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Bundesverband Flachglas

Guideline on the Use of Triple Insulating Glass Units

In accordance with DIN EN 1279 Insulating glass units

Guideline on the Use of Triple Insulating Glass Units

Contents

1.0 Introduction

The bulletin applies to triple insulating glass units (IGU) in accordance with EN 1279.

The Energy Saving Regulation (EnEV) is Germany's main body of legislation for an efficient use of energy in new and existing buildings.

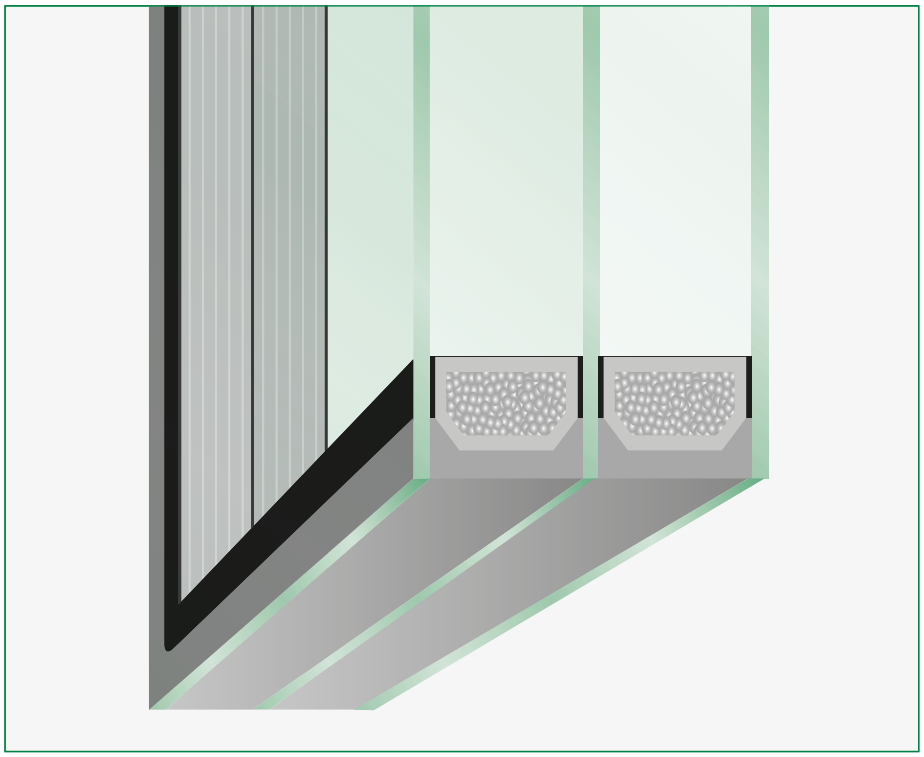
Due to the increased energy requirements set out in the amendments to the Energy Saving Regulation (EnEV) over the past 10 years, triple insulating glass units have become more or less standard products. This applies to both thermal-insulation glass units and the usual additional functions such as safety barrier glazing, sound insulation, solar control glass, etc...

The production of large amounts of triple insulating glass units has an enormous impact on production technology and the quality standards to be met for this.

The significantly increase in the use of triple insulating glass units requires a great many aspects to be recognised and taken into account. This Guideline is intended to address important questions which the manufacturers, designers and processors of triple insulating glass units are strongly recommended to bear in mind.

This Guideline does not cover the bonding of triple insulating glass units to frame profiles (see also BF Bulletin 001/2007 "Compass for bonded windows").

Schematic configuration of triple insulating glass unit



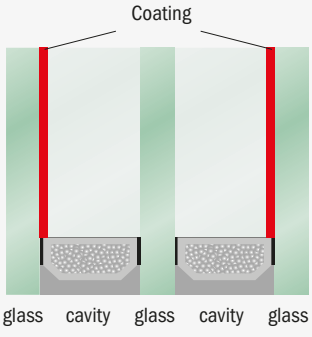
2.0 Triple insulating glass units

2.1 Configuration of triple insulating glass units

Triple insulating glass units achieve U_g-values significantly below 1,0 W/m²K.
The configuration of a triple insulating glass unit of this kind must therefore include two highly thermally insulating coatings, one facing each cavity. In addition, both cavities must be filled with inert gas.

2.2 Standard products

Standard products require large quantities of raw materials and semi-finished products. Krypton as filler gas for achieving lower U_g-values is not available in the quantities required for using it in triple insulating glass units as a standard product. Argon is therefore normally used.



Coatings are usually applied to positions 2 and 5. Other coating positions are possible for specific applications, but should be technically agreed with the manufacturer. Increasing cavity widths increase the climatic loads and expose the glass and the edge seal to higher loads. (See also Section 3.0) Smaller cavity widths (when using argon as filler gas) increase the U_g-values, whereas larger cavity widths decrease the U_g-values.

2.3 Typical U_g-values

Configuration	Emissivity	Coating	U_g-values (W/m²K)
			Argon gas filling (90 %)
4-10-4-10-4	0.03	Positions 2 + 5	0.8
4-12-4-12-4	0.03	Positions 2 + 5	0.7
4-14-4-14-4	0.03	Positions 2 + 5	0.6
4-16-4-16-4	0.03	Positions 2 + 5	0.6
4-18-4-18-4	0.03	Positions 2 + 5	0.5

Table 1: Examples of typical U_g-values

2.4 Achievable g-values

With the configuration described in 2.1, triple thermal-insulation glass units achieve a total thermal transmittance (g-value) of over 50 % which can vary slightly in each individual case depending on the base glass and coated glass used.

Solar control glass provides for significantly lower indoor room temperatures and, unlike other solar shading measures, has the key advantage of an unobstructed view from inside to outside as well as easy cleaning and high weather resistance. It is also fully operable at great building heights and when exposed to high wind loads.

Solar control insulating glass units have a total energy transmittance (g-value) of ~0.2 – 0.45, which is achieved by ultra-thin coatings applied to the glass surface along with low U_g-values as in a thermal insulating glass unit.
In addition to the almost colour neutral coatings, there is also the option of reflective and colour coatings which are sometimes still preferred.

Depending on the system selected, solar control coatings are located at positions 1 or 2 of an insulating glass unit. They can also be combined with glare protection systems and shading devices.

As set out in the Energy Saving Regulation (EnEV), evidence must be provided for thermal insulation in winter (annual heating demand, transmission heat loss) and thermal insulation in summer (reduction of air conditioning demand). These calculations require the U_g- and g-values of the insulating glass units.

If there is a coating on the central pane (coating on faces 3 and 5 or 2 and 4), e.g. for influencing the g-values of triple IGU, then the central pane must usually be toughened.

Guideline on the Use of Triple Insulating Glass Units

3.0 Factors affecting durability

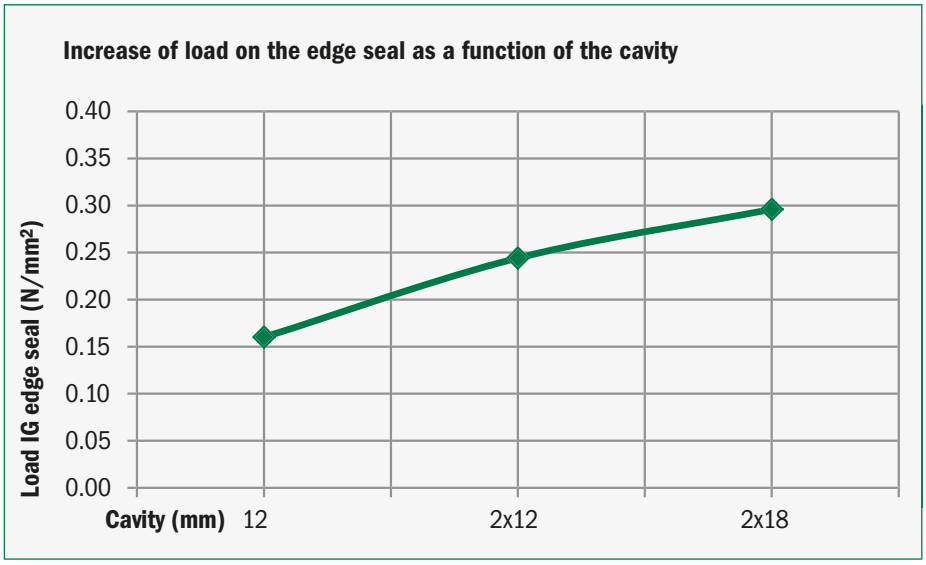
3.1 Glass design

Professional glass design in accordance with the Building Code is specified in the DIN 18008 series of standards “Glass in building - Design and construction rules”. Dimensioning is a design activity that should be agreed and remunerated separately.

3.2 Climatic loads

For verification of insulating glass units the effect of the pressure differences between the cavity and the ambient atmosphere must be taken into account. Based on the conditions during the insulating glass production, the pressure differences result from the temperature and pressure changes of the ambient atmosphere. The atmospheric pressure changes are caused by the meteorological conditions and the difference in the altitude between the production site and the final place where the insulating glass unit is installed.

The following example graph is for illustration only: The values (N/mm^2) shown in the graph apply only to the selected parameters such as the IGU configuration and load type.



- As in the example given in EN 1279-1 Clause 6, the boundary test conditions for this were selected in accordance with EN 1279-2.
- The thickness of the outer sealant (back cover) was assumed to be 3 mm.
- A simplified calculation was carried out (plate model).

(see BF-Bulletin 019/2015 “Guideline for Glass Design in Accordance with DIN 18008”)

3.3 Edge seal

The edge seal is the assembled edge of an insulating glass unit, designed to ensure that moisture and gas transmissions between the inside and outside of the unit are limited. It must be designed with a certain mechanical strength and with a certain physical and mechanical stability. Evidence must be provided in accordance with the DIN EN 1279 series of standards for insulating glass units. The details of the insulating glass edge seal are specified in the system description. Under particular conditions (e.g.place of installation, installation situation, configuration, shape, unfavourable side ratios, glass thickness) the back cover may require to be adapted. For the design of the edge seal refer to DIN EN 1279-1, Clause 6.1 and FprEN 16612:2018. For special installation situations contact the insulating glass manufacturer.

3.4 Special functions

The values for double insulating glass units obtained from experience cannot be applied directly to triple insulating glass units. (See also BF-Bulletin 017/2014 "Sound Insulating Glass"). For the frame construction the user must take into account the increase in total glass thickness and greater pane weight due to the the third pane and the additional cavity.

The special requirements of combinations with special functions such as safety (horizontal glazing, safety barrier, sound insulation, devices installed in the cavity) etc. require specific solutions for triple insualting glass units.

The statutory requirements for safety precaution must be taken into account as set out in DIN 18008-1 Clause 5.1.4.

4.0 Transport, storage and glazing

The requirements and recommendations for the transport, storage and glazing are contained in the BF-Bulletins 002/2008 "Guidelines for the Handling of Multi-Pane Insulating Glass Units" and 022/2018 "Glazing Guideline".

5.0 Other characteristics

5.1 External condensation

The following applies to all insulating glass units: The lower the thermal transmittance - the lower the U_g-value, the warmer the internal pane and the colder the external pane at low external temperatures. This also naturally applies to triple insulating glass units. In addition, the external pane directly "exchanges radiant heat" with the environment. Depending on the individual installation situation, re-radiation and windstill conditions will lead to considerable additional cooling of the external pane, particularly on clear nights. If the temperature of the external pane surface falls below the dew point temperature of the adjacent external air, condensation will result on the external pane and even the formation of ice, if the temperatures are low enough. This process is a natural phenomenon and generally known as the formation of dew or frost. The condensate will disappear with the heating of the external pane and external air, e.g. by the morning sun. This is a physical phenomenon and an indication of the excellent thermal insulation performance of the triple insulating glass unit.

Condensation can be reduced by special coatings at position 1.

5.2 Insulating glass effect

EN 1279-1 Annex G describes the "insulating glass effect" caused by variations in temperature and barometric pressure which results in concave or convex deflections of the individual glass panes with the occurrence of optical distortions. This is a physical effect and cannot be completely avoided. It is up to the designers/planners to include an option for reducing this effect if higher requirements need to be met.

5.3 Butyl leakage into the cavity

Butyl migration may occur in IGU configurations due to physical, chemical and mechanical effects.

Guideline on the Use of Triple Insulating Glass Units

6.0 Requirements for the visual quality of triple IGU

6.1 EN 1279 Part 1

The new EN 1279-1 (2018-10), Annex F now includes requirements for visual quality. This Annex is normative and the requirements are therefore mandatory. One important difference to the visual guideline is that EN 1279-1 Annex F stipulates an observation distance of “not less than 3 m".

The one-year co-existence phase of EN 1279 (2018-10) started on 19 March 2019. Both versions of EN 1279-1 (2004 and 2018) can therefore be used until 19 March 2020, after which the 2018 version must be used.

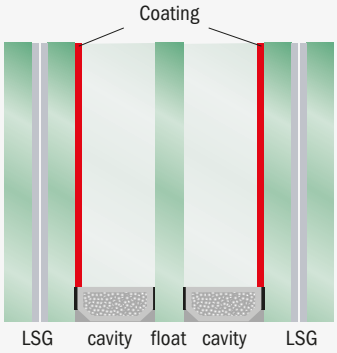
6.2 Guideline to Assess the Visual Quality of Glass in Buildings

The new EN 1279-1 made it necessary to revise the “Guideline to Assess the Visual Quality of Glass in Buildings” dating from the year 2009 as well. The structure (incl. Tables) of EN 1279-1 was adopted to ensure the comparability of the two documents. As the observation distance continues to be “1 m”, the requirements of the Guideline are much stricter than those in EN 1279-1.

6.3 Requirements for IGU pre-products

Depending on the configuration, a wide range of basic products (float glass, TSG, LSG, HSG, etc.) are used for the production of IGUs. The relevant product standards (e.g. EN 572-2, EN 12543, EN 1096-1) define the various allowable defects. Depending on the selected function of the IGU (e.g. sound insulation or burglar resistance) and based on the configuration required, the visible pre-product can have many visible surfaces.

The requirements for IGU set out in both EN 1279-1 and the visual guideline, are stricter than those permitted by the pre-product standards (number of surfaces x number of allowable defects).
It is recommended to agree on the use of the “Guideline to Assess the Visual Quality of Glass in Buildings” or on another mandatory quality level for each contract.



Model glass configuration triple IGU:
LSG 8 (44.2) coated/cavity/float/cavity/
LSG 8 (44.2) coated.

First LSG pane 44.2 with 2 surfaces of each float glass pane. Each film also with 2 surfaces, the coating is another surface, a total of 9 surfaces.

Central pane also 2 surfaces, third LSG pane, configuration 44.2, also 9 surfaces.

Total of overall configuration:
20 individual surfaces

7.0 Window and façade constructions (Measures should be addressed for the entire system)

Possible measures to further improve the thermal performance of window and façade constructions are, for example:

- Improve the thermal properties of the frame profiles
- Use of thermal insulation glass with thermally improved edge seal (see also BF-Bulletin 004/2008: "Guide to Warm Edge" and BF Data Sheets with representative Psi-values for window and façade profiles
- Thermal improvement of the glazing system using, e.g., an increased glass bite
- Multi-layer concepts (coupled window, multi-skin façade systems, etc.)

8.0 Literature

[1] DIN 18008-1 (2019): Glass in building - Design and construction rules – Part 1: Terms and general bases

[2] DIN 18008-2 (2019): Glass in building - Design and construction rules – Part 2: Linearly supported glazings

[3] DIN EN 410 (2011-04): Glass in building – Determination of luminous and solar characteristics of glazing

[4] DIN EN 673 (2011-04): Glass in building – Determination of thermal transmittance (U-value) – Calculation method

[5] DIN EN 1279-1 (2018-10): Glass in building - Insulating glass units - Part 1: Generalities, system description, rules for substitution, tolerances and visual quality

[6] DIN EN 1991 (2010-12): Eurocode: Actions on structures

[7] BF-Merkblatt 002/2008 „Guidelines for the Handling of Multi-Pane Insulating Glass Units"

[8] BF-Bulletin 004/2008: „Guide to Warm Edge"

[9] BF-Bulletin 006/2019 "Guideline to Assess the Visual Quality of Glass in Buildings"

[10] BF-Bulletin 022/2018: "Glazing Guideline"

[11] BF Information Sheet "Effect of Glazing Systems on the Daylight Supply of Indoor Rooms"

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