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ISO RECOMMENDATION
R 140

FIELD AND LABORATORY MEASUREMENTS OF AIRBORNE AND IMPACT SOUND TRANSMISSION

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BRIEF HISTORY

The ISO Recommendation R 140, *Field and Laboratory Measurements of Airborne and Impact Sound Transmission*, was drawn up by Technical Committee ISO/TC 43, *Acoustics*, the Secretariat of which is held by the British Standards Institution (B.S.I.).

A tentative code for field and laboratory measurement of airborne and impact sound transmission, resulting from informal international discussions, has been in use in several European countries for a number of years. Proposals for standardization based on this code were first submitted to Technical Committee ISO/TC 43 at the time of its meeting, held in Berne, in September 1955. Following the discussion at this meeting, the Secretariat drew up a revised draft proposal, which it circulated to the members of the Technical Committee in 1956. As a result of comments sent in, the Secretariat set up a second revised draft proposal. This document was submitted to the Technical Committee during its meeting, held in Paris, in January 1957. The outcome of this was a third draft, this being then approved, subject to certain editorial modifications, for submission to the members of Technical Committee ISO/TC 43 for postal ballot, which led to its adoption as a Draft ISO Recommendation.

On 30 June 1958, this Draft ISO Recommendation (No. 219) was distributed to all the ISO Member Bodies and was approved, subject to some editorial amendments, by the following Member Bodies:

Austria	Italy	Spain
Burma	Japan	Sweden
Denmark	Netherlands	Switzerland
Finland	New Zealand	United Kingdom
France	Poland	U.S.A.
Germany	Portugal	U.S.S.R.
Hungary	Romania	

One Member Body opposed the approval of the Draft: Canada.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in January 1960, to accept it as an ISO RECOMMENDATION.

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INTRODUCTION

Various workers in the field of research on sound insulation in buildings have for some years used similar methods for the measurement of sound transmission, but these methods have differed sufficiently to make direct comparisons of the results difficult if not impossible. The purpose of this ISO Recommendation is to define methods for the measurement of sound transmission in buildings and for the expression of the results, both for field and laboratory measurements in this sphere, so that data obtained by different workers may be directly compared.

It is hoped that this ISO Recommendation will not restrict in any way the development of new techniques for the measurement of sound transmission in buildings. In some respects the present methods are inadequate and these proposals will, no doubt, be revised as improved methods come into use.

For laboratory measurements of the insulation of a partition, the specification is confined to measurement of its sound insulation when flanking transmission is excluded (see clause 2.4).

In buildings, the sound insulation of a wall or floor alone cannot in general be determined, since a significant transmission between adjoining rooms may take place by paths other than directly through the intervening partition. Moreover, study may be required of transmission between rooms having no common partition, e.g. diagonal transmission. The significant quantity is then the difference between the space average sound pressure levels (see clause 2.1) in the source room and the receiving room. Since this depends on the total absorption in the receiving room, the measured values are adjusted to a reference value of the absorption to give a normalized value, so that the results of measurements at different places may be comparable.

In the case of sound produced by impacts, the method adopted is to specify a machine for producing standard impacts on a floor, and the transmission is characterized by the spectrum of the noise produced in the receiving room. For field measurements, the receiving room may be any room in the building and not necessarily the room directly beneath the floor being tested. Since the spectrum depends on the absorption in the receiving room, the measured values are adjusted to a reference absorption.

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ISO Recommendation R 140 January 1960

FIELD AND LABORATORY MEASUREMENTS OF AIRBORNE AND IMPACT SOUND TRANSMISSION

1. SCOPE

This ISO Recommendation defines methods of measuring the airborne sound insulation of walls, and the airborne and impact sound insulation of floors, both in the field and in the laboratory, for example in buildings with room sizes as in dwellings.

The way in which the airborne and impact sound fields are generated, the frequency range of measurement and the characteristics of the necessary filters are described. Definitions are also given of the quantity measured in each case, and of the method of normalizing the results to make them comparable.

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2. DEFINITIONS

For the purpose of this ISO Recommendation, the following definitions and symbols apply:

2.1 *Average sound pressure level* (L), in a room. Ten times the common logarithm of the ratio of the average of the mean square sound pressure to the square of the reference sound pressure, the average being taken over the entire room with the exception of those parts where the direct radiation of the sound source or the near field of the boundaries (walls, etc.) is of significant influence.

$$L = 10 \log_{10} \frac{p_1^2 + p_2^2 + \ldots . p_n^2}{n p_o^2} \text{ dB} \qquad (1)$$

where $p_1, p_2 \ldots . p_n$ = r.m.s. sound pressures at n different positions in the room, and
p_o = reference sound pressure.

Other types of space average of the sound pressure may be allowable, if they can be shown to give (to within $\pm$ 1 dB) the same level difference (see clause 2.2) as that given by the average defined above.

2.2 *Average sound pressure level difference (level difference)* (D), between a room containing a source of sound and another room. Difference between the average sound pressure level in the room containing the sound source and the average sound pressure level in the receiving room.

$$D = L_1 - L_2 \qquad (2) *$$

where L_1 = average sound pressure level in the source room, and
L_2 = average sound pressure level in the receiving room.

* This definition is given to cover the cases that arise in practice where a simple measurement of the level difference without any correction for absorption is all that is required.

2.3 *Normalized level difference* (D_n). Level difference corresponding to a reference value of the total absorption in the receiving room.

The normalized level difference is defined as follows:

$$D_n = D + 10 \log_{10} (A_o/A) \quad (3)$$

where D = measured level difference,
A = measured absorption in the receiving room, and
A_o = reference absorption (see clause 3.5).

2.4 *Sound reduction index* * (R) or *Transmission loss* * of a partition. The sound reduction index or transmission loss is defined as follows:

$$R = L_1 - L_2 + 10 \log_{10} (S/A) \quad (4)**$$

where L_1 = average sound pressure level in the source room,
L_2 = average sound pressure level in the receiving room,
S = area of the test specimen, and
A = total absorption in the receiving room.

2.5 *Normalized impact sound level* (L_n) in the receiving room in a specific frequency band. Difference between the average sound pressure level and 10 times the common logarithm of the ratio between the reference absorption and the measured absorption of the receiving room.

The normalized impact sound level is defined as follows:

$$L_n = L - 10 \log_{10} (A_o/A) \quad (5)$$

where L = average sound pressure level produced by the standard tapping machine (see clause 5.1) in the receiving room,
A = measured absorption in the receiving room, and
A_o = reference absorption (see clauses 5.5 and 6.1).

3. AIRBORNE SOUND TRANSMISSION: FIELD MEASUREMENTS

3.1 **Generation of sound field.** The airborne sound should be generated by a sound source or sources in the source room.*** A warble tone or white noise from loudspeakers or white noise from any other continuously sounding source should be used.

The sources should be placed to give as diffuse a sound field as possible.

NOTE: The spectral components should be so numerous that local differences of the measured sound pressure level should not exceed 10 dB in either the source room or the receiving room.

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* Sound reduction index: British terminology.
Transmission loss: American terminology.

** The quantity R is primarily defined as $10 \log_{10} P_1/P_2$

where P_1 = sound power incident on the partition under test, and
P_2 = sound power transmitted through the partition under test.

Under the assumption of a diffuse statistical sound field, the formula (4) can be derived. But since the conditions assumed cannot be guaranteed in all cases, the quantity R has here been defined directly by formula (4).

*** The number of loudspeakers and microphone positions to be used is not specified as these will depend on the conditions and on the accuracy required.

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3.2 **Frequency range of measurements.** The measurements should be made at $^1/_3$ or $^1/_2$ octave intervals (although under certain conditions when using white noise 1 octave intervals may be permissible).

When $^1/_3$ octave intervals are used, the frequencies of measurement should be:

100 125 160 200 250 320 400 500 640 800 1 000
1 250 1 600 2 000 2 500 and 3 200 c/s.*

If $^1/_2$ or 1 octave intervals are used, may be chosen

either the series beginning at 100 c/s and ending at 3 200 c/s,
or the series beginning at 125 c/s and ending at 4 000 c/s.

3.3 **If a warble tone is used,** the frequency deviation should be at least $\pm$ 10 per cent of the mean frequency, at a modulation frequency of about 6 c/s, except that for frequencies above 500 c/s a frequency deviation of $\pm$ 50 c/s is sufficient.

3.4 **If white noise is used,** the measurements of the sound pressure level in the source room and the receiving room should be made with pass band filters, of nominal width $^1/_3$ or $^1/_2$ octave, with mid-frequencies equal to the above values or sufficiently close to them to cover the frequency range 100 to 3 200 c/s adequately in $^1/_3$ or $^1/_2$ octave steps. The discrimination characteristics of the filters should be so chosen, in relation to the sound spectra to be measured, that errors in the measured level difference arising from the transmission of frequencies outside the nominal pass band should not exceed 1 dB.

NOTE: It is recommended that the sound source should be restricted to a band of frequencies of nominal width not exceeding 1 octave, since by so doing, the requirements for the discrimination of $^1/_3$ octave filters are considerably relaxed. A combination of filters having the following characteristics will in general be satisfactory.

Source filter. Between $^1/_6$ octave above and $^1/_6$ octave below the mid-frequency f_o of the band under measurement, the discrimination (i.e. the difference between the transmission loss of the filter at the frequency concerned and the minimum transmission loss in the pass band) should not exceed 1 dB.

At $^1/_2$ octave above and $^1/_2$ octave below f_o, the discrimination should be at least 2 dB and should not exceed 6 dB.

At 1 octave above and 1 octave below f_o, the discrimination should exceed 12 dB.

At 2 octaves and more above and below f_o, the discrimination should exceed 30 dB.

Measurement filter. Between $^1/_{12}$ octave above and $^1/_{12}$ octave below f_o, the discrimination should not exceed 1 dB.

At $^1/_6$ octave above and $^1/_6$ octave below f_o, the discrimination should be not less than 2 dB and should not exceed 4 dB.

At $^1/_3$ octave above f_o, the discrimination should be not less than 8 dB, and
at $^1/_3$ octave below f_o, the discrimination should exceed 12 dB.

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* The range from 100 to 3 200 c/s is close to the range previously used by many countries of 100 to 3 000 c/s. It has been extended to 3 200 c/s to fit in with the preferred 1/3 octave spacing of the measurements. The specification of 1/3 octave band filters can be met by a design of selective amplifier.

At 1 octave above f_o, the discrimination should be not less than 20 dB, and at 1 octave below f_o, the discrimination should exceed 30 dB.

At 3 octaves and more above f_o, the discrimination should be not less than 30 dB, and at 3 octaves and more below f_o, the discrimination should exceed 45 dB.

3.5 **Statement of results.** The normalized level difference should be given at all frequencies of measurement, preferably in the form of a curve, taking the reference absorption as 10 m². The estimated accuracy of the results should be stated.

It should be noted that the laboratory relation using the term $10 \log_{10} (S/A)$ (see clause 2.4), can be useful for comparing the behaviour of a partition under normal practical conditions with laboratory results. The value so computed should be denoted by R', in order to distinguish clearly between the values with and without flanking transmission.

It should be appreciated that a single average figure does not give complete information on the behaviour of a partition, but if a single average figure ($\bar{D}_n$ or $\bar{R}'$) is required, it is recommended that the arithmetic mean to the nearest decibel of the values over the range of mean frequencies 100 to 3 200 c/s should be used. The frequencies used and the method of averaging should be specified.

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4. AIRBORNE SOUND TRANSMISSION: LABORATORY MEASUREMENTS

4.1 **Method for measuring the sound reduction index (R) or transmission loss.** The test specimen should be inserted in an opening between two reverberant rooms.

The volume and shape of each test room should be chosen so as to give an adequately diffuse sound field, taking into consideration the methods used for generation of the sound field and for the measurement of the sound pressure level. The volume should be greater than 50 m³.*

It is recommended that the size of the test partition should be approximately 10 m², with a minimum dimension of not less than 2.5 m.

A smaller size may be used if the wavelength of free flexural waves at 100 c/s is smaller than the minimum dimension of the specimen.

The edge conditions of a test wall or floor should be as near to practical conditions as possible and should be stated.

The sound transmitted by any indirect path should be negligible compared with the sound transmitted through the test specimen.

4.2 **Complementary data.** The specifications for the generation of the sound field, the determination of the average sound pressure levels, the frequency range of measurements and the statement of results are the same as for the field measurements.

The sound reduction index R (transmission loss) should be computed from equation (4) (see clause 2.4). If a single average value $\bar{R}$ is required, it should be computed as for $\bar{R}'$ (see clause 3.5).

The size of the test specimen and the volume of the reverberant rooms should be given in the report.

* A volume of at least 100 m³ is desirable.

5. IMPACT SOUND TRANSMISSION: FIELD MEASUREMENTS

5.1 **Generation of sound field.** The impact sound should be generated by a tapping machine placed successively at three positions at least on the test floor. For floors which are non-homogeneous in the horizontal direction, the position of the tapping machine should be carefully described.

The tapping machine should be constructed in accordance with the following specification:

It should have five hammers placed in a line, the distance between the two end hammers being about 40 cm.

The time between successive impacts should be 100 ± 5 milliseconds.

The effective mass of each hammer should be 0.5 kg (within ± 2.5 per cent).

The drop of a hammer on a flat floor should be equivalent to a free drop without friction of 4 cm (within ± 2.5 per cent).

The part of the hammer which strikes the floor should be a cylinder of brass or steel, 3 cm in diameter, with a spherical end having a radius of about 50 cm.

In the case of a fragile floor covering, hammers should be used having the part that strikes the floor coated with a layer of rubber, of which the dimensions, composition and vulcanization are specified.*

The hammer should strike the floor only once each time it is released and should always fall through an effective height of 4 cm.

5.2 **Method of measuring transmission.** The transmission of sound in a building due to a tapping machine on a test floor is characterized by the octave band spectrum of the average sound pressure level produced in the receiving room.

5.3 **Determination of average sound pressure levels.** The space average sound pressure level should be determined as for airborne sound under clause 2.1 using an indicating device which reads r.m.s. values approximately.

The reference sound pressure should be:

$$2 \times 10^{-4}\ \text{dyn/cm}^2,\ \text{i.e.}\ 2 \times 10^{-5}\ \text{N/m}^2.$$

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* The hammer with a rubber coating should geometrically resemble the hammers of brass or steel only. The part of each hammer below a plane perpendicular to the axis of the cylinder, at 5 mm distance from the lowest point of the curved end of the hammer, should be of rubber of the following composition and vulcanization (" cure "):

Natural rubber	100	parts by weight
Zinc oxide	15	,, ,,
Stearic acid	2	,, ,,
Carbon black EPC	40	,, ,,
Phenylbetanaphthylamine	1	,, ,,
2.2′ benzo thiazyl disulphide (Altax)	1.2	,, ,,
Diphenylguanidine	0.4	,, ,,
Sulphur	3	,, ,,

Cure: 45 min at 142 °C (2.9 atmospheres).

The rubber layer thus has a plane and a curved surface, and a maximum thickness of 5 mm. It should be stuck or vulcanized on the metal.