INTERNATIONAL STANDARD

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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
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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 ISO/IEC Directives, Part 3.

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.

International Standard ISO 389-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

This first edition cancels and replaces ISO 389:1991. It is a minor revision in order to make it part of the ISO 389 series.

ISO 389 consists of the following parts, under the general title *Acoustics — Reference zero for the calibration of audiometric equipment*:

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

— *Part 2: Reference equivalent threshold sound pressure levels for pure tones and insert earphones*

— *Part 3: Reference equivalent threshold force levels for pure tones and bone vibrators*

— *Part 4: Reference levels for narrow-band masking noise*

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— *Part 5: Reference equivalent threshold sound pressure levels for pure tones in the frequency range 8 kHz to 16 kHz*

— *Part 6: Reference equivalent threshold sound pressure levels for acoustic test signals of short duration*

— *Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions*

Annex A of this part of ISO 389 is for information only.

Introduction

Each part of ISO 389 specifies a specific reference zero for the calibration of audiometric equipment. The present part 1 is applicable to audiometric equipment for the transmission of pure tones by air conduction and supra-aural earphones. ISO 389-2 is applicable to audiometric equipment for the transmission of pure tones by air conduction and insert earphones. ISO 389-3 is applicable to pure-tone bone-conduction audiometers, ISO 389-4 specifies reference levels for narrow-band masking noise, and ISO 389-7 specifies reference levels for presentation in free and diffuse sound fields.

The first edition of ISO 389 specified a standard reference zero for the scale of hearing threshold level applicable to pure-tone air conduction audiometers in terms of the response of certain models of earphone measured on an artificial ear or coupler of stated type. Five of these earphone-coupler combinations corresponded with those used at that time in standardizing laboratories in France, Germany, the United Kingdom, the USA and the USSR. In a second set of values, the corresponding reference equivalent threshold sound pressure levels (RETSPL) for eleven audiometric earphones were given, referred to a single type of coupler, the National Bureau of Standards, Washington, USA type 9A coupler, which was later specified in IEC 303:1970 (now IEC 60303).

Most of the earphone-coupler combinations mentioned in the first edition of ISO 389 are now no longer in use. The ISO member bodies of the countries primarily concerned with those types of standard earphones and artificial ears agreed to eliminate obsolete data. This was done in the second edition of ISO 389. It contained only RETSPL values for two earphone models still widely in use for audiometric purposes, namely Telephonics type TDH 39 with cushion type MX 41/AR (or model 51) and Beyer type DT 48, both in conjunction with an acoustic coupler complying with IEC 303:1970.

The two remaining sets of data differ mainly as a consequence of differences between the acoustical properties of the coupler and those of the average human ear.

For the same reason, the RETSPL for an earphone of a model not covered by ISO 389 could not be inferred from the data given in that International Standard. Until then it had been necessary to obtain the appropriate values by subjective comparison with one of the specified models of earphone.

In principle, RETSPL values would be rendered independent of earphone model if they were referred to an artificial ear having acoustical properties exactly simulating those of the average human ear. A device designed with this aim in view was standardized in 1970 in IEC 318:1970 (now IEC 60318).

Addendum 1 to ISO 389:1985 was therefore prepared, based on an assessment of technical data provided by laboratories listed in annex A on RETSPL values relative to the IEC artificial ear, covering a variety of earphone models.

These data were analysed to produce a set of RETSPL values which, within an acceptable tolerance, provide a standard audiometric reference zero for 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 A for information.

Use of the standard reference zero specified in Addendum 1 obviated the need for subjective calibration of supra-aural audiometric earphones which meet the broad requirements specified, and thus promotes agreement and uniformity in the expression of hearing threshold levels throughout the world, without inhibiting the development of improved models of supra-aural earphone.

The data of Addendum 1 were incorporated in ISO 389:1991.

In both ISO 389 and ISO 389/Add. 1, the RETSPL values were specified for pure tones in octave steps from 125 Hz to 8 000 Hz and for the intermediate audiometric frequencies 1 500 Hz, 3 000 Hz and 6 000 Hz. However, in addition, 750 Hz is sometimes used as an intermediate audiometric frequency, and Addendum 2 to ISO 389:1985 therefore specified RETSPL values for that frequency.

Moreover, it had been considered desirable to harmonize intermediate frequencies used in pure-tone audiometry with the preferred frequencies in acoustics as specified in ISO 266. Addendum 2 therefore specified RETSPL values at all preferred frequencies in one-third-octave steps in the frequency range from 125 Hz to 8 000 Hz. Details of the derivation of the RETSPL values are given in annex A for further information. The data of Addendum 2 were also incorporated in ISO 389:1991.

The RETSPL value specified at 750 Hz is intended for calibration of audiometers providing pure tones of a fixed frequency of 750 Hz. The other RETSPL values specified are primarily intended for calibration of pure-tone audiometers having a continuously variable frequency, but they may also be used in other applications, for example for establishing reference levels for masking noise. The frequencies given in ISO 389:1985 and Addendum 2 are consistent with the frequencies used in ISO 389-3 for the specification of the standard reference zero for the calibration of bone conduction audiometers. Three sets of RETSPL values were specified. Two of these concern the same earphone models as in ISO 389:1985. The third set of RETSPL values were specified for supra-aural earphones other than those covered by ISO 389:1985 but which fulfil the requirements specified in ISO 389/Add. 1.

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 part of ISO 389 specifies a standard reference zero for the scale of hearing threshold level applicable to pure-tone air conduction audiometers, in order 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 response of two different standard models of earphone measured on a coupler complying with IEC 60303 and in terms of other supra-aural earphones of models specified in 4.3 measured on an artificial ear complying with IEC 60318.

It is 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 derivation and application of the recommended reference levels are given in annex A.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 389. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 389 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60303, *IEC provisional reference coupler for the calibration of earphones used in audiometry.*[1)]

IEC 60318, *An IEC artificial ear, of the wide band type, for the calibration of earphones used in audiometry.*[2)]

1) Now revised as IEC 60318-3.
2) Now revised as IEC 60318-1.

3 Terms and definitions

For the purposes of this part of ISO 389, the following terms and definitions apply.

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

3.2
acoustic coupler
cavity of specified shape and volume which is used for the calibration of a supra-aural earphone in conjunction with a calibrated microphone to measure the sound pressure developed within the cavity

NOTE An acoustic coupler is specified in IEC 60303.

3.3
artificial ear
device for the calibration of an earphone which presents to the earphone an acoustic impedance equivalent to the impedance presented by the average human ear

NOTE 1 It is equipped with a calibrated microphone for the measurement of the sound pressure developed by the earphone.

NOTE 2 An artificial ear is specified in IEC 60318.

3.4
threshold of hearing
level of a sound at which, under specified conditions, a person gives 50 % 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 oxotoxic drugs, or familial hearing loss

3.6
equivalent threshold sound pressure level (monaural earphone listening)
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, the sound pressure level set up by the earphone in a specified acoustic coupler or artificial ear when the earphone is actuated by that voltage which, with the earphone applied to the ear concerned, would correspond to the threshold of hearing

3.7
reference equivalent threshold sound pressure level (RETSPL)
at a specified frequency, the modal value of the equivalent threshold sound pressure levels of a sufficiently large number of ears of otologically normal persons, of both sexes, aged between 18 and 30 years inclusive, expressing the threshold of hearing in a specified acoustic coupler or artificial ear for a specified type of earphone

NOTE The relationship between hearing threshold levels for air conduction and age is specified in ISO 7029.

3.8
hearing level (of a pure tone)
at a specified frequency, for a specified model of earphone and for a specified manner of application, the sound pressure level of this pure tone produced by the earphone in a specified acoustic coupler or artificial ear minus the appropriate reference equivalent threshold sound pressure level

3.9
hearing threshold level (of a given ear)
at a specified frequency and for a specified model of transducer, the threshold of hearing expressed as hearing level

NOTE For appropriate test conditions see, for example, ISO 6189 and ISO 8253-1.

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 used to calibrate it.

4.2 Beyer DT 48 and Telephonics TDH 39 earphones

The recommended standard values for two different earphones in a coupler complying with IEC 60303 are given in Table 1.

The Beyer DT 48 earphone shall be used with a flat cushion when placed on a human ear but the cushion shall be replaced by an adapter[3)] when placed on the coupler. The TDH 39 earphone shall be used with an MX 41/AR (or model 51) cushion both on the human ear and on the coupler.

The earphone shall be applied to the coupler without acoustic leakage with a nominal static force of 4,5 N ± 0,5 N, not including the weight of the earphone itself.

Table 1 — Recommended reference equivalent threshold sound pressure levels in a coupler complying with IEC 60303

Frequency Hz	**RETSPL** (Reference: 20 µPa) dB	
125	47,5	45
160	40,5	37,5
200	34	31,5
250	28,5	25,5
315	23	20
400	18,5	15
500	14,5	11,5
630	11,5	8,5
750	9,5	7,5
800	9	7
1 000	8	7
1 250	7,5	6,5
1 500	7,5	6,5
1 600	7,5	7
2 000	8	9
2 500	7	9,5
3 000	6	10
3 150	6	10
4 000	5,5	9,5
5 000	7	13
6 000	8	15,5
6 300	9	15
8 000	14,5	13
Model of earphone	Beyer DT 48 with flat cushion	Telephonics TDH 39[a] with MX41/AR (or model 51) cushion

[a] In 1963 the filter cloth in the Telephonics TDH 39 earphone was changed, but matched to produce the same earphone response on the 9A coupler. During the change, about 1 000 units were produced with an unmatched cloth. The data given in this part of ISO 389 are averages of data from several earphones manufactured both before and after 1963.

NOTE Values are rounded to the nearest half decibel.

3) The adapter is specified in reference [1] (see Bibliography).

4.3 Other supra-aural earphones

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

These values are applicable to earphones meeting the following requirements (but models of earphone specified in 4.2 are excluded in order to avoid uncertainties which might otherwise arise):

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

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

c) when placed in contact with a plane surface, the circle of contact of the earphone (or its cushion) shall be of a diameter comparable 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 if provided, shall be such that contact with an artificial ear of the type specified in IEC 60318 is effective only at a diameter of 25 mm;

NOTE 1 This requirement means that the angle at the vertex of any 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, if provided, shall not be so soft as to cause significant deformation when the earphone is applied to an artificial ear as determined by the following test: when a static force of 5 N is changed to 10 N, the apparent sensitivity level at 1 kHz shall not change by more than 0,2 dB;

g) the contour of the earphone, or its cushion if provided, 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 artificial ear under the following conditions:

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

b) without acoustic leakage;

c) with nominal static force of 4,5 N ± 0,5 N, not including the weight of the earphone itself.

Table 2 — Reference equivalent threshold sound pressure levels in an artificial ear complying with IEC 60318

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

NOTE Values are rounded to the nearest half decibel.

Annex A
(informative)

Notes on the derivation and application of the recommended reference levels

A.1 Derivation

A.1.1 General

It is very important to note that the RETSPLs given in Table 1 and Table 2 refer, as closely as can be ascertained from existing data, to the same hearing threshold levels. The differences between the values are mainly due to differences between the acoustical properties of the acoustic coupler and those of the artificial ear.

A.1.2 Octave frequencies and additional audiometric frequencies 1 500 Hz, 3 000 Hz and 6 000 Hz

The RETSPLs given in Table 1 for the Beyer DT 48 earphone correspond to an average of 15 determinations published, or otherwise communicated to the International Organization of Standardization, 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 1 for the Telephonics TDH 39 earphone were derived at a later date by subjective loudness balancing methods. For details, see references [2] to [5] in the Bibliography.

The RETSPL values given in Table 2 were obtained by averaging the results of transfer measurements on several examples of six models of earphone. These measurements, carried out by the laboratories mentioned below, compared the sound pressure level developed in the acoustic coupler (see IEC 60303) and the IEC artificial ear (see IEC 60318) for equal electrical excitation of the earphones.

The participating laboratories were

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 [6].