"RE-AFFIRMED 1995"

Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART II STATEMENT OF PRECISION REQUIREMENTS

UDC 699·844:620·16

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 3 *September* 1982

Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART II STATEMENT OF PRECISION REQUIREMENTS

Acoustics Sectional Committee, LTDC 5

Chairman

DR M. PANCHOLY
Emeritus Scientist, National Physical Laboratory, New Delhi 110 012

Members	*Representing*
DR K. ACHYUTHAN	Ministry of Defence (R & D)
SHRI R. S. VOHRA (*Alternate*)	
SHRI SANDEEP AHUJA	Ahuja Radios, New Delhi
SHRI S. P. JERATH (*Alternate*)	
COL T. R. BHALOTRA	Ministry of Defence (DGI)
LT COL KISHAN LAL (*Alternate*)	
DR A. F. CHHAPGAR	National Physical Laboratory (CSIR), New Delhi
SHRI TEK CHANDANI (*Alternate*)	
DR P. N. GUPTA	Department of Electronics, New Delhi
SHRI R. K. JAIN	Electronic Component Industries Association, (ELCINA), New Delhi
SHRI L. K. VISHWANATH (*Alternate*)	
SHRI K. S. KALIDAS	Railway Board, New Delhi
SHRI V. JAYARAMAN (*Alternate*)	
SHRI J. S. MONGA	Botton Industrial Corporation, New Delhi
SHRI M. S. MONGA (*Alternate*)	
SHRI B. C. MUKHERJEE	National Test House, Calcutta
SHRI J. K. BHATTACHARYA (*Alternate*)	
DR (MISS) SHAILAJA NIKAM	All India Institute of Speech & Hearing, Mysore
SHRI K. D. PAVATE	Central Electronics Engineering Research Institute (CSIR), Pilani
SHRI M. R. KAPOOR (*Alternate*)	
SHRI A. V. RAMANAN	Films Division, Bombay
RESEARCH ENGINEER	Directorate General of All India Radio, New Delhi
SHRI M. SANKARALINGAM	Directorate General of Supplies & Disposals, New Delhi
SHRI R. S. ARORA (*Alternate*)	
SHRI SARWAN KUMAR	Directorate General of Civil Aviation, New Delhi
SHRI K. CHANRACHUDAN (*Alternate*)	

(*Continued on page* 2)

(*Continued from page* 1)

Members	*Representing*
SHRI M. N. SHUKLA	Posts and Telegraphs Board, New Delhi
SHRI S. K. TANDON (*Alternate*)	
SUPERINTENDENT SURVEYOR OF WORKS (FOOD)	Central Public Works Department, New Delhi
SHRI L. K. VISHWANATH	Peico Electronics & Electricals Ltd, Bombay; *and* The Radio Electronics & Television Manufacturers' Association, Bombay
SHRI K. D'SA (*Alternate*)	
SHRI R. C. JAIN, Head (Electronics)	Director General, ISI (*Ex-officio Member*)

Secretary

SHRI PAVAN KUMAR
Assistant Director (Electronics), ISI

Indian Standard

MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND OF BUILDING ELEMENTS

PART II STATEMENT OF PRECISION REQUIREMENTS

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 26 October 1981, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 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.

0.3 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.

0.4 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.

0.5 In agreement with modern statistical methods, the concepts of repeatability and reproducibility of complete results are used in this standard, 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.

0.6 This standard which covers statement of precision requirements is a part of the series of Indian Standards on measurement of sound insulation in buildings and of building elements. Other standards in this series are:

Part I	Requirements for laboratories
Part III	Laboratory measurements of airborne sound insulation of building elements
Part IV	Field measurements of airborne sound insulation between rooms
Part V	Field measurements of airborne sound insulation of facade elements and facades
Part VI	Laboratory measurements of impact sound insulation of floors
Part VII	Field measurements of impact sound insulation of floors
Part VIII	Laboratory measurements of the reduction of transmitted impact noise by floor-coverings on a standard floor.

0.7 While preparing this standard, assistance has been derived from, ISO/DIS 140/II 'Measurement of sound insulation in buildings and of building elements: Part II Statement of precision requirements', issued by the International Organization for Standardization.

0.8 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part II) lays down procedures for assessing uncertainty in the acoustical measurements described in Parts III to VIII of IS : 9901† due to non-systematic influences.

1.2 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 series (Parts III to VIII) of IS : 9901† are stated in **4**.

2. TERMINOLOGY

2.0 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part III/Sec 8)-1974‡ shall apply in addition to the following.

*Rules for rounding off numerical values (*revised*).
†Measurement of sound insulation in buildings and of building elements.
‡Electrotechnical vocabulary: Part III Acoustics, Section 8 Architectural acoustics.

2.1 Result — The final value obtained by following the complete set of instructions in the test procedure.

2.2 True Value — For practical purposes, it is the value towards which the average of single results obtained by *n* laboratories tends, when *n* tends towards infinity. Consequently, such a true value is associated with the particular method of test.

2.3 Accuracy — 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 uncertainty which affects the result, the more accurate is the procedure.

2.4 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.

2.5 Repeatability — Qualitatively, it is the closeness of agreement between successive results obtained with the same test procedure, on the same test specimen and under the same conditions (same operator, same apparatus, same laboratory and same intervals of time). Quantitatively, it is 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.

2.6 Reproducibility — Qualitatively, it is the closeness of agreement between individual results obtained with the same method on the same test specimen but under different conditions (different operators, different apparatus, different laboratories and different time). Quantitatively, it is the value below which the absolute difference between two single test results (pair) on the same test specimen 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.

2.7 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 = number of observed values x_i, and

x = an estimator for the true value of the mean.

2.8 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.

2.9 Standard Deviation — The positive square root s of the variance, s is an estimator for the true value of σ of the standard deviation.

2.10 Degrees of Freedom — The number of degrees of freedom v is equal to the number of independent terms contained in the expression for the variance. In the simple case of consecutive (ungrouped) observations:

$$v = n - 1$$

2.11 Probability Level — The probability that the statement in question is true. In this standard, a probability level of 95 percent is used.

3. MEASUREMENT PROCEDURE

3.1 General

3.1.1 For routine testing according to this series of standards, 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 may, 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 may consider his work as being under control and take the average of the two results as the estimated value of the quantity being tested.

3.1.2 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.

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

3.2 Check of Repeatability

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

3.2.2 A set of six-complete measurements, for example, R, $D_n T_r$ or 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 **4** and Table 1. If these values are exceeded at any one frequency, all the results are rejected and the method of checking 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 shall be improved to obtain the required repeatability.

NOTE — When carrying out repeatability checks, the details of the test procedure should 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 of r unattainable under practical conditions. Rather, these influences be varied in such a way as to obtain independent and representative samples of the quantities affecting the repeatability (that is, the average sound pressure levels in the rooms).

4. REQUIREMENTS FOR REPEATABILITY

4.1 Since the procedure outlined in this 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. A simplified method for carrying out inter-laboratory measurement for determining these values is described in Appendix A.

4.2 Laboratory Measurements

4.2.1 The test procedure shall be so chosen, within the standardized procedures of this series (Parts III to VIII) of IS : 9901*, that the repeatability checked according to **3.2** does not exceed the values given in Table 1.

4.3 Field Measurements

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

*Measurement of sound insulation in buildings and of building elements.

TABLE 1 REQUIREMENTS FOR REPEATABILITY (*r*)

(*Clauses* 3.2.2, 4.1 *and* 4.2.1)

THIRD-OCTAVE BAND CENTRE FREQUENCY	*r* FOR AIRBORNE SOUND REDUCTION INDEX *R*	*r* FOR NORMALIZED IMPACT SOUND LEVEL L_n
(1)	(2)	(3)
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

4.3.2 If instruments and a procedure checked by a laboratory are 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.

APPENDIX A

(*Clause* 4.1)

COOPERATIVE DETERMINATION OF REPEATABILITY

A-1 The repeatability attainable under given testing conditions is related to the standard deviation obtained from numerous measurements under the same conditions by the equation:

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

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 probability level of 95 percent and the appropriate number of degrees of freedom (*see* Table 2).

TABLE 2 FACTOR *t* FOR CALCULATING THE REPEATABILITY FOR A PROBABILITY LEVEL OF 95 PERCENT

Number of Degrees of Freedom v	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

A-1.1 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:

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

where

s_i = standard deviation evaluated in the i-th laboratory from n_i consecutive ungrouped results, and

k = number of laboratories involved.

A-1.2 The number of laboratories and the number of results in each shall be so chosen that the number of degrees of freedom given by the denominator of the expression in the square root 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 shall correspond as far as possible with the examples given in series (Parts III to VIII) of IS : 9901*.

*Measurement of sound insulation in buildings and of building elements.