INTERNATIONAL STANDARD

ISO 8253-2

Second edition
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Acoustics — Audiometric test methods —

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

Acoustique — Méthodes d'essais audiométriques —

Partie 2: Audiométrie en champ acoustique avec des sons purs et des bruits à bande étroite comme signaux d'essai

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. 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 8253-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

This second edition cancels and replaces the first edition (ISO 8253-2:1992), of which it constitutes a minor revision.

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

— *Part 1: Basic pure-tone air and bone conduction threshold audiometry*

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

— *Part 3: Speech audiometry*

Introduction

ISO 8253-1 covers procedures for the determination of thresholds of hearing using pure tones presented to the subject by means of earphone or bone vibrator.

This part of ISO 8253 covers procedures for the determination of thresholds of hearing in a sound field. In general, sound field testing implies binaural listening to a test signal, presented by means of one or more loudspeakers in a test room. The test signal may be a pure tone, a frequency-modulated tone or a narrow band of noise. The acoustical characteristics of the sound field are determined by the choice of test signal, by the number and acoustical properties of the loudspeakers used, as well as by the acoustical characteristics of the test room.

Sound field audiometry may be used for various purposes, e.g. the evaluation of hearing acuity in young children and the determination of the functional gain of a hearing aid when worn by a particular listener.

Acoustics — Audiometric test methods —

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

1 Scope

This part of ISO 8253 specifies relevant test signal characteristics, requirements for free, diffuse, and quasi-free sound fields, and procedures for sound field audiometry using pure tones, frequency-modulated tones or other narrow-band test signals presented by means of one or more loudspeakers. The primary purpose is the determination of hearing threshold levels in the frequency range 125 Hz to 8 000 Hz, but this range can be extended to 20 Hz to 16 000 Hz.

This part of ISO 8253 does not include specifications for the use of hand-held loudspeakers. Speech as a test signal is not covered.

The purpose of this part of ISO 8253 is to ensure that tests of hearing, using sound field audiometry, give as high a degree of accuracy and reproducibility as possible.

Examples of graphical representations of the results are given in Annex A.

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 226, *Acoustics — Normal equal-loudness-level contours*

ISO 266, *Acoustics — Preferred frequencies*

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 8253-1:—[1)], *Acoustics — Audiometric test methods — Part 1: Basic pure-tone air and bone conduction threshold audiometry*

IEC 60581-7:1986, *High fidelity audio equipment and systems — Minimum performance requirements — Part 7: Loudspeakers*

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

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

1) To be published. (Revision of ISO 8253-1:1989)

3 Terms and definitions

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

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

3.2
otologically normal person
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, exposure to potentially ototoxic drugs, or of familial hearing loss

3.3
reference point
midpoint of a straight line connecting the ear canal openings of the listener when positioned in the listening position in the sound field

3.4
reference axis
axis perpendicular to the radiating surface of the loudspeaker

NOTE 1 For single radiator or horn loudspeakers, the axis passes through the geometric centre of the diaphragm or the horn.

NOTE 2 For multi-unit loudspeakers, the position of the axis is defined by the manufacturer.

3.5
threshold of hearing
level of a sound at which, under specified conditions, a person gives 50 % of correct detection responses on repeated trials

3.6
threshold sound pressure level
for a given listener, a specified signal and a specified manner of signal presentation, sound pressure level at the **reference point** (3.3) in the specific sound field, in the absence of the listener, which in the presence of the listener in the test position would correspond to the **threshold of hearing** (3.5) of the listener

3.7
reference threshold sound pressure level
for a specific signal and a specified manner of signal presentation, median value of the **threshold sound pressure levels** (3.6) of a sufficiently large number under test of **otologically normal persons** (3.2), of both genders, aged between 18 years and 25 years inclusive, expressing the **threshold of hearing** (3.5) at the **reference point** (3.3) in the specific sound field

3.8
hearing level
for a specified signal and a specified manner of signal presentation, sound pressure level of this signal at the **reference point** (3.3) in the specific sound field minus the appropriate **reference threshold sound pressure level** (3.7)

3.9
hearing threshold level
for a specified signal and a specified sound field, **threshold of hearing** (3.5) expressed either as **hearing level** (3.8) or as sound pressure level

3.10
carrier frequency of a frequency-modulated tone
average value of the periodically varying tone frequency

NOTE The carrier frequency is designated as the nominal test frequency.

3.11
frequency deviation
maximum difference between the instantaneous frequency of the frequency-modulated tone and the carrier frequency

3.12
free sound field
sound field where the boundaries of the room exert a negligible effect on the sound waves

3.13
quasi-free sound field
sound field where the boundaries of the room exert only a moderate effect on the sound waves

NOTE The requirements for a quasi-free sound field are specified in 5.4.

3.14
diffuse sound field
sound field which in a given region has statistically uniform energy density, for which the directions of propagation at any point are randomly distributed

3.15
white noise
noise whose power spectral density is independent of frequency

3.16
noise bandwidth
difference between the upper and lower band-edge frequencies of a noise band

NOTE At these frequencies the power spectral density of the noise is reduced to one-half of its average within the noise band.

3.17
centre frequency of a noise band
geometric mean of the band-edge frequencies which define the **noise bandwidth** (3.16)

3.18
functional gain of a hearing aid
for a specified test signal, a specified type of sound field, a specified manner of signal presentation, and for a particular listener, difference in thresholds of hearing of the listener with and without the hearing aid

4 Test signal characteristics

4.1 General

This part of ISO 8253 covers test signals that are either pure tones, frequency-modulated (FM) tones or narrow bands of noise.

4.2 Pure tones

Pure tones shall be used only in a free sound field which is in accordance with the specifications given in 5.2.

NOTE In other types of sound field, pure tones may show large spatial variations in sound pressure level due to standing waves.

When test tones of fixed frequencies are used, they shall be chosen from the audiometric test frequencies given in IEC 60645-1 or the frequencies given in ISO 266.

The actual frequency shall be within ± 1,5 % of the nominal frequency. This corresponds to the specification of an audiometer complying with the requirements of IEC 60645-1, type 1 and type 2.

4.3 FM tones

FM tones are defined by the following characteristics, which shall be reported:

a) carrier frequency;

b) waveform of modulating signal;

c) repetition rate of modulating signal;

d) frequency deviation.

The carrier frequency shall be chosen from the audiometric test frequencies as specified in IEC 60645-1 or the frequencies given in ISO 266.

The waveform of the modulating signal shall be either sinusoidal or triangular. The triangular waveform shall have symmetrical rising and falling portions on a linear or on a logarithmic frequency scale.

The carrier frequency shall be within ± 3 % of its nominal frequency.

The repetition rate of the modulating signal shall be within the range 4 Hz to 20 Hz with a tolerance of ± 10 % of its nominal value.

The frequency deviation shall be in the range ± 2,5 % to ± 12,5 % with a tolerance of ± 10 % of its nominal value.

If the modulating waveform is sinusoidal, its total harmonic distortion shall not exceed 5 %. If it is triangular, its ramps shall not deviate from a linear form by more than 5 % of its amplitude. For the triangular waveform, the durations of the rising and falling portions shall not differ by more than 10 %.

4.4 Narrow bands of noise

The centre frequency and the bandwidth of a narrow band of noise shall comply with the specifications for narrow-band masking noise according to IEC 60645-1. The centre frequency and the bandwidth shall be reported.

NOTE 1 When bandwidths exceed one-third octave, reference threshold sound pressure levels may differ from those valid for bandwidths up to one-third octave.

NOTE 2 Signal power outside the passband, which is mainly determined by the slopes and stop-band rejection characteristics of the filter, may influence the results of sound field audiometry, in particular on hearing-impaired test subjects.

4.5 Harmonic distortion

If pure tones are available as test signals, the linearity of the complete system shall be such that the total harmonic distortion does not exceed 5 % at 125 Hz and 3 % at 250 Hz, 500 Hz and 1 000 Hz when measured acoustically at the reference point in the test room. These conditions shall be met over the whole dynamic range available.

NOTE It is usually sufficient to measure the harmonic distortion at the maximum available output sound pressure level.

The harmonic distortion of loudspeakers can only be tested in a free sound field. Where only a quasi-free or a diffuse sound field is available, harmonic distortion may be measured electrically across the loudspeaker input terminal. The total harmonic distortion shall be less than 1 % and the loudspeaker shall comply with the specifications given in IEC 60581-7:1986, Clause 10.

If pure tones are not available as test signals, the linearity of the equipment shall be tested by connecting an external pure-tone generator to replace the original test signal source.

When FM tones are used as test signals, the r.m.s. output level of the external pure-tone generator shall be equal to that delivered by the test signal source when in normal use.

When narrow bands of noise are used as test signals, the output of the external pure-tone generator shall be set to a level 9 dB above the root mean square (r.m.s.) value delivered by the test signal source when in normal use.

4.6 Signal gating

The signal shall be either presented as singular sound bursts of a duration in the range 1 s to 2 s or repeatedly gated on and off. The requirements given in IEC 60645-1 regarding rise and fall times, on/off-times and on/off ratio as well as under- and overshoot shall be complied with when measured electrically at the loudspeaker terminals with pure tones as test signals.

NOTE The reverberation characteristics of the test room may exert a significant influence on the decay of the acoustic test signal.

4.7 Signal level control

4.7.1 Step size

The signal level shall be variable in intervals of 5 dB or less.

4.7.2 Accuracy

The maximum accumulated error in the difference between any two signal level settings over the total signal level range of the attenuator shall not exceed 3 dB, as measured acoustically at the reference point. In addition, the specifications given in IEC 60645-1 shall be complied with.

4.7.3 Dynamic range

In the frequency range 500 Hz to 6 000 Hz, the test signal hearing level at the reference point shall cover at least the range 0 dB to 80 dB.

NOTE It is desirable that the same test signal hearing level range be covered outside this frequency range.

4.8 Means and scales for calibration

The equipment shall provide means for adjusting the level of each test sound separately. The scale shall be expressed in hearing level or sound pressure level. Measurements shall be made with a sound level meter conforming to IEC 61672-1, type 1.

For pure tones and one-third-octave bands of noise in a frontally incident field, and for one-third-octave bands of noise in a diffuse sound field, reference threshold sound pressure levels corresponding to the normal binaural threshold of hearing as specified in ISO 226 shall be taken as reference threshold sound pressure levels. These data shall be used also for FM tones complying with the requirements of 4.3. For other combinations of test signal and sound field type, no standardized data exist.

NOTE 1 In practice, other angles of incidence are also used, e.g. 45°. No standardized reference threshold sound pressure levels presently exist. However, in Annex B, correction values for 45° and 90° angles of incidence are given.

NOTE 2 It is recognized that, in applications where only the differences in thresholds of hearing between two listening conditions are to be determined (e.g. with/without hearing aid), relative values of the test sound pressure level can suffice.

5 Sound field characteristics

5.1 General

The environment in which sound field audiometry is undertaken can vary considerably. Three types are specified that allow a suitable sound field to be established in most situations in practice. Two well-defined types are specified, the free sound field and the diffuse sound field. In practice, it may not always be possible to meet these specifications, and, therefore a third sound field, the quasi-free sound field, is specified for the purposes of this part of ISO 8253. It is essential that the user determine which specification is appropriate to the sound field under consideration.

Sound pressure level measurements shall be made with a sound level meter complying with IEC 61672-1, type 1, with the exception of the measurements using a directional microphone given in 5.3.

The signals for testing the sound field shall be the same as those used for audiometry.

5.2 Free sound field

To establish that free sound field conditions are adequately met, the following requirements shall be complied with.

a) The loudspeaker shall be arranged at the head height of a seated listener, the reference axis being directed through the reference point. The distance between the reference point and the loudspeaker shall be at least 1 m.

b) With the test subject and the subject's chair absent, the sound pressure level produced by the loudspeaker at positions 0,15 m from the reference point on the left-right and up-down axis shall deviate by no more than $\pm$ 1 dB from the sound pressure level at the reference point for any of the test frequencies up to and including 4 000 Hz, and by no more than $\pm$ 2 dB for any of the test signals at frequencies above 4 000 Hz. The difference in sound pressure levels between the left-right positions shall not exceed 3 dB at any frequency above 4 000 Hz.

c) With the test subject and the subject's chair absent, the difference in sound pressure levels produced by the loudspeaker at points on the reference axis 0,15 m in front of and 0,15 m behind the reference point shall deviate from the theoretical value given by the inverse sound pressure distance law by no more than $\pm$ 1 dB for any of the test signals.

NOTE These requirements can only be met in an anechoic room.

5.3 Diffuse sound field

To establish that diffuse sound field conditions are adequately met, the following requirements shall be complied with.

a) With the test subject and the subject's chair absent, the sound pressure level measured with an omnidirectional microphone at positions 0,15 m from the reference point on the front-back, right-left and up-down axes shall deviate by no more than $\pm$ 2,5 dB from the sound pressure level at the reference point for any of the test signals. Furthermore, the difference between levels for the extreme right-left positions shall not exceed 3 dB. The orientation of the microphone shall be kept the same at each position.

b) At frequencies of 500 Hz and above, the sound pressure levels at the reference point shall be within 5 dB for the two directions of measurement that give maximum and minimum readings of the incident sound energy when measured with a directional microphone with a front-to-random sensitivity index of 5 dB. For other directional microphones, the relationship between front-to-random sensitivity index and the allowable field variation is given in Table 1.

Table 1 — Microphone requirements for diffuse sound field measurement

Microphone front-to-random sensitivity index[a,b]	Allowable field variation dB
$\geqslant 5$	5
4,5	4,5
4	4
< 4	microphone not suitable

[a] The test should be carried out in a sufficient number of directions, which depend on the type of microphone and the characteristics of the loudspeaker arrangement and include at least the two planes where maximum and minimum sound pressure levels may be expected.

[b] More than one loudspeaker is necessary to produce the desired sound field. The loudspeakers may require to be fed with non-coherent electrical signals to reduce the effects of standing waves.

5.4 Quasi-free sound field

To establish quasi-free sound field conditions, the following requirements shall be complied with.

a) The loudspeaker shall be arranged at the head height of a seated listener, the reference axis being directed through the reference point. The distance between the reference point and the loudspeaker's reference point shall be at least 1 m.

b) With the test subject and the subject's chair absent and all other normal working conditions maintained, the sound pressure levels produced by the loudspeaker at positions 0,15 m from the reference point on the left-right and up-down axis shall deviate by no more than $\pm$ 2 dB from the sound pressure level at the reference point for any of the test signals.

c) With the test subject and the subject's chair absent, the difference in sound pressure levels produced by the loudspeaker at points on the reference axis 0,10 m in front of and 0,10 m behind the reference point shall deviate from the theoretical value given by the inverse sound pressure distance law by no more than $\pm$ 1 dB for any of the test signals.

The usable frequency range of the quasi-free sound field is defined by the frequency range within which these requirements are complied with.

6 Ambient noise levels in the test room

The ambient noise levels in the test room shall comply with the requirements given in Table 2. If lowest hearing threshold levels other than 0 dB are to be measured in a particular test room, the appropriate maximum ambient sound levels are obtained by adding to the values of Table 2 the value of the lowest hearing threshold level to be measured.

7 Preparation and instruction of test subject

In the preparation and instruction of test subjects, as well as other conditions for the audiometric tests, comply with the requirements of and follow the procedures given in ISO 8253-1:—, 4.4, 4.6, 5.1 and 5.2, as applicable. In addition, the subject shall be instructed to keep his/her head at the reference point, to avoid movements, and to face in the required direction.

Some means should be provided to assist the test subject to maintain this head position.

8 Determination of hearing threshold level

8.1 General

The audiometric test may be conducted using a manual, an automatic-recording or a computer-controlled audiometer. The testing may be monaural or binaural.

The position of the reference point relative to the loudspeaker(s) shall be clearly defined and identified.

Ensure that the type of test stimulus is consistent throughout the test and is noted on the audiogram. Arrange for the order of presentation when using a manual or computer-controlled audiometer to be from 1 000 Hz upwards, followed by the lower frequency range. Carry out a repeat test at 1 000 Hz.

The presentation and interruption of test signals, familiarization, and measurements and calculations of hearing threshold levels shall comply with the relevant requirements of ISO 8253-1:—, 6.2 to 6.4.

Hearing threshold levels are generally determined in the frequency range 125 Hz to 8 000 Hz, but this range can be extended to 20 Hz to 16 000 Hz according to ISO 389-7.

For low-frequency signals with high levels, the risk of vibro-tactile perception of the test signal should be considered.

8.2 Monaural testing

If testing is to be monaural, either occlude the non-test ear with a hearing protector or mask it. Use narrow-band noise masking only when pure tones or FM tones are used as test signals, but not when narrow-band noise is used as the test signal. Report the type of hearing protector used when the non-test ear is occluded.

NOTE 1 The sound attenuation obtained by occlusion is often in practice moderate and can thus give rise to measurement errors, particularly when testing an ear that is considerably less sensitive than the occluded non-test ear.

NOTE 2 When masking is used, the presentation of the masking noise through an insert earphone can be of advantage.

8.3 Binaural testing

In binaural testing, it is often impossible for the test subject to determine if the test signal is being heard through both or only one ear. Thus, a hearing threshold level determined by means of binaural testing represents a binaural threshold of hearing or is dominated by the more sensitive ear.

The test subject may be instructed to indicate where the test signal is heard, i.e. right, left or both. However, the subject should be reminded of the primary task, i.e. to respond to the faintest signal heard.

9 Testing with a hearing aid

If the functional gain of a hearing aid when worn by a particular listener is to be determined, use the procedures given in Clauses 7 and 8.

10 Screening audiometry

Perform sound field screening audiometry in accordance with ISO 8253-1:—, Clause 9.

NOTE It is recognized that hand-held loudspeakers are sometimes used for screening purposes. Resultant variations in the distance between the loudspeaker and the test subject can cause large variations in sound pressure levels and thus it is possible that the test situation does not meet the requirements of Clause 5.

Table 2 — Maximum permissible ambient sound pressure levels, L_{max}, in one-third-octave bands for sound field audiometry

Mid-frequency of one-third-octave band[a,b] Hz	Maximum permissible ambient sound pressure levels (ref. 20 µPa)[c] L_{max} dB	
	Lowest test tone frequency	
	125 Hz	250 Hz
31,5	52	60
40	44	53
50	38	46
63	32	41
80	27	36
100	22	32
125	17	25
160	14	18
200	12	12
250	10	10
315	8	8
400	6	6
500	5	5
630	5	5
800	4	4
1 000	4	4
1 250	4	4
1 600	5	5
2 000	5	5
2 500	3	3
3 150	1	1
4 000	– 1	– 1
5 000	1	1
6 300	6	6
8 000	12	12
10 000	14	14
12 500	15	15

[a] Using the values given in this table, the lowest hearing threshold level to be measured is 0 dB, with a maximum uncertainty of + 2 dB due to ambient noise. If a maximum uncertainty of + 5 dB due to ambient noise is permitted, the values in this table may be increased by 8 dB. The values are derived from ISO 8253-1, assuming binaural listening conditions.

[b] When narrow-band noise is used as a test signal, maximum permitted ambient sound pressure levels should be lower than those specified in this table.

[c] With most of the current sound level meters, it is difficult to measure sound pressure levels below 5 dB.

11 Reporting of data

11.1 General

Together with the results from sound field audiometry, the following shall be reported:

a) type of sound field;

b) type of audiometer used (manual or automatic-recording);

c) type and characteristics of the test signal;

d) position of test subject relative to loudspeaker(s);

e) identification of reference for the scale of signal level (hearing level or sound pressure level);

f) lowest measurable hearing threshold level due to ambient noise, if other than 0 dB;

g) whether the non-test ear was occluded and, if so, how.

If screening audiometry has been performed, state the screening level.

11.2 Equipment calibrated by hearing level

If the equipment for sound field testing is calibrated in terms of hearing level, either tabulate the results or plot them as an audiogram, as specified in ISO 8253-1:—, Clause 10. Examples of symbols and an audiogram are shown in Annex A. Identify the audiogram as being derived using the sound field concerned. Note and report the use of masking or of occlusion of the non-test ear.

11.3 Equipment calibrated by sound pressure level

If the equipment for sound field testing is calibrated in terms of sound pressure level, either tabulate the results or present them graphically. See Annex A for an example.

It is recommended that the same scales for the abscissa and ordinate as for the audiogram in 11.2 be used.

12 Maintenance and calibration of equipment

12.1 General

Correct calibration of audiometric equipment is highly important for reliable results. In order to ensure this, the following scheme, consisting of three stages of examination and calibration procedures is recommended.

Stage A: routine examination and listening tests

Stage B: periodic electroacoustic tests

Stage C: basic calibration tests

12.2 Intervals between tests

The recommended intervals at which the various tests are to be carried out are by necessity only a guide. They should be adhered to unless and until there is evidence that a different interval is appropriate.

Carry out stage A tests weekly and tests of the sound pressure levels at the reference point at intervals of no more than 3 months. Perform the periodic electroacoustic tests, stage B, at intervals of, ideally, three months to six months, but in no case shall intervals of 1 year be exceeded.

Different intervals from three months to six months may be acceptable in the light of experience with particular equipment and use, provided that the stage A tests are regularly and carefully applied.

The basic calibration test, stage C, need not be employed on a routine basis if stage A and B tests are regularly performed. Stage C tests are required when the test facility is first established, following equipment replacement or major repair or when, after a long period of time, it is suspected that the equipment is no longer performing fully to specification. However, submit equipment for a stage C test within an interval of no more than five years.

12.3 Stage A: routine examination and listening tests

The purpose of routine checking is to ensure, as far as possible, that the equipment is working properly and that its calibration has not noticeably altered. The ambient noise conditions during test shall be comparable to the conditions when the equipment is in normal use.

The test procedure is as follows.

a) Clean and examine the equipment and all accessories. Examine plugs and cables for signs of wear and damage. Replace damaged or badly worn leads.

b) Switch on the equipment and leave on for the recommended warm-up time or at least 5 min. Carry out any setting-up procedures as specified by the manufacturer.

c) Ensure that the reference point is at the correct position and clearly identified.

d) Verify that the audiometer output and ambient noise levels are approximately correct by having a person listen for just-audible test signals. This person shall have well-known hearing threshold levels within the normal range. Perform the test with all appropriate test signals. The same person should be used as listener each time this is performed.

e) Listen to the test sounds at a higher level, e.g. a hearing level of 60 dB to 70 dB or equivalent sound pressure level, on all appropriate functions and with all test signals available. Listen for proper functioning, absence of distortion, freedom from interrupter clicks, etc.

f) Listen at low levels for any sign of hum or noise or any other unwanted sound from the audiometer or test environment. Verify that the attenuators do attenuate the signals over their full range. Verify that no sound radiated from the equipment is audible at the subject's position.

g) Check that the subject's response system and talk-back and monitor circuits operate correctly.

12.4 Stage B: periodic electroacoustic tests

Periodic electroacoustic tests consist of measuring and comparing results with appropriate standards. For pure-tone signals, the measurements shall be as follows:

a) frequencies of test signals;

b) sound pressure levels at the reference point;

c) attenuator steps (over a significant part of the range);

d) harmonic distortion;

e) masking noise levels.

For test signals other than pure tones, measurement of a) and d) require spectral analysis equipment and need only be performed in cases of suspected malfunction.

Sound level measurements shall be made with a sound level meter complying with the requirements of IEC 61672-1, type 1.

In addition, routine examination and listening tests according to stage A shall be performed.

12.5 Stage C: basic calibration tests

A basic calibration shall ensure that the audiometric equipment, the sound field and the ambient noise levels meet all relevant specifications.

If changes in the acoustic characteristics of the test room occur, e.g. by altered positions of furniture or equipment or ambient noise sources, perform a basic calibration and measurement of the sound field characteristics as given in Clause 5.

Annex A
(informative)

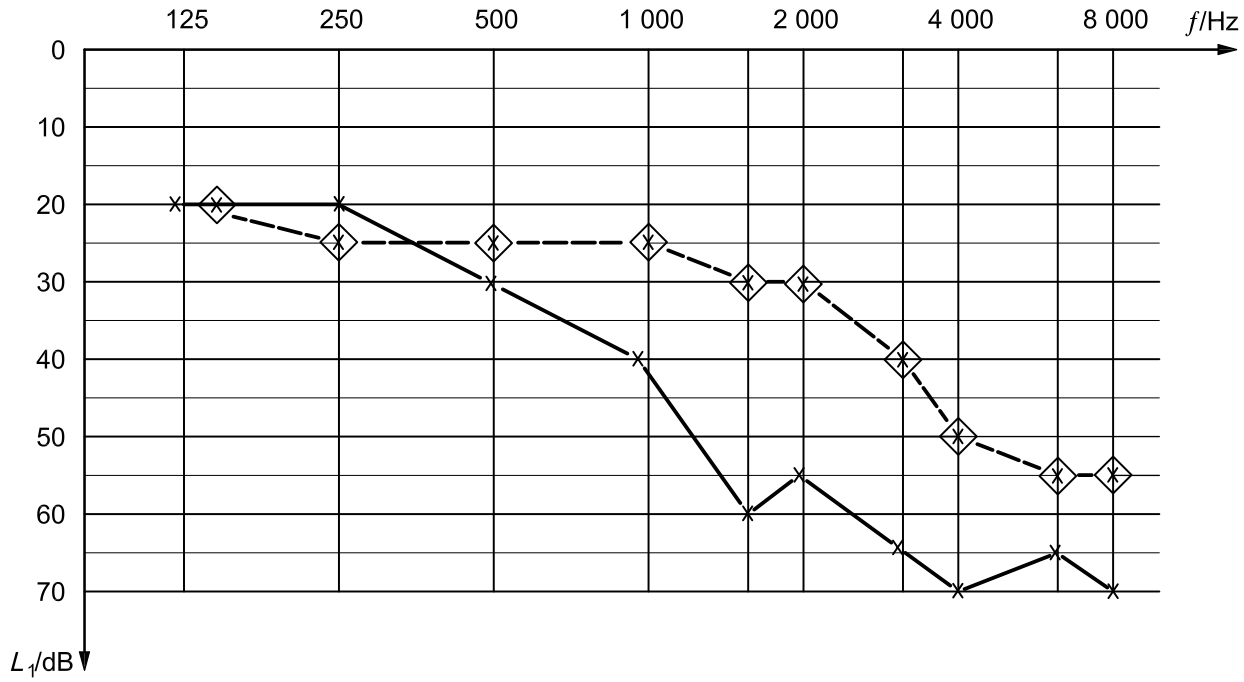
Graphical display of results

Examples are given in Figures A.1 and A.2.

When plotting the results as an audiogram, the type of sound field used should be identified, together with other conditions. The symbols given in Table A.1 are suggested.

Table A.1 — Symbols for test conditions

Conditions for measuring threshold of hearing	Symbol
Monaural, left ear without hearing aid	×
Monaural, right ear without hearing aid	○
Binaural without hearing aid	B
Monaural, left ear with hearing aid	
Monaural, right ear with hearing aid	
Binaural with hearing aid	



Key

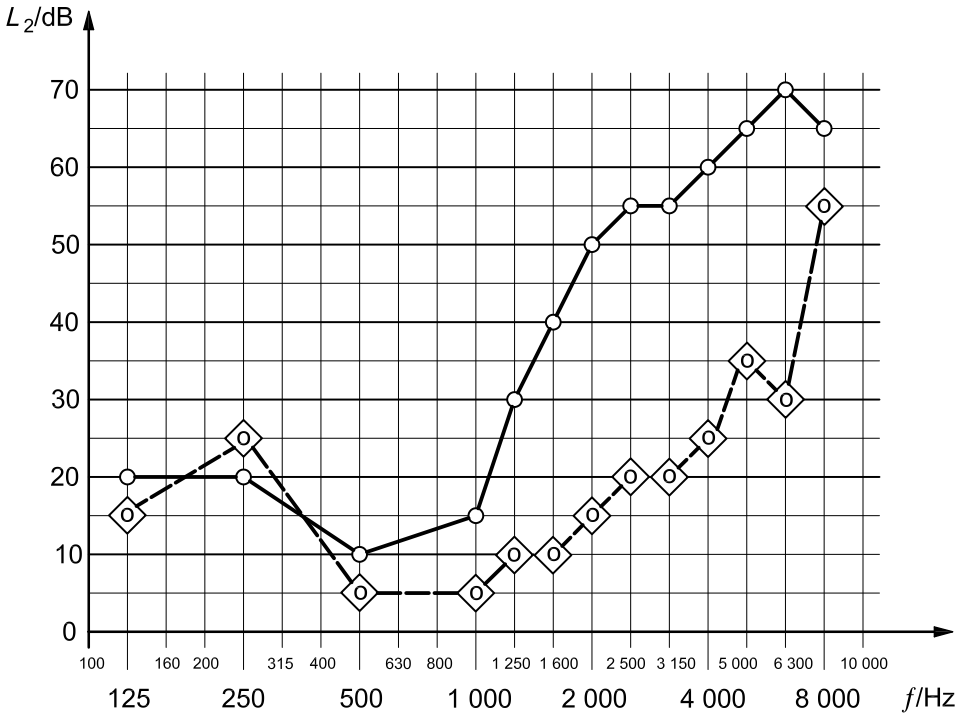
f frequency

L_1 hearing threshold level

× monaural, left ear without hearing aid

 monaural, left ear with hearing aid

Figure A.1 — Hearing threshold levels



Key

f frequency

L_2 threshold sound pressure level

O monaural, right ear without hearing aid

monaural, right ear with hearing aid

Figure A.2 — Threshold sound pressure levels

Annex B
(informative)

Correction values for 45° and 90° angles of incidence

It is acknowledged that for various reasons not all sound field audiometry utilizes loudspeakers at an angle of incidence of 0° (on-axis, frontal location). A survey of practice has shown off-axis positions to be used in significant numbers at angles of incidence of 45° and 90°. Table B.1 gives figures for the increased sound pressure levels at test frequencies from 200 Hz to 12 500 Hz at angles of incidence 45° and 90° (from Reference [3]).

Table B.1 — Increase in sound pressure level at the ear closest to the loudspeaker

Test frequency Hz	Correction value for angle of sound incidence[a] dB	
	45°	90°
125	0,5	1
160	1	1,5
200	1	1,5
250	1	2
315	1,5	2,5
400	2,5	3,5
500	3	4,5
630	3,5	5
800	3,5	5
1 000	4	5,5
1 250	4	6
1 500	3,5	5
1 600	3,5	4,5
2 000	3	2
2 500	3,5	2
3 000	5	2,5
3 150	5	2
4 000	4	− 0,5
5 000	6	4
6 000	7,5	9,5
6 300	7,5	10
8 000	5,5	8,5
10 000	4,5	6
12 500	1,5	8

[a] For off-axis location of the loudspeaker relative to 0° angle of incidence, rounded to the nearest 0,5 dB.

Bibliography

[1] ARLINGER, S.D., JERLVALL, L.B. Reliability in warble tone sound field audiometry. *Scand. Audiol.* 1987, **16**, pp. 21-27

[2] MORGAN, D.E., DIRKS, D.D., BOWER, D.R. Suggested threshold sound pressure levels for frequency-modulated (warble) tones in the sound field. *J. Speech Hear. Disord*. 1979, **44**, pp. 37-54

[3] SHAW, E.A.G., VAILLANCOURT, M.M. Transformation of sound pressure level from the free field to the eardrum presented in numerical form. *J. Acoust. Soc. Am*. 1985, **78**, pp. 1120-23

[4] WALKER, G., DILLON, H., BYRNE, D. Sound field audiometry: Recommended stimuli and procedures. *Ear Hear.* 1984, **5**, pp. 13-21

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