TRANSMISSION LOSS MEASUREMENTS: VALIDITY OF THE SOUND INTENSITY TECHNIQUE IN LABORATORY AND IN THE FIELD.

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INTRODUCTION

In recent years a new method for transmission loss measurement, based on the sound intensity technique, has been developed. The advantages of the sound intensity method in comparison with the conventional two-room method are well known [1-6] particularly in the presence of flanking transmission or when it is necessary to put in evidence the contribution of different parts of the wall construction.

In the present paper the results of a recent experimental analysis, carried out both in the laboratory and in the field, are reported. The measurements, carried out with both methods, were made with different types of wall constructions. The results are compared and critically discussed. It is shown that the two methods give comparable results, particularly in the laboratory, where the flanking transmission is negligible. In the field the difference can be greater. It is also shown how in the reactive field the measurements were more difficult and sometimes, different ways of elaborating the measurement data give different values of sound transmission loss.

BASIC EQUATIONS AND PROCEDURES

The sound reduction index of a partition is defined as:

$$R = 10\log\frac{W_1}{W_2} \qquad (1)$$

where W_1 $(W_1 = p_1^2 S / 4\rho c)$ is the sound power incident on the test specimen and W_2 $(W_2 = p_2^2 S / 4\rho c)$ is the sound power transmitted through the test specimen.

The ISO 140 series distinguishes the sound reduction index R, measured in the laboratory $(R = L_1 - L_2 - 10\log A / S)$, and the sound insulation of partition D_n, measured in situ. Because of the flanking transmission and the mounting of the partition, there can be a great discrepancy between the laboratory and the in situ measurements of the same test specimen.

With the sound intensity technique the determination of the sound power W_2 $(W_2 = I_n S_m)$ transmitted through the test specimen is indipendent of the flanking transmission and it is therefore also possible to obtain in situ a value of the sound reduction index R_I. The sound intensity technique gives this equation:

$$R_I = L_1 - L_{I_n} - 6 + 10\log\left(\frac{S}{S_m}\right) \qquad (2)$$

where S is the surface of the test specimen and S_m is the measurement surface completely enveloping the test specimen.

Measurements with the sound intensity technique requires that a number of criteria be met. One of these criteria is that the pressure-intensity index ($L_K = L_p - L_I$) should be less than 10 dB. Another important criterion used is that the dynamic capability of the instruments should be less than the pressure-intensity index. The dynamic capability index is given by subtracting 7 (or 10) to the residual intensity index ($L_{K_0} = L_{p_0} - L_{I_0}$). The residual intensity L_{Io} is the value of the sound intensity given by the instruments when the intensity should be null. Because these indexes are given for each frequency band, it is possible that the criterion would not be satisfied for all the frequency bands. Correction for residual intensity is possible by some sound intensity analysers or by post-elaboration with a computer. Another correction that can be used in order to make the results more comparable with the conventional two-room method is the Waterhouse correction (or room correction). This correction takes into account the higher energy density close to the test specimen boundary in the source room.

EXPERIMENTAL RESULTS

Laboratory measurements

6 specimens, made up of partition walls or tile-lintel floors, were measured both with the conventional two room method and with the sound intensity method. Each specimen, measuring about 10 m^2 (3.00 x 3.30 m) was placed in a 25 cm deep niche. The measurements were carried out on a 7x6 grid, using the scanning method, at a distance of 10-15 cm from the specimen. The microphone separation was 12 mm. For each area, the pressure-intensity index was kept under control. Thus, it was necessary to add absorbing material inside the receiving room in order to lower the field's reactivity. In spite of this, in some cases it was not possible to meet the validity criteria at all the frequencies.

The values of the single-number quantity obtained with this technique were very close to the corresponding conventional measurements, with a maximum difference of 1 dB, as can be seen from table 1.

N°	*Type of test specimen*	*Thickness (cm)*	*Rw ISO 140*	*RwI Intens.*
1	Panel-floor with polyurethane	26	51.5	52.0
2	Air brick wall with plaster	14	42.0	41.5
3	Double wall with interspace	28.5	47.5	48.5
4	Double wall with insulating material	28.5	50.0	51.0
5	As in 4 with rubber joint on one of the walls	28.5	51.5	52.0
6	Tile-lintelfloor	25	51.0	51.5

Table 1: Comparison between single-number quantities obtained in the laboratory with the conventional method and the sound intensity method.

In situ measurements

The partition in question was not homogeneous, and was made up of modular elements with 3-meter-high and 1-meter-wide pre-fabricated panels and a 30-cm-wide extra panel considerably thinner than the other panels.

With the sound intensity method it was possible to determine the overall sound reduction index of the partition and the sound reduction index of the single elements by carrying out measurements on small homogeneous surfaces. As can be seen from the values of the single-number quantities shown in table 2, there is an important difference between the different parts of the partition. The sound intensity in this wall has maximum values corresponding to the angles where there is a small fissure, and in the area correspomding to the thinnest panel.

Part of the wall	*Thickness (cm)*	*Rw ISO 140*	*Rw Intens.*
Overall	6-10	28.5	30.0
Thin panel	6	---	24.0
Thick panel	10	---	33.0
Core of the wall	10	---	34.5

Table 2 - Comparison of single-number quantities of sound insulation obtained in situ with the conventional method and the sound intensity method.

DISCUSSION

As already said, in the laboratory the validity criteria for sound intensity measurements were not met at all the frequencies, and particularly at frequencies below 315-400 Hz. For one of the measurements (specimen 5) they were not met at any frequencies. In such circumstances, negative average intensity values were also obtained at certain frequencies. Such difficult measuring conditions were due to the high reactivity of the acoustic field and to the high insulation of the measured panels, and therefore to the low value of the acoustic intensity transmitted through the test specimen.

The contribution of the sound intensity for each frequency is signed, i.e. it is positive if coming out of the measured surface and negative if going into the surface. Since in this case it is not physically possible for the intensity to go into the surface, it would be a mistake to consider the values as signed. At the same time, it is not advisable to take the unsigned intensity value because one would get an uncontrolled increase in intensity.

Figure 1 (a and b) shows the values of the sound reduction index obtained by elaborating differently the results of the intensity measurements for specimens 4 and 5. The six curves in each graph refer to the values of the sound reduction index obtained in the following ways:

- measurement with conventional method (ISO 140/3);
- sound intensity measurements with final intensity given by the average of the values of each measured point, each taken as signed (R INT. Signed);
- with final intensity given by the average of the unsigned values of all the points in the grid (R INT. Unsigned);
- with final intensity given by the average of only the positive values of all the points in the grid (R INT. Positive);
- with final intensity obtained by taking each value as signed and by applying the correction for the residual intensity (R INT. Signed - L_{k0});
- with final intensity obtained by taking only the positive values and adding Waterhouse's correction (R INT. Positive + WH).

The figure shows two contrasting examples: for specimen 4 the validity criteria were met at most frequencies, while for specimen 5 they were never met. In the first case the different ways of calculating the data give coinciding results. In the second case it can be seen that, by taking the signed values, it is not possible to obtain values of the sound reduction index at many frequencies, while with unsigned values the results obtained are wrong. By considering valid only the positive intensity values it is possible to obtain insulating capacities very similar to those obtained with the traditional method at all the frequencies.

The figure also shows the curves obtained by applying the residual intensity correction and Waterhouse's correction.

The residual intensity correction gives acceptable results only above 200 Hz, since below that frequency the microphone separation has to be 50 mm. Waterhouse's correction can be appreciated only at low frequencies, where it slightly improves the results.

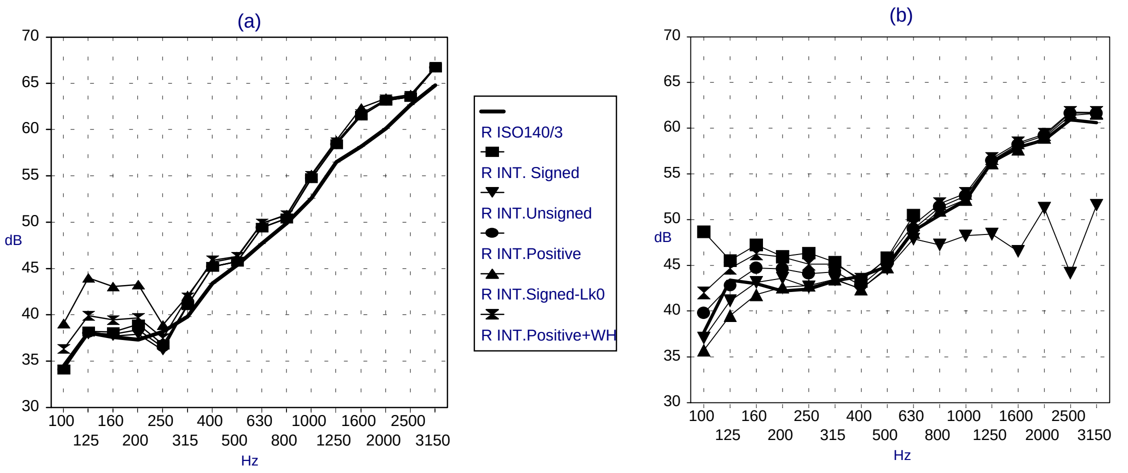

Figure 2 - Sound reduction index of specimens 5 (a) and 6(b), obtained with the intensity method, calculating the results in five different ways, and with the conventional method.

CONCLUSIONS

From the measurements carried out in the laboratory, where the flanking transmission is small, the sound intensity technique gives results which largely coincide with those of the traditional method. In in situ measurements and in the measurements in which it is necessary to put in evidence the contributions of the single parts of a partition, this technique has great advantages.

When the validity criteria of the sound intensity measurements are not met, the measurement data can be calculated by using only the positive values of the intensity. In this way it is possible to obtain acceptable results when one needs only general indications on the behaviour of the partition. In order to obtain valid and correct values it is always necessary that both validity criteria be met.

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