

THE INFLUENCE OF GLASS ON THE AIRBORNE SOUND INSULATION OF WINDOWS

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1. Analysis of window desing

From the viewpoint of acoustics, the window is a rather complicated structure and its sound insulation depends upon numerous designing modifications, some of which are of decisive importance. They include glazing, infiltration, the window frame with fixed glass and the window structure itself.

The window structure consists of elements with different acoustic properties and places of contact among the window structural elements. The transition of noise through a window can be classified as follows:

- sound transmission through the glazed area,
- sound transmission through the window frames and wings,
- sound transmission through joints and gaps.

The desing of a window structure corresponding with the basic acoustic evaluation criteria results from the following relation:

$$R_{wo} = R_{woz} + \Delta R_{woz} - \Delta R_{woš} \pm \Delta R_{wor}, \quad (1)$$

where R_{woz} is the sound insulation index of the glass (dB), ΔR_{woz} is the increase resulting from the window desing modifications (dB), $\Delta R_{woš}$ is the decrease resulting from the joints and gaps (dB), ΔR_{wor} is the increase and decrease resulting from the frames and wings (dB).

1.1. Sound transmission through the glazed area

Glass makes 70–80% of a window area (depending upon its surface, frame and wing design) and in general is the decisive element of the window acoustics properties.

Due to its low basis weight, the glazed surface is a thin plate whose sound insulation has numerous negative properties such as resonance and coincidence, depending on frequency. The resonance effect is obvious at low frequencies and at a glass thickness less than 4 mm sound insulation decreases often in the sound insulation area. With glass of thickness below 4 mm, the effect of coincidence is outside the sound insulation sphere.

In the frequency course R (dB) of glass of a thickness above 4 mm the effect of resonance is suppressed at low frequencies. The lowest resonance frequencies are outside of the sound insulation sphere. At higher frequencies, the sound insulation decreases due to the coincidence.

1.2. Single or double glass

Based upon experimental measurements (Measurements were performed by STU SvF Bratislava - acoustic laboratories and the Centre for Civil Engineering, Prague and Zlin [1-5, 9, 10], in accordance with ISO 140-1 and ISO 140-3, the sample glass thickness was 480 mm, weight $1800 \text{ kg} \cdot \text{m}^{-3}$ with $R_w = 52 \text{ dB}$, the window was placed asymmetrically with the distance more than 500 mm from the floor, ceiling and walls, the window jamb was lined by material with absorptance less than 0.1, the rough jamb dimensions usually used in Slovakia is 1200/1200 mm) of sound insulation of sample windows with single or double glass of various thickness (weight) and distance between the glass layers, the following relationship for R_{woz} (dB) has been derived:

$$R_{\text{woz}} = 26.4 + 14 \log d/d_0 + 24 \log h/h_0 \quad (\text{dB}), \quad (2)$$

where d is the distance between the glass layers in mm ($d = 10 - 200 \text{ mm}$), $h = h_1 + h_2$ is the thickness of the first and second glass layers (from the interior) in mm ($h = 6 - 14 \text{ mm}$), $d_0, h_0 = 10 \text{ mm}$.

Basing upon experimental measurements, the following glass thicknesses has been chosen:

$h_1 \geq 1.5$ to $2h_2$ for the insulation double glass,

$h_1 \geq 1.5$ to $2h_2$ for the double and coupled windows.

Different glass thicknesses result in the suppression of the resonance and coincidence effects. Thicker glass shows higher sound insulation from the exterior side and makes up a barrier for noise from outside, the inner glass, due to lower weight, emits less sound energy.

For a glass system in that the air gap between the glass layers is joined with the outside environment and makes a de-compression cavity, from the viewpoint of sound insulation it is better to have an inner glass of higher thickness (weight).

It can be stated that

— for a larger gap between the glass layers d (mm), R_{woz} increases,

— for a higher glass thickness, R_{woz} increases.

Beside acoustic requirements, a glazed system must also meet thermal engineering requirements. They have therefore to be considered when designing the distance between the glass layers.

- | | |
|---|---------------|
| 1) PVC window with double glass 4/16/4 Planitherm | $R_w = 33$ dB |
| 2) Wooden window with doubles glass 9/12/6 | $R_w = 37$ dB |
| 3) Wooden window with triple glass 4/8/4/8/4 | $R_w = 32$ dB |

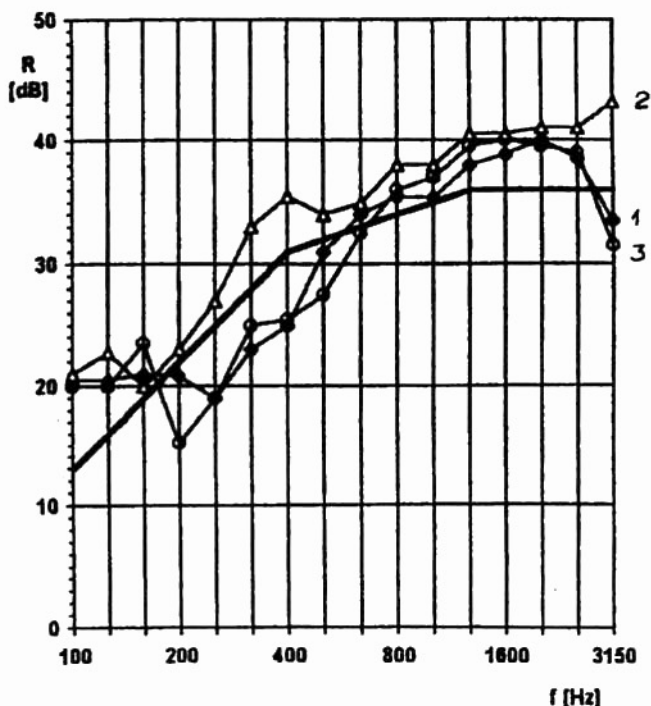


Fig. 1. Results of measuring.

1.3. Multiple glass

The energy requirements related to the window quality require multiple glazing. The adding of another glass layer results in increased glazing weight and sound insulation, correspondingly. The sound insulation improvement will not be very high — adding another glass divides the air gap into two narrower spaces whose resonance frequency causes reduction at low and medium frequencies. The effect of the higher glazing weight will be obvious at high frequencies.

Experimental measurements of glazed systems indicate that from the viewpoint of acoustics it is better to use two glass layers of different thickness than a triple glazing of equal weight (factory produced triple glazing).

The use of multiple glass is reasonable

- if the gaps between the glass layers are different $d_1 \geq 3d_2$ (mm),
- if the gap is wider $d_1 \geq 50$ mm,
- if glass thicknesses are highly different, the following glass thicknesses are suitable: $h_1 \geq h_3$ and $h_2 \geq 1.5 - 2h_3$,

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Composition of tested specimen:

Protocol No.: A30-2/98

Plastic window with thermal insulated double glazing

Specimen: No.2

composition of double glazing: 9 + 16 +6 (mm)

KONTRANITTERM+AR. KW31/44/1,3

Customer: Lignotesting a.s.
Lamačská cesta č.1
841 05 Bratislava

Date of adoption: 9.12.1998

Date of testing: 21.12.1998

Testing method: STN 730516

Acoustic chambers:

Receiving chamber: Volume $V = 57 \text{ m}^3$

Sending chamber: Volume $V = 53 \text{ m}^3$

Testing sound: noise generator

Filters: 1/3 of octave

Testing area: $S = 1,4 \text{ m}^2$

Tested specimen:

Name: Plastic window

Dimensions: 1180x1180 mm

Weight related to the area: 43.6 kgm^{-2}

Measurement conditions:

Temperature: 20 °C

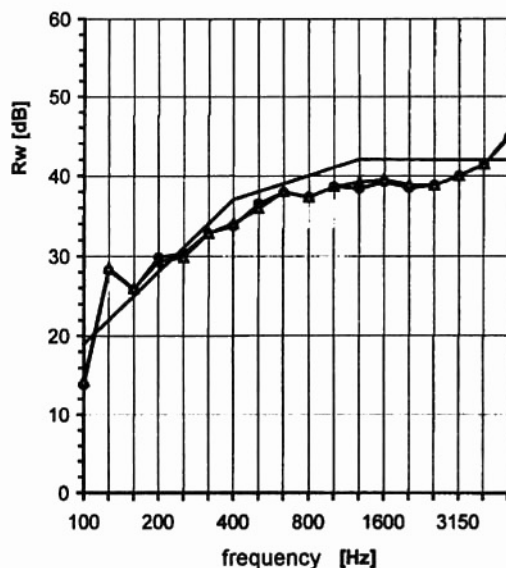
Pressure: 997 mB

Relative humidity: 33 %

Date: 7.1.1999

Measured by: Mgr.Daniel Szabó

Air sound insulation STN 730513
Air sound insulation index:
$R_{w1} = 37 \text{ dB}$
$R_{w2} = 38 \text{ dB}$



Approved by: Prof.Ing.Jozef Zajac,DrSc.

Fig. 2. Measure protocol.

Building Acoustics Analyzer B&K 4418

RECORD NO. 325	RECORD NO. 326
OPTION NO. 93	OPTION NO. 93
NRM. LEVEL DIFF.	
V= 57 S= 1.4	V= 57 S= 1.4
HZ CODES DB	HZ CODES DB
100 13.8	100 14.3
125 28.2	125 28.5
160 25.8	160 25.9
200 29.8	200 29.3
250 30.3	250 29.8
315 32.8	315 32.8
400 33.7	400 34.0
500 36.5	500 35.9
630 37.9	630 38.0
800 37.3	800 37.3
1000 38.6	1000 38.6
1250 38.4	1250 39.2
1600 39.2	1600 39.5
2000 38.5	2000 38.9
2500 38.8	2500 38.8
3150 40.0	3150 40.0
4000 41.4	4000 41.4
5000 44.7	5000 45.1
6300 44.8	6300 44.7
8000 46.2	8000 46.4

Fig. 3.

— for insulation double glass design,

— for glazing with a pre-set glass and with a insulation double glass, whereas d_i = gap width and h_i = glass highness.

Insulation double glass is used from the interior side, as the space between the pre-set glass and insulation double glass makes a de-compression cavity.

1.4. Desing modifications of glazing

a) It is good to use a noise absorbent along the air gap circumference:

— At a larger distance between the glass layers.

— The noise absorbent use is governed by functional possibilities valid for the desing of the absorbing lining.

— The R_{woz} (dB) increase along the air gap circumference resulting from the of noise absorbent is +2 to +3 dB, [11, 12].

b) Desing of separate window frames:

— The decrease of the noise insulation is influenced by the glazing and mounting.

— Depends upon the shape and number of window wings, and the way of joining the wings and frames of coupled and doubled windows.

c) Gas filled insulation double glass:

— In heavy gases, sound propagates at a lower rate.

— In the gas filling, forced oscillation does not occur so easily, and thereby, its level is lower.

d) Thermo-insulating double glass

— The glazed system weight increases, and thus the resonance at low frequencies will be suppressed.

e) Glass mounting

— Elastic mounting increases the transfer of sound waves of high wavelength, therefore the sound insulation decreases at low frequencies.

— With fixed glazing, the sound insulation decreases at medium and high frequencies.

— The glazing materials used at present do not affect the acoustic parameters significantly.

References

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