inter-noise 83

COMPARISON OF THE DIFFERENT METHODS FOR OUTDOOR MEASUREMENT OF THE AIRBORNE SOUND INSULATION OF WINDOWS AND FACADES

R. Schumacher and F.P. Mechel

Fraunhofer Institut für Bauphysik,
Nobelstr. 12, D-7000 Stuttgart 80, West Germany

INTRODUCTION

The different methods for field measurements of the airborne sound insulation of windows and facades exhibit considerable discrepancies compared with measurements carried out in the laboratory. Very often, the values obtained are scattered over a wide range (± 5 dB, i.e. a full class in the tables of indices for windows) depending on the chosen method, the different measurement parameters and the variations allowed. The full report to be published gives a review both of the literature and of test procedures used in practice. Experiments have been carried out with the aid of a rapid data acquisition system under both laboratory and free field conditions.

THE METHODS USED FOR OUTDOOR MEASUREMENTS

The German standard DIN 52 210 sets out the different methods for measuring of the sound insulation index of windows and façades, walls and special elements, both in the laboratory and in the free field. There are of course significant differences between the two cases, for example:

- the free field is quite unlike the diffuse field that forms in a reverberation chamber,

- there are influences on the results due to the surroundings, reflections from the ground, from nearby buildings, other significant noise sources, variations in the positions of the microphone and loudspeaker system, etc.

As a consequence the various methods have been categorized as follows:

1. Measurement with traffic noise

2. Measurement with loudspeaker noise

3. The "open-closed"-method.

The measurements have been undertaken with the test object built into a wall between the reverberation room and the free field under mixed laboratory/in-situ conditions (the reproducability and repeatibility have been found to be extremely good). A Brüel & Kjaer real-time-analyzer (Type 2131) was used in conjunction with a digital cassette-recorder (Type 7400), so that very short measuring periods were achieved as was effective computer interfacing.

DEPENDENCE ON MICROPHONE POSITION

When the incident sound approaches the test object primarily from one direction, the strength of the reflected field varies strongly as a function of position, even when broad band excitation is used.

The dependence of the sound pressure level on distance from the test object is shown in Fig. 1 and underlines the great importance of the microphone position in determining the sound insulation index. The measurements for single frequencies (125 Hz, 160 Hz, 500 Hz) are shown in Fig. 2. From these results we conclude that the microphone must be positioned as follows: distance between microphone and object: $<$ 5 cm, or $>$ 150 cm. With the corresponding corrections added (nearfield: $K = -6$ dB, farfield $K = -3$ dB), good agreement with laboratory results is obtained.

DEPENDENCE ON THE ANGLE OF INCIDENCE

The sound insulation index of windows and façades when examined in the free field depends on the angle of incidence δ. This is shown in Fig.3 for the simplest test object, the singly-folded lead foil, for a microphone position in the nearfield (1 cm). For the most practically significant angles in the range 35° to 55° the various deviations of the sound insulation index all lie within 2 dB of one another.

COMPARISION OF THE SOUND INSULATION MEASUREMENT METHODS

The following methods for testing under laboratory condition were considered in this study:

- calibration of loudspeaker method
- outdoor/indoor method
- plane of the window method
- nearfield method
- open-closed method.

The results, as shown in Fig. 4, indicate that under controlled conditions the sound insulation index for all these methods except the open-closed method is on the whole the same.

The open-closed method, which is highly favoured in practice because it is straightforward and inexpensive to perform, gives sound insulation indices that are 2 - 4 dB greater than average; an explanation for this phenomenon may be the lower L_1-level at an open window; therefore a correction factor of K = +2 dB has to be applied to the results.

The most reliable in-situ method for obtaining consistent results with laboratory measurements of the sound insulation index of windows and façades is the outdoor/indoor method. Results obtained using this method are however very sensitive to the microphone position in the free field and to the angle of sound incidence upon the test object. Thus it particulary important that the guidelines set out in the relevant Standards are rigidly adhered to. If the measurement is performed in the close nearfield ($\ll$ 5 cm) and the average performed by means of a continous movement in form of a meander; the variation in L_1-sound pressure level is low and shows the best fit to the laboratory results. With the exception of measuring the L_1-level at a 2 m distance in case of unevenly structured surfaces, this nearfield method is the one most generally to be recommended. The angle of sound incidence should be $\theta = 45°$ to give the best fit between free field and laboratory data.

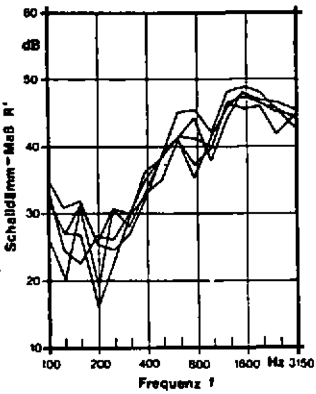

Fig. 1 The variation of the sound insulation index with distance between microphone and window, for different angles of incidence

δ = 30° ; x = 1 cm, 50 cm, 100 cm, 150 cm, 200 cm

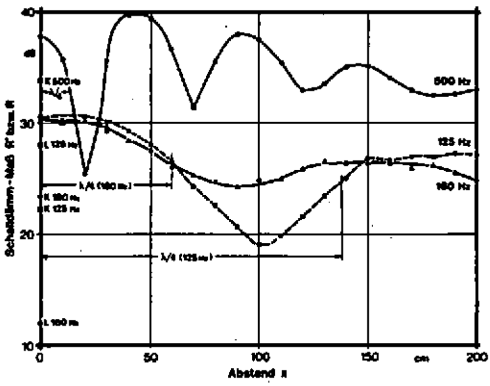

Fig. 2 The dependence of the sound insulation on the distance from a test object for an angle of incidence δ = 45° and 3 different one third octave bands.
For comparison the corresponding values obtained using the calibration method (K) and the laboratory method (L) are also shown.

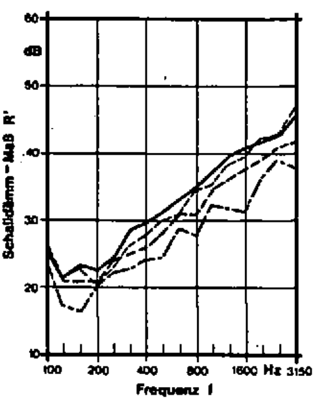

Fig. 3 Sound insulation index vs. frequency of the singly-folded lead foil with variation of the angle of incidence δ and a near field (1 cm) microphone position

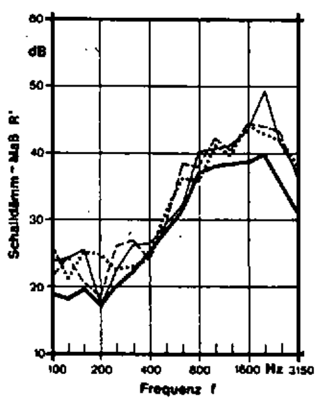

Fig. 4 Sound insulation index vs. frequency. Comparison of the different methods for the determination of the sound insulation; angle of incidence δ = 55°, pink noise with omnidirectional loudspeaker

······ calibration method
——— near-field (1 cm) method
– – – far-field (2 m) method
━━━ open-closed method