INTERNATIONAL STANDARD

ISO 1996-2

Third edition
2017-07

Acoustics — Description, measurement and assessment of environmental noise —

Part 2: Determination of sound pressure levels

Acoustique — Description, évaluation et mesurage du bruit de l'environnement —

Partie 2: Détermination des niveaux de pression acoustique

Reference number
ISO 1996-2:2017(E)

© ISO 2017



COPYRIGHT PROTECTED DOCUMENT

© ISO 2017, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Measurement uncertainty **3**

5 Instrumentation for acoustical measurements **5**
5.1 General 5
5.2 Calibration 6
5.3 Verification 6
5.4 Long-term monitoring 6

6 Principles **6**
6.1 General 6
6.2 Independent measurements 7

7 Operation of the source **8**
7.1 General 8
7.2 Road traffic 8
7.2.1 L_{eq} measurement 8
7.2.2 L_{max} measurement 9
7.3 Rail traffic 9
7.3.1 L_{eq} measurement 9
7.3.2 L_{max} measurement 9
7.4 Air traffic 10
7.4.1 L_{eq} measurement 10
7.4.2 L_{max} measurement 11
7.5 Industrial plants 11
7.5.1 L_{eq} measurement 11
7.5.2 L_{max} measurement 11

8 Meteorological conditions **12**
8.1 General 12
8.2 Favourable propagation 13
8.3 Effects of precipitation on measurements 13

9 Measurement procedures **13**
9.1 Selection of measurement time interval 13
9.1.1 Long-term measurements 13
9.1.2 Short-term measurements 14
9.2 Microphone location 14
9.2.1 Outdoors 14
9.2.2 Indoors 15
9.3 Measurements 15
9.3.1 Long-term unattended measurements 15
9.3.2 Short-term attended measurements 16
9.3.3 Residual sound 17
9.3.4 Frequency range of measurements 17
9.3.5 Measurements of meteorological parameters 17

10 Evaluation of the measurement results **18**
10.1 General 18
10.2 Determination of $L_{E,T}$, $L_{eq,T}$ and $L_{N,T}$ *18*
10.2.1 $L_{E,T}$ and $L_{eq,T}$ *18*
10.2.2 $L_{N,T}$ *18*

© ISO 2017 – All rights reserved

10.3 Treatment of incomplete or corrupted data ... 19
10.3.1 General ... 19
10.3.2 Wind sound ... 19
10.4 Level correction for residual sound ... 19
10.5 Determination of standard uncertainty ... 19
10.6 Determination of L_{den} ... 20
10.6.1 Determination from long-term L_{eq} measurements ... 20
10.6.2 Determination from long-term L_E measurements of individual events ... 20
10.6.3 Determination from short-term measurements ... 21
10.7 Maximum level, L_{max} ... 22

11 Extrapolation to other locations ... 22
11.1 General ... 22
11.2 Extrapolation by means of calculations ... 22
11.3 Extrapolation by means of measured attenuation functions ... 23

12 Calculation ... 23
12.1 General ... 23
12.2 Calculation methods ... 24
12.2.1 General ... 24
12.2.2 Specific procedures ... 24

13 Information to be recorded and reported ... 24

Annex A (informative) **Determination of radius of curvature ... 26**

Annex B (informative) **Microphone locations relative to reflecting surfaces ... 29**

Annex C (informative) **Selection of measurement/monitoring site ... 34**

Annex D (informative) **Correction to reference condition ... 36**

Annex E (informative) **Elimination of unwanted sound ... 41**

Annex F (informative) **Measurement uncertainty ... 42**

Annex G (informative) **Examples of uncertainty calculations ... 44**

Annex H (informative) **Maximum sound pressure levels ... 49**

Annex I (informative) **Measurement of residual sound ... 52**

Annex J (informative) **Objective method for assessing the audibility of tones in noise — Engineering method ... 54**

Annex K (informative) **Objective method for assessing the audibility of tones in noise — Survey method ... 56**

Annex L (informative) **National and European source specific calculation models ... 57**

Bibliography ... 60

 © ISO 2017 – All rights reserved

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 on 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*.

This third edition cancels and replaces the second edition (ISO 1996-2:2007), which has been technically revised.

A list of all the parts in the ISO 1996 series can be found on the ISO website.

© ISO 2017 – All rights reserved

Introduction

Measurements of environmental noise are complicated because there is a great number of variables to consider when planning and performing the measurements. As each measurement occasion is subject to current source and meteorological conditions which cannot be controlled by the operator, it is often not possible to control the resulting uncertainty of the measurements. Instead, the uncertainty is determined after the measurements based on an analysis of the acoustic measurements and collected data on source operating conditions and on meteorological parameters important for the sound propagation.

Because this document has the ambition both to comply with new and stricter requirements on measurement uncertainty calculations and to cover all kinds of sources and meteorological conditions, it has become more complicated than what a standard covering a single, specific source and application could have been. The best use of the standard is to use it as a basis for developing more dedicated standards serving specific sources and aims.

© ISO 2017 – All rights reserved

Acoustics — Description, measurement and assessment of environmental noise —

Part 2: Determination of sound pressure levels

1 Scope

This document describes how sound pressure levels intended as a basis for assessing environmental noise limits or comparison of scenarios in spatial studies can be determined. Determination can be done by direct measurement and by extrapolation of measurement results by means of calculation. This document is primarily intended to be used outdoors but some guidance is given for indoor measurements as well. It is flexible and to a large extent, the user determines the measurement effort and, accordingly, the measurement uncertainty, which is determined and reported in each case. Thus, no limits for allowable maximum uncertainty are set up. Often, the measurement results are combined with calculations to correct for reference operating or propagation conditions different from those during the actual measurement. This document can be applied on all kinds of environmental noise sources, such as road and rail traffic noise, aircraft noise and industrial noise.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1996-1:2016, *Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures*

ISO 20906:2009/Amd 1:2013, *Acoustics — Unattended monitoring of aircraft sound in the vicinity of airports — Amendment 1*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

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

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1996-1 and the following apply.

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

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

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

© ISO 2017 – All rights reserved

3.1
measurement time interval
time interval during which measurements are conducted

Note 1 to entry: For measurements of sound exposure level or equivalent-continuous sound pressure level, the measurement time interval is the time period of integration.

Note 2 to entry: For measurements of maximum sound pressure level or percent exceedance level, etc., the measurement time interval is the *observation time interval* (3.2).

3.2
observation time interval
time interval during which a series of measurements is conducted

3.3
prediction time interval
time interval over which levels are predicted

Note 1 to entry: It is now perhaps more common to predict sound levels using computers than to measure them for some sources such as transportation noise sources. The prediction time interval corresponds to the *measurement time interval* (3.1) except, for the former, the levels are predicted, and for the latter, the levels are measured.

3.4
long-term measurement
measurement sufficiently long to encompass all emission situations and meteorological conditions which are needed to obtain a representative average

3.5
short-term measurement
measurement during *measurement time intervals* (3.1) with well-defined emission and meteorological conditions

3.6
receiver location
location at which the noise is assessed

3.7
calculation method
set of algorithms to calculate the sound pressure level at a specified *receiver location* (3.6) from measured or predicted sound power levels and sound attenuation data

3.8
prediction method
subset of a *calculation method* (3.7), intended for the calculation of future noise levels

3.9
meteorological window
set of weather conditions during which measurements can be performed with limited and known variation in measurement results due to weather variation

3.10
emission window
set of emission conditions during which measurements can be performed with limited variation in measurement results due to variations in operating conditions

3.11
sound path radius of curvature
R_{cur}
radius approximating the curvature of the sound paths due to atmospheric refraction

Note 1 to entry: R_{cur} is given in metres.

© ISO 2017 – All rights reserved

Note 2 to entry: Often, the parameter used is $1/R_{cur}$ to avoid infinitely large values during straight ray propagation.

3.12
monitor
instrumentation used for a single automated continuous sound monitoring terminal which monitors the A-weighted sound pressure levels, their spectra and all relevant meteorological quantities such as wind speed, wind direction, rain, humidity, atmospheric stability, etc.

Note 1 to entry: Meteorological measurements need not be taken at each monitor provided such measurements are taken within an appropriate distance from the monitors and such distance is given in the report.

3.13
automated sound monitoring system
entire automated continuous sound monitoring system including all *monitors* (3.12), the base or central data collection position (host station) and all software and hardware involved in its operation

3.14
reference condition
condition to which the measurement results are to be referred (corrected)

Note 1 to entry: Examples of reference conditions are atmospheric sound absorption at yearly average temperature and humidity and yearly average traffic flows for day, evening and night, respectively.

3.15
independent measurement
consecutive measurements carried out with a time space long enough to make both source operating conditions and sound propagation conditions statistically independent of the same conditions of other measurements in the series

Note 1 to entry: In order to achieve independent conditions for meteorological conditions, a time space of several days is normally required.

3.16
low-frequency sound
sound containing frequency components of interest within the range covering the one-third octave bands 16 Hz to 200 Hz

Note 1 to entry: This definition is specific for this document. Other definitions can apply in different national regulations.

4 Measurement uncertainty

The uncertainty of sound pressure levels determined as described in this document depends on the sound source and the measurement time interval, the meteorological conditions, the distance from the source and the measurement method and instrumentation. The measurement uncertainty shall be determined in compliance with ISO/IEC Guide 98-3 (GUM). Choose one of the following approaches that are all GUM-compatible:

a) The modelling approach that consists in identifying and quantifying all major sources of uncertainty (the so-called uncertainty budget). This is the preferred method.

b) The inter-laboratory approach that consists in carrying out a round-robin test in order to determine the standard deviation of reproducibility of the measurement method.

NOTE 1 If more than one measurement method exists for a certain measurand, any systematic deviations are taken into account, for example, by implementing ISO 21748[1].

c) The hybrid approach that consists in using jointly the modelling approach and the inter-laboratory approach. In this case, the inter-laboratory approach is used for components of the uncertainty

© ISO 2017 – All rights reserved