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The sound insulation provided by windows

N J Tinsdeall

The sound insulation provided by similar types of windows varies considerably. This paper describes experiments on a number of elements which affect sound insulation, including the sealing of openable panes, the type of frame material, the size of the window panes, and the spacing of panes in multiple pane systems. It identifies the main factors and lists the potential insulation values for various types of window. This paper will be of interest to architects, planners and acoustic consultants.

INTRODUCTION

It is becoming increasingly important to protect people in buildings from external noise. Noise can enter a building through all parts of the envelope but windows and doors are usually the most acoustically weak areas in traditional brick/block buildings. Since doors usually open into non-critical areas (such as corridors, lobbies etc), windows which open into rooms warrant the most attention.

FACTORS THAT AFFECT SOUND INSULATION

The usual method of improving the sound insulation provided by a window is to install a second pane of glass separated from the primary pane, by using either:

- a secondary pane with a spacing of more than 50 mm (as required in the Noise Insulation Regulations, 1975[1]), or
- thermal glazing with a pane spacing which is usually less than 25 mm.

The pane spacing produces different insulation characteristics and is the main factor in controlling insulation.

Additional factors which affect the sound insulation include: sealing, frame type, window pane size, reveal lining and ventilation openings. The importance of these factors is outlined here.

PERFORMANCE TESTING

The tests were conducted between two reverberant rooms in a standard transmission suite: this is the usual laboratory method for measuring the sound insulation of building elements. Additional tests were made with the windows in an aperture between anechoic and reverberant rooms to simulate real field conditions (ie outdoors to indoors). Results are presented as graphs of sound insulation (sound reduction index R) plotted against frequency, and also as single figure ratings R_W (Table 1)[2].

The procedure for calculating the single figure rating is detailed in the box (page 4). Generally the results from the transmission suite method compared well with the

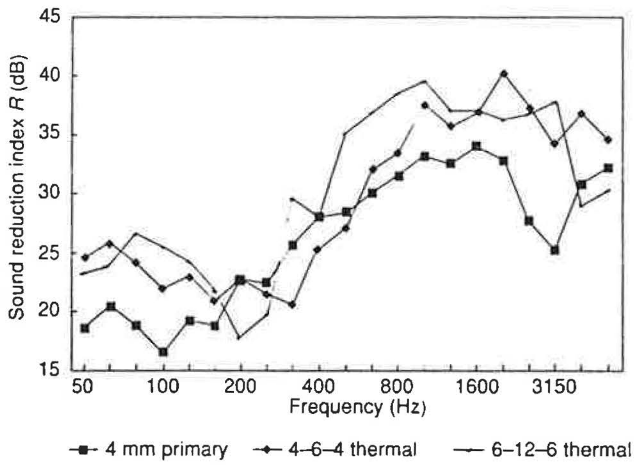


Figure 1 Effect of pane spacing, thermal glazing

Building Research Establishment
Garston, Watford, WD2 7JR
Telephone 0923 894040
Fax 0923 664010

Table 1 Single figure ratings (R_W) for glazing combinations described in the text

Frame and window details			Glazing details		
Material	Pane size	Seal type	Primary pane	Secondary (4 mm glass)	R_W
Wood	Large	Normal	4 mm	None	30
Wood	Large	Normal	4–6–4	None	32
Wood	Large	Normal	6–12–6	None	34
Wood	Large	Normal	4 mm	150 mm gap	42
Wood	Large	Normal	4 mm	300 mm gap	47
Wood	Large	Normal	6–12–6	150 mm gap	46
Wood	Large	Normal	6–12–6	300 mm gap	52
Wood	Large	Normal	4 mm	150 mm + liner	44
Wood	Large	Normal	4 mm	300 mm + liner	51
Wood	Large	Good	6–12–6	None	34
PVC-U	Large	Normal	6–12–6	None	35
PVC-U	Large	Poor	6–12–6	150 mm gap	33
Wood	Small	Normal	4 mm	None	29

additional tests in the anechoic chamber for the single-glazed windows, but not so well for the secondary glazed windows. The transmission suite method tends to exaggerate effects such as the mass spring mass resonance (which is described in the next section) compared with the idealised field tests. However, in spite of differences in the insulation spectra, the calculated single figure numbers differed by only 1 or 2 dB. The tests were conducted using commercially available window frames, fitting an aperture of 1.76 m × 1.19 m.

Effects of pane spacing

Figure 1 shows the improvement achieved when the single 4 mm glazing (a fixed pane of 1100 mm × 1100 mm and an opening pane of 510 mm × 1100 mm) was replaced by two types of thermal glazing (4–6–4 and 6–12–6)*. The same window frame was used for these tests, so any effect is due to the change of glass.

A reduction in the sound insulation at either 200 Hz (for the 6–12–6) or 315 Hz (for the 4–6–4) can be seen owing to the mass–spring–mass resonance of the two panes, and is a feature of all two-pane systems. It may be compared to the resonance of two masses joined by a spring. The spring in these windows is the air separating the two panes, which are the two masses. The frequency of this resonance is dependent on:

- the thickness of the glass (heavier glass leads to lower resonant frequency)
- the separation of the panes (greater separation leads to lower resonant frequency)

Hence when the pane spacing was increased to 150 mm, as for most secondary glazing systems, the frequency of resonance was reduced to below 80 Hz (for 4 mm thick glass). This may be seen in Figure 2 which demonstrates the improvement offered by the installation of an independent secondary pane. Increasing the air gap to 300 mm can offer a further improvement, mainly at frequencies below 500 Hz.

*For example, 4–6–4 indicates two 4 mm panes separated by a 6 mm gap.

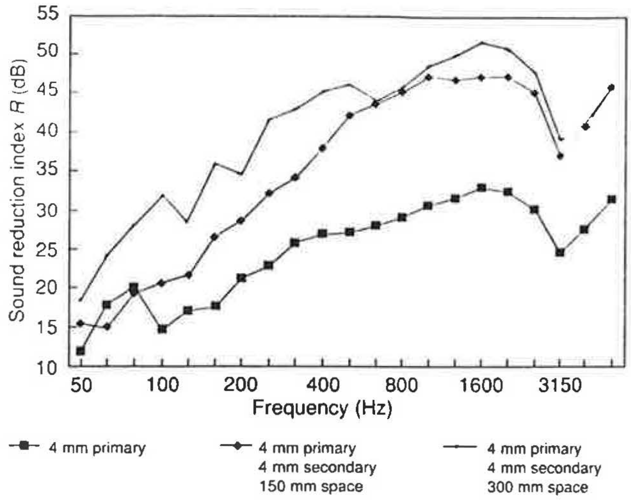


Figure 2 Effect of pane spacing, secondary glazing

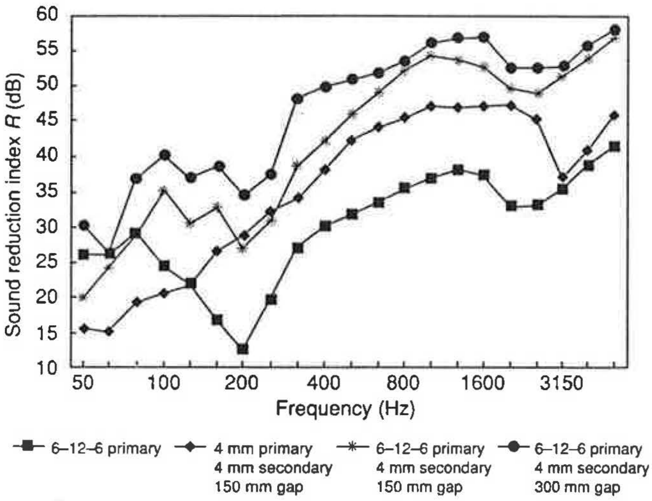


Figure 3 Installation of secondary glazing and thermal glazing

A further improvement was obtained when the 4 mm primary pane was replaced by a thermal double pane. Figure 3 illustrates the additional improvement that this offers.

Sealing

All the tests relating to the different pane spacings were undertaken using a frame with a good seal. This frame was fitted with the 6–12–6 thermal glazing, and a foam strip, of the type used to seal draughts, was used to create an additional seal round the openable pane. The results (see Figure 4) show an improvement over all frequencies above 500 Hz and are now very similar to those for the performance of a PVC-U window frame installed with similar glass. The effects of the poor sealing are usually apparent as a flattening of the sound insulation curve above 600 Hz, quite often with a marked dip around 1600 Hz, possibly because the gap behaves as a resonator[3].

In the experiments on secondary window systems the secondary window comprised two panes of 4 mm glass sliding in a plastic channel. It was found essential to seal the central joint between the sliding panes with tape to achieve maximum performance.

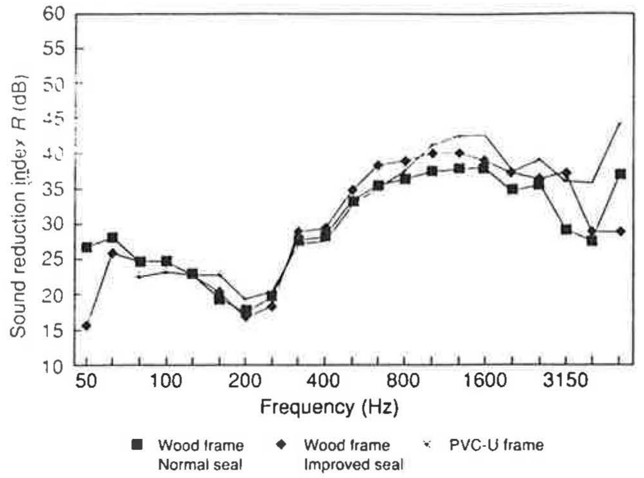


Figure 4 Sealing improvements to wood frame with 6–12–6 glass

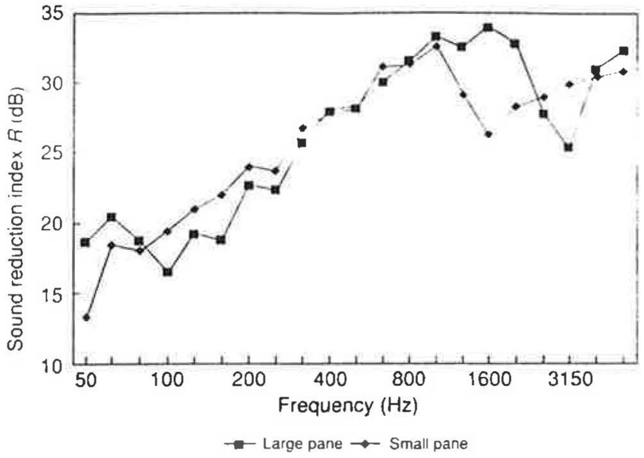


Figure 6 Effect of pane size

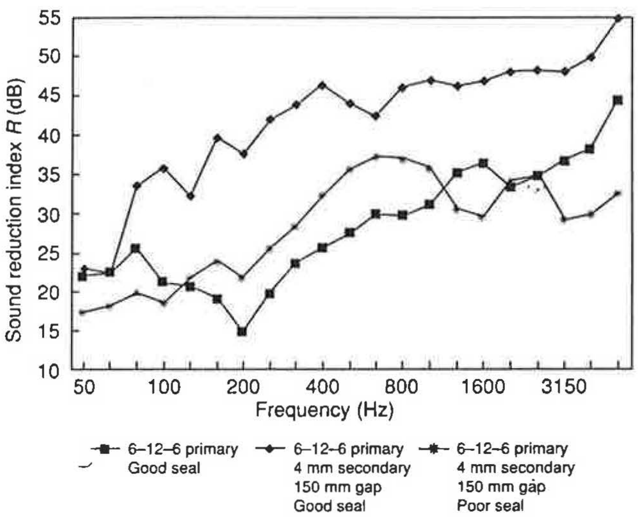


Figure 5 Effect of sealing on secondary glazing. PVC-U primary frame with 6–12–6 glass

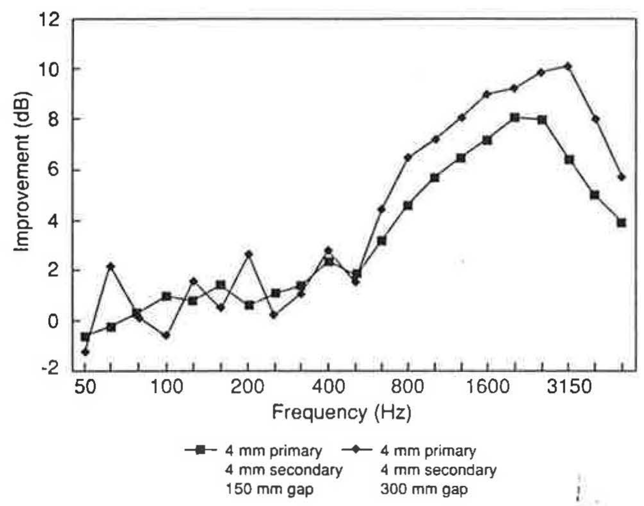


Figure 7 Improvements offered by a reveal liner. Large pane wood frame with 4 mm glass spacing

Figure 5 shows the effect of poor sealing in a secondary glazing system. The performance of a badly sealed primary window plus a secondary window is little better than the performance of the well sealed primary window alone.

Frame type

When the sealing of the standard wood frame was upgraded (Figure 4) the performance was similar to that of the PVC-U window suggesting that the performance of wood frames is comparable with that of PVC-U frames. However, the durability of the seals should be considered when selecting the frame construction. During our tests the performance of the wood frame degraded owing to a deterioration in the seal or slight warping of the window frame. Performance was restored by the use of additional seals.

For secondary glazed windows with very high performance, limited experimental evidence suggested that it would be advantageous to isolate the secondary frame from the primary frame; eg by mounting it on foam rubber, sealed with a mastic fillet.

Pane size

Small panes of 4 mm glass (24 panes each 210 mm × 240 mm) gave a marginally better performance at lower frequencies than the two large panes of approximately similar area (Figure 6). However, the small-pane window frames tend to have a number of openable lights, so the sealing is likely to be more critical. The effect of the poor sealing is indicated by the dip at 1600 Hz. The dip at 3150 Hz is due to the coincidence frequency of the 4 mm glass. This effect seems to be reduced for smaller panes of glass.

Reveal lining

The use of an absorbent reveal liner between the panes of a secondary window gives an improvement at higher frequencies (Figure 7).

Ventilation

Rather than opening a window, trickle ventilators are often used for background ventilation. This will have little adverse effect on the insulation provided by a single glazed window. However, the use of such ventilators will limit the sound insulation provided by a thermal double window. The reduction in the insulation occurs mainly above 315 Hz (depending on the size of the vent) with little or no effect at lower frequencies[4], so a properly designed system should be used where ventilation and high sound insulation are required.

CONCLUSIONS AND RECOMMENDATIONS

The sound insulation of windows is very dependent on the quality of the sealing. For continued performance the durability of the seal must be considered.

- The material from which the frame is made is not significant provided that the sealing round any openable panes is adequate.
- Multiple panes improve insulation. The greater the inner pane spacing the greater the possible insulation, although the sealing is often the limiting factor.
- Several small panes give slightly improved insulation at lower frequencies compared with a single pane of similar area.
- The use of an absorbent reveal liner is beneficial at higher frequencies.

REFERENCES

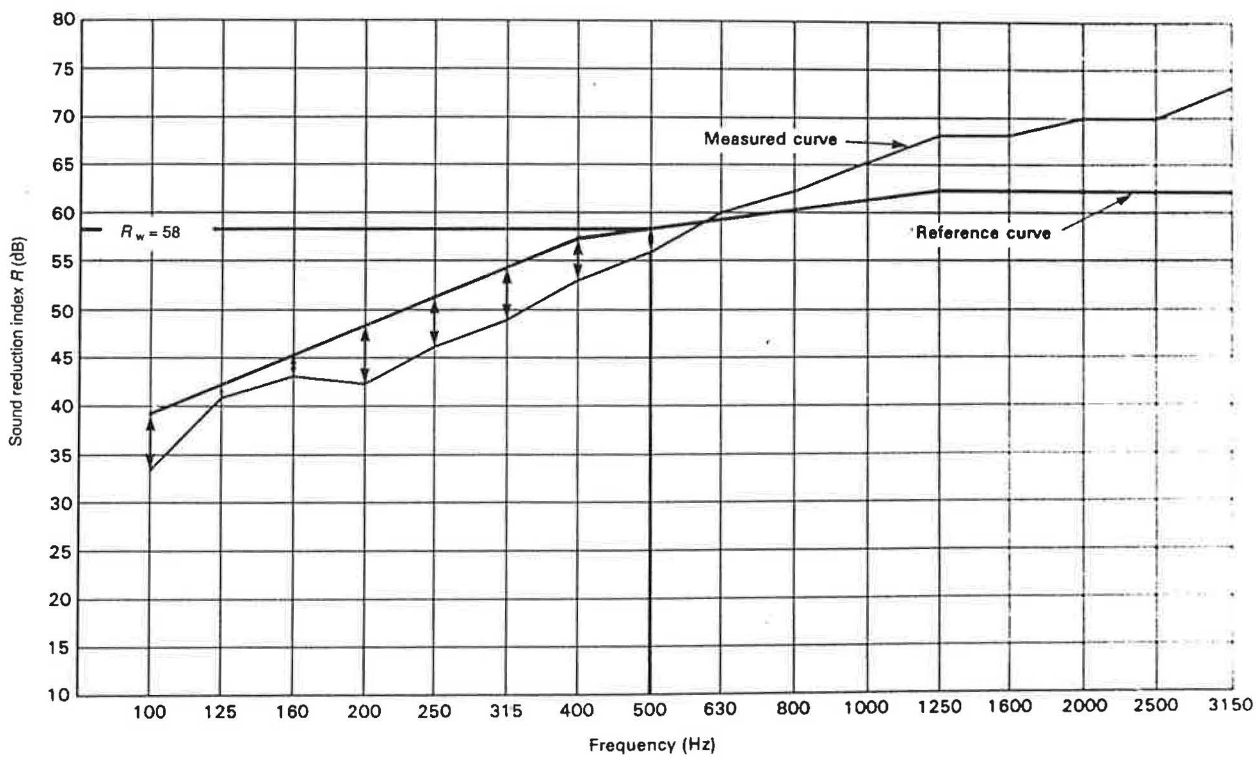
1 **Department of the Environment and the Welsh Office.** *Noise Insulation Regulations 1975.* Statutory Instrument 1975 Number 1763. London, HMSO 1973.

2 **British Standards Institution.** Methods for rating the sound insulation in buildings. Part 3: Method for rating the airborne sound insulation of façade elements and façades. *British Standard* BS 5821:Part 3: 1984. London, BSI, 1984.

3 **Burgess M A.** Resonator effects in window frames. *Journal of Sound and Vibration*, 1985, **103** 322–332.

4 **Jorro S.** Noise ingress through vents. *Building Services*, 1991, **13** (11) 51.

Example calculation of a single figure rating to BS 5821:Part 3:1984



Examples of rating procedure

To make a rating according to BS 5821:Part 3:1984, the reference curve is moved up or down with respect to the measured curve until the mean unfavourable deviation* (sum of unfavourable deviations/16) is as large as possible but not more than 2 dB. The single figure rating is taken as the level of the reference curve at 500 Hz when this fitting condition has been fulfilled.

*unfavourable deviations occur at frequencies where the measured curve is below the reference curve.

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