Influence of design and leakages of the window-wall connection on the sound insulation.

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ABSTRACT

Sound insulation performance of enclosures like lightweight exterior wall systems depends on the one hand on the sound insulation of the exterior wall design, on the other hand on the sound insulation of windows and doors and finally on the design of the connections between.

An investigation done under the laboratory conditions shows, that the influence of the connection design of the window element to the wall can reduce the resulting sound insulation remarkable, especially if there are higher requirements for the sound insulation against exterior noise.

The effect of leakages on reducing sound insulation also depends as expected on the type of material that is used for thermal insulation and air tightness and posssible leackages. Moreover also the position of leakages influences the result of the sound insulation – in some cases the wedges that are used to get the window in the right position are incorrectly processed and so sometimes have to be removed before finishing the connection and mounting of the window sills, with the consequence of a bad sound insulation performance. A handy tool was developed, based on a modified sound intensity method, that can help to find such leackages quickly.

Finally the different methods in ISO EN 10140-1 for the estimating of the sound insulation of joints were discussed.

Investigation shows, that it is necessary to be careful in designing such connections and also in choosing the right measurement or evaluation method to get reliable results for an estimation of the sound insulation performance of connections.

Keywords: Sound, Insulation, Transmission, windows

I-INCE Classification of Subjects Number(s): 51.3

1. INTRODUCTION

The quality of the airborne sound insulation of the building envelope in most cases are strongly influenced by the acoustic performance of window and door openings. In Europe the acoustical performance of these elements have to be declared according to the European Construction Products Regulation CPR[i]. The regulation lays down seven basic requirements for construction works. The fifth basic requirement is “Protection against noise: “The construction works must be designed and built in such a way that noise perceived by the occupants or people nearby is kept to a level that will not threaten their health and will allow them to sleep, rest and work in satisfactory conditions.”

The regulatory requirements to meet this European criteria are defined by the different European countries and their legislators. In Austria and in most European countries there exist requirements for the exterior wall itself, for the window or door itself and for the overall apparent sound index $R'_{res,w}$ which is the result of the transmission of the composed exterior envelope of a room.

To estimate the sound power ratio for composed elements in most cases the sound reduction index

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of each composing part is used, taking into account the relative area of the single parts. Here the problem arises, that there are just rare results concerning the connection between windows, doors and the reveal. This is partly caused by the problem, that there exists a great variety of possibilities for the construction of the joint.

In most cases, we try to get a tight connection, based on mineral wool or PU-foam usually combined with sealings or sealing foils.

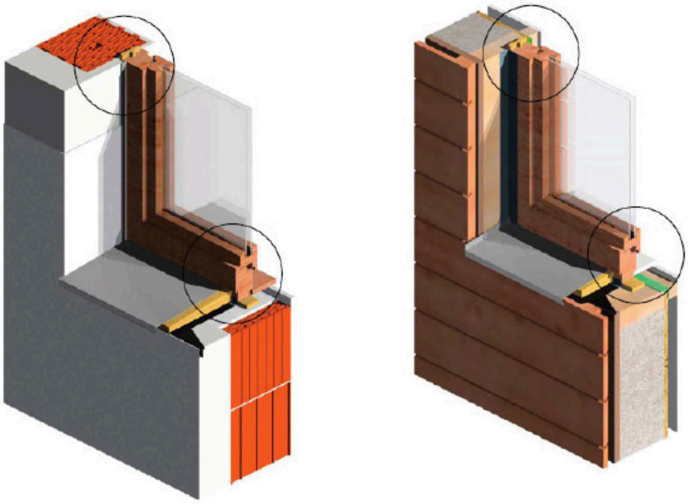


Figure 1 – Typical window – wall connection

Following the mentioned calculation model, which is also part of EN 12354-3[ii], the sound power ratio for the exterior wall can be estimated according to

$$\tau_e = \sum_{j=1}^{n} \frac{S_j}{S} 10^{-\frac{R_j}{10}} + \frac{l_0}{S} \sum_{k=1}^{m} l_{s,k} 10^{-\frac{R_{s,k}}{10}} \tag{1}$$

where is

R_j sound reduction index of part j of the element in dB

S_j area of a part j of the element in m^2

$R_{s,k}$ Sound reduction index of sealed connection k per unit length in dB

$l_{s,k}$ length of sealed slit or joint k in m

n number of parts

m number of connections or slits

An overall weighted sound reduction index can be estimated also in relation to the surface area of the composing parts.

$$R_{res,w} = -10\lg\left(\frac{1}{S_g} \sum_{i=1}^{n} S_i 10^{-\frac{R_{w,i}}{10}}\right) \tag{2}$$

where is

$R_{res,w}$ overall weighted sound reduction index in dB

$R_{w,i}$ weighted sound reduction index of part j of the element in dB

S_i area of a part j of the element in m^2

n number of parts

With this calculation models the actual influence of joint will be underestimated, if the construction of the joint has a high sound transmission related to the other composing parts. This can be caused by faults, cracks or other defects within the joint, which often is the case of a poor implementation.

As is well known, the sound transmission index of small openings, holes or slits is wave-length dependent and can become higher than one. The reasons for this undesired property are defraction effects of sound waves at the edges of the opening and also resonance effects of the opening itself.

A second important influence is the nearness of reflecting surfaces near the opening. Therefore it is important to pay attention to a tight design of the joint especially in edges and corners.

Figure 2 – Examples for bad window-wall connections

The above mentioned influences can lead to drastic reduction of the sound insulation performance of installed windows, caused by small defects in the connection to the wall. In the following chapter some examples of that influence are presented as measured under laboratory conditions and the effect on sound reduction index is shown.

2. Laboratory measurements

Caused by some damage cases we did a small study of the influence of different leackages on the overall sound transmission of an installed window. As mentioned above, also the effects of edges and corners should be included. For the filling of the gap between reveal and window frame mineral wool as well as elastic PU Foam was used. To get information about the performance influence of sealing tapes, usual material was applicated.

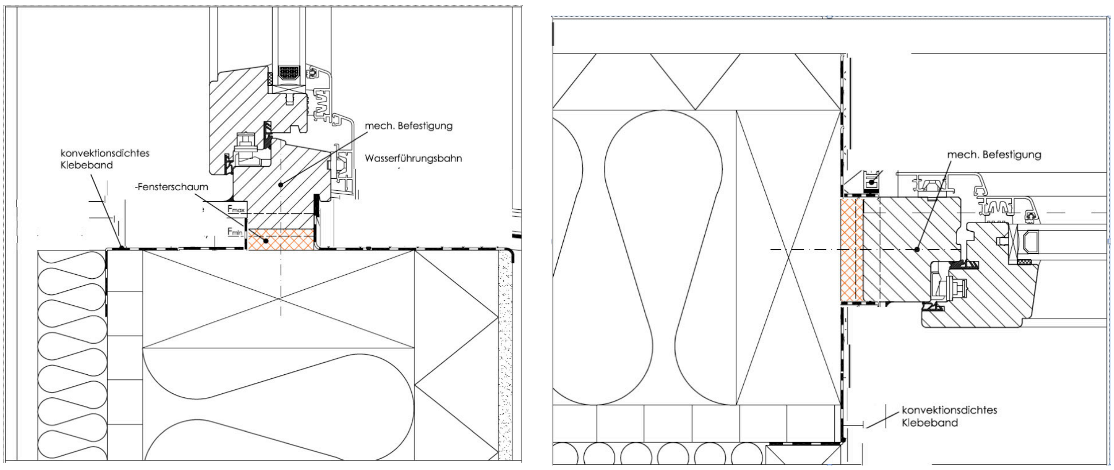
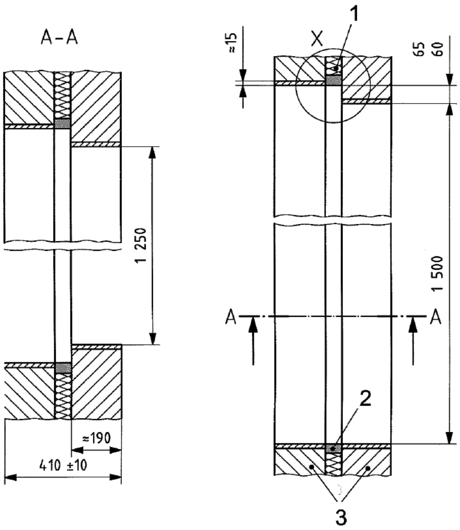


Figure 3 – Section: Typical design of a window joint sealing – lightweight construction (ecowall)

2.1 Testing facility for the sound transmission of windows

To get comparable and reproducible results, we used our laboratory testing facility “special small test opening” specified in section 3.3.3 of ISO 10140-5[iii].



1 …mineral wool

2 …reflecting sealing

3 …partition wall

all dimensions in mm

Figure 3 – left hand: Sketch of the testing facility opening acc. ISO 10140-5 and right hand: Sound transmission Lab of Graz University of Technology, Austria

We used two different window systems for the measurements, one with a wooden frame and a weighted sound reduction index R_w = 39 dB and a second one with a R_w = 41 dB with a wood/aluminum frame system. To get the above mentioned values, we used our standard mounting material, a kind of special high sound insulating sealing on both ides of the gap and some mineral wool between.

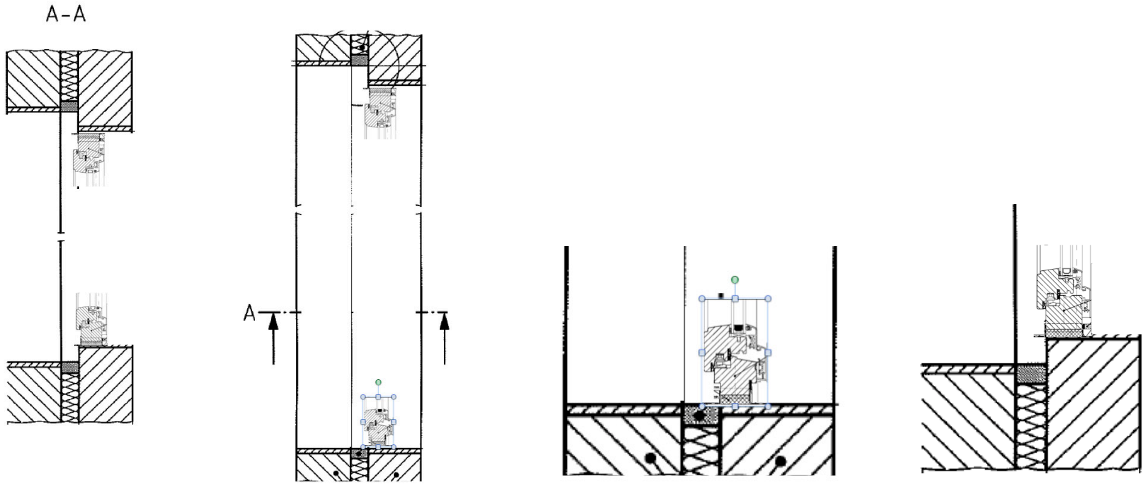


Figure 3 –horizontal (left hand sketch) and vertical section (second left hand sketch) and window mounting details

The measurements were performed according EN ISO 10140-2[iv] with the weighting according ISO 717-1[v].

2.2 Some measurement results

Table 1 – Some Measurement Results

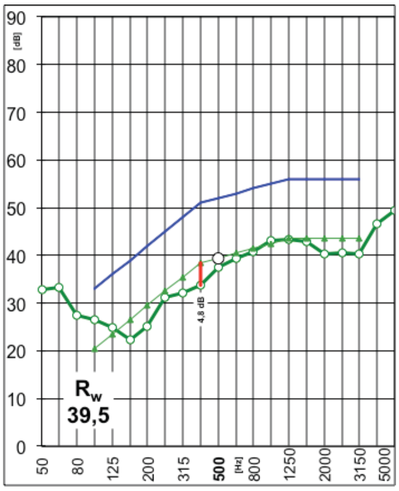
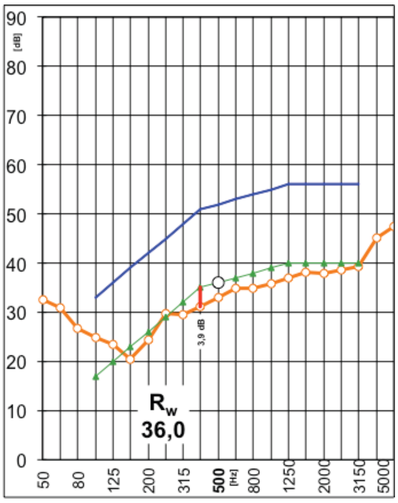
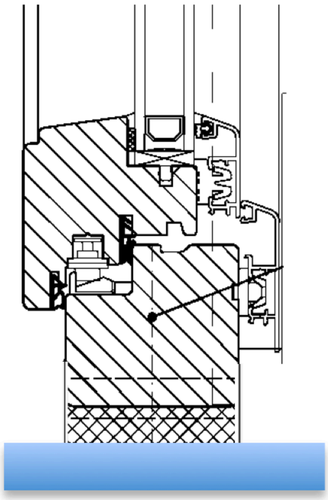
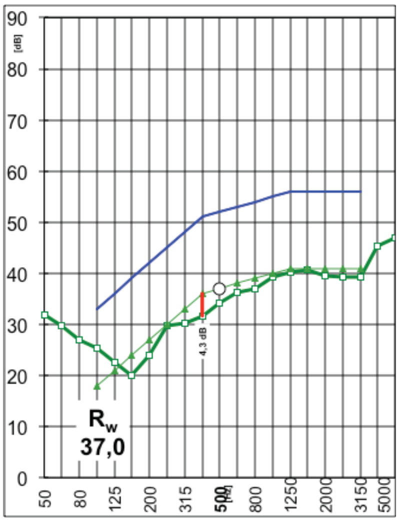
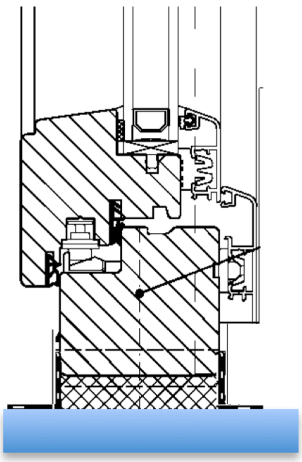
<table>
<tr><th>Chart</th><th>Picture</th><th>Description</th></tr>
<tr><td>
</td><td></td><td>Window System with
wooden frame
glazing:
6 – 20 – b4
glass –spacer - glass
R_w = 39 dB
Slit:
tight</td></tr>
<tr><td>
</td><td></td><td>Window System with
wooden frame
glazing:
6 – 20 – b4
glass –spacer - glass
R_w = 39 dB
Slit:
width: 8 - 15 mm
mineral wool</td></tr>
<tr><td>
</td><td></td><td>wooden frame
glazing:
6 – 20 – b4
glass –spacer - glass
R_w = 39 dB
Slit:
width: 8 - 15 mm
mineral wool +
sealing tape both sides</td></tr>
</table>

Table 2 – Some Measurement Results

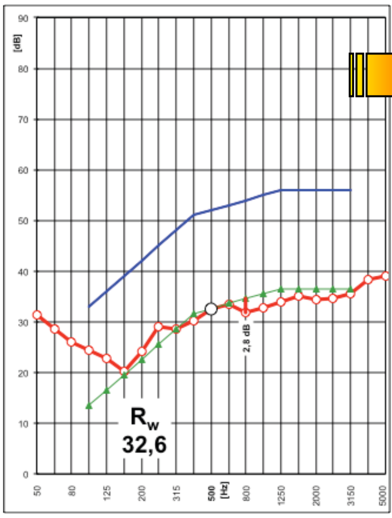
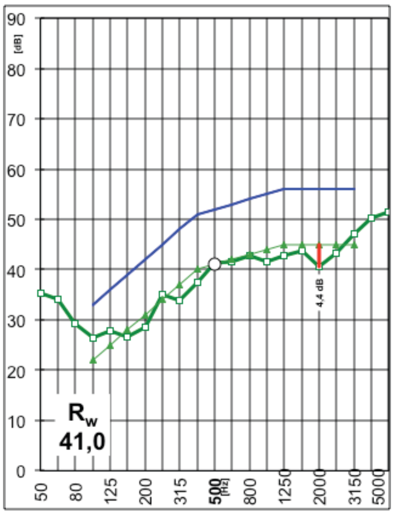
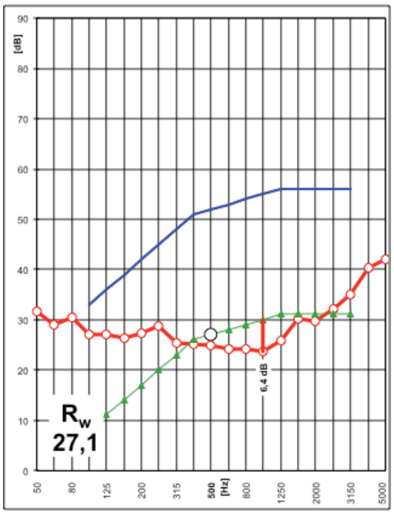
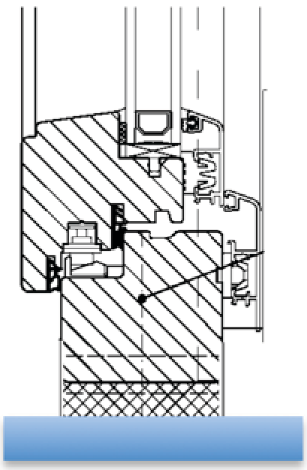
Chart	Picture	Description
		wooden frame glazing: 6 – 20 – b4 glass –spacer - glass R_w = 39 dB Slit: width: 8 - 15 mm mineral wool + sealing tape both sides gap 50 mm in corner
		Wood/alu frame glazing: 8 VSG – 20 – b6 glass –spacer - glass R_w = 41 dB Slit: width: 25 mm tight
		Wood/alu frame glazing: 8 VSG – 20 – b6 glass –spacer - glass R_w = 41 dB Slit: width: 25 mm mineral wool R_w =27 dB

Table 3 – Some Measurement Results

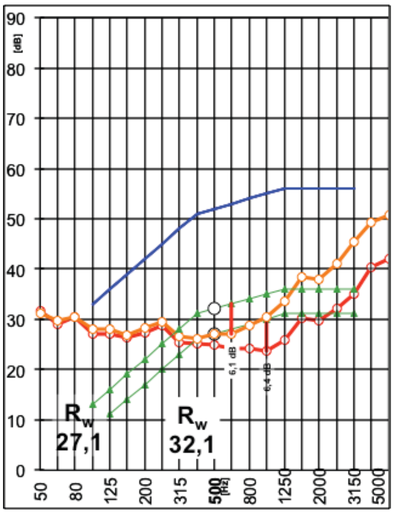
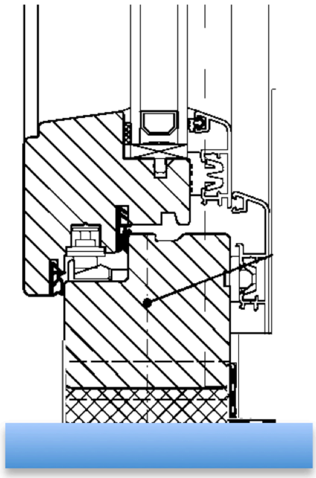
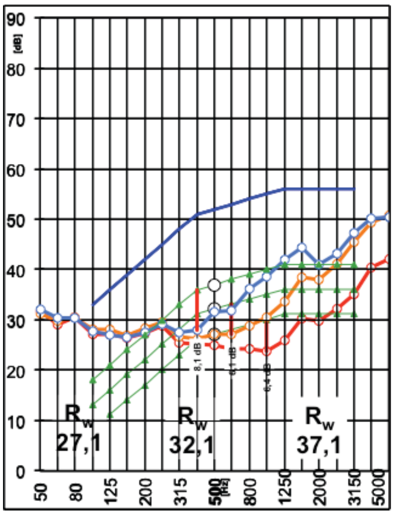
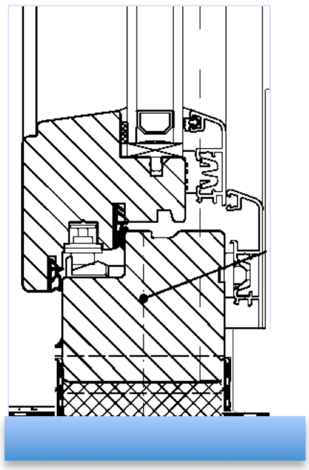
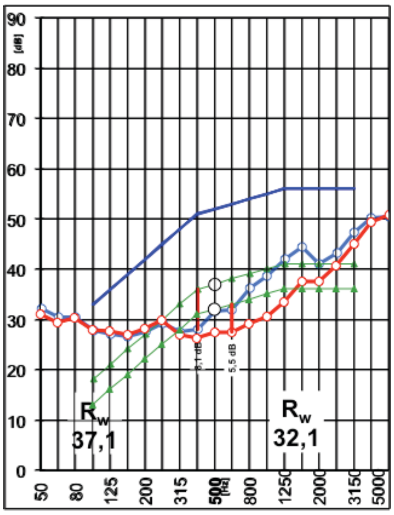
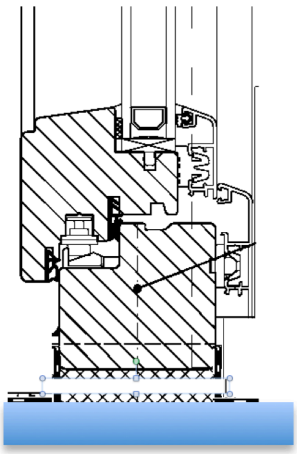
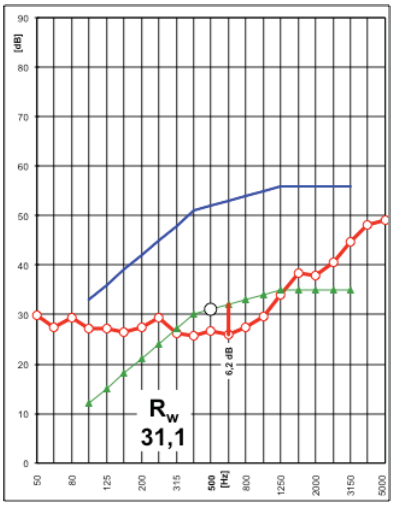
Chart	Picture	Description
		Wood/alu frame glazing: 8 VSG – 20 – b6 glass –spacer - glass R_w = 41 dB Slit: width: 25 mm mineral wool with sealing tape source room R_w =32 dB
		Wood/alu frame glazing: 8 VSG – 20 – b6 glass –spacer - glass Rw = 41 dB Slit: width: 25 mm mineral wool with sealing tape both sides Rw =37 dB
		Wood/alu frame glazing: 8 VSG – 20 – b6 glass –spacer - glass Rw = 41 dB Slit: width: 25 mm mineral wool with sealing tape both sides + 1 hole ⌀ 10 mm Rw =32 dB

Table 4 – Some Measurement Results

Chart | Picture | Description



Wood/alu frame

glazing:

8 VSG – 20 – b6

glass –spacer - glass

R_w = 41 dB

Slit:

width: 25 mm

mineral wool with

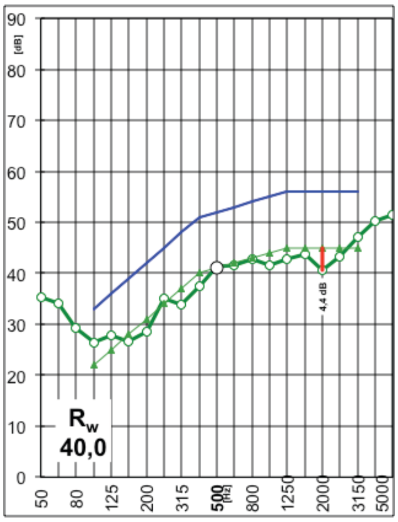
sealing tape source both

sides

+ 2 wedges: R_w =31 dB

wedges removed:

R_w =29 dB



Wood/alu frame

glazing:

8 VSG – 20 – b6

glass –spacer - glass

R_w = 41 dB

Slit: width: 25 mm

PU Foam uncut

R_w =37 – 39 dB

cutted + sealing tape

both sides:

R_w =40 dB

Wood/alu frame

glazing:

8 VSG – 20 – b6

glass –spacer - glass

R_w = 41 dB

Slit:

width: 25 mm

PU Foam uncut, with 2 wedges

R_w =31 dB

Wedges withdrawn: R_w = 22 dB

Wood/alu frame

glazing:

8 VSG – 20 – b6

glass –spacer - glass

R_w = 41 dB

Slit:

width: 25 mm

PU Foam uncut, wedges

withdrawn

+ sealing tape both sides

R_w =31 dB

Table 5 – Some Measurement Results

Chart	Picture	Description
Wood/aluminum frame		Wood/aluminium frame
glazing:		glazing:
8 VSG – 20 – b6		8 VSG – 20 – b6
glass –spacer - glass		glass –spacer - glass
R_w = 41 dB		R_w = 41 dB
Slit:		slit width: 25 mm
width: 25 mm		PU Foam cut
PU Foam cut		Open slit to parapet
R_w =39 dB		R_w =15 dB
1 hole ⌀ 10 mm		circumferential open slit:
Rw =35 dB		R_w =9 dB

2.3 “Sound transmission bridges” in situ

Especially for window connections of low energy houses sound insulation aspects are neglected, as the following examples show. In this cases a circumferential steel framing should be preferred to get a satisfying airborne sound insulation, especially in areas with a higher exterior sound level.

Figure 4 –window mounting in the insulation layer

A second big problem for a bad sound insulation performance are sometimes the window replacement to get a better thermal insulation performance. The proper refurbishment of the reveal seems to be a problem with regard to time constrains.

Figure 4 –building refurbishment: bad window mounting examples

After finishing the completion of the plaster the source of a bad sound insulation performance may be difficult to detect. So we did some further investigations to find a handy method that can help to detect sound transmission path of connections and slits.

2.4 Visible sound transmission

Today there are different methods exist to visualize sound transmission. E.g. well known methods are the acoustic camera based on beam forming or near-field holography. But our tests with this excellent tools to detect leakages or surfaces with a higher sound transmission were not really satisfying. On the one hand, in some cases under in situ room acoustical circumstances it is really difficult to get a reliable result, on the other hand the needed equipment is quite expensive.

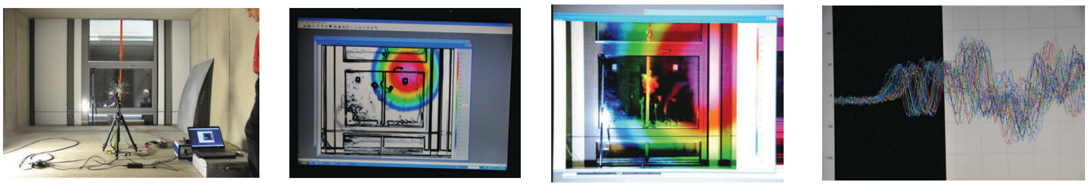


Figure 5 –visualization of sound transmission through a gap of the sealing of a window

A proper method is sound intensity measurement, which we used some times in the past, but to get a visualization, the preparation of the measurement takes some time.

So we discussed new ways, and tried out some different techniques. Based on a ingenious idea of Blasius Buchegger a first system could be developed and the results seem to be really excellent. Next steps will be to have a stand-alone system, that can be simply used also for insitu measurements.

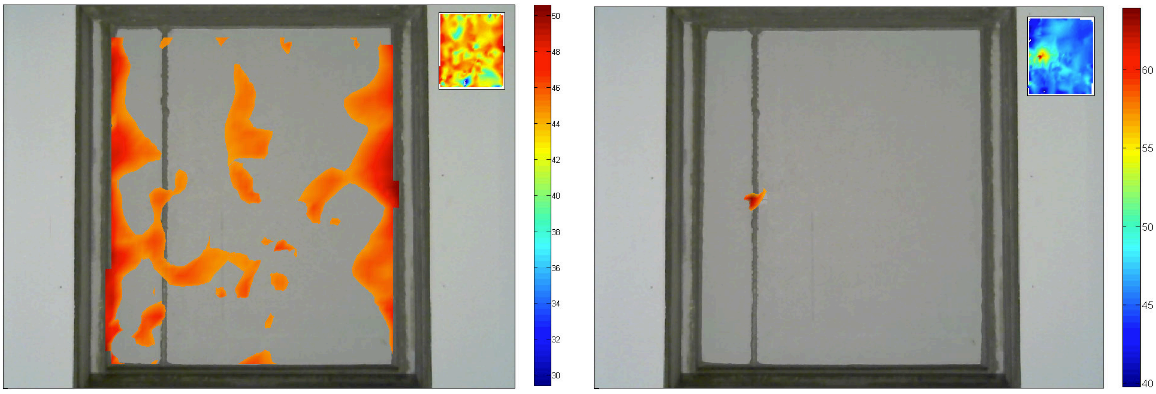


Figure 5 –visualization of sound transmission through the connection and a small gap of the sealing of a panel under laboratory conditions.

The system allows to get a full spectrum information with an adjustable “resolution and exposure” function which allows to focus on every specific analytical problem caused by sound transmission.

3. CONCLUSIONS

The quality of the window – wall connection can have a remarkable influence on the resulting airborne sound insulation of a building envelope. The calculation methods based on the area of the composing parts probably may underestimate the sound transmission of gaps in corners and edges of reveals especially with reflecting surfaces. Also the dimensions and geometry influences the sound transmission wave-length dependent. So it is important to pay attention not only to energy saving constrains when designing and carrying out the construction work of the window or door connection, but also to avoid bad influences on sound insulation aspects.

To detect such sound transmission paths a new visualization tool was developed. With this tool also the influence of a unsuitable design or acoustically incorrect mounting of windows and doors can be visualized as a reliable basis for a decision about further measures to improve sound insulation. The new tool seems to be a handy contribution to “Improve the world through noise control”.

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[iv] EN ISO 10140-2: 2010, Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation (ISO 10140-2:2010)

[v] EN ISO 717-1:2006, Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation (ISO 717-1:1996 + A1:2006)