

1. DESCRIPTION

1.1 What is BI-Combiset ?

BI-Combiset is the BGT brand name for laminated safety glass (VSG). It consists of at least two single panes of glass which are joined together by a strong, tear-resistant polyvinylbutyral film (PVB). The safety effect of VSG depends on the one hand on the high tear resistance of the PVB film and on the other hand on its excellent adhesion to the glass. The strength of the tough film makes it possible to manufacture laminated glass, which provides protection from thrown articles, break-in, gunshot and explosion. In addition the excellent adhesion to glass also provides a strong binding system for splinters and thereby a reduction in the risk of injury.

BI-Combiset can consist of combinations of float glass, tempered and semi-tempered glass or colour-coated glass. Moreover all VSG units can be further processed into insulating glass.

1.2 Manufacture

According to the desired function and the resulting structure one or more PVB intermediate layers are placed between the individual glass panes and then pressed together with the glass in a rolling process. The preconnected elements are thereafter put into an autoclave in which they are joined together under temperature and pressure into a solid and clearly transparent unit.

1.3 Brand symbol / approval markings

The corresponding brand symbol is applied according to the version and the product specification.

2. PROPERTIES

2.1 Impact resistance

As a high-quality safety glass, BI-Combiset fulfills the requirements of the pendulum impact test according to DIN 52337 and DIN 52338.

2.2 Bending strength

The bending strength of the laminated glass is determined by the strength of the individual panes.

	Strength	Permitted stress *
Float glass	45 N/mm ²	15 N/mm ²
ESG	120 N/mm ²	50 N/mm ²
TVG	70 N/mm ²	29 N/mm ²

In calculating the stress in laminated glass the adhesive effect of the films is not taken into account.

2.3 Temperature resistance

In the case of laminated safety glass (VSG) a temperature resistance of up to 60° C is specified. The continuous temperature load on VSG should not exceed 70° C.

The thermal coefficient of elongation is approx. $9 \times 10^{-6} \text{ K}^{-1}$ as for single glass.

The heat transition coefficient (k value) of VSG glass is hardly influenced at all by the mostly thin films. The changes with respect to single glass can be neglected.

- Taking account of a corresponding safety correction value.

2.4 Light transmission

The light transmission of VSG glass is similarly hardly influenced at all by the mostly thin films and accordingly corresponds to the sum of the individual glass panes. At a thickness of 8 mm BI-Combiset has a light transmission of approx. 88 %. For the high protective classes (e.g. B3, break-in resistance) the noticeable fall in light transmission can be compensated for by the use of white glass (float glass which is low in iron-oxide).

PVB films act as UV absorbers, i. e. the ultraviolet radiation of the sunlight is absorbed and not transmitted through. Thus for example sensitive products can be protected from „yellowing“

In comparison:

Structure	UV transmission in the visible range 280 - 380 nm
2 x 4 mm glass	43,3 %
2 x 4 mm glass + 0,38 mm film*	≤ 2,4 %
2 x 4 mm Glas + 0,76 mm film*	≤ 0,5 %

* Film for building glazing and other applications except for automotive.

2.5 Sound insulation

Laminated glass has better sound insulation properties in comparison with the same thickness of monolithic glass panes. Firstly the higher elasticity of the plastic compared with glass reduces the flexural stiffness for the same weight resulting in an improvement in vibration behaviour. Secondly the internal damping of laminated glass is higher than that for single glazing. The improvement in the evaluated sound absorbing value with PVB is typically approx. 2 dB.

3. TYPES OF LAMINATED SAFETY GLASS

3.1 BI-Combiset standard glass

Splinter-binding laminated safety glass made from two or more panes of plate glass contains as standard one 0,38 mm thick PVB film. Thicker films (0,76 mm; 1,14 mm; 1,52 mm) and more layers of film can be supplied.

3.2 BI-Combiset for attack-resistant glazing

BI-Combiset is also available in various types and versions of attack-resistant glazing. This glazing is used in the public, commercial and private areas whereby the user can determine the type of attack-resistant glazing and its resistance class according to the desired protective effect.

The safety classifications are:

3.2.1 Resistance to penetration by thrown items

Classes A1 to A3 according to DIN 52 290 Part 4

Classes P1 - P4 according to EN 356

3.2.2 Resistance to breaking in/out

Classes B1 - B3 according to DIN 52 290 Part 3

Classes P5 - P8 according to EN 356

Classes EH01 -EH3 according to VDS

BGT Bischoff Glastechnik possesses its own permits for these classifications. You can find the exact type descriptions with the permit numbers from the following lists.

3.2.3 Comparison of attack-resistant glass types

Type of glass	Resistance class according to DIN 52 290	Resistance class according to EN 356	Resistance class according to VdS	Applicational examples	Type of test	Testing institute / test certificate or approval
P1 - 07	-	P1	-	Single and multi-family houses	3 x falling ball from 1,5 m height	MPA 410 119 495
A1 - 07	A1	P2	-	In housing estates	3 x falling ball from 3,5 m height	MPA 410 118 895
A2 - 08	A2	P3	-	Remote houses	3 x falling ball from 6,5 m height	MPA 410 120 295
A3 - 08	A3	P4	-	Exclusive houses and villas	3 x falling ball from 9,5 m height	MPA 410 117 195
EH01 - 08	A3	P4	EH01	Exclusive houses and villas	3 x falling ball from 9,5 m height	VdS M 94 406 15A
EH02 - 09	-	-	EH02	Schools and kindergardens	9 x falling ball from 12,5 m height	VdS M 94 406 15B
B1 - 18	B1	P6	-	Parts of shops	30 - 50 axe strikes	MPA DB 95023
B2 - 20	B2	P7	-	Art and antique businesses	51 - 70 axe strikes	MPA DB 95024
EH2 - 24	-	-	EH2	Museums, psychiatric institutions	51 - 70 axe strikes	VdS M 954 1218 A
B3 - 24	B3	P8	-	Jewellers, courts of justice	over 70 axe strikes	MPA DB 96006
EH3 - 35	-	-	EH3	Manufacturing facilities for furs and leather goods	over 70 axe strikes	VdS M 954 1218 B

Up to class EH02 falling ball tests are carried out according to standard processes. Here it is determined whether a steel ball of about 4 kg can penetrate the sample upon impact with the required number of tests and at the corresponding falling heights. Higher resistance classes are tested under defined conditions for exam-

ple according to the German standard DIN 52290.

Typical applicational areas are the glazing of windows and doors of private and commercial premises against break-ins, the glazing of psychiatric clinics and courts of justice, as well as the glazing of animal cages, open-air enclosures and aquaria.

3.2.4 Gunshot resistance

Gunshot-resistant glazing is mainly used in banks, administrative and business premises.

BGT has its own permits available for this category (see table). Tests on splinter-free designs can be carried out as required by the customer.

Type of glass	Resistance class according to DIN 52 290	Resistance class according to EN 1063	Type of gun	Calibre	Test institute / test certificate or approval number
BR1 SA-15	-	BR1 SA	Rifle	22 lr	DSC 96 029
BR1 SF-21	-	BR1 SF	„	„	DSC 96 039
BR2 SA-22	C1 SA / B1	BR2 SA	Handgun	9 mm Para	DSC 96 030
BR3 SA-25	C2 SA	BR3 SA	Handgun	357 Magnum	DSC 96031
BR4 SA-29	C3 SA	BR4 SA	Handgun	44 Magnum	DSC 96032
BR5 SA-40	-	BR5 SA	Rifle	5,56 x 45	DSC 96 040
BR6 SA-51	C4 SA	BR6 SA	Rifle	7,62 x 51	DSC 96 041
SG1 SA-37	-	SG1 SA	Shotgun	12/70	DSC 96 042
SG2 SA-45	-	SG2 SA	Shotgun	12/70	DSC 96 043

3.2.5 Explosion resistance

Glazing in public buildings and military facilities, e.g. airports.

Classes D1 to D3 according to DIN 52 290 Part 5.

3.2.6 Installation information for attack-resistant glazing

BI-Combiset panes have been tested by official testing institutes. Changes in the structure are thus only possible by additional layers on the attack side with or without intermediate gaps, i. e. all tested glass can also be offered as insulating glass combinations.

Combinations with tempered glass panes have been subjected to supplementary tests and are approved for use under the type designation with the suffix „E“ (see also Point 7)

In principle the protection described can only be achieved if the panes are bordered on all sides with a frame. Glazing beads are funda-

mentally to be mounted on the opposite side from the likely attack side so that they can withstand attack. BI-Combiset panes can be constructed asymmetrically. For this reason when ordering and during glazing it is particularly important to be aware of the attack side and the protective side. This protective side is marked with a corresponding label in the manufacturing works.

3.3 **BI-CombisetHestral**

BI-Hestral, heat strengthened - or sometimes also called semi-tempered - glass, is a safety glass whose internal stress range is between normal float glass and tempered glass.

The difference between heat strengthened and fully tempered glass is the fracture appearance when broken. Whilst fully tempered glass breaks up into a multitude of small crumbs, heat

strengthened glass bursts out from the impact point with radial cracks.

BI-HESTRAL, when combined as a laminated glass, offers quite considerable advantages in certain applicational areas where particular safety criteria must be satisfied.

Due to the toughness of the film the necessary residual safety is achieved in the case of a breakage (e.g. due to vandalism or gunshot). In the most frequent cases only one pane is destroyed and the function and bearing capacity of the glass pane combination is retained. If both panes are destroyed the fracture appearances of the outer and inner pane are normally not congruent, which means that the laminated glass package still possesses a residual bearing capacity and thus the stability and function are largely retained. The broken pieces adhere to the film and remain dimensionally stable. No dangerous parts splinter off or fall down.

Laminated glass panes, in which both panes are fully tempered, would have a much lower stability in such a case. If both panes are broken thousands of tiny cracks occur due to the crumbling action, which causes the whole element to become unstable.

BI-CombisetHestral is therefore extremely recommendable for overhead, balustrade and façade glazing.

3.4 ALARM BI-Combiset

All BI-Combiset types can be provided with ALARM BI-TENSIT.

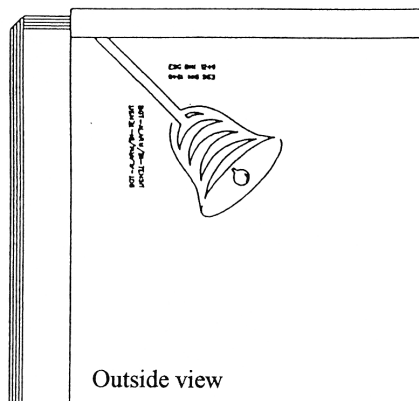


Fig. 1: BGT Alarm spider with 4 core flat cable. The conductor strips are burned into the surface of the glass.

The approval of ALARM BI-TENSIT as BI-Combiset laminated safety glass is granted under the number G 195034.

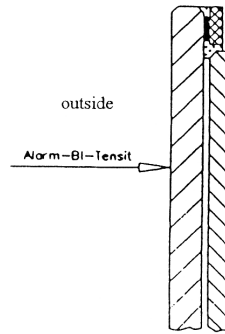


Fig. 2: ALARM BI-TENSIT combined with BI-Combiset laminated safety glass.

The insulation glazing has the approval - number G 195100.

3.5 BI-Combiset special combinations

VSG-glass can be manufactured with a multitude of functional glass products. Amongst these are BI-TENSIT safety glass; BI-COLOR colour-coated glass; BI-FireStop - fire protection glass, sun and sound insulating glass as well as white glass.

We would be happy to advise you on the great number of combination options.

4. APPLICATIONS

4.1 Overhead glazing/ roof glazing

In this application protection from falling objects - and at the same time in the case of glass breakages protection from pieces of glass - are the decisive factors. For the reason laminated safety glass is specified for overhead glazing. The splinter-binding properties of VSG guarantee a high level of safety. (In this connection read the special information under Point 3.3)

4.2 Balustrade glazing

To provide safety from falling balustrade glazing is usually made from laminated safety glass.

If there is mechanical overload (shock or impact) the glass breaks, however the broken pieces adhere firmly to the intermediate layer. The risk of injury is significantly reduced since no loose or sharp-edged glass splinters can occur.

4.3 Window glazing for high-speed vehicles

All VSG glass intended for use in vehicles must be approved and must carry the approval stamp. The tests are carried out by the safety glass testing centre at the premises of the National Material Testing Authority in Dortmund. The exact requirements for the respective application are officially specified.

4.4 BI-StepColor, walk-on glass

You can find a detailed description with applicational options and technical data in our product information sheet entitled: BI-StepColor

5. GLASS DIMENSIONS AND TOLERANCES

5.1 BI-Combiset strip dimensions

The glass panes which can be supplied in strip form are summarized in the following table.

Supplied loose on cradles

Typ 3/0,38/3 oder 3/0,76/3 (glass/film/glass in mm)				
Size (mm)	Panes/ stuck	Sq.m/ pane	Sq.m/ total	Weight (kg)
2000 x 3210	13	6,24	99,84	1216
2250 x 3210	13	7,22	101,08	1408
2400 x 3210	13	7,70	92,40	1501
Typ 4/0,38/4 oder 4/0,76/4				
2000 x 3210	10	6,24	74,88	1248
2250 x 3210	10	7,22	72,20	1444
2400 x 3210	10	7,70	69,30	1540

5.2 Dimensions

The normal maximum production thickness of BI-Combiset is 80 mm.

Maximal dimension (mm)	Minimal dimension (mm)
Autoclave 1: 2700 x 3800 2150 x 4050	300 x 400
Autoclave 2: 1910 x 6900	
Autoclave 3: 1800 x 3210	
max. pane weight:	
Single pane: 350 kg	
Total package: 1000 kg	

Other maximum formats can be realized by means of the vaulted door of the autoclave. Sizes in excess of the format 2700 x 3800 mm however can only be made in low piece quantities. Please ask our responsible sales staff.

5.3 Dimensional tolerances

The dimensional tolerances of BI-Combiset laminated safety glass are derived from the dimensional tolerance of the individual panes and the displacement tolerance during assembly.

5.3.1 Dimensional tolerances for cut edges and bordered edges

Pane size	Element thickness		
	Up to 8 mm	Over 8 mm	With minimum of 1 single pane from 10 mm thickness
to 1000 mm	± 1,0	± 1,5	± 2,5
to 1500 mm	± 1,5	± 2,0	± 3,0
to 2000 mm	± 1,5	± 2,0	± 3,5
to 2500 mm	± 2,5	± 3,0	± 4,0
over 2500 mm	± 3,0	± 3,5	± 4,5

5.3.2 Dimensional tolerances for ground edges

Pane size	Glass thickness		
Width or height	Up to 24 mm	Up to 35 mm	over 35 mm
Up to 500 mm	± 1,0		
Up to 1000 mm	+ 1,0 - 2,0	+ 1,0 - 3,0	+ 1,0 - 4,0
over 1000 mm	+ 1,0 - 3,0		

Combinations of BI-TENSIT, BI-HESTRAL, BI-COLOR and BI-FireStop cannot be modified or processed after manufacture

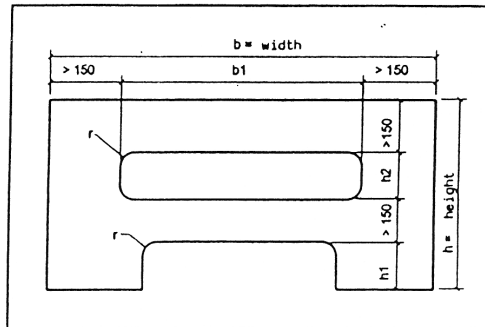
5.3.3 Cut-out tolerances

The highest value of the sums of all cut-out heights and widths

$h_1 + h_2$ with respect to h or

$b_1 + b_2$ with respect to b

should be taken from the following table depending upon the glass thickness.



The minimum size of the remaining glass land: 150 mm.

Corner radius, smallest radius r in mm:

- for finely-ground edges $r \geq 10$ mm

- for polished edges $r \geq 25$ mm

from glass thickness 26 mm $r \geq 20$ mm

For cut-outs with semi-circles the hole tolerances will apply.

Glass thickness in mm	Guide value for total height or width of all cut outs	Tolerances in mm
7	0,1 b or h	± 2
9	0,2 b or h	± 2
10 - 15	0,3 b or h	± 2
16 - 20	0,4 b or h	± 2
22 - 27	0,5 b or h	± 3

5.3.4 Hole tolerances

Hole diameter	Tolerances	
	Holes	Hole position
Up to 90 mm	- 0 / + 2 mm for glass thickness < 24 mm - 0 / + 3 mm for glass thickness ≥ 24 mm	± 2,0 mm
Up to 250 mm	- 0 / + 4 mm for glass thickness < 24 mm - 0 / + 5 mm for glass thickness ≥ 24 mm	± 2,0 mm

Larger diameters upon request.

Otherwise the technical production restrictions apply for the respective type of glass. More details can be found in the corresponding BGT product information sheets (BI-Tensit, BI-FireStop, BI-StepColor)

5.3.5 Offset tolerances

Offsets for tempered glass:

For tempered VSG combinations it is logical to use the holes and/or partial sections of the individual monolithic panes. Through this offsets occur during lamination, which are added together from the tolerances of the geometrical holes / partial sections and their positions. Offsets of 3 mm and more (depending on the size of the unit) must be included.

If the tolerances are very low this must be agreed technically beforehand.

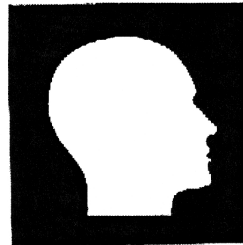
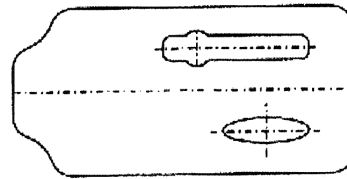
6. SPECIAL SHAPES

Laminated glass packages made from 2-fold non-tempered glass can be cut in a conventional way for package thicknesses of up to about 10 mm. If the thickness or number of panes is

more than this BGT can cut them on a modern CNC-controlled water-jet cutting system. By using the medium of water, mixed with grinding sand, glass panes of 3 - 65 mm thickness and with a maximum size of 2000 x 4000 mm can be processed. The cut edges have a ground matt appearance. The danger of being injured on this edge is very low.

The water-jet cutting system permits glass panes of all conceivable shapes and with complicated cut-outs and sections to be produced. This is done with the highest precision and quality, as can only guaranteed with a computer-controlled system.

Examples of shapes



7. TECHNICAL OVERVIEW OF
ATTACK-RESISTANT GLAZING
TYPES

Type of glass	Resistance classes (n)	Total thickness (mm)	Thickness tolerance (mm)	Weight kg/m ²	Max. dimension mm x mm	Evaluated sound insulation value (R _w dB)*	k-value W/m ² K	Light transmission %
P1 - 07	P1	7	+ 1 / - 0,5	16	2250 x 3200	33	5,8	90
P1 - 09	P1	9	+ 1 / - 0,5	21	2400 x 3600	34	5,8	89
P1 - 27	P1	27	+ 2 / - 0,5	31	2250 x 3600	≤ 37 [♦]	≥ 1,1 [♦]	≤ 82 [♦]
A1 - 07	A1	7	+1 / - 0,5	16	2250 x 3200	33	5,8	90
A1 - 08E	A1	8	+ 1 / - 0,5	16	2100 x 3200	34	5,8	90
A1 - 09	A1	9	+ 1 / - 0,5	21	2400 x 3600	34	5,8	89
A1 - 27	A1	27	+2 / - 0,5	31	2250 x 3600	≤ 37 [♦]	≥ 1,1 [♦]	≤ 82 [♦]
A2 - 08	A2	8	+ 1 / - 0,5	16	2250 x 3200	34	5,8	90
A2 - 08E	A2	8	+ 1 / - 0,5	16	2100 x 3200	34	5,8	90
A2 - 10	A2	10	+ 1 / - 0,5	21	2400 x 3600	35	5,8	89
A2 - 28	A2	28	+2 / - 0,5	31	2250 x 3600	≤ 37 [♦]	≥ 1,1 [♦]	82 [♦]
A3 - 08	A3	8	+ 1 / - 1	17	2250 x 3200	34	5,8	90
A3 - 08E	A3	8	+ 1 / - 1	17	2100 x 3200	34	5,8	90
A3 - 10	A3	10	+ 1 / - 1	22	2400 x 3600	35	5,8	89
A3 - 28	A3	28	+ 2 / - 0,5	32	2250 x 3600	≤ 38 [♦]	≥ 1,1 [♦]	≤ 82 [♦]
EH01 - 08	EH01 / A3	8	+ 1 / - 1	17	2250 x 3200	34	5,8	90
EH01 - 08E	EH01 / A3	8	+ 1 / - 1	17	2100 x 3200	34	5,8	90
EH01 - 10	EH01 / A3	10	+ 1 / - 1	22	2400 x 3600	35	5,8	89
EH01 - 28	EH01 / A3	28	+ 2 / - 0,5	32	2250 x 3600	≤ 38 [♦]	≥ 1,1 [♦]	≤ 82 [♦]
EH02 - 09	EH02	9	+ 1 / - 1	18	2250 x 3200	34	5,8	89
EH02 - 10E	EH02	10	+ 1 / - 1	18	2100 x 3200	34	5,8	89
EH02 - 11	EH02	11	+ 1 / - 1	23	2400 x 3600	35	5,8	89

Type of glass	Resistance classes (n)	Total thickness (mm)	Thickness tolerance (mm)	Weight kg/m ²	max. dimension mm x mm	Evaluated sound insulation value (R _w dB)*	k-value W/m ² K	Light-transmission %
EH02 - 27	EH02	27	+ 2 / - 0,5	33	2250 x 3600	≤ 38 ♦	≥ 1,2 ♦	≤ 82 ♦
B1-18	B1	18	+ 1 / - 1	37	2400 x 3600	39	5,8	n.b.
B1-18E	B1	18	+ 1 / - 1	37	2100 x 3200	39	5,8	n.b.
B2-20	B2	20	+ 1,5 / - 0,5	43	2400 x 3600	39	5,8	n.b.
B2-20E	B2	20	+ 1,5 / - 0,5	43	2100 x 3200	39	5,8	n.b.
EH2-24	EH2	24	+ 2 / - 0,5	48	2400 x 3600	40	5,8	n.b.
EH2-24E	EH2	24	+ 2 / - 0,5	48	2100 x 3200	40	5,8	n.b.
B3-24	B3	24	+ 1 / - 1,5	46	2400 x 3600	40	5,8	n.b.
B3-24E	B3	24	+ 1 / - 1,5	46	2100 x 3200	40	5,8	n.b.
EH3-35	EH3	35	+ 2 / - 0,5	76	2400 x 3600 max. 6,5 m ²	42	5,8	n.b.
EH3-35E	EH3	35	+ 2 / - 0,5	76	2100 x 3200 max. 6,5 m ²	42	5,8	n.b.

* Approx. Value without test certificate

♦ These values depend on the coating and the gas filling.

Insulated glass is identified clearly by the grey grid layout. For insulated glass the maximum sound insulation cannot be achieved simultaneously with minimum k values. Please enquire about the technical feasibility.

In the case of type descriptions which end in "E", there is the option of integrating our products: BI-TENSIT fully-tempered safety glass, BI-HESTRAL semi-tempered safety glass, BI-Color colour-printed glass and Alarm BI-TENSIT alarm glass.

Type of glass	Resistance class according to EN 1063	Resistance class according to DIN 52 290	Total thickness (mm)	Thickness tolerance (mm)	Weight kg/m ²	k-value W/m ² K	max. size mm x mm
BR1 SA-15	BR1 SA	-	15	+ 1 / - 1	37,5	5,8	2400 x 3300
BR1 SF-17	BR1 SF	-	17		42,5	5,8	2400 x 2940
BR1 SF-21	BR1 SF	-	21	+ 2 / - 1	52,5	5,8	2400 x 2380
BR2 SA-22	BR2 SA	C1 SA / B1	21	+ 2 / - 1	54,5	5,8	2400 x 2290
BR3 SA-25	BR3 SA	C2 SA	24	+ 2 / - 1	61,7	5,8	2400 x 2040
BR4 SA-29	BR4 SA	C3 SA	29	+ 3 / - 1	72,6	5,8	2400 x 1750
BR5 SA-40	BR5 SA	-	40	+ 3 / + 1	100,0	5,8	2400 x 1250
BR6 SA-51	BR6 SA	C4 SA	50	+ 3 / - 1	126,4	5,8	2400 x 1000
BR6 SF-72	BR6 SF		72	+ 3 / - 1	180,0	5,8	2400 x 710
BR7 SA-75	BR7 SA		75		188,0		2400 x 670
BR 7 SF-75	BR7 SF		75		188,0		2400 x 670
SG1 SA-37	SG1 SA	-	38	+ 3 / - 1	95,5	5,8	2400 x 1310
SG2 SA-45	SG2 SA	-	45	+ 3 / - 1	113,3	5,8	2400 x 1125

Sound absorption values and light transmission upon request.