

INTERNATIONAL
STANDARD

ISO
389-2

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**Acoustics — Reference zero for the
calibration of audiometric equipment —**

Part 2:

Reference equivalent threshold sound
pressure levels for pure tones and insert
earphones

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

*Partie 2: Niveaux de référence équivalents de pression acoustique
liminaire pour les écouteurs à son purs et à insertion*



Reference number
ISO 389-2:1994(E)

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.

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 389-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

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*
- *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*

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Part 1 will be a re-issue of ISO 389:1991.

Annexes A and B of this part of ISO 389 are for information only.

Introduction

Each part of International Standard ISO 389 specifies a specific reference zero for the calibration of audiometric equipment. ISO 389:1991 (to be re-issued as ISO 389-1) contains values of reference equivalent threshold sound pressure levels (RETSPL) for pure tones and two specified patterns of supra-aural earphones used in conjunction with an acoustic coupler conforming to IEC 303, and for other supra-aural earphones of specified patterns in conjunction with an artificial ear conforming to IEC 318. ISO 389-4 specifies reference levels for narrow-band masking noise based on these RETSPL data.

In some audiological applications it may, however, be desirable to use insert earphones to deliver either the test signal or the masking noise, e.g. to reduce the occlusion effect or interaural effects. RETSPL data for these kinds of earphone are specified in this part of ISO 389. It is based on an assessment of technical data provided by laboratories in different countries representing the most reliable data available at the time.

It is recognized that small differences may occur between results of hearing threshold level measurements obtained by audiometric equipment using different patterns of earphone, i.e. supra-aural or insert earphones.

Acoustics — Reference zero for the calibration of audiometric equipment —

Part 2:

Reference equivalent threshold sound pressure levels for pure tones and insert earphones

1 Scope

This part of ISO 389 specifies reference equivalent threshold sound pressure levels (RETSPL) for the calibration of pure-tone audiometers supplementary to those specified in ISO 389:1991¹⁾. Values given in this part of ISO 389 are applicable to insert earphones of a pattern specified in clause 4.

NOTE 1 For information, a note on the derivation of the reference values and the origin of the data input is given in annex A, and a bibliography is given in annex B.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 389. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 389 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 389:1991, *Acoustics — Standard reference zero for the calibration of pure-tone air conduction audiometers.*¹⁾

IEC 126:1973, *IEC reference coupler for the measurement of hearing aids using earphones coupled to the ear by means of ear inserts.*

1) To be re-issued as ISO 389-1.

IEC 711:1981, *Occluded-ear simulator for the measurement of earphones coupled to the ear by ear inserts.*

3 Definitions

For the purposes of this part of ISO 389, the definitions given in ISO 389:1991 together with the following definitions apply.

3.1 ear insert: Device used to provide the acoustic coupling between an earphone and the ear canal.

NOTE 2 This may be, for example, an earmould or a similar device with or without a connecting tube.

3.2 insert earphone: Small earphone coupled to the ear canal by means of an ear insert, or attached to a connecting element which is inserted into the ear canal. The ear insert may be a part of the insert earphone.

3.3 ear simulator: Device for measuring the output sound pressure of an earphone under well-defined loading conditions in a specified frequency range. It consists essentially of a principal cavity, acoustic load networks and a calibrated microphone. The location of the microphone is chosen so that the sound pressure at the microphone corresponds approximately to the sound pressure existing at the human eardrum.

3.4 occluded-ear simulator: Ear simulator which simulates the inner part of the ear canal, from the tip of an ear insert to the eardrum.

NOTE 3 An occluded-ear simulator is specified in IEC 711.

3.5 ear-insert simulator (earmould substitute, earmould simulator): Insert which terminates the entrance of the ear simulator and provides for passage of sound into the acoustic coupler or the occluded-ear simulator through an opening on its axis.

3.6 acoustic coupler for insert earphones: Cavity of specified shape and volume which is used for the calibration of an insert earphone in conjunction with a calibrated microphone to measure the sound pressure within the cavity.

NOTE 4 An acoustic coupler for insert earphones is specified in IEC 126.

4 Type of earphone

This part of ISO 389 applies to insert earphones of type Etymotic Research ER-3A, coupled to the human ear by ear inserts of type ER-3-14.

NOTE 5 Insert earphones of type EARTONE 3A are in all relevant aspects identical to ER-3A insert earphones. Ear inserts of type ER-3-14 are also offered as EARLINK 3A ear inserts.

The ear insert consists of a foam eartip with a nominal diameter of 13 mm and a nominal length of 12 mm. It contains an internal plastic tube with a nominal

internal diameter of 1,9 mm and a nominal effective length of 22 mm, as measured between the end of the foam eartip and the end of a sound tube nipple (nominal internal diameter 1,9 mm, nominal length 11 mm). The nipple connects the ear insert to the insert earphone output via a sound tube with a nominal internal diameter of 2 mm and a nominal effective length of 240 mm, as measured between the end of the nipple and the end of the earphone output (see figure 1).

The ear insert shall be inserted into the ear canal so that the outer end of the eartip is 2 mm to 3 mm inside the entrance of the ear canal.

5 Specifications

The reference equivalent threshold sound pressure levels (RETSPL) for earphones as specified in clause 4, in an acoustic coupler conforming to IEC 126 and in an occluded-ear simulator conforming to IEC 711, are given in table 1.

These values apply when the sound tube nipple of the insert earphone is fixed flush to the acoustic coupler and to the occluded-ear simulator in accordance with figure 2 of IEC 126:1973 or IEC 711:1981, respectively, by means of plastic tubing. The total effective length of the connecting elements between the insert earphone output and the ear insert simulator is then determined to be 251 mm (see figure 2).

NOTE 6 In the case of audiometers fitted with insert earphones other than that described in clause 4, the procedure given in A.2.2 of ISO 389:1991 should be used to determine corresponding RETSPL values.

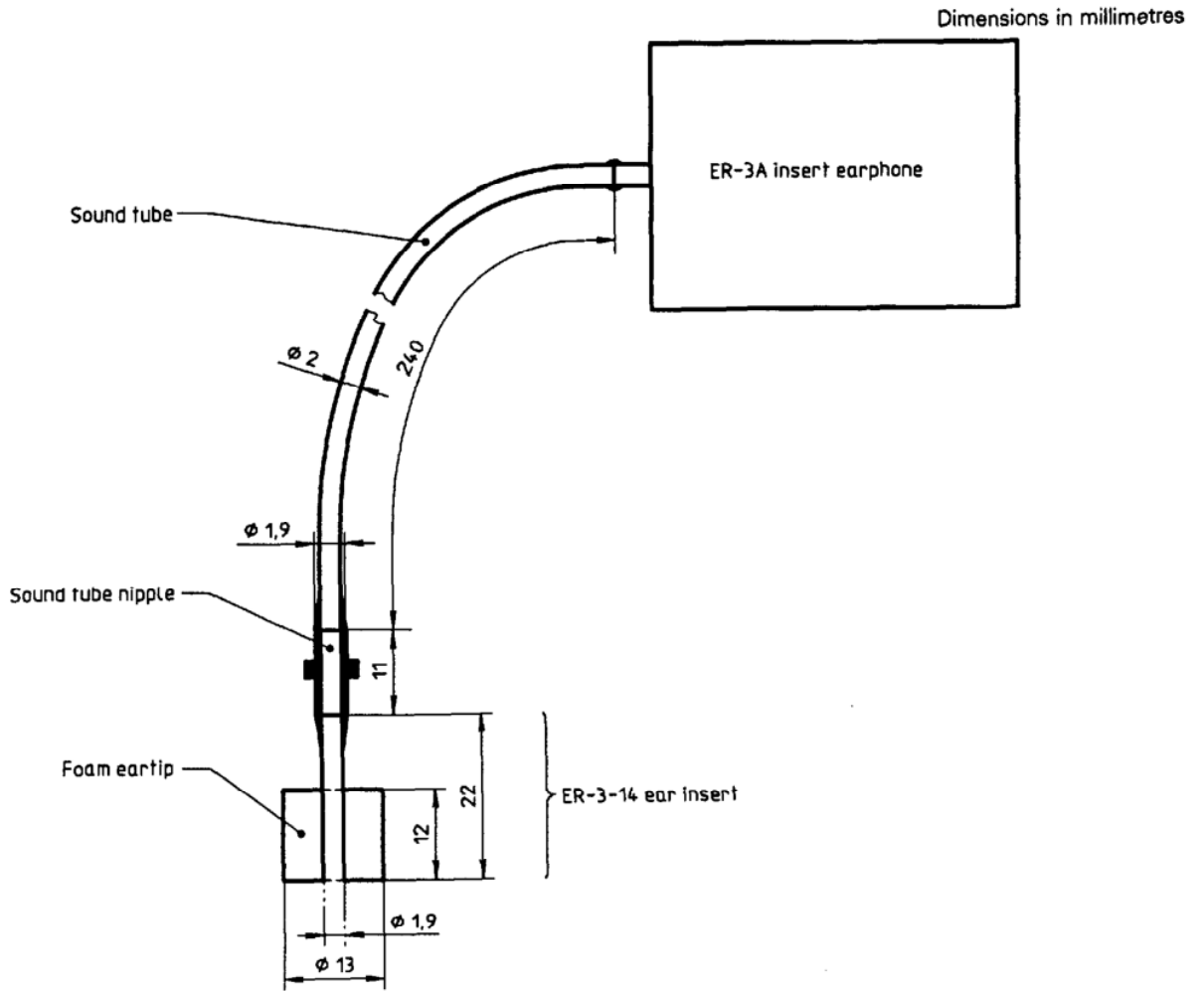


Figure 1 — An ER-3-14 ear insert and its coupling to an ER-3A insert earphone

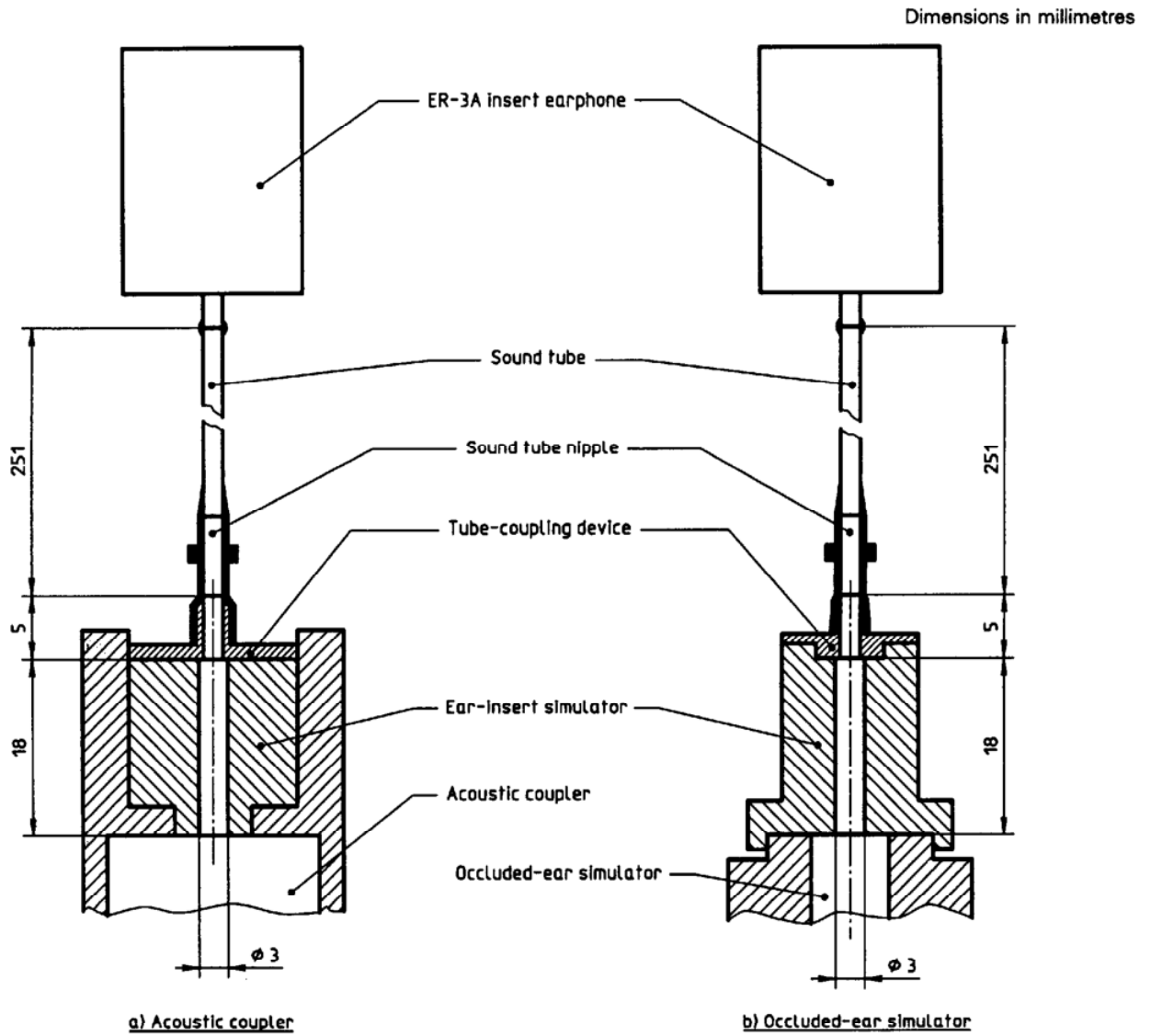


Figure 2 — Coupling of the insert earphone to the acoustic coupler or to the occluded-ear simulator

Table 1 — Reference equivalent threshold sound pressure levels in an acoustic coupler conforming to IEC 126 and in an occluded-ear simulator conforming to IEC 711

Frequency Hz	RETSPL (ref. 20 µPa) ¹⁾	
	dB	
	Acoustic coupler (IEC 126)	Occluded-ear simulator (IEC 711)
125	26,0	28,0
160 ²⁾	22,0	24,5
200 ²⁾	18,0	21,5
250	14,0	17,5
315	12,0	15,5
400 ²⁾	9,0	13,0
500	5,5	9,5
630	4,0	7,5
750	2,0	6,0
800 ²⁾	1,5	5,5
1 000	0,0	5,5
1 250	2,0	8,5
1 500	2,0	9,5
1 600 ²⁾	2,0	9,5
2 000	3,0	11,5
2 500	5,0	13,5
3 000	3,5	13,0
3 150 ²⁾	4,0	13,0
4 000	5,5	15,0
5 000	5,0	18,5
6 000	2,0	16,0
6 300	2,0	16,0
8 000	0,0	15,5

1) Values are rounded to nearest half-decibel.
2) Values for these frequencies are derived by interpolation.

Annex A (informative)

Notes on the derivation of RETSPL values

The RETSPL values specified in this part of ISO 389 were obtained from the results of three independent experimental investigations communicated to ISO/TC 43, *Acoustics*. Brief particulars of the tests are given in table A.1. More details on measurement methods and test subjects are given in the references quoted in annex B.

The insert earphone threshold data used in the development of this part of ISO 389 were not corrected for deviations of the test subject's hearing threshold levels from 0 dB, as measured with the reference earphone.

The RETSPL data were derived by averaging the data of the three investigations without weighting for different numbers of subjects.

Table A.1 — Investigations of RETSPL values

Test data	Investigations		
	Ref. [1]	Ref. [2]	Ref. [3]
Type of test earphone	ER-3A insert earphone conforming to clause 4		
Measurement method	Hearing threshold technique Reference earphone used to verify normal hearing of test subjects		
Type of reference earphone	Telephonics TDH-39	Telephonics TDH-39	Beyer DT 48
Number of ears tested	56	36	48
Number of subjects	28	18	23
Frequencies tested, in hertz	250, 500, 1 000, 2 000, 3 000, 4 000, 8 000	125, 250, 500, 1 000, 2 000, 3 000, 4 000, 6 000, 8 000	125, 250, 315, 500, 630, 750, 1 000, 1 250, 1 500, 2 000, 2 500, 3 000, 4 000, 5 000, 6 000, 6 300, 8 000
Hearing threshold levels of test subjects	≤ 10 dB at any test frequency below 4 000 Hz and ≤ 15 dB at test frequencies of 4 000 Hz and above		
Type of coupler used for insert earphone	IEC 126:1973, figure 2	IEC 126:1973, figure 2 IEC 711:1981, figure 2	IEC 126:1973, figure 2 IEC 711:1981, figure 2

Annex B (informative)

Bibliography

- [1] WILBER, L.A., KRUGER, B. and KILLION, M.C. Reference thresholds for the ER-3A insert earphone. *J. Acoust. Soc. Amer.*, **83** (2), 1988, pp. 669-676.²⁾
- [2] ARLINGER, S. and KINNEFORS, C. Reference equivalent threshold sound pressure levels for insert earphones. *Scand. Audiol.*, **18**, 1989, pp.195-198.
- [3] BRINKMANN, K. and RICHTER, U. Reference zero for the calibration of pure tone audiometers equipped with insert earphones. *Acustica*, **70**, 1990, pp. 202-207.
- [4] ISO 389-4:—³⁾, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 4: Reference levels for narrow-band masking noise.*
- [5] IEC 303:1970, *IEC provisional reference coupler for the calibration of earphones used in audiometry.*
- [6] IEC 318:1970, *An IEC artificial ear, of the wide-band type, for the calibration of earphones used in audiometry.*

2) This article is a compilation of the results of five experimental studies. For the purposes of this part of ISO 389, however, the results of one study only (Wilber, 1986) could be taken into account due to deviating test conditions used in the other studies.

3) To be published.

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Descriptors: acoustics, audiometry, audiometers, calibration, auditory threshold, reference data.

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