

INTERNATIONAL STANDARD



Electroacoustics – Audiometric equipment –
Part 1: Equipment for pure-tone and speech audiometry

<https://standards.iteh.ai>
Document Preview

[IEC 60645-1:2017](https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017)

<https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

[IEC 60645-1:2017](https://standards.iteh.ai/catalog/standards/iec/1218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017)

<https://standards.iteh.ai/catalog/standards/iec/1218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>



IEC 60645-1

Edition 4.0 2017-03
REDLINE VERSION

INTERNATIONAL STANDARD



Electroacoustics – Audiometric equipment –
Part 1: Equipment for pure-tone and speech audiometry

iteh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC 60645-1:2017](https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017)

<https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.140.50

ISBN 978-2-8322-4111-0

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	10
2 Normative references	10
3 Terms and definitions	12
4 Requirements for specific types of fixed frequency by type and class of audiometer	16
5 General requirements	18
5.1 General safety requirements	18
5.2 Acoustic safety requirements	18
5.3 Environmental conditions	18
5.4 Warm-up time	18
5.5 Power supply variation	18
5.5.1 Interruption of power supply	18
5.5.2 Mains operation	18
5.5.3 Battery operation	18
5.5.4 Other power supplies	19
5.6 Electromagnetic compatibility.....	19
5.7 Unwanted sound	19
5.7.1 General	19
5.7.2 Unwanted sound from and between any combination of transducers.....	19
5.7.3 Unwanted sound from an earphone	19
5.7.4 Unwanted sound from a bone vibrator.....	20
5.7.5 Unwanted sound radiated by an audiometer	20
5.8 Testing of automatic-recording audiometers.....	20
5.9 Interface connections.....	20
6 Test signals	20
6.1 Speech signals	20
6.1.1 Speech signal general requirements	20
6.1.2 Free-field equivalent earphone output level	20
6.1.3 Uncorrected earphone output level	21
6.1.4 Loudspeaker output level.....	21
6.1.5 Bone vibrator output level.....	21
6.1.6 Speech signal frequency response	21
6.1.7 Calibration signal.....	21
6.1.8 Live voice microphone frequency response.....	22
6.1.9 Scale reference and output level.....	22
6.1.10 Distortion requirements for speech signals	22
6.2 Pure tones	23
6.2.1 Frequency range and hearing level range	23
6.2.2 Frequency accuracy acceptance limits.....	24
6.2.3 Total harmonic distortion	24
6.2.4 Rate of frequency change	25
6.2.5 Frequency modulation	25
6.3 External signal sources	25
6.3.1 Signals	25

6.3.2	Frequency response	26
6.3.3	Playback device input	26
6.3.4	Signal-to-noise ratio for playback device input	26
6.3.5	Electrical sensitivity	26
6.3.6	Reference level for external signal source	26
6.4	Operator and test subject speech communication	26
6.4.1	General	26
6.4.2	Operator to test subject speech communication(talk-forward)	27
6.4.3	Test subject to operator speech communication(talk-back)	27
6.4.4	Operator to test subject speech communication for live voice speech audiometry	27
6.4.5	Test subject to operator speech communication for vocal response speech audiometry	27
6.5	Masking sound.....	27
6.5.1	General	27
6.5.2	Narrow-band noise	28
6.5.3	Speech weighted noise	30
6.5.4	Other masking sound.....	30
7	Transducers	30
7.1	Types of transducers	30
7.2	Headband	30
7.3	Loudspeaker	30
8	Signal level control	30
8.1	Marking of pure-tone and speech signal level controls	30
8.2	Signal indicator	31
8.3	Accuracy of Sound pressure level and vibratory force level acceptance limits	31
8.4	Hearing Signal level control	32
8.4.1	Manual audiometers	32
8.4.2	Automatic-recording audiometers	32
8.4.3	Accuracy of Signal level control acceptance limits	32
8.5	Masking sound level control.....	33
8.5.1	General	33
8.5.2	Masking sound level	33
8.5.3	Accuracy of Masking sound level acceptance limits	33
8.5.4	Masking sound level range	33
8.6	Tone Signal switching	33
8.6.1	Tone Signal switch for manual audiometers	33
8.6.2	On/off ratio for manual audiometers	34
8.6.3	Rise/fall times for manual audiometers	34
8.6.4	Automatic pulsed presentation	34
8.6.5	Subject's response system	35
8.6.6	Subject's response time for automated test procedures	35
9	Reference tone	35
9.1	General.....	35
9.2	Frequencies	35
9.3	Reference tone level control	36
9.3.1	Range.....	36
9.3.2	Intervals	36
9.3.3	Marking	36

9.3.4	Accuracy Acceptance limits	36
9.3.5	Operation	36
10	Calibration	36
11	Electrical output of test signals	37
12	Audiogram format	37
13	Test requirements to demonstrate conformity	38
13.1	General	38
13.2	Environmental conditions and power supply variation	38
13.3	Electromagnetic compatibility	39
13.4	Unwanted sound	39
13.4.1	Unwanted sound from an earphone	39
13.4.2	Unwanted sound from a bone vibrator	40
13.4.3	Unwanted sound radiated by an audiometer	40
13.5	Total harmonic distortion of test signals	40
13.6	Microphone for live voice speech testing	41
13.7	Signal accuracy	41
13.7.1	Accuracy of sound pressure level and vibratory force level	41
13.7.2	Accuracy of hearing level control	41
13.8	Masking sound	41
13.8.1	Narrow-band noise	41
13.8.2	Masking sound level	41
13.9	Headbands	41
13.9.1	General	41
13.9.2	Supra-aural and circumaural earphone headband	42
13.9.3	Bone vibrator headband	42
14	Maximum permitted expanded uncertainty of measurements U_{\max}	42
15	Marking and instruction manual	43
15.1	Marking	43
15.2	Instruction manual	44
	Annex A (informative) Relationship between tolerance interval, corresponding acceptance interval and the maximum permitted uncertainty of measurement	46
	Bibliography	47
	Figure 1 – Rise/fall envelope of test tones	35
	Figure A.1 – Relationship between tolerance interval, corresponding acceptance interval and the maximum permitted uncertainty of measurement	46
	Table 1 – Minimum facilities for fixed-frequency audiometers	16
	Table 2 – Minimum number of frequencies to be provided and the minimum range of values of hearing level for fixed-frequency type and class of audiometer	23
	Table 3 – Minimum range of values of hearing level for EHF audiometers	
	Table 3 – Maximum permissible acoustic total harmonic distortion, for supra-aural, circumaural, insert earphones and bone vibrators	25
	Table 4 – Narrow-band masking noise: upper and lower cut-off frequencies for a sound pressure spectrum density level of –3 dB referred referenced to the level at the centre frequency of the band	29
	Table 5 – Reference Standards for obtaining audiometric zero specifying reference equivalent threshold levels	37

Table 6 – Symbols for the graphical presentation of hearing threshold levels	38
Table 7 – Values of U_{\max} for basic measurements	43

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC 60645-1:2017](https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017)

<https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROACOUSTICS – AUDIOMETRIC EQUIPMENT –

Part 1: Equipment for pure-tone and speech audiometry

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60645-1 has been prepared by IEC technical committee 29: Electroacoustics.

This fourth edition cancels and replaces the third edition, published in 2012, and the first edition IEC 60645-2, published in 1993. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

This edition now includes the requirements for both pure-tone (prior edition of IEC 60645-1) and speech audiometers (prior edition of IEC 60645-2) into a single document. The technical requirements in this edition remain similar to the intent of the prior two documents, but now eliminate technical and editorial contradictions caused by two separate standards with different review cycles applying to an audiometer.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
29/927/FDIS	29/941/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60645 series, published under the general title *Electroacoustics – Audiometric equipment*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

Developments in the field of hearing measurements for diagnostic, hearing conservation and rehabilitation purposes have resulted in the availability of a wide range of audiometers. In addition it is possible to consider the audiometer in terms of a set of functional units which can be specified independently. By specifying these functional units it is then possible to specify the performance of other audiometric equipment which use these units. The IEC 60645 series consists of a number of parts. IEC 60645-1 is the first in the series and covers the requirements for both pure-tone and speech audiometers.

This standard describes ~~equipment~~ the performance requirements for pure-tone audiometers, which ~~is~~ are designed for the measurement of hearing in the frequency range from 125 Hz to 16 kHz, and speech audiometers, which are designed for performing live or recorded speech audiometry.

~~Due to the development of the later parts of IEC 60645, no reference is now made in part 1 to the use of broad-band noise for masking. Requirements for broad-band masking noise now only relate to its use with speech signals as described in IEC 60645-2.~~

When speech signal facilities are provided by an audiometer, performance requirements are given for both live voice and recorded speech material. Although live voice speech audiometry may not be capable of meeting the requirements of this standard, it is widely practiced, particularly with children, and therefore a specification is included in order to ensure as high a degree of reliability as possible. This standard does not specify the speech material that is used for test purposes or the required acoustic properties of the test room.¹

Speech audiometers use earphones or loudspeakers to present signals to the test subject. In this standard, specifications of the performance characteristics of speech audiometers and relevant calibration and test methods are given with respect to both a free-field equivalent output level method and an uncorrected ear simulator or acoustic coupler output level method.

In order to relate earphone listening to sound field listening, the concept of a free-field equivalent output level of an earphone, as described in IEC 60268-7, is used for specification and measurement purposes.

Although it is recognised that bone vibrators are used for speech audiometry purposes, their performance can be extremely variable when using speech signals. Therefore only known “good practice” specifications for bone conduction using speech signals are provided to promote consistency when this capability is provided.

The test requirements to demonstrate audiometer conformity are now specified separately. Conformance to the performance specification in this standard is demonstrated ~~only when the result of a measurement, extended by the actual expanded uncertainty of measurement of the testing laboratory, lies fully within the tolerances~~ when a measured deviation from a design goal equals or does not exceed the corresponding acceptance limit(s), and the laboratory has demonstrated that the associated uncertainty of measurement equals or does not exceed the maximum permitted uncertainty specified in this standard. ~~The tolerances that are to be met by the manufacturer of an audiometer are essentially the same as in the first edition of IEC 60645-1, while the tolerances as applicable to the testing of the audiometer are increased by U_{\max} compared with those of the previous edition.~~ The requirements for an audiometer are essentially the same as in the previous editions of IEC 60645-1 and IEC 60645-2.

¹ These requirements are specified in ISO 8253-1.

~~IEC 60645 series consists of the following parts:~~

~~IEC 60645-1, *Electroacoustics — Audiometric equipment — Part 1: Equipment for pure-tone audiometry*~~

~~IEC 60645-2, *Audiometers — Part 2: Equipment for speech audiometry*~~

~~IEC 60645-3, *Electroacoustics — Audiometric equipment — Part 3: Test signals of short duration*~~

~~IEC 60645-4, *Audiometers — Part 4: Equipment for extended high-frequency audiometry*~~

~~IEC 60645-5, *Electroacoustics — Audiometric equipment — Part 5: Instruments for the measurement of aural acoustic impedance/admittance*~~

~~IEC 60645-6, *Electroacoustics — Audiometric equipment — Part 6: Instruments for the measurement of otoacoustic emissions*~~

~~IEC 60645-7, *Electroacoustics — Audiometric equipment — Part 7: Instruments for the measurement of auditory brainstem responses*~~

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC 60645-1:2017](#)

<https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>

ELECTROACOUSTICS – AUDIOMETRIC EQUIPMENT –

Part 1: Equipment for pure-tone and speech audiometry

1 Scope

This part of IEC 60645 specifies general requirements for audiometers ~~and particular requirements for pure-tone audiometers~~ designed for use in determining hearing threshold levels, relative to standard reference threshold levels established by means of psychoacoustic test methods, ~~and those designed to perform psychoacoustic tests using speech material.~~

The object of this standard is to ensure:

- a) that tests of hearing in the frequency range 125 Hz to 16 kHz on a given human ear, performed with different pure-tone audiometers which comply with this standard ~~shall~~, give substantially the same results;
- b) that the results obtained represent a valid comparison between the hearing of the ear tested and the reference threshold of hearing;
- c) that a means of presenting speech material to a subject in a standardized manner is provided. This will ensure that tests of hearing using a specific speech signal and a specific manner of signal presentation, when performed with different audiometers which comply with this standard, give substantially the same results;
- d) that audiometers are classified according to the range of test signals they ~~generate present~~, according to the mode of operation or according to ~~the complexity of the range of auditory functions they test~~ their presumed primary application.

2 Normative references

[IEC 60645-1:2017](https://standards.iteh.ai/catalog/standards/iec/1218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017)

<https://standards.iteh.ai/catalog/standards/iec/1218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60268-3, *Sound system equipment – Part 3: Amplifiers*

IEC 60268-7, *Sound system equipment – Part 7: Headphones and earphones*

IEC 60268-17, *Sound system equipment – Part 17: Standard volume indicators*

IEC 60318-1, *Electroacoustics – Simulators of human head and ear – Part 1: Ear simulator for the measurement of supra-aural and circumaural earphones*

IEC 60318-3, *Electroacoustics – Simulators of human head and ear – Part 3: Acoustic coupler for the calibration of supra-aural earphones used in audiometry*

IEC 60318-4, *Electroacoustics – Simulators of human head and ear – Part 4: Occluded-ear simulator for the measurement of earphones coupled to the ear by means of ear inserts*

IEC 60318-5, *Electroacoustics – Simulators of human head and ear – Part 5: 2 cm³ coupler for the measurement of hearing aids and earphones coupled to the ear by means of ear inserts*

IEC 60318-6, *Electroacoustics – Simulators of human head and ear – Part 6: Mechanical coupler for the measurement of bone vibrators*

IEC 60601-1, *Medical electrical equipment – Part 1: General requirements for basic safety and essential performance*

IEC 60601-1-2, *Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral standard: Electromagnetic ~~compatibility~~ disturbances – Requirements and tests*

~~IEC 60645-2, *Audiometers – Part 2: Equipment for speech audiometry*~~

IEC 61260-1, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

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

ISO 266, *Acoustics – Preferred frequencies*

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, *Acoustics – Reference zero for the calibration of audiometric equipment – Part 3: Reference equivalent threshold force levels for pure tones and bone vibrators*

ISO 389-4:1994, *Acoustics – Reference zero for the calibration of audiometric equipment – Part 4: Reference levels for narrow-band masking noise*

<https://standards.iteh.ai/catalog/standards/iec/f218f577-7b94-4741-80bb-d8c222b54cb7/iec-60645-1-2017>

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 389-7, *Acoustics – Reference zero for the calibration of audiometric equipment – Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions*

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*

ISO 4869-1, *Acoustics – Hearing protectors – Part 1: Subjective method for the measurement of sound attenuation*

ISO 8253-1:2010, *Acoustics – Audiometric test methods – Part 1: Pure-tone air and bone conduction audiometry*

ISO 8253-2, *Acoustics – Audiometric test methods – Part 2: Sound field audiometry with pure-tone and narrow-band test signals*

ISO 8253-3, *Acoustics – Audiometric test methods – Part 3: Speech audiometry*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 equipment for pure-tone audiometry pure-tone audiometer

instrument for the measurement of hearing for pure tones and in particular of the threshold of hearing

Note 1 to entry: The pure-tone audiometer may be either of a fixed or continuous sweep frequency type.

3.2 manual audiometer

audiometer in which signal presentation and recording of results are performed manually

3.3 automatic-recording audiometer

audiometer in which signal presentation, hearing level variation, frequency selection or frequency variation and recording of the subject's responses are implemented automatically

Note 1 to entry: Hearing level change is under the subject's control and is recorded automatically.

3.4 equipment for speech audiometry speech audiometer

instrument for the measurement of hearing ~~for using~~ speech ~~test~~ material

3.5 air conduction

transmission of sound through the external and middle ear to the inner ear

3.6 bone conduction

stimulation of the inner ear mediated primarily by mechanical vibration of the cranial bones

3.7 extended high-frequency EHF

audiometric test frequency in the range from 8 kHz to 16 kHz

Note 1 to entry: The frequency 8 kHz is considered both as the highest frequency in the conventional range and as the lowest frequency of the extended high-frequency range.

3.8 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 has no history of undue exposure to noise, to potentially ototoxic drugs, or of familial hearing loss