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Acoustics — Determination and application of measurement uncertainties in building acoustics —

Part 1: Sound insulation

Acoustique — Détermination et application des incertitudes de mesure dans l'acoustique des bâtiments — Partie 1: Isolation acoustique

[Revision of second edition (ISO 140-2:1991) and ISO 140-2:1991/Cor.1:1993]

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ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO-lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five-month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12999-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

This edition cancels and replaces ISO 140-2:1991, which has been technically revised.

ISO 12999 consists of the following parts, under the general title *Acoustics — Determination and application of measurement uncertainties in building acoustics*:

— *Part 1: Sound insulation*

— *Part 2: Sound absorption*

Introduction

An assessment of uncertainties which is comprehensible and close to reality is indispensible for many questions in building acoustics. Whether a requirement is met, a laboratory delivers correct results or the acoustic properties of a product are better than the same properties of some other product can be decided only by adequately assessing the uncertainties associated with the quantities under consideration.

Uncertainties should preferably be determined following the principles of the Guide to the Expression of Uncertainty in Measurement. This Guide specifies a detailed procedure for the uncertainty evaluation which is based upon a complete mathematical model of the measurement procedure. At the current knowledge, it seems to be impossible to formulate these models for the different quantities in building acoustics. Therefore, only the principles of such an uncertainty assessment will be explained.

To come to uncertainties all the same, the concept of reproducibility and repeatability is incorporated which is the traditional way of uncertainty determination in building acoustics. This concept offers the possibility to state the uncertainty of a method and of measurements carried out according to the method, based on the results of inter-laboratory measurements.

Acoustics — Determination and application of measurement uncertainties in building acoustics —

Part 1:
Sound insulation

1 Scope

This part of ISO 12999 specifies procedures for assessing the measurement uncertainty of sound insulation in building acoustics. It gives guidelines for

— detailed uncertainty assessment;

— determination of uncertainties by inter-laboratory tests;

— application of uncertainties.

Furthermore, typical uncertainties are given for quantities determined according to ISO 10140, ISO 16283 and ISO 717.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 717 (all parts), *Acoustics — Rating of sound insulation in buildings and of building elements*

ISO 10140 (all parts), *Acoustics — Laboratory measurement of sound insulation in buildings and of building elements*

ISO 16283 (all parts), *Acoustics — Measurement of sound insulation in buildings and of building elements-field measurements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Whenever applicable, they are equivalent to those given in ISO 5725-1, in the Guide to the expression of uncertainty in measurement [1] and in the International vocabulary of basic and general terms in metrology [2].

3.1
measurand
particular quantity subject to measurement, e.g. the airborne sound insulation of a particular window pane determined according to ISO 10140

3.2
measurement result
value attributed to a measurand, obtained by following the complete set of instructions given in a measurement procedure

NOTE 1 to entry The measurement result may be a frequency band level or a single number value determined according to the rating procedures of ISO 717.

3.3
uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

3.4
standard uncertainty
u
uncertainty of the result of a measurement expressed as a standard deviation

3.5
combined standard uncertainty
u_c
standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

3.6
expanded uncertainty
U
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

3.7
coverage factor
k
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

3.8
repeatability condition
condition of measurement that includes the same measurement procedure, same operators, same measuring system, same location (laboratory or usual building), and replicate measurements on the same object over a short period of time

3.9
repeatability standard deviation
σ_r
the standard deviation of measurement results obtained under repeatability conditions

3.10
reproducibility condition
condition of measurement that includes different locations (laboratories or usual buildings), operators, measuring systems, and replicate measurements on the same or similar objects

3.11
reproducibility standard deviation
σ_R
the standard deviation of measurement results obtained under reproducibility conditions

3.12
in-situ condition
condition of measurement that includes the same location (laboratory or usual building), and replicate measurements on the same object by different operators using different measuring systems

3.13
in-situ standard deviation
σ_{situ}
the standard deviation of measurement results obtained under in-situ conditions

4 Detailed uncertainty budget

4.1 General

The derivation of a detailed uncertainty budget is desirable to find out which uncertainty contributions are the most important ones and how these contributions may be reduced. Furthermore, such a budget will reflect the individual sound fields during the measurement. Consequently, the uncertainty is valid for an individual measurement result and not for a whole family of results. This chapter will give guidelines on the derivation of such uncertainty budgets.

4.2 Influences on the result of building acoustic measurements

Measurement results in building acoustics are influenced by many parameters which can be arranged into groups corresponding to repeatability and reproducibility conditions. Uncertainty components mentioned below are thought to be of importance for most measurands in building acoustics. Nevertheless, other uncertainty components may arise under special circumstances.

The first group of uncertainty components comprises all the influences which occur under repeatability conditions. To these influences belong

— imperfect spatial and temporal averaging when determining averaged sound pressure levels;

— uncertainties in the background noise correction if the background noise is not stationary; and

— uncertainties associated with the determination of room absorption, e.g. due to imperfect spatial averaging.

Effects of static pressure, humidity and temperature can be neglected here when the measurements are carried out within a short period of time wherein these quantities remain constant.

All influences leading to deviations between different laboratories are covered by the second group. These are uncertainties due to differences in the airborne or structure-borne sound fields involved which may be caused by

— different sizes or aspect ratios of the test openings;

— different loss factors of the test facilities;

— different room geometries;

— different boundary conditions;

— remaining flanking transmission.

Further uncertainty components of the second group are

— the measurement equipment including the calibration; and

— effects of temperature, static pressure and humidity.

The sum of all uncertainty contributions from the first and the second group contain all influences covered by the term reproducibility conditions.

A third group of influences is made up of only one element. This is the product scatter of usual building elements. This uncertainty component is not handled within the scope of this standard even though there are cases where it exceeds all the other components.

4.3 Calculation of the standard uncertainty of the measurand

The measurand Y is determined by *N* input quantities X_1, X_2, ..., X_N through a functional relationship f

$$Y = f(X_1, X_2, ...X_N) \tag{1}$$

A probability distribution (normal, rectangular, student-t, etc.) is associated with each of the input quantities. Its expectation (mean value) is the best estimate for the value of the input quantity and its standard deviation is a measure of the dispersion of values, termed uncertainty.

For the case of negligible correlation between the input quantities, the combined standard uncertainty of the estimate of the measurand y is given by the following equation:

$$u_c(y) = \sqrt{\sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i} \right)^2 u^2(x_i)} \tag{2}$$

where

f is the function given in equation (1);

$u(x_i)$ is the standard uncertainty of the estimate x_i representing the input quantity X_i.

At the current state of knowledge, the derivation of a functional relationship covering all effects mentioned in 4.2 is not possible for all measurands in building acoustics one reason being the unknown degree of correlation between input quantities [3].

5 Uncertainty determination by inter-laboratory measurements

5.1 General

Standard deviations determined by inter-laboratory measurements may serve as an estimate for the standard uncertainty. The general concept and the procedure for determining these standard deviations are given in ISO 5725-1 and ISO 5725-2, respectively. As many operators and laboratories as possible should participate in such inter-laboratory measurements in order to obtain reliable results.

5.2 Measurement situations

In building acoustics, three different measurement situations are to be distinguished.

The situation A is that a building element is to be characterized by laboratory measurements. In this case, the measurand is defined by the relevant part of ISO 10140 including all additional requirements e.g. for the measurement equipment and especially for the test facilities. Therefore, all measurement results that may be obtained in another test facility or building also comply with this definition. The standard uncertainty thus is the standard deviation of reproducibility as determined by inter-laboratory measurements.