7C 43

INTERNATIONAL STANDARD ISO 140/II

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Acoustics — Measurement of sound insulation in buildings and of building elements — Part II : Statement of precision requirements

Acoustique — Mesurage de l'isolation acoustique des immeubles et des éléments de construction — Partie II : Spécifications relatives à la fidélité

First edition — 1978-07-15

UDC 534.833.522.4.08 Ref. No. ISO 140/II-1978 (E)

Descriptors : acoustics, acoustic measurement, acoustic insulation, buildings, structural members, tests, testing conditions, precision, reproducibility.

ISO 140/II-1978 (E)

Price based on 5 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 140/II was developed by Technical Committee ISO/TC 43, *Acoustics*, and was circulated to the member bodies in May 1976.

It has been approved by the member bodies of the following countries :

Australia	India	Romania
Austria	Israel	South Africa, Rep. of
Belgium	Italy	Spain
Canada	Japan	Sweden
Czechoslovakia	Korea, Rep. of	Switzerland
Denmark	Mexico	Turkey
Finland	Netherlands	United Kingdom
France	New Zealand	U.S.A.
Germany	Norway	U.S.S.R.
Hungary	Poland	

No member body expressed disapproval of the document.

Annexes A and B are integral parts of this International Standard.

Acoustics – Measurement of sound insulation in buildings and of building elements – Part II : Statement of precision requirements

0 INTRODUCTION

It is not possible to specify completely the construction of laboratory test facilities or the sound field conditions obtained. Therefore, some details of the test set-up and the procedure must be left to the choice of the operator. This, together with the statistical character of sound fields within rooms, leads to uncertainties in the results due to non-systematic (random) and systematic influences.

Random influences can be determined by repeated measurements under essentially similar conditions, variations being made in order to obtain representative samples of the actually existing conditions (for example, position of loudspeaker and microphone). The repeatability obtained is a measure of the confidence to be placed in the results with respect to random influences.

Systematic influences (for example, size and shape of test rooms, mounting conditions of test specimen, calibration of measuring equipment) cannot be determined by a simple procedure. Generally, comparison measurements in different test set-ups and knowledge of the random uncertainties under these conditions are necessary in order to assess the systematic influences.

In agreement with modern statistical methods, in this International Standard the concepts of repeatability and reproducibility of complete results are used, rather than the variance of the individual quantities comprising the result. Repeatability and reproducibility offer a simple means of checking and stating the precision of measurements.

1 SCOPE AND FIELD OF APPLICATION

This International Standard lays down procedures for assessing uncertainty in the acoustical measurements described in ISO 140, parts III to VIII, due to non-systematic influences.

The results may be used for checking different measuring arrangements in one laboratory and for comparing such conditions in different laboratories or in field situations. Minimum values for the precision required when carrying out tests according to ISO 140 are stated in annex A.

The values obtained are not intended for use in test reports as a statement of accuracy of actual measurements. However, reference to this International Standard may be made when test conditions and/or instrumentation meet the requirements set forth herein.

2 REFERENCES

ISO 140/III, *Acoustics – Measurement of sound insulation in buildings and of building elements – Part III : Laboratory measurements of airborne sound insulation of building elements.*

ISO 140/IV, *Acoustics – Measurement of sound insulation in buildings and of building elements – Part IV : Field measurements of airborne sound insulation between rooms.*

ISO 140/V, *Acoustics – Measurement of sound insulation in buildings and of building elements – Part V : Field measurements of airborne sound insulation of facade elements and facades.*

ISO 140/VI, *Acoustics – Measurement of sound insulation in buildings and of building elements – Part VI : Laboratory measurements of impact sound insulation of floors.*

ISO 140/VII, *Acoustics – Measurement of sound insulation in buildings and of building elements – Part VII : Field measurements of impact sound insulation of floors.*

ISO 140/VIII, *Acoustics – Measurement of sound insulation in buildings and of building elements – Part VIII : Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a standard floor.*

3 DEFINITIONS

3.1 result : The final value obtained by following the complete set of instructions in the test procedure.

3.2 true value : For practical purposes, the value towards which the average of single results obtained by *n* laboratories tends, as *n* tends towards infinity.

Consequently, such a true value is associated with the particular method of test.

3.3 accuracy of the mean : The closeness of agreement between the true value and the mean result which would be obtained by applying the test procedure a very large number of times.

The smaller the systematic part of the experimental errors which affect the results, the more accurate is the procedure.

3.4 precision : The closeness of agreement between the results obtained by applying the test procedure several times under prescribed conditions.

The smaller the random part of the uncertainty, the more precise is the procedure.

3.5 repeatability : Qualitatively, the closeness of agreement between successive results obtained with the same test procedure on the same test specimen, under the same conditions (same operator, same apparatus, same laboratory, and short intervals of time).

Quantitatively, the value below which the absolute difference between two single test results (pair) obtained in the above conditions may be expected to lie with a specified probability. This quantity is denoted by r.

3.6 reproducibility : Qualitatively, the closeness of agreement between individual results obtained with the same method on identical test specimens but under different conditions (different operators, different apparatus, different laboratories and different times).

Quantitatively, the value below which the absolute difference between two single test results (pair) on identical test specimens obtained by operators in different laboratories, using the prescribed test procedure, may be expected to lie with a specified probability. This quantity is denoted by Q.

3.7 arithmetic mean : The arithmetic mean $\bar{x}$ for a given set of results is defined by the equation

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

where

n is the number of observed values x_i;

$\bar{x}$ is an estimator for the true value of the mean.

3.8 variance : Qualitatively, a measure of the dispersion of a series of random results about their average.

Quantitatively, for a given set of results, the sum of the squares of the deviation of each result from the arithmetic mean, divided by the number of degrees of freedom. In the simple case of n consecutive (ungrouped) observations, the variance is calculated according to the equation

$$s^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2$$

where s^2 is an estimator for the true value σ^2 of the variance.

3.9 standard deviation : The positive square root s of the variance; s is an estimator for the true value σ of the standard deviation.

3.10 degrees of freedom : The number ν of degrees of freedom is equal to the number of independent terms contained in the expression for the variance. In the simple case of n consecutive (ungrouped) observations

$$\nu = n - 1$$

3.11 confidence level : The probability that the statement in question is true. In this International Standard, a confidence level of 95 % is used.

4 MEASUREMENT PROCEDURE

4.1 General remarks

For routine testing according to ISO 140, on many occasions only one test on a specimen is carried out. In such cases no reliable figure for the confidence to be placed in the result is obtained. In the interest of reliability, it would therefore be advantageous to perform two tests and check the difference of the results against the repeatability r of the test procedure. If their difference is less than or equal to r, the test operator can consider his work as being under control and take the average of the two results as the estimated value of the quantity being tested.

Before routine acoustical testing is taken up by an organization, the repeatability of the test procedure and the test set-up shall be checked as to its capability of producing reliable and repeatable results. These checks should be repeated from time to time, especially whenever changes in the procedure, the test set-up or the instrumentation are made.

It is recommended that different testing organizations collaborate so as to check each other's results for reproducibility.

4.2 Check of repeatability

As a standard check of repeatability of airborne and impact sound measurements under given conditions, the following method should be used.

A set of six complete measurements, for example of the airborne sound reduction index R, the standardized level difference D_{nT} or the normalized impact sound pressure level L_n, respectively, as a function of frequency, is grouped into pairs of consecutive measurements, without changing the original order of the set. The difference in results between the two members of every pair is compared at all frequencies with the requirements in annex A, table 1. If these values are exceeded at any one frequency, all of the results are rejected and the method of check is repeated completely. In case of a second failure to achieve the prescribed values, the test procedure and/or the test set-up are considered inadequate and should be improved to obtain the required repeatability.

NOTE — When carrying out measurements for repeatability checks, the details of the test procedure must not be replicated to the extent of using, for example, identical positions for the microphone, loudspeaker or tapping machine, as this would result in values for r unattainable under practical conditions. Rather, these influences should be varied in such a way as to obtain independent and representative samples of the quantities affecting the repeatability (i.e. the average sound pressure levels in the rooms).

ANNEX A

REQUIREMENTS FOR REPEATABILITY

A.1 GENERAL REMARKS

Since the procedure outlined in this International Standard has not yet been used in building acoustics on a broad scale, precise numerical data of the standard deviation of complete results exist only for one laboratory. From these values, tentative figures for repeatability requirements have been calculated and are given in table 1. It is proposed that further repeatability values for airborne and impact sound insulation for laboratory and field measurements be determined by different organizations in order to confirm and supplement the existing data. A simplified method for carrying out inter-laboratory measurement for determining these values is described in annex B.

A.2 LABORATORY MEASUREMENTS

The test procedure should be so chosen — within the standardized procedures of ISO 140, parts III to VIII — that the repeatability checked according to 4.2 does not exceed the values given below.

A.3 FIELD MEASUREMENTS

In field measurements, the acoustical conditions of test are not under the control of the operator and must in most cases be accepted as they are.

If an instrumentation and procedure checked by measurements in the laboratory is used, the repeatability due to these influences alone can be considered essentially similar to that of laboratory measurements. However, the overall repeatability in situ cannot be stated since the appropriate values of the standard deviation are not known for the given situation, and may under unfavourable conditions considerably exceed the laboratory values.

TABLE 1 — **Requirements for repeatability *r***

Third-octave band centre frequency	***r* for airborne sound reduction index *R***	***r* for normalized impact sound pressure level L_n**
Hz	dB	dB
100	5	3
125	5	2
160	5	2
200	5	2
250	3	2
315	2	2
400	2	2
500	2	2
630	1	1
800	1	1
1 000	1	1
1 250	1	1
1 600	2	1
2 000 and above	2	1

ANNEX B

CO-OPERATIVE DETERMINATION OF REPEATABILITY

The repeatability attainable under given testing conditions is related to the standard deviation obtained from numerous measurements under the same conditions by the equation

$$r = 1{,}96\sqrt{2\,\sigma^2}$$

For a sufficiently large number of results, r can be approximated by the equation

$$r \approx ts\sqrt{2}$$

where t is the factor derived from Student's distribution for a confidence level of 95 % and the appropriate number of degrees of freedom (see table 2).

The determination of repeatability according to this method in one laboratory is very laborious, since approximately 35 degrees of freedom are considered necessary for calculating sufficiently exact values of s.

Moreover, a more reliable value of the standard deviation of the standardized procedure will be obtained if a number of measurements on separate test specimens of the same construction are carried out in different laboratories. In this case, the standard deviation for calculating the repeatability is given by the equation

$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 + \ldots + (n_i - 1)s_i^2 + \ldots + (n_k - 1)s_k^2}{(n_1 + n_2 + \ldots + n_i + \ldots + n_k) - k}}$$

where

s_i is the standard deviation evaluated in the i-th laboratory from n_i consecutive (ungrouped) results;

k is the number of laboratories involved.

The number of laboratories and the number of results in each should be so chosen that the number of degrees of freedom, given by the denominator of the expression under the square root sign of the above equation, is at least 35. However, for each individual laboratory, at least five results are necessary. The test conditions for the determination of s should correspond as far as possible with the examples given in ISO 140, parts III to VIII.

TABLE 2 — **Factor t for calculating the repeatability for a confidence level of 95 %**

Number of degrees of freedom, ν	t
1	12,706
2	4,303
3	3,182
4	2,776
5	2,571
6	2,447
7	2,365
8	2,306
9	2,262
10	2,228
11	2,201
12	2,179
13	2,160
14	2,145
15	2,131
16	2,120
17	2,110
18	2,101
19	2,093
20	2,086
21	2,080
22	2,074
23	2,069
24	2,064
25	2,060
26	2,056
27	2,052
28	2,048
29	2,045
30	2,042
40	2,021
60	2,000
120	1,980
∞	1,960