



Glazing Guideline

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drainage. Moreover, any contact between metal and glass must be permanently prevented.

Prior to glazing, and irrespective of the framing material, ensure that the construction meets the necessary processing conditions; has been tested for adequate strength and secure fixing; has been checked for the presence of adequately dimensioned openings for pressure equalisation; that the type of glass used is suitable for the intended use; and that there are the correct fittings for installing the glass panes. Any deviations from the requirements of this Guideline shall be indicated.

2.2 Calculation of suitable/necessary glass thickness

The thickness of the glass units must be specified prior to execution. Depending on the installation location, dimensioning of the glass thickness(es) should take account of all expected design loads such as wind loads, live loads, snow load, negative or positive pressures in the cavity, dead load, etc. Dimensioning of glass thicknesses (structural design) is a professional planning task (in accordance with DIN 18361) that should be agreed and remunerated separately. Special care should be given to the following:

- The locally applicable standards, rules and regulations, including the safety concept, impacts on the building and components, selection of the glass type, minimum glass thickness(es) required and glass design, must be observed.
- All impacts must be determined as realistically as possible in accordance with the national rules and regulations, including wind loads corresponding to the location in the façade and with superimposition of the isochore pressures, as well as additional snow and dead loads resulting from possible snow accumulations on horizontal glazing systems.
- Safety barrier glazing systems require structural engineering verification as well as evidence of impact resistance.
- If the selected glass configurations/types of glass and/or the design specifications do not conform to the technical rules/applicable standards, additional tests/verification may be necessary.
- Any differences in altitude between the production site and the place of installation, including the transport route, must be taken into account.

2.3 The Glazing System – Basic Principles

The basic requirements are shown schematically in Fig. 1. They may vary depending on the building use (e.g. rooms with high air humidity) and climate zone (e.g. climate zones with relatively high air humidity) and must be adapted accordingly. For instance, it may be necessary to fit the glazing beads to the outside and not the inside of the building or provide additional openings for pressure equalisation.

All glazing systems without sealant in the rebate area must feature adequate openings specific to cross section and position to ensure drainage of moisture that has leaked into or accumulated in the rebate area, so that the rebate area will dry quickly. Avoid standing water or permanent moisture on the glass unit. Special designs must be agreed with the insulating glass manufacturer for durability and material compatibility.

In order to ensure all of the above, the glazing must be used, cleaned and maintained properly. The processing/fabrication instructions set out by the system manufacturers must also be followed, if available.

Avoid filling the rebate area completely, because application of the sealant to the rebate area without any bubbles is almost impossible to achieve. This leads to a higher risk of moisture exposure that may damage the insulating glass unit or frame over time. It is therefore recommended to use only systems with sealant-free rebate area. Special cases, e.g. windows and facade systems subject to burglar resistance requirement or bonded window systems must be agreed with the window/facade producer and the insulating glass manufacturer with regard to durability and material compatibility. In such cases proven and tested systems are recommended.

2.4 Material Compatibility

- The principle of material compatibility can be described as follows: “Materials are compatible if there is no occurrence of detrimental interactions.” For glazing systems, it is mainly the components that must be compatible when they interact and when they come in direct or indirect contact with the edge seal of the insulating glass unit. These components include:
 - Glazing sealants
 - Cleaning agents
 - Glazing blocks
 - Interlayers of glass units
 - Edge seal systems of insulating glass units



- Accessories which come into contact with interlayers of glass units and edge seal systems
- Subsidiary building materials (e.g. chalk powder, films, foils)
- Protective films for the glass unit

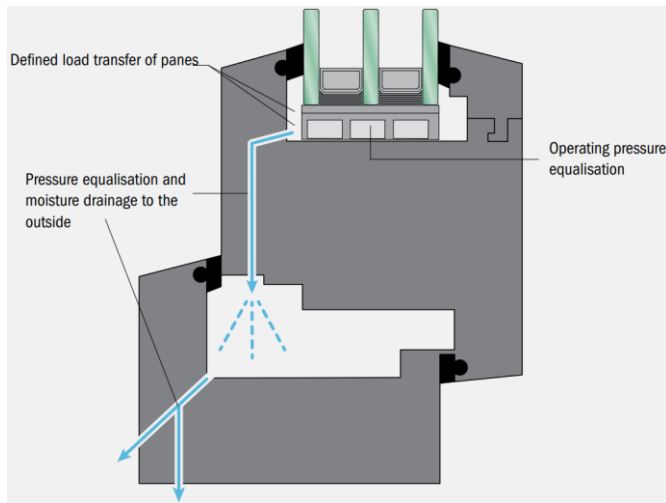


Fig. 1: General design/structural requirements

Interactions between the wide range of bonding materials, sealants and accessories used cannot be excluded, but are acceptable unless they have a negative effect on the functional requirements, durability or visual appearance of the building component.

The procedures for verification are described in the ift-Guidelines DI 01/1 and DI 02/1 (ift Richtlinien DI 01/1 and DI 02/1).

3 Requirements for the glazing rebate

3.1 Requirements for Geometry and Detailing/Execution

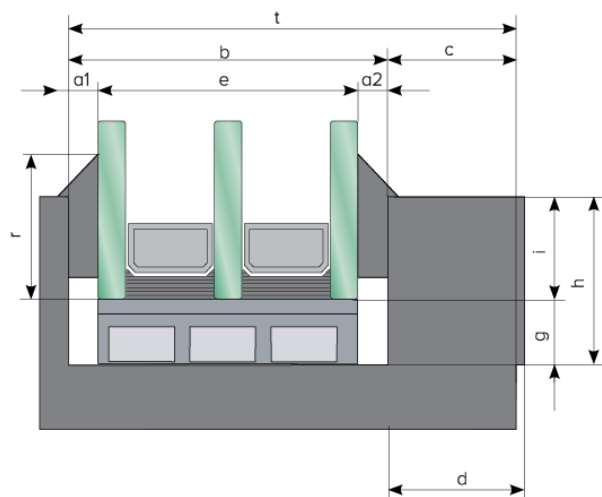
- The materials used for the frame or glass retention system must be suitable for the glazing.
- The dimensions of the glazing rebate and the glazing beads must provide for adequate cover of the glass edges to ensure safe load accommodation and must also compensate for the permitted tolerances. It should be noted that special glass toughened glass, laminated glass and laminated safety glass or patterned glass) may have different tolerances and/or dimensions.

- The width of the glazing rebate must also be designed to accommodate the required thickness of sealing material on both sides of the glass pane and for the proper attachment of the glazing beads.

3.2 Requirements for the glazing rebate

The requirements for the glazing rebate, bite and sealant selection are specified for instance in DIN 18545, DIN EN 15651-2 and DIN EN 12488. A schematic illustration of a glazing system and the associated terms is given in Fig. 2. This essentially corresponds to the description given in DIN 18545.

The requirements set out in DIN 18545 usually apply to glazing systems with gunned sealants (wet glazing), but can in principle also be applied to other glazing systems using different sealing methods in accordance with DIN 18545.



- Dimensions
- a_1 = external sealant thickness / external gasket
 - a_2 = internal sealant thickness / internal gasket
 - b = glazing rebate width
 - c = contact width of glazing bead
 - d = width of glazing bead
 - e = thickness of glazing unit
 - g = glazing rebate platform, recommended: min. 5 mm
 - h = glazing rebate upstand
 - i = glass bite (usually $\approx (2/3) \cdot h \leq 20$ mm)
 - r = cover of insulating glass edge seal
 - t = total rebate width

Fig. 2: Diagram of glazing rebate based on DIN 18545:2015-07 and DIN 52460:2015-12



As a rule, the glass bite should be at least 2/3 of the glazing rebate upstand and should not exceed 20 mm in the structure in order to minimize the thermal load. If the glass bite exceeds 20 mm it must be ensured that the permissible temperature differences within the pane for the glass type used are not exceeded and that there is no risk of glass breakage caused by mechanical loads (see Table 1). In addition to the requirements for minimum glass bite in accordance with DIN 18545, the requirements of DIN 18008-2 must be met. DIN 18008-2 specifies a minimum glass bite of 10 mm and a minimum contact width of 5 mm. If these requirements cannot be met, the deflection must be limited to 1/100 (serviceability criterion) as per DIN 18008. Deviation from the above requirements is possible on a case-by-case basis in consultation with the insulating glass manufacturer. See also the BF Bulletin 021/2017 "Serviceability of glazing with linear support" (Merkblatt 021/2017 "Gebrauchstauglichkeit linienförmig gelagerter Gläser").

Longest side of the glazing unit	Minimum glazing rebate upstand h for	
	Single glazing	Insulating Glass Units
Up to 1000 mm	10 mm	18 mm
Over 1000 up to 3500 mm	12 mm	18 mm
Over 3500 mm	15 mm	20 mm

Tab. 1: Minimum glazing rebate upstand to DIN 18545:2015-07

For slimline glazing bars in insulating glass units with an edge length of up to 500 mm, the glazing rebate upstand can be reduced to 14 mm and the glass bite to 11 mm.

4 Requirements for glazing systems

A distinction is made between wet glazing and dry glazing. Dry glazing uses sealing lips, sealing strips or gaskets. Wet glazing generally uses gunned sealants. But there are also some mixed systems on the market. They use gunned sealants for external weather sealing and gaskets for sealing the interior.

The glazing systems must be watertight from the outside to the inside. For air permeability it is the contrary, air tightness must be ensured from the inside to the outside. Moisture drainage and pressure equalisation must be from the inside to the outside.

4.1 Wet Glazing Systems Using Sealants

The necessary thickness of the face clearance of wet glazing is usually ensured by glazing tapes.

Glazing using double-sided glazing tapes

This is a common glazing method for glazing timber units but also frames made from other materials. The glass is supported on both the inside and outside by a resilient glazing tape. This minimises constraints resulting from installation and use. The thickness of the glazing tape determines the thickness of the face clearance and should be selected according to the size of the glazing, the frame material, the colour of the profile, etc. and the manufacturer's instructions. The glazing tape avoids rigid fixation of the glass edge.

The geometry of the sealing joint can also be achieved via the details of the glazing rebate stop and the glazing bead.

For further information refer to IVD Guidance Sheet No. 10 (Merkblatt Nr. 10).

Glazing with single-sided glazing tape

The external glazing tape must ensure that the fitted insulating glass unit is not rigidly fixed in the rebate and prevent exposure to local excess stress/strain. For further information on this glazing system refer to the ift Guideline VE-13/2 "Glazing of timber windows without glazing tape" (ift-Richtlinie VE-13/2 "Verglasung von Holzfenstern ohne Vorlegeband"). This guideline specifies the minimum clearance between the glazing bead and glass pane. The Guideline VE-13/2 does not apply to windows made from different frame materials, shop windows and special glazing systems e.g. fire safety, roof and underwater glazing, glazing for indoor pools, or for bonded glazing systems.

Glazing without glazing tape

Glazing systems without glazing tapes must be carefully selected and designed. When choosing this type of glazing, adherence to the tolerances specified in the ift Guideline VE 13/2 "Glazing of timber windows without glazing tape" (Verglasung von Holzfenstern ohne Vorlegeband) is essential. If not, constraints with risk of breakage of the insulating glass unit cannot be ruled out.



4.2 Dry glazing – Sealing lips, sealing strips and gaskets

The gaskets used must be compatible with the glazing system. Sealing must be carried out in line with the principles described in Section 4.0. Corners and joints need particular care to ensure a permanent functional seal.

The gaskets can be made from materials such as EPDM, silicone, TPE or PVC. On the weather side or if fitted to indoor pools and wet rooms or rooms with a high potential of moisture formation, the weather seals must be tight on both sides around the perimeter in one continuous length. The same applies to dynamic loads, e.g. pressure load cycles or torsion, which must be accommodated safely and without failure of weather tightness. Comply with the requirements set out in EN DIN 12365.

The gaskets must be compatible with the frame fixing and the thickness of the glass unit, incl. tolerances, and must feature adequate elastic force.

4.3 Flatness

Select frame materials whose glass supporting areas remain permanently flat when exposed to the design loads.

4.4 Deflection Limit

The frames must be adequately rigid to ensure that deflection under maximum load does not exceed 1/200 of the edge length (see also BF Bulletin 021/2017 “Serviceability of linearly supported glazing” (BF Merkblatt 021/2017 “Gebrauchstauglichkeit linienförmig gelagerter Verlasungen).

4.5 Tightness and Sealing

Sealants and gaskets must be resistant to e.g. weather, environmental impacts and cleaning agents. Sealing joints should be checked regularly with regard to their functionality and replaced if necessary (the same applies to gaskets etc.) As a rule, gunned sealants can be used to seal the joints of all frame materials used in fenestration. Comply with the sealant manufacturer’s instructions. Efficient sealing is highly dependent on the pre-treatment/ preparation of the materials/substrates. All surfaces in the sealing system must be inspected/tested. Any changes to the adherends require re-testing and approval by the producer/manufacturer. An integrated approach is required particularly in relation to the long-term serviceability of the window constructions.

5 Transport, Storage and Installation

5.1 Transport and Storage

Proper transportation and storage are essential for maintaining the quality and durability of single glazing and insulating glass units. Glass surfaces, glass edges and the edge seal of insulating glass units must not be damaged during transport, storage and installation. Special care must be taken that:

- Single glass and insulating glass units are transported only on racks or in suitable crates with transport securing devices.
- Glass panes must normally be transported with support over the full pane thickness. This applies in particular to large and heavy glass units.
- When manipulating the insulating glass unit for glazing operations, it is permissible to briefly lift the insulating glass unit by applying the lifting device to one sheet of the insulating glass unit.
- Where heavy IGUs are to be manipulated on only one pane, the insulating glass manufacturer must be consulted.
- The instructions of the insulating glass and sealant manufacturer are observed.
- The units are stored and positioned only approximately vertically / perpendicular on suitable racks / fixtures.
- The provisions set out by the government safety organisations (Berufsgenossenschaften) for transportation, storage, manipulation and installation are complied with.
- The supports to prevent tilting, the base and the top securing devices must not cause any damage to the glass surface, glass edge or edge seal. The supports must be positioned perpendicular to the pane surface and ensure full contact of the glass unit over its entire width.
- When transporting glass units of different sizes care should be taken that the glass edges do not cause any friction marks on neighbouring glass surfaces. When stacking several glass panes, spacers (e.g. paper inlays, intermediate pads, stacking shims) are required. They must not absorb any moisture.
- Insulating glass units must normally be protected on-site from damaging chemical or physical effects.
- Transport on racks



Glass panes transported on racks must be secured in doing so, the securing device must not exert inadmissible pressure on the panes.

- Transport in crates

If shipped in lightweight crates which are not designed for exposure to static or dynamic loads, carefully check in each case how to handle the crates or how e.g. transport ropes, can be used. The crates may only be stored, set down and opened in a vertical position on suitable racks or fixtures. Crates are a means of transport and not designed for long-term storage.

- Insulating glass units (IGUs) left outdoors must be protected from extended exposure to moisture or solar radiation by a suitable full-size ventilated cover.

5.2 Installation

Prior to installation, check each glass unit supplied for any visible damage. In accordance with DIN 18008-1, section 4.1.4, panes exhibiting edge damage penetrating into the glass volume by more than 15 % of the pane thickness shall not be installed. Dead load and external impacts (e.g. wind loads, live loads or snow loads) must be safely transferred to the primary loadbearing structure.

5.3 Blocking

Glazing blocks have the following functions:

- Transfer the weight of the glass pane in the frame in such a way that the frame supports the glass pane
- Ensure the position of the frame remains unchanged
- Ensure operability of opening elements
- Permanently separate the glass pane edges from the frame and ensure a minimum 5 mm clearance to the glazing rebate platform
- Support the glass pane in accordance with structural engineering principles

The frames must therefore be dimensioned in such a way that they will perfectly bear the load of the glass panes. For blocking design, see also the Glaziers' Technical Guideline No. 3 "Blocking of glazing units" (Technische Richtlinie des Glaserhandwerks Nr. 3 "Klotzung von Verglasungseinheiten") and DIN EN 12488.

Before fitting the glass in the blocking area, remove any excess sealant protruding beyond the glass edge of the insulating glass. Blocking must not exert excessive pressure on the glass edge.

Blocking must not cause excessive deflection of the frame profiles. The maximum deflection limits set out by the system providers must be taken into account so that the function and durability of the construction and glazing is not impaired for the intended period of use.

When using LG/LSG, and/or heavy glass units (> 500 kg) it is recommended to mark the support edges and detail them in KGN quality (smooth ground edge) (DIN 1249-11) as necessary. It may be necessary to consult the glass producer before ordering.

5.4 Protection against UV radiation

The edge seal of insulating glass is usually not permanently resistant to UV radiation. The edge seal must therefore be fully covered by the frame or protected against UV radiation by adequate measures (e.g. cover strips, enamelling, or similar). Without such protective measures the edge seal of the insulating glass must be made from UV resistant material (silicone). This principle also applies to the storage of insulating glass units on transport racks.

5.5 Processing tools and devices

Use only suitable processing tools and devices. The glass edge must not come into contact with rigid objects, such as caulking chisels, screwdrivers, etc. Use block levers carefully to prevent spalling and flaking of the glass edges.

5.6 Transport and installation at high altitudes

Installation and/or transport of insulating glass units to premises which are located at much higher or lower altitudes than the production site require special precautions in terms of design and may require pressure equalisation. Depending on the glass products used, there are also other parameters which come into play, such as size, dimensions of the insulating glass unit (IGU) and cavity temperature. All enquiries/orders are subject to providing information on the place of installation of the insulating glass unit.

6 Additional requirements depending on the application

6.1 Glazing exposed to extreme thermal loads

Partial or point-wise temperature loads on glass panes cause thermal stress which can lead to sudden breakage due to differences in thermal expansion. For this reason,



it is important to avoid temperature differences over the glass surface and throughout the glazing.

Thermal loads may result from, for example, the following situations:

- Films, paints, posters, solar control and anti-glare systems, furniture:

The subsequent application of absorbing films, (finger) paints, posters, the addition of internal blinds leading to heat accumulation or too small a gap between furniture and glass, etc., may cause thermally induced glass breakage when exposed to solar radiation. For further information on thermal loads on glass see VFF Guidance Sheet V.02. "Thermal loads on glass in windows and façades". (Thermische Beanspruchung von Gläsern in Fenstern und Fassaden) and the BF Information sheet 006/2016 "BF information on subsequently applied films" (BF-Information zu nachträglich angebrachten Folien). Verifications and evaluations can also be done using thermal stress analysis.

- Cast asphalt flooring:

Placing cast asphalt indoors or on balconies and terraces results in strong irregular and one-sided heating of the glass. Protect the glass from these effects by suitable means.

- Radiators:

Radiators should be positioned at least 30 cm away from the glass pane. For insulating glass units combined with an internal toughened glass sheet, the minimum distance can be reduced to 15 cm. The radiator should be of the same width as the insulating glass unit to ensure uniform heating of the glass pane. Heat shields placed between the radiator and the glass pane will reduce heat losses and the thermal load on the glass pane. The heat shield should be positioned at least 10 cm away from the glass pane.

6.2 Glass in sliding doors or sliding windows

In the case of sliding units, e.g. parallel sliding or lift and slide doors, the space between the moving and fixed element can heat up considerably when the doors are open. It is therefore recommended that the glass panes facing this space be made of toughened glass, TSG, TSG with heat-soak test or HSG. If this space between the two insulating glass units is adequately ventilated, the use of toughened glass may not be necessary. If no empirical values are available for sufficient ventilation between consecutive panes of a construction, a thermal glass stress analysis can be performed to estimate the thermal load. This also applies to partially opened sliding units. Adequate ventilation can be ensured, for example, by a door stop.

This also applies to, e.g. installation locations where the sliding door is not exposed to direct solar radiation. For specific cases, the thermal load should be evaluated in consultation with the glass supplier.

6.3 Rooms with high air humidity (high hygrometry)

Buildings or rooms with high air humidity include indoor pools, bathrooms, factory floors in breweries, butchers shops, bakeries, flower shops, dairies, dry cleaners, etc., but also rooms such as non-ventilated bedrooms and living rooms where condensate may form on the surfaces inside the room. Here more stringent requirements apply to both the internal tightness of the structure and the materials used. In all cases a well-functioning pressure equalisation via the glazing rebate to the outside and permanent drainage must be ensured. Additional openings in the top corner of the glazing rebate have proven their efficiency in practice.

6.4 Horizontal Glazing

In contrast to vertical glazing, horizontal glazing is exposed to e.g. higher thermal and mechanical loads (wind, snow and ice loads as well as dead loads). The glazing system must be able to permanently accommodate all these loads. In some cases, narrower cavities are required to reduce the exposure of the insulating glass unit to higher climatic loads (isochore pressure). If the outer pane of the insulating glass unit is designed as eaves, only stepped insulating glass can be used. For thermal reasons the outer pane should generally be TSG or HSG. A complete IGU unit projecting beyond the glazing system is not permitted. In this case a stepped insulating glass configuration is recommended.

6.5 Stepped insulating glass

This type of insulating glass unit is characterised by at least one edge, including the edge seal, being exposed to UV radiation. For stepped IGU versions observe the instructions given in Section 5.4 "Protection against UV radiation".

6.6 Balustrades

Glass units can be used as balustrades/barriers without additional railings. However, the glass units must always be made of LSG or TSG.



For dimensioning of the corresponding glass thicknesses and selecting the necessary types of glass plus the requirements for the glass retention system, comply with the regulations in the relevant glass design and construction standards. In Germany this is the standard DIN 18008-4.

6.7 Spandrel units

Spandrel units are classified as

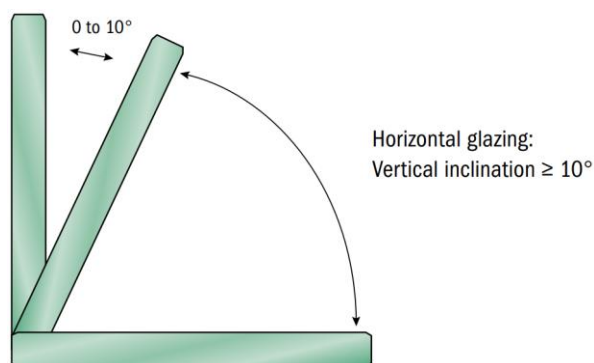
- spandrel panes and
- spandrel panels.

Spandrel panes are single or double (IGU) glass units made of TSG. Spandrel panes are used in ventilated external wall constructions (cold facade). Spandrel panels are made of single or double spandrel panes which are thermally insulated on the back. They are used in non-ventilated façades (warm facades).

When installing spandrel units with insulating glass units located in front of front-wall insulating units or in “shadow boxes”, the higher temperature in the cavity, edge seal and the other components of the spandrel units must be taken into consideration (see DIN 18008 Part 1, Table 4).

General requirements for glazing of spandrel units

Double spandrel panes and double spandrel panels must be glazed in accordance with the principles set out in this guideline. Comply also with any other instructions given by the glass and/or system manufacturer.



6.8 Painted glass

There are various processes for glass to be coloured or used as a mirror. For installation/intended use and/or fixing of these types of glass and mirrors, comply with the manufacturer’s instructions and the Glaziers’ Technical Guidelines. This also applies to assessing the visual quality.

6.9 All-glass corners/glass joints

Additional instructions need to be taken into account when designing and detailing glass joints and all-glass corners made of insulating glass. These include:

- Exposed glass edges, especially in stepped insulating glass, should normally be ground smooth (KGN as per DIN 1249-11). It is recommended to polish visible edges.

- Joint geometry:

Joint width $b \geq 8 \text{ mm}$.

Joint depth $t \approx 0.5 \cdot b$, min. 6 mm.

- Joints between glass panes, known as “butt joints” may not generally be included in structural calculations. In the case where the butt joints in question take on static functions, appropriate dimensioning of said joints and a corresponding proof of usability/approval by the building authorities is required.
- Comply with the processing and application instructions of the sealant producer, the relevant codes of practice, and the VFF Guidance Sheet V.07 “Glass joints and all-glass corners of windows and façades” (Merkblatt V.07 “Glasstöße und Ganzglasecken in Fenster und Fassaden”).

7 Characteristics of Glass Products

7.1 Float glass

Float glass in compliance with EN 572-2 is the basic glass of all further glass products. It defines float glass as flat, transparent, clear or coloured soda-lime silicate glass with parallel and polished surfaces, produced by continuous casting and flotation in a metal bath. It has a very good optical quality.

Basic glass is used to produce refined glass products such as coated glass, insulating glass units, toughened safety glass and laminated safety glass as well as decorative glass.

The general characteristics of basic soda-lime silicate glass products are specified in EN 572-1.

7.2 Toughened safety glass (with/without Heat Soak Test)

Toughened safety glass (TSG) is covered by the product standard EN 12150-2. TSG is heat soaked in accordance



with EN 14179 to reduce the risk of spontaneous breakage. Comply also with the national rules and regulations for the use of heat-soaked glass.

7.3 Heat strengthened glass

Heat strengthened glass (HSG) is covered by the product standard EN 1863-2 in combination with the verification of suitability of use by the relevant manufacturer and/or as specified by the Administrative Provision for the Technical Building Rules of the individual German states (Verwaltungsvorschrift Technische Baubestimmungen).

Table 2 lists the essential characteristics of float glass, HSG and TSG. More characteristics are specified in the relevant product standards.

	Float glass	HSG	TSG
Ultimate bending strength σ_B	45 N/mm ²	70 N/mm ²	120 N/mm ²
Resistance to temperature differentials and sudden temperature change Δ_T	40 K	100 K	200 K
Cutting capability	Yes	No	No
Breakage pattern	Some radial cracks, large pieces	Some radial cracks, large pieces	Break with small crumb structure

Tab. 2: Characteristics of glass products

7.4 Patterned glass

Patterned glass is covered by EN 572-5. Due to the coarsely breaking fracture structure and the special breakage pattern caused by the production process, the uses of patterned glass or wired patterned glass (a patterned glass with wire inserts) must be selected very carefully and compliance with the building code regulations and further technical application instructions (e.g. DIN 18008) must be ensured.

Texture

Standard cutting to size orients the texture parallel to the upper edge. Exceptions are possible only if the texture is specified in the drawing and the order states "TEXTURE according to drawing" If the texture covers more than one glass unit, this requirement must be specially noted in the order. The same principle applies to motif glass, e.g. sandblasted or printed glass.

7.5 Laminated glass and laminated safety glass

Laminated glass or laminated safety glass with exposed glass edges are permitted only if the edge is

- smooth-ground (KGN),
- polished (KPO) or
- bevelled (GK)

in accordance with DIN 1249-11.

The desired edge quality must be specified in the order. Optical effects at the supporting edge along with interlayer residues in the arressed area and interlayer films protruding from LSG final-cut sizes are inevitable due to the manufacturing process.

Optical changes may occur in an edge zone of approx. 15 mm of the glazing if the film at the glass edge is permanently exposed to moisture. So as to prevent these optical/visual alterations, the construction must be carried out in such a manner that the structure itself, or the provision of an adequate system of ventilation, brings it about that permanent exposure of the film on the glass edge to moisture and dampness is avoided.

In the area of canopies, for example, this can be achieved using a laminated safety glass with a projecting edge (step). It is essential that the glass edges are cleaned professionally at appropriate intervals to preserve the performance of the laminated glass over its entire service life.

The cleaning intervals must be specified in such a way that the occurring soiling does not lead to a permanent effect of moisture on the edges of the laminated glass. The cleaning intervals must be specified according to the location, e.g. city centre locations, areas with anticipated high pollution from other parts of the building. It should also be noted that interaction with other materials may produce specific characteristics (e.g. bubbles, see also 2.4).

For further information on the use of laminated safety glass, refer to the BF Bulletin 013/2013 "Laminated safety glass (LSG) for use in building" (Merkblatt 013/2013 "Verbund sicherheitsglas (VSG) für die Anwendung im Bauwesen").

7.6 Coated glass

Glass products can be coated with a wide variety of coatings. These coatings are applied to change the visual appearance of the glass or its technical performance or to obtain specific surface characteristics. The most commonly applied coatings change the energy performance of the glazing and include primarily coatings to improve ther-



mal insulation or change solar transmittance. Coating usually results in a specific colour appearance. The aesthetic requirements (reflection of coated glass, colouring by the coating or the glass substrate) must be agreed with the manufacturer from the design/planning stage.

It is therefore important when specifying the optical properties and agreeing the anticipated visual quality of the finish with the manufacturer, to use models of the building components on a 1:1 scale right from the beginning, particularly for larger projects. Products can also be specified in a first step on the basis of “work samples” usually sized 200 x 300 mm. The above requirements must likewise be met by curved and flat glazing.

For further information refer to the following guidance sheets, guidelines and standards:

- VFF Guidance Sheet V.03 “Colour consistency of transparent glass in building” Issue 09/2004 (VFF Merkblatt V.03 “Farbgleichheit transparenter Gläser im Bauwesen”, Ausgabe 09/2004)
- Guideline “GEPVP – Code of Practice for in-situ Measurement and Evaluation of the Colour of Coated Glass used in Facades”, Issue 2005
- ISO/DIS 11479 „Glass in building – Coated glass – Part 2: Colour of facade“, 2011 version

Coating options for curved glass in relation to geometry, glass configuration and size must be agreed with the manufacturer on a case-by-case basis. The wide range of parameters mentioned above makes it impossible to specify generally achievable U_g -values, g -values, etc. The specified U_g -values and luminous and solar characteristics usually refer to flat glazing systems of identical glass configurations. They are determined in accordance with EN 673 and EN 410.

7.6.1 Glass with “easy-to-clean” coatings – Photocatalytic layers

When processing, glazing and handling “easy-clean” glass, care must be taken to follow the coating producer’s special glazing guidelines for avoiding silicone/ silicone oil. For cleaning the glass, use the normal cleaning methods and materials. Do not use abrasive cleaning agents. Soiling during the construction phase must be removed immediately with plenty water.

Wet glazing

The commonly used silicones for wet glazing can be replaced by alternative sealants approved by the glass/coating producer.

Dry glazing

For dry glazing it has become common practice to treat the gaskets/weather seals with silicone oil to improve processability. This is not permitted for photocatalytic, hydrophilic products because of the high creep characteristics of silicone oils which destroy the coating function.

Further processing information is available from the glass producers.

7.7 Insulating Glass Units (IGU)

7.7.1 Insulating glass with an exposed edge seal

Precautionary measures must be taken to protect exposed edge seals from UV radiation (cover strips, partial print, etc.), see Section 5.4.

Coated IGU is usually stripped of its coating at the edge seal. If there are exposed edge seals, the interface between coated and uncoated areas may show in the façade in the form of colour effects. This is caused by the production process and physical effects.

7.7.2 Small insulating glass panes

Insulating glass units defined as “small” have an edge length of < 50 cm (double-glazed insulating glass) and < 70 cm (triple-glazed insulating glass). The glass and the edge seal of such small-sized units are exposed to higher loads compared to larger sizes. The various parameters which affect small-sized insulating glass units must be taken into account.

The cavity of an insulating glass unit is hermetically sealed during manufacture, i.e. the air pressure and temperature conditions at the production site are sealed in the cavity. Fluctuations in temperature and air pressure (e.g. due to changing weather conditions or transportation to different geographical altitudes) also change the pressure inside the cavity. This exerts stress on the glass and the edge seal.

For further information, see BF Bulletin 003 “Guideline on the Use of Triple Insulating Glass Units”.

For unfavourable aspect ratios ($\geq 3:1$) and insulating glass units with large cavity widths (1 cavity > 16 mm or 2 x cavity > 12 mm), it is recommended that the pane(s) with risk of breakage, often the thinner pane, should always be made of TSG or HSG.



If small panes are installed in windows with glass-separating (“genuine”) glazing bars, an interesting option is provided by “Wiener Sprossen” bars which have an almost identical visual appearance.

7.7.3 Insulating glass with thermal insulation or solar control function

The technical characteristics of coated insulating glass units are the result of coating the cavity glass surfaces. The technical parameters are partly a function of the installation location of this coating. For installation, there is a sticker which indicates the correct installation position.

If coated insulating glass is to be combined with wired glass, consultation with the insulating glass producer is required. The combination of coated insulating glass units with tinted glass requires a tinted glass pane made of TSG or HSG.

7.7.4 Sound control insulating glass

Sound control insulating glass is defined as single glass or insulating glass units which considerably improve sound insulation. Sound insulation is mainly determined by the installed system comprised of window and facade. Aspects which need to be taken into account include:

- In general, sound control insulating glass units are subject to the same glazing principles as insulating glass units.
- The mass per unit area of sound control glass units is usually higher. Special attention should therefore be paid to detailing and the stability of the frames, building hardware and glazing blocks.
- The sound insulation provided by sound control glass will only work efficiently if the overall window unit including fixing and execution of the connecting joints is absolutely air tight.
- The contact pressure of the casement/sash must be ensured in one continuous perimeter length
- Staggered sealing planes
- Maximum distance of gaskets
- Use of sound control insulating glass (as per EN 12758)
- Correct wall connecting joints
- Type of opening of the window (e.g. side-hung or tilt-and-turn windows)

- Size of window (see correction values set out in DIN 4109 Part 35 and EN 14351-1, Annex B).

Sound control glass usually has an asymmetric configuration. The fitting position of the thicker pane is insignificant for the sound insulation function because of the normally diffuse incident sound. Except for noise situations with directed sound, the thicker pane should therefore be fitted to the outside for visual reasons.

7.7.5 Mid-pane devices

Observe the BF Bulletin 016 “BF Bulletin for the assessment of glazing bars in the cavity” (BF-Merkblatt 016 “BF-Merkblatt zur Beurteilung von Sprossen im SZR”). Care must be taken that the glazing bars are positioned parallel to the frame profiles. When calculating the load case of climatic design loads, the constraint on the deflection of the pane due to the glazing bars must be taken into account. The climatic loads may deflect the panes and reduce the cavity width. To ensure operability of the (moving) function, observe the system-specific minimum cavity widths as a function of the unit dimensions in addition to the structural design loads in accordance with the relevant standards (wind loads, live loads, climate loads).

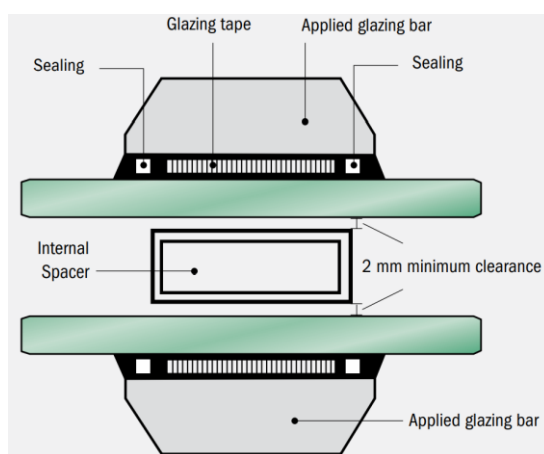


Fig. 5: Example of “Wiener Sprosse” glazing bar

7.8 Technical glass or active glass

Technical glass is defined as glass products whose function or characteristics can be changed by applying electrical voltage. These products require much closer cooperation of all parties involved than is usual for fenestration projects. This requires the involvement of, for example, the project planners/ designers (architect, general contractor, etc.), technical specialists (e.g. planner of technical build-



ing services (HVSE), facade designers, structural engineers), glass manufacturers, window and façade/curtain wall manufacturers, and building services technicians (e.g. electrical engineering, heating technology).

In addition to the product-specific glazing guidelines, for design/planning and execution the following must be taken into account (see also ift Guideline EL 01/1 (ift-Richtlinie EL 01/1) or the VFF Guidance Sheet KB.03 “Smart Windows” (VFF-Merkblatt KB.03):

- Basic operating options and control concepts
- Information on access points and wiring/cable routing
- Acceptance and operability test

7.9 Curved glass

Use of curved glass requires detailed design and planning of the window and façade system. The installation details of these products must also be taken into consideration. The BF Bulletin 009/2011 “Guide for thermally curved glass in buildings” (BF-Merkblatt 009/2011 “Leitfaden für thermisch gebogenes Glas im Bauwesen”) by the German Federal Flat Glass Association (Bundesverband Flachglas) provides initial guidance.

7.10 Mirrors

When using and installing mirrors, observe the Technical Guideline No. 11 “Mirrors – Handling and Installation” (Technische Richtlinie Nr. 11 “Spiegel – Handhabung und Montage”) by the Federal Glaziers’ Association (Bundesinnungsverband des Glaserhandwerks).

7.11 Vacuum glass

Vacuum glass is characterised by excellent thermal insulation properties, small thickness and low weight. It should be noted that the requirements for installation and processing (specified by e.g., the manufacturers) of vacuum glass differ from those for standard insulating glass units.

7.12 Suitability of use of glass products

Tabelle 3 zeigt eine Auswahl der möglichen Verwendbarkeit der zuvor beschriebenen Glasprodukte in Abhängigkeit der Nutzungsart, inkl. der zugehörigen technischen Regelwerke.



Suitability of use of glass types depending on type of use

Type of use	FG ^q	TSG ^a	LSG			Standards/Regulations
			FG	HSG	TSG	
A Vertical glazing (without barrier function)						
A.1 Vertical glazing (linear support)						DIN 18008-2
A.2 Vertical glazing (point-fixed)	SG ^r 					DIN 18008-3 DIN 18008-3
	IGU 					
A.3 Ventilated facade						DIN 18516-4
A.4 Structural Glazing	Internal 					ETAG 002
	External 					
A.5 Glass fins						Project-Related Construction Technique Permit
A.6 Shop windows						DIN 18008-2d
A.7 Floor-to-ceiling shop windows, all-glass door systems and draught porches						DGUV Regel 108-005, ARBSTÄTTV, DGUV Inform. 208-014, ASR A1.7
A.8 Sound-proofing wall						DIN 18008-2, ZTV-LSW 06
B Horizontal glazing (above circulation areas)						
B.1 Horizontal glazing ^e (linear support)	Above 					DIN 18008-2
	Below 					
B.2 Horizontal glazing ^{e,f} (point-fixed)						DIN 18008-3
B.3 Walk-on glazing						DIN 18008-5
B.4 Walk-on and barrier glazing	Above 					DIN 18008-6
	Below 					
B.5 Glass bar						vBG
B.6 Glass canopy						DIN 18008-2
B.7 Glass louvres						DIN 18008-2



C Barrier glazing							
C.1 Floor-to-ceiling glazing (Cat. A)	SG						DIN 18008-4
	IGU						
C.2 All-glass balustrade with fitted rail (Cat. B)							DIN 18008-4
C.3 Railing cladding – point-fixed ¹ (Cat. C1)							DIN 18008-4
C.4 Railing cladding - linear support (Cat. C1)							DIN 18008-4
C5. Underneath transoms (Cat. C2)	SG						DIN 18008-4
	IGU						
C.6 Floor-to-ceiling with projecting load-bearing bar (Cat. C3)	SG						DIN 18008-4
	IGU						
C.7 Double skin facade	Internal ^{n*}						DIN 18008-4
	External						
C.8 Lift shaft							DIN 18008-4, DIN EN 81-20
D Glazing in buildings with special use							
D.1 Office rooms (walls, doors, etc.)							ARBSTÄTTV, ASR A1.6, DGUV R.108-005
D.2 Schools							DGUV VORSCHRIFT 81
D.3 Child day-care centre							DGUV Regel 102-602
D.4 Hospital							DGUV Information 207-016
D.5 Shopping areas							DGUV Regel 108-005
D.6 Swimming pools							GUV-R 1/111, DGUV Regel 107-001
D.7 Sports halls							DIN 18032-1, DGUV 202-044
D.8 Squash halls							DIN 18038p, DGUV 202-044
D.9 Car park, bus station etc.							ARBSTÄTTV Anh. 1.7(4), ASR A1.6, ASR A1.7



D.10 Entrance halls and foyers	■	■	■	■	■	ARBSTÄTTV, DGUV R. 108-601, ASR A1.7
E Non-safety barrier indoor applications						
E.1 Shower enclosures	■	■	■	■	■	DIN EN 14428
E.2 Door infill sections	■	■	■	■	■	ARBSTÄTTV, DGUV Inform. 208-014
E.3 Door glazed panels in upper thirds of door	■	■	■	■	■	DGUV Information 208-014
E.4 All-glass door	■	■	■	■	■	ARBSTÄTTV, DGUV Inform. 208-014, ASR A1.7, DGUV Regel 108-005

Table 3: Suitability of use of glass types depending on type of use

- Minimum required type of glass
- Recommended type of glass
- Restricted type of glass
- Inadmissible type of glass
- Alternative type of glass

- a** In accordance with DIN 18008-2, due to the confidence level from nickel sulphide inclusions (spontaneous breakage), monolithic single glass or external monolithic IGU panes made of toughened safety glass (TSG) and TSG with heat-soak test can only be fitted if their upper edge is located less than 4 m above circulation areas. As an exception to the above, TSG with heat-soak test can be used as a monolithic single glass or an external monolithic IGU pane without restriction of the installation height if, by appropriate quality assurance measures, reliability class RC2 as set out in DIN 1990 is achieved by an appropriate limitation of the confidence level.
- b** According to DIN 18008-3 only if retaining clips are used.
- c** Use of LSG is subject to National Technical Approval (abZ) or Project-Related Approval (ZiE).
- d** No additional rules have been drawn up so far.
- e** If only monolithic glass is used, the requirements for the applicable type of glass apply to the lower pane if IGU is used.
- f** According to DIN 18008-3 only for plate point fixing. Only single glazing is allowed.
- g** In accordance with DIN 18008-5, the top glass sheet of HSG can be replaced with TSG. However, float glass as a top glass sheet is not allowed. For point-fixed support only LSG made of HSG panes is permitted.
- i** In accordance with DIN 18008-4, coarsely breaking types of glass may be fitted directly behind TSG glazing exposed to impact, provided that the latter has passed the pendulum impact test.
- j** As a rule, at least one pane in insulating glass units must be LSG.
- k** LSG made from float glass and rated as Category B glazing is not covered by the verification parameters in Table B.1 of DIN 18008-4.
- l** Support by retaining clips is subject to Project-Related Approval (ZiE) or National Technical Approval (abZ).
- m** Only Category C1 and C2 single glazing with linear support on all sides as specified in DIN 18008-4 can be configured as monolithic TSG.
- n** No safety barrier function.

- o** The material used for light transmitting areas up to 2.0 m in height must be unbreakable or these areas must be adequately shielded.
- p** As set out in DIN 18038 (now withdrawn) the back panel must be made of at least 12 mm TSG.
- q** Float glass in accordance with EN 572
- r** Single glazing
- s** TSG or LSG is recommended below the spandrel height.

Taken from: Glasbau, Grundlagen · Berechnung · Konstruktion, (Glass construction, Principles Calculation Design) 2nd Edition, Jens Schneider, Johannes Kuntsche, Sebastian Schula, Frank Schneider, Johann-Dietrich Wörner VDI-Buch, Springer Vieweg, Springer-Verlag Berlin Heidelberg, 2001, 2016



8 Maintenance of glass

8.1 Surface defects of glass

Defects on the glass surface can be caused by mechanical, thermal and chemical impacts.

8.1.1 Corrosion by alkaline agents

Due to mortar splashes, cement slurry, and washouts from fiber cement boards or untreated concrete surfaces, alkaline components can sometimes find their way onto glass surfaces and cause slight chemical burning and etching of the glass units.

Particularly during the construction process, the glass units already installed onsite must be protected from such effects. While fresh splashes of mortar or cement slurry which have not yet set can be rinsed off using clean water, the damage caused to the glass surface by corrosion can still be repaired in the most favourable cases using special cleaning agents such as acetic acid, whitening or cerium oxide. Long-term damage is usually irreparable. Check also whether any functional layers located on position 1 are subject to special cleaning instructions.

Glass can be (temporarily) protected by protective systems. These protective systems must also be checked for compatibility, including any change to the glass surface by application of these systems (e.g. changed surface stress of the glass caused by adhesives that may be shown by changed wetting characteristics).

8.1.2 Weld spatter/flying sparks from grinding and cutting wheels

Spatter from nearby site welding or grinding/cutting operations can cause permanent pitting of the glass surface and in some cases hot metal particles can fuse into the surface. Protect the glazing e.g. by mobile protective walls, timber panels, or similar measures.

8.1.3 Facade cleaning agents

During the construction process large amounts of dirt and debris are frequently deposited on facades, particularly on the walls. Efflorescence may also occur. Most agents used for cleaning these areas contain hydrofluoric acid whose components can corrode the glass surface. This must be prevented by covering the glazing with suitable protective systems.

8.1.4 Maintenance work

Once construction is complete, maintenance work may involve using substances such as caustic agents, wood preservatives, facade sealants or anti-fungal agents to prevent mould. The chemical components of these agents may attack the glass surfaces. Observe the manufacturer's instructions.

8.1.5 Streaking due to abrasion from glazing sealants

Various sealants are prone to abrasion during the cleaning process which produces streaks on the surface of the pane. Protect the glass unit from exposure to the above effects. General protective measures cannot be specified due to the great variety of causes. They must be dealt with and evaluated in each case and taken into account from the design and planning stage. Use of streak-free sealants is recommended

8.1.6 Cleaning and maintenance of glass

Periodically clean and maintain the glass products to guarantee their long-term function. The intervals can vary, depending on the glass product, installation situation and installation location, and must be specified individually. Observe the BF Bulletin 012/2012 "Cleaning Glass" (BF-Merkblatt 012/2012 "Reinigung von Glas").

Prior to removing particularly firmly attached dirt deposits, always check the compatibility of the cleaning agents used by testing and provide evidence of compatibility, as necessary.



9 Literature

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- [2] DIN EN 572-2 "Glass in building – Basic soda lime silicate glass products" Part 2 "Float glass"
- [3].DIN EN 673 "Glass in building – Determination of thermal transmittance (U-value) – Calculation method"
- [4].DIN 1249-11 "Glass in building – Glass edges"
- [5] DIN EN 1863-2 "Glass in building – Heat strengthened soda lime silicate glass" Part 2 "Evaluation of conformity/Product standard"
- [6] DIN EN 12150-2 "Glass in building – Thermally toughened soda lime silicate safety glass" Part 2 "Product standard"
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- [8] DIN EN 13830 "Curtain walling – Product standard"
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- [25] ift-Guideline VE-13/2 "Glazing of timber windows without glazing tape"
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- [27] Glaziers' Technical Guideline No. 3 "Blocking of glazing units"
- [28] Glaziers' Technical Guideline No. 11 "Mirrors – Handling and installation"

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