BF-Bulletin 017 / 2014 – Revision Index 1 – October 2022

Bundesverband
Flachglas

Sound insulation glass

Sound insulation glass

Contents

1.0 Introduction

Structural sound insulation is of key importance when it comes to reducing noise pollution in both residential and public buildings. This means adequate sound insulation of external components such as walls, windows and façades in particular. Sound insulation as such comprises measures to prevent sound generation (primary measures) and measures to reduce sound transmission from a sound source to a recipient (secondary measures). Sound insulation with glass, windows and façades is a secondary measure. The crucial point here is the details and design of the overall unit, i.e. frames, locking systems, joint seals, gaskets, wall connections and glazing.

This document is intended to explain the characteristic quantities, relevant standards and rules and regulations as well as the sound insulation properties (acoustic performance) of insulating glass units.

2.0 Sound insulation with glass

Sound insulation of glass, windows and façades always refers to the complete building component. It is always recommended to verify acoustic statements by laboratory measurements for the entire window or façade unit in accordance with EN ISO 10140. Up to approx. 40 dB, the impact of the window frame is low. The sound reduction index is therefore mainly influenced by the glazing. The sound insulation of glazing, usually insulating glass units (IGUs), is given by the single number value R_W. This value is influenced by the parameters described in the following. All influencing parameters must be accompanied by the note “usually”. In sound insulation in particular, a general approach cannot adequately take account of specific individual cases. Optimum individual results are not always additive due to the mutual interaction of the individual parameters. In principle it is possible to use the physical and technical findings mentioned here for determining the sound insulation of an IGU, but accurate results can be obtained only by measurement. A mathematical determination on the basis of the weight per unit area of the glass unit is neither correct nor permitted.

Sound insulation glass

2.1 Pane weight

The heavier the pane per weight per unit area, the higher is usually the sound reduction index. Single-leaf components reduce sound insulation in a certain frequency range. This is called critical frequency which is material specific and dependent on the component thickness. Figure 1 (top) shows an example of the sound insulation in relation to frequency for three pane thicknesses.

$$f_g = 12000\ \text{Hz} \times \frac{1}{d}$$

f_g = critical frequency in Hz
d = thickness of component in mm

Internal and external glass panes in IGUs should differ in thickness. Usually, the more asymmetrical the glass thicknesses of the individual panes, the higher the sound reduction index with otherwise equal overall glass thickness. The reason for this is the difference in critical frequencies of the individual IGU panes.

2.2 Pane stiffness

Usually, the more elastic the configuration of the individual panes, the higher the sound reduction index. Laminated glass panes with acoustic interlayers make use of this finding: the elastic connection of two individual panes combines a high pane mass with low flexural strength. This considerably improves sound insulation both in the lower and higher frequency ranges.

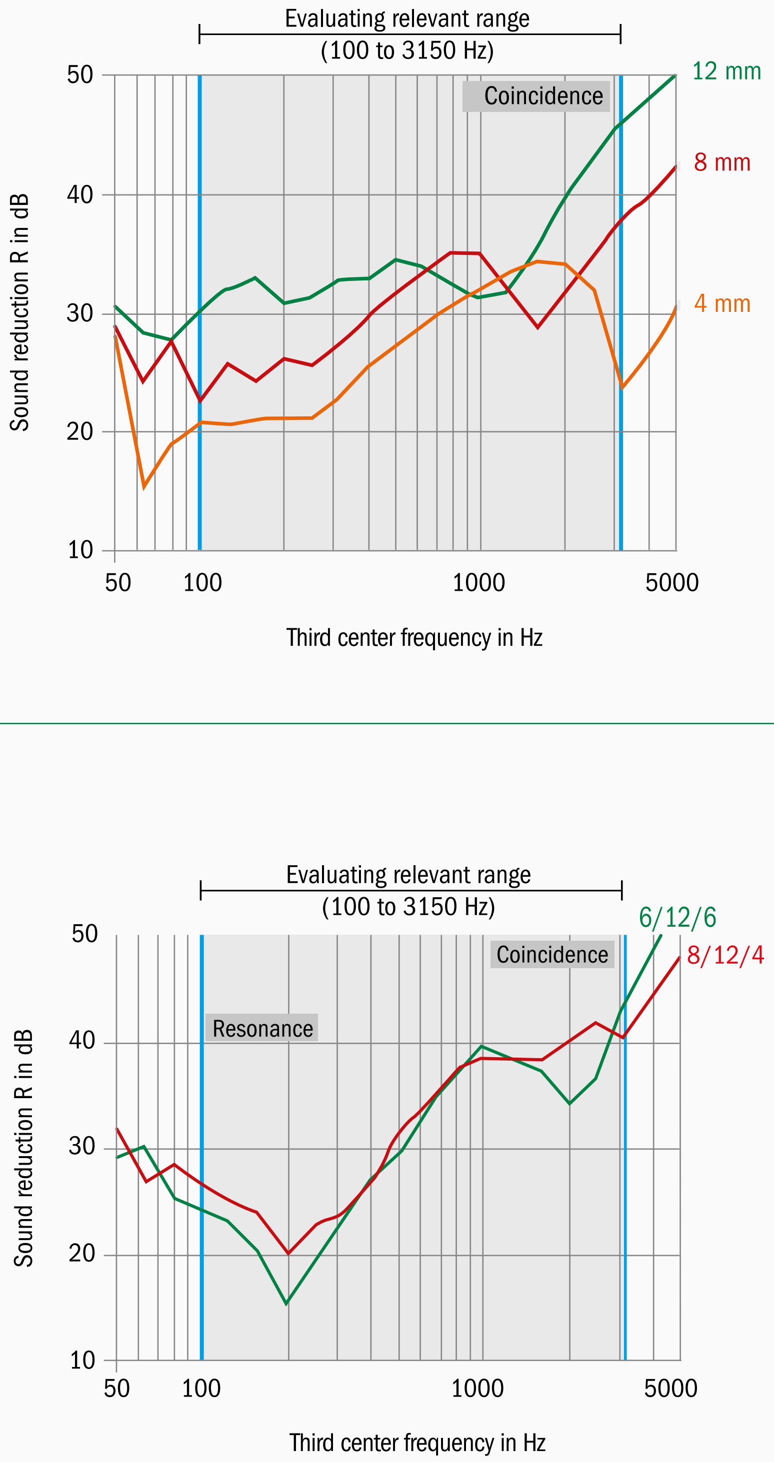


Figure 1:
Top: Sound insulation in relation to frequency
Bottom: Critical frequencies/coincidence and resonance - comparison of asymmetrical and symmetrical IGU configurations

2.3. Cavity

Usually, the wider the cavity, the higher the sound reduction index (at least no reduction in the single number value). Changing the cavity width will usually change the U_g-value. In terms of acoustic performance, triple IGUs are somewhat less good than double IGUs with the same nominal mass and thickness.

2.4 Gas filling

Most IGUs are currently filled with argon and krypton. There is also the well-known sulphur hexafluoride (SF6) gas, whose use is now banned in the EU for climate protection reasons.

2.5 Angular dependence

Depending on the installation situation, a directional grazing sound incidence may occur, e.g. in tall buildings or on busy roads. In these cases, the laboratory testing conditions for diffuse sound incidence do not exactly reproduce the real situation. The actual sound reduction rating is lower than the one obtained from laboratory testing (free field conditions – e.g. distribution of sound energy in laboratory testing is more uniform as compared to a linear or point source of sound, e.g. traffic noise). These circumstances can be taken into account by stepping up the requirements for sound insulation against those set out in DIN 4109.

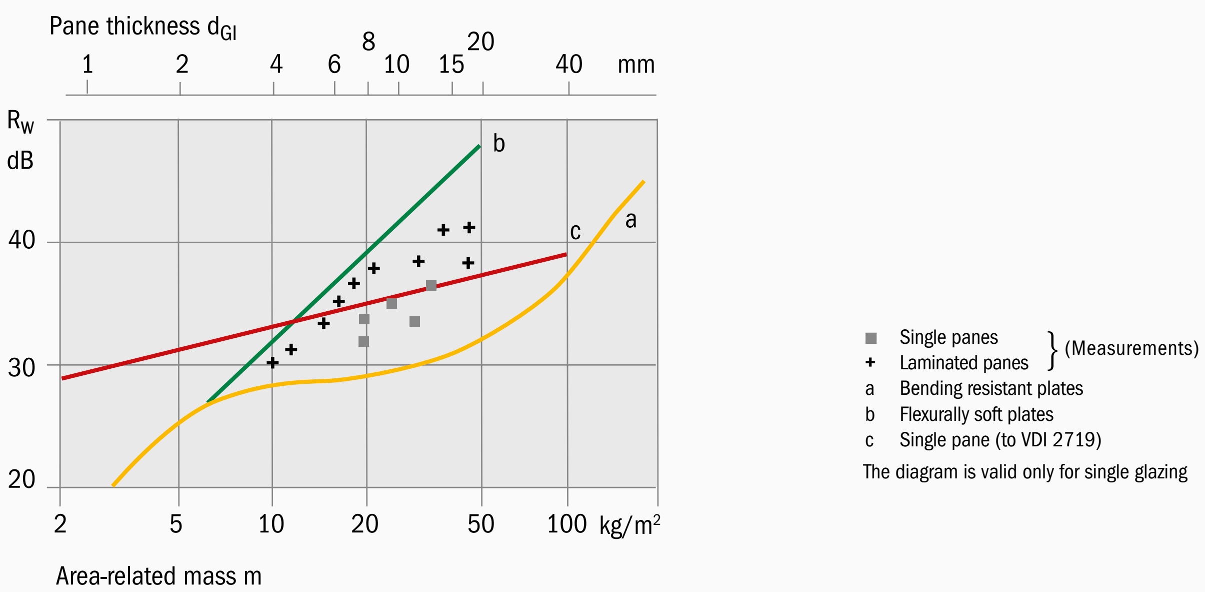
2.6 Resonance

The weighted sound reduction index of double and multiple configurations and double and triple insulating glass units is usually better than that of single panes. As the panes are coupled by the intervening "gas cushion" (air or inert gases - argon or krypton), resonances occur which reduce the sound insulation performance in the lower frequency range. This is shown in the measurement curve of the relevant sound insulation test certificates. This dip is also referred to as resonance frequency (characteristic frequency of a component based on the mass-spring-mass system). Since the human ear is relatively insensitive to low frequencies, this characteristic should not be overrated. On the other hand, sound insulation can be improved by shifting the resonance frequency of a component to lower frequencies, because the single number rating does not take account of frequencies < 100 Hz. Due to resonance frequency, the sound insulation of a double IGU with a glass configuration of e.g. 4/12/4 or a triple IGU (4/8/4/8/4), with the same weight per unit area, is not much better than that of a single glass pane of equal thickness.

The resonance frequency of a double configuration can be approximated using this equation:

$$f_r = 1200 \sqrt{\frac{1}{d_L}\left(\frac{1}{d_1}+\frac{1}{d_2}\right)}$$

f_r = resonance frequency in Hz
d_L = clear cavity in mm
d_1, d_2 = thickness of both panes in mm



The diagram is valid only for single glazing

Figure 2: Weighted sound reduction index R_W of single and laminated panes

3.0 Determination of the sound insulation of glass

The European standard DIN EN 12758 specifies the sound insulation properties of glass products. Accordingly, the sound reduction indices must be determined in accordance with DIN EN ISO 10140 and DIN EN ISO 717-1.

DIN EN ISO 10140 describes the laboratory measurement of sound insulation.

The measurement results are used to calculate the weighted sound reduction index R_W and the associated spectrum adaptation terms C and C_{tr} in accordance with DIN EN ISO 717-1.

3.1 Measurement

Measurement is carried out in accordance with DIN EN ISO 10140, Parts 1 + 2 in a test facility with suppressed flanking transmission in accordance with DIN EN ISO 10140-5. The laboratory test facility consists of two adjacent rooms (source room and receiving room) with a separating wall. The separating wall contains a 1.25 m x 1.50 m opening into which the 1.23 m x 1.48 m glass test specimen is installed.

In the source room, sound is generated in a frequency range of 100 to 3150 Hz and a measurement range of 50 to 5000 Hz. From the values obtained for the sound pressure levels in the source and receiving rooms, 16 frequency-dependent sound reduction indices R are determined according to the following equation:

$$R = L_1 - L_2 + 10\,lg\,\frac{S}{A}$$

L_1 = average energy sound pressure level in source room, in dB

L_2 = average energy sound pressure level in receiving room, in dB

S = area of free test opening into which the test specimen is installed, in m, in m^2

A = equivalent sound absorption area in receiving room, in m^2.
The latter is determined by measuring the reverberation time.

3.2 Weighted sound reduction index

Determination of the 16 frequency-dependent sound reduction indices R is followed by calculation of the weighted sound reduction index R_W in accordance with DIN EN ISO 717-1, expressed in "decibels" (dB) (unit of measurement). The values R obtained by measurement are compared with the reference values in accordance with EN 717-1. As shown in Figure 3, the reference curve set out in EN 717-1 is shifted vertically and parallel to the ordinate in the measurement graph until the average shortfall to the measurement curve does not exceed 2 dB. Exceedances are not taken into account. The ordinate value of the shifted reference curve at 500 Hz corresponds to the weighted sound reduction index R_W („single number value").

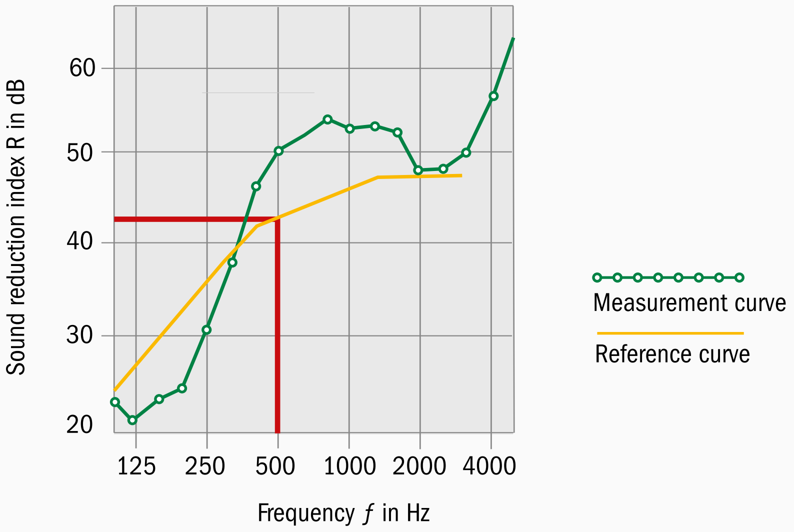


Figure 3: Determination of weighted sound reduction index in accordance with DIN EN ISO 717-1

To take account of the different frequency spectra of noise sources such as noise inside buildings and road traffic noise, the spectrum adaptation terms C and Ctr have been introduced for building acoustics in the range of 100 to 3150 Hz, in accordance with DIN EN ISO 717-1 (see Figure 4). They are used to adapt the weighted sound reduction index in the 100 to 3150 Hz frequency range.

There are additional spectrum adaptation terms for other frequency ranges which must be specified and, as required, agreed on a case-by-case basis. Spectrum adaptation terms are product properties derived from the measured sound insulation curve of the glass products based on the relevant noise source.

Noise source	***Relevant spectrum adaptation term***
Living activities (talking, music, radio, TV) Children playing Rail traffic at medium and high speeds* Highway road traffic > 80 km/h* Jet aircraft, close by* Works emitting mainly medium and high frequency noise*	C (Spectrum No. 1)
Urban road traffic Rail traffic at low speed* Aircraft, propeller-driven Jet aircraft, at a distance Disco music Works emitting mainly low and medium frequency noise	C_{tr} (Spectrum No. 2)

*In several European countries, calculation models for highway road traffic noise and railway noise exist, which define octave band levels; these could be used for comparison with spectra Nos. 1 and 2, e.g. in France: $R_A = R_W + C$ or $R_{Atr} = R_W + C_{tr}$

Figure 4: Spectrum adaptation terms C and C_{tr}

Depending on the requirement, R_W is defined in more detail with different indices. DIN 4109 specifies the following:

Symbols	***Meaning***
R'_w	Weighted sound reduction index in dB with sound transmission from flanking elements
R_W	Weighted sound reduction index in dB without sound transmission from flanking elements
$R'_{w,total.}$	Resulting weighted sound reduction index of the total element composed of various sub areas (e.g. window/wall) of differing sound insulation (also referred to as $R'_{w,res.}$).
$R_{w,P}$	Laboratory weighted sound reduction index (previous characteristic in accordance with DIN 4109:1989-11)
$R_{w,R}$	Weighted sound reduction index – calculation value (previous characteristic in accordance with DIN 4109:1989-11)
$R_{w,B}$	Weighted sound reduction index – measured in the building (previous characteristic in accordance with DIN 4109:1989-11)

3.3 Uncertainties

Acoustic uncertainties in buildings are specified in DIN EN ISO 12999-1, Clause 7.2 Table 3, their application in Clause 8.

The uncertainty of R_W values obtained from laboratory testing is at least 1.2 dB. (Gaussian distribution or normal distribution, confidence level 68 % for two-sided test) If the requirements for the confidence level are higher (e.g. 90 %) for a two-sided test, the uncertainty increases to as much as 2 dB. For further details refer to DIN EN ISO 10140-1 Annex D.

3.4 Calculation of sound reduction indices

Due to the great variety of possible glass configurations, it is almost impossible to measure the acoustic properties of all of them. In recent years software tools have therefore been developed to calculate sound reduction indices on the basis of simulation and/or interpolation.

According to initial findings, there is a large dispersion in the results of the different software tools. There are so far no recognised methods to evaluate and validate these kinds of calculation tool.

Calculated sound reduction indices are therefore not allowed for verification and declaration of performance / CE marking in accordance with the European product standards. They are only used to estimate the acoustic performance of unmeasured glass configurations.

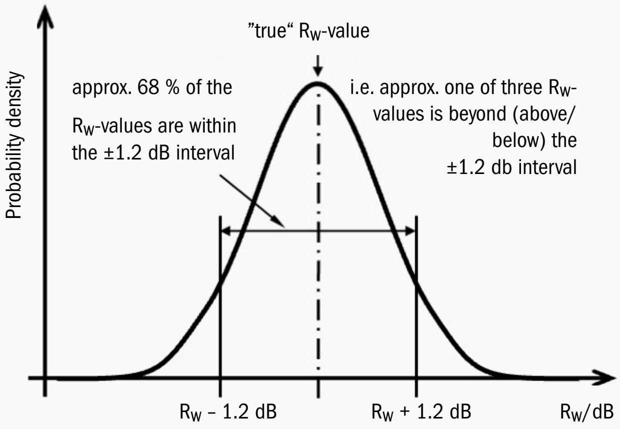


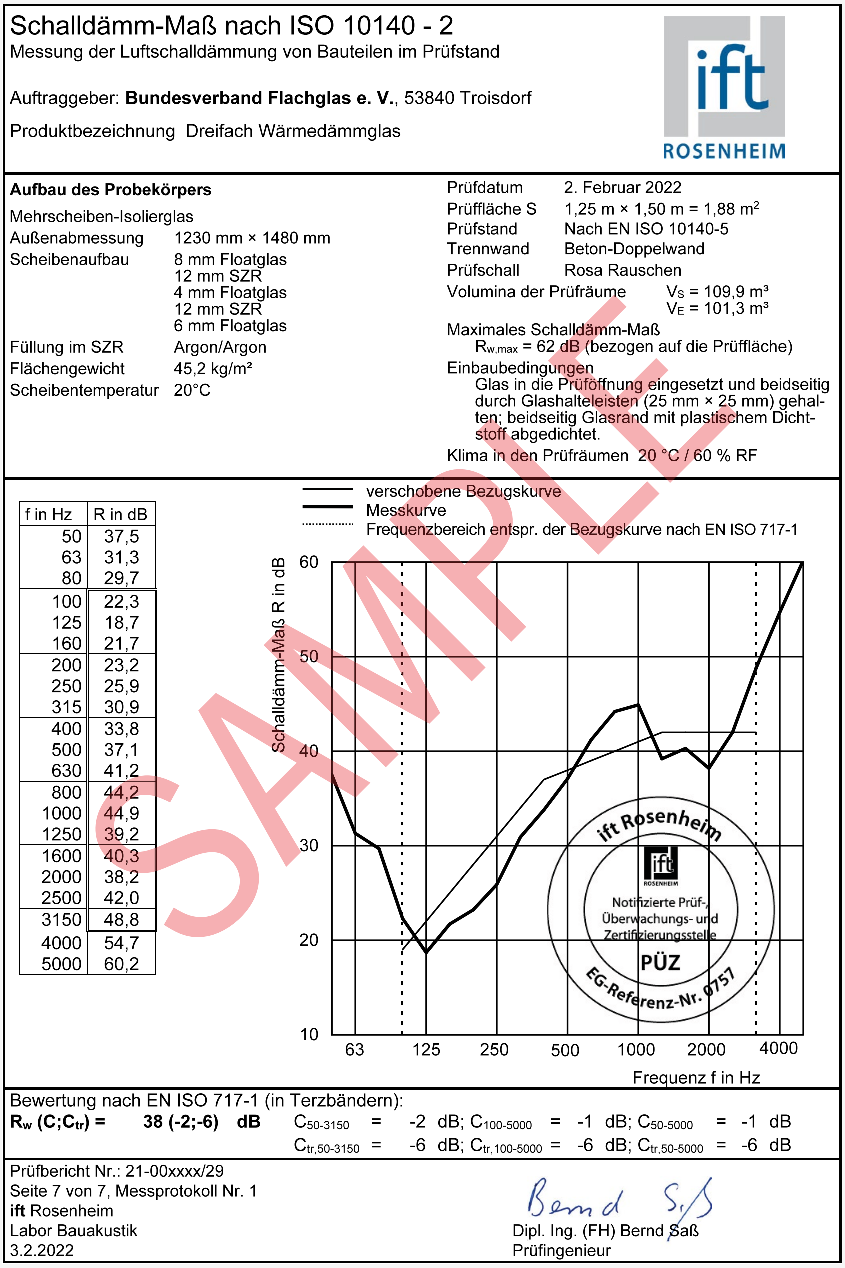
Figure 5

3.5 Use of previous test reports

Test reports for airborne sound insulation dating from before 2010, are based on standards older than DIN EN ISO 10140-2 (EN ISO 140, EN 20140 or DIN 52210).

These standards differ from DIN EN ISO 10140-2 in the details governing special measurement boundary conditions. Thanks to the accuracy of the overall measurement procedure, however, the deviations are so minor that they barely affect the sound reduction index or spectrum adaptation terms.

Older test reports must have been be issued or certified by a notified testing body.



Schalldämm-Maß nach ISO 10140 - 2

Messung der Luftschalldämmung von Bauteilen im Prüfstand

Auftraggeber: **Bundesverband Flachglas e. V.**, 53840 Troisdorf

Produktbezeichnung Dreifach Wärmedämmglas

Aufbau des Probekörpers

Mehrscheiben-Isolierglas

Außenabmessung	1230 mm × 1480 mm
Scheibenaufbau	8 mm Floatglas 12 mm SZR 4 mm Floatglas 12 mm SZR 6 mm Floatglas
Füllung im SZR	Argon/Argon
Flächengewicht	45,2 kg/m²
Scheibentemperatur	20°C

Prüfdatum	2. Februar 2022
Prüffläche S	1,25 m × 1,50 m = 1,88 m^2
Prüfstand	Nach EN ISO 10140-5
Trennwand	Beton-Doppelwand
Prüfschall	Rosa Rauschen
Volumina der Prüfräume	V_S = 109,9 m³ V_E = 101,3 m³

Maximales Schalldämm-Maß
$R_{w,max}$ = 62 dB (bezogen auf die Prüffläche)

Einbaubedingungen
Glas in die Prüföffnung eingesetzt und beidseitig durch Glashalteleisten (25 mm × 25 mm) gehalten; beidseitig Glasrand mit plastischem Dichtstoff abgedichtet.

Klima in den Prüfräumen 20 °C / 60 % RF

f in Hz	R in dB
50	37,5
63	31,3
80	29,7
100	22,3
125	18,7
160	21,7
200	23,2
250	25,9
315	30,9
400	33,8
500	37,1
630	41,2
800	44,2
1000	44,9
1250	39,2
1600	40,3
2000	38,2
2500	42,0
3150	48,8
4000	54,7
5000	60,2

ift Rosenheim
Notifizierte Prüf-, Überwachungs- und Zertifizierungsstelle
PÜZ
EG-Referenz-Nr. 0757

Bewertung nach EN ISO 717-1 (in Terzbändern):

R_w (C;C_{tr}) = 38 (-2;-6) dB $C_{50-3150}$ = -2 dB; $C_{100-5000}$ = -1 dB; $C_{50-5000}$ = -1 dB
$C_{tr,50-3150}$ = -6 dB; $C_{tr,100-5000}$ = -6 dB; $C_{tr,50-5000}$ = -6 dB

Prüfbericht Nr.: 21-00xxxx/29
Seite 7 von 7, Messprotokoll Nr. 1
ift Rosenheim
Labor Bauakustik
3.2.2022

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Prüfingenieur

Figure 6: Model test report for a triple insulating glass unit

Figure 6 shows an excerpt of a typical test report for a triple insulating glass unit in accordance with ISO 10140-2.

4.0 Planning standards

The planning and details of a building are governed by the relevant standards, rules and regulations specified in the Building Code. The resulting requirements must be selected depending on the application or use and supplemented by further rules and regulations, if necessary.

This applies to, e.g. the requirements for “increased” sound insulation. This may not be required by the Building Code but can be agreed on a case-by-case basis by the parties involved in the building construction, for example in the tender specifications.

The building codes of the German States specify sound insulation of buildings according to use. § 15 “Thermal / sound insulation and protection against vibration” of the model building code (MBO) of 2002, revision 2016, requires the following:

„(2) [1]The sound insulation of buildings must be in accordance with their intended use. (2) [1]Noise from stationary facilities in buildings or on building sites must be insulated in such a way that it does not cause danger or unreasonable nuisance.“

In this context a distinction must be made between the requirements for sound insulation in public law (DIN 4109) and private law (VDI).

The model administrative provisions for “technical building rules” specify the technical building rules for compliance with the basic requirements for buildings. They also include the technical rules for sound insulation. In accordance with Sections 3 and 15 Clause 2 MBO 1, buildings must be erected, modified and maintained in such a way that they provide sound insulation according to the intended use.

Compliance with these requirements is subject to the technical rules for sound insulation from Section A 5.2. A 5.2.1 therefore combines DIN 4109 with Annexes A 5.2/1 to 5.2/5 as technical rules for the building supervisory authorities. The date of printing refers to the 2016 edition. New editions of Parts 1 and 2 of DIN 4109 were already been published in January 2018.

While thermal insulation is based on basic and generally applicable requirements, in sound insulation the specific planning is the most important prerequisite for noise protection tailored to the project. This requires the relevant external noise level to be determined.

The requirements of DIN 4109 cover the entire external building component composed of wall, window and door. The planning of sound insulation is based on the values obtained for windows and/or doors. The sound reduction index of glass is used to determine the sound reduction indices of windows and doors. The values for the windows and doors differ from the glass values, due to the frame and details/configuration. Calculation of the R_W value is based on the methods set out in DIN EN 14351-1 and DIN 4109.

For more details and planning of the sound insulation details see “VFF-Merkblatt Schall.01 ‘Schallschutz mit Fenstern, Türen und Fassaden’” (VFF Guidance Sheet Sound 01 “Sound Insulation of windows, doors and façades”).

5.0 Rules for substitution and standardised sound reduction indices

In the absence of measured sound reduction indices for specific glass configurations, DIN EN 12758 permits the use of test results of similar configurations subject to compliance with the standardised rules for substitution. Alternatively, the standardised sound reduction indices from DIN EN 12758 can be used.

For more details refer to the BF-Bulletin 023 “Rules for substitution and standardised sound reduction indices in accordance with DIN EN 12758:2019-12”.

6.0 Summary

In order to meet the increasingly stringent requirements for noise protection, which includes also sound insulation of buildings, careful design/planning and detailing are required. A satisfactory final result will be achieved if all parties concerned are involved in in the design and planning stages as early as possible.

Expert planners should be involved in particular in the planning of the required sound insulation. As already described, the building components of windows and façades - and therefore glass - play a central role in contemporary architecture both for residential and office buildings. This means that sound insulation must be carefully planned and attention given to a good quality product.

7.0 Literature

Elstner M., Häuser K., Schmid R. W., Walk R.: „Gestalten mit Glas“ (Design with glass), Interpane 8. edition, January 2011

VFF Merkblatt, Schall.01 „Schallschutz mit Fenstern, Türen und Fassaden“ (VFF Guidance Sheet, Sound 01 “Sound Insulation of windows, doors and façades”)

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Weller B., Tasche S. (Eds.), “Glasbau 2013”

Elstner M., Broich M., Goldau D., Schäfer S., „Schallschutz mit Glas“ (Sound insulation with glass), Wilhelm Ernst & Sohn, 1st Edition 2013

Sound insulation glass

8.0 Overview of weighted sound reduction indices (R_W) of different glass configurations (double and triple)*

Double IGU configurations			**30 dB**	31 dB	32 dB	33 dB	34 dB	**35 dB**	36 dB	37 dB	38 dB	39 dB
		8 - 16 AR - 4							🟩	🟩		
All configurations with sound insulation interlayer/film		LSG 44.2* - 16 AR - 4									🟩	🟩
		LSG 44.2 - 16 AR - 6										
		LSG 44.2 - 16 AR - 8										
		LSG 12.8 - 16 AR - 8										
		LSG 8.8 - 16 AR - 10										
		10 - 16 AR - 12.8 LSG										
		LSG 66.2 - 16 AR - LSG 44.2										
		*44.2 is composed of 2x4 mm glass and interlayer thickness 0.76 mm										

Triple IGU configurations			**30 dB**	31 dB	32 dB	33 dB	34 dB	**35 dB**	36 dB	37 dB	38 dB	39 dB
	Monolithic configurations	4 - 12 AR - 4 - 12 AR - 4		🟩	🟩	🟩						
		4 - 12 KR - 4 - 12 KR - 4			🟩	🟩						
		6 - 12 AR - 4 - 12 AR - 4						🟩	🟩			
		6 - 10 KR - 4 - 10 KR - 4						🟩	🟩			
		8 - 12 AR - 4 - 12 AR - 4							🟩	🟩	🟩	🟩
		6 - 12 KR - 4 - 12 KR - 4								🟩	🟩	
		8 - 12 AR - 4 - 12 AR - 6								🟩	🟩	🟩
		8 - 12 KR - 4 - 12 KR - 6									🟩	🟩
All configurations with sound insulation interlayer/film	1x LSG	6 - 12 AR - 4 - 12 AR - LSG 44.2										
		8 - 12 AR - 4 - 12 AR - LSG 44.2										
		8 - 12 KR - 4 - 12 KR - LSG 44.2										
		6 - 12 KR - 4 - 12 KR - LSG 44.2										
	2x LSG	LSG 44.2 - 12 AR - 6 - 12 AR - LSG 55.2										
		LSG 44.2 - 12 KR - 6 - 12 KR - LSG 55.2										

*The Table shows representative values

	40 dB	41 dB	42 dB	43 dB	44 dB	**45 dB**	46 dB	47 dB	48 dB	49 dB	**50 dB**
	🟩	🟩	🟩								
	🟩	🟩	🟩								
			🟩	🟩	🟩						
				🟩	🟩	🟩					
				🟩	🟩	🟩					
								🟩	🟩	🟩	

	40 dB	41 dB	42 dB	43 dB	44 dB	**45 dB**	46 dB	47 dB	48 dB	49 dB	**50 dB**
	🟩	🟩	🟩								
		🟩	🟩	🟩							
		🟩	🟩								
		🟩	🟩	🟩							
						🟩	🟩	🟩			
							🟩	🟩	🟩		

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