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Published in:
Proceedings of Nordic Acoutical Meeting 1986

Publication date:
1986

Document Version
Publisher's PDF, also known as Version of record

NORDIC ACOUSTICAL MEETING

NAM 86

20-22 August 1986
at Aalborg University
Aalborg, Denmark
Proceedings edited by
Henrik Møller and Per Rubak

SOUND INSULATION FOR SEALED TRIPLE GLAZINGS

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INTRODUCTION

The Danish Acoustical Institute is carrying out a project series concerning optimization of sound insulation for windows. The total project comprises investigations of hermetically-sealed double and triple glazings and frame/sash constructions. Until now, double and triple glazings have been investigated. The influence of glass thicknesses, laminating, glass spacing(s), and gas filling on the sound reduction index has been examined. The aim of the experiments is to give manufacturers of windows and glazings better possibilities of optimizing the sound insulation in relation to total weight, thickness, and price of the glazing. The investigations are described in detail in the project reports [1] and [2] (in Danish). The complex of problems and the conclusions are summarized in [3]. The main results for double-glazed windows were presented at NAS–84 [4]. The present paper presents the main results for triple-glazed windows.

DESIGN OF EXPERIMENTAL INVESTIGATION

In order to achieve maximum usefulness of the project results, "realistic" test specimens were chosen for the eperiments, i.e. the glazings were commercially produced hermetically-sealed units and were not extremely heavy, thick, nor expensive. Some samples are shown on Fig. 1.

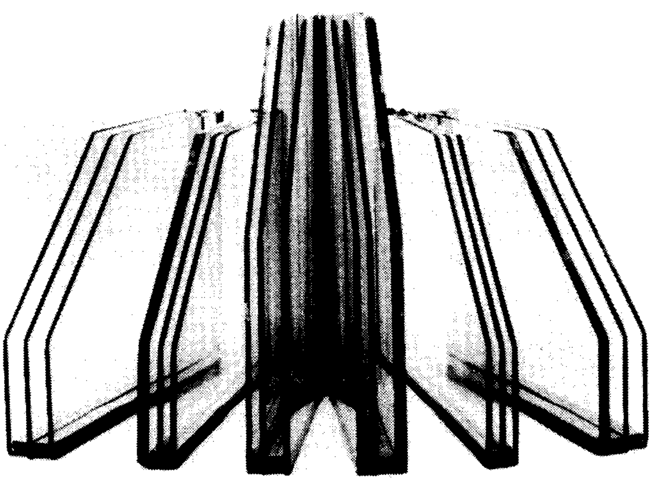

Fig. 1. Samples of different hermetically-sealed triple-glazed units

The tested types of glazings are found in Table 1. The full measurement programme for the test series and descriptions are found in [2]. At the design of the experiments special importance was attached to examining glazings with small spacings (6–9 mm) and glazings with gas filling. Further it was considered essential to examine the effect of different fillings in the two cavities of triple-glazed units.

The size of the windows was 12 M × 12 M corresponding to a test opening of 1,21 m × 1,21 m. As this size of facade windows is the most widespread size in Denmark, it is recommended as test size in the Danish Standard DS 1084 for classification of sound insulating windows. Most measurements were performed with glazings mounted in a firm frame (wood), but selected types of glazings were also tested in an openable window (wood). A sectional view of the windows and their mounting in laboratory are shown in [3]. The measurements are carried out in the transmission rooms at the Technical University of Denmark. The test facility, measurement procedure and instrumentation are described in [2]. The test method is ISO 140/3–1978.

SOME MEASUREMENT RESULTS

In [2] R_w-values (ISO 717/3–1982) are found in tabular form. Decimal values are found, too, even if the R_w-value is defined as an integer value. This implies an easier assessment of the significance of the differences. Besides there are presented a large number of comparisons of sound reduction index curves, which illustrate the influence of the examined parameters one by one and some examples of mutual influences are also found.

A table with R_W-values for glazings mounted in a firm frame is found below. Further, a few diagrams are presented, showing some selected measurement results. The glazings are described by a "code" specifying the glass thicknesses and the spacings in the indicated order. The letters *GG*, *GL*, *LG* and *LL* specify the cavity fillings in the same order, G = gas filling (SF_6) and L = atmospheric air. The mark 4/2/4 defines a laminate consisting of 4 + 4 mm glass with a 2 mm thick intermediate layer of soft polymethacrylate. The "*F*" before the glazing code in the diagrams means that the result is found for the glazing in a firm window.

Triple Glazing	Weight	Thickness	R_W / Δ_{max} [dB / dB]			
			Cavity Fillings in the Sealed Unit			
[mm]	[kg/m²]	[mm]	GG	GL	LG	LL
4-6-4-6-4	30	24	30 /10,2	32 / 9,4		32 / 8,6
4-9-4-9-4	–	30	31 / 8,2	34 / 8,7		31 / 6,7
4-12-4-6-4	–	–	32 / 8,6	35 / 8,4	32 / 7,1	32 / 6,6
4-12-4-12-4	–	36	32 / 7,4	35 / 7,8		32 / 6,0
6-6-4-6-4	35	26	34 / 7,7	37 / 9,6		36 / 7,0
6-9-4-9-4	–	32	*			35 / 6,4
6-12-4-6-4	–	–	37 / 7,2	38 / 8,0		36 / 5,8
8-6-4-6-4	40	28	36 /10,0	38 / 7,2	37 / 8,8	37 / 6,7
8-9-4-9-4	–	34	37 / 6,3	38 / 4,2		37 / 6,0
8-12-4-6-4	–	–	38 / 3,9	39 / 4,3	38 / 5,9	38 / 4,8
8-12-4-12-4	–	40	38 / 6,2	39 / 4,8	39 / 5,1	39 / 6,5
8-20-4-6-4	–	42	41 / 5,5	41 / 4,5		40 / 5,2
4/2/4-6-4-6-4	42	30	36 / 9,4	40 / 7,4		38 / 7,4
4/2/4-9-4-9-4	–	36	38 / 9,3			38 / 4,9
4/2/4-12-4-6-4	–	–	40 / 6,6	42 / 6,4		40 / 6,9
4/2/4-12-4-12-4	–	42	41 / 9,3	41 / 6,4		40 / 8,0
4/2/4-20-4-6-4	–	44	43 / 5,0	42 / 4,4		42 / 6,5

* The planned measurement is missing due to a wrong supply

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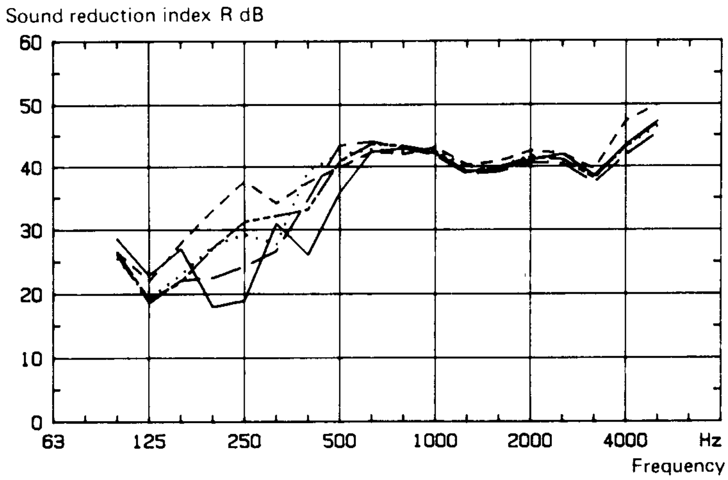
Table 1. R_w-values for sealed triple glazings mounted in a firm window (1,21 m × 1,21 m)

The influences of glass thicknesses and laminating are similar to the results for double glazings. A small asymmetry in glass thicknesses has a great effect, whereas the effect of a further change in asymmetry can be rather small. Use of laminated glass increases the sound reduction index at the high frequencies. The influence on the R_w-value is typical 2 dB, but varies between 0 and 3 dB, depending on the type of glazing. With deep resonance dips at the low frequencies there might be no increase in R_w, cf. Fig. 2 and 3 (full lined curves).

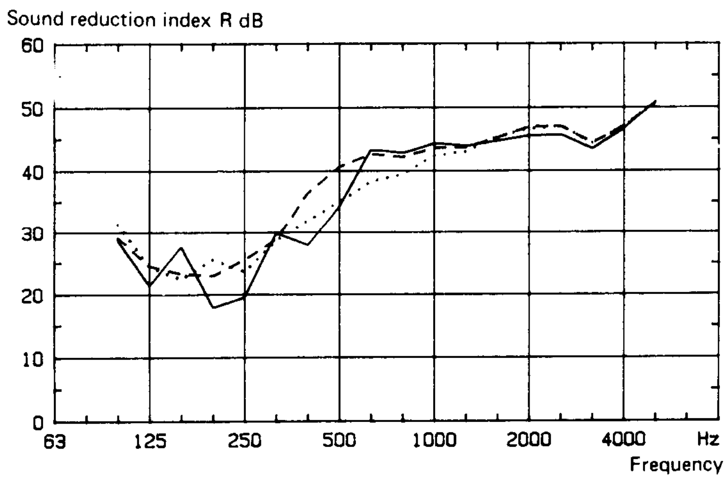
On Fig. 2 it is shown that changes in glass spacings can influence the sound reduction index considerably at some frequencies. It should be noticed, that asymmetric spacings are advantageous. The glazings are gasfilled, and the significance of spacings is less pronounced with atmospheric air in one or both cavities.



————	F	8-6-4-6-4 GG	Rw = 36 dB	Δmax =10.0 dB ;	Rw(dec) = 36.1 dB
— — —	F	8-9-4-9-4 GG	Rw = 37 dB	Δmax = 6.3 dB ;	Rw(dec) = 37.0 dB
—-—-—	F	8-12-4-6-4 GG	Rw = 38 dB	Δmax = 3.9 dB ;	Rw(dec) = 38.8 dB
....	F	8-12-4-12-4 GG	Rw = 38 dB	Δmax = 6.2 dB ;	Rw(dec) = 38.9 dB
- - - - - -	F	8-20-4-6-4 GG	Rw = 41 dB	Δmax = 5.5 dB ;	Rw(dec) = 41.0 dB

Fig. 2. Comparison of sound reduction index curves for triple-glazed units with different combinations of spacings, but all with gasfilling and identical glass combination

For some types of glazings the choice of gas filling is important to the sound insulation as illustrated on Fig. 3. A better sound insulation is obtained with gas filling in one cavity than with gas filling or air in both cavities. It is assumed that the main reason for this phenomenon is mismatch of modes in the two cavities due to different sound velocities for SF_6 and atmospheric air. It should be noticed that the order of glass thicknesses, spacings and fillings are not unimportant. As an instructive example it could be mentioned that for the glazing 4–12–4–6–4 with fillings *GG*, *GL*, *LG* and *LL* the measured R_w-values are 32, 35, 32 and 32 dB, respectively.



————	F	4/2/4-6-4-6-4 GG	Rw = 36 dB	Δmax = 9.4 dB ;	Rw(dec) = 36.7 dB
- - - - - -	F	4/2/4-6-4-6-4 GL	Rw = 40 dB	Δmax = 7.4 dB ;	Rw(dec) = 40.5 dB
....	F	4/2/4-6-4-6-4 LL	Rw = 38 dB	Δmax = 7.4 dB ;	Rw(dec) = 38.6 dB

Fig. 3. Comparison of sound reduction index for a triple glazing 4/2/4-6-4-6-4 with different combinations of cavity fillings

It should be mentioned that in some literature the upper resonance frequency of a triple glazing is considered unimportant. However, if both cavities are small and gasfilled, it is found that both resonance dips are pronounced. Obviously, this is the case for the lower curves on Figs. 2 and 3.

CONCLUSIONS

The experimental results indicated below should be evaluted in the light of ordinary triple glazings being symmetric as regards both glass thicknesses, spacings and fillings. In Denmark typical glass thicknesses are 3 to 4 mm and typical spacings in triple-glazed units are 6 to 9 mm.

Based on R_w (ISO 717/3–1982) as a measure of the sound insulation property of a window, the following main results have been achieved from the experiments with triple-glazed windows (the gas used is SF_6). The sound insulation is improved by:

- Asymmetry in glass thicknesses
- Using laminated glass
- Increasing the glass spacings – this applies especially to glazings with gas-filled cavities
- Gas filling in one of the two cavities of the glazing

The last-mentioned result is particularly interesting because it is a rather simple way of improving the sound insulation. Gas filling in both cavities of a triple glazing causes only in a few cases an increase in sound insulation. With small spacings (6 to 9 mm) the sound insulation is reduced by the gas filling. The experiments have been carried out using SF_6, which is the type of gas mostly used. The results cannot be applied right away when using other types of gas with substantially different acoustic properties.

The experiments showed that an optimization of glazing details often results in a 3 to 5 dB higher sound insulation (R_w-value), alternatively a lower weight, thickness or price. The results from Fig. 3 can be considered as an example of optimization. The thickness and weight is the same for all three glazings. The price differences are small, but in fact the most expensive glazing is the poorest one with R_w = 36 dB. If "forgetting" the gas filling in one cavity, the R_w-value is improved with 4 dB!

The importance of each construction detail is connected with different frequency ranges, and different changes cannot replace one another right away. In practice, the effect of glass thicknesses is primarily connected to frequencies below 1000 Hz and above 2000 Hz, lamination to the frequency range above 1000 Hz, spacing to the frequency range below 800 Hz and gas filling to frequencies below 1000 hz.

The importance of the frame/sash construction depends on a number of factors which are not yet completely examined. However, some aspects are indicated in [2] and [5]. It has been established that the effect may be favourable in one frequency range (below approx. 1000 Hz) and unfavourable at other frequencies. When using a glazing with a high sound insulation, the sound reduction index of the total construction can be reduced by sound transmission through the frame and sash material, primarily in the frequency range of 500–2000 Hz. This was also found for some of the windows in the present investigation. Further it is well known that leaks are of special importance at frequencies above approx. 500 Hz. The problems connected to frame/sash construction are being examined more closely in a project which will be finished by the end of 1986.

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