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A REVIEW OF THE METHODS USED FOR QUICK TESTING OF SOUND INSULATION

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A wide range of simplified methods for the measurement of sound isolation in buildings was reviewed in an earlier Conference Paper (1). The present paper deals with the methods which are gaining widest acceptance and shows how the results of BS 5821 may be obtainable by simplified procedures.

Impulse Method (2,3) This has been under development in France for some time using a pistol or explosive source, whilst current work in Spain includes the development of a multiple spark source. The equipment is small, easily portable and can be independent of external power. If the time functions

$$Q(t),\ P_1(t) \text{ and } P_2(t)$$

represent the output of the source and the resulting pressure variations at a point in the source room and receiving room respectively, then in the frequency domain

$$Q(t)\leftrightarrow Q(\omega),\quad P_1(t)\leftrightarrow P_1(\omega) \text{ and } P_2(t)\leftrightarrow P_2(\omega)$$

The transfer function between the pressures at the two detection points is

$$H(\omega) = P_2(\omega)/P_1(\omega)$$

and in the frequency band f_1 to f_2, the isolation between measurement positions 1 and 2 is:

$$D_{12} = 10 \log \frac{\int_{f_1}^{f_2} |P_1(\omega)|^2 d\omega}{\int_{f_1}^{f_2} |P_2(\omega)|^2 d\omega} \quad \text{dB}$$

The processing may be either digital or analogue instrumentation, but the present tendency is to make tape recordings in the field and process digitally in the laboratory.

Steady State Methods In America, the ASTM has a provisional standard for a simplified method (4,5) using A weighted measurements in each room and a source with specified spectrum. Other methods have recommended C weighted source room with A weighted receiving room measurements. In the ASTM method the simple level difference is $D = L_s - L_r + 10 \log S_r/A_r$.

Where L_s is the average sound pressure in the source room, L_r the average sound pressure in the receiving room, S_f the floor area of the receiving room for the conditions of measurement. The specified source output was chosen after a study of the absorption characteristics of many rooms in order to ensure that the sound pressure level produced in most rooms would fall within required limits. It is important to control the spectrum when a wide band measurement is to be made. The normalisation in terms of floor area will be discussed later.

The use of C weighted source room and A weighted receiving room measurements gives similar emphasis, on an octave scale, to both source room frequencies (C weighting) and receiving room frequencies (A weighting) if one assumes that the transmission curve approximates to the inverse of the A weighting.

Normalisation In discussions which were held in a study group on short test methods on behalf of ISO, it was agreed that careful control of source type and position, as well as microphone positions, could ensure that levels were measured with sufficient accuracy. However, normalisation of the level difference, to take the receiving room characteristics into account was more difficult. Methods of normalisation include a) inspection b) near-field far-field level measurements c) reverberation time measurement leading to normalisation in terms of reverberation time or absorption d) use of reference sound source e) Introduction of additional absorption. Methods b) and c) are used most widely. In Method b) it is assumed that the near-field measurement is controlled by the source and the far-field by the room characteristics. The ASTM procedure uses this method with a source of defined spectrum. The source is first calibrated by measurements in a room of known absorption, obtained through reverberation time, and in the room under investigation. We then have $L_N - L_F = C + 10 \log A_r$. Where L_N and L_F are the near field and far field levels, C is the calibration constant and A_r is the required room absorption. A_r is obtained through the combination of five different measurements, and is subject to error. The measurements are near-field far-field and reverberation time measurements in the calibration room and near-field and far-field levels in the receiving room. In method c) it is assumed that a standard room has R.T. of 0·5 secs independent of size or frequency and the correction is 10 log (T/0.5). It is necessary to determine T and, whilst inspection or calculation is difficult, even a large error e.g. 1 sec instead of 2 sec gives only 3 dB difference. However, the normalisation correction could be reduced by adding absorption to a reverberant receiving room. Steady state measurement of reverberation time involves a source of known power (L_W) and a far field measurement (L_F) using the relation $10 \log T = L_F + 10 \log V - L_W - 14$, where V is the room volume. The measurement is affected by the source and microphone position and should be averaged over a number of positions. The decay method requires specialised equipment.

Comparison of Methods of Normalisations If rooms are investigated when furnished ready for occupation, normalisation is not necessary for an assessment of subjective satisfaction of the existing conditions. Measurements in unfurnished rooms require normalisation. Assuming that an unfurnished room has a reverberation time of two secs, the normalisation correction of $10 \log {}^{T}/0{\cdot}5$ gives 6 dB. If the room has dimensions of 5m by 4m by 2·5m, its total absorption is $4m^2$, giving a normalisation correction of $10 \log {}^{A_0}/_{A} = 4$ dB, for $A_o = 10m^2$. The difference between the two methods of normalisation is dependent only on the room dimensions and for $A_0 = 10m^2$ and $T_0 = 0{\cdot}5$ sec, we have: Normalisation by R.T. - (Normalisation by A) = 10 log (0·032V) dB. Both the normalisations are zero for a room about $30M^3$ in volume, which might have dimension 4m by 3m by 2·5m. The two corrections also remain equal in this room but not zero, if the reverberation time changes. The difference between the two methods of normalisation is seen to depend on the volume of the room, not its acoustical conditions and the method of normalisation must be specified to ensure both accuracy and repeatability, since room volumes cannot be controlled.

The normalisation proposed in the ASTM method permits the reference absorption to vary according to room dimensions, making use of the fact that, in a furnished room, the absorption is given approximately by the floor area S_f. The correction is then $10 \log S_f/A_r$, where A_r is the absorption measured during the test. The floor area $S_f = V/_h$, where h is the ceiling height, and since $A = 0{\cdot}16V/_T$, we obtain (Normalisation by R.T.) - (Normalisation by A) = 10 log (0·32h). This gives a constant difference e.g. - 1dB for h = 2·5m, which is more acceptable than a dependency on room volume. It also follows from Sabine's formula that, if $S_f = A$, then $T = 0{\cdot}16\,{}^{V}/S_f = 0{\cdot}16h$. For h = 2·5m, T = 0·4 sec and this method of normalisation is seen to be similar to normalisation by reverberation time.

It is necessary that a simplified measurement method should include a normalisation method of comparable simplicity. The near-field far-field method has the virtue of simplicity and relates to normalisation by reverberation time, but its accuracy may be queried since it depends on the combination of five separate measurements.

Comparison of BS 5821 with Simplified Procedures. Computations on a large number of insulation measurements taken according to BS 2750 have given the rating by BS 5821 as well as C weighted source room and A weighted receiving room levels Normalisation was by A weighted reverberation time. The results showed a correlation coefficient of 0.97 between BS: 5821 rating and normalised C-A level difference.

References

1) H.G.Leventhall I.O.A. Conference Proceedings, May 1979 (East Leake).
2) P. de Tricaud, Applied Acoustics, 1975, 245-55.
3) J.Roland, I.O.A. Conference Proceedings, November 1980 (Windermere).
4) ASTM: E 597-77T, 1977
5) T.J.Schultz, Noise and Vibration Bulletin, Jan. 1978.