Different aspects of the effect of sealing on the acoustic performance of windows

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INTRODUCTION

The window as a part of external wall has a number of essential functions which are of vital importance for quality of rooms in the building. One of them is protection against external noise and most often the traffic noise is the main source of acoustic problems. Proper sound insulation of windows is not only a question of glazing its structure and components. The analysis of collected results of acoustic tests shows the considerable differences in the sound reduction index values obtained for windows with the same glazing. In the case of windows made of PVC sections of different systems with standard units 4/16/4 the values of $R_{A2} = R_w + C_{tr}$ index (mainly used for sound insulation assessment when traffic noise is considered) were in the range of 27 – 33 dB (R_w = 32 – 39 dB). Furthermore significant differences in sound insulation were observed in the case of windows of the same system, the same type, shape and glazing, but taken from different manufacturers. To find the reasons for such a spread various technical factors we analysed e.g. the type of window, its division into sashes, size and shape of glazing, sound insulation of frame and the influence of sealing. In the last case two main aspects were considered; the sealing as the direct path of sound transmission and perimeter gaskets as the support element of window sash.

SAMPLES AND MEASUREMENT CONDITIONS

The analysis is based on results of laboratory tests carried out on 156 samples of windows made of PVC sections belonging to 27 different systems. For each system 4 –8 samples taken from single producer were tested. All windows have the same standard 4/16/4 glazing. Measurements were carried out on single test facility (complying with ISO 140 standard) with the same equipment and operator.

SEALS AS A DIRECT PATH OF TRANSMISSION

In accordance with Polish regulations in the case of buildings with natural ventilation the air tightness of windows should be reduced so the value of air permeability coefficient should be within the range of a = (0.5 – 1) $m^3/mhdaPa^{2/3}$. Windows with full air tightness (a < 0.3) can be used only in buildings with mechanical ventilation or another system of air inlet. Then two sets of results were investigated separately; obtained for windows with full and reduced air tightness (in both cases the same samples were tested once before and then after air tightness reduction).

Windows with full air tightness. The air tightness of window is described by the value of air permeability coefficient “a”. Actual values of this coefficient for investigated windows were between (0,0 – 0,2) $m^3/mhdaPa^{2/3}$. In such a range no significant dependence of sound insulation on the “a” value was observed. Such dependence exists in the case of traditional wooden windows but the shape of their junction between fixed and operable members is quite different than in contemporary PVC or aluminium windows where the joint between frame and sash has a form of additional chamber in the whole cross section of frame. This chamber is closed by external and internal gaskets (see figure 1). It is not open staggered crack like in traditional wooden windows so the mechanism of sound transmission via the joint is different.

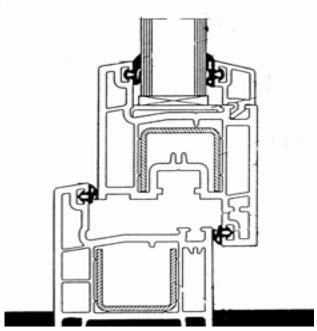

FIGURE 1 Cross section of PVC window frame, joint between fixed and operable members

The type of gaskets and their cross sections were also examined in respect of windows acoustic performance. No significant influence of the type or shape of seals sections on the sound insulation curves was noticed. However the location of external gasket is of some importance. In the case of windows with central gasket (MD) considerable drop in sound insulation can be observed in the 1000 Hz band in comparison with AD systems. But for windows with standard 4/16/4 glazing this local decrease in sound insulation has no influence on the values of single number quantities.

Windows with reduced air tightness. Reduction of air tightness always caused a negative effect in sound insulation but the effect wasn’t the same in each investigated case. The drop in sound insulation was observed mainly in the range of (500 – 1600) Hz. Figure 2 shows mean values of the decrease in sound insulation against frequency in case of PVC windows with 4/16/4 glazing. The maximum drop can be noticed in (800 – 1000) Hz bands.

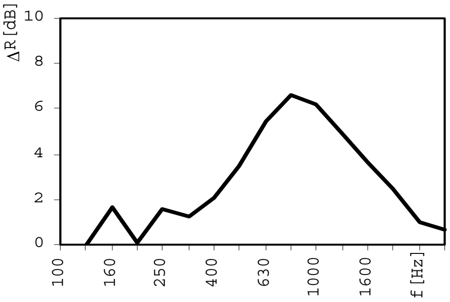

FIGURE 2 Decrease of sound insulation as an effect of window air tightness reduction, mean values

Single number quantities also diminish as an effect of window air tightness reduction. For particular samples (156 cases were analysed) decrease in sound reduction index reaches values of ΔR_w = (0 – 7) dB. Less affected was the

$R_{A2} = R_w + C_{tr}$ index because it is more dependent on low frequency bands.

Analysis of the results indicate that the decrease depends rather on the method of air tightness reduction than on the final value of air permeability coefficient. Different methods were considered; cutting of small part of gaskets in a way that the slots form a sort of labyrinth, using perforated or flat seals for the part of connection, using “ventilation” seals with a rough surface giving a small gap on the whole sash perimeter, assembling special devices in the space between frame and sash, or using micro opening of sash. Generally better results, i.e. a smaller drop in sound insulation, are given by solutions using local small gaps made in the seals (cuttings, flat or perforated seals). In this case the location of gaps is of crucial importance. They should form proper labyrinth inside the window frame which acts as a acoustic attenuator. Suitable location of cuttings depends on the window type and its division into sashes but in systems with central gasket (MD) drop in sound insulation was always bigger than in (AD) systems.

Methods of air tightness reduction which cause continuous gap on the whole perimeter (“ventilation” seals or micro-openings) result in bigger decrease in sound insulation than local cuttings. Because of absence of labyrinth the effect of gap can be observed in the wider range of frequency.

SEALS AS THE SUPPORT OF WINDOW SASH

The analysis of existing data as well as the results of additional experiments indicate that the seals acting as a support of window sash also influence their acoustic performances.

While comparing sound insulation curves obtained for single sash operable and fixed windows taken from the same manufacturer having the same dimensions and the same glazing in each investigated case the operable window had better sound insulation by (2 - 4) dB in the middle frequency range. Example of such a comparison is shown in figure 3.

FIGURE 3 Measurement results; both windows with the same dimensions and glazing were taken from one producer.

The main difference between these two tested samples is that in the case of fixed window glazing is inserted directly into frame mounted steadily in the test opening while in the operable window glazing is inserted in the same manner in the sash frame then the whole sash is put into the frame but perimeter gaskets separate these two elements. The conclusion can be derived that the resilient seals influence the sash (glazing) support conditions and cause the increase of sound insulation of the whole window.

Direct measurements carried out on PVC windows with 4/16/4 glazing confirm such a hypothesis. The initial test was taken for the whole single sash window, then next measurement for sash taken from it and mounted rigidly in the test opening. Results were normalized to the area of sash. The single number indices obtained for window were 2-3 dB higher than for the sash alone. This illustrates the range of influence of sash support conditions on the sound insulation of window. It should be one of the reasons that the sound reduction index of investigated PVC windows with standard 4/16/4 glazing was in the range of (32 – 39) dB while the glazing itself tested on (1230 x 1480) mm samples obtain no more than R_w = 32 dB.

Other observations follow from more detailed analysis of air permeability coefficient of PVC windows with the same 4/16/4 glazing. Not only the final mean values of this coefficient were investigated but also component values obtained for different air pressure which during tests increase form 60 to 300 (350) Pa. The value of “a” changes depending on pressure but it was observed that for windows of different systems the changes have different dynamics. Figure 4 shows mean values of air permeability coefficient normalised to 0 for windows of analysed PVC systems (systems are described by numbers). In each system 4 –8 samples were considered. The systems for which the increase of “a” value together with pressure is clearly visible show better acoustic properties than systems characterized by flat curves (No 3, 5, 6 in the figure). The considerable increase of “a” value means that the seals more easily open under air pressure so it can be say that the connection is “pliable”. It confirm that the “stiffness” of sash support influence the sound insulation of window.

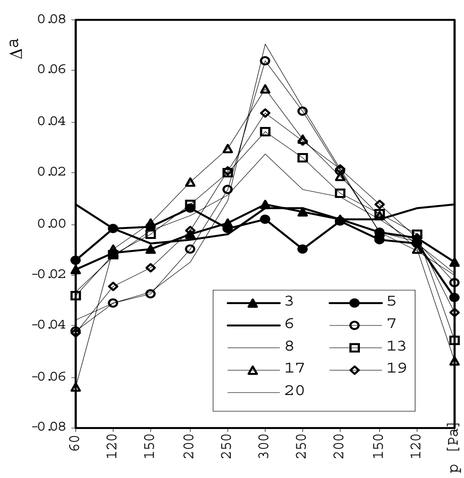

FIGURE 4 Mean values of air permeability coefficient normalised to 0 for windows of analysed systems N^o 3, 5, 7...

CONCLUSIONS

In contemporary PVC or aluminium windows the joint between frame and sash form an additional sealed chamber in the whole cross section of frame, so the mechanism of sound transmission via the junction is different than in traditional wooden windows. No strict relationship between air permeability coefficient value and sound insulation was found.

Reduction of window air tightness usually causes drop in sound insulation in the range of (500 – 1600) Hz resulting in decrease of single number quantities. Its value depend rather on the method of air tightness reduction than on the final value of air permeability coefficient.

The perimeter gaskets also influence the sound insulation of windows acting as a sash support element. Analysis of existing measurements results indicates, that the systems with more “pliable” support have better acoustic performances.