

INTERNATIONAL STANDARD

ISO
389-4

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Acoustics — Reference zero for the calibration of audiometric equipment —

Part 4:

Reference levels for narrow-band masking
noise

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

Partie 4: Niveaux de référence pour bruit de masque en bande étroite



Reference number
ISO 389-4:1994(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 389-4 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

This first edition of ISO 389-4 cancels and replaces ISO 8798:1987, of which it constitutes a minor revision.

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*

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— *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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Introduction

ISO 389:1991 (to be re-issued as ISO 389-1) and ISO 389-2 specify the reference zero for the calibration of pure-tone air-conduction audiometers. ISO 389-3 specifies the corresponding data for pure-tone bone-conduction audiometers.

For clinical diagnostic and other audiometric purposes, it is often necessary to prevent the test signal being heard through the ear not being tested. This masking is usually achieved by the presentation of a narrow band of noise, the centre frequency of which coincides with the frequency of the pure-tone signal, and which is delivered by means of the ordinary supra-aural or insert earphones of the audiometer.

IEC 645-1 specifies that masking levels for narrow-band noise be calibrated in terms of effective masking level and that the noise bandwidth be between one-third and one-half of an octave.

The noise level required to just mask a pure tone of a given hearing level has been calculated from known psychoacoustical data for ipsilateral masking, i.e. when the tone to be masked and the masking noise are presented through the same earphone to the same ear.

In most audiometric applications the masking noise is, however, applied by means of an earphone on the ear not being tested. The exact level of the tone reaching that ear from the transducer on the test side is influenced by skull attenuation and by the presence of the occlusion effect from the masker earphone. These phenomena have to be considered with regard to masking levels used in the audiometric procedure.

Acoustics — Reference zero for the calibration of audiometric equipment —

Part 4:

Reference levels for narrow-band masking noise

1 Scope

This part of ISO 389 specifies reference levels for narrow-band masking noise presented by air conduction from an earphone in pure-tone audiometry. The data are given in terms of levels to be added to the reference equivalent threshold sound pressure levels for the corresponding pure-tone frequencies as specified in ISO 389:1991 or ISO 389-2, respectively, when the masking earphone is placed on the appropriate acoustic coupler, ear simulator or artificial ear.

Data are given for noise bandwidths of one-third and one-half octaves.

NOTE 1 Some notes on the derivation of the reference levels are given in annex A.

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⁾

ISO 389-2:1994, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 2: Reference equivalent threshold sound pressure levels for pure tones and insert earphones.*

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

IEC 303:1970, *IEC provisional reference coupler for the calibration of earphones used in audiometry.*

IEC 318:1970, *An IEC artificial ear, of the wideband type, for the calibration of earphones used in audiometry.*

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 and ISO 389-2 and the following definitions apply.

3.1 bone conduction: Transmission of sound to the inner ear primarily by means of mechanical vibration of the cranial bones.

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

3.2 masking: Process by which the threshold of hearing for a sound is raised by the presence of another (masking) sound.

3.3 effective masking level (of a noise band): Level equal to that hearing level of a pure tone, the frequency of which coincides with the geometric centre frequency of the noise band, to which the threshold of hearing of the pure tone is raised by the presence of the masking noise band.

3.4 narrow-band noise: Signal obtained from white noise with a continuous spectrum and constant power spectrum density by means of a band-pass filter having a substantially constant attenuation over its bandwidth (see 3.6).

3.5 pure-tone audiometer: Electroacoustic instrument, equipped with earphones, that provides pure tones of specified frequencies at known sound pressure levels. In addition, the instrument may be equipped with bone vibrator(s) and/or masking facilities.

3.6 noise bandwidth: Difference between the upper and lower band-edge frequencies of the noise band. At these frequencies the power spectrum density of the noise is reduced to one-half of its value at the centre frequency.

3.7 critical bandwidth for masking: That frequency band of sound, being a portion of a continuous noise spectrum of wider bandwidth, which effectively masks a tone coinciding with the centre frequency of the band.

3.8 reference level for narrow-band masking noise: For a specific type of earphone and for a specified acoustic coupler, ear simulator or artificial ear, the term to be added to the appropriate reference equivalent threshold sound pressure levels of a pure tone at the geometric centre frequency of the noise band to obtain the sound pressure level of the narrow-band masking noise corresponding to the effective masking level of 0 dB.

NOTE 2 Acoustic couplers, an occluded-ear simulator and an artificial ear are specified in IEC 126, IEC 303, IEC 711 and IEC 318, respectively.

3.9 occlusion effect: Increase in level of a bone-conducted signal reaching the inner ear when an earphone or earplug is placed over or at the entrance of the ear canal, thereby forming an enclosed air volume in the outer ear. The effect depends on the type of earphone or earplug and is greatest at low frequencies.

4 Specifications

Reference levels for narrow-band masking noise in pure-tone audiometers are specified in table 1. The data are given in terms of levels to be added to the reference equivalent threshold sound pressure levels for the corresponding pure-tone frequencies, as specified in ISO 389:1991 or ISO 389-2, when the masking earphone is placed on the appropriate acoustic coupler, ear simulator or artificial ear as specified in IEC 126, IEC 303, IEC 711 or IEC 318, respectively. The reference levels are presented for noise bandwidths of one-third and one-half octaves for preferred one-third octave and for additional intermediate audiometric frequencies. For any noise bandwidth between one-third and one-half octaves, the reference level is the level derived by interpolation.

Table 1 — Reference levels for narrow-band masking noise

Centre frequency Hz	Reference levels for bandwidth	
	One-third octave dB	One-half octave dB
125	4	4
160	4	4
200	4	4
250	4	4
315	4	4
400	4	5
500	4	6
630	5	6
750	5	7
800	5	7
1 000	6	7
1 250	6	8
1 500	6	8
1 600	6	8
2 000	6	8
2 500	6	8
3 000	6	7
3 150	6	7
4 000	5	7
5 000	5	7
6 000	5	7
6 300	5	6
8 000	5	6

Annex A

(informative)

Notes on the derivation of the reference levels

The derivation of the reference levels is based on the assumption that a noise band of critical bandwidth effectively masks a tone of a frequency equal to the geometric centre frequency of the band at a signal-to-noise ratio of -4 dB, independent of frequency. This assumption, together with the values used for the critical bandwidth, were taken from the sources given in annex B.

An additional assumption is that the noise power spectrum density is substantially constant within the passband.

The reference levels were calculated as follows:

- a) when the noise bandwidth is less than the critical bandwidth, the reference level for narrow-band masking noise, ΔL , is 4 dB;
- b) when the noise bandwidth exceeds the critical bandwidth, the reference level for narrow-band masking noise, ΔL , in decibels, is given by the following formula:

$$\Delta L = 4 \text{ dB} + 10 \lg [b(f)/c(f)] \text{ dB}$$

where

$b(f)$ is the bandwidth, in hertz, of the noise band centred on the frequency f ;

$c(f)$ is the critical bandwidth, in hertz, around the frequency f .

The values of the critical bandwidth which were used in the derivation of the values specified in table 1 are given in table A.1.

Table A.1 — Critical bandwidth as a function of frequency

Centre frequency f Hz	Critical bandwidth ¹⁾ $c(f)$ Hz
125	100
160	100
200	105
250	105
315	105
400	110
500	115
630	125
750	135
800	140
1 000	160
1 250	190
1 500	225
1 600	240
2 000	300
2 500	385
3 000	480
3 150	510
4 000	685
5 000	915
6 000	1 150
6 300	1 250
8 000	1 700

1) Critical bandwidth values are rounded to the nearest 5 Hz at centre frequencies up to and including 5 000 Hz, and to the nearest 50 Hz for higher frequencies.

Annex B

(informative)

Bibliography

- [1] ISO 389-3:1994, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 3: Reference equivalent threshold force levels for pure tones and bone vibrators*.
- [2] IEC 645-1:1992, *Audiometers — Part 1: Pure-tone audiometers*.
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