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Acoustics — Reference levels for narrow-band masking noise

Acoustique — Niveaux de référence pour bruit de masque en bande étroite

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8798 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Acoustics — Reference levels for narrow-band masking noise

0 Introduction

ISO 389 together with ISO 389/Add.1 and ISO 389/Add.2 specify the standard reference zero for the scale of hearing threshold level applicable to pure tone air conduction audiometers. ISO 7566 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 from being heard through the ear not being tested by means of masking. This 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 earphones of the audiometer.

IEC Publication 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.

Insert earphones are sometimes used to deliver the masking noise. However, this International Standard does not specify reference levels for narrow-band masking noise for such transducers since no standardized reference equivalent threshold sound pressure levels are available.

1 Scope and field of application

This International Standard specifies reference levels for the calibration of 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 when the masking earphone is placed on the appropriate acoustic coupler or artificial ear.

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

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

2 References

ISO 389, *Acoustics — Standard reference zero for the calibration of pure tone air conduction audiometers.*

ISO 389/Add.1, *Acoustics — Standard reference zero for the calibration of pure tone audiometers — ADDENDUM 1.*

ISO 389/Add.2, *Acoustics — Standard reference zero for the calibration of pure tone air conduction audiometers — ADDENDUM 2.*

ISO 7566, *Acoustics — Standard reference zero for the calibration of pure-tone bone conduction audiometers.*

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

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

IEC Publication 645-1, *Audiometers — Part 1: Pure tone audiometers.* [1)]

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 air conduction: Transmission of sound through the outer and middle ear to the inner ear.

3.2 acoustic coupler: A 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 Publication 303.

3.3 artificial ear: A 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. It is equipped with a calibrated microphone for the measurement of the sound pressure developed by the earphone.

NOTE — An artificial ear is specified in IEC Publication 318.

3.4 bone conduction: Transmission of sound to the inner ear when excited by mechanical vibration of the cranial bones.

3.5 hearing threshold: The sound pressure level or vibratory force level at which, under specified conditions, a person gives 50 % of correct detection responses on repeated trials.

3.6 equivalent threshold sound pressure level (monaural earphone listening): For a given ear, at a specified frequency, for a specified type 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 hearing threshold.

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 hearing threshold in a specified acoustic coupler or artificial ear for a specified type of earphone.

NOTE — The values of RETSPL for supra-aural earphones are specified in ISO 389, ISO 389/Add.1 and ISO 389/Add.2.

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

3.9 masking: The process by which the hearing threshold for a sound is raised by the presence of another (masking) sound.

3.10 effective masking level (of a noise band): A 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 hearing threshold of the pure tone is raised by the presence of the masking noise band.

3.11 narrow-band noise: A 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 3.13).

3.12 pure tone audiometer: An 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.

3.13 noise bandwidth: The 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.

3.14 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.

3.15 reference level for narrow-band masking noise: For a specific type of earphone and for a specified acoustic coupler or artificial ear, the term to be added to the appropriate

1) At present at the stage of draft. (Revision, in part, of IEC Publication 645 : 1979.)

RETSPL 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.

3.16 occlusion effect: The 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 the calibration of 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 when the masking earphone is placed on the appropriate acoustic coupler or artificial ear. 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 dB	
	One-third octave	One-half octave
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

Notes on the derivation of the reference levels

(This annex does not form an integral part of the standard.)

A.1 Source of data

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 clause A.2.

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:

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

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 2.

Table 2 — 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.

A.2 Bibliography

SCHARF, B. Critical bands, *Foundations of modern auditory theory* (ed. TOBIAS, J.V.), **1**, Academic Press, New York, 1970.

ZWICKER, E. und FELDTKELLER, R. *Das Ohr als Nachrichtenempfänger*, S. Hirzel Verlag, Stuttgart, 1967.

ZWICKER, E. and TERHARDT, E. Analytical expressions for critical-band rate and critical bandwidth as a function of frequency. *J. Acoust. Soc. Amer.*, **68(5)**, 1980: pp. 1523-1525.

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