Guideline to Assess the Visible Quality of Glass in Buildings

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1. Scope

This guideline applies to assessment of the visible quality of architectural glass units (used in building shells and in finishing of buildings/structures).The assessment is made according to the following testing principles with the help of the allowable discrepancies specified in the table in section 3.

The glass surfaces which remain visible after installation are the subject of assessment. Glass products constructed of coated glass, tinted glass, laminated sheet or tempered glass (toughened safety glass, heat-strengthened glass) can also be assessed with the help of the table in section 3.

The guideline does not apply to specially constructed glass units, such as glass units with elements installed in the gas-filled cavity or in the laminate, glass products using ornamental glass, wired glass, special security glazings, fire-resistant glazings and non-transparent glazings. These glass products are to be assessed with reference to the materials used, to the production procedures and to the relevant information from the manufacturer.

The assessment of the visible quality of the edges of glass products is not the subject of this guideline. The rebate zone does not apply as an assessment criterion to edges without frames in constructions that are not framed on all sides. The intended use must be indicated in the order.

Special conditions should be agreed upon for inspecting the outward appearance of glass in façades.

2. Testing

In testing, the visibility through the pane, i.e. the view of the background, is the generally applicable criterion, not the appearance in reflection. The discrepancies may not be specially marked.

The glazing units are to be tested according to the table in section 3 from a distance of about 1 metre from the inside to the outside and at a viewing angle which corresponds to the normal usage of the room. The test is carried out under diffuse daylight conditions (e.g. overcast sky), without direct sunlight or artificial lighting.

The glazing units in rooms (indoor glazing) are to be inspected with normal (diffuse) illumination intended for the use of the rooms and at a viewing angle that is preferably vertical to the surface.

If glazings are assessed from the outside, they must be examined in installed condition, taking into consideration the usual viewing distance. Inspection conditions and viewing distances arising from requirements in product standards for the viewed glazings may differ from this and are not taken into consideration by this guideline. The inspection conditions described in these product standards often cannot be adhered to at the building.

3. Allowable Discrepancies for the Visible Quality of Architectural Glass Products

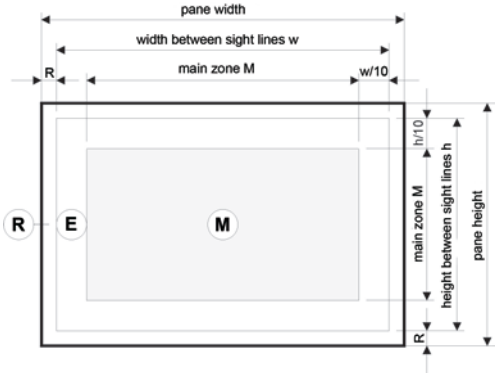
Table prepared for coated or uncoated float glass, toughened safety glass, heat-strengthened glass, laminated sheet and laminated safety glass, plus their combinations as two-layer insulating glass	
Zone	**The following are allowable per unit:**
R	External shallow damage to the edge or conchoidal fractures which do not affect the glass strength and which do not project beyond the width of the edge seal.
	Internal conchoidal fractures without loose shards, which are filled by the sealant.
	Unlimited spots or patches of residue or scratches.
E	**Inclusions, bubbles, spots, stains, etc.:** Pane area ≤ 1 m^2 : max. 4 cases, each < 3 mm Ø; Pane area > 1 m^2 : max. 1 case, each < 3 mm Ø, per meter of perimeter
	Residues (spots) in the gas-filled cavity: Pane area ≤ 1 m^2 : max. 4 cases, each < 3 mm Ø; Pane area > 1 m^2 : max. 1 case, each < 3 mm Ø, per meter of perimeter
	Residues (patches) in the gas-filled cavity: max. 1 case ≤ 3 cm^2,
	Scratches: total of individual lengths: max. 90 mm – Individual length: max. 30 mm
	Hair-line scratches: not allowed in higher concentration
M	**Inclusions, bubbles, spots, stains, etc.:** Pane area ≤ 1 m^2: max. 2 cases, each < 2 mm Ø; 1m^2 < pane area ≤ 2 m^2: max. 3 cases, each < 2 mm Ø; pane area > 2 m^2: max. 5 cases, each < 2 mm Ø
	Scratches: Total of individual lengths: max. 45 mm – Individual length: max. 15 mm
	Hair-line scratches: not allowed in higher concentration
E+M	Maximum number of allowable discrepancies as in zone E. Inclusions, bubbles, spots, stains etc. of dimensions 0.5 – 1.0 mm are allowable without any area-related limitation, except when they appear in higher concentration. “Higher concentration” means that at least 4 inclusions, bubbles, spots, stains etc. are located within a circle with a diameter of ≤ 20 cm.

Comments:
Discrepancies of dimensions ≤ 0.5 mm will not be taken into account. The optically distorted fields they cause may not be more than 3 mm in diameter.

Allowable discrepancies for three-layer thermal insulating glass, laminated sheet and laminated safety glass:
The allowable frequency of discrepancies in the zones E and M is increased by 25% per additional glass unit and per laminated glass pane over the above values. The result is always rounded up.

Toughened safety glass, heat-strengthened glass, laminated sheet and laminated safety glass of toughened safety glass and/or heat-strengthened glass:

1. The local roller waves on the glass surface (except for toughened safety glass and heat-strengthened glass of ornamental glass) may not exceed 0.3 mm relative to a length of 300 mm.
2. The warp relative to the total glass edge length (except for toughened safety glass and heat-strengthened glass of ornamental glass) may not be greater than 3 mm per 1000 mm glass edge length. Greater warps may occur for square or near square formats (up to 1 : 1.5) and for single panes with a nominal thickness < 6 mm.



R = rebate zone
the visually concealed area in the installed state (no limits on discrepancies, with the exception of mechanical damage to the edges)

E = edge zone
Area around edge with width w/10 or h/10 respectively – see diagram (less stringent assessment)

M = main zone
(most stringent assessment)

4. General Comments

The guideline provides a measure for assessing the visible quality of architectural glass units. In assessing an installed glazing product, it is assumed that in addition to the visible quality, the characteristics required for the glazing product to fulfil its function will also be taken into account.

Characteristic values for glazing products, such as sound insulation ratings, thermal conductance and visible transmittance, which are documented for the corresponding function, refer to test panes as specified by the applicable testing standard. Other pane dimensions and combinations, installation types and external influences can result in differences to the specified values and optical impressions.

The multitude of diverse glazing products means that the table in section 3 cannot be applied without restrictions. In some circumstances, an assessment referring to the specific product is necessary. In such cases, e.g. for security glazing, the particular specifications are to be assessed relative to the function and to the installation situation. In assessing certain properties, the product specific characteristics are to be observed.

4.1 Visual Properties of Glazing Products

4.1.1 Intrinsic Colour

All materials used in glazing products have an intrinsic colour, which is determined by the raw materials and becomes increasingly evident with increasing thickness. Coated glass is used for functional reasons. Coated glass also has its intrinsic colour. This intrinsic colour can differ for transmittance and/or reflectance. Fluctuations in the colour impression are possible due to the iron oxide content of the glass, the coating process, the coating itself, variation in the glass thickness and the unit construction and cannot be avoided.

4.1.2 Differences in Colour for Coatings

An objective assessment of the differences in colour with coatings requires the difference in colour to be measured or examined under conditions that have been previously exactly defined (glass type, colour, illuminant). Such an assessment cannot be the subject of this guideline. (For further information see the information sheet “Farbgleichheit transparenter Gläser im Bauwesen”, published by the Association of Window and Façade Manufacturers, VFF.)

4.1.3 Assessment of the Visible Section of the Edge Seal of the Insulating Glass Unit

Features on the glass and spacer resulting from production processes can be recognisable in insulating glass units in the visible section of the edge seal. By definition, this section is not included in the area between the sight lines that is subject to assessment. If the edge seal of the insulating glass unit is exposed on one or more sides due to design requirements, features resulting from production processes may be visible in the area of the edge seal.

The permissible deviation of the spacer(s) in relation to the parallel straight glass edge or to other spacers (e.g. in three-layer insulating glass) is 4 mm up to an edge length of 2.5 m. For longer edge lengths the permissible deviation is 6 mm. For two-layer insulating glass the tolerance of the spacer is 4 mm up to an edge length of 3.5 m and 6 mm for longer edge lengths. If the edge seal of the insulating glass unit is exposed due to design requirements, typical features of the edge seal may become visible that are not covered by this guideline. In such cases individual arrangements must be agreed on.

Special frame designs and edge seal designs for insulating glass must be coordinated with the respective glazing system.

4.1.4 Insulating Glass Units with Internal Muntins

Muntins can occasionally cause clattering noises due to environmental influences (e.g. effects specific to multiple glazing), shaking or manually excited vibrations.

Visible sawcuts and slight removal of paint near the sawcuts are caused by the production process.

In assessing deviations from right angles and misalignment within the glazing zones, the manufacturing and installation tolerances and the overall impression are to be taken into account.

Effects of temperature-dependent changes in the length of muntins in the gas-filled cavity are fundamentally unavoidable. Misalignment of muntins caused by production cannot be ruled out.

4.1.5 Damage to External Surfaces

The cause of mechanical or chemical damage to the external surfaces recognised after installation should be determined. These discrepancies can be assessed according to the criteria of section 3.

In addition, the following standards and guidelines also apply:

- Technical guidelines of the glazing trade
- VOB/C ATV DIN 18 361 “Glazing works”
- Product standards that apply to the viewed glazing products
- Leaflet on how to clean glass, issued by the Federal Association for Architectural Glazing (amongst others)
- “Richtlinie zum Umgang mit Mehrscheiben-Isolierglas” (Guidelines on handling multilayer insulating glass), issued by the Federal Association for Architectural Glazing

and the relevant technical information and installation instructions of the manufacturers.

4.1.6 Physical Properties

Some inevitable physical phenomena that occur in the visible glass surface may not be taken into account when assessing the visual quality. These phenomena are:

- interference effects
- effects specific to multiple glazing
- anisotropy
- condensation on the external surfaces of the panes
- wetting of glass surfaces

4.2 Explanation of Terms

4.2.1 Interference Effects

In insulating glass units of float glass, interference effects may cause spectral colours to appear. Optical interference is due to superposition of two or more light waves at a single point.

The effects are evident as more or less intensively coloured zones, which change when pressure is applied to the glass. This physical effect is reinforced by the plane-parallel surfaces of the glass. The parallel surfaces ensure an undistorted view through the glass. Interference effects occur at random and cannot be influenced.

4.2.2 Effects Specific to Multiple Glazing

An insulating glass unit includes a volume of air or other gas, hermetically sealed by the edge seal. The state of the gas is essentially determined by the altitude of the manufacturing site, and the barometric pressure and 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 (high or low pressure conditions), the panes are forced to deflect inwards or outwards, resulting in optical distortion.

Multiple reflections can also occur in varying intensity at the surfaces of glass units.

These reflections can be seen particularly well if the background viewed through the glazing is dark.

This effect is a physical property of all insulating glass units.

4.2.3 Anisotropy

Anisotropy is a physical property of heat-treated glass resulting from the internal distribution of stresses. It is possible that dark rings or stripes can be perceived, which vary with the viewing angle, if the glass is viewed in polarised light and/or through polarising glasses.

Polarised light is present in normal daylight. The extent of polarisation depends on the weather conditions and the position of the sun. The effect of birefringence is more evident at an oblique viewing angle or for glass panes mounted at right angles to each other across a façade corner.

4.2.4 Condensation on the External Surfaces of the Panes

Condensation can occur on the external glass surfaces when the glass surface is colder than the adjacent air

(cf. condensation on car windows).

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

Condensation on the indoor surface of a glass unit is promoted by insufficient air circulation, e.g. due to deep window recesses, curtains, flowerpots, window-boxes, blinds, unfavourably positioned heating radiators and lack of ventilation.

Condensation can form at times on the outdoor surface of insulating glass units with high thermal insulation, when the ambient relative humidity is high and the ambient 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 holders, sealant residues, silicone compounds, smoothing agents, lubricants or environmental influences. This can become evident when the glass surfaces are wet by condensation, rain or cleaning water.

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