Sound Insulation with Hilti Firestop products

The enclosed pages are taken from the
Hilti Sound Insulation Brochure
Edition March 2006

Please note the tables in this extract may be out of date

For Further information about additional properties of our Firestop seals
and for Material Safety data sheets
visit the technical library at www.hilti.co.uk/cfs

For further details including details of product European Technical Approvals, Guidance on product selection and
detailed design assistance please contact Hilti (Gt Britain) Ltd Technical Advisory Service.

Quality Management System Certification

Issued by: The Swiss Association for Quality and Management Systems SQS.
Registration No: 12455 (The current certificate can be downloaded from www.hilti.co.uk)
Field of activity: Market Organisation.
Note: The certificate of Hilti (Gt. Britain) Ltd. is a sub-certificate to the master certificate of Hilti Aktiengesellschaft,FL-9494 Schaan with the field of activity: Research, Development, Manufacturing, Sales and Service.
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Standard details showing the assembly required to obtain the required acoustic performance can be found in the product details in the Hilti Firestop specifiers binder or can be downloaded from the technical library.

CAD files of the standard details FS ***-** can be downloaded from the technical library at www.hilti.co.uk/cfs

Revision History

June 2011   First release
May 2013    Update
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1. Introduction

Sound insulation in buildings is of great significance to the health and well-being of the occupants.

Sound insulation is of particular importance in residential construction because an apartment provides not only a place of rest and relaxation, it also serves to screen off the personal domestic environment from that of neighbours. Specific regulations apply to certain types of buildings such as schools, hospitals, hotels and office accommodation.

The sound insulation requirements to be complied with are laid down in directives, standards and regulations throughout the world.

Hilti firestop products are not only tested and approved internationally in accordance with the stipulations of passive fire prevention regulations, they are also comprehensively tested to ensure compliance with sound insulation requirements.

These pages describe the general principles of sound insulation and show how these are applied in practice on the basis of practical examples.
2. Important terms

Airborne sound

“Airborne sound” is the term applied to fluctuations in pressure which spread out in a wave pattern and thereby induce oscillation in the objects or parts of a structure they collide with.

Airborne sound in buildings is transformed into structure-borne sound as it strikes walls, floors or ceilings and is passed on through the structure in this form before subsequently radiating into neighbouring rooms as airborne sound. At the same time, the sound becomes weaker as it passes through a wall or ceiling.

Structure-borne sound

Sound that carries or spreads through a solid object is known as structure-borne sound. Structure-borne sound is usually not perceived as sound or noise but is noticed, if at all, in the form of vibration. It becomes audible, nevertheless, when radiated from the surfaces of the structure and thus transformed into airborne sound.

As the energy loss in the transmission of structure-borne sound through solid objects is minimal, the sound can travel over great distances. Accordingly, measures must be taken to isolate living accommodation and other occupied rooms from structure-borne sound.

Sound insulation

The measures intended to reduce the generation of sound (primary measures) are known as sound prevention. Sound insulation is the term applied to measures designed to reduce the transmission of sound from its source to the hearer (secondary measures). Insulation to reduce the transmission of sound in buildings is subject to legislation and regulations in most countries.
**Frequency (frequency of oscillation)**

Frequency is the number of oscillations per second (1/s) and is given in Hertz (Hz). The pitch of a sound rises as the frequency increases. The frequencies of relevance in building construction lie within the 100 to 3150 Hz range. Below this frequency level, the human ear becomes increasingly insensitive to sound. In general construction, frequencies in excess of 3150 Hz are rarely encountered and thus negligible.

**Sound pressure / loudness**

The fluctuation in pressure which occurs as sound radiates is known as sound pressure (p). Sound pressure is thus the alternation in pressure that is superimposed upon the static pressure (air pressure) of the surrounding medium. The unit of measurement generally applied to sound pressure is mPa.

As the sound pressures occurring in everyday life differ by up to 5 decimal powers, preference is given to use of the sound level L in logarithmic units for representation of sound pressure. The logarithmic unit dB is used as a measure of loudness. Loudness is often given in dB(A). This unit indicates the loudness adjusted to the sensitivity of our hearing (perceived loudness).

<table>
<thead>
<tr>
<th>Sound level (dB)</th>
<th>Noise rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unbearable</strong></td>
<td>4 more than 120 dB</td>
</tr>
<tr>
<td><strong>Very loud</strong></td>
<td>3 90 - 120 dB</td>
</tr>
<tr>
<td><strong>Loud</strong></td>
<td>2 65 - 90 dB</td>
</tr>
<tr>
<td><strong>Speech and music</strong></td>
<td>1 30 - 65 dB</td>
</tr>
</tbody>
</table>

- **Jet engine** (at a distance of 25 m)
- **Jet aircraft taking off** (at a distance of 100 m)
- **Aircraft engine**
- **Boilersmith’s workshop Pop group**
- **Car horn** (at a distance of 7 m)
- **Loud factory building Jackhammer**
- **Traffic noise (heavy traffic)**
- **Loud conversation, shouting Car (at a distance of 5 m)**
- **Conversation at a distance of 1 m Office noise**
- **Conversation**
- **Whispering at close range Moderate domestic environment Quiet road in residential area**
- **Rustling leaves Whispering**
- **Quiet clock ticking Gently rustling leaves Steady, light rainfall**

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*Infrasonic* | *Hearing range* | *Ultra sonic* |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1000</td>
<td>10000</td>
</tr>
</tbody>
</table>

*Speech*
3. Airborne sound insulation

Airborne sound insulation is understood to mean the measures taken to reduce the transmission of sound between two adjoining rooms. The reduction in sound transmission depends, above all, on the mass of the structural component separating the rooms. The DIN 4109 standard uses the surface area related mass of the component (relative to 1 m²). The applicable calculation tables can be found in DIN 4109, appendix sheet 1.

Example: A concrete wall has a density of about 2300 kg/m³. For an area of 1 m² and wall thickness of 20 cm, this results in a weight per unit area of 460 kg/m². According to the calculation table in DIN 4109, this provides a sound insulation value of 55 dB. In order to achieve a higher sound insulation value, the weight per unit area must be increased correspondingly, either by using concrete of a higher density or by increasing the thickness of the wall.

In accordance with DIN 4109 appendix sheet 1, the sound reduction index $R_w$ for typical wall structures is:

<table>
<thead>
<tr>
<th>Material Description</th>
<th>$R_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm double-skin drywall with 80 mm insulation</td>
<td>46 – 50 dB</td>
</tr>
<tr>
<td>100 mm drywall as above but with high-density panels</td>
<td>57 – 60 dB</td>
</tr>
<tr>
<td>20 cm solid cellular concrete</td>
<td>approx. 43 dB</td>
</tr>
<tr>
<td>20 cm solid concrete</td>
<td>approx. 55 dB</td>
</tr>
</tbody>
</table>

In accordance with ISO 140, sound reduction is determined within the 50 – 5000 Hz range and expressed in decibels (dB). The various reference values for airborne sound insulation vary from country to country. Nevertheless, the CEN (European Standards Committee) has agreed to use the designations “weighted sound reduction index” ($R_w$) or the “weighted standard sound level difference” ($D_{nw}$), in accordance with ISO, as the generally applicable standard.

The specifications for the sound insulation properties of a wall between living areas vary from country to country and according to national regulations. For example, in Germany, the minimum sound insulation value for a wall between living areas, in accordance with DIN 4109, is 53 dB while in Great Britain, in accordance with Approved Document E, it is 49 dB.
4. Test setup and measurement

Thanks to extensive measurement of sound reduction values and individual ratings for each product, Hilti firestop products allow compliance with the applicable sound insulation specifications for fireproofed penetrations through walls and floors and joints between building components.

The measurement of sound reduction values takes place in close cooperation with the leading test institutes in the field of architectural acoustics. The measurements are carried out in accordance with the ISO 140 series of standards.

Measurements are taken to determine the following values:

- **The sound reduction index** $R$ indicates the airborne sound reduction rating of a building component. $R$ is calculated from the sound level difference $D$ between the equivalent absorption area of the room receiving the sound and the test surface area of the building component.

- **The weighted sound reduction index** $R_w$ is calculated from the frequency-dependent sound reduction value for the component relative to its reference curve.

- **The standard sound level difference** $D_n$ is the designation given to the difference in sound level between two rooms with a reference surface area of 10 m² and is thus a measure of the airborne sound reduction.

- **The weighted standard sound level difference** $D_{nw}$ is the frequency-dependent standard sound level difference relative to the reference curve.

The $D_{nw}$ values for the sound level difference refer to a wall surface area of 10 m² and, according to DIN EN ISO 140-10, are applicable, above all, to small-sized building components such as air ducts or cable trays. This ensures that the results obtained from various test setups can be compared with each other. The diagram below illustrates the relationship between the $D_{nw}$ values: it shows that better $R_w$ values can be obtained in larger walls.

<table>
<thead>
<tr>
<th>Wall surface area as shown</th>
<th>0.3 m²</th>
<th>1 m²</th>
<th>3 m²</th>
<th>10 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dnw:</td>
<td>52 dB</td>
<td>52 dB</td>
<td>52 dB</td>
<td>52 dB</td>
</tr>
<tr>
<td>Rw:</td>
<td>37 dB</td>
<td>43 dB</td>
<td>47 dB</td>
<td>51 dB</td>
</tr>
</tbody>
</table>

When comparing sound insulation values, the wall surface area must always be taken into account.
The results of sound measurements
Sound reduction measurement results can be illustrated, for example, in a diagram as shown below, in which the sound reduction index $R$ is marked out against the frequency over the 50 Hz to 5000 Hz ($=5$ kHz) range (red line).

This curve (red line) is subsequently compared with a reference curve in accordance with ISO 717, in this case with reference curve A (green line). Reference curve A is displaced vertically in such a way that a difference of max. 32 dB results. The result of the measurement, the weighted sound reduction index $R_w$, corresponds to the intersection of the 500 Hz line with the reference curve A.
Interpretation of results for the complete component

The sound insulation value of a wall in which, for example, firestop products are incorporated, is calculated without taking secondary paths as per DIN 4109 annex 1 into account, as follows:

Example for Hilti CP 673 firestop coating

a) Determination of $R_w$ from $D_{nw}$

Report: IAB number 51640 / 3093

Surface area: Wall $s_1 = 10$ m$^2$, Test specimen $s_2 = 0.3$ m$^2$

Original: $D_{nw} = 52$ dB

Calculated according to

\[
R_w = D_{nw} - 10 \times \log \left(\frac{s_1}{s_2}\right)
\]

\[
= 52 - 10 \times \log \left(\frac{10}{0.3}\right)
\]

\[
= 52 - 15
\]

\[
= 37 \text{ dB}
\]

b) Determination of the sound reduction index for a wall

In accordance with DIN 4109 BBL 1, the resulting sound reduction index for a wall can be calculated as follows:

$R_w$ – wall 55.0 dB

$R_w$ – product 37.0 dB

Wall surface area 10.0 m$^2$

CP 673 surface area 0.3 m$^2$

The resulting sound reduction index for this wall is 51 dB.

The question now is: What is the maximum surface area of Hilti CP 673 that may be used without falling below the value of, for example, 53 dB in residential accommodation? The sound reduction values for openings of various sizes can be calculated as shown above:

<table>
<thead>
<tr>
<th>Opening in m$^2$</th>
<th>Wall surface area in m$^2$</th>
<th>$R_w$ index for the wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small opening</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>0.1</td>
<td>10</td>
<td>53</td>
</tr>
<tr>
<td>0.3</td>
<td>10</td>
<td>51</td>
</tr>
<tr>
<td>0.5</td>
<td>10</td>
<td>49</td>
</tr>
<tr>
<td>1.0</td>
<td>10</td>
<td>47</td>
</tr>
</tbody>
</table>

Accordingly: In order to comply with the 53 dB value specified by DIN 4109A, maximum area of 0.1 m$^2$ may be sealed with Hilti CP 673 in a 10 m$^2$ partition wall in living accommodation.
Secondary paths and sound transmission through flanking components

Sound transmission through secondary paths is understood to mean all sound transmissions that occur through paths other than the separating component itself. This includes transmission through:

- Flanking components
- Ducts
- Openings
- Unsealed or poorly sealed joints etc.

Transmission through flanking components presents the most significant source of secondary path sound transmission and should thus already be taken into account during the planning of a building.

Water installations

For water installations, the sound volume level is given for the applicable appliance, measured in a standardized test setup. Accordingly, in Germany DIN 4109 specifies a maximum sound volume level for each type of installation and not a specific sound reduction value, as is the case with airborne sound. In Germany, the limiting value for such installations is 30 dB (A), while in Great Britain no set value is specified.
5. Structure-borne sound insulation

In contrast to airborne sound, structure-borne sound is transmitted through solid objects. It subsequently becomes audible, however, when radiated from surfaces and transformed into airborne sound. Structure-borne sound spreads through solid objects with little loss and thus makes sound reduction measures necessary.

Structure-borne sound is generally understood to mean sound generated and transmitted into the structure of a building by installations such as toilet flushing systems. Footstep sound, however, is also regarded as structure-borne sound. The transmission of structure-borne sound in buildings is controlled by various national regulations (DIN, Approved Document E, …).

The transmission of structure-borne sound from plumbing installations into walls or ceilings can be reduced through use of acoustically-insulated Hilti pipe rings such as the Hilti MPN-RC. In floors, the transmission of footstep or impact noise can be reduced through application of a floating screed layer with the appropriate acoustic insulation characteristics.

Measures must also be taken to prevent the transmission of oscillations or vibration to the structure where pipes or cable trays pass through walls or ceilings. Sound will otherwise be radiated as airborne sound from the walls or ceilings. In accordance with Approved Document E, pipes must be isolated from the structure by a suitable, acoustic insulation material and the gap between the pipe and the wall or floor filled with a suitable sealing compound.

In contrast to airborne sound, the procedure for testing for structure-borne sound transmission is not standardized. Hilti therefore carries out the tests using a setup that simulates the conditions met in practice.
**Test setup and measurement (Hilti)**

A steel pipe passes through a wall and is suspended from the ceiling at both ends. The space around the pipe in the wall opening is sealed in accordance with approval requirements using the firestop product to be tested. Oscillations are induced in the pipe by the so-called “shaker”.

Sensors mounted on the wall and the pipe detect the difference in the structure-borne sound level between the wall and the pipe.

**Results of structure-borne sound measurements**

In conjunction with the “Institut für Akustik und Bauphysik” (IAB) of Oberursel, Germany, Hilti has produced a simplified presentation and interpretation of the results. In doing so, the mean value from the octave representation of the airborne sound level difference between the pipe and the wall is taken in the 250 to 2000 Hz range. This is the frequency range in which speech is heard and in which the human ear is particularly sensitive. Comparisons are made between the freely suspended pipe, the pipe set in the wall with mortar and the pipe installed in the opening in accordance with the firestop product approval.
Mean airborne sound level difference between pipe and wall in dB:

<table>
<thead>
<tr>
<th>Product</th>
<th>Wall</th>
<th>Type of pipe</th>
<th>Freely suspended</th>
<th>Set in mortar</th>
<th>Installed with product</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP 601 S</td>
<td>200 mm solid wall</td>
<td>Steel pipe</td>
<td>56</td>
<td>10</td>
<td>54</td>
</tr>
<tr>
<td>CP 606</td>
<td>200 mm solid wall</td>
<td>Steel pipe</td>
<td>56</td>
<td>9</td>
<td>53</td>
</tr>
<tr>
<td>CP 606</td>
<td>100 mm drywall</td>
<td>Steel pipe</td>
<td>56</td>
<td>9</td>
<td>46</td>
</tr>
<tr>
<td>CP 611 A</td>
<td>200 mm solid wall</td>
<td>Steel pipe</td>
<td>56</td>
<td>10</td>
<td>48</td>
</tr>
<tr>
<td>CP 612 (FS-One)</td>
<td>200 mm solid wall</td>
<td>Steel pipe</td>
<td>56</td>
<td>9</td>
<td>51</td>
</tr>
<tr>
<td>CP 620</td>
<td>200 mm solid wall</td>
<td>Steel pipe</td>
<td>56</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>CP 657</td>
<td>200 mm solid wall</td>
<td>Steel pipe</td>
<td>54</td>
<td>9</td>
<td>57</td>
</tr>
</tbody>
</table>

**Interpretation of results**

Pipes in which oscillations are induced through the flow of water or the vibration of machines or appliances must be isolated from the structure as far as possible. An acoustic insulation (sound reduction) value of 45 dB is regarded as “good”.

Optimum airborne sound isolation can be achieved by means of air gaps, but this has the disadvantage of allowing the passage of fire, smoke and fumes. Filling the gap between the pipe and the wall with mortar results in a rigid connection to the wall and thus a significant level of structure-borne sound transmission. Hilti firestop products, especially Hilti CP 601S elastic firestop sealant, Hilti CP 606 firestop joint filler, Hilti Intumescent Firestop FS-One, Hilti CP 611A intumescent firestop mastic and the Hilti CP 657 firestop system remain elastic under practical conditions and provide significantly better isolation from structure-borne sound, achieving a level approximately equal to that of a freely suspended pipe.
6. Tested Hilti systems

In order to meet the requirements of sound insulation applications, Hilti products are tested in cooperation with independent institutes in accordance with national and international standards.

Overview of Hilti products and the corresponding sound transmission standard tests

<table>
<thead>
<tr>
<th>Hilti product</th>
<th>Wall thickness / wall type</th>
<th>Airborne sound reduction ISO Document E</th>
<th>Structure-borne sound application</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP 601S</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td></td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 604</td>
<td>200 mm / solid structure</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CP 606</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td></td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td>CP 611A</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td></td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 612 (FS-One)</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td>CP 617 power outlets</td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 620</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td></td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 636</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td>CP 637</td>
<td>100 mm / solid structure</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CP 638</td>
<td>100 mm / solid structure</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CP 643N / CP 644</td>
<td>Sound insulation with jackets only in combination with filling the circular gap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP 645</td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td></td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 648</td>
<td>Massivbau</td>
<td>✓ ✓</td>
<td>Plastic pipe</td>
</tr>
<tr>
<td>CP 657</td>
<td>200 mm / solid structure</td>
<td>✓ ✓</td>
<td>Steel pipe</td>
</tr>
<tr>
<td></td>
<td>100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 670 / CP 673</td>
<td>1x50, 200 mm / solid structure</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1x50, 100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2x50, 200 mm / solid structure</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2x50, 100 mm / drywall</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 672</td>
<td>approx. 100 mm / drywall</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CP 675</td>
<td>solid structure, surface-mounted</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>solid structure, built-in</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>CP 680 / CP 682</td>
<td>Massivbau</td>
<td>✓</td>
<td>Toilet flushing system</td>
</tr>
</tbody>
</table>
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