from the edge of the bevel on the glass surface.			
Depending on the length of the printed edge:			
Tolerance of print and patterns	Enamel length: ≤ 100 mm ≤ 1000 mm ≤ 2000 mm ≤ 3000 mm ≤ 4000 mm	Tolerance: ±1,0 mm ±2,0 mm ±2,5 mm ±3,0 mm ±4,0 mm	Not applicable
Defects <= 0.5 mm (very small enamel imperfections - pinholes, i.e. the starry-sky effect) are permitted and disregarded. Repair of defects with ceramic enamel before tempering is permitted. Repaired discrepancies shall not be visible from a distance of 3 metres.			

5.2.3 Colour tolerances

The actual enamel colour can be determined by viewing a tempered sample through the unpainted side of the glass. Colour differences may occur when colours are selected using standard systems. Such differences result from many factors and cannot be eliminated. The factors listed below affect the assessment of perceptible colour differences between two ceramic-printed glass panes. The composition of the glazing unit used for the project (glass type, interlayer) will also affect colour perception; a sample should be produced for each project and approved by the customer.

NOTE:
Print on surfaces 2 and 3: When laminating digitally printed/screen-printed glass with the print located on surface 2 or 3 (facing the laminating interlayer), it is mandatory to

maintain a minimum margin (clearance) of 5 mm from the edge of the pane. Failure to comply with this requirement creates a high risk of glass delamination. Failure to meet this design condition results in complete loss of the product warranty.

Print on surfaces 1 and 4: Printing directly to the outer edge of the glass is permitted and possible only where the print is applied to the external surfaces, i.e. surface 1 or 4.

Effect on colour: It should also be remembered that lamination with an interlayer colour other than transparent will change the final shade and colour perception of the print.

5.2.4 Effect of the base-glass type on print colour

The colour of the base glass depends on the manufacturer, glass thickness and production batch, and therefore affects the final colour of the printed glass. The colour also depends on the degree of coverage by the ceramic paint layer. Because the ceramic-print layers are relatively thin, printed surfaces are not completely opaque to light. Visible light reaching the fired enamel is partly absorbed and partly reflected. As a result, the enamel colour may be perceived differently depending on the prevailing lighting conditions.

NOTE: Printed glass is always assessed after tempering.

5.2.5 Effect of the enamel type used

Ceramic enamel is made from inorganic materials that provide the specified colour. The enamel itself may vary slightly from the original colour, and enamel colours can therefore be compared only within a single production batch. For non-standard print colours and patterns or special Customer requirements, a reference sample may be produced and approved by the customer. Colours obtained by digital printing will always differ from those shown in colour charts and from colours in submitted photographs.

NOTE 1: The manufacturer does not guarantee identical shades on items produced using several batches of ceramic ink.
NOTE 2: If a project is completed in several stages, ML System cannot guarantee colour repeatability. Over a long period, the risk of differences in the final colour increases significantly, mainly because ink or glass from a different batch may be used than at the start of the project.

6 GLASS ENGRAVING

Glass engraving is performed using a laser, which provides a precise method of engraving the required patterns, letters and graphics on the glass surface. Any pattern may be engraved subject to agreement with the manufacturer and Customer approval. The tolerances and dimensions are the same as for monolithic glass.

Table 33. Thickness range and dimensions of engraved glass

Glass thickness range [mm]	Minimum glass dimensions [mm]	Maximum glass dimensions [mm]
3 - 100	150 × 350	2200 × 4000

- Surface engraving is engraving on the surface of the glass. It can be performed on glass that has already been tempered, or the engraved glass can subsequently be tempered.

- Subsurface engraving is engraving within the glass. A minimum glass thickness of 5 mm is used for this process.

6.1 Defects not subject to claims

Characteristic streaks may occur during surface engraving of glass. This is a natural consequence of the engraving process and is not grounds for a complaint. The effect is more noticeable on large glass surfaces.

7 HEAT-STRENGTHENED GLASS (TVG)

Heat-strengthened glass (TVG) in accordance with PN-EN 1863 is obtained by heat treatment. The purpose of this treatment is to increase the mechanical and thermal strength of the glass. The main differences between heat-strengthened and tempered glass are the different fragmentation pattern and the lower strength of TVG glass compared with ESG. If broken, heat- strengthened soda-lime-silicate glass fractures in a manner similar to annealed glass (e.g. float glass). The nature of heat strengthening prevents the product from being as flat as annealed glass. The difference in flatness depends on the glass type, e.g. coated or patterned, the glass dimensions, i.e. nominal thickness, dimensions and dimensional ratio, and the process used, i.e. vertical or horizontal. For a horizontal process, the following forms of distortion occur:

- overall bow,
- roller-wave distortion,
- edge lift.

All glass processing shall be performed before heat strengthening. The table below presents the differences in glass strength after the TVG and ESG processes.

NOTE: Heat-strengthened glass is not safety glass.

Table 34. Mechanical strength values for TVG and ESG glass.

Type of glass	Heat-strengthened glass (TVG) [N/mm2]	Tempered glass (ESG) [N/mm2]
colourless, coated	120	70
enamelled	75	56
patterned and drawn sheet glass	90	55

8 CHEMICALLY STRENGTHENED GLASS (CVG)

Chemically strengthened glass (CVG) is a material that, through chemical strengthening, acquires exceptional resistance to mechanical damage and temperature differences. Compared with conventionally tempered glass, CVG has greater resistance to bending and other types of stress. The strengthening process consists of immersing the glass in a special chemical solution, causing ion exchange at the material surface, which creates internal compressive stress and increases the hardness of the outer glass layer.

NOTE: Chemically strengthened glass is not safety glass.
This means that if it cracks or breaks, it does not disintegrate into small, blunt fragments as tempered or laminated glass does. CVG may break into sharper fragments, creating a risk of injury, particularly where the glass is exposed to strong impact or high temperatures. Although chemically strengthened glass offers many benefits, including increased strength and lower weight, it must always be used in accordance with the applicable safety standards and selected for locations where the risk of breakage does not endanger users.

8.1 Dimensions and tolerances

Table 35. Thicknesses and tolerances

Nominal glass thickness [mm]	Tolerance [mm]
1	± 0,1
1,3	± 0,1
1,6	± 0,1

2	± 0,2
3	± 0,2
4	± 0,2
5	± 0,2
6	± 0,2
8	± 0,3
10	± 0,3
12	± 0,3

Table 36. Tolerances for width W and length L

Nominal side dimension, W or L [mm]	Tolerances, t [mm]
≤ 2000	± 2,5
2000 < H or B <= 3000	± 3,0
> 3000	± 4,0

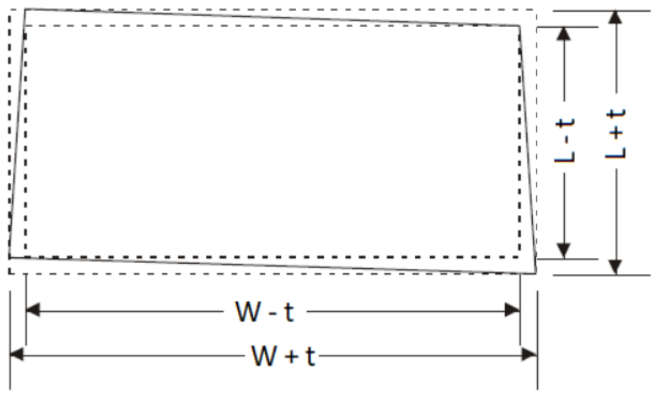


Fig. 20. Dimensional tolerance limits for rectangular panes

9 TYPE-APPROVED GLASS

Type-approved glass meets stringent quality requirements for tempered and laminated glass in accordance with UN ECE Regulation No. 43 and is intended for use in mobility-sector vehicles such as buses, trains, etc.

10 LAMINATED GLASS

Laminated glass consists of two or more glass panes (e.g. annealed or tempered) bonded by one or more film interlayers that prevent the panes from separating if broken. Because the film bonds the two glass panes together, laminated glass acquires safety-glass properties.

10.1 Dimensional tolerances

Table 37. Side-length tolerances for rectangular panes [mm]

Width or length [mm]	Glass thickness laminated glass ≤ 8 mm	Laminated-glass thickness > 8 mm	
		Thickness of an individual component < 10 mm	Thickness of an individual component >= 10 mm
≤ 2000	+3,0/-2,0	+3,5/-2,0	+5,0/-3,5
≤ 3000	+4,5/-2,5	+5,0/-3,0	+6,0/-4,0
> 3000	+5,0/-3,0	+6,0/-4,0	+7,0/-5,0

Table 38. Difference between diagonal lengths for rectangular panes [mm]

Width or length [mm]	Glass thickness laminated glass ≤ 8 mm	Laminated-glass thickness > 8 mm	
		Thickness of an individual component < 10 mm	Thickness of an individual component >= 10 mm
< 2000	6	7	9
< 3000	8	9	11
> 3000	10	11	13

10.1.1 Laminate thickness

NOTE: Laminate thickness is measured at the midpoint of each of the four edges. The mean is calculated and rounded to 0.1 mm.

Table 39. Glass-thickness tolerance [mm]

Thickness	Deviations
2 - 6	± 0,2
8 - 12	± 0,3

Table 40. Limit deviations for laminated-glass interlayer thickness [mm]

Interlayer thickness	Deviations

≤ 2	± 0,1
> 2	± 0,2

Table 41. Example laminated-glass make-up.

Interlayer thickness	Thickness
VSG 44.1mm	8,38mm
VSG 44.2 mm	8,76mm
VSG 55.2mm	10,76mm
VSG 66.4mm	13,52mm

Example calculation of the tolerance for a finished laminate: 4 mm float/0.76 mm PVB/4 mm float
Deviation for 4 mm float = 0.2 mm
Deviation for 0.76 mm PVB film = 0.1 mm
0,2mm + 0,1mm + 0,2mm = 0,5mm

Note 1: The first two numbers correspond to glass thickness; the value after the decimal point indicates the multiple of 0.38 mm film.
Note 2: It should be borne in mind that 0.38 mm film has a net thickness of 0.25 mm after lamination.

10.1.2 Displacement of glass panes

L, W - glass length and width,

d - displacement between panes.

Table 42. Displacement value, d

Width W or length L [mm]	Displacement [mm]
L, W <= 1000 mm	2
1000 mm < L, W <= 2000 mm	3
2000 mm < L, W <= 4000 mm	4
L, W > 4000 mm	6

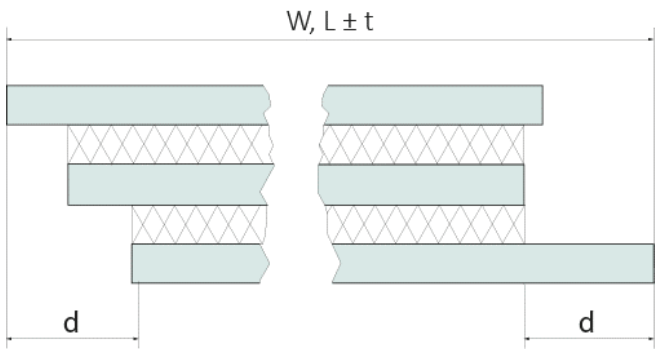


Fig. 20. Displacement in laminated glass

10.1.3 Flatness

The flatness of laminated glass depends on the flatness of its components and may be affected by production conditions.

NOTE: Special flatness requirements must be agreed before the order is placed.

10.2 Limitations

10.2.1 Edge stability of laminated glass

Exposure of laminated-glass edges to sealants or chemical and physical agents may result in deterioration (e.g. discolouration, reduced adhesion between the glass and interlayer, or delamination). All materials in direct contact with laminated glass must be compatible with its components. Particular attention shall be paid to moisture in direct contact with the edges of laminated glass. Condensation or direct exposure to water adversely affects the properties of laminated glass.

10.2.2 Laminated glass made of tempered glass

Due to surface roller-wave distortion, overall bow and anisotropy, the quality of tempered laminated glass will differ from that of annealed laminated glass.

10.2.3 Interlayer

Laminated glass with coloured or matt interlayers may undergo a slight change of shade over time due to weather conditions, including ultraviolet (UV) radiation. The coating process, iron-oxide content of the glass, changes in glass thickness and the laminated-glass construction may cause slight colour differences between panes of the same type from different production batches. Every interlayer has a slight degree of haze. As the number of interlayers increases, the haze may become more visible. Additional optical effects such as spots, stripes and streaks may also be visible.

NOTE: Loss of the original film colour and the phenomena described above are not grounds for a complaint.

10.3 Surface assessment of laminated glass

10.3.1 Assessment method

Laminated glass shall be positioned vertically and parallel to a matt grey screen in bright, diffuse daylight or equivalent light. The observer shall stand 2 m from the glass and view it perpendicularly. The matt screen shall be behind the glass. Any observed defects shall be marked.

10.3.2 Assessment area

The same assessment zones as for tempered glass are used. The rebate-zone width is 15 mm for panes with an area <= 5 m2 and 20 mm for panes > 5 m2.

10.3.3 Definition of defects

Spot defects Opaque spots, bubbles and foreign-body inclusions.

Linear defects Foreign-body inclusions, scratches, scuffs and abrasions.

Glass defects Cracks and fissures.

Interlayer defects Wrinkles, shrinkage and streaks.

10.3.4 Permissible spot defects

Permissible spot defects in laminated glass are independent of the individual glass thickness. The permissible number of spot defects increases by 1 for each layer thicker than 2 mm.

Table 43. Permissible spot defects

Number of glass components	Defect size d [mm]	0,5 < d ≤ 1,0	1,0 < d ≤ 3,0			
	Glass area A [m2]	Any area	A ≤ 1	1 < A ≤ 2	2 < A ≤ 8	A > 8
2	Number or density permissible defects	Unlimited (must not form clusters)	1	2	1/m2	1,2/m2
3			2	3	1,5/m2	1,8/m2
4			3	4	2/m2	2,4/m2
≥ 5			4	5	2,5/m2	3/m2
Defects smaller than 0.5 mm are disregarded. Defects larger than 3 mm are not permitted.						

Table 44. Permissible linear defects

A cluster of defects occurs when four or more defects are located within:	2 layers	3 layers	4 layers	More than 5 layers
Distances [mm]	200	180	150	100

10.3.5 Permissible linear defects in the vision area

Table 45. Permissible linear defects

Linear defects shorter than 30 mm are permitted	
Glass area [m2]	Permissible number of defects longer than 30 mm
≤ 5	Not permitted
5 to 8	1
> 8	2

Table 46. Other defects

Type of defect	Tolerance
Cracks	Not permitted
Wrinkles and streaks	Not permitted in the vision area
Edge chips and bubbles	Permitted if not noticeable during inspection
Defects with Ø <= 5 mm	Permitted within the area intended for framing and within the rebate zone
Interlayer defects	Not permitted in the visible area; recesses are permitted

Table 47. Defects in the rebate zone

Location of defect	Defect
Rebate zone intended for framing	If bubbles occur, the affected area shall not exceed 5% of the zone area rebate zone
Rebate zone not intended for framing	Defects that are not noticeable during inspection are permitted inspection.

10.4 Additional tests

At the Customer's special request, additional tests may be performed to confirm the quality of the laminated-glass manufacture. Quality may be confirmed by a ball-drop strength test on a test specimen and by a heat-resistance bake test. If additional tests are required for a given production batch, a request for the ball-drop test and bake test must be submitted before the order is placed.

10.5 Marking

Under PN-EN 14449, permanent marking of laminated glass and laminated safety glass products is not required.

11 INSULATING GLASS UNITS

An insulating glass unit consists of at least two glass panes separated by one or more spacer bars and hermetically sealed around the edge.

1 - cavity between panes 2 - primary sealant 3 - secondary sealant 4 - spacer bar containing desiccant

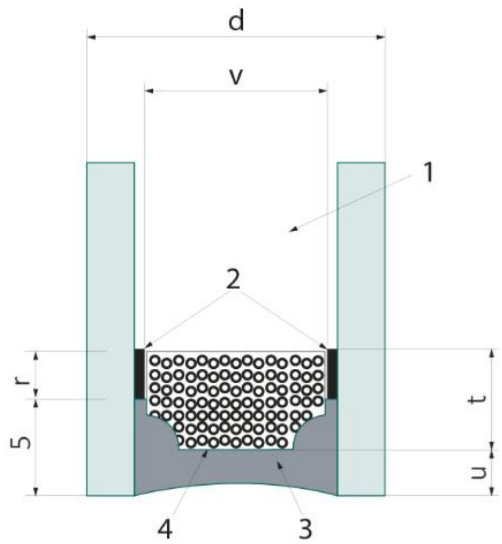


Fig. 21. Diagram of an insulating glass unit

d - total unit thickness r - mean height of the primary sealant on the glass surface t - spacer-bar height u - mean effective height of the secondary sealant above the spacer bar v - spacer-bar width

11.1 Types of insulating glass units

Type A - installation conditions where the edge is protected from UV and no permanent shear forces act on the insulating-glass seal.

Type B - installation conditions where at least one edge is not protected from UV and no permanent shear forces act on the insulating-glass seal.

Type C - units bonded to doors, windows and curtain-wall façades, with possible shear forces in the seal and with or without permanent UV exposure. Permanent shear forces can be eliminated by mechanical support that carries the weight.

11.2 Glass panes

The glass panes are the basic components described in the preceding sections of this Company Standard. They include, among others:

- float glass
- thermally tempered glass
- heat-strengthened glass
- chemically strengthened glass
- ceramic-printed glass
- engraved glass
- laminated glass

11.3 Type of sealant

Butyl - polyisobutylene, primary sealant.

Polysulphide or polyurethane (thiokol) - secondary sealant that must not be exposed to direct ultraviolet radiation.

Silicone - secondary sealant that may be exposed to direct ultraviolet radiation.

NOTE: For insulating glass units with exposed edges and/or stepped insulating glass units, minor visible colour variations in the mixed silicone compound are permitted, including discolouration, streaks and soiling at the edge.

11.4 Spacer bars

The spacer bars used are bent at the corners and joined along the sides at a maximum of four locations (the gap at a spacer-bar joint shall not exceed 1 mm). This applies to each cavity of rectangular insulating glass units with an area up to 6 m2. Visible raw material (e.g. in the form of a silver line), connectors and slight discolouration or scratches in the cut area are consequences of the production process.

11.4.1 Spacer-bar positioning tolerances

For a double-glazed unit, the spacer-bar straightness tolerance is 4 mm for lengths up to 3.5 m and 6 mm for longer panes.

1 - spacer bar 2 - theoretical spacer-bar shape 3 - theoretical spacer-bar position 4 - deviation from straightness

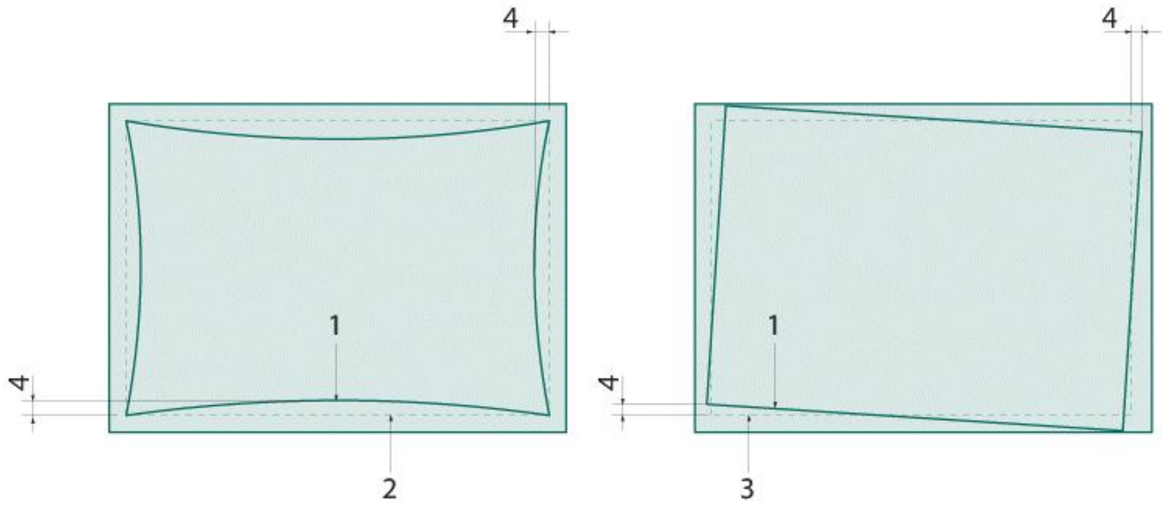


Fig. 22. Spacer-bar straightness tolerances

The permissible deviation of a spacer bar relative to the parallel straight glass edge or to other spacer bars (e.g. in a triple-glazed unit) is 3 mm for an edge length up to 2.5 m. For longer panes, the permissible deviation is 6 mm. This value ensures excellent stability of the entire insulating glass unit after sealing with the primary and secondary sealants.

NOTE: Both spacer bars and any relative displacement between them within the stated tolerance may be visible,
but this has no effect on the functionality or service life of the product.

11.5 Marking of insulating glass units

The marking of insulating glass units complies with PN-EN 1279-5.

11.6 CE mark

The CE mark is shown on an affixed label (or, where this is not possible, on the packaging or in the accompanying documentation).

11.7 Requirements for insulating glass units

The dimensions, construction, glass types and properties of an insulating glass unit shall be selected on the basis of design calculations that take account of the conditions of use. For rectangular insulating glass units, the width W shall be stated first, followed by the length L. Dimensions shall be stated in whole millimetres, and the component panes shall be listed starting with the exterior pane. Where a triple-glazed insulating glass unit contains two coated glass panes (including one as the middle pane), tempering of the middle pane is recommended because of the thermal load. Tempering is likewise recommended for glass with a higher energy-absorption coefficient. However, the final decision and associated risk rest with the customer. The permissible operating temperatures of each component of the insulating glass unit shall also be considered in its design. Durability is ensured by compliance with PN-EN 1279. Where coated glass is used, the position of the reflective coating in the insulating glass unit shall be specified in the order. Positions 2 or 3 are recommended and, for a triple-glazed unit, also positions 4 and 5. Dimensional data should be supplied on the basis of accurate drawings in DXF, DWG or a similar file format.

NOTE: If an order containing patterned glass does not specify the orientation of the pattern, it is assumed as standard that the pattern will run along the dimension corresponding to the glass height stated in the order.

11.7.1 Spandrel insulating glass units

Because of the specific construction of opaque spandrel areas, which have high solar-radiation absorption, extremely high temperatures may occur within the spandrel zone.

If proper ventilation and heat dissipation from the area behind the spandrel are not provided in accordance with the design, rheological and thermal phenomena may occur in the glazing units, including:

- primary sealant (butyl) flowing beyond the spacer-bar area,
- loss of seal in insulating glass units (failure of the secondary barrier),

thermal destruction of the unit, optical defects or thermal glass breakage.
Exclusion of warranty liability:

The above phenomena, where caused by design or execution defects in façade ventilation attributable to third parties, do not constitute manufacturing defects and are not covered by warranty claims.

In addition, warranty rights for spandrel units in the areas described above are unconditionally excluded if:

1. A polysulphide-based material (thiokol) was used as the secondary sealant instead of a dedicated silicone resistant to high temperatures and UV radiation.
2. The unit does not use high-performance solar-control glass with light transmission LT < 60%.

11.8 Non-rectangular insulating glass units

Subject to agreement between the customer and the manufacturer, insulating glass units of shapes other than rectangular may be produced. In such cases, the viewing orientation (outside to inside) must be agreed between the customer and the manufacturer in each case.

11.9 Insulating-glass tolerances

Table 48. Insulating-glass thickness deviations from the nominal thickness

Type of unit insulating glass unit	Component panes	Thickness tolerance of the insulating glass unit*
Double-glazed	All panes are annealed float glass	± 1,0 mm
	At least one pane is laminated, patterned or non-annealed glass	± 1,5 mm
Triple-glazed	All panes are annealed float glass	± 1,4 mm
	At least one pane is laminated, patterned or non-annealed glass	+ 2,8 mm -1,4 mm
For non-standard shapes, the minimum permissible tolerances for side lengths and diagonal differences shall be increased by ± 3.0 mm for the individual glass thicknesses.		

NOTE: The insulating-glass sealant may protrude beyond the edge seal into the cavity and onto the glass.

Permissible butyl squeeze-out in insulating glass units

Minor butyl squeeze-out is permitted in insulating glass units provided that it does not affect functionality, i.e. tightness and adhesion to the spacer bar and glass. The permissible extent of butyl squeeze-out into the cavity is:

- Along the spacer bar: up to 2 mm.
- At the corners: up to 5 mm.

Butyl waviness, i.e. uneven application, is also permitted within the same tolerances as squeeze-out. Any break in the butyl around the entire perimeter of the unit is not permitted.

It should be remembered that butyl squeeze-out may be caused by:

- elevated temperature inside the insulating glass unit,
- excessive compressive force at the glass fixing,
- incompatibility of materials used during installation on site.

In such cases, the complaint may be rejected.

11.10 Assessment of insulating glass units

On the basis of PN-EN 1279-1, the quality of Type A, B and C insulating glass units (section 11.1) made from glass components is assessed. Assessment shall be carried out in transmitted light, not reflected light (look through the pane, not at the pane), from a distance of at least 3 metres from the glass surface. Insulating glass units assessed from the exterior shall be assessed under their installed conditions. Observation time shall not exceed 1 minute per m2 of glass.

NOTE: Defects shall not be marked on the glass, and assessment shall be performed under diffuse daylight conditions (e.g. an overcast sky), without direct sunlight or artificial lighting.

11.10.1 Assessment area

Zone R (rebate zone) - a 15 mm zone usually covered by the frame or corresponding to the edge seal for an unframed edge.

Zone E (edge zone) - a 50 mm-wide zone at the edge of the visible area.

Zone M - main/central zone

For glass not intended for installation in frames or for assembly into units, the requirements for zone R are the same as for zone E.

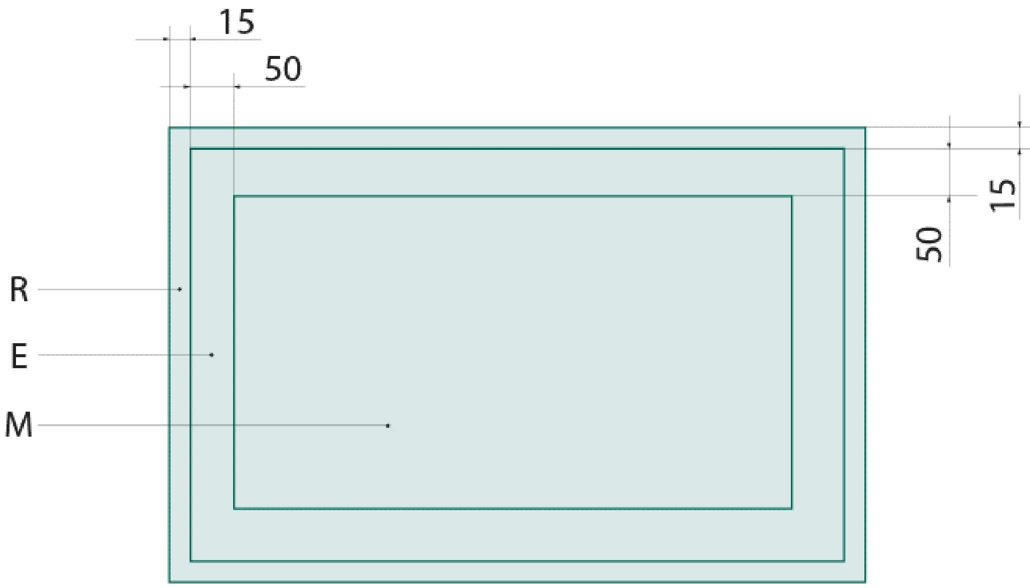


Fig. 23. Defect zones of glass panes

11.10.2 Permissible spot defects

Table 49. Permissible number of spot defects

Assessment zone	Defect size [Ø in mm] (excluding "halo"*)	Glass area S [m2]			
		S ≤ 1	1 < S ≤ 2	2 < S ≤ 3	S > 3
R	Any size	Unlimited			
E	Ø ≤ 1	Permitted if fewer than 3 occur in each area of Ø <= 200 mm			
	1 < Ø ≤ 3	4 pcs.	1 defect per linear metre of the glass perimeter		
	Ø > 3	Not permitted			
M	Ø ≤ 1	Permitted if fewer than 3 occur in each area of Ø <= 200 mm			
	1 < Ø ≤ 2	2 pcs.	3 pcs.	5 pcs.	5 pcs. + 2/m2
	Ø > 2	Not permitted			

* "Halo" - a locally distorted area, usually around a spot defect where the defect is within the glass pane

11.10.3 Permissible contamination

Table 50. Permissible number of contaminants in the form of dots and stains

Assessment zone	Dimension [Ø in mm] and defect type	Glass area S [m2]	
		S ≤ 1	S > 1
R	Any size	Unlimited	
E	Dots Ø <= 1	Unlimited	
	Dots 1 < Ø <= 3	4 pcs.	1 defect per metre of perimeter
	Stain Ø <= 17	1 pc.	
	Dots Ø > 3 and stains > Ø 17	Maximum 1 pc.	
M	Ø ≤ 1	Maximum 3 defects in each area of Ø <= 200 mm	
	Dots 1 < Ø <= 3	Maximum 2 defects in each area of Ø <= 200 mm	
	Dots Ø > 3 and stains > Ø 17	Not permitted	

11.10.4 Permissible linear defects

Table 51. Permissible number of contaminants in the form of dots and stains

Assessment zone	Individual lengths [mm]	Total length [mm]
R	Unlimited	
E	≤ 30	≤ 90
M	≤ 15	≤ 45

11.10.5 Permissible number of defects for units made of more than two glass panes

The permissible number of defects specified for a double-glazed insulating glass unit made of two monolithic glass panes is increased by 25% for each additional glass component (in a multi-pane unit or as a component of laminated glass). The permissible number of defects is always rounded up.

Examples:

1. To determine the permissible number of defects for a triple-glazed insulating glass unit made of three monolithic glass panes, multiply the permissible defect values in the above tables by 1.25.
2. To determine the permissible number of defects for a double-glazed insulating glass unit made of two laminated-glass panes, each consisting of two components, multiply the permissible defect values in the above tables by 1.5.

11.10.6 Permissible butyl squeeze-out in insulating glass units

Minor butyl squeeze-out is permitted in insulating glass units provided that it does not affect their functionality, i.e. tightness and adhesion to the spacer bar and glass. The permissible extent of butyl squeeze-out into the cavity is:

- Along the spacer bar: up to 2 mm.

- At the corners: up to 5 mm.

Butyl waviness, i.e. uneven application, is also permitted within the same tolerances as squeeze-out. Any break in the butyl around the entire perimeter of the unit is not permitted. It should be remembered that butyl squeeze-out may be caused by:

- elevated temperature inside the insulating glass unit,
- excessive compressive force at the glass fixing,
- incompatibility of materials used during installation on site.

In such cases, the complaint may be rejected.

11.10.7 Visual assessment criteria for other insulating glass units

The tables above shall not be used to assess an insulating glass unit containing at least one component made, among other materials, of rolled patterned glass, wired glass or drawn sheet glass.

The visual quality of thermally toughened safety glass incorporated in an insulating glass unit, or in laminated glass forming a component of an insulating glass unit, shall comply with the standard applicable to the relevant product. In addition to these requirements, for heat-treated float glass the overall bow relative to the total glass-edge length shall not exceed 3 mm per metre of edge length. Greater overall bow may occur in square or near-square panes and in individual panes with a nominal thickness < 6 mm.

11.10.8 Physical characteristics excluded from assessment

Colour consistency - differences in colour impression may occur due to the iron-oxide content of the glass, the coating process, the coating itself, variations in glass thickness and the unit construction, and cannot be avoided.

Colour differences in insulating glass units - glazing made from insulating glass units containing coated glass may exhibit different shades of the same colour; the effect may be intensified when viewed at an angle. Possible causes include slight differences in the colour of the glass substrate to which the coating is applied and slight differences in the thickness of the coating itself.

Interference effect - in insulating glass units made of float glass, interference may cause spectral colours to appear. Optical interference is caused by the superposition of two or more light waves at one point. It is perceived as variations in the intensity of coloured bands that change when pressure is applied to the glass. This physical effect is intensified by the parallelism of the glass surfaces. Interference occurs randomly and cannot be avoided.

Multiple reflections - multiple reflections of differing intensity may occur on the surfaces of insulating glass units. These reflections are particularly visible if the background viewed through the unit is dark. This is a physical property of all insulating glass units.

Anisotropy (iridescence) - insulating glass units containing heat-treated glass components may display the visual phenomenon known as anisotropy; see PN-EN 12150-1 and PN-EN 1863-1.

Condensation on the external surface of an insulating glass unit - condensation may occur on external glass surfaces when the glass surface is colder than the adjacent air. The intensity of condensation on the external surfaces depends on the U-value, air humidity, air movement and the internal and external temperatures. When the relative humidity of the surroundings is high and the surface temperature of the glass falls below the ambient dew-point temperature, condensation forms on the glass surface.

Specific effect caused by barometric conditions - an insulating glass unit contains a sealed volume of air or another gas, hermetically enclosed by the edge seal. The gas condition is determined primarily by the altitude, barometric pressure and air temperature at the time and place of manufacture. If the insulating glass unit is installed at a different altitude, or if the temperature or barometric pressure changes (higher or lower pressure), the panes will deflect inward or outward, causing optical distortion.

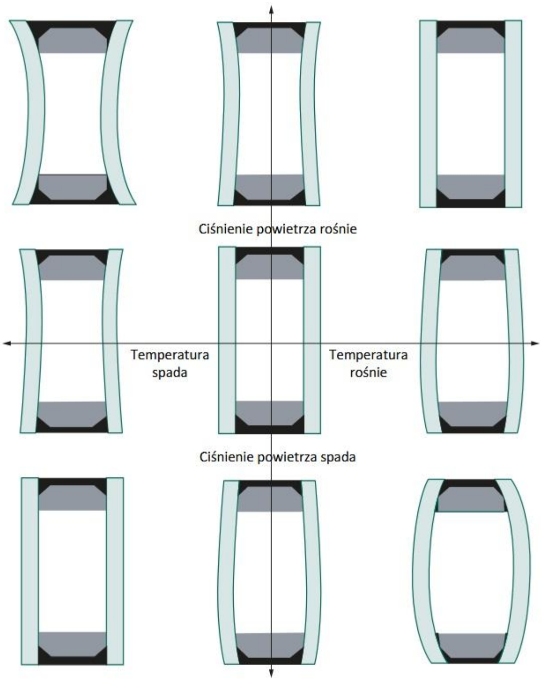


Fig. 24. Effect caused by barometric conditions.

Wettability of glass surfaces - the appearance of glass surfaces may differ due to the effects of rollers, fingerprints, labels, suction cups, sealant residues, silicone compounds, smoothing agents, lubricants, environmental influences, etc. This may become visible when the glass surfaces are wet with condensation, rain or cleaning water.

Pane displacement - the load-bearing side of an insulating glass unit shall always be the side with the minimum displacement. The optical and visual quality of installed insulating glass units is governed by PN-EN 1279.

Spacer-bar deformation - due to the manufacturing process, a spacer bar in an insulating glass unit may be bent or wavy.

Brewster fringes - interference coloration. If the surfaces of the glass panes are almost perfectly parallel and the surface quality is high, interference colours may occur in insulating glass units. These are bands of changing colour caused by separation of the light spectrum. If the light source is the sun, the colours change from red to blue. This phenomenon is not a defect; it results from the construction of the insulating glass unit.

Newton's rings - an optical phenomenon occurring in insulating glass units where two glass panes touch or almost touch at the centre. It appears as a pattern of concentric coloured rings centred on the point of contact or near-contact of the two panes. The rings are approximately circular or elliptical.

Glass coloration caused by different stress across the glass section - some processed glass also displays coloration characteristic of a tempered or heat- strengthened product; see PN-EN 12150-1 or PN-EN 1863-1. This phenomenon is not a glass defect.

Glass breakage - glass is an amorphous, homogeneous solid that is both brittle and hard. It has negligible internal stresses, which allows it to be cut and processed. It breaks as a result of external thermal or mechanical factors. This applies particularly to glass with increased energy absorption. To increase resistance to breakage caused by thermal or mechanical loads, the glass shall be tempered or strengthened.

There is a risk of spontaneous glass breakage caused by thermal shock. This occurs when cooled, non-tempered glass has two areas with a large temperature difference of approximately 40 °C. Thermal shock is characterised by a distinctive fracture line (Wallner lines) in the glass; the crack normally starts at the glass edge and is perpendicular to that edge. The most common causes of thermal breakage are decorations or stickers placed on the glass, partial shading (e.g. by a blind, tree, canopy or fence), close proximity to air-conditioning units or heaters, and leaving glass panes packed and strapped on a rack in direct sunlight.

Thermal cracks occurring after delivery to the Customer are not covered by warranty or complaints. To avoid this phenomenon, the glass should be thermally tempered. Glass breakage occurring after delivery to the Customer is not covered by the warranty and cannot form grounds for a complaint. External defects, edge damage, external scratches, damage and stains, e.g. caused by chemical reactions on the external surfaces of products, that arise outside the manufacturer's premises are likewise not covered by warranty or complaints.

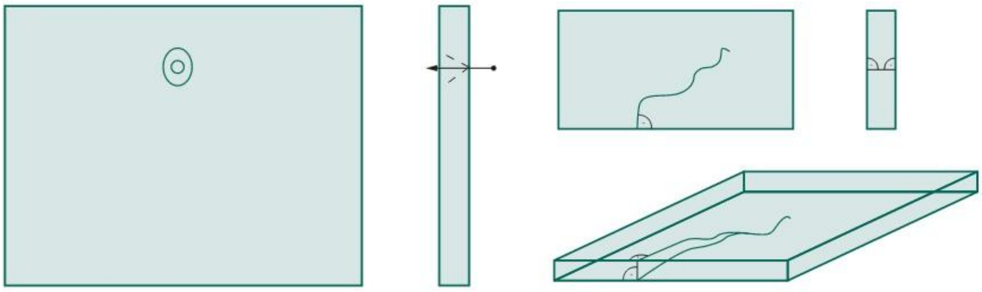


Fig. 25. Left - gunshot; right - thermal crack.

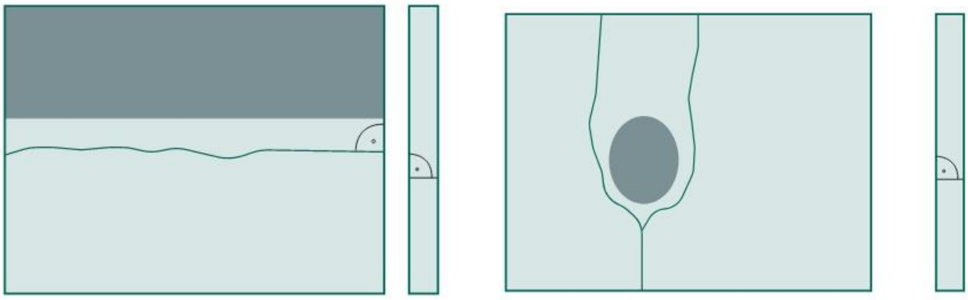


Fig. 26. Thermal cracks.

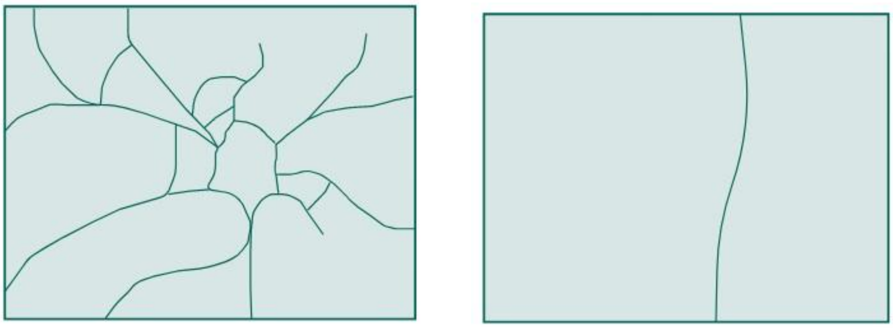


Fig. 27. Left - impact on the glass surface; right - torsional crack.

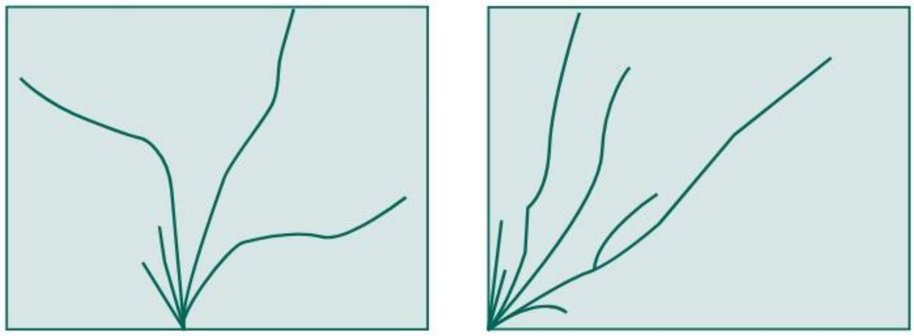


Fig. 28. Left - impact on the edge; right - impact on the corner.

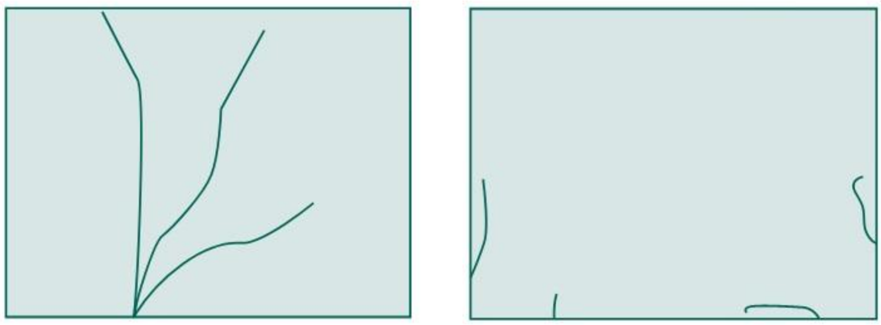
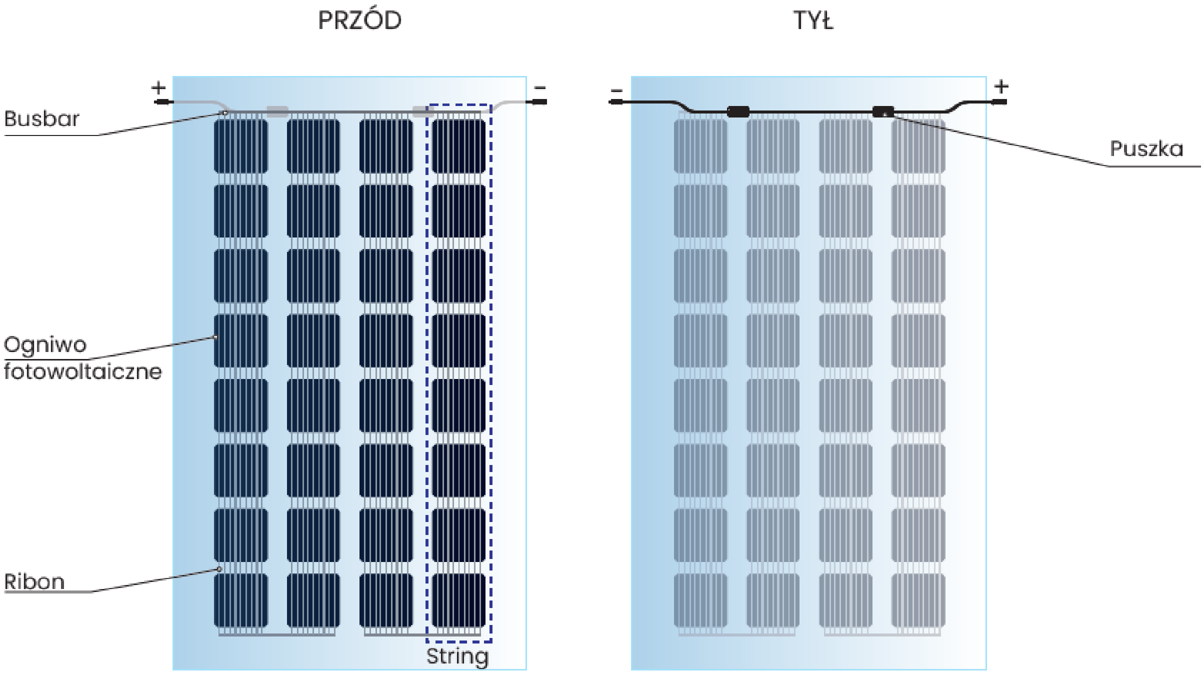
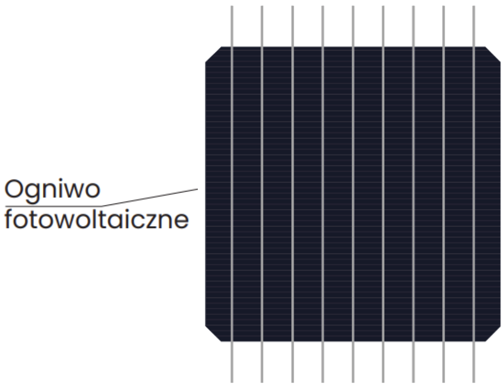


Fig. 29. Left - pressure on the edge; right - jamming.

12 BIPV / PHOTONWALL / PHOTONROOF

BIPV (Building-Integrated Photovoltaics) is a technology that enables solar panels to be integrated directly into the building structure. Unlike conventional photovoltaic systems mounted on roofs or façades, BIPV incorporates photovoltaic cells directly into building elements such as roofs, façades, windows, cladding panels and envelopes. The panels therefore perform both an energy-generating and an architectural function, combining energy production with the building's aesthetics and functionality.





12.1 Quality criteria for BIPV elements

12.1.1 Cell alignment

Cells shall be arranged evenly and symmetrically relative to the module design axis. The permissible alignment deviation is 2 mm per linear metre of cells in each string. Exceeding this value is not permitted and results in rejection of the module. Inspection is performed using an automated optical inspection (AOI) vision system or other optical methods.

12.1.2 Busbar straightness

Busbars shall follow a straight path consistent with the design. Busbar deviation or bending from straightness shall not exceed 2 mm for a busbar up to 100 cm long; the permissible deviation may increase by a further 2 mm for each additional commenced 100 cm of element length.

12.1.3 Busbar masking

Busbars shall be completely covered by the protective/concealing mask. Complete absence of masking is not permitted. Only minor underpainting or gaps are permitted, provided that there are no more than two breaks in the masking with a total length not exceeding 10 mm per linear metre of busbar.

12.1.4 Ribbon masking

Only minor breaks or omissions are permitted, provided that there are no more than two breaks in the masking with a total length not exceeding 10 mm per linear metre of ribbon.

12.1.5 Visual defects - microcracks

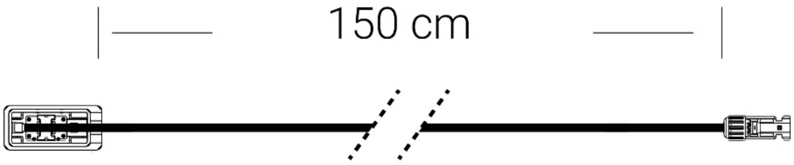
Cells shall be free of structural defects. Inspection is performed using an electroluminescence (EL) tester and visual inspection. Only isolated superficial hairline microcracks (inactive) are permitted, provided they do not restrict current conduction, do not generate dark areas in the EL image and do not present a risk of propagation under thermal stress.

12.1.6 Connector position

Connectors shall be installed in the specified position in accordance with the design documentation or customer requirements (with a positional tolerance of ±5 mm relative to the module design axis). If no detailed agreement or information on connector position is provided, the manufacturer will install them at the structurally optimal location. Sealant squeeze-out from beneath the connector is permitted provided that it does not affect the tightness or functionality of the connection.

12.1.7 Connection-lead length

The connection-lead length shall comply with the design documentation or customer requirements. If no detailed arrangements are made, a length deviation of ±5 cm from the nominal value is permitted. Unless otherwise agreed, the standard lead length is 150 cm. The length is measured between the junction box and the connector and refers to the cable alone, excluding the body of the junction box and the connector.



12.1.8 Backrail position

Backrails fitted to the module shall be positioned in accordance with the design so as to ensure correct geometry and allow subsequent installation of the modules. The permissible backrail position deviations are:

- ±2.0 mm vertically,
- ±5.0 mm horizontally.

12.1.9 Photovoltaic-cell shades

Differences in the shades of individual photovoltaic cells within a single module are permitted. Differences in cell colour do not affect the efficiency of the photovoltaic module. Variations in cell shade within a panel may result from factors such as the cell production process and the structure of the panel itself.

• Non-uniformity of semiconductor materials:
A single panel may contain slight differences in the quality or purity of semiconductor materials (e.g. silicon), which affect cell colour. In polycrystalline and monocrystalline cells, different silicon crystals may have different optical properties, and individual panel segments may therefore vary in shade.

• Photovoltaic-panel structure:
Each photovoltaic panel consists of many cells connected together to obtain the required voltage and power. Depending on the production technology, the panel structure may also affect cell colour. For example, cells made from different semiconductor materials (e.g. monocrystalline, polycrystalline or thin-film silicon) may differ in colour, which may be noticeable within a single panel. These differences have no effect on performance, however, because all cells in the panel operate according to the same physical principles.

• Effect of weather conditions:
Colour differences may also develop as a result of prolonged exposure of panels to weather conditions. As the panels age, individual cells may degrade to different degrees, and the outer panel layers may undergo slight colour changes depending on their position in the panel and exposure to sunlight, temperature or humidity.

Although such changes may affect appearance, they do not affect the energy efficiency of the photovoltaic panel, because the cell itself remains fully functional and the colour changes are superficial. Minor colour differences are a characteristic feature of BIPV products resulting from physicochemical processes and do not constitute a product quality defect provided they remain within the tolerances defined by the design reference sample.

Special provision for bifacial modules: The above criteria and permissible shade variations also apply to modules manufactured using bifacial technology. For such products, only the front side is subject to visual and aesthetic assessment. The rear side of the module is not assessed for colour, and any variations in shade, structure or visibility of structural components on the rear side do not constitute grounds for a complaint.

12.1.10 Ceramic/digital printing on BIPV modules

Where ceramic-enamel or digital-printed glass is used in BIPV modules to obtain the required architectural effect, print quality and defects are assessed strictly in accordance with the guidelines in Section 5 of this Company Standard ("Ceramic-Printed Glass"). Due to the specific nature of BIPV technology,
the following conditions apply:

- Colour tolerances and batch repeatability: The actual enamel colour is determined by viewing a tempered sample through the unpainted side of the glass. Colour differences may occur when colours are selected using standard systems (e.g. RAL or NCS). These differences result from numerous physicochemical factors and cannot be completely eliminated.

- Effect of laminate construction and BIPV components: The final visual appearance and colour of the print are affected by the complete layered construction of the BIPV module, including the type of base glass used, the type and colour of the interlayer and the presence of the photovoltaic cells themselves. A reference sample must be produced before each project and formally approved by the customer.

- Effect of the base glass and lighting conditions: The colour of the base glass depends on the manufacturer, glass thickness and the specific production batch, which directly modifies the final colour of the printed glass. Thin print layers are not completely opaque to light (light is partly absorbed and partly reflected), and the enamel colour may therefore be perceived differently depending on the lighting conditions and angle of incidence.

- Limitations of repeatability between stages and materials:

  o Enamel-colour conformity can be compared only within one

  production batch. The manufacturer does not guarantee identical colour shades on BIPV elements produced using several different batches of ceramic ink or enamel.

  o Colours produced by digital printing will always differ from the

  reference colours shown in printed colour charts and digital photographs.

  o If a project is completed in several stages spread over

  time, the manufacturer does not guarantee colour repeatability. Over a long period, the risk of differences in the final shade increases significantly because suppliers' raw-material batches of ink, enamel or base glass may change.

NOTE 1: Printed glass in BIPV modules is always assessed after tempering. NOTE 2: Print on surfaces 2 and 3: When laminating glass with digital or screen printing located on surface 2 or 3 (facing the laminating interlayer), it is mandatory to maintain a minimum margin of 5 mm from the edge of the pane. Failure to comply creates a high risk of glass delamination. Failure to meet this design condition results in complete loss of the product warranty.

12.2 Inspection methods and visual-assessment conditions

12.2.1 Visual-assessment conditions

All visual assessments of BIPV elements, including enamel-printed elements, shall be carried out under strictly defined inspection conditions that reflect the natural exposure of the product in the building and comply with the general standards for architectural glass.

- Visual inspection (inspection conditions): Performed under artificial or natural diffuse lighting of at least 1000 lx, perpendicular to the module surface (at an observation angle of approximately 45° to the glass plane when checking reflections).

- Aesthetic assessment distance:

  - FoFor BIPV modules in the form of a single laminated glass pane (not incorporated in an insulating glass unit), assessment is performed from a distance of at least 2 metres.

  - BIPV modules incorporated in insulating glass units are assessed from a distance of at least 3 metres.

- Observation time: The maximum time for general visual inspection of one element shall not exceed 20-30 seconds.

- Scope of assessment (active side): Only the active front side of the BIPV module, which remains visible and exposed after installation on the building, is subject to aesthetic inspection and assessment. The inactive side (module rear, backing laminate, junction boxes, wiring and backrail systems) performs structural and technical functions and is not subject to aesthetic assessment criteria unless its condition directly affects electrical performance or product safety. Where bifacial cells are used, despite their ability to generate power from both sides, the principal aesthetic function of the BIPV façade or canopy remains assigned to the front side. Accordingly, for bifacial modules, only the front side is subject to visual assessment. The rear side is not inspected for colour uniformity, film discolouration or other visual features, and any aesthetic differences on the rear side do not constitute a product defect.

- Defect-visibility principle: Any imperfections, deviations, microscopic inclusions, air bubbles, print irregularities or gaps in masking that are not clearly visible to the unaided eye from the specified inspection distance of 2 or 3 m within the defined observation time are considered permissible and are not classified as product quality defects. They may not constitute grounds for product rejection during acceptance or for subsequent complaints.

12.2.2 Inspection methods

EL (electroluminescence) tester: Mandatory for detecting internal defects in the silicon structure, including microcracks and interruptions in conductive paths, that are invisible during standard visual inspection.

Other inspection methods - sampling inspection (in accordance with FPC): The following tests and measurements are performed on a sampling basis (on a specified sample batch) to provide ongoing assessment of the correctness of technological processes and ensure quality stability in accordance with Factory Production Control (FPC) requirements:

• Dimensional inspection: Performed using calibrated measuring instruments

(steel tape, calliper and dedicated gauges) to verify geometric parameters such as connector position, backrail positioning and output-lead length.
• I-V test (current-voltage): Performed using an AAA-class flash simulator

(flasher) to determine the final current-voltage characteristic, nominal power (Pmax) and electrical efficiency of the BIPV module.
• Infrared thermography (IRT): Used at the final or verification stage to

check correct module operation under electrical load (continuous-operation simulation) and rule out thermal anomalies (hotspots) before the product is transferred to the finished-goods warehouse.

12.3 Maintenance and warranty conditions

12.3.1 Maintenance and warranty conditions

Proper operation of BIPV modules forming an integral part of the building structure requires systematic technical and electrical maintenance.

- The building owner or manager is obliged to carry out an annual technical and electrical inspection of the BIPV installation. The interval between consecutive services shall not exceed 12 months.
- The inspection shall be performed by a certified service company holding the relevant authorisations (e.g. electrical authorisation for photovoltaic installations in accordance with the requirements of the country of installation).

12.3.2 Scope of service and reporting

Each service must conclude with the issue of an official technical report
or confirmation of inspection, including:

- Measurements of electrical parameters (insulation resistance and circuit continuity).
- Visual inspection of module condition (cleanliness, connectors and wiring).
- Infrared thermography (optional, recommended for early detection of thermal anomalies).

12.3.3 Basis for complaint assessment (e.g. hotspots)

Thermal anomalies (hotspots), bypass-diode damage or module power degradation may result from external factors such as localised contamination, shading or insufficient ventilation. Therefore:

- A necessary condition for accepting a complaint concerning functional defects, including hotspots, is that the claimant submits a complete set of reports from the annual technical inspections of the photovoltaic installation.
- Failure to confirm regular servicing of the installation by an entity authorised in the country of installation constitutes grounds for rejecting the complaint due to improper product operation and maintenance.

12.3.4 Commissioning after installation

After mechanical installation of the BIPV modules on the building façade or roof, the investor/contractor shall commission the electrical installation and begin exporting/using the generated energy as soon as possible, and no later than 30 days after installation of the elements.

- Risk if energy is not taken off: Leaving modules in an open-circuit state (without load) for an extended period while they are exposed to solar radiation causes a dramatic increase in their operating temperature. Because the light energy is not converted into electricity and transferred to the grid, it is converted entirely into heat.
- Technical consequences: This leads to extreme thermal stresses, accelerated degradation of laminate layers and a risk of damage to bypass diodes in junction boxes due to overvoltages induced in the disconnected wiring.
- Warranty exclusion: Damage to the module structure, delamination, interlayer discolouration and damage to bypass diodes caused by delayed commissioning of the installation and leaving modules unloaded for more than 30 days after installation are treated as installation/operational errors and are not covered by the manufacturer's warranty.

13 HANDLING OF FINISHED PRODUCTS

13.1 Packaging

As standard, finished products are transported on wooden or metal A-frames or L-frames. The base and sides of the rack shall form a right angle. All metal parts of the rack that come into contact with insulating glass units shall be lined with rubber or another cushioning material. Insulating glass units placed on racks shall be secured with straps against movement during transport. Cork, cardboard or other separators shall be used between the panes.

NOTE: Any other type of packaging shall be agreed between the customer and the manufacturer.

13.2 Transport

In most cases, transport is carried out using specialist trucks adapted for carrying glass. The customer is responsible for correct unloading and for reporting any damage identified upon delivery. Customer collection is carried out at the customer's request and risk with respect to glass breakage and damage during transport. For agreed returns, correct packing, securing and loading of the glass are the responsibility of the returning party.

13.3 Storage

Finished products in the form of monolithic glass, laminated glass and insulating glass units shall be stored in covered, dry and ventilated premises at a temperature not exceeding 40 °C, protected from precipitation and direct sunlight.

NOTE: The manufacturer is not liable for defects caused by incorrect storage by the customer.

13.4 Installation

A finished product in the form of monolithic glass, laminated glass or an insulating glass unit is only one component of the complete glazing system. Glazing contractors are responsible for compatibility and for selecting the correct glass for the window/façade system. ML SYSTEM S.A. accepts no liability for the use of finished products in glazing systems that do not comply with regulations or for use contrary to their intended purpose. Installation conditions for insulating glass units are described in Annex C to PN-EN 1279-5.

13.5 Washing and cleaning

- The glass surface shall be washed regularly according to the degree of soiling, at least once every 12 months.
- Solid contaminants such as cement mortar must not be removed when dry. In such a case, the glass surface shall be thoroughly wetted with clean water to soak the contamination and the hard or sharp residues shall then be gently washed away.
- Grease and sealant residues shall be removed, for example, with ethanol or isopropyl alcohol (also known as isopropanol or propan-2-ol), and then rinsed thoroughly with water.
- Reflective, matt, satin and etched coatings (located on surface 1) must not be cleaned using corrosive or alkaline substances (fluorine, chlorine) or cleaning powders, as these may damage the coating.

NOTE: The glass manufacturer is not liable for glass defects caused by incorrect washing, unsuitable cleaning agents, external contaminants (atmospheric or otherwise), or the use of tools/objects that may damage the glass, such as a steel scraper.

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