INTERNATIONAL STANDARD

ISO 389-1

Second edition
2017-12

Acoustics — Reference zero for the calibration of audiometric equipment —

Part 1: Reference equivalent threshold sound pressure levels for pure tones and supra-aural earphones

Acoustique — Zéro de référence pour l'étalonnage d'équipements audiométriques —

Partie 1: Niveaux de référence équivalents de pression acoustique liminaire pour les écouteurs à sons purs supra-auraux

Reference number
ISO 389-1:2017(E)

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

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 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.

The committee responsible for this document is ISO/TC 43, *Acoustics*.

This second edition cancels and replaces the first edition (ISO 389-1:1998), which has been technically revised.

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

— data for additional models of earphone have been introduced;

— wording and definitions have been aligned with the current versions of standards in the field of audiology.

A current list of all parts in the ISO 389 series can be found on the ISO website.

Introduction

Each document in the ISO 389 series specifies reference threshold levels for the calibration of audiometric equipment. This document is applicable to equipment for pure-tone air-conduction audiometry that uses supra-aural earphones.

In principle, reference equivalent threshold sound pressure levels (RETSPLs) would be rendered independent of earphone model if they were referred to an ear simulator having acoustical properties exactly simulating those of the average human ear. A device designed with this aim in view is standardized in IEC 60318-1. The original data for the ISO 389 series were presented in ISO 389:1985, Addendum 1, which was prepared based on an assessment of technical data provided by laboratories listed in Annex B on RETSPL values specified on the IEC 60318-1 ear simulator and covering a variety of earphone models. These data were analysed to produce a set of RETSPL values which are, within an acceptable uncertainty, applicable to earphones of any model within a broadly defined class. A note on the derivation of the standard values and the origin of the data input is given in Annex B for information.

In recent years, new supra-aural earphone models have been developed and other models have been revised. If applicable, their RETSPLs were specified both on the IEC 60318-1 ear simulator and the IEC 60318-3 acoustic coupler, as a result of direct threshold measurements under the preferred test conditions given in ISO 389-9. These model-specific RETSPL values are given in this document in separate tables, along with the IEC 60318-3 acoustic coupler RETSPLs for Telephonics TDH 39[1)] and Beyer DT 48[2)] earphones, which were adopted from the former editions of ISO 389.

1) TDH 39 is the name of a product supplied by Telephonics. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product name.

2) DT 48 is the name of a product supplied by Beyerdynamic. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

Acoustics — Reference zero for the calibration of audiometric equipment —

Part 1:
Reference equivalent threshold sound pressure levels for pure tones and supra-aural earphones

1 Scope

This document specifies a standard reference zero for the scale of hearing threshold level applicable to pure-tone air conduction audiometers, to promote agreement and uniformity in the expression of hearing threshold level measurements throughout the world.

It states the information in a form suitable for direct application to the calibration of audiometers, that is, in terms of the reference equivalent threshold sound pressure levels of generic supra-aural earphones specified in 4.2, measured on an ear simulator complying with IEC 60318-1 and in terms of model-specific data given in two additional tables for the IEC 60318-3 acoustic coupler and the IEC 60318-1 ear simulator, respectively.

The data are based on an assessment of the information available from the various standardizing laboratories responsible for audiometric standards and from scientific publications.

Some notes on the application and derivation of the reference levels are given in Annexes A and B.

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.

IEC 60318-1:2009, *Electroacoustics — Simulators of human head and ear — Part 1: Ear simulator for the measurement of supra-aural and circumaural earphones*

IEC 60318-3, *Electroacoustics — Simulators of human head and ear — Part 3: Acoustic coupler for the calibration of supra-aural earphones used in audiometry*

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 https://www.electropedia.org/

3.1
air conduction
transmission of sound through the external and middle ear to the inner ear

3.2
acoustic coupler
device for measuring the acoustic output of sound sources where the sound pressure is measured by a calibrated microphone coupled to the source by a cavity of predetermined shape and volume which does not necessarily approximate the acoustic impedance of the normal human ear

Note 1 to entry: An acoustic coupler is specified in IEC 60318-3.

3.3
ear simulator
device for measuring the acoustic output of sound sources where the sound pressure is measured by a calibrated microphone coupled to the source so that the overall acoustic impedance of the device approximates that of the normal human ear at a given location and in a given frequency band

Note 1 to entry: An ear simulator is specified in IEC 60318-1.

3.4
hearing threshold
lowest sound pressure level or vibratory force level at which, under specified conditions, a person gives a predetermined percentage of correct detection responses on repeated trials

3.5
otologically normal person
person in a normal state of health who is free from all signs or symptoms of ear disease and from obstructing wax in the ear canal, and who has no history of undue exposure to noise, exposure to potentially ototoxic substances, or familial hearing loss

3.6
equivalent threshold sound pressure level for monaural earphone listening
sound pressure level set up by the earphone in a specified *acoustic coupler* (3.2) or *ear simulator* (3.3) when the earphone is actuated by that voltage which, with the earphone applied to the ear concerned, would correspond to the *hearing threshold* (3.4) for a given ear, at a specified frequency, for a specified model of earphone and for a stated force of application of the earphone to the human ear

3.7
reference equivalent threshold sound pressure level
RETSPL
median value of the *equivalent threshold sound pressure levels* (3.6) of a sufficiently large number of ears of *otologically normal persons* (3.5), of both sexes, aged between 18 years and 25 years inclusive, expressing the threshold of hearing in a specified acoustic coupler or ear simulator for a specified type of earphone at a specified frequency

Note 1 to entry: Other statistical quantities, e.g. mean or modal values, have been used for the derivation of reference data given in this document (see also Annex B).

Note 2 to entry: The relationship between hearing threshold levels for *air conduction* (3.7) and age is specified in ISO 7029.

4 Specifications

4.1 General

The reference equivalent threshold sound pressure levels (RETSPLs) depend on the model of earphone and on the model of acoustic coupler or ear simulator used for calibration. To reduce the uncertainty of hearing threshold measurements, the model-specific data sets given in 4.3 or 4.4 shall be applied whenever available for the respective earphone in conjunction with the respective ear simulator/acoustic coupler. If model-specific data sets are not available and the earphone complies with the requirements of 4.2. a) to h), the generic data set given in 4.2 shall be used.

4.2 Generic supra-aural earphones in conjunction with an IEC 60318-1 ear simulator

The RETSPL values for generic supra-aural earphones in an ear simulator complying with IEC 60318-1 are given in Table 1. The values are applicable to earphones meeting the following requirements:

a) the earphone and its cushion, if any, shall be axially symmetrical;

b) the construction and material shall be suitable for providing a good acoustic seal between the earphone (or its cushion) and the human ear;

c) when placed in contact with a plane surface, the contact area of the earphone (or its cushion) shall be compatible with the sagittal dimensions of the human pinna;

d) no part of the earphone (or its cushion) shall protrude beyond the plane of contact given in c), and the recess shall be approximately in the form of a truncated cone;

e) the contour of the earphone (or its cushion) shall be such that contact with an ear simulator of the type specified in IEC 60318-1 is effective only at a diameter of 25 mm;

NOTE 1 This requirement means that the angle at the vertex of any recess cone which is tangential to the earphone contour on a diameter exceeding 25 mm will be greater than 116°.

f) the material of the cushion shall not be so soft as to cause significant deformation when the earphone is applied to the ear simulator as determined by the following test:

1) when a static force of 5 N is changed to 10 N;

2) the output sound pressure level at 1 kHz for a given input voltage shall not change by more than 0,2 dB;

g) the contour of the earphone (or its cushion) shall be such that, when placed on the human ear, contact is made with the pinna and not with the cranial tissue posterior to the pinna;

NOTE 2 This requirement excludes earphones of the circumaural type.

h) a headband shall be provided to hold the earphone on the human pinna with a static force of 4,5 N ± 0,5 N.

The RETSPL values apply when the earphone is coupled to the ear simulator as follows:

a) the earphone and the ear simulator are coaxial and the axis is vertical;

b) without acoustic leakage;

c) with the static force given in Table 1.

Table 1 — Generic RETSPLs in an ear simulator complying with IEC 60318-1

Frequency Hz	RETSPL (Reference: 20 µPa) dB
125	45
160	38,5
200	32,5
250	27
315	22
400	17
500	13,5
630	10,5
750	9
800	8,5
1 000	7,5
1 250	7,5
1 500	7,5
1 600	8
2 000	9
2 500	10,5
3 000	11,5
3 150	11,5
4 000	12
5 000	11
6 000	16
6 300	21
8 000	15,5
Static force: 4,5 N ± 0,5 N	
NOTE Values are rounded to the nearest half decibel.	

4.3 Model-specific earphones in conjunction with an IEC 60318-1 ear simulator

The RETSPL values for specific supra-aural earphones in an ear simulator complying with IEC 60318-1 are given in Table 2.

The RETSPL values apply when the earphone is coupled to the ear simulator as follows:

a) the earphone and the ear simulator are coaxial and the axis is vertical;

b) without acoustic leakage;

c) with the static force given in Table 2.

The Sennheiser HDA 280[3)] earphone shall be measured using the ear-simulator-flat-plate adapter in conjunction with the conical ring (see IEC 60318-1:2009, B.2 and Figure B.4).

3) HDA 280 is the name of a product supplied by Sennheiser. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

Table 2 — Model-specific RETSPLs in an ear simulator complying with IEC 60318-1

Frequency Hz	RETSPL (Reference: 20 µPa) dB
125	38,5
160	33
200	28,5
250	24
315	20,5
400	16,5
500	13,5
630	9,5
750	6,5
800	6
1 000	6
1 250	7
1 500	8,5
1 600	8,5
2 000	10
2 500	9,5
3 000	9,5
3 150	10
4 000	11,5
5 000	14,5
6 000	17
6 300	18,5
8 000	28,5
Model of earphone	Sennheiser HDA 280[3)]
Static force	5,3 N ± 0,5 N
References	[12] and [13]
NOTE Values are rounded to the nearest half decibel.	

4.4 Model-specific earphones in conjunction with an IEC 60318-3 acoustic coupler

The RETSPL values for specific earphones in an acoustic coupler complying with IEC 60318-3 are given in Table 3.

The RETSPL values apply when the earphone is coupled to the acoustic coupler as follows:

a) the earphone and the acoustic coupler are coaxial and the axis is vertical;

b) without acoustic leakage;

c) with the static force given in Table 3.

The Beyer DT 48[2)] earphone shall be used with a flat cushion when placed on a human ear but the cushion shall be replaced by an adapter (see Reference [3]) when placed on the coupler. The Telephonics TDH 39[1)] earphone shall be used with an MX 41/AR (or model 51) cushion both on the human ear and on the coupler. The Sennheiser HDA 280[3)] earphone shall be placed directly on the rim of the acoustic

coupler. The RadioEar DD 45[4)] earphone shall be used with its cushion centrically placed on the top of the rim of the coupler.

Table 3 — Model-specific RETSPLs in an acoustic coupler complying with IEC 60318-3

Frequency Hz	RETSPL (Reference: 20 µPa) dB				
125	47,5	45	47,5	38,5	47,5
160	40,5	37,5		33,5	40,5
200	34	31,5		29	33,5
250	28,5	25,5	26,5	24,5	27
315	23	20		20,5	22,5
400	18,5	15		16,5	17,5
500	14,5	11,5	13,5	13	13
630	11,5	8,5		9,5	9
750	9,5	7,5	8,5	7	6,5
800	9	7		7	6,5
1 000	8	7	7,5	7	6
1 250	7,5	6,5		8	7
1 500	7,5	6,5	7,5	9,5	8
1 600	7,5	7		9	8
2 000	8	9	11	8	8
2 500	7	9,5		7,5	8
3 000	6	10	9,5	7,5	8
3 150	6	10		8	8
4 000	5,5	9,5	10,5	10,5	9
5 000	7	13		16	13
6 000	8	15,5	13,5	20,5	20,5
6 300	9	15		20	19
8 000	14,5	13	13	16,5	12
Model of earphone	Beyer DT 48[2)] with flat cushion	Telephonics TDH 39[a,1)] with MX41/AR (or model 51) cushion	Telephonics TDH 49/50[5)]	Sennheiser HDA 280[3)]	RadioEar DD 45[4)]
Static force	4,5 N ± 0,5 N	4,5 N ± 0,5 N	4,5 N ± 0,5 N	5,3 N ± 0,5 N	4,5 N ± 0,5 N
References	See Annex B	See Annex B	[16]	[12] and [13]	[14] and [15]

NOTE Values are rounded to the nearest half decibel.

[a] In 1963, the filter cloth in the Telephonics TDH 39[1)] earphone was changed, but matched to produce the same earphone response on the acoustic coupler. The data given in this document are averages of data from several earphones manufactured both before any change and after the change to the new matched cloth.

4) DD 45 is the name of a product supplied by RadioEar. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

Annex A
(informative)

Application of the RETSPLs

A.1 Audiometers, which are fitted with earphones of one of the models specified in this document, shall be calibrated using the RETSPLs given in the appropriate table. The acoustical output of the earphone shall be measured on the type of ear simulator or acoustic coupler specified. When the earphone is applied to the human ear, the headband used should provide the nominal static force given in the table that specifies the RETSPLs.

NOTE A headband for a mean head width of 145 mm will usually provide the nominal application force given in the tables for the listed types of earphone.

A.2 In the case of audiometers fitted with earphones of models neither mentioned in this document nor meeting the requirements of 4.2, it is necessary to first determine the corresponding RETSPLs for this model of earphone under the preferred test conditions specified in ISO 389-9.

Annex B
(informative)

Notes on the derivation of the RETSPLs

B.1 Octave frequencies and additional audiometric frequencies 1 500 Hz, 3 000 Hz and 6 000 Hz

The RETSPLs given in Table 3 for the Beyer DT 48[2)] earphone correspond to an average of 15 determinations published, or otherwise communicated to ISO during the period from 1950 to 1961. The values have been determined by a cooperative investigation carried out by the following five standardizing laboratories:

— Centre National d'Études des Télécommunications, Palaiseau, France;

— Physikalisch-Technische Bundesanstalt, Braunschweig, Germany;

— National Physical Laboratory, Teddington, United Kingdom;

— National Bureau of Standards, Washington, DC, USA;

— V.N.I.I.M. Laboratory, Leningrad, USSR.

The RETSPLs given in Table 3 for the Telephonics TDH 39[1)] earphone were subsequently derived by subjective loudness balancing methods. For details, see References [4] to [7].

The RETSPL values given in Table 1 were obtained by averaging the results of transfer measurements on several examples of six models of earphones. These measurements, carried out by the laboratories mentioned below, compared the sound pressure level developed in the acoustic coupler (see IEC 60318-3) and the IEC ear simulator (see IEC 60318-1) for equal electrical excitation of the earphones.

The participating laboratories were as follows:

— Audiologiske Institutt, Rikshospitalet, Oslo, Norway;

— Karolinska Institutet, Stockholm, Sweden;

— National Bureau of Standards, Washington, DC, USA;

— National Physical Laboratory, Teddington, United Kingdom;

— Physikalisch-Technische Bundesanstalt, Braunschweig, Germany.

For details, see Reference [8].

The RETSPLs for the Telephonics TDH 49/50[5)] were directly taken from ANSI/ASA S3.6-2010[15].

B.2 Supplementary frequencies

The RETSPL values for supplementary frequencies have been derived by interpolation from those values specified for octave frequencies and the additional audiometric frequencies f 1 500 Hz, 3 000 Hz and 6 000 Hz and supported by experimental data.

5) TDH 49/50 are the names of products supplied by Telephonics. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.