Bundesverband
Flachglas

Planning aid: Integrated, flexible Systems in Multiple-sheet insulating glass for architects, planners and users

Planning, performance and evaluation of ISiM (Integrated Systems in Multiple-sheet insulating glass)

ISiM units have been successfully used in all kinds of designs for over 20 years now, and have already proved themselves many times over in continuous operation. Integrating a solar control system into an insulating glass unit produces additional positive effects compared with the individual systems. Advantages over external shading systems and room-side anti-glare protection systems:

- No additional cleaning costs for the solar control system
- Maintenance-free
- Simple integration into buildings listed under preservation orders
- No annoying wind noises
- Variable privacy screening, anti-glare protection and solar control
- Combinability with e.g. fire protection, sound insulation

Crucial to ensuring many years of fault-free use of ISiM in buildings is knowledge of the performance capability, the areas of application and the potential of these systems. In the evaluation of summertime and wintertime thermal insulation, the properties of ISiM acquire a special status: basically a low Ug-value is required. For wintertime thermal insulation, the highest possible total energy transmittance (g-value) is desirable; for summertime thermal insulation, on the other hand, a g_{total} value adapted (reduced) to the cooling load is required.

The question of total energy consumption (primary energy demand) is playing an increasingly important role in the planning of buildings. In addition to heat energy in winter, air conditioning during the summer and the illumination of rooms make a significant difference. An intelligent arrangement of the glass surfaces for subsequent energy consumption is therefore of crucial importance.

The complexity of the subject means that it needs to be intelligibly explained to planners, because the scope of energy input provided by flexible solar control (shielding in summer – opening in winter) is very large.

The German Energy Saving Regulations (EnEV) govern, in conjunction with the latest standards, compliance with limit values for summertime thermal insulation. Calculation of the characteristic solar-energy value in accordance with EnEV is based on the fundamental principles described here.

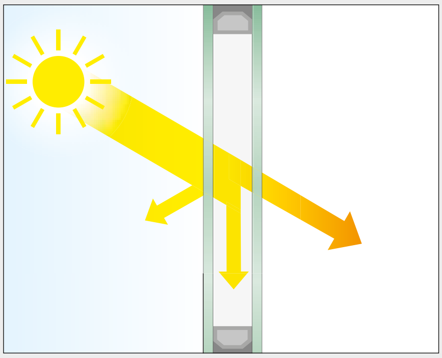
Principles

Full solar radiation must be taken as the basis for summertime thermal insulation. Light transmittance, light reflection and light absorption factors take into account only 45 % of the solar spectrum and are not sufficient for assessing summertime thermal insulation.

Three terms are crucial to summertime thermal insulation:

Transmission

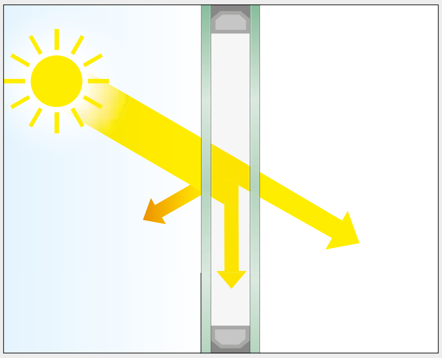
Radiation transmission



Transmission - τ_e
How much radiation passes through a component. 0 to 100 % or 0 to 1.

Reflection

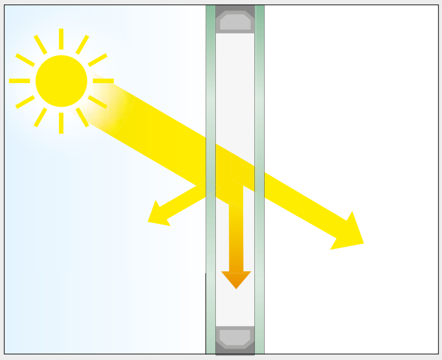
Radiation reflection



Reflection - ρ_e
How much radiation is reflected by a component. 0 to 100 % or 0 to 1.

Absorption

Radiation absorption



Absorption - α_e
How much radiation is absorbed and heats the component. 0 to 100 % or 0 to 1.

(Figure 1)

How much solar energy arrives inside the room?

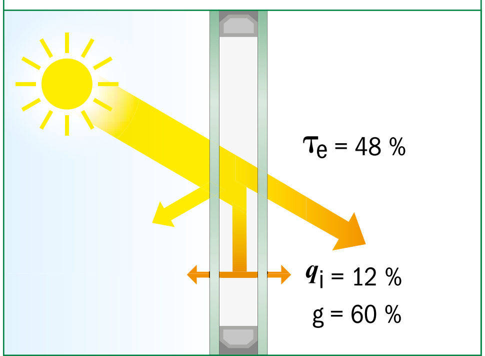
The characteristic quantity for calculating the total energy input through a component is the g-value.

Example:
The sun shines on a 1 m² window. The radiation energy in our case is 800 W/m². The g-value of double or triple insulating glass panes with heat-insulating layer ranges between 0.49 and 0.63, and in our example 0.60 or 60 %.

This produces the following energy input through the glass:
800 W/m² x 1 m² x 0.60 = 480 W

The smaller the g-value, the less energy that penetrates into the room.

τ_e = Radiation transmission
q_i = Secondary heat output factor, inside
g = Total energy transmittance



(Figure 2)

Solar control can reduce the energy input

Total energy transmittance g_{total}
The total energy transmittance of the glazing including solar control g_{total} can be calculated in simplified form using the following equation.

$$g_{total} = g \times Fc$$

g_{total} = total energy transmittance of the glazing including solar control

g = total energy transmittance for the glazing

Fc = reduction factor for solar control equipment

Flexible solar control offers the possibility of achieving adjustable g_{total} values ranging between the g-value of the insulating glass pane and the g_{total} value of the overall system.

Reduction factor Fc
This property is defined in DIN 4108 Part 2 as the reduction factor Fc. The reduction factor Fc can fluctuate between 0 (theoretically the best solar control) and 1 (no solar control). The lower Fc is, the more effective the solar control and the lower the energy input. The Fc value indicates the ratio between the energy transmittance through a window with solar control and one without solar control. An Fc value determined for an ISiM unit varies on account the type of coating and its position in the multiple-sheet insulating glass.

Example:
Double thermal insulating glass:
g-value glazing 0.60
g_{total}-value 0.12

$$\mathbf{Fc} = \frac{g_{total}}{g} = \frac{0.12}{0.60} = \mathbf{0.20}$$

Example:
Triple thermal insulating glass
g-value glazing 0.60
g_{total}-value 0.08

$$\mathbf{Fc} = \frac{g_{total}}{g} = \frac{0.08}{0.60} = \mathbf{0.13}$$

DIN 4108-2 shows Fc values in Table 8 for intermediate systems of 0.65 to 0.90 depending on colour and transparency. These values are very much on the safe side and must be understood as maximum values. Footnote b to this table includes the recommendation to conduct a precise calculation for solar control equipment between sheets, since significantly better values can be obtained (see examples, Figures 3, 4, 5 and 6).

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Effectiveness of variable ISiM

The major advantage of flexible solar control systems is that their effectiveness (reduction factor Fc or g_{total}) can be varied depending on the situation. This is also a crucial advantage in view of the utilization of daylight. Regulating solar control in such a way that enough light always enters the room to be able to dispense with artificial lighting opens up further potential for savings.

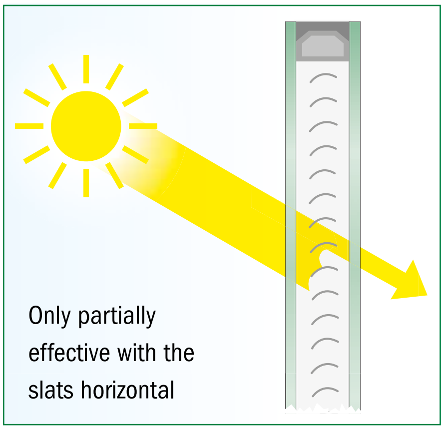
Daylight delivers for every watt up to 4x more brightness than artificial light, additionally reducing the cooling loads for the same illuminance.

For practical applications, a more complex consideration therefore results:

The effectiveness of solar control depends in this example on the chosen slat position, i.e. on the corresponding user behaviour (see Figures 3 and 4).

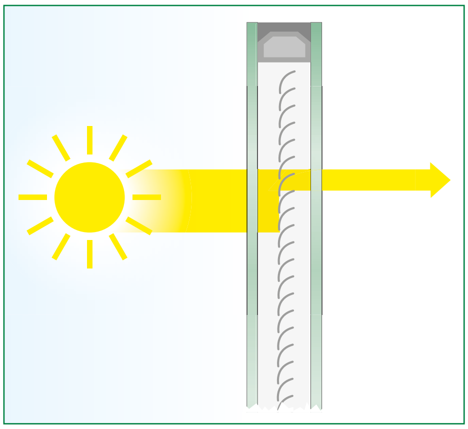
On the other hand, the values change with the position of the sun and the associated angle of radiation incidence (see Figures 5 and 6). The steeper the angle of the sun, the lower the g_{total} value.

Example: g_{total} = 0.36
with slats open



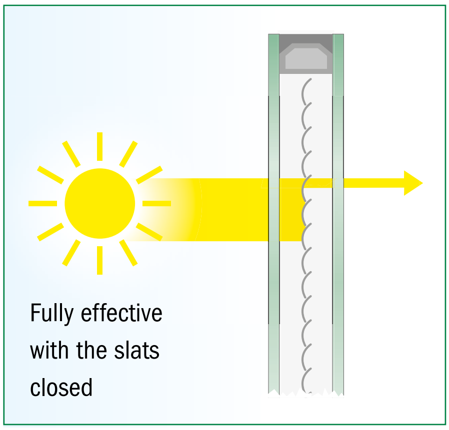
(Figure 3)

Example: slat silver; angle 45°
g_{total} = 0.33 at 0° sun angle



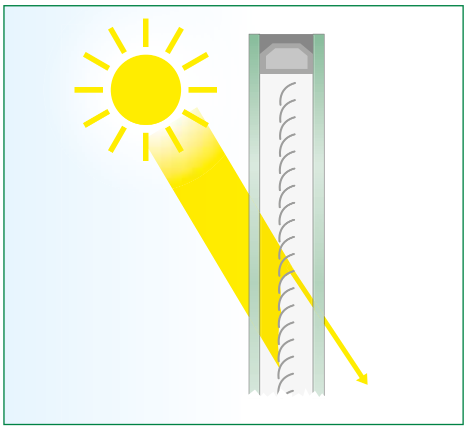
(Figure 5)

Example: g_{total} = 0.12
with slats closed



(Figure 4)

Example: slat silver; angle 45°
g_{total} = 0.08 at 60° sun angle



(Figure 6)

Product properties

ISiM

ISiM units help to reduce energy transmittance (g-value) in summer, in that the solar energy is reduced, anti-glare protection against direct light is regulated, creating a more agreeable room atmosphere. Integrated systems also help in winter to provide a cosier living climate, since the superposition of several planes (glass and hanging) reduces heat transfer (U value). This is also a significant aspect at nighttime or at many times during the day in winter when sunlight is no longer essential for room illumination.

Notes for a glass structure

Combined triple insulating glass structures with thermal insulation/solar control layer at plane 2 and thermal insulation layer at plane 5 are now increasingly being used, in which the hanging is consequently located between two coated glass planes. An increase in the hanging temperature – particularly the slats – is thus unavoidable, although the temperature must not, depending on the structure, exceed certain limits. The slats reduce the transfer of solar energy, convert some of that energy into heat and transfer this in part to the interior. The choice of coating planes must be coordinated with the system manufacturer to limit the rise in temperature. It is therefore important to make the right choice, both for the type of glass to be used and for the colour of the slats, the radiation absorption of which should be as low as possible.

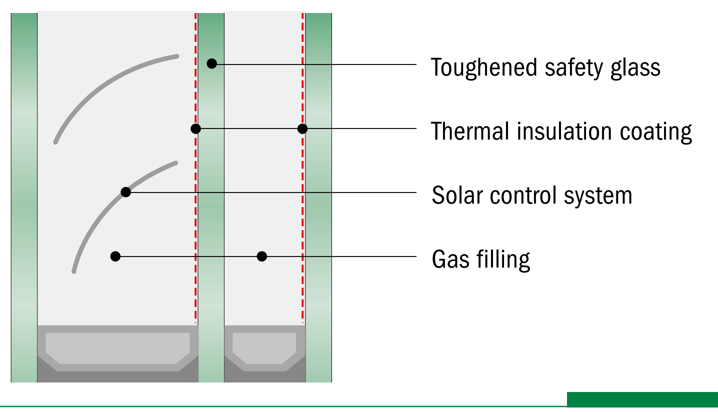
The position of the hanging – i.e. the decision as to which cavity the hanging is to be located in, for example for triple glazing – is therefore of fundamental importance. It is recommended to install the hanging in the outer cavity, i.e. between planes 2 and 3. The coatings should preferably be positioned at planes 3 and 5 (see Figure 7).

Technical data for the overall system can be requested from the manufacturers.

Climate loads can cause the panes to be deformed and reduce the cavity. In addition to the structural design loads as set out in the applicable standards (wind, traffic, climate loads), it is necessary, depending on the element dimensions, to comply with the system-specific minimum distances of the cavity to safeguard the movable function. Control functions can, in addition to glass dimensioning, support the performance capability under unfavourable climatic conditions (e.g. low outside temperatures).

Choice of colour for hangings

While the choice of colour can be made according to creative considerations when ISiM units are used indoors (e.g. partition walls), it is recommended in the case of the outer façade to confine the choice of colour on surfaces with low absorption levels (bright colours).



(Figure 7)

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Product types

1. What is a shutter system?
A shutter system is a hanging consisting of adjustable aluminium slats which, when adjusted, regulate the incidence of light and incoming solar radiation. The slats also have raising, lowering and turning functions. The shading and privacy-screening functions can thus be regulated whenever necessary.

1.1. Operation possibilities
Moving the slats facilitates a rapid change from blackout, with the slats sloped at an angle, to full room brightening, with the slats horizontal. There are numerous possibilities for operating the shutter system, which essentially can be divided into two categories: electrical and manual.

Manual operation is by cord, rod, chain, crank, etc. Electrical operation can be achieved for example by the following different variants: individual or group controls, infrared remote controls, temperature or solar monitors, timers and BUS systems. A wide range of connections and combinations is possible.

1.2. Range of colours for slats
As well as standard colours, virtually all RAL shades can be used as special colours (see note, Page 5).

1.3. Special applications
Special combinations, special usage possibilities, special forms, glass combinations with thermal insulation and solar control and facade glass are possible, as is screen-printed and sandblasted glass. Further fields of application are: sound insulation, safety and security protection, fire protection, laser and X-ray protection, model sheets (special forms).

2. What is a roller-blind system?
A roller-blind system is a roll-up and roll-down fabric/film hanging which, depending on the material used, offers a variety of solar control options. This hanging material is wrapped over a shaft that is visible or integrated in a head profile.

Roller blinds consist of metal-coated polyester films or fabrics with a surface as reflective as possible facing the outside. Roller blinds can be moved up and down. Glazing with roller blinds is possible both in the vertical and in the overhead area.

2.1. Operation options
Roller blinds too can have manual and electrical drives to move the hanging.

2.2. Special applications
The running direction can be freely chosen on many roller blind systems, from the top down or from the bottom up.

Special combinations, special usage possibilities, special forms, glass combinations with thermal insulation and solar control and facade glass are possible, as is screen-printed and sandblasted glass. Further fields of application are: sound insulation, safety and security protection, fire protection, laser and X-ray protection, model sheets (special forms).

Non-transparent hangings can be used for privacy screening or blackout.

3. What is a plissé hanging?
A plissé hanging is a fabric/film hanging whose material is horizontally prefolded and is folded up like a concertina into a pack and opened. The solar control effect depends on the material used. The dimensions of the folds are variable.

3.1. Operation options
The hanging can be raised and lowered manually or by means of a motor.

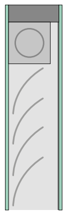
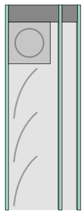
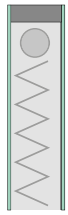
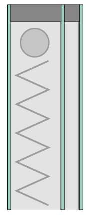
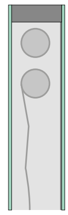
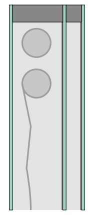
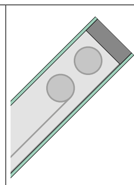
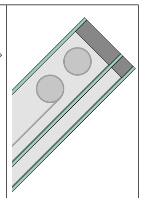
3.2. Special applications
Special combinations, special usage possibilities, special forms, glass combinations with thermal insulation and solar control and facade glass are possible, as is screen-printed and sandblasted glass. Further fields of application are: sound insulation, safety and security protection, fire protection, laser and X-ray protection, model sheets (special forms).

Continuous function and longevity
The performance capability of ISiM is verified in accordance with the normative specifications and requirements and Test Guideline VE 07/2 of ift Rosenheim.

The following BF Technical Guides provide further information on ISiM:

- BF Technical Guide 005/2009 Processing Guidelines Solar Control Systems in the Cavity – Installation in Insulating Glass
- BF Technical Guide 007/2010 Guideline for Assessing the Visual Quality for Systems in Multiple-Sheet Insulating Glass
- BF Technical Guide 008/2010 Installation Recommendations for Integrated Systems in Multiple-Sheet Insulating Glass

Examples of manufacturer-independent function values

								
System	Shutter		Plissé		Roller blind			
Size/area*								
Min. width	400	400	400	400	350	350	350	350
Min. height	400	400	400	400	400	400	400	400
Max. area	4.5 m²	4.5 m²	4.5 m²	4.5 m²	2.4 m²	2.4 m²	2.4 m²	2.4 m²
Max. width	2500	2500	2500	2500	1300	1300	1300	1300
Max. height	3000	3000	3000	3000	3000	3000	2700	2700
Functions **								
Raising / Lowering	■	■	■	■	■	■	■	■
Turning	■	■						
Technical properties								
Ug-value acc. EN 673, in W/m²K ε_n thermal insulation layer 0.03 solar control top	1.2	0.7	1.2	0.7	1.1	0.6	1.2 ****	0.7 ****
g-value$_{Glas}$ acc. EN 410 ε_n thermal insulation layer 0.03 solar control top	0.60	0.50	0.60	0.50	0.60	0.50	0.55	0.47
g_{total}-value *** acc. EN 13363-2, shutter closed, slat colour silver, dependent on sun altitude angle	0.12 - 0.08	0.08 - 0.06						
g_{total}-value *** acc. EN 13363-2 film closed, dependent on film type					0.12 - 0.03	0.11 - 0.03	0.12 - 0.03	0.11 - 0.03
g_{total}-value *** acc. EN 13363-2 plissé closed dependent on plissé fabric			0.12 - 0.07	0.09 - 0.07				

* The product-specific minimum and maximum dimensions must be agreed based on the specific project and specific manufacturer
** System-specific limitations in function may be encountered depending on size and height-to-width ratio
*** System-specific deviations in the values may be encountered depending on the material used
**** Values are dependent on the angle of inclination
All values and properties of ISiM must be specified on a manufacturer-specific basis

This bulletin was produced by: Working group 'Systems inside the cavity' at Bundesverband Flachglas e.V. · Mülheimer Straße 1 · D-53840 Troisdorf

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