

Guideline to Assess the Visual Quality of Glass in Buildings



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Introduction

Architectural glass products are produced and processed for a wide variety of applications. A distinction is generally made between single glass (a monolithic glass pane or two or more glass sheets combined by lamination) and insulating glass units as a combination of several single glass sheets with cavities in-between, which are governed by specific technical rules.

The production steps for these types of glass differ depending on the product characteristics. Each production step can influence the visual quality of the glass units. This means that, even during the production of single glass sheets, unavoidable optical effects occur which can only be reduced by visual inspection and removal of the nonconforming parts. This also applies to all the subsequent processing steps.

This Guideline aims to describe the visual qualities of glass which permit an acceptable cost-benefit ratio. It is recommended that the contracting parties always agree on the quality level of the products to be supplied (e.g. by clear instructions in a bill of quantities, the specifications). The Guideline fulfils at least the requirements of EN 1279-1:2018 Annex F and defines the standard quality level.

Requirements exceeding this standard quality must be agreed separately.

1.0 Scope

This Guideline applies to the assessment of the visual quality of glass in buildings (used in building shells and for finishing buildings/works). The assessment is based on the test principles described below using the allowable discrepancies listed in the Table in Section 3.

The subject of assessment is the clear glass surface which remains visible after installation. The Table in Section 3 can also be used to assess glass products such as coated glass, body tinted glass, laminated glass or toughened glass (toughened safety glass, heat strengthened glass).

Switchable/dimmable glass and glass with integrated moving devices must be assessed in transparent/bright condition.

This Guideline does not cover special glass such as glass products using patterned glass, wired glass, special safety glass (LSG and LG made of more than two panes), fire-rated glass and non-transparent glass products. These glass products must be assessed according to the materials used, the production processes and the information provided by the manufacturers. Devices installed in the cavity or laminate are not assessed.

This Guideline does not cover the assessment of the visual quality of the edges of glass products. Exposed glass edges are not subject to the assessment criterion for the rebate zone, but an assessment must be made of at least the edge zone or a separate agreement must be concluded. The intended use must be specified in the order.

Special conditions must be agreed for inspecting the external appearance of the glass façade.

2.0 Test and Inspection

As a rule, the vision through the glazing, i.e. the view of the background and not the incident view from the outside is what determines the assessment. The deficiencies must not be especially marked.

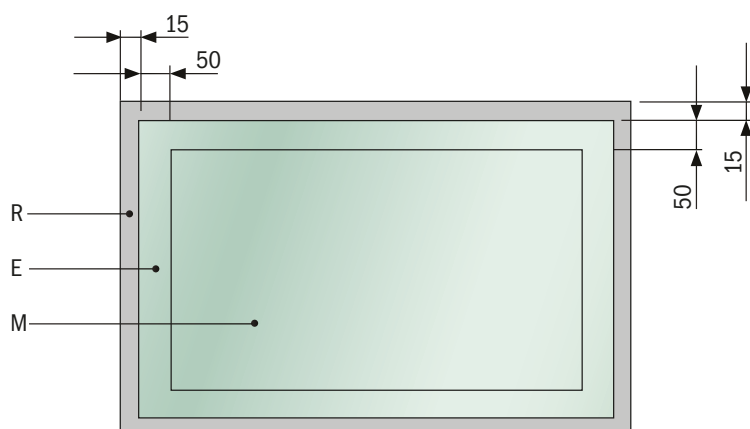
The glass must be inspected from a distance of at least 1 m from the inside to the outside for a period of up to 1 minute per 1 m² and at a viewing angle which corresponds to the normal usage of the room (in the range from vertical up to 30° to the glass surface) in accordance with the Table in Section 3. The tests should preferably be carried out in diffuse daylight (e.g. overcast sky) without direct sunlight or artificial lighting. These conditions must be simulated for carrying out the assessment in the production process.

The glass units inside rooms (internal glazing) are to be assessed at normal (diffuse) illumination provided for using the rooms and at a viewing angle preferably perpendicular to the surface. Changes to the room illumination, e.g. by installing new luminaires are likely to change the optical impression of the glass units.

For any assessment from the outside to the inside, the glass must be assessed in the installed condition at the usual viewing distances. Product standards may specify different test/inspection conditions and viewing distances for the glass products covered by this Guideline. For many projects it is not possible to comply with the test/inspection conditions set out in these product standards on site.

3.0 Allowable Discrepancies for the Visual Quality of Architectural Glass Products

3.1 Zones for Assessing the Visual Quality



R = Rebate zone

Area of 15 mm that is usually covered by the frame (no restrictions except for mechanical damage to the edge – see also Section 4.1.3)
Exposed glass edges are not subject to the “rebate” assessment criterion (see above).

E = Edge zone

Area at the edge of the visible surface, with a width of 50 mm.
For glass edges < 500 mm 1/10 of the glass edge lengths must be defined as edge zone.

M = Main zone: The remaining area

3.2 Allowable Characteristics of Double Insulating Glass: - Combination of Float Glass, TSG, HSG, either coated or uncoated

Zone	Size of defects (without fields, Ø in mm)	Pane size S (m ²)			
		S ≤ 1	1 < S ≤ 2	2 < S ≤ 3	S > 3
R	All sizes	Without restrictions			
E	Ø ≤ 1	Maximum allowance of 2 in an area of Ø ≤ 20 cm			
	1 < Ø ≤ 3	4	1 per metre of perimeter		
	Ø > 3	Not allowed			
M	Ø ≤ 2	2	3	5	5 + 2 per additional m ² over 3 m ²
		Maximum allowance of 1 in an area of Ø ≤ 50 cm			
	Ø > 2	Not allowed			

Table 1: Allowable number of spots

Zone	Size and type (Ø in mm)	Pane size S (m ²)	
		S ≤ 1	1 < S
R	All	Without restrictions	
E	Spots Ø ≤ 1	Allowance of 3 in each area of Ø ≤ 20 cm	
	Spots 1 mm < Ø ≤ 3	4	1 per metre of perimeter
	Stains Ø ≤ 17	1	
	Spots Ø > 3 and stains Ø > 17	Not allowed	
M	Spots Ø ≤ 1	Allowance of 3 in each area of Ø ≤ 20 cm	
	Spots 1 < Ø ≤ 3	Not allowed	
	Spots Ø > 3 and stains Ø > 17	Not allowed	

Table 2: Allowable number of residues (spots and stains)

Zone	Individual length (mm)	Total of individual lengths (mm)
R	Without restrictions	
E	≤ 30	≤ 90
M	≤ 15	≤ 45

Table 3: Allowable number of scratches

Hair-line scratches are not allowed in higher concentration

In installed condition, the allowable discrepancies for lengths are increased by 25 % over the above values. The result is always rounded to a full 5 mm. Any optically distorted fields they cause may not be more than 3 mm.

The following are allowable in the rebate zone R: External shallow damage to the edge or conchoidal fractures/flakes which do not affect the glass strengths and which do not project beyond the width of the edge seal, and internal conchoidal fractures/flakes without loose shards which are filled by the sealant.

3.3 Allowable Discrepancies for Triple Insulating Glass, Laminated Glass (LG) and Laminated Safety Glass (LSG)

The allowable frequency of discrepancies in zones E and M in Tables 1 to 3 is increased by 25 % over the above values per additional glass unit and laminated glass unit. The result is always rounded up.

3.4 Allowable Discrepancies for Monolithic Single Glass Panes

The allowable frequency of discrepancies in zones E and M in Tables 1 to 3 is reduced by 25 % below the above values. The result is always rounded up.

3.5 Additional Requirements for Thermally Treated Glass Units

Toughened safety glass (TSG), heat-strengthened glass (HSG) laminated glass (LG) and laminated safety glass (LSG) made of TSG and/or HSG:

- The local roller waves on the glass surface (except for TSG made of patterned glass and HSG made of patterned glass) may not exceed 0.3 mm for a measured length of 300 mm.
- The warp relative to the total glass edge length (except for TSG made of patterned glass and HSG made of patterned glass), may not exceed 3 mm per 1,000 mm of glass edge length. Greater warps may occur for square formats and approximately square formats (up to 1:1.5) and for single panes with a nominal thickness < 6 mm.

Bonded glass systems are usually subject to higher requirements to comply with the approval requirements for the structural joint geometry.

4.0 Further Visual Aspects for the Visual Assessment of Glass in Buildings

The Guideline is a benchmark for assessing the visual quality of architectural glass. When assessing an installed glass product, it is assumed that, in addition to the visual quality, the characteristics required by the glass product to fulfil its function must also be taken into account.

The characteristic values of glass products for sound insulation, thermal insulation and light transmittance, etc. specified for the relevant functions refer to the test panes in accordance with the applicable test standards. Different pane sizes and combinations/configurations as well as installation and external influences may change the specified values and visible appearance.

Due to the great variety of glass products the Tables provided in Section 3 are not always applicable. A product-specific assessment may be necessary in certain circumstances. In such cases, e.g. special glazing, the particular characteristics and requirements resulting from use and installation location must be assessed. When assessing specific properties, observe the product-specific characteristics.

4.1 Visual Properties of Glass Products

4.1.1 Intrinsic Colour

All materials used for glass products have an intrinsic colour which is determined by the raw materials and can become more obvious with increasing thickness. Coated glass is used for functional reasons. Coated glass also has an intrinsic colour. This intrinsic colour can differ for the vision through the glass and/or the incident view onto the glass. Fluctuations in the colour impression are possible due to the iron oxide content of the glass, the coating process, the coating itself, variations in the glass thickness and the unit configuration and cannot be avoided.

4.1.2 Colour Differences with Coatings

An objective assessment of the differences in colour of coatings requires the difference in colour to be measured or examined under conditions that have been previously exactly defined (glass type, colour, illuminant). This Guideline cannot cover this type of assessment. (For further information, see the information sheet "Colour consistency of transparent glass in building" (Farbgleichheit transparenter Gläser im Bauwesen) published by VFF; the Association of Window and Facade Manufacturers)

4.1.3 Assessment of the Visual Section of the Insulating Glass Edge Seal, Spacer Straightness

Features on the glass and spacer resulting from the production process are likely to occur on the visible section of the edge seal of insulating glass units, i.e. outside the clear glass surface.

These features may become visible if the edge seal of the insulating glass unit is exposed on one or more sides due to design requirements.

The permissible deviations of the spacer(s) in relation to the parallel straight glass edge or to other spacers (e.g. triple thermal-insulation glass) are given below up to an edge length of:

< 2.5 m	3 mm
2.5 m – 3.5 m	4 mm
> 3.5 m	5 mm

The deviations must not be exceeded 2 mm per 20 cm edge length.

If the edge seal of the insulating glass units is exposed due to design requirements, typical features of the edge seal may become visible which are not covered by this Guideline and must be agreed on a case-by-case basis.

Special frame designs and edge seal designs of insulating glass must be adapted to the relevant glazing system.

4.1.4 Insulating Glass Units with Internal Muntins

Muntins can occasionally cause clattering noises due to environmental influences (e.g. insulating glass effect) as well as shaking or manually activated vibrations.

Visible saw marks are caused by the production process. Large areas of detached paint are not allowed in the cut area.

Assessment of the deviations from right angles and misalignment within the glazing zones must take account of the manufacturing and installation tolerances and the overall impression.

It is principally not possible to avoid the effects of temperature-dependent changes in the length of muntins located in the cavity. The misalignment of muntins caused by production cannot be completely avoided.

4.1.5 Damage to External Surfaces

The cause of mechanical or chemical damage to external surfaces detected after glazing must be identified. These discrepancies can also be assessed according to the criteria set out in Section 3.

The following standards and guidelines also apply:

- Technical guidelines of the glazing trade
- VOB/C ATV DIN 18361 “Glazing works”
- Product standards that apply to the glass products in question.
- Leaflet on how to clean glass, issued by the Federal Association for Architectural Glazing (amongst others).
- “Richtlinie zum Umgang mit Mehrscheiben-Isolierglas” (Guideline on handling insulating glass units), issued by the Federal Association for Architectural Glazing and the relevant technical information and applicable installation instructions of the manufacturers.

4.1.6 Physical Properties

It is not possible to define assessment criteria in this Guideline for some unavoidable physical phenomena that may occur in the visible glass surface.

These include:

- Interference patterns
- Insulating glass effect
- Anisotropy
- Condensation on the external surface of the panes
- Wetting of glass surfaces

4.2 Explanation of Terms

4.2.1 Interference Patterns

Interference patterns in the form of spectral colours may occur in insulating glass units of float glass. Optical interference is due to superposition of two or more light waves at a single point.

They appear as more or less intensively coloured zones which change when pressure is applied to the glass. This physical effect is reinforced by the plane parallelism of the glass surfaces. This plane parallelism ensures an undistorted vision through the glass. Interference patterns occur at random and cannot be influenced.

4.2.2 Insulating Glass Effect

Insulating glass units are characterised by an air/gas volume enclosed by the edge seal. The state of this volume is mainly determined by the barometric air pressure, the altitude of the production facility above mean sea level (m.s.l.) and the air temperature at the time and place of production. Installing insulating glass at other altitudes, with temperature variations and fluctuations in the barometric air pressure (high or low pressure), inevitably induces concave or convex bulging of the individual panes and therefore optical distortions.

Multiple reflections of varying intensity can also occur on glass surfaces.

These reflections can appear more pronounced if, for example, the background to the glazing is dark.

This phenomenon is a law of physics.

4.2.3 Anisotropy

Anisotropy is a physical property of heat-treated glass caused by internal stress distribution. Dark rings or stripes can become visible in polarised light or when viewed with polarising glasses, depending on the viewing angle.

Polarised light is present in normal daylight. The extent of polarisation is dependent on the weather and the solar altitude. Birefringence is more evident at an acute angle or for glass panes mounted at right angles to each other.

4.2.4 Condensation on the External Surfaces of Panes

Condensation can form on the external glass surfaces when the glass surface is colder than the adjacent air (e.g. misted car windows).

The extent of condensation on the external surfaces of a glass pane is determined by the U_g -value, the air humidity, air movement and the indoor and outdoor temperatures.

Condensation on the internal surface of a glass unit is promoted by insufficient air circulation, e.g. due to deep window reveals, curtains, flower pots, window boxes, blinds, unfavourably placed radiators, insufficient ventilation, etc.

Condensation can form temporarily on the external surfaces of highly thermally insulating glass units exposed to weather when the external relative humidity is high and the air temperature is higher than the surface temperature of the pane.

4.2.5 Wetting of Glass Surfaces

The wetting of glass surfaces can differ due to the effect of rollers, fingers, labels, paper grain, vacuum suction cups, sealant residues, silicone compounds, smoothing agents, lubricants and environmental effects. This can become visible when the glass surfaces are wet from condensation, rain or cleaning water.

This Guideline was prepared by: Bundesinnungsverband des Glaserhandwerks, Hadamar (Federal Glazing Trade Association) · VFF Verband Fenster + Fassade (National Association of Window and Facade Manufacturers), Frankfurt/Main · Bundesverband Flachglas e. V. (Federal Association for Architectural Glazing), Troisdorf.

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