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Acoustics — Pure tone air conduction threshold audiometry for hearing conservation purposes

Acoustique — Audiométrie liminaire tonale en conduction aérienne pour les besoins de la préservation de l'ouïe

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Foreword

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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.

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The member body of the following country expressed disapproval of the document on technical grounds :

France

Acoustics — Pure tone air conduction threshold audiometry for hearing conservation purposes

0 Introduction

This International Standard lays down requirements and procedures for conducting pure tone air conduction threshold audiometry when it is deemed by the responsible authority appropriate to monitor the hearing of subjects exposed to noise at work. Monitoring audiometry provides a safeguard against the effects of noise causing hearing loss and monitors the effectiveness of procedures such as organizational measures and the wearing of hearing protectors. Since hearing conservation concerns normal hearing as well as impaired hearing, requirements are presented for measuring hearing sensitivity down to levels below the standard reference zero for the calibration of pure tone audiometers. This International Standard does not present procedures for accomplishing either bone conduction pure tone audiometry or speech audiometry.

In obtaining a reliable measure of hearing sensitivity many factors are involved. It is essential that audiometers, when in service, be checked and the calibration maintained. This International Standard presents an outline of a calibration scheme. To avoid masking of the test tone of the audiometer by ambient noise in the audiometric test room, the levels of the ambient noise have to lie below certain values. This International Standard gives maximum permissible ambient sound pressure levels not to be exceeded when hearing threshold levels down to 0 dB (see ISO 389) have to be measured. It indicates the maximum ambient sound pressure levels which are permissible when other minimum hearing threshold levels have to be measured.

Recent exposure to noise may temporarily elevate hearing threshold levels. Procedures to minimize temporary threshold shift during audiometric testing are given.

Methods of conducting audiometric tests with manual and automatic recording fixed frequency audiometers are presented in this International Standard. For manual audiometry, a bracketing and an ascending method are specified. Also computer controlled or other automated equipment may be used for the audiometric procedure. It is essential that the preparation and the instruction of the test subject as well as the conduct of an audiometric test be carried out by a qualified person.

In this International Standard, rules are given to obtain the hearing threshold levels from an audiometric recording and to construct an audiogram. Provisional data is given for the difference existing between hearing threshold levels recorded by manual audiometers and those recorded by automatic recording audiometers.

This International Standard presents measures of the reliability of audiometric measurements and contains a bibliography.

1 Scope

This International Standard specifies procedures and requirements for air conduction pure tone threshold audiometry without masking that are applicable to individuals whose hearing sensitivity might be adversely affected by occupational noise exposure and presents techniques for automatic recording and manual audiometry.

2 Field of application

The procedures and requirements presented in this International Standard are restricted to air conduction pure tone threshold audiometry by earphones; other audiometric techniques, such as bone conduction pure tone threshold audiometry, masking and speech audiometry, are not specified. Techniques for computer controlled audiometry are not specified, but shall elicit results equivalent to manual audiometry. The specifications in this International Standard are not intended for clinical purposes nor are they applicable without modification in other circumstances, such as at schools or at health service institutes.

3 References

- ISO 389, *Acoustics — Standard reference zero for the calibration of pure-tone audiometers.*¹⁾
- ISO 4869, *Acoustics — Measurement of sound attenuation of hearing protectors — Subjective method.*
- IEC Publication 303, *IEC provisional reference couple for the calibration of earphones used in audiometry.*
- IEC Publication 318, *An IEC artificial ear, of the wideband type, for the calibration of earphones used in audiometry.*
- IEC Publication 645, *Audiometers.*

1) See also ISO 389/Add. 1.

4 Definitions

For the purpose of this International Standard the following definitions apply :

4.1 pure tone audiometer : An electroacoustic instrument, equipped with earphones, which provides pure tones of specified discrete frequencies at known sound pressure levels.

4.2 manual audiometer : A pure tone audiometer in which the signal presentations, frequency and hearing level selection and recording of the responses of the subject are performed manually.

4.3 automatic recording audiometer : A pure tone audiometer in which hearing level variations are under subject's control and are recorded automatically.

4.4 computer controlled audiometer : A pure tone audiometer in which the test procedure is controlled by computer. For the purpose of this International Standard a computer is considered as any electronic device that has a program controlling the test procedure.

4.5 air conduction : The transmission of sound through the external and middle ear to the internal ear.

4.6 audiometric recording : A display of the responses of a subject to the signals emitted by an audiometer.

4.7 hearing level : The hearing level of a pure tone at a specified frequency, for a specific type of earphone and for a specified manner of applications, is the sound pressure level of this signal set up by the earphone in a specified coupler or artificial ear minus the appropriate reference equivalent threshold sound pressure level.

4.8 hearing threshold level : The hearing threshold level of a given ear at a specified frequency is the threshold level at that frequency, derived by a specified method from an audiometric recording, expressed as hearing level.

4.9 audiogram of a subject : Presentation, in graphical or tabular form, of the hearing threshold levels of the subject's ears, determined under specified conditions and by a specified method, as a function of frequency.

5 Audiometers

5.1 General requirements

Audiometers shall be initially constructed and calibrated according to the requirements of ISO 389 and IEC Publication 645, concerning type 4 monitoring air conduction pure tone manual and automatic recording audiometers, and shall be maintained and calibrated regularly according to 5.3. Computer controlled audiometers shall be constructed so that they meet the requirements concerning monitoring air conduction pure tone manual audiometers and are operating according to the specifications given in 8.1 and 8.3 and give results equivalent to 8.2 and 8.4.

5.2 Specific requirements

5.2.1 Frequencies and sound pressure levels of test tones

Audiometers shall be provided with test tones of at least the following frequencies : 500, 1 000, 2 000, 3 000, 4 000 and 6 000 Hz, and preferably also with 8 000 Hz. The hearing levels shall preferably cover at least the range from -10 dB to +70 dB but should cover at least the range from 0 dB to 70 dB.

5.2.2 Order of presentation of test tones

Automatic recording audiometers shall be so adjusted that the test tones are presented in one of the following sequences : 500, 1 000, 2 000, 3 000, 4 000, 6 000, (8 000) Hz or 1 000, 2 000, 3 000, 4 000, 6 000, (8 000), 500 Hz. The test tone frequency 8 000 Hz is recommended. The sequence of the test tones shall be the same to both ears.

The test tones of automatic recording audiometers shall be pulsed, according to the specification given in IEC Publication 645.

For manual and computer controlled audiometers, the test tones shall be presented in the sequence : 1 000, 2 000, 3 000, 4 000, 6 000, (8 000), 500, 1 000 Hz to one ear followed by the same sequence to the other ear. The test tone frequency 8 000 Hz is recommended.

NOTE — In special cases the test frequency 500 Hz may be omitted. If so, appropriate adjustments should be made to the requirements in 5.2.1 and 6.1.1.

5.2.3 Attenuation rate of automatic recording audiometers

For automatic recording audiometers the preferred attenuation rate shall be 5 dB/s. If another rate is used, it shall be 2,5 dB/s.

5.3 Maintenance and calibration

It is essential that the audiometer, when in service, is calibrated in accordance with ISO 389 and complies with the calibration requirements of IEC Publication 645.

In order to ensure this the following scheme, consisting of a regularly performed check procedure supplemented by basic calibrations, is specified as a minimum requirement.

5.3.1 Check procedure

A listening check according to 5.3.1.1 shall be performed at the beginning of each day of testing. A subjective test according to 5.3.1.2 shall be performed at least once a week and preferably daily. An objective calibration check according to 5.3.1.3 shall be carried out once every three months.

5.3.1.1 Listening check

An experience tester with normal hearing shall listen carefully for distortions, attenuator and tone-switch transients and other unwanted sound from the audiometer at a minimum of three attenuator settings at all test frequencies. If any unwanted sounds from the audiometer are heard, the audiometer shall be withdrawn from service for inspection and repair.

5.3.1.2 Subjective calibration check

Take an audiogram of a person having known stable hearing, with hearing threshold levels not exceeding 25 dB at each test frequency, and compare the test results with the known audiogram. If the results indicate hearing threshold level differences exceeding 10 dB at any frequency the audiometer shall be withdrawn from service and subjected to an objective calibration check or basic calibration.

5.3.1.3 Objective calibration check

Measure the frequency of all test tones. Measure the sound pressure levels of the test tones at each frequency at each earphone.

NOTE — The audiometer may be set to 70 dB hearing level for this purpose and the appropriate correction made.

In addition, perform a listening check according to 5.3.1.1. The audiometer shall be withdrawn from service and subjected to a basic calibration, if any departures from the requirements of type 4 audiometers, given in IEC Publication 645 concerning frequency accuracy and sound pressure level accuracy, or if any unwanted sounds have been observed.

5.3.2 Basic calibration

A basic calibration shall be performed by a competent laboratory every 2 years, or when judged necessary as a result of the periodic checks given in 5.3.1.

The procedure shall be such that after its application the audiometer is calibrated in accordance with ISO 389 and meets the requirements of type 4 instruments given in IEC Publication 645 relating to :

- frequency accuracy;
- harmonic distortion;
- accuracy of sound pressure levels;
- on/off ratio and rise/fall time of tone switch for manual audiometers;
- pulsed tone for use with automatic recording audiometer (see also 5.2.3);
- earphones;
- general requirements.

When the instrument is returned after basic calibration it should be checked according to 5.3.1.1 and 5.3.1.2 before being put back into service.

6 Conditions for audiometric test rooms

6.1 Ambient noise

6.1.1 Maximum permissible ambient sound pressure levels

In order to avoid masking of the test tones the ambient sound pressure levels in the audiometric test room shall not exceed certain values as described in this clause.

The maximum permissible ambient sound pressure level, L_{\max} , measured at the head position in the test room, but with the subject absent, is given by the formula :

$$L_{\max} = k + A$$

where

k is as given in tables 1 to 3;

A is the average sound attenuation of the audiometric earphone (measured, for example, according to the procedure specified in ISO 4869.)

NOTE — When values of A are known for a particular pattern of audiometric earphone, these values should be used. Values of $k + A$ are, however, given in the third column of tables 1 to 3, for convenience, for the case of typical current supra aural earphones. The data are based on experimental values for two commercially available earphone types^{[7][8]}.

The ambient sound pressure level measurements should be made at a time when conditions are representative of those existing when audiometric tests are carried out.

The values provided in tables 1 to 3 assume that the lowest test frequency is 500 Hz.

If minimum hearing threshold levels other than 0 dB have to be measured, the maximum permissible ambient sound pressure levels, shall be calculated by adding to the values given in the tables 1, 2 and 3 the minimum hearing threshold levels to be measured. For example, if the minimum hearing threshold level to be measured is -10 dB, 10 dB is subtracted from the values presented in the tables 1, 2 and 3.

NOTES

1 Audiometry for hearing conservation purposes is not recommended when the ambient noise exceeds the values in table 1 by 10 dB or more, even when the minimum hearing threshold level to be measured is higher than 10 dB.

2 Psycho-acoustical check on ambient noise

If sound pressure level measurements cannot be carried out, a psycho-acoustical check on the ambient noise may be performed by conducting an audiometric test on at least two test subjects during the time in which the audiometry would normally be conducted and by comparing these audiograms with audiograms taken in the same manner and on the same subjects in an audiometric test room conforming to 6.1.1. Hearing threshold levels obtained in the audiometric test room under consideration which are higher by 5 dB or more indicate a requirement for reduction of the noise in the room. For this check, the hearing threshold levels of the test subjects at any frequency shall not be higher than the lowest hearing level to be measured during regular testing.

6.2 Other environmental requirements

The test subject and the audiometrician should be comfortably seated during audiometric testing and should not be disturbed nor distracted by events unrelated to the test procedure nor by people in the surroundings. If manual audiometry is employed the subject shall be clearly visible to the audiometrician but shall not be able to see the audiometer settings change nor the test tone switched on or interrupted.

Table 1 — Values of k and typical values of L_{max} in 1/3-octave bands, when the lowest hearing threshold level to be measured is 0 dB

1/3-octave band centre frequency	k	L_{max} (re 20 μ Pa)
Hz	dB	dB
31,5	78	78
40	73	73
50	68	68
63	63	64
80	58	59
100	53	55
125	48	51
160	43	47
200	37	42
250	32	37
315	28	33
400	18	24
500	11	18
630	9	18
800	9	20
1 000	8	23
1 250	7	25
1 600	6	27
2 000	6	32
2 500	7	35
3 150	7	38
4 000	8	40
5 000	9	38
6 300	10	36
8 000	15	39

NOTES

1 The data in table 1 have been based on a criterion of negligible audiometric error due to masking by ambient noise in 50 % of cases. It is recommended to use lower values of L_{max} when practicable.

If an octave band analysis of the ambient noise is made and octave band sound pressure levels do not exceed the values given in table 2, the audiometric room is considered appropriate for hearing threshold level measurement, when the lowest hearing level to be measured is 0 dB.

If one or more of the octave band sound pressure levels exceed the values given in table 3 the room is considered inappropriate for audiometric measurements, without further noise abatement measures, when hearing levels of 0 dB have to be measured.

If one or more of the measured octave band sound pressure levels have values between those given in table 2 and table 3, a 1/3-octave band analysis should be made to determine whether 1/3 octave band sound pressure levels do not exceed the values given in table 1.

2 The data in table 1 refer to Beyer DT 48 earphones and TDH 39 earphones with MX 41/AR cushions.

Table 2 — Values of k and typical values of L_{max} in octave bands, when the lowest hearing threshold level to be measured is 0 dB

Octave band centre frequency	k	L_{max} (re 20 μ Pa)
Hz	dB	dB
31,5	73	73
63	58	59
125	43	47
250	28	33
500	9	18
1 000	7	20
2 000	6	27
4 000	7	38
8 000	10	36

Table 3 — Values of k and typical values of L_{max} in octave bands, above which hearing threshold level measurements shall not be carried out when the lowest hearing threshold level to be measured is 0 dB

Octave band centre frequency	k	L_{max} (re 20 μ Pa)
Hz	dB	dB
31,5	80	80
63	70	70
125	55	57
250	39	44
500	19	26
1 000	13	28
2 000	11	37
4 000	13	44
8 000	16	41

7 Preparation and instruction of subjects before audiometric testing

The preparation, instruction of subjects, and the conduct of audiometric tests shall be undertaken by a qualified person. A qualified person is understood to be someone who has followed an appropriate course of instruction in the theory and practice of audiometric testing of occupational noise-exposed subjects. This qualification may be specified by national authorities.

7.1 Preparation of test subjects

The following procedure should ideally be adopted. The audiometric test should be preceded by an otoscopic examination. If obstructing wax is found in the external ear canal(s), this should be removed and audiometry postponed for a suitable delay period as specified by a medically qualified person. For hygienic reasons, audiometry may also be postponed in cases of inflammation or eczema of the outer ear. Subjects shall be kept away from noise at least 15 min prior to the audiometric test and shall be present at least 5 min in advance of testing to avoid errors due to excessive physical exertion.

NOTES

1 If it is not practicable to carry out an otoscopic test in advance, at least a visual inspection should be performed and the audiometry may be carried out thereafter. If the result indicates a hearing loss, examination for wax should be carried out, the wax should be removed and the audiometry repeated after a suitable delay period.

2 Recent exposure to noise may cause a temporary elevation of the hearing threshold levels. If significant noise exposure cannot be readily avoided, temporary threshold shift will be reduced if those selected for an audiometric test are provided with hearing protectors with high attenuation at least on the day the audiometric test is undertaken, but preferably also on the day before audiometric testing. Steps should be undertaken to ensure that the hearing protectors are worn correctly during the noise exposure before audiometric testing and the subjects avoid exposure to excessive noise.

Before testing, the following actions shall be undertaken:

- a) spectacles, head ornaments, and hearing aids, when worn, shall be removed;
- b) hair shall be removed from between the earphones and the head;
- c) the earphones shall be fitted by a qualified person to ensure proper seal and comfortable fit and subjects shall be instructed not to touch the earphones thereafter;
- d) subjects shall be instructed to avoid unnecessary movements, to obviate extraneous noise.

Thereafter, and prior to the test tone presentation, the subject shall undergo a rest period of at least half a minute.

7.2 Instruction of test subject in the test procedure

It is essential for audiometric testing that relevant briefing in the test procedure be given unambiguously and that it is fully understood by the test subject. The briefing shall include :

- a) the response task when a sound is heard. Response can be, for example, raising a finger, a hand or pressing a button;
- b) the task when the sound is no longer heard. This can be, for example, lowering the finger, the hand or releasing the button;
- c) an indication of the need to respond as soon as possible;

Also information on the following :

- d) an indication that the sounds may be very faint;
- e) the pitch sequence of the sounds and which ear will be tested first;
- f) an indication that the test may be interrupted by the subject himself in case of any disturbing events.

After the briefing, the subject shall be asked if he has understood. If there is any doubt, the briefing shall be repeated verbally.

8 Conduct of audiometric test and determination of hearing threshold levels from an audiometric recording

Measurements of hearing threshold levels shall not be undertaken until the test subject has been familiarized with one or more of the test tones and with the response task.

The procedure for conducting an audiometric test with an automatic recording audiometer and the procedure for manual audiometry are described in 8.1 and 8.3 respectively. Methods of determining hearing threshold levels from an audiometric recording are specified in 8.2 and 8.4. If computer controlled or other automated equipment is used, the procedures described in 8.1 to 8.4 should be adapted to produce equivalent results.

8.1 Conduct of audiometric test with an automatic recording audiometer

8.1.1 Familiarization

Start the attenuation system, and if wanted the recording mechanism, at the first test frequency. Observe the subject's performance. A practice run for 20 to 30 s will indicate whether the subject has understood the instructions. If so, start the recording. If not, repeat the instructions.

8.1.2 Hearing threshold level measurements

After the recording has been started, continue the test until both ears have been tested once. Permit the subject 1 min rest, without disturbing the earphones. Repeat the test without a familiarization session at one or two of the first frequencies at the first ear. If the results agree with those of the first test, discontinue. If a deviation of more than 5 dB at the frequency retested or at both frequencies retested is discernible, continue with the remainder of the repeat test.

8.2 Determination of hearing threshold levels in automatic recording audiometry

If the remainder of the repeat test was not carried out, the following procedure shall be applied to the recording of the first test for each frequency and for each ear. If the remainder of the repeat test was carried out, the following procedure shall be applied to the results of the repeated tests :

Step 1 : Ignore the first reversal following a change of frequency and any reversals associated with trace excursions of 3 dB or less.

Step 2 : Average the peaks and average valleys of the tracing at a given frequency and ear.

Step 3 : Determine the mean of the two averages obtained in step 2. This mean value, rounded up to the nearest whole number in decibels, is taken as the hearing threshold level at that frequency and that ear.

An audiometric recording at any frequency and for either ear is considered of doubtful reliability and shall be repeated if any of the following conditions apply :

- a) less than 6 reversals remain after step 1;
- b) the peaks deviate by more than 10 dB among themselves;
- c) the valleys deviate by more than 10 dB among themselves.

NOTE — When the trace excursions are regular, results very close to those obtained by the procedure given above may be obtained more simply by "visual averaging".

8.3 Conduct of audiometric test with a manual audiometer

Two methods of conducting an audiometric test with a manual audiometer are specified : a bracketing and an ascending method. These methods differ in the sequence of the levels of the test tones, presented to the test subject. Applying the ascending method, consecutive test tones are presented having ascending levels until a response occurs. In the bracketing method, consecutive test tones are presented having ascending levels until a response occurs, after which test tones are presented having levels in a descending order.

8.3.1 Presentation and interruption of test tones

The test tones shall be presented with a duration of 1 to 2 s. When a response occurs, the interval between the tone presentations shall be varied randomly, but shall not be shorter than the test tone duration.

8.3.2 Initial familiarization

Present a test tone of 1 000 Hz at a hearing level of 40 dB to one of the subject's ears. Usually, a test tone at a level of 40 dB at 1 000 Hz is sufficient to evoke a clear response of the subject. If a response is not evoked, increase the level in steps of 10 dB until a response occurs. Then proceed to the following familiarization session.

Present the first test tone (i.e. 1 000 Hz) completely attenuated and gradually increase the level of the test tone until a response occurs. Interrupt the tone for 1 to 2 s and present it again at the same level.

If the responses are consistent with the pattern of tone presentation, proceed to hearing threshold level measurement. If not, repeat the familiarization session. After a second failure, repeat the instructions.

8.3.3 Hearing threshold level measurements

The measurements according to the ascending method differ from those according to the bracketing method only in step 2 of the measurements, presented below.

Step 1 : After familiarization with a test tone of 1 000 Hz, present the first test tone at a level which is 10 dB below the level of the subject's response during the familiarization session. After each failure to respond to a test tone, increase the level of the test tone in steps of 5 dB until a response occurs.

Step 2 (ascending method) : After the response, decrease the level by 10 dB and begin another ascending level series. Continue until three responses out of a maximum of five trials occur at a single level.

Step 2 (abridged ascending method) : An abridgement of the ascending method has been shown to yield nearly equivalent results and may be appropriate in some cases. In this abridgement the testing at each frequency is continued until two responses out of three trials occur at a single level.

If, using the ascending method, less than three responses out of five trials (or less than two responses out of three trials in the abbreviated method) have been obtained at a single level, present a test tone at a level 10 dB higher than the level of the last response. Then repeat the test procedure.

Step 2 (bracketing method) : After the response, increase the level of the test tone by 5 dB and begin a descending level series in which the level of the tone is decreased in steps of 5 dB until no response occurs. The level of the test tone is then decreased another 5 dB and the next ascending level series is begun at this level. This should be continued until three ascending and three descending level series have been completed.

Step 2 (abridged bracketing method) : Abridgements of the bracketing method may be appropriate in some cases. This consists of omitting the further descent of 5 dB after the tone is no longer heard; or by carrying out two ascending and two descending series, provided that the four minimum response levels differ by no more than 5 dB.

Step 3 : Proceed to the next test frequency, beginning 10 dB below the lowest level that evoked a response at the closest test frequency. Go lower, if necessary. Finish all test frequencies at one ear.

NOTE — For any frequency the familiarization, or an abbreviation of it, may be repeated.

If the results at 1 000 Hz of the repeat measurement for that ear agree to 5 dB or less with those of the first measurements for the same ear, proceed to the other ear. If 10 dB or a larger deviation in hearing threshold level is discernible, retest at further frequencies in the same order until agreement to 5 dB or less has been obtained considering, however, that the total test time does not exceed a certain limit (for example 20 min) beyond which reliable results become progressively difficult to obtain.

Step 4 : Proceed until both ears have been tested.

8.4 Determination of hearing threshold levels in manual audiometry

The hearing threshold levels for each frequency and ear shall be determined according to the following procedures, depending upon the measurement method used.

If the remainder of the repeat test was carried out, the procedures shall be applied to the results of the repeat test.

8.4.1 Determination if the ascending method has been applied

Determine the lowest level at which responses occur in at least half of the ascending level series. This level is defined as the hearing threshold level.

NOTE — If minimum response levels span more than 10 dB at a given frequency the test should be considered of doubtful reliability and should be repeated, if possible.

8.4.2 Determination if the bracketing method has been applied

For each frequency and ear, average the minimum levels at which responses occur in the ascending level series. Again, for each frequency and ear, average the minimum levels at which responses occur in the descending level series. Determine the mean value of the two averages thus obtained for each frequency and ear. This mean value, rounded up to the nearest decibel, is taken as the hearing threshold level for that frequency and ear.

NOTE — If the lowest response levels in the ascending level series deviate more than 10 dB between themselves or if the lowest response levels in the descending level series deviate more than 10 dB between themselves the test should be repeated, if possible.

8.5 Limitation of air-conduction threshold audiometry

If the hearing threshold level measurements result in a hearing level of 40 dB or more in either ear at any frequency, these results should be interpreted with caution due to the phenomenon of cross-hearing.

9 Audiogram

9.1 Construction of audiogram

Audiograms may be presented in tabular or graphical form. An audiogram shall clearly indicate the reference zero of the audiometer, the type of audiometer with which the hearing threshold levels have been determined (i.e. manual, computer controlled or automatic recording audiometer) and any further information specified in this International Standard (i.e. lowest test tone level, lowest test frequency).

For audiograms in graphical form, one octave on the frequency axis shall correspond to 20 dB on the hearing level axis. The following symbols are recommended for hearing threshold levels :

at the right ear : O

at the left ear : X

If no response occurs at the maximum output level of the audiometer, the following symbols should be inserted at these levels :

at the right ear : \bigcirc

at the left ear : X

Symbols shall be drawn on the audiogram chart so that the midpoint of the symbol centres on the intersection of the frequency abscissa and the hearing level ordinate at the appropriate level and frequency. If the hearing threshold levels of both ears are equal at any frequency and both are to be represented on the same chart, place the left ear symbol inside that of the right ear. With the exception of symbols representing no-response, symbols at adjacent frequencies may be connected by straight lines.

9.2 Comparison of audiograms

To compare audiograms which have been recorded by automatic recording and manual audiometry, 3 dB should be added to the hearing threshold levels determined by means of automatic recording audiometers^[13]. For statistical analysis of results of hearing threshold level measurements, the data on the reliability of these measurements given in the annex are suitable.