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Acoustics — Standard reference zero for the calibration of pure-tone bone conduction audiometers

*Acoustique — Zéro normal de référence pour l'étalonnage des audiomètres à sons purs en
conduction osseuse*

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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 7566 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.

Acoustics — Standard reference zero for the calibration of pure-tone bone conduction audiometers

0 Introduction

A standard reference zero for the scale of hearing threshold level applicable to pure-tone air conduction audiometers is specified in ISO 389. For clinical diagnostic and other audiometric purposes, it is often necessary to compare the measured hearing threshold levels of a person for sound transmitted to the inner ear by the air conduction and bone conduction pathways, respectively. Bone-conducted sound is provided for this purpose by an electromechanical vibrator applied to the mastoid prominence or to the forehead of the person under test.

The standard reference zero for air conduction audiometry is defined in ISO 389 in terms of reference equivalent threshold sound pressure levels (RET SPLs), i.e. threshold sound pressure levels produced in a coupler or artificial ear of specified characteristics by supra-aural earphones of various patterns, when excited electrically at a level corresponding to the hearing threshold of young otologically normal persons. Similarly, this International Standard provides a reference zero for bone conduction audiometry in terms of reference equivalent threshold force levels (RET FLs), i.e. the vibratory force levels produced by a bone vibrator on a specified mechanical coupler when the vibrator is excited electrically at a level corresponding to the hearing threshold of young otologically normal persons. In some countries, the preferred location is the mastoid prominence; in other countries, the forehead location is used in addition to the mastoid prominence. Different RET FL values are valid for each of the two positions (see annex C).

For bone conduction measurements, it is necessary to specify the static force of application of the vibrator to the skull of the test subject and to the mechanical coupler, as well as certain geometrical features of the vibrator tip. In addition, it is usually necessary to apply masking noise to the ear not under test, since excitation of the skull by the vibrator may be heard by that ear instead of (or in addition to) the ear intended for the test. An appropriate specification of the masking noise is, therefore, required as an adjunct to the reference equivalent threshold force levels, and such a specification is given in this International Standard. Due to the so-called "occlusion effect" whereby the wearing of the transducer needed to provide the (air-conducted) masking noise causes a lowering of the bone conduction threshold of hearing of the ear receiving the masking signal, it is necessary for the level of masking noise to be raised to cancel out the occlusion effect and provide adequate masking of the ear not under test. The specification of masking noise given in this International Standard is based on the procedures used in the experimental investigations from which the reference zero of this International Standard is derived.

Use of this reference zero to calibrate audiometers will ensure that measured bone conduction hearing threshold levels of persons with unimpaired hearing or with hearing losses of purely sensorineural type (i.e. having unimpaired outer and middle ear function) will be compatible with the air conduction hearing threshold levels of the same persons when using the reference zero of ISO 389. Although exact equivalence of air conduction and bone conduction thresholds for any individual in these classes cannot be expected, due to biological variability of sound transmission through the external and middle ear and through the skull, this International Standard will ensure that systematic deviations averaged over groups of such persons are reduced to a practical minimum.

This International Standard is based on an assessment of technical data provided by laboratories in three countries using methods of threshold testing which, in the respects described, were essentially uniform. Examination of the data showed that the experimental results were consistent. It has, therefore, been possible to standardize a reference zero by means of RET FL values which are to be used for all bone vibrators used in audiometry having similar characteristics to those used by the laboratories. The systematic uncertainties introduced by this deliberate simplification will be small in comparison to the usual step size of hearing level controls in clinical audiometers (5 dB).

1 Scope and field of application

This International Standard specifies the following data applicable to the calibration of bone vibrators for pure-tone bone conduction audiometry :

- a) Reference equivalent threshold force levels (RET FLs), corresponding to the hearing threshold of young otologically normal persons (see 3.9) by bone conduction audiometry. RET FL is the vibratory force level transmitted to a mechanical coupler of specified characteristics (see 5.3) by a vibrator when applied to the mechanical coupler under stated conditions of test and when energized at the voltage level corresponding to the normal hearing threshold for location on the mastoid prominence.

NOTE — Interim values for the differences in reference equivalent threshold force levels between location on the forehead and mastoid are included for information in annex C.

- b) Essential characteristics of the bone vibrator and of its method of coupling to a person under test and to the mechanical coupler.



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- c) Essential characteristics and datum level of the masking noise applied to the ear not under test.

Guidance on the practical application of this International Standard in the calibration of audiometers is given in annex B.

NOTE — Recommended procedures for carrying out bone conduction audiometry are specified in ISO 8253.

2 References

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

ISO 6189, *Acoustics — Pure tone air conduction threshold audiometry for hearing conservation purposes.*

ISO 7029, *Acoustics — Threshold of hearing by air conduction as a function of age and sex for otologically normal persons.*

ISO 8253, *Acoustics — Basic pure-tone audiometric test methods.*¹⁾

ISO 8798, *Acoustics — Reference levels for narrow-band masking noise.*¹⁾

IEC Publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

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 373, *Mechanical coupler for measurements on bone vibrators.*²⁾

IEC Publication 645, *Audiometers.*

3 Definitions

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

3.1 air conduction : The 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 : The transmission of sound to the inner ear primarily by means of mechanical vibration of the cranial bones.

3.5 bone vibrator : An electromechanical transducer intended to produce the sensation of hearing by vibrating the cranial bones.

3.6 vibratory force level (force level) (of a vibration) : The force level, in decibels, which is 20 times the common logarithm of the ratio of the r.m.s. value of the force transmitting the vibration to the reference value, 1 μN .

3.7 mechanical coupler : A device designed to present a specified mechanical impedance to a vibrator applied with a specified static force and equipped with an electromechanical transducer to measure the vibratory force level at the surface of contact between vibrator and mechanical coupler.

NOTE — A mechanical coupler is specified in IEC Publication 373.

3.8 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.

3.9 otologically normal person : A 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.

3.10 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.

3.11 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 relation between hearing threshold levels (for air conduction) and age is specified in ISO 7029.

1) At present at the stage of draft.

2) At present at the stage of draft. (Second edition of IEC Publication 373-1971.)