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OTIIMA | MUCH MORE THAN A WINDOW

GLASS HANDBOOK

RESPONSIBILITY

The current document has been developed OTIIMA | MUCH MORE THAN A WINDOW.

SCOPE

The scope of the current document is to describe all the production tolerances and controls that have to follow the staff of OTIIMA during the different processes that the materials by means of a planned and systematic method.

APPLICATION

The current document is applicable to the following processes:

- Glass cutting.
- Glass edge working.
- Drill-holes and cut-outs of glass.
- Application of ceramic and digital paint on the glass surface.
- Thermal treatment of glass.
- Heat-soak tested glass.
- Laminated glass manufacturing.
- Curved annealed glass.
- Insulating glass manufacturing.
- Structural bonding.

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1. APPLICABLE STANDARDS

OBJECT	EN STANDARD	ASTM STANDARD
Float glass	EN 572	ASTM C 1036
Heat strengthened glass	EN 1863	ASTM C 1048
Tempered glass	EN 12150	ASTM C 1048
Tempered + HST glass	EN 14179	---
Laminated glass	EN 12543	ASTM C 1172
Safety laminated glass	EN 14449	ASTM C 1172
Pendulum safety classification	EN 12600	ANSI Z97.1
Manual attack safety classification	EN 356	ANSI Z97.1
Coated glass	EN 1096	ASTM C 1376
Double glazing unit	EN 1279	ASTM E 2188 ASTM E 2190
Structural sealing	EN 13022	ASTM C 1135 ASTM C 1184 ASTM C 1401
Curved glass	ISO 11485	ASTM C1464

2. SPECIAL STANDARDS

SPECIAL STANDARDS TO BE APPLIED	STANDARDS TO BE APPLIED IN CASE OF REQUEST
ISO 9001	KITEMARK (BSI)
ISSO 14001	IGCC / SGCC
Client requirements	CEKAL
Guidelines of the different suppliers	PASS VEC
	EOTA 002
	APPLUS – SPC

OTIIMA | MUCH MORE THAN A WINDOW has a wide range of certified products according to European and American standards. However, if the reference project requires special certifications, it must be analysed before the beginning of the production. Please, contact for this purpose with your OTIIMA's commercial reference.

3. DOCUMENTATION

OBJECT	EN STANDARD	ASTM STANDARD
Certification ISO 9001	---	---
Certification ISO 14001	---	---
Float glass declaration of conformity	EN 572	ASTM C 1036
Data sheets	EN 410 EN 673	NFRC

Heat strengthened glass declaration of conformity	EN 1863	ASTM C 1048
Tempered glass declaration of conformity	EN 12150	ASTM C 1048
Tempered + HST glass declaration of conformity	EN 14179	---
Curved tempered glass declaration of conformity	ISO 11485	ASTM C1464
Laminated glass declaration of conformity	EN 14449	ASTM C 1172
Laminated curved glass declaration of conformity	ISO 11485	ASTM C1464
Pendulum safety classification declaration of conformity	EN 12600	ANSI Z97.1
Manual attack declaration of conformity	EN 356	ANSI Z97.1
Coated glass declaration of conformity	EN 1096	ASTM C 1376
HST furnace calibration certification	EN 14179	---
HST treated glass list with diagrams	---	---
Special certifications	CEKAL, BSI, Pass Vec	IGCC / SGCC
Acoustic performances declaration of conformity	EN ISO 717	---
Insulated glass declaration of conformity	EN 1279	ASTM E 2188 ASTM E 2190
Certification test for laminated safety glass	EN 12543	ANSI Z.97 SGCC
Thermal stress analysis	---	---
Structural sealing calculation and approvals	EN 13022	ASTM C 1135
Various materials data sheets	---	---
Production reports	---	---

4. CUT-GLASS GLASS TOLERANCES

Glass unit should not be bigger than the rectangle prescribed which results from the nominal dimensions given, expressed in mm (without decimals), increased by the higher tolerance allowed, and it shouldn't be smaller than the rectangle prescribed, reduced by the lower tolerance given. Rectangle sides prescribed should

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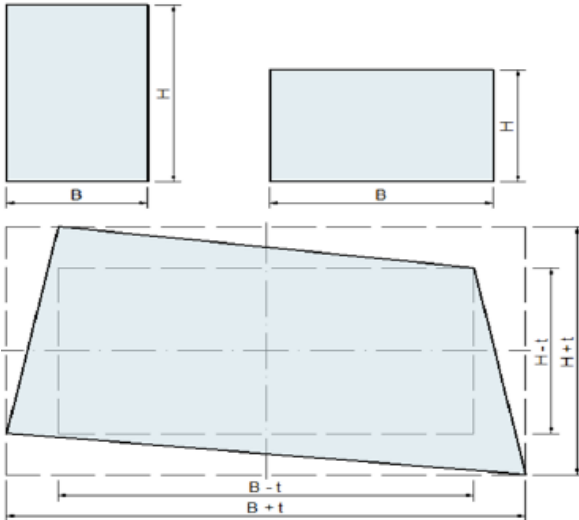
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be parallel, and they should have a common centre. Width and length limits shall be prescribed by these rectangles too.



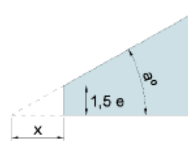
4.1. FLOAT, TEMPERED AND HEAT STRENGTHENED GLASS

Applicable dimensional tolerances during monolithic float and thermally treated glass production are shown below:

Rectangular glass units	Dimension B – H (mm)	Tolerance B – H (mm)	Diagonal tolerance (mm)
Cut glass and arrised edges	< 2000	+1 -2	≤ 2
	2000 – 4000	+1 -2	≤ 3
	4000 – 6000	+1 -3	≤ 3
Ground and polished edges	< 2000	+1 -2	≤ 2
	2000 – 4000	+1 -2	≤ 2
	4000 – 6000	+1 -3	≤ 3
	> 6000	+2 -3	≤ 2
Shaped glass units	Dimension B – H (mm)	Tolerance B – H (mm)	Diagonal tolerance (mm)
Cut glass and arrised edges	< 2000	+1 -2	N/A
	2000 – 4000	+1 -3	N/A
	4000 – 6000	+1 -3	N/A
Ground and polished edges	< 2000	+1 -2	N/A
	2000 – 4000	+1 -3	N/A
	4000 – 6000	+1 -3	N/A
	> 6000	+2 -3	N/A

4.2. CORNER CUT-OFF TOLERANCES FOR SHAPED GLASS

Glass units with small angles shall comply with the more restrictive corner cut-off tolerances shown below (“X” value or “1,5e”), in order to warrant the glass stability during the following processes.



Type	Angle (°)	X (mm)
Corner cut-off for laminated, heat strengthened and tempered glass units	≤ 12	30
	≤ 20	18
	≤ 25	12
	≤ 45	8
Corner cut-off for double and triple glass units	≤ 12	65
	12 - 20	33

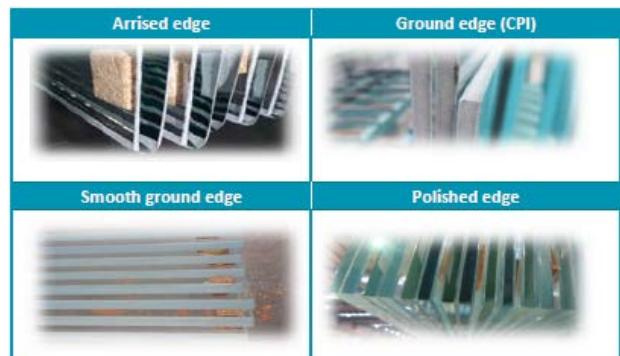
4.3. CONCLUDING OBSERVATIONS

Negative tolerances will be increased 1 mm in case of thickness equal or bigger than 12 mm in both monolithic and laminated glass panes.

Tolerance will be defined according to the longer side.

In case of decimal measurement, it will be rounded to a number without decimals, according to the international standards.

5. GLASS EDGE WORKING



5.1. EDGE IMPERFECTIONS

Imperfections cannot be dangerous in case of handling, and they cannot be bigger than:

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Edge	Acronym	Acceptable imperfections
Cut and arised edge	- AA	Shell or chips on glass surface
		Total amount of 50 mm ² per each edge. Maximum of 15 mm ² per each shell/chip. Max depth: 1/4 of glass thickness.
Ground edge	CPI	Shell or chips on glass and edges surface
		Total amount of 50 mm ² per each pane. Maximum of 10 mm ² per each shell/chip. Max depth: 1/4 of glass thickness.
Smooth ground edge / Polished edge	CPB CPM	Shell or chips on glass and edges surface
		They cannot be visible from 1meter distance The marks of grounding wheels cannot be noticeable with fingernail.

5.2 EDGE WORKING IN LAMINATED GLASS

See item 8.2 ("Laminated glass – Type of edge worked").

5.3 CONCLUDING OBSERVATIONS

The possibility of producing mitre joints has to be defined with OTIIMA | MUCH MORE THAN A WINDOW's Technical Department and/or Production.

In case of requesting an arised edge finish, or directly obtained from the glass cut, it should be consulted with OTIIMA | MUCH MORE THAN A WINDOW's Technical Department to confirm its viability.

If needed, glass edges can be slightly repaired as long as the mechanical integrity of the unit is assured.

In relation to glass panes that are going to be part of an insulating glass unit, external shallow damage to the edge or conchoidal fractures which do not affect the glass strength and which do not project beyond the width of the edge seal are accepted, as well as internal conchoidal fractures without loose shards and which are going to be filled by the sealant.

The tolerances previously described over the edge working could be affected in case of laminated glass due to the need of removing the excess of interlayer after the lamination process, being possible to cause small chips (specially in case of structural interlayers) that do not affect the integrity of the unit.

6. MANUFACTURE TOLERANCES

All glass units with drills, cut-outs and countersunk shall comply with the limitations and tolerances contained in EN 12150 Standard.

6.1 DRILLING DIAMETER TOLERANCE

Drill diameter \varnothing should not be less than glass nominal thickness (e). The admissible drill nominal diameter will be the sum of nominal diameter and tolerance ± 1 mm.

Nominal diameter (mm)	Tolerance \varnothing (mm)
$\varnothing \geq e$	± 1

6.2 LIMITATIONS AND TOLERANCES FOR DRILL HOLES, CUT-OUTS AND COUNTERSUNK

Acceptable limitation and tolerance	Detail
The client's design has to take into account that the distance "a" from the edge of a hole to the glass edge should be not less than "2e" (two times the glass thickness)	
The client's design has to take into account that the distance "b" between the edges of two holes should not less than "2e" (two times the glass thickness).	
The client's design has to take into account that the distance "s" of the edge of a hole to the corner of the glass should be not less than 6e (six times the glass thickness).	
Displacement between aligned holes on the same pane ± 2 mm.	
Positioning tolerance of holes in relation to the reference glass edge ± 2 mm.	
Displacement between aligned holes on the different panes which form a laminated glass ± 2 mm.	

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6.3 CONCLUDING OBSERVATIONS

In case of decimal measurement, it will be rounded to a number without decimals, according to the international standards.

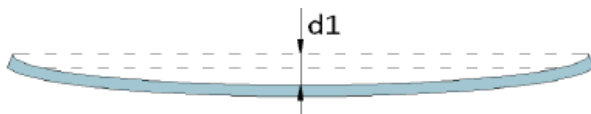
If more information is required, please contact with OTIIMA | MUCH MORE THAN A WINDOW Technical Department.

7. THERMALLY TREATED GLASS

Because of the nature of the thermal treatment (tempered or heat strengthened), it is impossible to obtain a final product with the same flatness than a float glass. The magnitude of the deformations will be determined by many factors, as the type of treatment, glass thickness, dimension, the use of coat, and so on.

Different types of deformation, and their maximum acceptable tolerances, are shown below.

7.1 OVERALL BOW / MAXIMUM BOW



Glass thickness (mm)	Acceptability	Ratio W/L *
Thickness 4 - 6 mm	2 mm/m	Max. 1/10
Thicknesses 8 - 19 mm	1,5 mm/m	Max. 1/10

* Square shapes could increase the overall bow tolerance

7.2 ROLLER WAVE



Glass thickness (mm)	Average value *	Maximum value
Thickness 4 - 6 mm	0,12 mm	0,15 mm
Thickness 8 - 10 mm	0,10 mm	0,12 mm
Thickness 12 - 19 mm	0,08 mm	0,12 mm

* Average value over the total amount of glass produced per project

7.3 EDGE LIFT



Glass thickness (mm)	Average value *	Maximum value
All thicknesses	0,20 mm	0,25 mm

* Average value over the total amount of glass produced per project

7.4 SURFACE COMPRESSION

Thermal treatment	Surface compression *
Heat Strengthened glass	24 - 52 MPa
Tempered glass	> 69 MPa

* Surface compression/breakage pattern could be affected by the application of digital or ceramic frit

7.5 ANISOTROPY

Anisotropy will be considered as an own effect of the thermally treated glass, never as a defect. Its dark appearance can be noticed, with more or less intensity, depending on the vision angle and lighting conditions, being more noticeable in the case of viewing the glass units through polarized lenses.

The distribution and pattern of the anisotropy use to be homogeneous over the entire surface of the glass, with the exception of the edge areas (especially the corners) and the surface next to any manufactured work, as the drills.

7.6 WHITE HAZE

In case of white haze presence, its significance will be evaluated according to the inspection method shown in section 13 of this handbook.

7.7 HEAT SOAK TEST

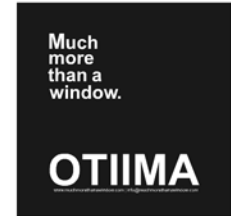
The Heat Soak Test process allows to reduce the risk of spontaneous breakage due to nickel sulphide inclusions in tempered glass, but it does not completely eliminate this risk, as indicated in EN 14179. It must be taken into account that the ratio of breakages is indicative and it could vary depending on several factors.

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However, if requested by the client, the HST process carries the following risks:

- Possible increase in the deformation values of the glass, in comparison with those defined in items 8.1, 8.2 and 8.3.
- Greater visibility of the anisotropy.

7.8 CONCLUDING OBSERVATIONS

In case a particular roller wave direction could be required, it must be specified by the client and agreed before the beginning of the production, in order to maintain the criteria during the production of the whole project, as long as the dimension of the glass units allow it.

Roller wave will be measured in the central area of the glass, excluding a perimeter area of 150 mm.

All measurements will be carried out according to the general indications of EN 1863, EN 12150, EN 14179.

For dimension > 6.000 mm, the previous tolerances must be agreed with the Technical Department of OTIIMA | MUCH MORE THAN A WINDOW.

Tolerances previously described are referred to glass panes with high-width ratio up to 1/10. In case of higher ratios, the tolerances must be agreed with the Technical Department of OTIIMA | MUCH MORE THAN A WINDOW.

For thermally treated glass units with drill holes, cut-outs and/or countersunk, the tolerances mentioned in this point could be different, so they must be agreed with the Technical Department of OTIIMA | MUCH MORE THAN A WINDOW.

In case of decimal measurement, it will be rounded to a number without decimals, according to the international standards.

8. LAMINATED GLASS

Acceptable imperfections for laminated glass units shall be in accordance with the values shown in the table below. In addition, visual inspection and imperfection acceptance will be in accordance with the procedure expressed in item 12 of this manual.

8.1 ALLOWED IMPERFECTIONS

Type	Acceptable imperfections
Air bubbles	< 0,5 mm 0,5 mm ≤ Ø bubble ≤ 1,0 mm (in case there is no accumulation of bubbles, understanding by accumulation a maximum of 3 bubbles at a distance less than 180 mm)
Scratches on the interlayer	Not allowed
Cracks on the interlayer	Not allowed
Interlayer retraction	- 2 mm

The admissible visual defects will be determined in item 12 of this manual.

It has to be taken into consideration that, in the edge area (15 mm) of glass units with their edges covered with the frames, the admissible point defects can be up to 5 mm in diameter. For glass units that are installed with their edges exposed, the acceptability conditions of the defects on the edge area will be the same as in section 12.

8.2 TYPES OF EDGE WORKED

The possibility of running the edge work after it has been laminated will be conditioned by different reasons, being necessary for the client to transmit to the Technical Department the requirements regarding the corresponding edge work, in order to be able to carry out a preliminary study of the possibilities before the production starts.

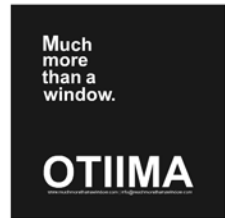
Type of edge worked	Detail
Edge worked before the lamination process The displacement tolerances between both glass units are described in section 9.3.	
Edge worked after the lamination process Both glass units will be aligned, no tolerance of displacement between them will exist.	

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The values of the respective levels will be the same as those established in section 5.3 of this manual.

8.3 EDGE DISPLACEMENT

It is essential that a reference edge exists, also called "control edge", for all laminated glass, especially when the edges are exposed, or when the glass units have an aesthetic purpose.

Edge aligned in rectangular laminated glass	Dimension B – H (mm)	Reference angle (mm)	Rest of edges (mm)
Cut glass and arrised edges	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 3,5
	4000 – 6000	≤ 0,5	≤ 4,5
Ground and polished edges glass	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 3,5
	4000 – 6000	≤ 0,5	≤ 4,5
	> 6000	≤ 0,5	≤ 5,5

Edge aligned in shaped laminated glass	Dimension B – H (mm)	Reference angle (mm)	Rest of edges (mm)
Cut glass and arrised edges	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 4,5
	4000 – 6000	≤ 0,5	≤ 4,5
Ground and polished edges glass	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 4,5
	4000 – 6000	≤ 0,5	≤ 4,5
	> 6000	≤ 0,5	≤ 5,5

8.4 CONCLUDING OBSERVATIONS

Tolerance will be defined according to the longer side.

For glass with drills, the tolerances of misalignment between glass units will not be taken into account, giving priority to the correct alignment between drills.

In case of laminated glass units which combine drill holes, cut-outs and/or countersunk as well as heat treatment, the Technical Department of OTIIMA | MUCH MORE THAN A WINDOW must be informed for its analysis and expert advice.

An excess of plastic interlayer outside the laminated glass will not be considered as a defect in any case.

In case of decimal measurement, it will be rounded to a number without decimals, according to the international standards.

9. INSULATING GLASS UNIT

Glass unit which consists of at least two glass panes, separated by one or more spacer, hermetically sealed along the entire perimeter and mechanically stable.

9.1 OVERALL THICKNESS OF THE GLASS UNIT

The overall admissible thickness of the insulating glass unit will be the sum of the theoretical thickness plus its tolerance, which will be according to the glass typology. In case of triple glazing, the tolerances indicated below will be increased by 50%.

Glass type	Tolerance (mm)
With annealed panes	±1
With 1 or more heat treated panes	±1,5

9.2 EDGE DISPLACEMENT

The glass units which conform the insulating glass unit could show a maximum displacement according to the tolerances shown in the table below. For each laminated glass that the unit contains, these values will be increased by 0.5 mm.

In case of triple glazing, another 0.5 mm will be added.

Edge aligned in rectangular glass	Dimension B – H (mm)	Reference angle (mm)	Rest of edges (mm)
Cut glass and arrised edges	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 3,5
	4000 – 6000	≤ 0,5	≤ 4,5
Ground and polished edges glass	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 3,5
	4000 – 6000	≤ 0,5	≤ 4,5
	> 6000	≤ 0,5	≤ 5,5

Edge aligned in shaped glass	Dimension B – H (mm)	Reference angle (mm)	Rest of edges (mm)
Cut glass and arrised edges	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 4,5
	4000 – 6000	≤ 0,5	≤ 4,5
Ground and polished edges glass	< 2000	≤ 0,5	≤ 3,5
	2000 – 4000	≤ 0,5	≤ 4,5
	4000 – 6000	≤ 0,5	≤ 4,5
	> 6000	≤ 0,5	≤ 5,5

9.3 PIB APPLICATION (First insulating barrier)

The application of the butyl should be regular and continuous along the perimeter of the spacer bar.

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The expansion of the butyl after the unit has been pressed could slightly stand out towards the vision area.

9.4 SPACER BAR

The position of spacer bar must be the nominal one +2 / -0mm (see drawing attached below), without noticeable waves localized. In triple glazing, tolerance will be increased to +3 / -0mm.



9.5 SEALANT (Second insulating barrier)

The sealant bite will have a maximum tolerance of +2/-0mm (+3mm for triple glazing) with respect to the value obtained from the calculation according to the corresponding standard, and measured from the most unfavourable pane of the glass. The sealant must not have bubbles, and it must be well adhered to the glass. Its homogeneity will be given according to the manufacturer's specifications.

9.6 COATING DELETION

The coatings usually require to be fully removed from the edge zone (standard coating deletion: 10mm). The visual appearance type must be chosen before the production starts.

Type	Acceptable tolerance	Detail
Standard Colour line	Also known as red line. The coating is deleted in such way that it falls within the PiB. In turn, it's assumed that the unit could show around 1 mm of white line.	
Alternative White line	Also known as transparent line. The tolerance for the standard over stripping is -1 / +4 mm. Occasionally, a maximum white line of 5 mm could be reached, especially in shaped glass units or in the corners, as well as it's assumed that the unit could show around 1 mm of red line.	

The dimensional values previously mentioned have the goal of defining a reference tolerance for the production of insulating glass units. However, the acceptability criterion in relation to the presence of higher dimensional tolerances will be subjected to its visibility once the unit will be installed on the building.

The coating edge deletion is carried out by the use of abrasive discs, which can leave more or less visible marks on the surface of the glass depending on the coating type and the silicone to be used, being more visible in case of using grey silicones and/or large coating deletions.

However, it must be considered only as an aesthetic effect.

9.7 SPECIAL SEALANT SYSTEMS

There are different special sealant systems, among which the following stand out:

Type	Acceptable tolerance (*)	Detail
All-glass Emptying	The silicone is removed in such way that a channel is left along the edge of the cavity of the unit. As a general rule, this channel will have U shape, unless a different solution is required by the client. In that case, the Technical Department of TVITEC must be informed for its analysis and expert advice.	
Punctual insertions Toggles and U-profiles	Punctual insertions are introduced in the silicone of the unit according to the drawings forwarded by the client. The positional tolerance along the unit would be ± 10 mm, while its transversal positioning would be according to the attached drawing.	
Continuous insertions U-profiles	Continuous insertions are introduced in the silicone of the unit according to the drawings forwarded by the client. The transversal positioning would have a tolerance according to the attached drawing.	

* Silicone depth under the special sealant system could vary depending on each situation, according to silicone depth calculations.

The client must advise the Technical Department of the presence of a special sealant system for its analysis and expert advice before the beginning of the production.

9.8 APPLICATION OF SILICONE TO STEPPED EDGES

The stepped edge of the insulating glass units can be opacified by applying silicone. It must be taken into account that this process is carried out manually by applying a material which purpose differs from this one, so it cannot be considered as an alternative to the use of digital or ceramic frit.

The applied silicone thickness is not regular and it could vary significantly within the same unit.

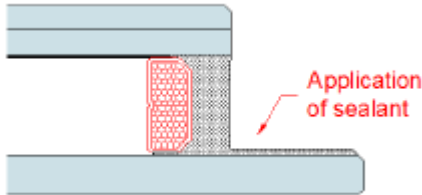
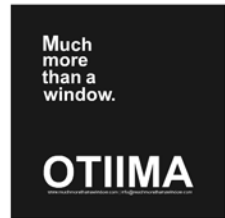
For those reasons, OTIIMA | MUCH MORE THAN A WINDOW recommends for this kind of applications the use of digital or ceramic frit in order to achieve a uniform and aesthetically correct aspect.

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9.9 CONCLUDING OBSERVATIONS

In case of decimal measurement, it will be rounded to a number without decimals, according to the international standards.

The coating deletion tolerances will be confirmed after the first production, and may be modified as a result of production limitations.

In case of shaped glass, the current tolerances may be varied.

For glass installed with its edges covered, a standard coating deletion will be applied.

The client must define a reference angle.

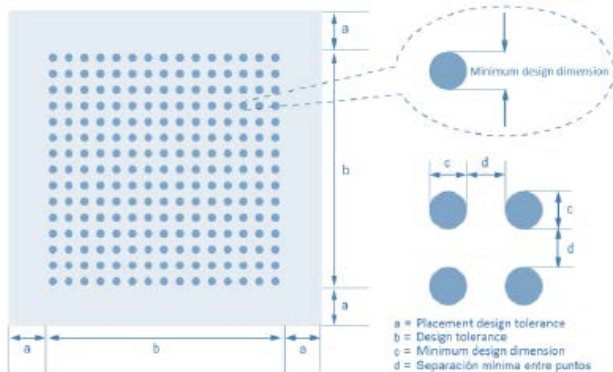
A slightly gap between the PIB and the secondary seal could become visible, especially in the corners, but it doesn't affect the tightness of the unit.

10. PRINTED AND ENAMELED GLASS

All printed, enamelled or acid treated glass will comply with the following points.

10.1 SILKSCREENED GLASS

The following indications shall be taken into consideration when the pattern is designed.



Design indications	Tolerance	
Minimum standard design dimension (points / lines)	1,7 mm	
Minimum distance (points / lines)	0,8 mm	
Set up	Design = 1,2 mm	Each 2 uds.
	Design 1,2 - 1,7 mm	Each 5 uds.
	Design 1,7 - 2,0 mm	Each 10 uds.
	Design > 2 mm	Variable
Placement with respect to the reference point	≤ 1.000 mm	± 2,0 mm
	≤ 3.000 mm	± 3,0 mm
	> 3.000 mm	± 4,0 mm

If the application of different colours on the same glass surface is required, it should be consulted with OTIIMA | MUCH MORE THAN A WINDOW's Technical Department, in order to know its viability.

10.2 DIGITALLY PRINTED GLASS

The following indications shall be taken into consideration when the pattern is designed.

Design indications	Tolerance	
Minimum design dimension (points / lines)	0,9 mm	
Minimum negative design dimension (points / lines)	1,7 mm	
Minimum distance (points / lines)	0,4 mm	
Placement with respect to reference point	≤ 1.000 mm	± 1,0 mm
	≤ 3.000 mm	± 1,5 mm
	> 3.000 mm	± 2,0 mm

10.3 ALLOWED IMPERFECTIONS

The "guideline for assessing the visual quality of enamelled glass - Troisdorf 2014" will be taken as reference as a general criterion for glass inspection with the following notes and specific conditions:

Inspection conditions:

Reviewing distance: 3m.

Reviewing angle: 90° ± 30°

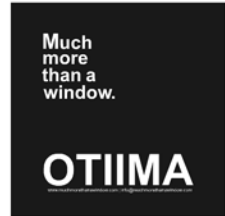
It must be reviewed under normal daylight conditions, without direct sunlight or artificial lighting, in front of an opaque background.

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Evaluation shall be done in reflection (in case of spandrel glass) and in reflection/transmission in case of vision glass. If the glass is observed in transmission, areas with different intensities could be detected.

Imperfection	Main zone	Edge zone
Permissible spot-shaped defects in the enamel	0,5 mm < \emptyset \leq 1,0 mm Max. 3 cases / m ² (separation \geq 100 mm) 1,0 mm < \emptyset \leq 2,0 mm Max. 2 cases / sheet.	0,5 mm < \emptyset \leq 1,0 mm Max. 3 cases / m ² (separation \geq 100 mm) 1,0 mm < \emptyset \leq 2,0 mm Max. 2 cases / sheet.
Hairline scratches and baked-in foreign bodies	Allowed for lengths up to 10 mm	Allowed for lengths up to 10 mm
Clouding	Not allowed	Not allowed
Water marks	Not allowed	Not allowed
Paint overhang at the edges	N/A	Not allowed for visible edges with polished edge, except in the case of roller application, where it will be allowed on the bevelled edge
Unprinted glass border	N/A	Screen printing and digital printing permissible up to 2mm.

10.4 CONCLUDING OBSERVATIONS

Non-visible defects from the inspection distance will not be considered.

Discrepancies \leq 0.5 mm are allowed without limitation.

Fritted pattern with elements having small dimensions and/or small separation could cause a cloudy effect called *Moire effect* that cannot be considered as a defect.

Digital printing can generate linear or punctual marks, more or less visible, and inherent to this technology.

The positioning tolerance will be measured from the reference point.

Repair frit defects (with the same colour) are allowed if they are not visible under the inspection conditions described.

The colour variation tolerance (ΔE) will be according to the specifications of the supplier of the paint, and must be defined in each case.

Dimensional tolerances included in this document will be maintained.

In case of decimal measurement, it will be rounded to a number without decimals, according to the international standards.

12 VISUAL ASSESSMENT

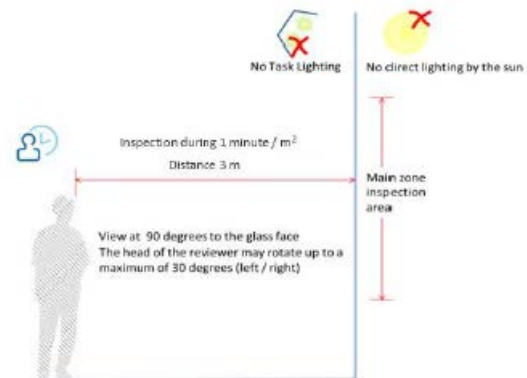
This section is based on both European Standard EN 1279-1 and *Guideline to Assess the Visual Quality of Glass in Buildings (Hadamar Guideline)*.

The imperfections and the levels of acceptability described below will be applied to each glazing unit, taking into account the features corresponding to each product.

Patterned glass, wired glass, wired patterned glass and fire-rated glass are not covered by this criterion.

12.1 INSPECTION METHOD

It will be considered the following inspection method, which will take place from inside to outside taking into account the way the glass will be installed.

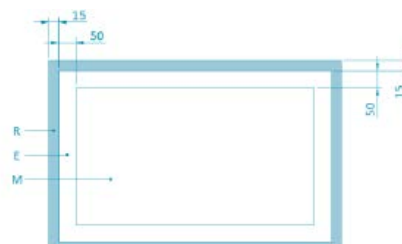


If a revision under reflection conditions is required (from outside), the glass units shall be observed in the same way they would be observed once they are installed on façade.

12.2 ACCEPTABILITY

The level of acceptability of the imperfections that are detected will depend on the nature of the imperfection, the dimension of the glass and the zone in which it is located, as well as on the quantity. The glass unit will be divided into the following areas:

- Zone R: Area of 15 mm that is usually covered by the frame or by the sealant of an edge without profile.
- Zone E: Area at the edge of the visible surface with a width of 50 mm.
- Zone M: Main zone.



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*For glass edges < 500 mm, a perimeter area of 10% will be considered as zone E.

The evaluation of the acceptability of the imperfections will be according to the following tables, depending on the zone of the pane in which they are located and always taking into account that those tolerances are applicable only in case the defects are readily apparent under the inspection conditions previously mentioned.

12.2.1 SPOTS

It can be considered as a *spot* every spherical or semi-spherical anomaly over the visual transparency when viewed through the glass. It can consist of a solid or gaseous inclusion, a lack of coating or a punctual defect of a laminated glass.

Zone	Dimension* (Ø mm)	Glass dimensions (m ²)			
		S ≤ 1	1 < S ≤ 2	2 < S ≤ 3	3 < S
R	No restrictions	No restrictions			
E	Ø ≤ 1	Max. allowance of 2 cases / Ø ≤ 20 cm			
	1 < Ø ≤ 3	4	1 / m of perimeter		
	Ø > 3	No admissibles			
M	Ø ≤ 2	2	3	5	5+2/m ² extra
	Ø > 2	Not allowed			

*The halo is excluded (maximum of Ø 3 mm), which is defined as an area with distortion that is usually located around a spot in case the defect appears on the glass pane.

12.2.2 RESIDUES

It can be considered as a *residue* the material that remains on the surface of the glass, and which usually has patch shape. It normally comes from residues of the sealant.

Zone	Dimension and type* (Ø mm)	Glass dimensions (m ²)	
		S ≤ 1	1 < S
R	No restrictions	No restrictions	
E	Spots Ø ≤ 1	Max. allowance of 3 cases / Ø ≤ 20 cm	
	Spots 1 < Ø ≤ 3	4	1 / m of perimeter
	Spots Ø > 3	Not allowed	
	Stains Ø ≤ 17	1	
	Stains Ø > 17	Not allowed	
M	Spots Ø ≤ 1	Máx. 3 / Ø ≤ 20 cm	
	Spots Ø > 1	Not allowed	
	Stains Ø ≤ 17	1	
	Stains Ø > 17	Not allowed	

*It can be considered as a residue to each defect bigger than a spot, which normally shows an irregular shape and partially mottled.

12.2.3 LINEAR DEFECTS

It can be considered as a *linear defect* those scratched that are located on the surface of the glass and which shows a patch or linear shape, occupying a large length or area. Fine scratches are allowed if they are not grouped in clusters.

Zone	Individual length (mm)	Total length (mm)
R	No restrictions	
E	≤ 30	≤ 90
M	≤ 15	≤ 45

12.3 CONCLUDING OBSERVATIONS

Tolerances shown in paragraph 13.2 will be increased by 25% per each extra glass pane.

Example: the allowable defects (shown in tables of the paragraph 13.2) of a double-glazing unit made up of two laminated glass panes (each laminated glass pane is made up of 2 panes) will be increased by 50%. This means that, in case of detecting a scratch on zone E, it could have a maximum length of 45 mm, and the total length of all the scratches detected in this area could be 135 mm.

Tolerances shown in paragraph 13.2 will be reduced by 25% in case of monolithic glass panes.

In installed condition, tolerances shown in paragraph 13.2 will be increased by 25%.

In case of double-glazing units made up of one or more heat-treated glass panes, the overall bow will not exceed 3 mm/m (additional deflections caused by the pillowing effect or by the installation system are not included in the mentioned tolerance).

The tolerance previously described could be higher in case of having square shape (or close to square shape) glass panes (ratio 1:1.5), or in case of glass thickness below 6 mm. This tolerance is independent of the one described in paragraph 8.1, as it's only referred to monolithic glass panes. It could be increased by other production or external factors.

No preview or marking of the glass is permitted.

No polarized glasses or magnifying devices are permitted.

The measurement of the defects will be carried out by using a measurement tape with an interval of 0,5 mm.

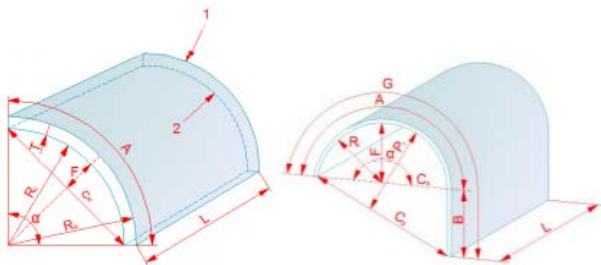
The applicable tolerances for fire-resistant glass will be according to the tolerances defined by the supplier of this type of glass.

PRODUCT TOLERANCES

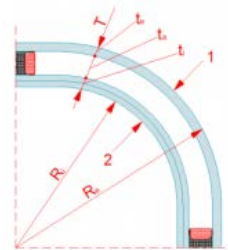
CURVED GLASS

13. CURVED GLASS TERMINOLOGY

The main concepts referred to curved glass production are defined here below:



- Arc (A): length of the curved portion.
- Flat (B): flat segments forming a part of curved glass.
- Chord of the arc (Ca): line segment that connects end points of an arc.
- Cai: inner chord of the arc.
- Cae: outer chord of the arc.
- Chord of the girth (Cg): line segment that connects end points of a girth.
- Displacement (d): misalignment at any one Edge of the constituent glass panes making up the curved laminated and/or insulating glass.
- d1: displacement of one of the edges of the glass during the manufacture of laminated curved glass
- d2: displacement of the edges of the glass during the manufacture of insulating glass.
- Rise depth (F): segment between the middle of the arc of the circle and the middle of the chord that subtends the arc.
- Girth (G): distance around the concave or convex surface measured perpendicular to the height including any flats.
- Length (L): Dimension of the straight Edge of the curved glass.
- Shape accuracy (Pc): accuracy of the contoured form including curvature, arc(s) and even flats.
- Depth (Pr): maximal distance between the upper part of the girth (G) and the corresponding chord (Cd).
- Edge straightness deviation - warp (Rb): deviation from straightness of the straight edges of the glass.
- Outer radius (Re): radius of convex face. ▪ Inner radius (Ri): radius of concave face.
- Thickness (T): nominal thickness of the final product.
- Ti: thickness of the inner glass.
- Ta: thickness of the cavity.
- Te: thickness of the outer glass.
- Twist deviation (V): one or more of the corners of the glass are not in the same plane.
- Angle (α): angular measurement of a segment of a curve in degrees.



14. MEASUREMENT METHODOLOGY

15.1 SHAPE ACCURACY, GIRTH AND LENGTH

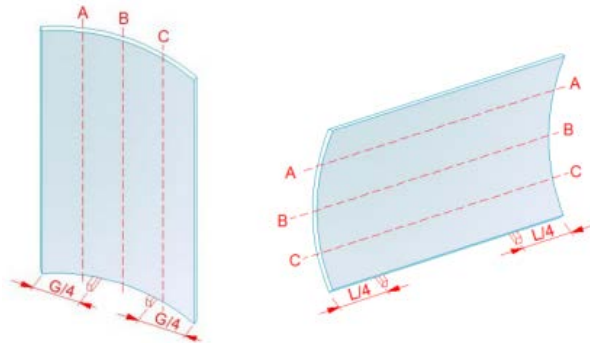
Shape accuracy is measured perpendicular to the glass using a gauge or a 1:1 scale template.

Girth dimension on the convex surface is measured using a flexible steel tape measure of 1 mm in scale interval

Length of the sides is measured using a steel tape or a straightedge of 1 mm scale interval.

14.2 EDGE STRAIGHTNESS DEVIATION

The edge straightness deviation should be measured with the glass in a vertical position as shown below:



It will be horizontally placed a straightedge ruler with 0,1 mm intervals along the length of the glass to measure the gap between the glass specimen and the ruler.

14.3 CROSS-CURVE DEVIATION

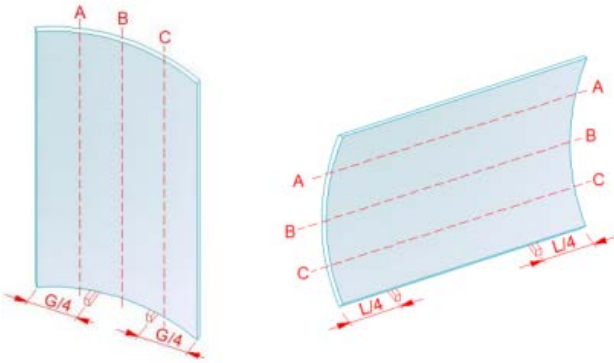
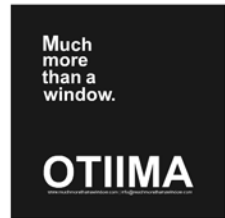
A straightedge along the vertical edge will be placed on the concave surface of glass, in order to measure the distance between the glass and the straightedge as shown below:

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14.4 TWIST DEVIATION

In order to measure the twist deviation, the specimen will be placed on vertical position supported by wooden blocks. Two strings will be placed connecting opposite corners, so they cross in the middle by the concave surface. The distance between both strings will be measured.

15. DIMENSIONAL TOLERANCES

The Current paragraph describes production tolerances for curved glass in relation to the specific curving processes.

15.1 SHAPE ACCURACY, GIRTH AND LENGTH

Shape accuracy, girth and length **tolerances** will be defined by the following table, taking into account that nominal thickness is referred to the glass thickness as well as to each component thickness.

	Tolerance	
	Thickness < 10 mm	Thickness ≥ 10 mm
ΔP_c (*)	2/3 T	1/2 T
ΔG	± 2 mm/m	± 3 mm/m
ΔL	± 2 mm/m	± 3 mm/m

* Measured perpendicular to the glass.

Measurement method of the mentioned tolerance will be according to what has been defined in paragraph 15.1.

15.2 EDGE STRAIGHTNESS DEVIATION

Edge straightness deviation tolerance will be one of the following, whichever is greater: $\Delta R_b \leq 3 \text{ mm/m}$ $\cdot 2 \text{ mm}$



Measurement method of the mentioned tolerance will be according to what has been defined in paragraph 15.2.

15.3 CROSS-CURVE DEVIATION

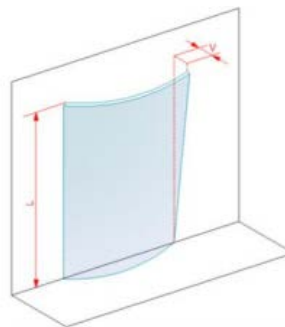
Cross-curve deviation tolerance shall not exceed 4 mm/m of the length. It's important not to confuse cross-curve deviation from Edge straightness deviation. Measurement method of the mentioned tolerance will be according to what has been defined in paragraph 15.3.

15.4 TWIST DEVIATION

Twist deviation tolerance will be determined by the following table, taking into account that these tolerances are only applicable for glass panes up to 12 mm (*):

Lenght (mm)	Tolerance (mm)
$L \leq 1200$	$V < 4$
$1200 < L \leq 1500$	$V < 5$
$1500 < L \leq 2000$	$V < 6$
$2000 < L \leq 2400$	$V < 7$
$L > 2400$	$V < 8$

*For thicker glass panes, the Technical Department of TVITEC must be informed for its analysis and expert advice.



Measurement method of the mentioned tolerance will be according to what has been defined in paragraph 15.4.

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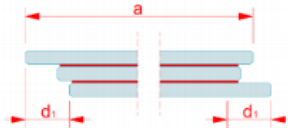


15.5 LAMINATED GLASS TOLERANCES

Total laminated glass thickness will be equivalent to the sum of nominal thickness of the different components, plus their own tolerances.

15.5.1 DISPLACEMENT

Maximum displacement (d_1) between glass panes will be determined by the following table:



L or G	Tolerance
L o G ≤ 1000 mm	$d_1 \leq 2 \text{ mm}$
L o G > 1000 mm	$d_1 \leq 2 \text{ mm / m}$

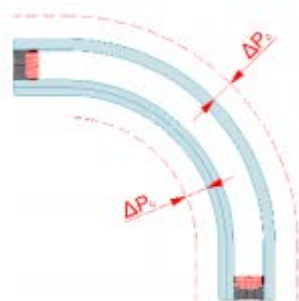
15.6 INSULATING GLASS UNIT TOLERANCES

Total thickness of an insulating glass unit will be equivalent to the sum of tolerances of the different components, plus 3 mm.

15.6.1 SHAPE ACCURACY

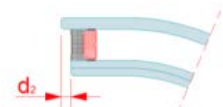
Shape accuracy will be according to the following equation, always according to the limits defined in paragraph 16.1:

$$\Delta P_c = \Delta P_{c1} + \Delta P_{c2} + 2 \text{ mm (*)}$$



*Pc1 is referred to the first component of the insulating glass unit, while Pc2 is referred to the second component.

16.6.2 DISPLACEMENT



Maximum displacement (d_2) between glass panes will be determined by the following table:

L or G	Tolerance
L o G ≤ 1000 mm	$d_2 \leq 3 \text{ mm}$
L o G > 1000 mm	$d_2 \leq 3 \text{ mm / m}$

15.7 CONCLUDING OBSERVATIONS

- Those tolerances over curved glass production which are not included in previous paragraphs will be abided by the tolerances defined for flat glass.
- Heat treatment distortion tolerances determined for flat glass (roller wave, edge dip, overall bow) are not applicable to the production of curved glass.
- It exists the possibility of having a different tonality on curved glass units than the one for flat glass units due to the different reflection over a curved surface.
- Apart from the innate optical effects of the curved glass panes, it must be taken into account that the production of this type of glass could emphasize and make more evident the typical optical effects of flat glass panes (for example: anisotropy or roller wave, on which the tolerances defined in paragraph 8.2. of this document are not applicable in case of curved glass).