INTERNATIONAL STANDARD

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Acoustics — Audiometric test methods —

Part 1: Pure-tone air and bone conduction audiometry

Acoustique — Méthodes d'essais audiométriques —

Partie 1: Audiométrie à sons purs en conduction aérienne et en conduction osseuse

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8253-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

This second edition cancels and replaces the first edition (ISO 8253-1:1989) and ISO 6189:1983, which have been technically revised.

ISO 8253 consists of the following parts, under the general title *Acoustics — Audiometric test methods*:

— *Part 1: Pure-tone air and bone conduction audiometry*

— *Part 2: Sound field audiometry with pure-tone and narrow-band test signals*

— *Part 3: Speech audiometry*

Introduction

This International Standard specifies requirements and procedures for carrying out basic audiometric tests in which pure tones are presented to the test subject using earphones or bone vibrators. Electrophysiological test methods are not included.

In order to obtain a reliable measure of hearing ability, many factors are involved. IEC 60645-1 specifies requirements for audiometers. It is essential that audiometric equipment, when in service, be checked and the calibration maintained. This part of ISO 8253 outlines a calibration scheme. To avoid masking of the test signal by ambient noise in the audiometric test room, the levels of the ambient noise shall not exceed certain values, depending upon the method of signal presentation to the test subject, i.e. by different earphones or by bone vibrator. This part of ISO 8253 gives maximum permissible ambient sound pressure levels which shall not be exceeded when hearing threshold levels down to 0 dB have to be measured. It indicates the maximum ambient sound pressure levels which are permissible when other minimum hearing threshold levels require measurement. It sets out procedures for determining hearing threshold levels by pure-tone air conduction and bone conduction audiometry. For screening purposes, only methods for air conduction audiometry are outlined.

Audiometry can be performed by using:

a) a manual audiometer;

b) an automatic recording audiometer;

c) computer-controlled audiometric equipment.

Methods for threshold audiometry are given for these three types of signal presentation. For screening purposes, only methods using a manual or a computer-controlled audiometer are set out. The procedures are applicable to the majority of adults and children. Other procedures may yield results equivalent to those derived by the procedures specified in this part of ISO 8253. For very young, aged or sick people, some modification of the recommended procedures is likely to be required. This may result in a less accurate measurement of hearing.

Acoustics — Audiometric test methods —

Part 1:
Pure-tone air and bone conduction audiometry

1 Scope

This part of ISO 8253 specifies procedures and requirements for pure-tone air conduction and bone conduction threshold audiometry. For screening purposes, only pure-tone air conduction audiometric test methods are specified. It is possible that the procedures are not appropriate for special populations, e.g. very young children.

This part of ISO 8253 does not cover audiometric procedures to be carried out at levels above the hearing threshold levels of the subjects.

Procedures and requirements for speech audiometry, electrophysiological audiometry, and where loudspeakers are used as a sound source are not specified.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 389-1, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 1: Reference equivalent threshold sound pressure levels for pure tones and supra-aural earphones*

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

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*

ISO 389-5, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 5: Reference equivalent threshold sound pressure levels for pure tones in the frequency range 8 kHz to 16 kHz*

ISO 389-8, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 8: Reference equivalent threshold sound pressure levels for pure tones and circumaural earphones*

IEC 60645-1:2001, *Electroacoustics — Audiological equipment — Part 1: Pure-tone audiometers*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement* (*GUM:1995*)

3 Terms and definitions

For the purposes of this part of ISO 8253, the following definitions apply.

3.1
air conduction
transmission of sound through the external and middle ear to the inner ear

3.2
ear simulator
device for measuring the acoustic output of sound sources where the sound pressure is measured by a calibrated microphone coupled to the source so that the overall acoustic impedance of the device approximates that of the normal human ear at a given location and in a given frequency band

NOTE An ear simulator is specified in IEC 60318-1[4] and IEC 60318-4[6].

3.3
acoustic coupler
device for measuring the acoustic output of sound sources where the sound pressure is measured by a calibrated microphone coupled to the source by a cavity of predetermined shape and volume which does not necessarily approximate the acoustic impedance of the normal human ear

NOTE An acoustic coupler is specified in IEC 60318-3[5] and IEC 60318-5[7].

3.4
bone conduction
transmission of sound to the inner ear primarily by means of mechanical vibration of the cranial bones

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

3.6
mechanical coupler
device designed to present a specified mechanical impedance to a vibrator applied with a specified static force and equipped with a mechano-electrical 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 60318-6[8].

3.7
otologically normal person
person in a normal state of health who is free from all signs and symptoms of ear disease and from obstructing wax in the ear canal and who has no history of undue exposure to noise, exposure to potentially ototoxic drugs, or familial hearing loss

3.8
hearing threshold
lowest sound pressure level or vibratory force level at which, under specified conditions, a person gives a predetermined percentage of correct detection responses on repeated trials

3.9
equivalent threshold sound pressure level
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 ear simulator when the earphone is actuated by that voltage which, with the earphone applied to the ear concerned, would correspond to the hearing threshold

3.10
reference equivalent threshold sound pressure level
RETSPL
at a specified frequency, the median value of the equivalent threshold sound pressure levels of a sufficiently large number of ears of otologically normal persons of both sexes aged from 18 years to 25 years inclusive, expressing the hearing threshold in a specified acoustic coupler or ear simulator for a specified type of earphone

NOTE ISO 389-1 refers to an age range of 18 years to 30 years inclusive, and specifies modal values.

3.11
equivalent threshold vibratory force level
for a given ear, at a specified frequency, for a specified configuration of bone vibrator and for a stated force of application of the bone vibrator to the human mastoid or forehead, the vibratory force level set up by the bone vibrator on a specified mechanical coupler when the bone vibrator is actuated by that voltage which, with the bone vibrator applied to the mastoid or forehead concerned, would correspond to the hearing threshold

3.12
reference equivalent threshold vibratory force level
RETVFL
at a specified frequency, the median value of the equivalent threshold vibratory force levels of a sufficiently large number of ears of otologically normal persons of both sexes aged from 18 years to 25 years inclusive, expressing the hearing threshold in a specified mechanical coupler for a specified type of bone vibrator

NOTE ISO 389-3 refers to an age range of 18 years to 30 years inclusive, and specifies an arithmetic mean.

3.13
hearing level of a pure tone
HL of a pure tone
at a specified frequency, for a specific type of transducer and for a specified manner of application, sound pressure level or vibratory force level of a pure tone, produced by a transducer in a specific ear simulator or mechanical coupler, minus the appropriate reference equivalent threshold sound pressure level or reference equivalent threshold vibratory force level

3.14
hearing threshold level of a given ear
at a specified frequency and for a specific type of transducer, hearing threshold at that frequency, expressed as hearing level

3.15
occlusion effect
change (usually an increase) in level of a bone-conducted signal reaching the inner ear when an earphone or an earplug is placed over or at the entrance of the ear canal, thereby forming an enclosed air volume in the external ear

NOTE The effect is greatest at low frequencies.

3.16
masking
process by which the hearing threshold of a given ear for a particular sound is raised by the presence of another (masking) sound

3.17
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

NOTE IEC 60645-1:2001, 8.5.2 a), specifies that masking levels for narrow-band noise be calibrated in terms of effective masking level.

3.18
vibrotactile threshold level
level of the vibratory force or sound pressure at which a person gives 50 % of correct detection responses on repeated trials due to the sensation of vibration on the skin

3.19
pure-tone audiometer
electroacoustic instrument, equipped with earphone(s), that provides pure tones of specified frequencies at known sound pressure levels

NOTE In addition, it may be equipped with bone vibrator(s) and/or masking facilities.

3.20
manual audiometer
audiometer in which the signal presentations, frequency and hearing level selection and recording of the results are performed manually

3.21
automatic-recording audiometer
audiometer in which signal presentations, hearing level variation, frequency selection or frequency variation, and recording of the responses of the test subject are implemented automatically

NOTE Hearing level change is under the control of the test subject and is recorded automatically.

3.22
automatic fixed-frequency audiometry
audiometry in which hearing level variations are under the control of the test subject and are recorded automatically for specific frequencies

3.23
automatic sweep-frequency audiometry
audiometry in which hearing level variations are under the control of the test subject and where the frequency is varied continuously or in steps much smaller than one-third octave

3.24
screening audiometry
pass-fail procedure where pure tones of a fixed level, the screening level, are presented

3.25
audiogram
presentation, in graphical or tabular form, of the hearing threshold levels of the ears of the test subject, determined under specified conditions and by a specified method, as a function of frequency

4 General aspects of audiometric measurements

4.1 General

Hearing threshold levels can be determined by air conduction and bone conduction audiometry. In air conduction audiometry, the test signal is presented to the test subject by earphones. In bone conduction audiometry, the test signal is presented by a bone vibrator placed on the mastoid or forehead of the test subject. It is recommended that threshold level determinations be started with air conduction measurements followed by bone conduction measurements. Hearing threshold levels can be determined using test tones with fixed frequencies (fixed-frequency audiometry) or a test signal with frequency varying with time according to a predetermined rate of change (sweep-frequency audiometry). Methods for fixed-frequency audiometry are given in Clause 6 and sweep-frequency audiometry is described in Clause 7. In air and bone conduction measurements, the hearing threshold levels of both ears shall be determined separately. Under specified conditions, masking noise shall be applied to the ear not under test (contralateral ear). The masking noise is presented to that ear through a supra-aural, circumaural or insert-type earphone.

4.2 Standard reference zero for the calibration of audiometric equipment

The standard reference zero for air conduction audiometers is given in ISO 389-1, ISO 389-2, ISO 389-5, and ISO 389-8 and for bone conduction audiometers in ISO 389-3 in terms of reference equivalent threshold sound pressure levels or vibratory force levels (RETSPL or RETVFL, respectively) at specified frequencies. Different RETVFL values are valid for different locations of the vibrator, i.e. at the mastoid or forehead. ISO 389-3:1994 presents values for mastoid location and its Annex C gives corresponding difference values for forehead location of the vibrator.

4.3 Requirements on audiometric equipment

Audiometers shall be constructed in accordance with IEC 60645-1 and calibrated in accordance with the requirements of the relevant part of ISO 389. In occupational audiometry and for testing of schoolchildren, a type 4 audiometer (IEC 60645-1:2001) may be used and the frequency range sometimes limited to 500 Hz and upwards.

4.4 Qualified tester

A qualified tester is understood to be someone who has followed an appropriate course of instruction in the theory and practice of audiometric testing. This qualification may be specified by national authorities or other suitable organizations. Throughout this part of ISO 8253, it is assumed that tests are carried out only by, or under the supervision of, a qualified tester.

The tester should make decisions on the following aspects of the audiometric test which are not specified in detail in this part of ISO 8253, namely whether:

a) the left or the right ear is tested first (usually the ear considered to be more sensitive is chosen);

b) masking is required;

c) responses of the test subject correspond to the test signals;

d) there is any external noise event or any behaviour response of the test subject that might invalidate the test;

e) to interrupt, terminate or repeat all or part of the test.

4.5 Test time

Care shall be taken not to fatigue the test subject unduly since reliable results may be progressively difficult to obtain if the test subject is not given a rest from testing after about 20 min.

4.6 Conditions for audiometric test environments

Ambient sound pressure levels in an audiometric test room shall not exceed the values specified in Clause 11.

The test subject and the tester shall be comfortably seated during audiometric testing and shall be neither disturbed nor distracted by unrelated events nor by people in the vicinity.

Air temperature in the audiometric test room should be in the range permitted for offices by local authorities. The audiometric test room should allow for sufficient exchange of air.

If the audiometer is operated manually, the test subject shall be clearly visible to the tester who shall, however, not be able to see the audiometer settings change nor the test tone being switched on or interrupted. When using an automatic recording audiometer, the recording mechanism shall not be visible to the test subject.

When the test is carried out from outside the audiometric test room, the test subject shall be visually monitored through a window or by a closed-circuit TV system. Acoustic monitoring of the subject should be undertaken.

4.7 Measurement uncertainty

The uncertainty of hearing threshold levels determined in accordance with any of the procedures specified in this part of ISO 8253 depends on a variety of parameters, such as:

a) the performance of the audiometric equipment used;

b) the type of transducers used and their fitting by the tester;

c) the frequency of test tones;

d) the conditions of the test environment, especially the ambient noise;

e) the qualification and experience of the tester;

f) the cooperation of the test subject and the reliability of responses;

g) the use of non-optimized masking noise.

Due to the complexity of the measurement process, including the personal behaviour of both the test subject and the tester, it is difficult to express the measurement uncertainty in a single generally valid figure. However, a detailed evaluation of measurement uncertainty provides useful information on the reliability of audiometric test results and provides a sufficient estimate of the uncertainty in most applications.

The uncertainty of results of measurements according to this part of ISO 8253 shall be evaluated in accordance with ISO/IEC Guide 98-3. If reported, the expanded uncertainty together with the corresponding coverage factor for a stated coverage probability, as defined in ISO/IEC Guide 98-3, shall be given. Guidance on the determination of the expanded uncertainty is given in Annex A.

5 Preparation and instruction of test subjects before audiometric testing and positioning of transducers

5.1 Preparation of test subjects

Recent exposure to noise may cause a temporary elevation of the hearing threshold levels. Therefore, significant noise exposure should be avoided before audiometric testing or it shall be noted. In order to avoid errors due to excessive physical exertion, test subjects should be present at least 5 min prior to testing.

Normally, the audiometric test is preceded by an otoscopic examination carried out by a qualified person. If obstructing wax is found in the canal(s) of the outer ear it shall be removed and audiometry may be delayed for a suitable period. The ear should also be checked for the possibility of collapsing ear canals and appropriate action taken, if necessary.

NOTE 1 Preliminary information about the type of hearing loss and masking requirements can be obtained by performing tuning fork tests.

NOTE 2 The qualifications of a person can be specified by national authorities or other suitable organizations. The qualified person need not be the same person as the qualified tester mentioned in 4.4.