

INTERNATIONAL STANDARD

**ISO
389-7**

First edition
1996-12-15

Acoustics — Reference zero for the calibration of audiometric equipment —

Part 7:

Reference threshold of hearing under free-field
and diffuse-field listening conditions

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

*Partie 7: Niveau liminaire de référence dans des conditions d'écoute en
champ libre et en champ diffus*



Reference number
ISO 389-7:1996(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 389-7 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

This first edition of ISO 389-7 constitutes a partial revision of ISO 266:1987 with respect to the threshold of hearing for pure tones under free-field listening conditions T_f [ISO 226:1987, table 1 (column 4) and annex A (MAF-curve)], the threshold of hearing for one-third-octave noise bands under diffuse-field listening conditions T'_f [ISO 226:1987, table 4 (column 3)], and the difference between these thresholds, ΔL [ISO 226:1987, table 4 (column 2)]. The equal-loudness level contours contained in ISO 226 are at present under revision within ISO/TC 43 and are not covered by this part of ISO 389.

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 earphone*
- *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*

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

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.

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[ISO 389-7:1996](https://standards.iteh.ai/catalog/standards/sist/4d521cfb-4c81-434c-9670-587a937887e4/iso-389-7-1996)

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Introduction

Each part of ISO 389 specifies a specific reference zero for the calibration of audiometric equipment. ISO 389:1991 (to be re-issued as ISO 389-1) and ISO 389-2 are applicable to audiometric equipment for the transmission of pure tones by means of supra-aural or insert earphones, respectively. Corresponding audiometric test methods are specified in ISO 8253-1.

In some audiological applications it may, however, be desirable to deliver the test signals by means of loudspeakers, either in a free sound field or in a diffuse sound field. Corresponding audiometric test methods are specified in ISO 8253-2. This part of ISO 389 specifies the reference zero for the calibration of audiometric equipment used for sound field audiometry.

In common with other subjective phenomena, the threshold of hearing varies in detail from person to person but, for a group of otologically normal persons within a restricted age range, values for the central tendency can be determined to characterize the group. This and other parts of ISO 389 specify threshold data applicable to otologically normal persons in the age range from 18 to 25 years. Compared with ISO 226, a more stringent age criterion has been applied in order to define a population as homogeneous as practicable with respect to the relationship between the threshold of hearing and age.

The data specified in this part of ISO 389 relate to

- a) pure tones heard under conditions of binaural listening in free progressive plane waves with the subject directly facing the source of sound (frontal incidence), and with the sound pressure level measured in the free progressive wave at the centre position of the listener's head with the listener absent;
- b) one-third-octave bands of (white or pink) noise heard under conditions of binaural listening in a diffuse sound field with the sound pressure level measured in the sound field at the centre position of the listener's head with the listener absent.

For frequencies up to 8 kHz, each set of data may be equally applied to any other bands of (white or pink) noise for which the bandwidth is less than the critical bandwidth.

The data are based on an assessment of technical information provided by laboratories in different countries representing the most reliable data available at the time. For information, a note on the derivation of the reference values and the origin of the data is given in annex A and a bibliography is given in annex B.

Acoustics — Reference zero for the calibration of audiometric equipment —

Part 7:

Reference threshold of hearing under free-field and diffuse-field listening conditions

1 Scope

This part of ISO 389 specifies a reference threshold of hearing for the calibration of audiometric equipment used under the following conditions.

- a) The sound field in the absence of the listener consists of either a free progressive plane wave (free field) or a diffuse sound field. In the case of a free progressive plane wave, the source of sound is directly in front of the listener (frontal incidence).

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NOTE 1 Correction values for the threshold of hearing under free-field listening conditions and selected angles of sound incidence deviating from frontal incidence are given in ISO 8253-2 for information.

- b) The sound signals are pure (sinusoidal) tones in the case of free-field conditions, and one-third-octave band of (white or pink) noise in the case of diffuse-field conditions.
- c) The sound pressure level is measured in the absence of the listener at the position where the centre of the listener's head would be.
- d) Listening is binaural.
- e) The sound pressure levels corresponding to the reference threshold of hearing are determined by the median value of the thresholds of an adequately large group of listeners.
- f) The listeners are otologically normal persons in the age range from 18 to 25 years inclusive.

NOTE 2 The data given in this part of ISO 389 have been derived from listeners who have hearing threshold levels of 10 dB or less according to ISO 389:1991. This selection criterion is not identical with that used when data for ISO 389:1991 were derived.

- g) The threshold of hearing is determined by means of the bracketing or ascending method, as specified in ISO 8253-1.

The data are given in numerical form for the preferred frequencies in the one-third-octave series from 20 Hz to 16 000 Hz inclusive, in accordance with ISO 266 and for intermediate audiometric frequencies.

Figure 1 gives a graphical presentation.

It should be emphasized that the threshold data differ from the audiometric zero specified in ISO 389:1991 and ISO 389-2, since the latter refer to monaural listening through earphones with sound pressure levels referred to

specified couplers and ear simulators. Direct comparison between the data in ISO 389:1991 or ISO 389-2, respectively, and in this part of ISO 389 is therefore not appropriate.

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 266:—¹⁾, *Acoustics — Preferred frequencies*.

ISO 8253-1:1989, *Acoustics — Audiometric test methods — Part 1: Basic pure tone air and bone conduction threshold audiometry*.

3 Definitions

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

3.1 threshold of hearing: Level of a sound at which, under specified conditions, a person gives 50 % of correct detection responses on repeated trials.

3.2 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 canals, and who has no history of undue exposure to noise, exposure to potentially ototoxic drugs, or familial hearing loss.

3.3 reference threshold of hearing: At a specified frequency, the sound pressure level of a pure tone or a one-third-octave band of noise corresponding to the median value of the binaural thresholds of hearing of otologically normal persons within the age limits from 18 to 25 years inclusive.

3.4 diffuse sound field: Sound field consisting of sound waves arriving at a given location more or less simultaneously from all directions with equal probability and level.

4 Specification

The reference thresholds of hearing for the listening conditions specified in clause 1 are given in table 1. This table also gives the differences between sound pressure levels of one-third-octave bands of noise in a diffuse sound field and the sound pressure levels of pure tones in a frontally incident free progressive wave for equal thresholds of hearing. A graphical illustration of the reference thresholds of hearing is given in figure 1.

1) To be published. (Revision of ISO 266:1975)

Table 1 — Reference thresholds of hearing for the listening conditions listed in clause 1 and differences between sound pressure levels in the two types of sound field for threshold of hearing

Frequency f Hz	Reference threshold of hearing under the condition of		Difference ¹⁾ $\Delta L = T_f - T_f'$ dB
	free-field listening ¹⁾ (frontal incidence) T_f (ref. 20 μ Pa) dB	diffuse-field listening ¹⁾ T_f' (ref. 20 μ Pa) dB	
20	78,0 ^{*)}	78,0	0
25	68,0	68,0	0
31,5	59,0	59,0	0
40	50,5	50,5	0
50	43,5	43,5	0
63	37,5	37,5	0
80	31,5	31,5	0
100	26,5	26,5	0
125	22,0	22,0	0
160	18,0	18,0	0
200	14,5	14,5	0
250	11,0	11,0	0
315	8,5	8,5	0
400	6,0	5,5	0,5
500	4,0	3,5	0,5
630	2,5	1,5	1,0
750	2,0	1,0	1,0
800	2,0	1,0	1,0
1 000	2,0	0,5	1,5
1 250	1,5	0	1,5
1 500	0,5	-1,0	1,5
1 600	0	-1,0	1,0
2 000	-1,5	-1,5	0
2 500	-4,0	-3,0	-1,0
3 000	-6,0	-4,0	-2,0
3 150	-6,5	-4,5	-2,0
4 000	-6,5	-5,0	-1,5
5 000	-3,0	-3,5	0,5
6 000	2,5	-0,5	3,0
6 300	4,0	0,5	3,5
8 000	11,5	5,5	6,0
9 000	13,5	8,0	5,5
10 000	13,5	9,5	4,0
11 200	12,0	10,5	1,5
12 500	11,0	13,0	-2,0
14 000	16,0	21,0	-5,0
16 000	43,5	47,0	-3,5 ^{*)}

1) Rounded to the nearest half decibel.

*) At 20 Hz and 16 000 Hz, experimental data for T_f or ΔL , respectively, were reported from one laboratory only.

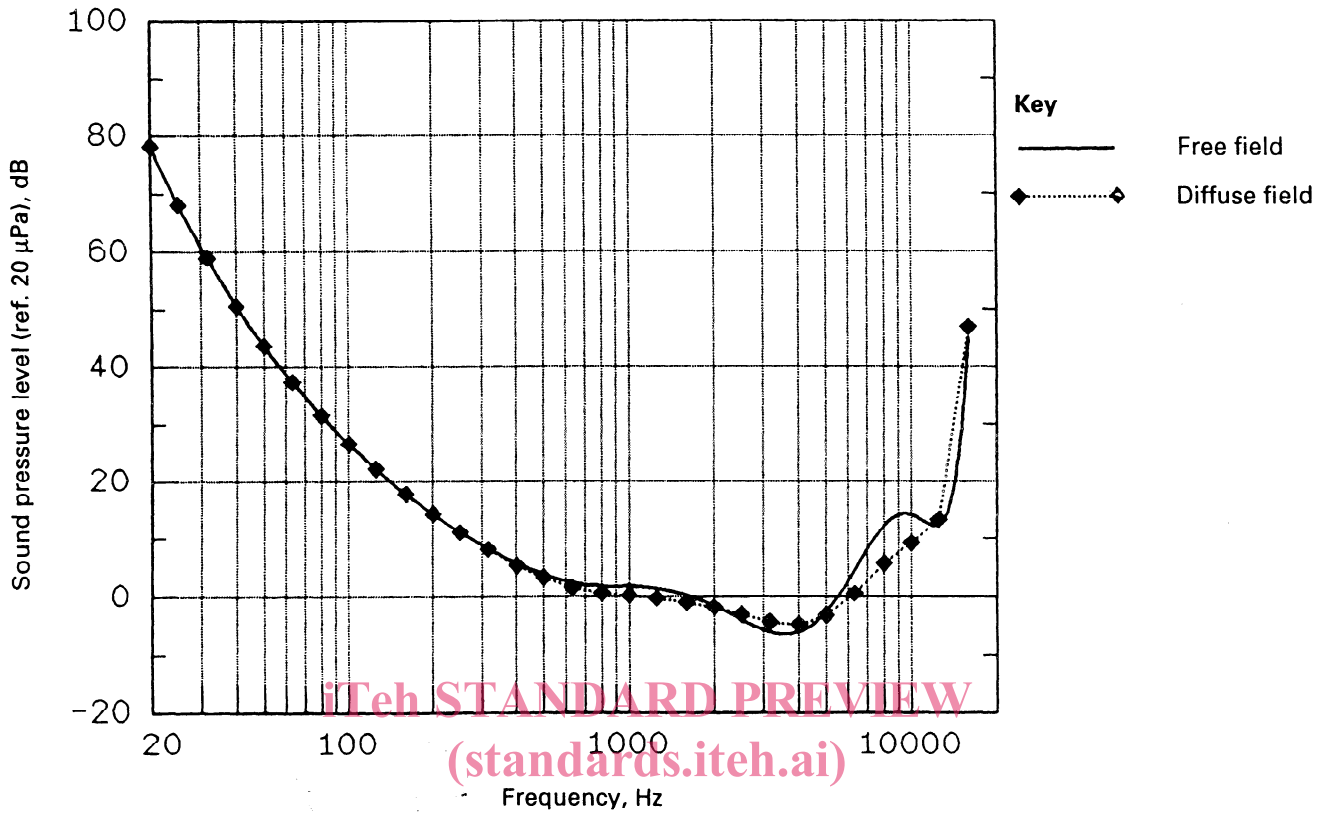


Figure 1 — Reference thresholds of hearing for pure tones under binaural free-field listening conditions (frontal incidence) and for one-third-octave bands of noise under binaural diffuse-field listening conditions

Annex A (informative)

Notes on the derivation of the reference thresholds of hearing

A.1 Under free-field listening conditions

The reference thresholds of hearing under free-field listening conditions specified in this part of ISO 389 are obtained from the results of seven independent experimental investigations communicated to ISO/TC 43.

NOTE — See references [1] to [7] in annex B.

Brief particulars of the tests are given in table A.1. The reference thresholds of hearing as given in table 1, column 2, were derived by calculating a smooth curve giving the best fit to all experimental data according to the least-squares rule. The functions used were a 4th-order polynomial relation at frequencies up to 800 Hz and a 12th-order polynomial relation at frequencies above 800 Hz, applied to the logarithm of frequency and the threshold sound pressure levels. The figures at the preferred one-third-octave frequencies and at intermediate audiometric frequencies were calculated from these polynomial relations. The experimental data used in the calculation process were neither corrected for deviations of the test subject's hearing threshold levels from 0 dB, as measured using conventional audiometry, nor weighted with respect to the number of test subjects used.

Figure A.1 shows the data from references [1] to [7] and the fitted curve.

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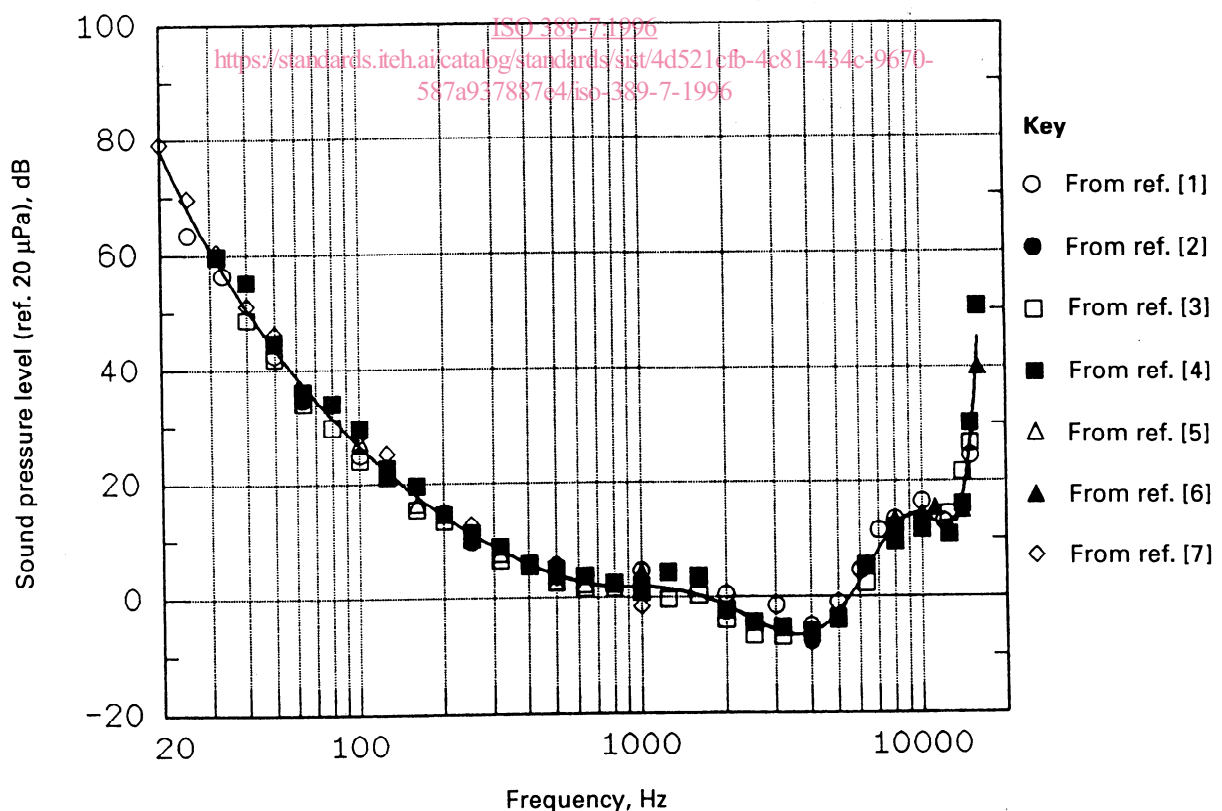


Figure A.1 — Experimental data used for the derivation of the reference thresholds of hearing under free-field listening conditions and the calculated curve giving best fit to these data