SLOVENSKI STANDARD
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Acoustics - Determination of uncertainties associated with sound emission measures - Part 1: Sound power levels determined from sound pressure measurements (ISO/DIS 5114-1:2023)

Akustik - Bestimmung der Unsicherheiten von Schallemissionsmessgrößen - Teil 1: Bestimmung von Schallleistungspegeln aus Schalldruckmessungen (ISO/DIS 5114-1:2023)

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Acoustics — Determination of uncertainties associated with sound emission measures —

Part 1:
Sound power levels determined from sound pressure measurements

ICS: 17.140.01

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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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Introduction

An assessment of uncertainties that is comprehensible and close to reality is indispensable for reporting and applying measured sound power levels. 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 is impossible to formulate these models for sound power level measurements. To come to uncertainties all the same, the concept of reproducibility is additionally described in this document. 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 of uncertainties associated with sound emission measures —

Part 1: Sound power levels determined from sound pressure measurements

1 Scope

This document gives guidance on the determination of (measurement) uncertainties of sound power levels determined according to ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3744, ISO 3745, ISO 3746 and ISO 3747.

2 Normative references

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

ISO 3741:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

ISO 3743-1:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for small movable sources in reverberant fields — Part 1: Comparison method for a hard-walled test room*

ISO 3743-2:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms*

ISO/DIS 3744:—,[1)] *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3745:2012, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 3746:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3747:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

ISO 12001:1996, *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

1) Under preparation. Stage at the time of the ballot: ISO/DIS 3744:2022

IEC 61260 (all parts), *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1:2013, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

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

3.1
measurand
particular quantity subject to measurement, e.g. the sound power level of a particular sound source determined according to ISO/DIS 3744:—

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 sound power level in octave bands, one-third octave bands or an A-weighted sound power level.

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

3.4
expanded uncertainty
U
quantity defining an interval about the result of a measurement that is expected to encompass a large fraction of the distribution of values that can reasonably be attributed to the measurand

3.5
coverage factor
k
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

3.6
reproducibility condition
condition of measurement that includes different laboratories, operators, measuring systems, and replicate measurements on the same or similar objects

3.7
standard deviation of reproducibility of the method
σ_{R0}
standard deviation of measurement results obtained under reproducibility conditions using a specified method

Note 1 to entry: In statistics, it is usually distinguished between the standard deviation of the basic population σ and the empirical standard deviation derived from a sample *s*. Despite this, the symbol σ is used for all standard deviations in this document to be in line with other standards on sound emission.

3.8
total standard deviation
σ_{tot}
standard deviation of measurement results obtained under reproducibility conditions

3.9
standard deviation for the operating and mounting conditions
σ_{omc}
standard deviation of measurement results caused by variations of operating and mounting conditions

4 General concept to describe the uncertainty of measured sound power levels

The uncertainties of sound power levels, $u(L_W)$, in decibels, determined in accordance with the International Standard used (ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3744, ISO 3745, ISO 3746 or ISO 3747) are estimated by the total standard deviation, in decibels:

$$u(L_W) \approx \sigma_{\text{tot}} \tag{1}$$

This total standard deviation is obtained using the modelling approach described in ISO/IEC Guide 98-3. This requires a mathematical model which in case of lack of knowledge may be replaced by results from measurements, including results from round robin tests.

This standard deviation is expressed by the standard deviation of reproducibility of the method, σ_{R0}, in decibels, and the standard deviation, σ_{omc}, in decibels, describing the uncertainty due to the instability of the operating and mounting conditions of the source under test in accordance with:

$$\sigma_{\text{tot}} = \sqrt{\sigma_{\text{R0}}^2 + \sigma_{\text{omc}}^2} \tag{2}$$

Formula (2) shows that variations of operating and mounting conditions expressed by σ_{omc} should be taken into account before a measurement procedure with a certain grade of accuracy (characterized by σ_{R0}) is selected for a specific machine family. The standard deviation σ_{R0} includes all uncertainty due to conditions and situations allowed by the International Standard used (different radiation characteristics of the source under test, different instrumentation, different implementations of the measurement procedure), except that due to instability of the sound power of the source under test. The latter is considered separately by σ_{omc}.

Values for the machinery-specific standard deviation σ_{R0} may be derived from dedicated round robin tests (see Clause 6) or by using the mathematical modelling approach (see Clause 7). They should be given in noise test codes specific to machinery families.

NOTE 1 If different measurement procedures offered by ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3744, ISO 3745, ISO 3746 or ISO 3747 are used, systematic numerical deviations (biases) can additionally occur.

Derived from σ_{tot}, the expanded measurement uncertainty, U, in decibels, shall be calculated from:

$$U = k\,\sigma_{\text{tot}} \tag{3}$$

The expanded measurement uncertainty depends on the degree of confidence that is desired. For a normal distribution of measured values, there is 95 % confidence that the true value lies within the range $(L_W + U)$ to $(L_W - U)$. This corresponds to a coverage factor of $k = 2$. If the purpose of determining the sound power level is to compare the result with a limit value, it can be more appropriate to apply the coverage factor for a one-sided normal distribution. In that case, the coverage factor $k = 1{,}6$ corresponds to a 95 % confidence level.

NOTE 2 The expanded uncertainty, as described in this document, does not include the standard deviation of production which is used in ISO 4871 for the purpose of making a noise declaration for batches of machines.

5 Determination of σ_{omc}

The standard deviation σ_{omc} which describes the uncertainty associated with the instability of the operating and mounting conditions for the particular source under test shall be taken into account when determining the measurement uncertainty. It is determined from repeated measurements carried out on the same source at the same location by the same persons, using the same measuring instruments and the same measurement position(s). To determine σ_{omc}, sound pressure level measurements are repeated either at the single microphone position associated with the highest sound pressure level, or at multiple microphone positions. These positions shall be distributed on an enveloping surface in approximated hemifree fields or in a volume in approximated diffuse fields.

Measurements are then corrected for background noise. Background noise measurements should be taken at the same location, and as close as possible in time to the measurement when the machine is operating. Further, if background sound levels are within 10 dB of the total measured level, then the uncertainty associated with the variation in background sound level should be considered.

For each of these repeated measurements, the mounting of the machine and its operating conditions shall be readjusted. For the individual sound source under test, σ_{omc} is designated as σ'_{omc}. It is possible that a noise test code provides a value of σ_{omc} which is representative for the machine family concerned. This value should take into account all possible variations of operating and mounting conditions specified in the noise test code.

The standard deviation σ_{omc} is calculated by:

$$\sigma_{\text{omc}} \approx \sqrt{\frac{1}{N-1}\sum_{j=1}^{N}\left(L_{p,j}-L_{\text{pav}}\right)^2} \ \text{dB} \qquad (4)$$

where

$L_{p,j}$ is the sound pressure level measured at a prescribed position or averaged over the surface or volume and corrected for background noise for the j^{th} repetition of the prescribed operating and mounting conditions, in decibels;

L_{pav} is its arithmetic mean level calculated for all these repetitions, in decibels;

N is the number of repetitions of the prescribed operating and mounting conditions.

In general, the mounting and operating conditions to be used for noise emission measurements are prescribed by machinery specific noise test codes. Otherwise, these conditions shall be defined precisely and described in the test report.

Some recommendations for defining these conditions and consequences for the expected values of σ_{omc} are given hereafter.

The test conditions shall represent normal usage and conform to manufacturers' and users' recommended practice. However, even in normal usage, variations within a specified operation mode, variations in material flow, and other conditions varying between different phases of operation can occur. This uncertainty covers both the uncertainty due to variation in long-term operating conditions (e.g. from day to day) and fluctuations of noise emission measurements repeated immediately after readjusting mounting and operating conditions.

Machines that stand exclusively on soft springs or on heavy concrete floors do not normally exhibit any effect of mounting. However, there can be large discrepancies between measurements on heavy concrete floors and those made *in situ*. The uncertainty due to mounting can be highest for machinery that is connected to auxiliary equipment. Hand-held machines can also cause problems. This parameter should be investigated if movement of the machine or mounts causes changes in noise. If there is a range of possible mounting conditions to be included in a single declaration, then σ_{omc} is estimated from the standard deviation of the sound levels for these mounting conditions. If there is any known effect due to

