ARADAS

GLASS №2

ANNEX Nº 2, 16-07-2019, Version Nº 2

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ARADAS in collaboration with GLASS LT prepared these documents - ARADAS GLASS Annexes Nº 2, 3, 5. Annex Nº 2 is prepared in accordance with the European standard applied to insulating glass units (EN 1279) and other standards regarding to glass in building products.

GLASS LT
STIKLO PAKETŲ GAMYBA

ANNEX Nº2

16-07-2019
Version No 2

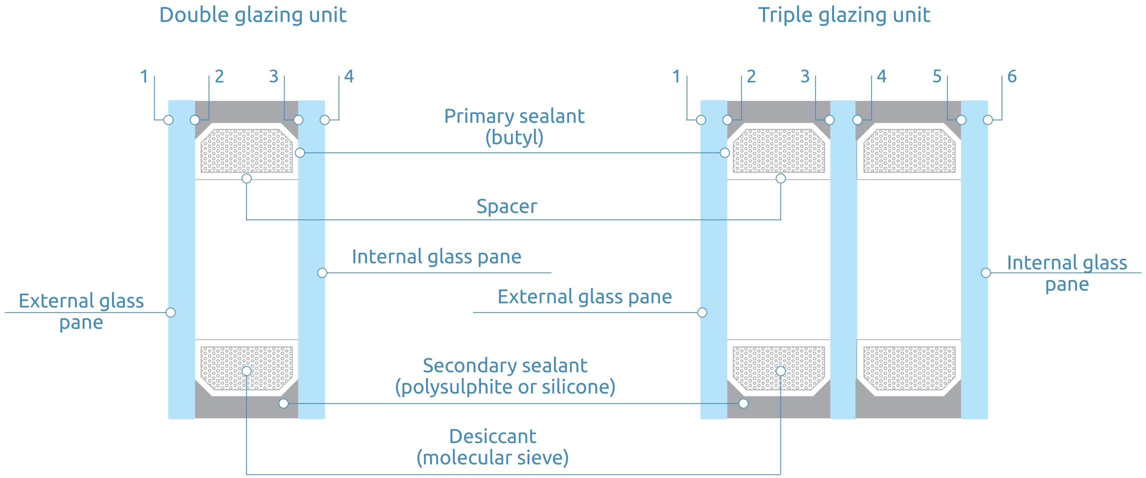
PRODUCT CHARACTERISTICS

We offer argon filled insulating glass units, consisting of two or three glass panes, separated by aluminum or warm spacer with bent or cut corners.

Notes:
a) Other non-standard structures of insulating glass units are also available;
b) Automatic filling with argon gas is not guaranteed for products smaller than 180x350 mm and products of non-rectangular shapes;
c) We recommend toughening for tinted or reflective on the tinted mass glass panes with thickness from 6mm;
d) By default, pattern of patterned glass is oriented vertically, and pattern is faced inwards;
e) Warranty is applied to the product (Annex No 3);

1. THE DURABILITY OF GLASS PRODUCTS

The durability of glass products depends also on:
- Building and construction movements due to various actions;
- Building and construction vibrations due to various actions;
- Deflection and racking of the glass support due to various actions;
- Glass support design (e.g. drainage of infiltrated water in the rebate, prevention of direct contact between glass support members and glass);
- Accuracy of glass support and glass support member dimensions;
- Quality of the assembling of glass support members up to a glass support;
- Quality of installation of the glass support into or onto the buildings or constructions;
- Glass support expansion/contraction/movement due to adsorbed moisture from the air or other sources or due to temperature variations.



ANNEX Nº2

16-07-2019
Version No 2

2. CHARAKTERISTICS OF GLASS AND SAFETY LEVELS (STR 2.04.01:2018) Table 1

No.	Type of parameter	Classification	Remarks
1.	Pendulum body impact resistance	3, 2, 1	Where resistance class 3 is the lowest, class 1 – the highest.
2	Mode of breakage	A	Numerous cracks appear forming separate fragments with sharp edges, some of which are large. This type of breakage is typical of annealed glass.
		B	Numerous cracks appear, but the fragments hold together and do not separate. This type of breakage is typical for laminated, film applied glass and wired glasses.
		C	Disintegration occurs, leading to a large number of small particles that are relatively harmless. This type of breakage is typical for thermally toughened glass.

Fig. 2. Type of glass breakage (from left to right: annealed, toughened, and laminated glass panes).

ANNEX Nº2

16-07-2019
Version No 2

3. RECOMMENDED DIMENSIONS OF INSULATING GLASS UNITS IN ACCORDANCE WITH GLASS THICKNESS

Double glazing units — Table 2

Glass thickness, mm	Structure	Cavity between glasses, mm	Maximum area, m^2	Maximum side length, mm	Ratio of sides
4 / 4	4-9-4 4-12-4 4-16-4	9 12 16	2,40 2,80 3,00	2500 2500 2500	1:6
6 / 4	6-12-4 6-16-4	12 16	3,20 3,50	3000 3000	1:6
6 / 6	6-12-6 6-16-6	12 16	4,50 6,00	3200 3500	1:8
8 / 6	8-14-6 8-16-6	14 16	7,50 8,00	3500 3700	1:8
8 / 8	8-14-8 8-16-8	14 16	8,50 9,00	3500 4000	1:10
10 / 8	10-16-8	16	12,50	5000	1:10

Triple glazing units — Table 3

Glass thickness, mm	Structure	Cavity between glasses, mm	Maximum area, m^2	Maximum side length, mm	Ratio of sides
4 / 4 / 4	4-9-4-9-4 4-12-4-12-4 4-16-4-16-4	9 12 16	2,40 2,80 3,00	2500 2500 2500	1:6
6 / 4 / 4	6-12-4-12-4 6-16-4-16-4	12 16	3,20 3,50	3000 3000	1:6
6 / 6 / 6	6-12-6-12-6 6-16-6-16-6	12 16	4,50 6,00	3200 3500	1:8
8 / 6 / 6	8-14-6-14-6 8-16-6-16-6	14 16	7,50 8,00	3500 3700	1:8
8 / 8 / 8	8-14-8-14-8 8-16-8-16-8	14 16	8,50 9,00	3500 4000	1:10
10 / 8 / 8	10-16-8-16-8	16	12,50	5000	1:10

Notes:
a) Laminated glass thickness is calculated using coefficient: float glass thickness / 0,63;
b) Glass thickness values are only recommendations, and can be considered individually in each case;
c) Standard polysulphide sealing depth is 3.5 – 4.5 mm. If area of the glass unit is ≥8.00 – <9.00 m^2, then recommended sealing depth of polysulphide is 6.5 mm. If area of the glass unit is ≥9,00 m^2, then recommended sealing depth of polysulphide is 8.5 mm.

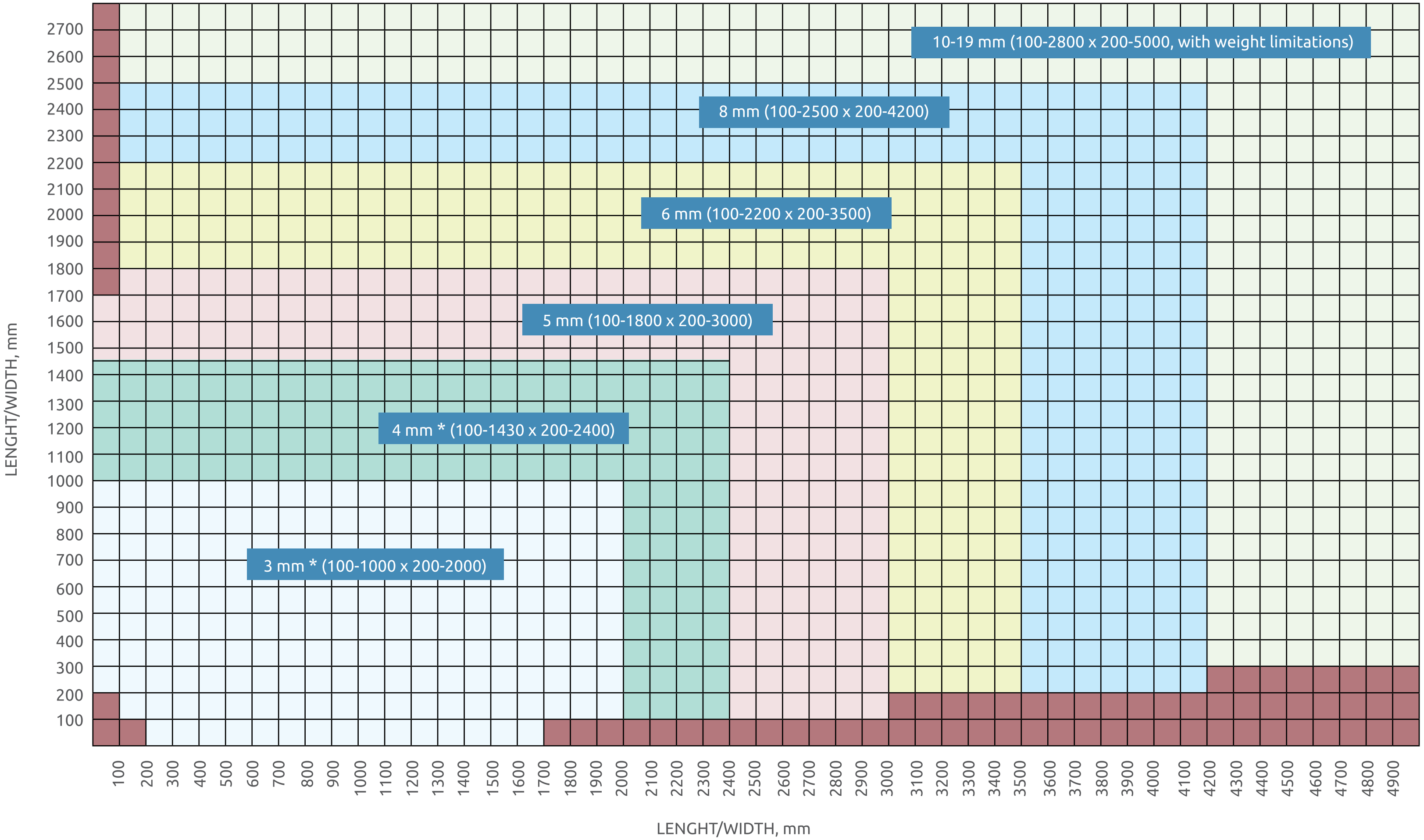
d) Tables provide maximum dimensions of the glass unit, under the following conditions:
- Vertical glazing;
- Glazing height 0 – 8 meters;
- All four sides are fixed;
- Not applied to corner glazing;
- Average wind load in Lithuania – 0.5 kN/m^2.

ANNEX Nº2

16-07-2019
Version No 2

4. RECOMMENDED DIMENSIONS OF TOUGHENED AND HEAT STRENGTHENED GLASSES IN ACCORDANCE WITH GLASS THICKNESS

Table 4



ANNEX Nº2

16-07-2019
Version No 2

Glasses (of any thickness value) falling within red zone cannot be heat treated, their quality will not meet requirements of standards LST EN 12150 or LST EN 1863.
Toughening is performed to glass panes with thickness of 3-19 mm. Heat strengthening is performed to glass panes with thickness of 4-10 mm.

Notes:
a) Minimum and maximum dimensions of toughened clear glass are provided in Table 4;
b) Minimum dimension of soft coated glass long edge is 250 mm; for other dimensions, see Table 4;
c) Permissible ratio of edges and maximum area of toughened clear and selective glasses are given in Table 5;
d) Weight limits are applied to glass panes with thickness of 15 and 19 mm: ≤480 kg.

Table 5

Glass thickness, mm	Maximum ratio between long and short edges	Maximum glass area, m^2
4	6	3
5	8	5,5
6	10	6,5
8	12	9
10	16	12
12	17	14

Allowable distortion of thermally toughened glass*

Table 6

Type of horizontally toughened glass	Maximum allowable value for distortion	
	Overall bow (mm/m)	Roller wave (mm/per 300 mm length)
Uncoated float glass (EN 572-1 ir EN 572-2)	3	0.3
Others	4	0.5

* for heat treated float glass which will be a part of insulating glass unit, the overall bow relative to the total glass edge length may not be greater than 3 mm/m glass edge length. Greater overall bow may occur for square or near square formats (up to 1:1.5) and for single panes with a nominal thickness < 6 mm.

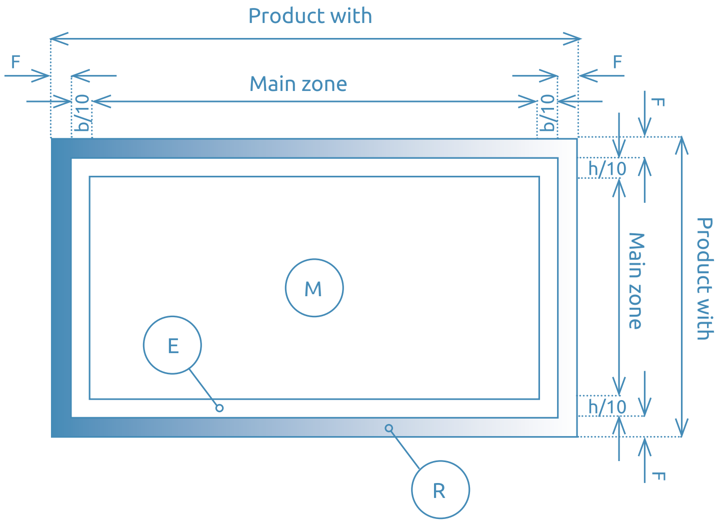
ANNEX Nº2

16-07-2019
Version No 2

5. OBSERVATION CONDITIONS OF INSULATING GLASS UNITS

When checking defects, the most important is general view through the insulating glass unit: the panes shall be examined in transmission and not in reflection.
The discrepancies shall not be marked on the pane. The insulating glass units shall be observed in accordance with Tables 7-9 of Section 6 at a distance of not less than 3m from and at a viewing angle as perpendicular to the glass surface.

The assessment is carried out under diffuse daylight conditions (e.g. overcast sky), without direct sunlight or artificial lighting. Maximum time for assessment is up to 1 minute per 1 m². This observation shall not be used for insulating glass unit with at least one component made of patterned glass, wired glass, wired patterned glass, drawn sheet glass, fire resistant laminated glass. In these cases, it is necessary to consult the manufacture.



R–sealant zone: width of 15 mm off the edge of the glass unit along the entire perimeter.
E–edge zone: width of 50 mm from the sealant zone of the visible area (not so strict assessment criteria).
M–main zone: (more strict observation criteria).

Fig. 4 Observation zones.

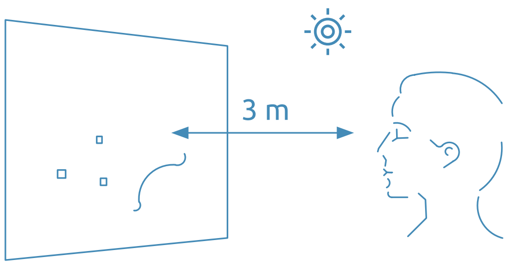


Fig. 3. Position of observer during inspection.

ANNEX Nº2

16-07-2019
Version No 2

6. OBSERVATION OF VISUAL QUALITY OF INSULATING GLASS UNITS

Allowable number of spot faults* — Table 7

Zone	Size of fault [Ø], mm (excluding halo)	Size of the pane [S], m²			
		S ≤ 1	1 < S ≤ 2	2 < S ≤ 3	3 < S
R	All sizes	No limitation			
E	Ø ≤ 1	Accepted if less than 3 in each area of Ø ≤ 20 cm			
	1 < Ø ≤ 3	4	1 per meter of perimeter		
	Ø > 3	Not allowed			
M	Ø ≤ 1	Accepted if less than 3 in each area of Ø ≤ 20 cm			
	1 < Ø ≤ 2	2	3	5	5+2/m²
	Ø > 2	Not allowed			

* spot fault – spherical or semi spherical disturbance of the visual transparency looking through the glass (e.g., a gaseous inclusion, a solid inclusion a pinhole in a coating or a spot defect in a laminated glass).

Allowable linear/extended fault — Table 9

Zone	Individual lengths, mm	Total of individual lengths, mm
R	No limitation	
E	≤ 30	≤ 90
M	≤ 15	≤ 45
In E and M zones hairlines scratches are allowed provided that they do not form a cluster.		

Allowable number of residue spots and stains* — Table 8

Zone	Dimensions and type [Ø], mm	Size of the pane [S], m²	
		S ≤ 1	1 < S
R	All sizes	No limitation	
E	Spots, Ø ≤ 1	No limitation	
	Spots, 1 < Ø ≤ 3	4	1 per m of perimeter
	Stain, Ø ≤ 17	1	
	Spots, Ø > 3 and stain Ø > 17	Maximum 1	
M	Spots, Ø ≤ 1	Maximum 3 in each area of Ø ≤ 20 cm	
	Spots, 1 < Ø ≤ 3	Maximum 2 in each area of Ø ≤ 20 cm	
	Spots, Ø > 3 and stain, Ø > 17	Not allowed	

* residue – is a material that remain on the glass surface, that can have the form of spot or patch (e.g., residue of primary or secondary sealant).

The allowable number of discrepancies defined in Tables 7-9 is increased by 25 % per additional glass component.
Examples:
Triple glazed units: the number of allowable faults is increased by 25% (multiplied by 1.25).
Laminated glass made of 3 glass components: the number of allowable faults is increased by 75% (multiplied by 1.75).
Allowable edge defects:
External part and edge damage and shells, which do not exceed ¼ thickness of glass, do not affect strength of the glass and do not exceed limits of sealant zone. Shells, facing to cavity without loose fragments, when they are sealed with sealant.
Insulating glass units used to bonded glazing: on the exterior or interior glass in zone R outside and edge damages or shells are allowable, if they do not exceed ¼ of the glass thickness and are not visible from a distance of 3 meters.
Laminated glass: film shrinkage up to 6 mm from the edge, linear defects, displacement of laminated glass components up to 3 mm allowed.

ANNEX Nº2

16-07-2019
Version No 2

7. ALLOWABLE DIMENSIONAL TOLERANCES OF INSULATING GLASS UNITS

Allowable dimensional deviations of length and width — Table 10

Double / triple IGU:	Tolerances on width and height, mm	Misalignment, mm
All panes ≤ 6 mm and width and height ≤ 2 m	±2	≤ 2
6 mm < thickest pane ≤ 12 mm or 2 m < width and height ≤ 3,5 m	±3	≤ 3
Thickest pane ≤ 12 mm and 3,5 m < width and height ≤ 5 m	±4	≤ 4
1 pane > 12 mm or width and height > 5 m	±5	≤ 5

Thickness tolerances on the insulating glass units* — Table 11

Glazing	Pane	Insulating glass unit thickness tolerance, mm
Double glazing	All panes are annealed float glass	±1.0
	At least one pane is laminated, patterned or not annealed glass	±1.5
Triple glazing	All panes are annealed float glass	±1.4
	At least one pane is laminated, patterned or not annealed glass	+2.8/-1.4

* if one glass component has a nominal thickness greater than 12 mm (or 20 mm in the case of laminated glass), the insulating glass unit manufacturer should be consulted.

Tolerance on spacer straightness

For double glazing the tolerance on the spacer straightness is 4 mm up to a length of ≤ 3.5 m, and 6 mm for longer lengths (> 3.5 m).
For tripe glazing the tolerance on the spacer straightness in relation to the parallel straight glass edge or to other spacers is 3 mm up to a length of ≤ 2.5 m, and 6 mm for longer lengths (> 2.5 m).
Observation shall be carried out perpendicularly to glass plane, looking at the spacer at eye level. Furthermore, we also recommend the use of dark color spacer to reduce visually undesirable, but allowable spacer unstraightness.

Other allowable deviations:

- Inflow of the inner sealant (butyl) into insulating glass unit cavity is allowed up to 2 mm. Over a period of time, due temperature and wind, inflow of butyl may increase.
- Color deviation of secondary sealant (polysulphide or silicone) may occur.
- Due to manufacturing technology, small amount of desiccant (absorbent) or spacer cutting residues may appear inside glass unit cavity.
- Due to manufacturing technology, more than two spacer joint piece are permitted inside glass unit.
- Glass unit marking on one of glass unit spacer segments corresponds with quality requirements and is not considered as defect.
- Due to manufacturing technology, we cannot assure that safety glass marking will be aligned in one corner.
- In glass units with component of glass with coating it is impossible to ensure that the coating would be completely removed during edge deletion process. Over a period of time, residue of coating in the edge zone is affected by corrosion.

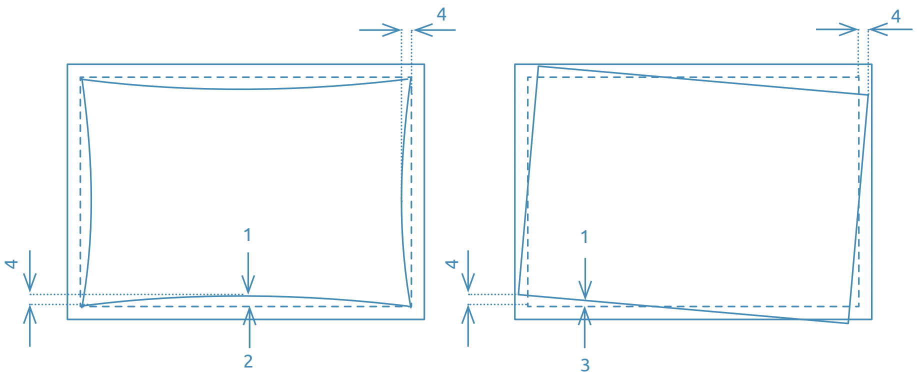


Fig. 5 Examples of spacer deviation (1 – spacer, 2,3 – theoretical position and shape of the spacer, 4 – deviation).

ANNEX Nº2

16-07-2019
Version No 2

8. ALIUMINIUM SPACERS, WARM SPACERS, DECORATIVE BARS INSIDE THE GLASS

Aliuminium spacers
Maximum allowable dimensions:
- Vertical position up to 1100 mm;
- Horizontal position for all widths up to 800 mm (maximum distance between junctions).

Warm spacers
Maximum allowable dimensions:
- Vertical position up to 1600 mm;
- Horizontal position: 10/22 up to 1200mm; 10/26 up to 1300mm; 10/32 up to 1500mm; 12/26 up to 1400mm; 12/32 up to 1600mm (maximum distance between junctions).

Decorative bars inside the glass
Minimum bending radius (R):
- 8 mm width of insert - R >80 mm (only arches); 18 mm width of insert - R >170 mm; 26 mm width of insert - R >200 mm; 45 mm width of insert - not bendable;
- Different width decorative bars inside the glass: 18, 26, 45 mm can be joined together.;
- In order to reduce vibration and thermal bridge, disk spots are adhered between glass pane and insert. Disk spots are fixed on cross junctions. Quantity and distance depend on inserts quantity and length.
- Disk spots are not used, when insulating glass unit decorative bars inside the glass is less than ≤12 mm thick or when insert with width of 8 mm is used.

Allowable deviations:
- Material (cutting) residue and insignificant color difference can be present on the insert cutting edges.
  These are caused by manufacturing process and cannot be fully eliminated.
- Even by using disk spots, it not always succeeds to avoid vibration of insert: the risk of rattling may occur.
- Insert positions in the glass unit may have ±4 mm deviation from template dimensions.
- Allowable gap between joint piece and insert (or insulating glass unit spacer): ≤2 mm.

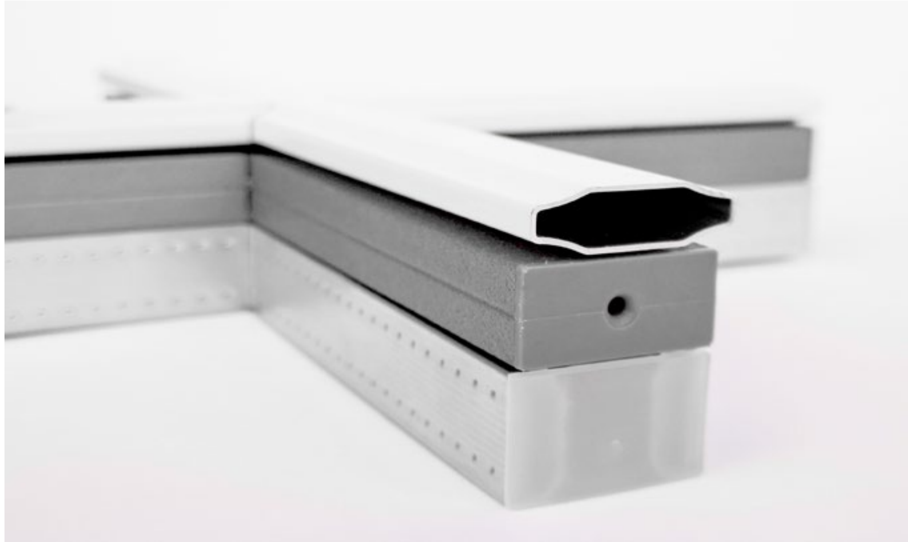


Fig. 6 Aliuminium spacer, warm spacer, decorative bar inside the glass.

Allowable sections of decorative bars inside the glass — Table 12

Width of bars inside the glass, mm	8	18	26	45	Maximum dimensions of the section, mm
8	X	-	-	-	700 x 700
18	-	X	X	X	1200 x 700
26	-	X	X	X	1200 x 700
45	-	X	X	X	1200 x 1200

ANNEX Nº2

16-07-2019
Version No 2

9. INSULATING GLASS UNITS WITH PRESSURE TWO-WAY VALVES

Insulating glass units, which will be transported or installed in high areas (higher than 600 meters above sea level) must be ordered with installed pressure valves in glass unit and toughened glass panes.
Going up – atmospheric pressure is lowering. After rising to 10 meters, mercury column height in barometer will lower one millimeter. In higher areas, insulating glass unit will expand because of pressure difference.

Negative consequences for insulating glass unit in mountain areas above sea level:

- Glass breakage;
- Loss of glass unit sealant zone insulating properties;
- Large glass panes deflections. In accordance to avoid above mentioned consequences, insulating glass units must be ordered with pressure.

In accordance to avoid above mentioned consequences, insulating glass units must be ordered with pressure valves and toughened glasses.

Changes of pressure due to altitude above sea level

Table 13

Altitude above sea level		Absolute barometer		Absolute atmospheric pressure		
Feet	**Meter**	**Inches Hg**	**Mm Hg**	**psia**	**kg/cm²**	**kPa**
0[1)]	**0**	**29,92**	**760.0**	**14.696**	**10.333**	**101.33**
500	153	29.38	746.3	14.43	1.015	99.49
1	305	28.86	733.0	14.16	0.996	97.63
1,5	458	28.33	719.6	13.91	0.978	95.91
2	610	27.82	706.6	13.66	0.960	94.16
2,5	763	27.32	693.9	13.41	0.943	92.46
3	915	26.82	681.2	13.17	0.926	90.81
3,5	1 068	26.33	668.8	12.93	0.909	89.15
4	1 220	25.84	656.3	12.69	0.892	87.49
4,5	1 373	25.37	644.4	12.46	0.876	85.91
5	1 526	24.90	632.5	12.23	0.860	84.33

ANNEX Nº2

16-07-2019
Version No 2

Changes of pressure due to altitude above sea level

Table 13 (start pg. 11)

Altitude above sea level		Absolute barometer		Absolute atmospheric pressure		
Feet	Meter	Inches Hg	Mm Hg	psia	kg/cm²	kPa
6	1 831	23.99	609.3	11.78	0.828	81.22
7	2 136	23.10	586.7	11.34	0.797	78.19
8	2 441	22.23	564.6	10.91	0.767	75.22

Fig.9 Installation of two-way pressure valve into glass unit.

Two-way pressure valve is installed in insulating glass unit height edge. Valve becomes integral part of glass unit after sealing. In normal conditions valve stays closed, but when the difference between atmospheric pressure and pressure inside IGU is higher than 80±10 mbar, valve opens and equalize this difference. Valve closes when pressure difference decreases to ±25 mm mbar.

NOTES:

- Pressure two-way valve works only in vertical position, therefore is installed in height edge of glass unit.
- Pressure valve will start its function after carefully removing (cutting) plug in the end of tube. This is necessary to perform before installing insulating glass unit in a window frame or before transporting over mountains where atmospheric pressure will change critically.
- Not allowed to pull the tube, as it may result in pressure valve falling inside the cavity of the glass unit.
- Avoid long storage of glass units with open valves in very dirty storage places, as it may cause dust to get into the valve mechanism and interrupt its function.
- Furthermore, before installation into window frame pay attention, whether the tube is not clamped, and valve can perform its function freely.

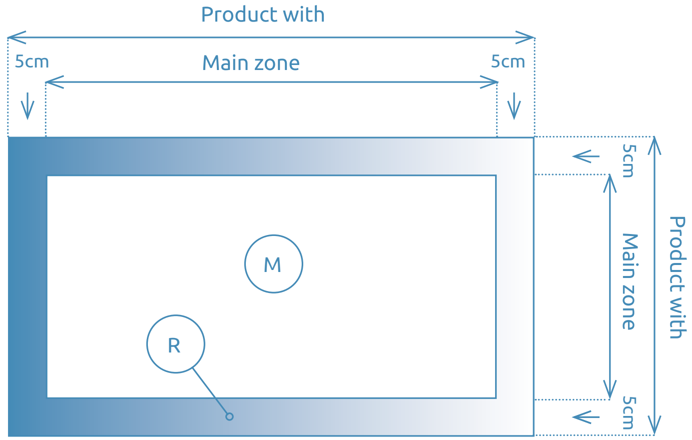
ANNEX Nº2

16-07-2019
Version No 2

10. INSULATING GLASS UNITS WITH INTEGRATED BLINDS

Blinds are designed to control room lighting and to shade it from bright sunshine. However complete darkening cannot be achieved due to following reasons:

- Cord that connects blind slats create spaces between them;
- Slats have holes for the cord to pass through;
- Gaps are left on both sides of blinds slats to allow them to expand reacting to temperature (at least ≥2,5 mm from both sides between blind slats and insulating glass unit spacer).

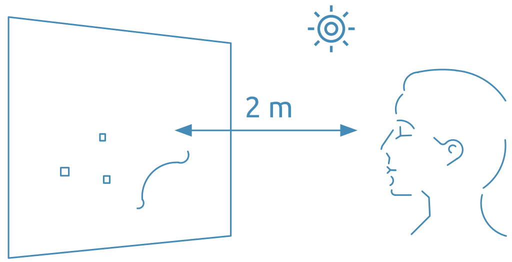


R – edge zone: 5 cm of length and 5 cm of width of glass pane surface. This zone involves head and bottom rails, blinds slats/roller blinds and spacer bar.
M – main zone: surface area except edge zone. This zone involves central part of blinds with more strict observation criteria.

Fig. 10 Observation zones for the insulating glass units with integrated blinds

Observation of visual quality of insulating glass unit with integrated blinds:

- Glass unit shall be placed vertical, blinds shall be lowered, and slats rotated 45° angle;
- Observation shall be performed from the distance of 2 m from insulating glass unit with a viewing angle of 90° to the glass surface;
- The discrepancies shall not be marked on the pane;
- Not allowed to carry out observation when direct sunlight falls on blinds slats;
- Insulating glass unit surface shall be divided into two observation zones: edge and main;



ANNEX Nº2

16-07-2019
Version No 2

Allowable visual criteria for the insulating glass units with integrated blinds — Table 14

Zone	Allowable deviations:
R	Foreign residues, spots, painting defects: 1 per 1 m², diameter ≤3 mm
	Impurities on blinds slats/stains on fabric: 1 per 1 m², diameter ≤3 mm
	Total of individual lengths of linear/extended faults on fabric – ≤30 mm. Individual length – ≤15 mm
M	Foreign residues, spots, painting defects: 1 per 1 m², diameter ≤2 mm
	Impurities on blinds slats/stains on fabric: 1 per 1 m², diameter ≤2 mm
	Total of individual lengths of linear/extended faults on fabric – ≤3. Individual length – ≤10 mm.

Allowable dimensional tolerances of blinds/roller — Table 15

Width deviation, mm	Height deviation, mm
+0/-1	+8/-0

Blinds cord diameter and internal rotation device deviations may influence an insignificant inclination of bottom slat when lifting the blinds. This inclination is more visible in case of long and narrow blinds.
The situation when bottom slat remains lifted is also possible. This happens because blinds controlling and holding cords do shrink. Shrinking of the cords is happening when temperature rises and elongation when temperature falls.
Blinds bottom slat deflection is possible due to its own weight. Such deflection is less visible, but possible in tilting-only blinds with fixed bottom slat.
When raising the blinds, slats folds unequally, thus deviation of blinds from horizontal axis in raised position may be noticeable.

ANNEX Nº2

16-07-2019
Version No 2

Allowable bottom slats inclination deviation from horizontal

Table 16

	Bottom position, mm	Middle position, mm	Top position, mm
Inclination deviation from horizontal*	±2	±5	±7

* calculated from the middle of bottom blinds slat.

Maximum individual slats deviation from horizontal shall be less than 2 mm per meter of length. Measurement must be taken in several points, when slats are in horizontal position.

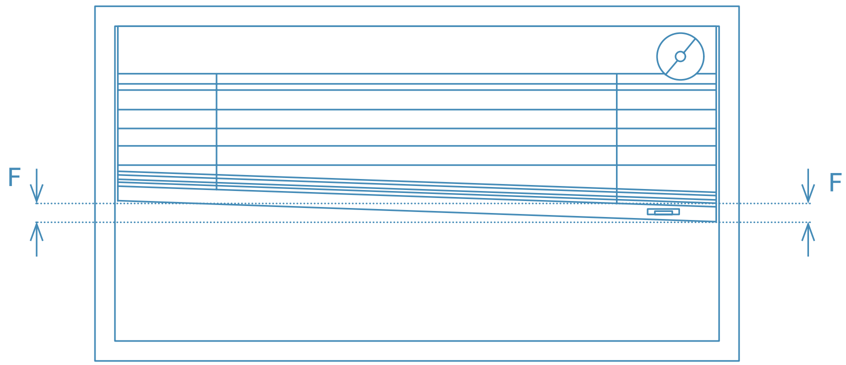


Fig. 11 Bottom slat inclination from horizontal.

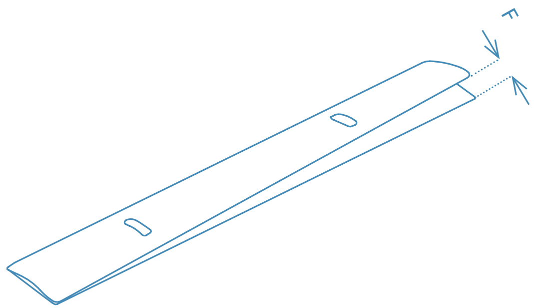


Fig. 12 Deviation of slat parallel from horizontal.

ANNEX Nº2

16-07-2019
Version No 2

Allowable bottom slat deflection — Table 17

Blinds width, m	Allowable blinds slats deflection, mm
<1,5	5
1,5 – 2,5	10
>2,5 m	15

Allowable number of partially rotated slats — Table 18

Number of slats in blinds	Allowable number of partially rotates slats
<50	0
50 – 100	1
100 – 150	3
150 – 200	4
>200	5

Partial blinds slats rotation
When lowering blinds, some strips may get stuck and stay unturned.

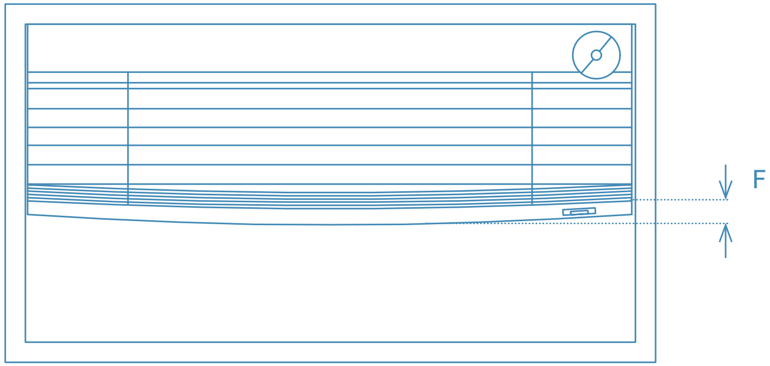


Fig. 13 Deflection of bottom slat in the middle zone.

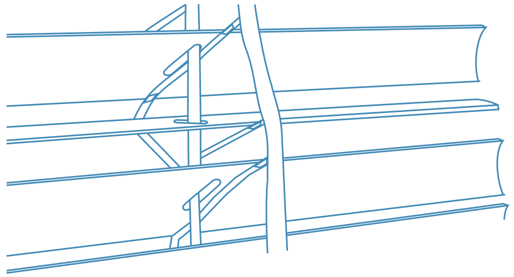


Fig. 14 Partially rotated slat.

ANNEX N°2

16-07-2019
Version No 2

Angle for closing of blinds slats

Blinds slats closing angle controls room lighting. Closing is controlled by ladder cords. Closed slats angle must be not less than 60°, measuring from axis perpendicular to glass unit internal glass pane. Inclination angle deviations depend on blind height.

Allowable deviation of closing angle — Table 19

Blinds height, m	Deviation of closing angle	Minimum closing angle
<1	5°	55°
>1	10°	50°

Method of evaluation if blinds slats inclination/closing angle is correct is described below:

- Completely close the blinds. The concave side of the slat shall face to the interior of the facade;
- After determining which slat corresponds to the eye level, take position of 1 m distance from inner glass;
- Look outside through closed blind slats;
- Should be impossible to see objects on the other side of the glass, in the 15 cm zone below eye level – that corresponds to slat closing inclination angle of around 60°.

Note: inclination angles of adjacent slats may differ.

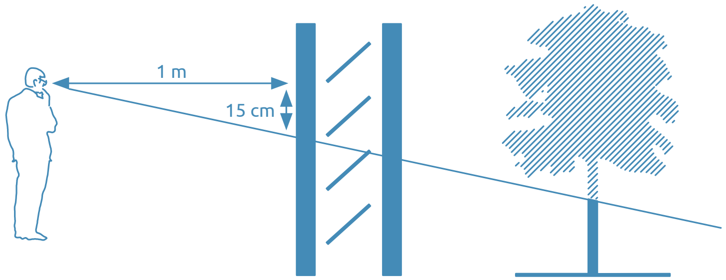


Fig. 15 Position of observer during inspection.

Blinds slats rotation angle

Blinds slats shall rotate at least by angle 90° around its longitudinal axis.

Overlapping of blinds slats

Individual slats shall overlap by more than 1 mm at maximum 60° closing angle.

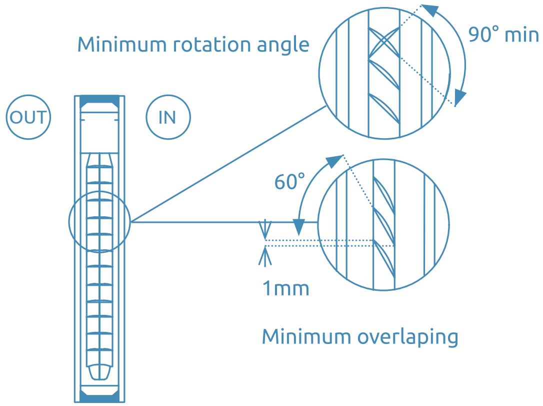


Fig. 16 Overlapping of slats.

Allowable deviation for external control

Allowable deviation for external inclination control rod is ±5 mm.

Friction of blinds into spacers

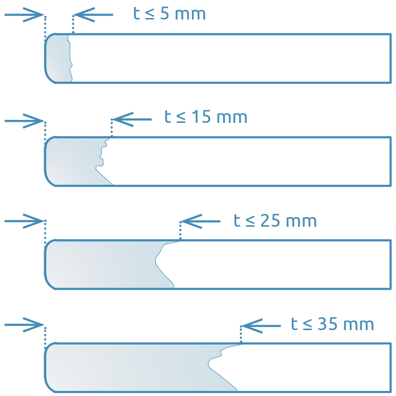
When blinds are moving, dark scurf (aluminum dust) occurs on blinds slats due to constant friction into lateral spacers. Observation shall carry out by following Directive of IFT Rosenheim:

- Check, if 10% of slats ends have changed the color. Select the blinds slat covered in dust to the most;
- Determine depth of discoloration according to Table 20;
- Determine blinds slat color according to Table 21;
- Determine dust color according to Table 21;
- Determine difference between color of blinds slats and dust;
- Check, if discoloration level is permissible according to Table 22.

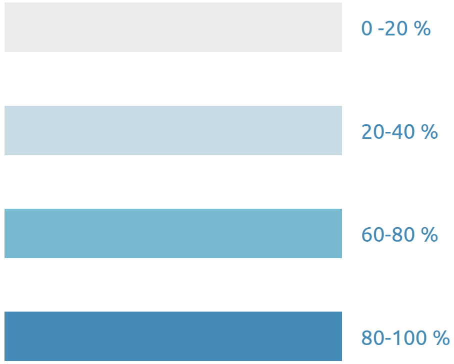
ANNEX Nº2

16-07-2019
Version No 2

Level of dust of blinds on the ends of the slats — Table 20



Color deviation of slats — Table 21



Allowable discoloration of blinds slats — Table 22

Depth of dicoloration, mm	Dicoloration, %				
	0-20%	**20-40 %**	**40-60 %**	**60-80 %**	**100 %**
t ≤ 5 mm	OK	OK	OK	OK	OK
t ≤ 15 mm	OK	OK	OK	OK	NO
t ≤ 20 mm	OK	OK	OK	NO	NO
t ≤ 35 mm	OK	OK	NO	NO	NO
t > 35 mm	NO	NO	NO	NO	NO

Roller blinds material curling
Material curling is possible near side spacers between which the roller blinds is moving. If curling does not disturb roller blinds operation and they are functioning properly both when raising or lowering, curling is not considered as defect.
Note: for insulating glass units with soft coated glass panes: in case of totally raised blinds, cord connecting blinds slats may touch glass coating and damage it. In such a case blinds should be only rotated. Using of special guiding spacer bars is also recommended. Though, it nevertheless does not guarantee that blinds will not touch the glass coating.

The most common installation faults of insulating glass units with integrated blinds
Disbalance: often installers try to correct window or door frame faults by adjusting glass unit position after it's installation into frame, by moving weight center to one or the other side. Such procedure is inappropriate in case of
glass units with integrated blinds or roller blinds. Faults must be corrected in frames themselves.
Butyl: when installing glass units with blinds or roller blinds, it is necessary to take into consideration different thermal expansion of window components as a reaction to temperature variations. Inadequate consideration of these factors can cause butyl to inflow into glass unit cavity interior.
It must be ensured, that after installation, the glazing bead pressure would not be greater than 8 N/cm, avoiding complete glass unit squeezing in a frame. Short time pressure up to 10 N/cm is permitted during installation. Higher pressure may cause butyl to inflow into glass unit cavity and cause staining of blinds or roller blinds.

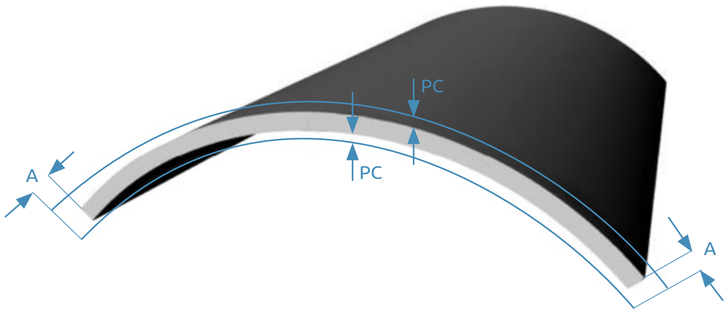
ANNEX Nº2

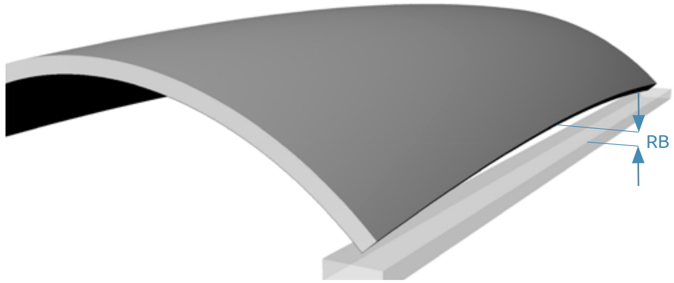
16-07-2019
Version No 2

11. BENDED GLASS PANES AND INSULATING GLASS UNITS

For bended glass and insulating glass units are permissible not only the defects, which are characteristic to flat glazing and glass unit, but also marks of burning, coating defects and surface marks. Visual glass quality is observed under diffused daylight conditions (e.g. overcast sky), without direct sunlight or artificial lighting, from a distance of 3 m, looking from inside to outside at the angle corresponding to the casual use of the room in question.

Reflection of bended glass units differs from reflection of flat glass units, as glazing transparency and color are conditioned by glazing convexity.
The below mentioned permissible deviation is applied to cylindrically bended glazing, side length of which is up to 4000 mm, while maximum bending angle is 90°. In case of larger dimensions and angles, the manufacturer has to be consulted.





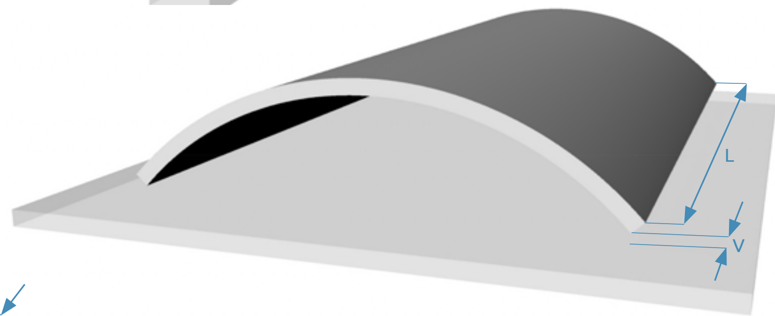


Fig. 17 Deviation of bended glazing.

ANNEX Nº2

16-07-2019
Version No 2

Allowable deviation of bended glasses

Table 23

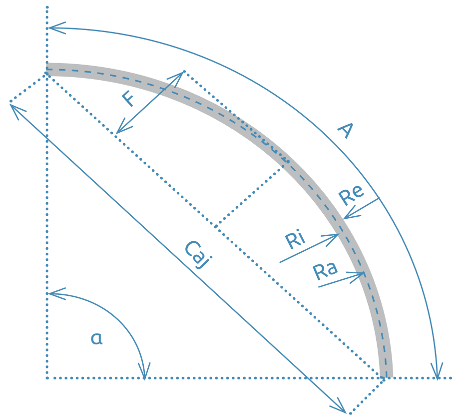
	Glass thickness, mm	Float glassmm	Toughened glass, mm	Laminated glass, mm	Insulating glass unit, mm
Arch (A) / Height (L) ≤2000 mm	≤12	±2	±2	±2	±2
Arch (A) / Height (L) ≤2000 mm	>12	±3	±3	±3	±3
Arch (A) / Height (L) >2000 mm	≤12	±3	±3	±3	±3
Arch (A) / Height (L) >2000 mm	>12	±4	±4	±4	±4
Shape accuracy (PC)	-	± 3mm/m absolut value: min. 2 mm, max. 4 mm		± 3mm/m absolut value: in. 2 mm, max. 5 mm	
Side straightness deviation (RB), mm per meter of length	≤12	±2	±2	±2	±2
Side straightness deviation (RB), mm per meter of length	>12	±3	±3	±3	±3
Twisting deviation (V)*, mm per linear meter	-	±3	±3	±3	±3
Glass displacement (d) <5 m²	-	-	-	±2	±3
Glass displacement (d) >5 m²	-	-	-	±3	±4

* the longest sides are measured.

As bended glass units are affected by higher environmental stress than flat glass units, edge sealant has to withstand a higher load. Therefore, that may have impact on sealant parameters.
In case of bended glasses, it is necessary to provide very accurate dimensions. It is necessary to indicate below listed parameters when ordering cylindrically bended glass units, so that technically and economically optimal solution could be selected. At least two of these parameters shall be provided:

- Arch length;
- Bending radius;
- Arch height (internal and external);
- Angle.

Length of straight side and number of glass panes should be additionally marked.



Ra – Radius in the middle of the glass pane (neutral arch);
Ri – Internal radius;
Re – External radius;
F – Arch height;
Caj – Internal chord;
α– Angle.

Fig. 18 Parameter of bended glass pane.

ANNEX Nº2

16-07-2019
Version No 2

12. ENAMELLED AND SILKSCREEN PRINT METHOD PAINTED GLASS

Enamelled and painted using silkscreen printing glass surface quality is observed visually from 4 meters distance, looking into glass surface from uncoated side. During observation, normal angle for coated glass and light beam passing through inspector eyes after reflection or passing through coated glass cannot exceed 30°.

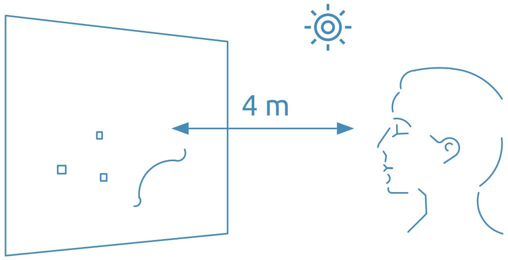
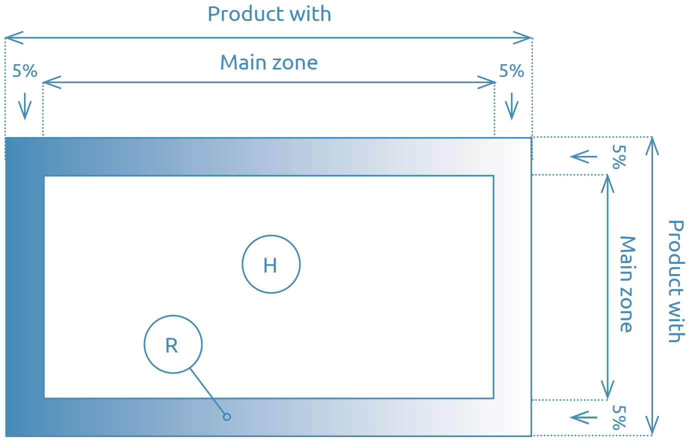


Fig. 19 Position of observer during inspection.

Inspection shall be carried out in normal daylight without direct sunlight or direct artificial lighting. Enamel defects invisible from 4 meters distance are not considerable. If enamelled glass inspection will be carried out from both sides, this must be agreed with manufacturer first. Each inspection should not take longer than 20 seconds.



R – edge zone: 5 % of length and 5 % of width of glass pane surface.
H – main zone: surface area except edge zone.

Fig. 20 Observation zones.

If enamelling is ordered by leaving clear edges i.e., enamel coating is partial, then this zone has to be omitted during evaluation, while the main glazing zone (H) continues to the edge of glass pane.

ANNEX Nº2

16-07-2019
Version No 2

Allowable defects for fully and partially enamelled glass*

Table 24

<table>
<tr><th>Defect</th><th colspan="2">H zone</th><th>R zone</th></tr>
<tr><td>Enamel defects</td><td colspan="2">≤3, diameter ≤25 mm^2, total area ≤25 mm^2</td><td>Width: ≤3 mm, (in specific cases ≤5 mm), length: no limitation</td></tr>
<tr><td>Hairline scratches (visible only at changing lighting)</td><td colspan="2">Length: ≤50 mm</td><td>No limitation</td></tr>
<tr><td>Stains in clusters</td><td colspan="2">Not allowed</td><td>No limitation</td></tr>
<tr><td>Water stains</td><td colspan="2">Not allowed</td><td>No limitation</td></tr>
<tr><td>Paint excess at the edges</td><td colspan="2">–</td><td>Allowable for glasses intended to install in frame.
Not allowed for glasses with not covered edges.</td></tr>
<tr><td rowspan="8">Allowable dimensional deviations for partially enamelled glass</td><td colspan="2">Depending on enamel width:</td><td rowspan="8">–</td></tr>
<tr><td>Enamel width, mm:</td><td>Deviation, mm:</td></tr>
<tr><td>≤100</td><td>±1,5</td></tr>
<tr><td>≤500</td><td>±2,0</td></tr>
<tr><td>≤1000</td><td>±2,5</td></tr>
<tr><td>≤2000</td><td>±3,0</td></tr>
<tr><td>≤3000</td><td>±4,0</td></tr>
<tr><td>≤4000</td><td>±5,0</td></tr>
<tr><td rowspan="2">Allowable enamel position deviation for partially enamelled glass</td><td>Enamel ≤2000</td><td>±2,0</td><td rowspan="2">–</td></tr>
<tr><td>Enamel >2000</td><td>±4,0</td></tr>
</table>

* defects ≤0,5 mm are allowable and not considered.

ANNEX Nº2

16-07-2019
Version No 2

Allowable defects for silkscreen print coated glass * ** Table 25

Defect	H zone		R zone
Allowable deviations of geometrical shape	Depending on silkscreen printed glass edge length:		No limitation
	Edge length, mm:	Deviation, mm:	
	≤30	±0,8	
	≤100	±1,0	
	≤500	±1,2	
	≤1000	±2,0	
	≤2000	±2,5	
	≤3000	±3,0	
	≤4000	±4,0	
Picture defects	Defects shall be not closer than 250mm from each other		No limitation
Allowable deviation of picture position	Silkscreen printing ≤2000	±2,0	–
	Silkscreen printing >2000	±4,0	

* defects ≤0,5 mm are allowable and not considered. ** moiré effect is possible in very detailed drawings (silkscreen mesh ≤5 mm). Therefore, it is necessary to consult the manufacturer.

Fig. 21 Moiré effect in insulating glass unit.

ANNEX Nº2

16-07-2019
Version No 2

NOTES:

- Fully enamelled glass is not marked with safety glass mark, as there is no possibility to do this due to technology of manufacturing.
- Shade differences are possible. They are caused by lighting, viewing conditions and the color of clear glass.
- One enamelled glass batch color shade may differ from another batch, therefore it is recommended to enamel all glass in the one viewing zone at the same time (this means, to order enamelled glass panes for the entire related area at the same time).
- It is recommended to approve standard enamel/silkscreen print samples when placing the order. One sample is intended to customer, the other to manufacturer.
- Same color painted glasses but from different manufactures may do not match due to different supplier of paints and different painting technology used. In such situation manufacture needs standard sample in order to achieve closest matching shades of color.
- Enamelling procedure does not guaranty absolute opacity of the glass. In order to avoid this effect, enamelled glass products have to be installed using dark, opaque background. Otherwise, due to irregular transparency of individual areas, visual effect of irregular colors may occur, though relative glass areas were enamelled by using identical colors (it of high importance when using glazing enamelled with light colors).
- Interference phenomenon may appear due to physical laws on black color painted products in certain natura lightening. Stains, similar to oil stains on the water, may appear on the painted products. Interference phenomena appear randomly, and they cannot be eliminated.
- It is recommended not to polish edges of enamelled glasses, due to physical laws effect of lighter edges occurs.
- In order to avoid direct temperature fluctuations, moisture effect and mechanical impact, we recommend ordering glass units with enamel coating faced to glass unit cavity. On exceptional cases (e.g., for interior of the object), enamel can be oriented outwards the glass unit, though a priori consultation with the manufacturer is required.
- Construction, where glass unit with enamelled glasses will be mounted, must ensure appropriate ventilation for moisture not to accumulate around the glass unit. It is necessary to pay attention to the distance between the glass unit and insulation wool, or other material, which is insulating heat, because the glass unit may significantly heat up. Due to the action of high temperature, chemical vapors may be emitted from sealants of the glass unit and may deposit on the glass panes.
- After thermally toughening of the glass pane, enamel has to be fully and evenly melted within the entire area of coverage and tested by isopropanol test, that is, by running through the toughened area of enamel with the marker. Marks of the marker have to be easily cleaned by the help of the diluent and in the end have to leave no marks.
- Enamelled glass is maintained the same way as toughened glass. It has to be protected against mechanical impact. Do not use acid- or alkali-based cleaners.
- We recommend enamel external glass pane, which is intended for bonded glazing, within entire edge perimeter of the glass. Enamelling zone has to be ~1-1.5 mm wider than the sealant zone. In such a way, the sealant zone is covered, thus hiding most often visually unfavorable unevenness of the primary and secondary sealant.

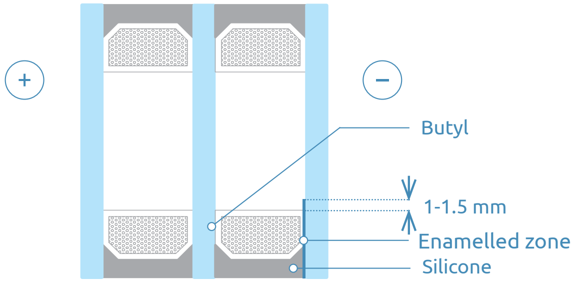


Fig. 22 Enamel zone for insulating glass units intended for bonded glazing.

13. OTHER VISUAL ASPECTS OF INSULATING GLASS UNITS

Some physical effects can occur that are visible on the glass surface and shall not be taken into account when assessing the visual quality. They are not considered as defects.

Interference effect

In insulating glass units made of float glass, interference effects may cause spectral colors to appear. Optical interference is due to superposition of two or more light waves at a single point. The effects are seen as variation in intensity of the colored zones, which change when pressure is applied to the glass. This physical effect is reinforced by the parallelism of the surfaces of the glass. Interference effects occur at random and cannot be avoided.

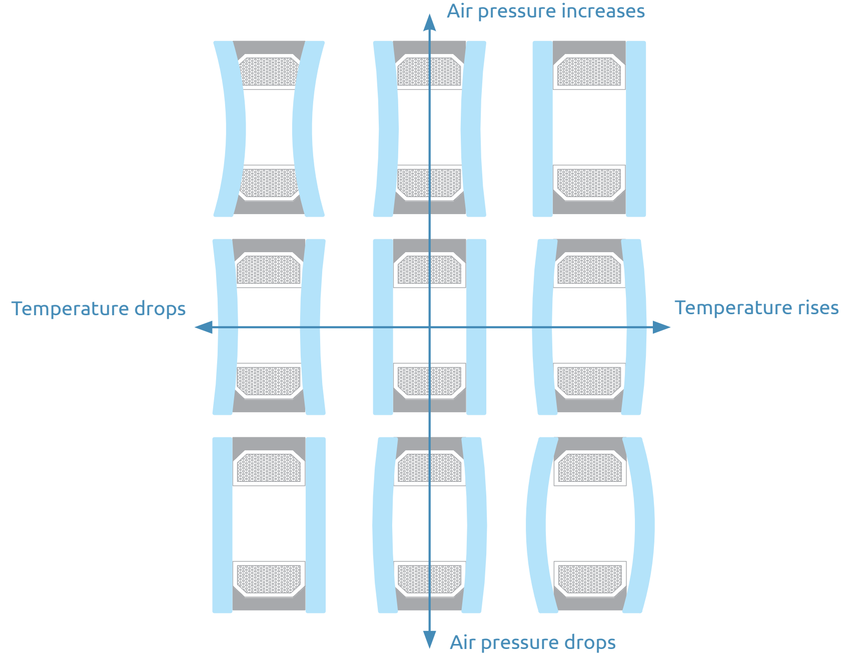


Fig. 23 Concavity/convexity of glasses, depending on temperatureand atmospheric pressure.

Concave or convex glass

An insulating glass unit includes a volume of air or other gas, hermetically sealed by the edge seal. The state of this gas is determined by barometric air pressure, by altitude and the air temperature at the time and place of manufacture. If the insulating glass unit is installed at another altitude, or when the temperature or barometric pressure changes (higher or lower pressure), the panes will deflect inwards or outwards, resulting in optical distortion. Insulating glass units, which will be transported or installed in areas where atmospheric pressure will change critically must be ordered with installed pressure valves (or other alternative equipment) in glass unit and toughened glass panes. Level of convexity also depends on rigidity and size of glass sheets, including width of the cavity: when thick glasses is of small dimensions and/or cavities are narrow, possibility of convexity significantly reduces. Visual effect of distortion is also affected by roller wave and overall bow of toughened glass, when glass is laminated-toughened or with more reflective glass coating (e.g., mirrored glass) is used. This phenomenon proves high quality of the glazing unit - its insulating properties.

Fig. 24 Distortion effect, depending on concavity/convexity of glass panes due to overall bow and roller wave of toughened glasses, etc.

ANNEX Nº2

16-07-2019
Version No 2

Condensation on the external surface of the insulating glass unit (steaming)

In certain conditions, condensation may appear on internal (inside room) or external glass unit surface.
Condensation on glass surface inside the room commonly forms due to certain U [W/m2K] value, humidity, air circulation, and temperature inside and outside. It is important to add, that in case of such problems, good and frequent ventilation of premises is necessary first of all. This primarily relates to premises where natural reasons water vapor accumulates most: kitchens, bathrooms and bedrooms. This problem extremely frequently occurs where old leaky windows where replaced with new, tighter.
Moisture may form on external glass surface, when glass unit thermal insulation is especially good, air humidity is high and air temperature is higher than glass surface temperature.
This phenomenon in the first instance noticeable on winter mornings when glazing unit coefficient U [W/m2K] is very good.
This phenomenon proves high quality of the glazing unit.

Fig. 25 Moisture condensation on external glass pane of the insulating glass unit.

Difference in insulating glass unit color

Glass color (shade) is determined by its thickness, manufacturing process and composition of raw materials and constantly developing raw glass material manufacture technology. Color differences may occur after a certain period of time after acquisition of glass units and by additionally ordering new glass units, even if they are ordered from the same manufacturer.
Selective coating color variations (from different shades to different colors) are especially specific to standard windows with heat transfer coefficient U=1,1 [W/m2K]. Therefore, it is useful to take that into consideration and, if not replacing all windows at the same time, at least, replace all windows situated on the same side. In that way various colors of the adjacent windows may be avoided. Unfortunately, if after some time, one of those windows will break or will be replaced for any other reason, nobody will guaranty the same color of the other glass.
Float glass has very insignificant green shade, especially at the edges. It is visible, in case of thicker glasses.
Observation of difference of color shades is carried out in the construction object only from outside of the facade at no higher angle than 45°. Though observation of glass color shade is quite subjective and depends not only on distance, viewing angle for assessment, components of inside and outside the facade, but also on sensitivity of observer's eyes.

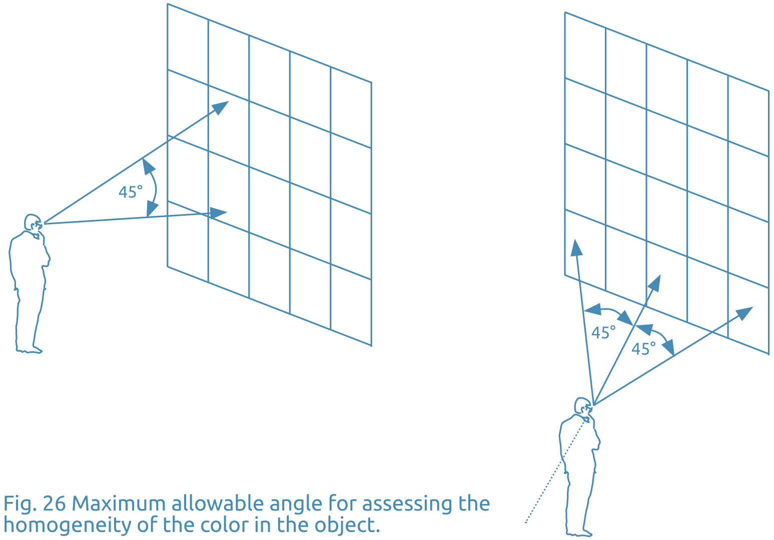


Fig. 26 Maximum allowable angle for assessing the homogeneity of the color in the object.

ANNEX Nº2

16-07-2019
Version No 2

Vibration of insert of insulating glass unit

This phenomenon is caused by natural vibration of the insert while opening or closing window, in windy conditions, when living on the street with intensive motor traffic. We recommend using insert, when minimum width of spacer of the glass unit ≥12 mm. In case of failure to follow this recommendation, in specific conditions (e. g. at high atmospheric pressures) glass pane may get in touch with insert. This may result in damage to glass coating or crack of glass pane.

Glass breakage

Glass, as cooled down liquid, is fragile material, which typically has certain internal tensions. Glass cannot be significantly deformed, and after passing elasticity limit it immediately breaks. Float glass tensions are equal and have marginal initial values, thus it may be cut and mechanically processed. Glass can crack only because of external, mechanical or thermal reasons. Thermal tensions come from covered areas or shadows, hot air pockets conditioned by insufficient air circulation, etc. (See Section 14).

Fig. 27 Anisotropy in heat-treated glass

Wetting of glass surfaces

Moisture retention of the glass surfaces can differ due to the effect of rollers, fingerprints, labels, vacuum suction holders influences etc. This can become evident when the glass surfaces are wet by condensation, rain or cleaning water.

Anisotropy (iridescence)

Anisotropy - is phenomenon specific to heat-treated glass due to internal tensions originating from toughening process. Different tension zones result in double light wave reflection. Due to this phenomenon dark circles or lines may be visible in polarized daylight.

ANNEX Nº2

16-07-2019
Version No 2

Compatibility of components within an insulating glass unit system

Sealants, laminated glass films, glass coatings, joint pieces, spacers, etc. are used in glass unit system. These all are chemical substances that can react with other substances. Migration of chemical substances takes place during direct or indirect contact. Reaction may be speeded up by direct contact between substances, molecular mass of migrating substance, ambient temperature, quantity of components, solubility of migrating substances. Materials, used for installing (sealants, glues, glazing blocks, etc.) shall be tested for using with materials used in glass unit's system. Chemical compatibility tests shall be carried out. When materials are incompatible, butyl liquefies and leaks inside the cavity of the glass unit, laminated glasses delaminate, visual quality and insulating properties of glass or glass unit impairs. Manufacturer of insulating glass units, being unable to control customer's selection of installing materials, cannot be responsible for defects relating to incompatibility of materials. We always suggest consulting the manufacturer of insulating glass units.

Note: when installing glass units into frames, we recommend avoiding usage of dark color components; for glass units with a component of enamelled glass, we recommend using constructions that will ensure sufficient ventilation. These factors may increase temperature at the surface of the glass unit or inside it up to more than 60 °C. Higher temperature than 60 °C may result in chemical evaporation of components used in glass unit's system. Selective and sun control coatings increasingly absorb solar energy, thus increasing temperature on the glass surface and inside cavity of the glass unit. Thus, chemical evaporation more often occurs and is visible on selective or sun control coatings.

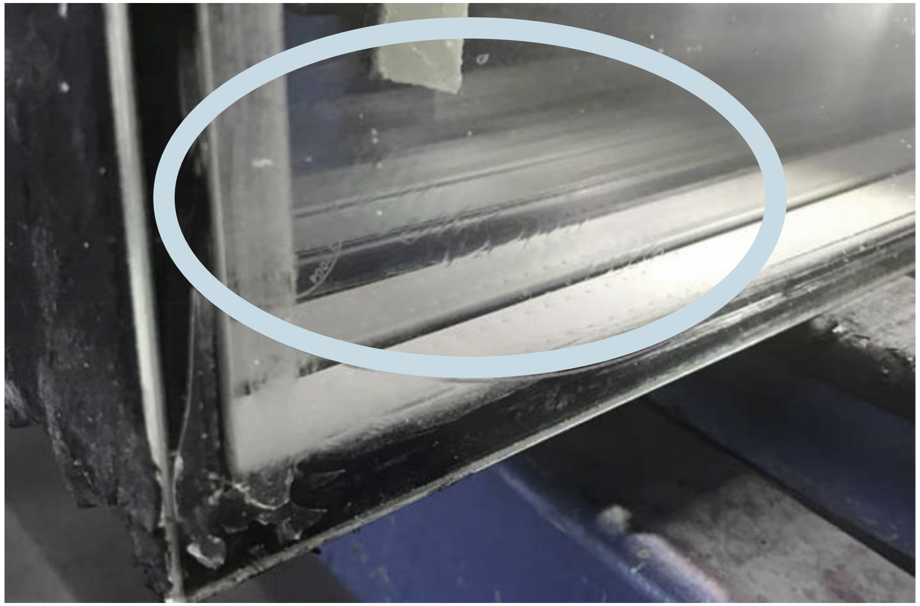


Fig. 28 Delamination of PVB film due to chemical incompatibility

Fig. 29 Chemical evaporation inside the insulating glass unit after exceeding recommended temperature of 60 °C

ANNEX Nº2

16-07-2019
Version No 2

14. BREAKAGE OF INSULATING GLASS UNITS*

In order to avoid breakage of insulating glass units, it is of high importance to be aware of types and reasons thereof. Recognition of reasons for breakage of the glass requires for extensive experience, thus we recommend delegating this task to specialists with long-term experience.
Most often, it is possible to determine the reason of crack by the view of broken glass. Though, there are cases, when it is hard to do. If possible, we always recommend performing glazing bead opening act and inspection of the insulating glass unit. When observing the crack, start with by assigning of the view of the broken glass to a certain group of breaks/cracks: mechanical or thermal.
Mechanical: breaking of the insulating glass unit may be induced by long-term heavy load conditioned by air pressure, height difference between the place of production and installation place of the insulating glass unit, constant strong wind, snowfall, etc. or by short-term load, occurring due to placing the insulating glass unit on the stone or metal, usage of unsuitable packaging bands on transportation stands, hit by the hammer into the glazing bead etc.

Thermal: reason for thermal breakage of the glass is temperature difference on the glass pane are. Critical temperature difference to float not thermally treated glass is ~35 °C (see Table 26). All conditions and factors, which increase this difference, also increase the risk of thermal cracking of the glass. E.g., the sun equally enlightens the entire glass surface, temperature distributes evenly in the entire glass area and there is no risk of cracking. Though, when one part of this glass is under the shade and the other part heats in the sunshine, then critical temperature difference, enabling cracking, may occur.
Thermally toughened glass can withstand temperature difference of ~200 °C. With reference to this reason, under natural conditions, thermal cracking of toughened glass is practically impossible. If it is impossible to eliminate factors, increasing possibility of thermal breakage, it is recommended to use toughened glass. It is not allowed to orient hot or cold air flow, generated by the air conditioner, directly at not toughened insulating glass unit. It is also not recommended to install artificial heat and light sources adjacent to the glazing unit.

Critical temperature difference to the glass are in accordance with the glass type

Table 26

Type and thickness of glass	**Allowable temperature difference, ΔT, °C**		
	As-cut or arrissed edge	**Smooth ground edge**	**Polished edge**
Float glass, ≤12 mm	35	40	45
Float glass, 15 mm or 19 mm	30	35	40
Float glass, 25 mm	26	30	35
Patterned glass	26	26	26
Wired-patterned or polished wired glass	22	22	22
Heat strengthened glass	100	100	100
Toughened glass	200	200	200
Laminated glass	Smallest value of the component panes		

ANNEX Nº2

16-07-2019
Version No 2

Factors increasing or decreasing the risk of thermal breakage of the glass

Table 27

Decreasing factors	Increasing factors
Flat terrain	Mountainous terrain
Sea climate	Continental climate
North countries	South countries
North, north west facade orientation	East, south-east, south facade orientation
Flat facade	Unequal facade with inner corners, roofs, balconies etc. structural components
Building in the open area	Building surrounded by other buildings, trees
Low solar energy absorption (outer glass - clear)	High solar energy absorption (outer glass - toned, reflective, toned - reflective)
Inner glass non-selective	Inner glass selective
Bonded glazing	Framed facade
Dark color facade frames	Light color facade frames
Aluminium frames	Wood frames
Superficial installation of glass into the frame	Deep installation into the frame
Arrissed, smooth ground, polished edges	As-cut edges
Small dimensions of glass pane	Large dimensions of glass pane
Glass without coverings	External, internal coverings (blinds, roller blinds etc.)
Moving shadows on the glass	Not moving shadows on the glass

ANNEX Nº2

16-07-2019
Version No 2

Table 28

Glass absorption, %	Risk of thermal breakage
80-85	Very high
60-70	High
45-55	Medium-high
30-40	Medium
18	Low

Risk of thermal breakage depends on:

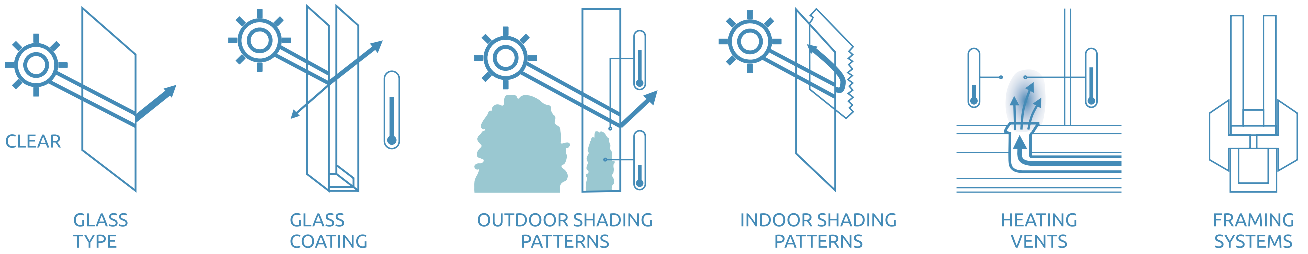


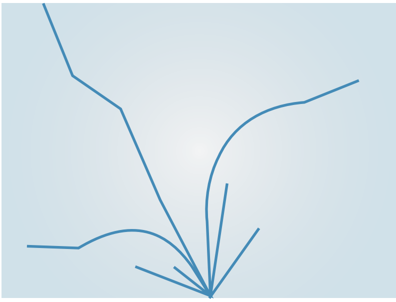
Fig. 30 Factors having influence on the risk of thermal breakage

For insulating glass units, which cracked due to mechanical or thermal reasons during warehousing, installation or operation, warranty does not apply.

ANNEX Nº2

16-07-2019
Version No 2

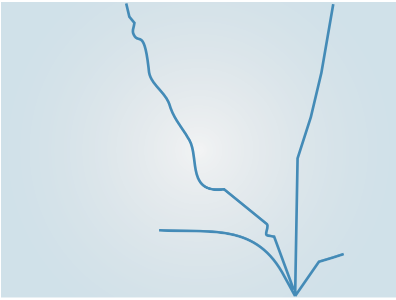
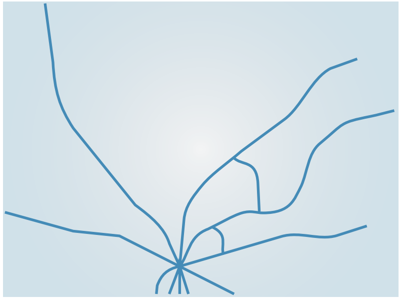
Types of mechanical breakage

Description:	Image of glass breakage:
BREAKAGE OF THE EDGE DUE TO HIT Type of glass: • polished glass; • laminated glass; • patterned glass. Cause of breakage: • placing insulating glass unit on the stone or metal; • hit of metal material to the glass edge; • other type of hit or impact; • usage of unsuitable packaging bands or transportation racks. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • transition crack line without perpendicular angle; • different size glass shells are visible on the side, depending on strength of the hit; • clear hitting center on the edge.	
BREAKAGE OF THE CORNER DUE TO HIT Type of glass: • polished glass • laminated glass, • patterned glass Cause of breakage: • placing insulating glass unit on the stone or metal; • hit of metal material to the glass corner; • turning of the insulating glass unit over its corner. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • at the corner is visible a clear hit center and different size glass shells or curvilinear cracks, depending on the strength of hit; • lines of the crack are in the middle or passes up to the other glass edges.	

ANNEX Nº2

16-07-2019
Version No 2

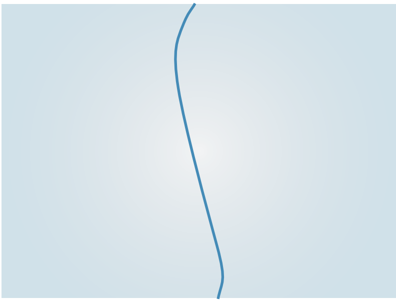
Types of mechanical breakage

Description:	Image of glass breakage:
BREAKAGE OF THE EDGE DUE TO PRESSURE Type of glass: • polished glass; • laminated glass; • patterned glass. Cause of breakage: • too small glazing blocks, in case of high glass weight; • too high pressure applied while clamping; • installation mistakes (e.g., incompletely screwed frame fastening screw); • too high pressure when applying wooden glazing bead without a gasket. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • transition crack line without perpendicular angle; • no or very few glass shells on the edge; • center of the crack is on the edge.	
BREAKAGE OF POLISHED GLASS SIDE Type of glass: • polished glass; • laminated glass; • patterned glass. Cause of breakage: • small stones between glass panes; • hit by hammer to the glazing bead; • other type of hit or impact. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • beginning of the crack is visible in the zone of the side; • possible of glass shells (scales) at the center of the crack.	

ANNEX Nº2

16-07-2019
Version No 2

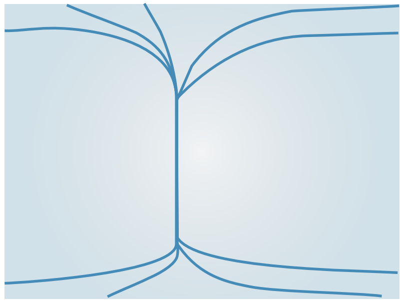
Types of mechanical breakage

Description:	Image of glass breakage:
BREAKAGE BECAUSE OF NIPPING Type of glass: • polished glass; • laminated glass; • patterned glass. Cause of breakage: • too small or unsuitable setting block, in case of heavy glass panes; • incorrect installation of glazing bead; • glass dimension/frame length deviations are not taken into consideration. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • beginning of the crack is visible in the zone of the edge; • possible of glass shells (scales) at the center of the crack; • often there is no curvilinear cracks in the main area.	
BREAKAGE BECAUSE OF TORSION Type of glass: • polished glass; • laminated glass; • patterned glass. Cause of breakage: • insufficient glass thickness (often in the case of double fastening); • window frame deformation; • high mechanical pressure to the insulating glass unit. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • transition crack line without perpendicular angle; • possible curvilinear cracks in the main glass area; • most often long fractures last from one edge to another.	

ANNEX Nº2

16-07-2019
Version No 2

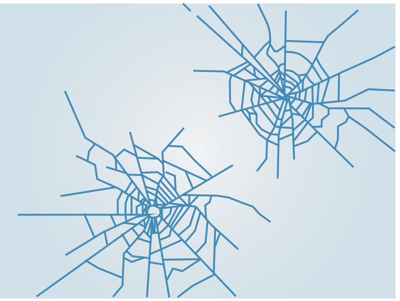
Types of mechanical breakage

Description:	Image of glass breakage:
BREAKAGE BECAUSE OF SURFACE PRESSURE Type of glass: • polished glass; • laminated glass; • patterned glass. Cause of breakage: • too high temperature, air pressure and/or height difference between production and installing place; • aquarium glasses within too small dimensions isfixed from 4 edges. Description: • crack angle starts by oriented in all direction, but not at perpendicular angle; • center of the crack is not visible; • crack lines pass from one corner to another one (S-shaped or arch shaped); • transition crack line without perpendicular angle; • no glass shells on the glass edge.	
BREAKAGE BECAUSE OF SHOT I Type of glass: • polished glass; • patterned glass; • all not heat-treated monolithic glasses. Cause of breakage: • gunshot; Description: • small, round-shaped center of entering; • larger center of exiting; • level, sharp edges of the center; • round shape – shot perpendicular to the surface; • oval shape – shot diagonal to the surface.	

ANNEX Nº2

16-07-2019
Version No 2

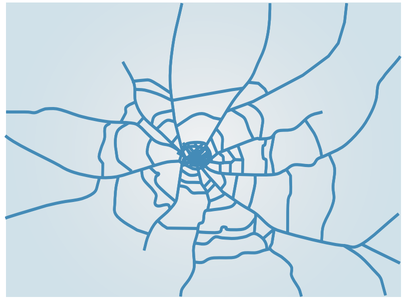
Types of mechanical breakage

Description:	Image of glass breakage:
BREAKAGE BECAUSE OF SHOT II Type of glass: • laminated glass; Cause of breakage: • gunshot; Description: • scattered glass area around the center of shooting; • large curvilinear cracks or shells around the centerof shooting; • when smaller the cartridge and the bigger shooting energy, then the smaller cracking edge and the cleaner the shooting hole; • larger center of exiting.	
BREAKAGE BECAUSE OF THROWN STONE I Type of glass: • polished glass; • patterned glass; • all type of monolithic glasses. Cause of breakage: • throw of stone or another heavy object; • breaking-in by using a heavy object (e.g., hammer). Description: • formless shape of the crack center; • crack lines arrange in the form of large spider web; • most often crack lines pass up to the glass pane edge.	

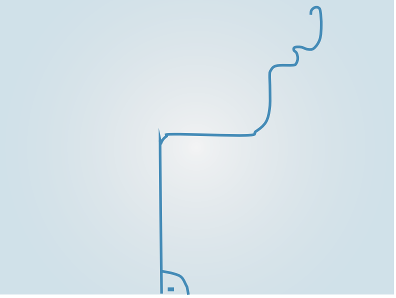
ANNEX Nº2

16-07-2019
Version No 2

Types of mechanical breakage

Description:	Image of glass breakage:
BREAKAGE BECAUSE OF THROWN STONE II Type of glass: • laminated glass; Cause of breakage: • throw of stone or another heavy object; • breaking-in by using a heavy object (e.g., hammer). Description: • formless shape of the crack center; • crack lines arrange in the form of large spider web; • most often crack lines pass up to the glass pane edge; • most often the glazing stays not fully through broken.	

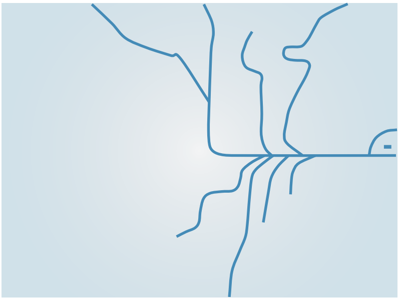
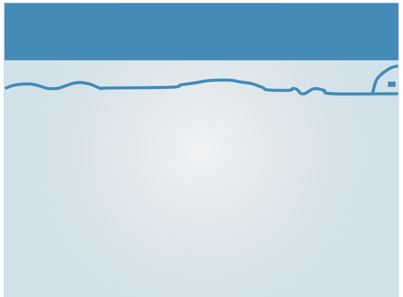
Type of thermal breakage

Description:	Image of glass breakage:
NORMAL THERMAL BREAKAGE Type of glass: • polished glass; • patterned glass; • laminated glass; • in case of wired glass, deviations are possible due to the grid. Cause of breakage: • partial covering of insulating glass unit during sunlight; • high solar energy absorption (outer glass – toned,reflective, toned-reflective); • not moving shadows on the glass; • the insulating glass unit sound reduction and heat insulation with solar control glass components are installed that open edges impact by direct sunlight. Description: • crack starts from the edge with perpendicular angle; • mostly no additional curvilinear or bigger glass shells; • crack line is waved, changing direction near source of heat or cold; • crack ends mostly with an angle.	

ANNEX Nº2

16-07-2019
Version No 2

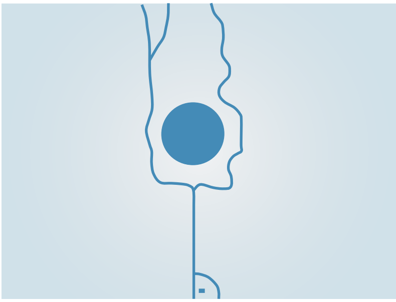
Type of thermal breakage

Description:	Image of glass breakage:
VERY LARGE THERMAL BREAKAGE Type of glass: • polished glass; • patterned glass; • laminated glass. • in case of wired glass, deviations are possible due to the grid. Cause of breakage: • welding works are carried out very close to the insulating glass unit; • hot air ventilator is very close to the insulating glass unit; • other type of high temperature heating source. Description: • crack starts from the edge with perpendicular angle; • mostly no additional curvilinear or bigger glass shells; • crack line is waved, changing direction near source of heat or cold; • crack ends mostly with an angle.	
SMOOTH THERMAL BREAKAGE I Type of glass: • polished glass; • patterned glass; • laminated glass. • in case of wired glass, deviations are possible due to the grid. Cause of breakage: • dark areas on the glass (e.g., stickers, advertising materials etc.); • partial covering by using internal blinds; • glass covering by a decoration or by other object which forms a shadow. Description: • crack starts from the edge with perpendicular angle; • mostly no additional curvilinear or bigger glass shells; • crack lines are slightly wavy, and passes in parallel to the source of heat or cold; • most often crack ends without an angle.	

ANNEX Nº2

16-07-2019
Version No 2

Type of thermal breakage

Description:	Image of glass breakage:
SMOOTH THERMAL BREAKAGE II Type of glass: • polished glass; • patterned glass; • laminated glass. • in case of wired glass, deviations are possible due to the grid. Cause of breakage: • dark areas on the glass (e.g., stickers, advertising materials etc.); • glass covering by a decoration or by other object which forms a shadow. Description: • crack starts from the edge with perpendicular angle; • mostly, at the beginning, there are no additional curvilinear crack or bigger glass shells; • crack line is waved, changing direction near source of heat or cold; • wavy lines may occur at the place of change in direction; • most often crack ends without an angle.	
THERMAL BREAKAGE (SHAPE OF WORM) Type of glass: • polished glass; • laminated glass. Cause of breakage: • welding works are carried out very close to the insulating glass unit; • hot air ventilator is very close to the insulating glass unit; • other type of high temperature heating spot. Description: • in the zone of main area; • impossible to distinguish between beginning and end; • fracture can be “S” shape or worm shape, without significant change of direction.	

ANNEX Nº2

16-07-2019
Version No 2

Other breakages

Spontaneous glass breakage – influenced by nickel sulphide (NiS) impurities in thermally toughened glass. This breakage is possible only for toughened glass, when during operation, by the action of temperature changes on the glass, NiS impurity expands faster than the glass itself. Internal tensions of the glass fail to withstand stress and the glass cracks into many small pieces. It occurs randomly and does not depend on the type of glass, insulating glass units or raw glass manufacturer, thus cannot be considered as glass defect. In order to reduce the risk of spontaneous breakage because of NiS impurities, we can order HST (Heat Soak Test) for an additional fee. Risk of breakage is reduced during this test, though even this HST test does not entirely eliminate the probability of spontaneous breakage.

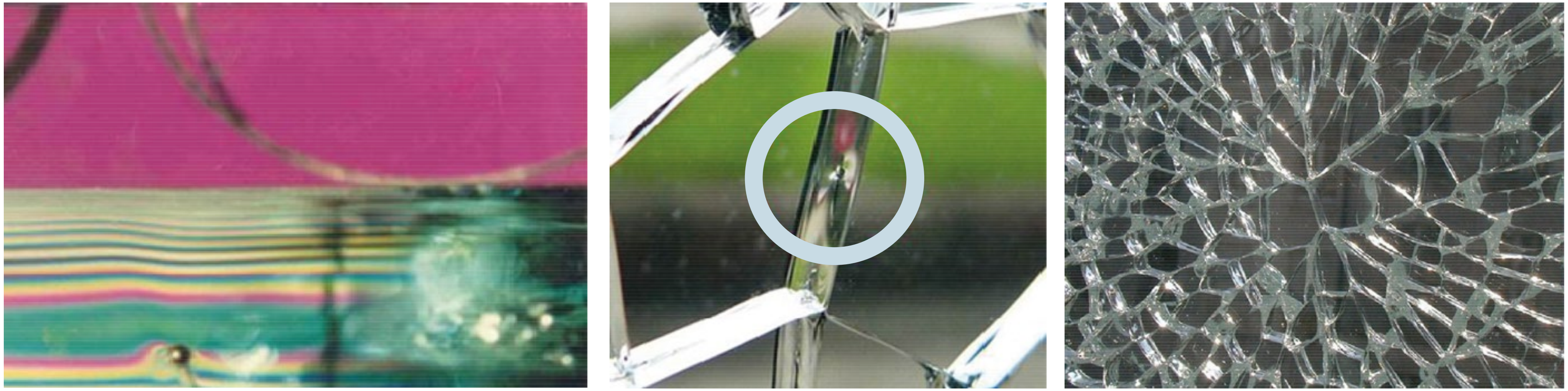


Fig. 31 Beginning of spontaneous glass breakage

Windows built with care