Material compatibility around insulating glass
Insulating glass sealant, Glazing sealant, Blocks

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1. Introduction

Insulating glass is being used increasingly these days in more and more complex applications. Due by this factor, the edge sealing materials come in contact with numerous other materials, so that under certain circumstances, harmful interactions cannot be ruled out. These harmful interactions affect the function of the total system consisting of insulating glass and construction. The following technical information explains the basics, causes, remedies and testing possibilities of such incompatibilities.

It also explains the responsibilities for the designs / constructions as well as the obligation of providing information, and the legal and technical consequences arising there from.

2. Basics

The compatibility of materials is defined in the German Standard DIN 52 480 “Joint and Glass Sealings – Concepts”

“Materials are compatible with each other if no harmful interactions occur between them”

This definition does not basically exclude interactions, as long as they are not harmful. Thus, the definition of “compatibility” contains a requirement according to which “harmful interactions” must be excluded.

2.1 What are interactions?

Interactions are all physical, physical-chemical or chemical processes that, for example, can occur when two different materials or material quantities are in physical contact. The interactions may cause changes in structure, colour, consistency etc.. In the context of our topic, the most important interactions are the physical-chemical ones, e.g., change of components, also referred to as migration.

2.2 What are harmful interactions?

In this context, harmful interactions are all interactions between materials or material quantities that affect the functions or lifetime of the concerned system negatively, e.g., of the insulating glass installed in a frame.

2.3 Basics of migration

To trigger the migration processes, at least two different materials are required, e.g., material A and material B. At least one of these two materials should consist of several components, e.g., material A. In material A, at least one of the components must be capable of migration. This component must be moveable in the texture or / mixture because of its molecular structure. Thus, it fulfils a necessary pre-condition for the
occurrence of a migration process. Finally, material B must fulfill the structural pre-conditions of migration processes, i.e., it must be able to accept the migrating component and / or transport it further. The typical and most important case of this physical-chemical interaction is the so called “plasticizer migration”. The material A contains a plasticizer (see 2.4), which moves from A to B after coming in contact with material B.

The driving force of this physical-chemical process is a difference in the content of the plasticizer in material A and material B. Thus there is a concentration slope, also called concentration gradient, between the two materials or, according to specialized terminology, the two phases. Without any concentration gradient, no migration will take place.

The gradient is one of the essential factors to determine the speed of the actual migration process. If the gradient is large, the process runs fast. If the gradient is small, it runs correspondingly slow.

Another item that influences migration speed is the temperature. High temperature accelerates the process while a low temperature decelerates it.

2.4 Plasticizer and plasticizer migration

A short explanation of the “plasticizer” denotation should be given for the sake of comprehensiveness. Substances, added to plastics to shape their mechanical properties, are denoted as “plasticizer”. As the name suggests, a plasticizer can work as a real solvent which converts plastics into a gel type substance.

Plasticizer migration represents a harmful interaction, if essential properties are changed to such an extent that the function of the system is affected negatively.

- The material loosing the plasticizer becomes harder, brittle and it shrinks in size.
- The material accepting the plasticizer becomes softer, more elastic and swells up.

Such interactions are dramatic in their effects, e.g., if the plasticizer accepting material looses its structure fully and dissolves completely.
3. Harmful interactions in practice

Some harmful interactions to be observed increasingly these days, when glazing insulating glasses, are discussed in the following pages:

3.1 Butt joint seal or block fixing

In case of damage, the typical harmful plasticizer migration can be observed here.

Plasticizer migration, leading to a total dissolution of one of the affected components, takes place during direct contact of the insulating glass edge seal with another unsuitable sealing material, for instance, when a weather sealing in an butt (figure 1), or also when fixing a block in the glazing rebate with the help of an unsuitable sealant.

From the sealant, not suitable for this purpose, components (plasticizer, but also oils and/or extenders) penetrate through the secondary seal of the insulating glass. They enter the primary seal of the insulating glass (butyle) and dissolve it in the final phase of the process regularly. This leads first to dilution of the butyle seal and the draining of a mixture of butyle components and the migrated material or the migrated material mixture (Figure 2).

![Figure 1: Weather sealing in a butt migration](image1)

![Figure 2: Dissolution of the butyle seal due to migration](image2)

This causes total damage to the insulating glass, because the blocking effect of the butyle seal against water vapour diffusion and gas diffusion is destroyed on account of the dissolution of the butyle seal.
Moreover, the distribution of the mixture from components of the butyle seal and the migrated material on the inner surfaces (pos. 2 and 3) of the insulating glass causes an optical damage. Under these conditions, an adequate work of the insulating glass is not possible and a replacement becomes unavoidable.

3.2 Profile displacement in case of organic spacer

Another typical case of a harmful is the migration process from an unsuitable glazing sealant in contact with insulating glass edge seal. An example would for this case is an insulating glass system with organic spacer in an eave sealing (figure 3).

Contact with the insulating glass sealant enables migration-capable material from the eave seal to come out. The migrating material is transported through the secondary sealant of the insulating glass up to the organic spacer profile. Later on it penetrates into the interface between glass surface and organic spacer profile and destroys the adhesion of the profile to the glass. As a consequence of temperature and air pressure fluctuations ("pumping movements") the profile glides on a "lubrication film" made of oil, plasticizers and / or extenders into the cavity. This damage scenario is also called the "garland effect" because of its appearance (figure 4).

When sealing eaves, besides the unsuitable selection of the glazing sealant, there is another often to be seen. The joint depth is dimensioned wrongly, i.e., it is set far too deep (see 4.2).

3.3 Selection of glazing blocks

The contact between the sealant in the insulating glass edge seal and the glazing blocks may produce harmful interactions if the block material is not suitable (figure 5).
The unsuitable block material takes components from the secondary sealant, it becomes glutinous and plastically (Figure 6). The block looses its mechanical stability, so that its work of dissipation of loads can no longer be performed. As a consequence window casements may be twisted so dramatically that window opening or closing becomes very difficult or even totally impossible. In the final stadium of the migration process, when large sections of the block have dissolved, the insulating glass may get displaced in the window frame by several millimetres, so that the edge seal is moves from the glazing rebate to the visible area.

Another possible consequence could be that the insulating glass units are no longer fixed properly. The glass products suffer non-planed stresses leading to various glass damages. Under certain circumstances, the loss of important components of the secondary sealant also impairs the function of the edge seal. Therefore it is absolutely essential to check the suitability of the block material in order to avoid faults of this kind. Special attention must be paid for example to block materials containing styrol bonds.

4. Avoiding errors in practice

4.1 General

The basic requirement for combining several materials to a “system” is the so called “system check”, which checks the mutual compatibility of all the combined components with respect to the function and usage. Test procedures as described below have to be carried out for all constructions. The “system manufacturer” is finally responsible for checking this compatibility. “System manufacturer” is the one who combines the components to the “system”, e.g., who installs an insulating glass in a framework.

While designing a system, the construction should be as simple as possible, because the risk of possible incompatibilities increases with the number of components.

The risk of harmful interactions can be ruled out where the materials are protected against mutual contact. Thus, for instance, an appropriate air gap can prevent material transport. If an air gap is not possible from the design perspective, appropriate “migration blockers” can be used – e.g., suitable metal foils or filling material – to interrupt the material transport paths and thus, to ensure compatibility. Obviously these changes should not affect other aspects of the construction.

Glazing blocks often are additionally fixed with a little amount of a sealant. This technique is a dangerous one, if the sealant for block fixing was not chosen with the criteria of compatibility. It is recommended to check if it is possible to fix the block without any sealant and thus to avoid a critical component in the system.

4.2 Joint dimensioning
For the design of joints between insulating glasses as well as for brickwork and corner joints corner the technical requirements with respect to the general design of joints and the sealant properties have to be considered.

The joint width depends on the dimensions of the mutually joined construction elements, e.g., insulating glass and frame. For the appropriate technical rules, please refer to standards and guidelines for glass processing and glazing. These rules must also be applied to joints between insulating glasses as well as brickwork joints.

The joint depth depends also on the dimensions of the construction elements to be mutually sealed. The joint depth shall not exceed a definite maximum value in case of single-component sealing materials.

One must remember that single-component sealant require an adequate quantity of water in the form of moisture for crosslinking. Moreover, the curing of these sealants proceeds from “outside to inside”. Therefore, on the way to the reactive part of the sealant, the moisture has to pass an increasing barrier. If the joint is too deep, the crosslinking process takes too much time. The result may be, even in case of normally compatible sealants, the possibility of harmful interactions, if parts or components remain unpolymerized for a very long time.

A typical construction, where the joint depth exceeds decisively the maximum permissible for a single-component sealant, is shown in figure 7. Due to the long diffusion path of the moisture, necessary for crosslinking, unpolymerized sealant is present at point A – the middle of the joint – for a very long time, at the same time very close to the edge seal of the horizontal marked insulating glass. Thus harmful interactions are an obligatory result of the impermissibly long crosslinking time, even the sealants are compatible in suitable constructions. Besides, loss of adhesion may occur in this case due to the shrinking of the joint, conditioned by crosslinking.

Remark: It is not the purpose of this technical information to show solutions for the design to be always suitable. On one hand, these solutions do not exist. On the other hand, creating an optimal design for the individual case should be left to the competence of the concerned expert.
5. Check of compatibility

At present, there is no standardized test procedure to verify the compatibility for all applications. Maybe an adequate test procedure has to be developed for each material combination and each design. By the way, in case of complex systems, it is necessary to check the mutual compatibility of the individual components as well as the compatibility of the total system. This is represented in the following graphics:

![Compatibility Graphics]

Sometimes it is impossible to avoid a three-component system, for instance consisting of a primary sealant A (butyle), a secondary sealant B and of a weather sealing C. In this case all possible combinations must be checked with respect to their mutual compatibility. Thus the following individual tests must be performed:

![Additional Compatibility Graphics]

The test $A \leftrightarrow B$ may be dropped, for instance if both sealants come from the same supplier, or their mutual compatibility is guaranteed. This testing system illustrates why the most simple constructions are advantageous.

Further on, for the checks of compatibility there is no general evaluation of the test results and there is also no evidence if the test results are relevant for practical application. If necessary, several test procedures have to be carried out. As well, checking compatibility to minimize the risk of harmful interactions requires an enormous amount of knowledge and extensive experience.

5.1 Check of compatibility in practice

In practice, the different components of a system rarely come from the same supplier. However, only in this case the supplier if all components of a system is capable to guarantee the compatibility of these components. In this case, the supplier has the possibility to recheck the compatibility, whenever the composition of one of the product is changed. He can thus guarantee that clients need not fear any change in compatibility.
If the components come from different suppliers, the test results will be applicable only to the tested product batch numbers and do not show any general evidence. The test results cannot necessarily be applied to other product batches, because a possible change in product composition is supposed not to be known in time and taken into account. Thus it is impossible to provide a list containing combinations of compatible materials, without contractual regulations between the concerned suppliers.

A general statement on the compatibility of products from different suppliers requires a corresponding bilateral contractual regulation between the concerned suppliers and the purchaser of the material. As long as there are no standardized requirements for components, this is the only way out.

The responsibility for compatibility in the case of combinations containing different sealants is to be shouldered basically by the person who combines these materials into a “system”. The suppliers of the “pre-products” are not responsible for the compatibility of materials they don’t know. This factor however, does not prevent them from advising their clients or helping them with technical tests. The practical conversion of the advice into a design, and the evaluation of test results however, is the prerogative of the system manufacturer.

It is remembered on the influence of the design of joints on the crosslinking of sealants, and therefore on the possibility of harmful interactions. Hence, the compatibility of the participating components is to be ensured in the sense of the absence of harmful interactions in the individual application.

6. Conclusion

Complicated material combinations require careful planning and execution. All participants of this process (suppliers, system designer, and system manufacturers) have to work hand in hand. If the components do not come from only one supplier, the procedures as described in this leaflet shall be carried out. With respect to complexity of these systems, it seems to be useful to proceed like it is obligatory for other areas of glass construction, for instance for fire protection glass constructions. For those constructions the “system description” describes precisely all components and their application. Further on the entire system has passed a so called “type test”. Every supplier has to ensure to deliver only with respect to the “system description” and it’s specifications for all components. Changes in the components are allowed only if it has been established, these changes do not affect the system and the result of the “type test”.

This technical information has been prepared by the working group “compatibility” of the technical committee of the German Bundesverband Flachglas.

The original text is based on a draft by Dipl.-Ing. Helmut Brook, Henkel Teroson GmbH. Revision and completion is provided.

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Cleaning of glass

3.2 Specially finished and externally coated glass
The specially finished and externally coated glass types described below are high-quality products. They require particular care and attention when cleaning. Damage to this glass can be more conspicuous or may impair its function. If necessary, separate recommendations from the individual manufacturers with regard to cleaning must also be observed, particularly with externally coated products. Do not use a „glass scraper“ for cleaning the glass surface.

• Some solar control glass types are designed as external coatings (position 1 = weather side). These can often be recognised by very high reflection, even in the spectral range of the visible radiation. At the same time, solar control glasses are often thermally tempered, particularly in the case of facade plates and sun skirts.

• Furthermore, reflection-reducing coatings (anti-reflection coatings), which by their very nature are difficult to detect, can be applied to the outside or inside of the glazing.

• External or internal heat insulation coatings are a special case here. In special window designs (box Windows or composite Windows), these coatings may, exceptionally, not face the cavity of the insulating glass unit. Mechanical damage to these coatings usually manifests itself in the form of streaks of surface abrasion due to the slightly rougher surface.

• Dirt-repellant/self-cleaning surfaces are visually difficult to identify. Because of the way they are used, these coatings are usually to be found on that side of the glazing unit exposed to the weather. Mechanical damage to self-cleaning coatings (Scratches) not only constitutes visually discernible damage to the glass, but can also lead to a loss of functionality in the damaged area. Silicone and grease deposits on these surfaces should also be avoided. Rubber scrapers in particular must therefore be free from silicone, grease and foreign bodies.

• Toughened safety glass (TG) and heat strengthened glass (HS) is permanently marked in accordance with statutory regulations and may be combined with the above-mentioned coatings. The surface of ESG is modified by thermal tempering compared with normal float glass. Under certain circumstances, the surface tension which has been introduced makes damage more visible than with nontempered glass (sometimes after a time delay).

3.3 Further notes
The use of portable polishing machines for removing surface damage can cause considerable abrasion of the glass body. This can cause optical distortion, which is perceived as a "Jens effect" and leads to a reduction in strength. Do not use polishing machines, particularly on the specially finished and externally coated glasses mentioned above.

And by the way:
It may be that glass surfaces might not be evenly wettable due to marks left by such things as stickers, rollers, fingers, sealant residues and also environmental influences. This phenomenon can only be seen when the pane is wet, i.e. when it is being cleaned.

1.0 Introduction
Glass can cope with a lot - but not with everything!
As part of the facade, glass is subject to natural and building-related soiling. Normal dirt, professionally cleaned at reasonable intervals, presents no problem to glass. However, depending on time, location, climate and building situation, significant chemical and physical accretions of dirt can accumulate on the glass surface, making professional cleaning particularly important.

This technical guide is intended to provide information on how to prevent and minimise soiling during the lifetime of different glass surfaces, and on how to clean them properly and in time.

2.0 Types of cleaning
2.1 During the construction phase
As a general principle, all aggressive soiling must be prevented during the construction phase. If this nevertheless occurs, then the dirt must be washed off without trace by the person responsible, immediately after it appears, using nonaggressive cleaning agents.

Concrete and cement slurries, plasters and mortars in particular are highly alkaline and cause etching and hence damage to the glass (dulling) if they are not immediately rinsed off with plenty of water. Dusty and granular deposits must be removed professionally, but under no circumstances removed when dry. As a result of his obligations to intervene and protect, the building contractor is responsible for controlling the interaction of the different trades, and in particular for informing subsequent trades of the necessary protective measures.

Soiling can be minimised by optimising the construction process and by separately arranging for protective measures, for example the application of protective films in front of windows and façade surfaces. The object of so-called initial cleaning is to clean the components after the building work is complete. It cannot be used to remove all the dirt accumulated during the entire construction period.

2.2 During use
Professional cleaning, matched to the particular glass and carried out at appropriate intervals, is essential to maintain the characteristics of the glass over its entire period of use.
3.0 Glass cleaning Instructions

3.1 General

The following cleaning information applies to all glass products used in the building. Plenty of clean water must be used whenever cleaning glass to avoid any scouring effect from dirt particles. Soft and clean sponges, leathers, cloths and rubber scrapers are suitable hand tools. Careful use of glass cleaning tools is a further prerequisite for avoiding damage to the glass. Separate cleaning tools must be used for glass, seals and frames. Cleaning tools can be backed up by the use of largely pH-neutral cleaning agents or commercially available domestic glass cleaners. If the dirt consists of grease or sealant residue, commercially available solvents such as ethyl alcohol or isopropanol can be used for cleaning. Alkaline Solutions, acids and agents containing fluoride are all chemical cleaning agents which must never be used.

The use of pointed, sharp metallic objects, e.g. blades or knives, can damage the surface (Scratches). A cleaning agent must not visibly attack the surface. Do not use a bladed scraper to clean whole areas of glass. If damage to glass products or surfaces caused by cleaning is noticed while cleaning is in progress, then work must be stopped immediately, and the right information on how to prevent further damage must be obtained without delay.
UNPACKING AND INSPECTION CHECKLIST FOR GLASS DELIVERIES

Dear customer, the transport of your glass is insured. Although we do everything to pack the glass as safely as possible, damages may occur due to incorrect handling during transport / unloading or unpacking. We kindly ask to follow our unpacking and inspection checklist to make it possible for us to understand the cause of potential glass damages and to be able to react as soon as possible.

1. Please notice, that the receipt of glass deliveries need to be accepted “under reserve / not checked”, in case you are not able to check all products for damages / breakages in the presence of the carrier.

2. Please check and document the crate / wooden packing for outside damages

3. Please check and document the condition of the tilt watch that is applied to outside of the crate (please report also when there is no tilt watch)

4. Prior to opening the crate please put some wedges under the crate to make sure no glass panes will fall out of the crate when the top cover is removed

5. Please open the crate on the side where indicated

6. Please inspect, document and report the glass units for damage within 48 hours after delivery
7. In case of damage: Please take some photos of the damaged glass, crate and the associated sticker with reference number / glass size and inform us immediately, as we must report the damage to transport insurance.

**A) Breather tube / Pressure compensation valve:**

Transportation:
This breather tube has to remain open during transportation (for example higher than 1200m above sea level, e.g. air transport, even in pressure compensated cabins).

Closure:
Before installation, the breather tubes have to be closed following the steps below:

- by using a needle make sure, the tube is open
- if the tube was closed, leave it open for at least 5 – 10 minutes
- cut the tube to 10 mm
- press the tube together and bend it over as shown in the pictures

Breather tube must not face the bottom of the insulating glass unit (no force/weight on breather tube).
Absolute beware of: pulling out the tube of the edge sealing buckling of the tube
Closure of the breather tube

Tools:

Engineers Pliers

Round Pliers
C) Procedure

Attention at all steps:
Do not pull out the tube out of the edge sealing!!!

Step 1: cut the tube to 10 mm

Step 2: press the tube together

Step 3: bend it over by using the round pliers

Installation instructions / Glass sticker

Check the sticker on each unit for indication of outside
Special Instructions on ORNILUX insulating glass:

It is critical to install ORNILUX insulated glass units in the correct facing direction to ensure bird collision performance. The UV reflection of the coating is uni-directional and must be installed properly. The laminated pane always has to be installed to the inside!
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 at the building.
### 3. Allowable Discrepancies for the Visible Quality of Architectural Glass Products

<table>
<thead>
<tr>
<th>Zone</th>
<th>The following are allowable per unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>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.</td>
</tr>
</tbody>
</table>
| E    | Inclusions, bubbles, spots, stains, etc.:  
| Pane area ≤ 1 m²: | max. 4 cases, each < 3 mm Ø.  
| Pane area > 1 m²: | max. 1 case, each < 3 mm Ø, per meter of perimeter. |
| Residues (spots) in the gas-filled cavity:  
| Pane area ≤ 1 m²: | max. 4 cases, each < 3 mm Ø.  
| Pane area > 1 m²: | max. 1 case, each < 3 mm Ø, per meter of perimeter. |
| Residues (patches) in the gas-filled cavity: | max. 1 case ≤ 3 cm² |
| 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 m²: | max. 2 cases, each < 2 mm Ø.  
| 1 m² < pane area ≤ 2 m²: | max. 3 cases, each < 2 mm Ø.  
| pane area > 2 m²: | 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 306 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.

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![Diagram](image.png)  

**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 fulfill 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 recognizable 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 8 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 length. 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 recognized after installation should be determined. These discrepancies can be assessed according to the criteria of section 3.
Technical Information

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-Isolierglass” (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 Mulitple 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 polarized light and/or through polarizing glasses.

Polarized light is present in normal daylight. The extent of polarization 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.