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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*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustic properties of building elements and of buildings*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12999-1:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the quantity $\sigma_{R95}$ was removed from Table 2;

— the text in Clause 7 referring to this quantity was removed and the wording adapted;

— a new Annex D was drafted with a new table containing $\sigma_{R95}$ and text explaining what it is;

— new references were added.

A list of all parts in the ISO 12999 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.


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# Introduction

An assessment of uncertainties that is comprehensible and close to reality is indispensable 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 ISO/IEC Guide 98-3. This Guide specifies a detailed procedure for the uncertainty evaluation that 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 are explained.

To come to uncertainties all the same, the concept of reproducibility and repeatability is incorporated which is the traditional approach for 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.

NOTE Whenever applicable, the terms and definitions used in this document are equivalent to those given in ISO 5725-1[2], in ISO/IEC Guide 98-3[7] and in ISO/IEC Guide 99[8].

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

# Part 1: Sound insulation

## 1 Scope

This document specifies procedures for assessing the measurement uncertainty of sound insulation in building acoustics. It provides for

— a detailed uncertainty assessment;

— a determination of uncertainties by inter-laboratory tests;

— an application of uncertainties.

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

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

**3.1**
**measurand**
particular quantity subject to measurement

EXAMPLE 1 The airborne sound insulation of a particular window pane determined in accordance with ISO 10140 (all parts).

EXAMPLE 2 The standardized level difference of a particular facade according to ISO 16283-3.

**3.2**
**measurement result**
value attributed to a *measurand* (3.1), 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 (all parts).

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**3.3**
**uncertainty**
parameter, associated with the *measurement result* (3.2), that characterizes the dispersion of the values that can reasonably be attributed to the *measurand* (3.1)

**3.4**
**standard uncertainty**
$u$
*uncertainty* (3.3) of the *measurement result* (3.2) expressed as a standard deviation

**3.5**
**combined standard uncertainty**
$u_c$
*standard uncertainty* (3.4) 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* (3.2) varies with changes in these quantities

**3.6**
**expanded uncertainty**
$U$
quantity defining an interval about the *measurement result* (3.2) that can be expected to encompass a large fraction of the distribution of values that can reasonably be attributed to the *measurand* (3.1)

**3.7**
**coverage factor**
$k$
numerical factor used as a multiplier of the *combined standard uncertainty* (3.5) in order to obtain an *expanded uncertainty* (3.6)

**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**
$\sigma_r$
standard deviation of *measurement results* (3.2) obtained under *repeatability conditions* (3.8)

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

**3.11**
**reproducibility standard deviation**
$\sigma_R$
standard deviation of *measurement results* (3.2) obtained under *reproducibility conditions* (3.10)

**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


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**3.13**
***in-situ* standard deviation**
$\sigma_{situ}$
standard deviation of *measurement results* (3.2) obtained under *in-situ conditions* (3.12)

## 4 Detailed uncertainty budget

The derivation of a detailed uncertainty budget is desirable to find out which uncertainty contributions are the most important ones and how these contributions can be reduced. Furthermore, such a budget reflects 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. Annex C gives provisions on the derivation of such uncertainty budgets.

## 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.

a) Situation A is that a building element is 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 are 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.

b) Situation B is described by the case that different measurement teams come to the same location to carry out measurements. The location may be a usual building or a test facility. The measurand, thus, is a property of one particular element in one particular test facility or the property of a building. The main difference from situation A is that many aspects of the airborne and structure-borne sound fields involved remain constant since the physical construction is unchanged. The standard uncertainty obtained for this situation is called *in-situ* standard deviation.

c) Situation C applies to the case when the measurement is simply repeated in the same location by the same operator using the same equipment. The location may be a usual building or a test facility. The standard uncertainty is the standard deviation of repeatability as determined by inter-laboratory measurements.

### 5.3 Measurement conditions

The acoustical measurement conditions for determining the different standard deviations shall correspond to the conditions given in the standardized measurement procedures. The test specimen shall not be remounted between repeated measurements.

Each laboratory shall use its normal measurement procedure when participating in an inter-laboratory measurement. No deviations from the test procedure laid down shall occur but repeating the measurements several times, the parameters left open in the measurement procedure shall be represented as well as possible. In particular, the set of microphone positions and source positions over which averaging is carried out for one measurement shall be selected anew, more or less randomly,

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