NEW INSULATION MATERIALS AS NOISE CONTROL SOLUTIONS

The world is becoming noisier and noisier - life is becoming more and more hectic. Many noise sources cannot simply be switched off and thus create additional stress in our everyday lives. Noise is now one of the greatest environmental problems of our times. Noise protection is therefore becoming increasingly important in the workplace, in public and other heavily frequented buildings and, not least, in residential buildings. The exacting requirements made of noise control have led to the development of powerful noise insulation materials with an absorption performance per unit thickness which is up to twice as high as that of traditional materials. In this article, the performance and the benefits of these new systems are presented.

PIPES AND VESSELS AS NOISE SOURCES

As far as industrial installations are concerned, especially pipes and vessels through which gases, vapours or liquids flow represent a significant source of noise. The reason for this is the high flow speed of the media. The noises are often amplified when turbulence occurs in the vicinity of obstacles such as sieves, grids, gates or valves.

Apart from reducing noise development and re-radiation effects, the principal measure taken to minimize noise is sound absorption. This includes insulating and cladding pipes and vessels, whereby the necessary thermal insulation can often be combined with acoustic improvements. Traditionally, insulation materials made of mineral wool with an additional cladding made of aluminium, stainless steel or galvanized sheet steel are used for such applications. The acoustic performance of these systems depends on the thickness of the mineral wool and cladding.

However, the areas in which insulation systems on the basis of mineral fibres can be used are limited. Due to the open-cell structure of the mineral wool, these systems cannot be applied to installations which are operated at a line temperature below the ambient temperature. In such cases, from a thermal point of view, the insulation is required to prevent condensation forming and minimize the diffusion of water vapour. If an open-cell insulation material such as mineral wool is used, it will lead - sooner or later - to water ingress in the insulation material. In damp environments too, for example in outdoor applications, a considerable amount of water can penetrate the insulation through gaps in the cladding system. This results not only in a drastic reduction of the acoustic and thermal properties of the insulation, but consequently often also in substantial corrosion damage under the insulation, which can soon necessitate complicated renovation work at considerable cost. Above and beyond this, fibrous insulation may simply not be desirable in certain areas.

ACOUSTIC INSULATION WITH ELASTOMERIC INSULATION MATERIALS

Closed-cell insulation materials on the basis of synthetic rubber are used as an alternative in the application areas described.

The latest tests on the acoustic performance of Armaflex show that this elastomeric material is excellently suited for insulating against structure-borne sound. Depending on the insulation thickness, the transmission of structure-borne sound can be reduced by up to 30 dB (A) in comparison to an uninsulated pipe. However, sound absorption is a different matter: investigations have shown that, depending on the insulation thickness, Armaflex achieves relatively good values in the high frequency range, but the material displays rather poor values in the low frequency range. The results can however be further improved by an additional metal cladding. Nevertheless, it is either not or only to a limited extent possible to satisfy high acoustic demands with traditional elastomeric insulation materials.

The acoustic properties of elastomeric insulation materials can be improved by a sound-absorbing layer. This absorbs the air-borne components of the sound emission and converts the acoustic energy into heat through friction. However, if closed-cell materials are used as sound absorbing layers, the air movement within the cell structure is restricted and thus the desired effect is prevented to a large extent.

In order to achieve significant improvements in the acoustic insulation properties of elastomeric materials for certain fields of application it was therefore necessary to change the structure of the material. After four years of research, Armacell in cooperation with the University of Bradford (Great Britain) has succeeded in de-
veloping the product ArmaSound. The material has high sound absorbing properties across the complete frequency range which is relevant for architectural acoustics. This was achieved by re-engineering the closed-cell elastomeric insulation material into a material with an open-cell micro-structure. With this technology it is even possible to adapt the acoustic absorption behaviour of the product to customer requirements where there are problems in specific frequency ranges. Figure 2 shows the sound absorption coefficient as, measured according to DIN EN 20354, for various absorber thicknesses. As is defined as the ratio of the absorbed sound energy to the incident sound energy, where a value of 0 represents complete reflection and 1 complete absorption. Here it can be seen that at a thickness of 25 mm the values for the sound absorption coefficient are greater than 0.8 from a frequency of 520 Hz onwards.

![Sound Absorption Coefficient for ArmaSound](image)

**Figure 2: Degree of sound absorption for ArmaSound at different insulation thicknesses in accordance with DIN EN 20354**

### REQUIREMENTS OF ISO 15665

As already mentioned at the beginning of this article, intrusive noise is often transmitted by pipes. ISO 15665 “Acoustics – Acoustic insulation for pipes, valves and flanges” is the new standard for examining the quality of acoustic insulation systems. This standard is already widely used in the chemical, petrochemical and other industries and is likely to replace existing standards in the future.

In order to reduce noise emissions, different classes are defined in this standard. Classes A, B and C are used, with class A denoting the lowest level and class C denoting the highest. Table 1 shows the values required for the minimum insertion loss which the insulation configuration being tested must achieve in order to fulfill the classification criteria in the relevant octave band centre frequency. Even slight deviations lead to the material being assigned to the next lower class. In order to account for re-radiation effects of the pipe insulation, the classification also makes a distinction depending on the pipe dimension.

<table>
<thead>
<tr>
<th>Class</th>
<th>Nom. pipe diameter D mm</th>
<th>Octave band centre frequency, Hz</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>Minimum insertion loss, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>&lt; 300</td>
<td>125</td>
<td>-4</td>
<td>-4</td>
<td>2</td>
</tr>
<tr>
<td>A2</td>
<td>≥ 300 &lt; 650</td>
<td>250</td>
<td>-4</td>
<td>-4</td>
<td>2</td>
</tr>
<tr>
<td>A3</td>
<td>≥ 650 &lt; 1 000</td>
<td>500</td>
<td>-4</td>
<td>-4</td>
<td>2</td>
</tr>
<tr>
<td>B1</td>
<td>&lt; 300</td>
<td>1 000</td>
<td>-9</td>
<td>-9</td>
<td>3</td>
</tr>
<tr>
<td>B2</td>
<td>≥ 300 &lt; 650</td>
<td>1 000</td>
<td>-9</td>
<td>-9</td>
<td>6</td>
</tr>
<tr>
<td>B3</td>
<td>≥ 650 &lt; 1 000</td>
<td>2 000</td>
<td>-7</td>
<td>-7</td>
<td>2</td>
</tr>
<tr>
<td>C1</td>
<td>&lt; 300</td>
<td>4 000</td>
<td>-5</td>
<td>-5</td>
<td>11</td>
</tr>
<tr>
<td>C2</td>
<td>≥ 300 &lt; 650</td>
<td>8 000</td>
<td>-7</td>
<td>-7</td>
<td>4</td>
</tr>
<tr>
<td>C3</td>
<td>≥ 650 &lt; 1 000</td>
<td>16 000</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 1: Minimum insertion loss for the various classes according to ISO 15665:2003

### TEST SET-UP

Details on the test set-up and test procedure can be taken directly from ISO 15665 and cannot be provided in detail here. However, a short explanation of the test is given to aid understanding. The tests were carried out at Peutz bv in the Netherlands. Figure 3 shows the test set-up including the sound source. The pipe is 5.560 mm long, has an outer diameter of 323 mm and a wall thickness of 6.3 mm. As the outer diameter is > 300 mm, the criteria of classes A2, B2 and C2 apply according to Table 1.

The insulation construction was mounted on the pipe inside the reverberation room, ensuring that the pipes were carefully sealed with a mastic in the two penetration areas. The measurements were carried out on the uninsulated and insulated pipe in each case. The mean sound pressure level was measured using a pivotable microphone in accordance with ISO 3741 in the frequency range of 100 Hz to 10 kHz.

The insertion loss for each frequency range was calculated using the following formula:

\[
D_w = L_b - L_c - (L_{br} - L_{cr})
\]

Where: \(D_w\) is the insertion loss (dB)

- \(L_b\) is the mean one-third octave sound pressure level of the uninsulated pipe (dB)
- \(L_c\) is the mean one-third octave sound pressure level of the insulated pipe (dB)
- \(L_{br}\) is the mean one-third octave sound pressure level in the room for comparison sound source of the uninsulated pipe (dB)
- \(L_{cr}\) is the mean one-third octave sound pressure level in the room for comparison sound source of the insulated pipe (dB)
The insertion loss for the octave band frequency can be calculated from the one-third octave band frequency as follows:

Where: \( D_{wi} \) is the insertion loss per one-third octave band of the corresponding octave band.

**TEST PROCEDURE**

As it is usually also necessary to fulfill thermal requirements when insulating pipes, it was clear that the sandwich constructions to be tested must satisfy both thermal and acoustic demands. Particular attention was paid to chilled pipes because the exclusive use of open-cell materials is not possible in these applications. Closed-cell insulation materials on the basis of synthetic rubber are particularly suitable for low-temperature insulations. Therefore, the basis of the sandwich construction should consist of a combination of closed-cell and the newly developed open-cell elastomeric insulation materials.

Preliminary tests on smaller sections of pipe had already provided indications of the insulation material configuration needed to fulfill the requirements of the relevant classification according to ISO 15665. The aim here was to keep the sandwich construction as thin as possible.

Insulation systems are often covered to protect them against mechanical damage. Here claddings have the secondary effect of influencing the acoustic properties of the insulation positively. Traditionally metal claddings are chosen. However, alternative systems are now available such as the elastomeric covering ArmaChek R. Due to the non-metallic structure of this covering system, the danger of the covering corroding can be ruled out. Furthermore, the use of a closed-cell insulation material reduces the risk of corrosion under the insulation significantly. However, as metal cladding systems are still often used, they were included in the tests. Figures 4 to 6 show the configurations of the systems tested, which are explained in more detail below.

ArmaSound Industrial System B (EL) consists of a first layer of Armaflex (25 mm), a second layer of ArmaSound (25 mm) and a covering layer of 2 mm Arma-Chek R. In the case of ArmaSound Industrial System C (EL) two additional layers of ArmaSound Barrier E (2 and 3 mm) were added to the sandwich configuration. This product is a heavy-duty plastic foil which reduces the transmission of air-borne noise and increases the sound damping capacity of acoustic insulation constructions. ArmaSound Industrial System C (MC) is a sandwich construction with a layer of Armaflex (32 mm), a layer of ArmaSound (25 mm) and an additional galvanized metal cladding. The metal cladding was fixed to the insulation material using spacers made of strips of Armaflex. In addition, the inside of the metal cladding was lined with a further 2.3 mm-thick layer of the product ArmaSound Barrier to prevent droning.
THE CLASSIFICATION OF THE SANDWICH CONSTRUCTIONS

Fig. 7: Acoustic performance for ArmaSound Industrial System B (EL)

Figure 7 shows that a significant reduction in the noise emitted by pipes can be achieved with relatively little effort. The classification criteria for class B2 were reliably achieved in all frequency ranges.

Fig. 8: Acoustic performance for ArmaSound Industrial System C (EL)

As Figures 8 and 9 show, the insulation systems ArmaSound Industrial System C (EL) and ArmaSound Industrial System C (MC) clearly exceed the requirement criteria for class C2 throughout the full frequency range.

Fig. 9: Acoustic performance for ArmaSound Industrial System C (MC)

CONCLUSIONS

By developing ArmaSound, Armacell has succeeded in providing a multi-functional elastomeric insulation material with excellent sound absorption properties. With the various sandwich constructions of the ArmaSound Industrial Systems product range, Armacell now supplies low-temperature insulation systems which conform to the relevant classification criteria of ISO 15665 for the acoustic insulation of pipes, valves and flanges. In most cases the systems greatly exceed the reductions required in the individual classes. It should in particular be noted that in comparison to traditionally used systems the constructions achieve the required noise reduction with a significantly reduced insulation thickness and are therefore usually also much lighter.

In comparison to conventional insulation systems, ArmaSound Industrial Systems offer further benefits. The integrated layer of closed-cell insulation material minimizes moisture ingress and thus the danger of under insulation corrosion. Due to the covering, which is also made of closed-cell elastomeric material, surface rust and/or galvanic corrosion can also be ruled out. But even in areas where metal claddings are desired or requested for reasons of tradition, excellent results regarding the reduction of noise and energy losses can be achieved with the combination of open-cell and closed-cell elastomeric products. In conclusion, it should be mentioned that, on request, the sound absorption behaviour of the newly developed product can be optimized to solve noise problems in defined frequency ranges.

The new ArmaSound Industrial Systems have excellent sound absorption properties and also protect installations against water penetration and energy losses.