International Standard 7029

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Acoustics — Threshold of hearing by air conduction as a function of age and sex for otologically normal persons

Acoustique — Seuil normal d'audition par conduction aérienne en fonction de l'âge et du sexe pour les personnes otologiquement normales

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Acoustics — Threshold of hearing by air conduction as a function of age and sex for otologically normal persons

0 Introduction

It is well known that the sensitivity of human hearing to pure tones falls progressively with age and that the loss of hearing is more rapid for high-frequency tones than for low-frequency tones. Moreover, the magnitude of this effect varies considerably between individuals.

In the case of young persons, data have been standardized (see ISO 389) specifying the modal values of the threshold of hearing for the otologically normal (as defined in ISO 389); these data form the basis for calibrating pure tone audiometers. These data do not discriminate between male and female persons and they do not specify the technique of audiometry to which they apply. It is known that these distinctions should, in principle, be made in order to obtain the most accurate value for audiometric zero. In this International Standard the distinction between males and females has been made since the difference is found to be significantly large in the case of older age groups. When an individual, who is more than 18 years old, is being tested with an audiometer, part of any observed hearing loss will most probably be associated with the person's age, and it is, therefore, important to be aware of this when estimating the amount of hearing loss attributable to other causes under investigation. Furthermore, there is a need for generally acceptable data to be standardized for this purpose.

Numerous data on the elevation of hearing threshold levels increasing with age exist in various publications, but there are certain numerical differences between them which may be attributed to the use of different criteria of selection for test populations, different audiometric techniques, etc. However, a thorough examination of the data has enabled a representative set of values to be established. This International Standard is based on these values which refer to screened populations of otologically normal persons as defined herein.

1 Scope and field of application

This International Standard specifies, for the range of audiometric frequencies from 125 to 8 000 Hz and for groups of otologically normal persons of a given age within the age limits of 18 to 70 years inclusive :

a) the expected value of the median hearing threshold shift relative to a group of persons 18 years of age;

b) the expected statistical distribution above and below the median value (see note 2 to 4.1).

The data in this International Standard are applicable as descriptive statistics of the hearing levels of populations of various ages. An example of this application is as a baseline of comparison for estimating the amount of hearing loss caused in a population due to a specific agent, for example, noise, and in this application the data of this International Standard are included as "Data Base A" in ISO 1999. The data may also be used to compare an individual's hearing with the normal distribution of the hearing threshold levels for the person's age group. In the audiological diagnosis of an individual person, it is, however, not possible to determine precisely which changes of the hearing threshold level are attributable to an accumulation of detrimental effects upon the hearing increasing with age and which changes have been caused by other factors such as, for example, noise.

2 References

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

ISO 1999, *Acoustics — Determination of occupational noise exposure and estimation of noise-induced hearing impairment.*[1)]

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

ISO 8253, *Acoustics — Pure tone audiometric test methods.*[2)]

IEC Publication 645, *Audiometers.*

1) At present at the stage of draft. (Revision of ISO 1999-1975.)

2) At present at the stage of draft.

3 Definitions

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

3.1 otologically normal person : A person in a normal state of health who at the time of testing is free from excess wax in the ear canals, is without known ear pathology and who has no history of undue exposure to noise.

3.2 hearing threshold level (of a given ear of a person at a given frequency) : The threshold of hearing as determined in a stated manner by means of a pure tone air conduction audiometer, expressed as the hearing level in decibels.

NOTES

1 Specifications for audiometers are given in IEC Publication 645.

2 For the calibration of audiometers, see ISO 389.

3 For appropriate test conditions see, for example, ISO 6189 and ISO 8253.

3.3 hearing level : The sound pressure level of a tone of given frequency which is generated by the earphone of a pure tone audiometer in an acoustic coupler of specified type, when expressed in decibels relative to the reference equivalent threshold sound pressure level (audiometric zero) for that frequency and for the pattern of earphone and acoustic coupler in question.

NOTE — Values of reference equivalent threshold sound pressure level for various patterns of earphone are specified in ISO 389.

4 Specification

4.1 Median values

The median value of hearing threshold deviation of otologically normal persons aged Y years shall be given by the following equation :

$$H_{\mathrm{md},Y} = \alpha(Y - 18\ \mathrm{years})^2 + H_{\mathrm{md},18} \quad \ldots \quad (1)$$

where $H_{\mathrm{md},18}$ is the median value of hearing threshold level of otologically normal persons of the same sex aged 18 years.

NOTES

1 For practical purposes, $H_{\mathrm{md},18}$ may be taken as zero, corresponding to the hearing threshold for young persons, as specified in ISO 389.

2 The median values specified in this International Standard are not the modal values used in ISO 389.

Values of the coefficient α for males and females shall be those given in table 1.

The range of Y for which formula (1) is valid is from 18 to 70 years inclusive.

Table 1 — Values of the coefficient α used to determine the median value of hearing threshold deviation for an otologically normal population of given age

Frequency in Hz	Value of α, in dB/year^2	
	Males	Females
125	0,003 0	0,003 0
250	0,003 0	0,003 0
500	0,003 5	0,003 5
1 000	0,004 0	0,004 0
1 500	0,005 5	0,005 0
2 000	0,007 0	0,006 0
3 000	0,011 5	0,007 5
4 000	0,016 0	0,009 0
6 000	0,018 0	0,012 0
8 000	0,022 0	0,015 0

4.2 Statistical distribution

4.2.1 The statistical distribution of hearing threshold levels of otologically normal persons of a given age shall be approximated, for the purpose of this International Standard, by the halves of two normal (Gaussian) distributions. One half lies above the median value, $H_{\mathrm{md},Y}$, and has the larger dispersion characterized by the parameter s_{u}; the other half lies below the median and has the smaller dispersion characterized by the parameter s_{l}.

Values of the parameters s_{u} and s_{l}, in decibels, are given by the following equations :

$$s_{\mathrm{u}} = b_{\mathrm{u}} + 0{,}445\ H_{\mathrm{md},Y} \quad \ldots \quad (2)$$

$$s_{\mathrm{l}} = b_{\mathrm{l}} + 0{,}356\ H_{\mathrm{md},Y} \quad \ldots \quad (3)$$

where b_{u} and b_{l} have the values given in table 2.

NOTE — The parameters s_{u} and s_{l} are defined so that they correspond to the standard deviation of the full normal distributions of which the upper and lower halves respectively comprise the actual distribution of hearing threshold levels.

Table 2 — Values of the parameters b_{u} and b_{l} used to determine respectively the upper and lower parts of the statistical distribution of hearing threshold levels, centred on the median value, for an otologically normal population of given age

Frequency in Hz	Value of b_{u}, in dB		Value of b_{l}, in dB	
	Males	Females	Males	Females
125	7,23	6,67	5,78	5,34
250	6,67	6,12	5,34	4,89
500	6,12	6,12	4,89	4,89
1 000	6,12	6,12	4,89	4,89
1 500	6,67	6,67	5,34	5,34
2 000	7,23	6,67	5,78	5,34
3 000	7,78	7,23	6,23	5,78
4 000	8,34	7,78	6,67	6,23
6 000	9,45	8,90	7,56	7,12
8 000	10,56	10,56	8,45	8,45

To calculate s_u, refer to table 2 for the appropriate frequency and sex to determine b_u and then apply equation (2) to determine s_u. Similarly, determine b_l from table 2 and then apply equation (3) to determine s_l.

4.2.2 To determine the hearing threshold level which can be expected to be exceeded by a given fraction, Q, of an otologically normal population of given age, proceed as described in 4.2.2.1 or 4.2.2.2.

NOTE — Values are given, for selected values of the parameters, in annex B.

4.2.2.1 For a fraction Q of the population such that $0,05 < Q < 0,5$, the value is given by the following equation :

$$H_{Q,Y} = H_{md,Y} + k \times s_u \quad \ldots \quad (4)$$

where k is a function of Q as specified in 4.2.2.3.

4.2.2.2 For a fraction Q of the population such that $0,5 < Q < 0,95$, the value is given by the following equation :

$$H_{Q,Y} = H_{md,Y} - k \times s_l \quad \ldots \quad (5)$$

where k is a function of Q as specified in 4.2.2.3.

4.2.2.3 Values of the multiplier k, corresponding to the normal (Gaussian) distribution, are given in table 3 for values of the fraction Q at intervals of 0,01 (1 %) from 0,05 to 0,95 (5 % to 95 %).

Table 3 — Values of the multiplier k

Q		k	Q		k
0,05	0,95	1,645	0,26	0,74	0,643
0,06	0,94	1,555	0,27	0,73	0,613
0,07	0,93	1,476	0,28	0,72	0,583
0,08	0,92	1,405	0,29	0,71	0,553
0,09	0,91	1,341	0,30	0,70	0,524
0,10	0,90	1,282	0,31	0,69	0,496
0,11	0,89	1,227	0,32	0,68	0,468
0,12	0,88	1,175	0,33	0,67	0,440
0,13	0,87	1,126	0,34	0,66	0,413
0,14	0,86	1,080	0,35	0,65	0,385
0,15	0,85	1,036	0,36	0,64	0,359
0,16	0,84	0,995	0,37	0,63	0,332
0,17	0,83	0,954	0,38	0,62	0,306
0,18	0,82	0,915	0,39	0,61	0,279
0,19	0,81	0,878	0,40	0,60	0,253
0,20	0,80	0,842	0,41	0,59	0,228
0,21	0,79	0,806	0,42	0,58	0,202
0,22	0,78	0,772	0,43	0,57	0,176
0,23	0,77	0,739	0,44	0,56	0,151
0,24	0,76	0,706	0,45	0,55	0,126
0,25	0,75	0,675	0,46	0,54	0,100
			0,47	0,53	0,075
			0,48	0,52	0,050
			0,49	0,51	0,025
			0,50		0,000

NOTE — Due to uncertainties in the experimental data on which this International Standard is based, tails of the statistical distributions for $0 < Q < 0,05$ and for $0,95 < Q < 1$ are unreliable and are not tabulated.

Annex A

Numerical example to illustrate the procedure

(This annex does not form an integral part of the standard.)

A.1 Example

Calculate the hearing threshold level exceeded by 25 % of an otologically normal male population of age 60 years at the audiometric frequency 4 000 Hz.

A.2 Procedure

Step 1 : Table 1, males, 4 000 Hz, gives $\alpha = 0{,}016$ dB/year^2

Step 2 : Equation (1), $Y = 60$ years, $\alpha = 0{,}016$ dB/year^2, gives $H_{md,60} = 28{,}2$ dB + $H_{md,18} = 28{,}2$ dB

(See the note to 4.1.)

Step 3 : Table 2, males, 4 000 Hz, gives $b_u = 8{,}34$ dB

NOTE — The example concerns 25 % of the population (upper quartile), hence the required parameter is that for the distribution above the median, i.e. b_u.

Step 4 : Equation (2), $b_u = 8{,}34$ dB, $H_{md,60} = 28{,}2$ dB, gives $s_u = 20{,}89$ dB

Step 5 : Table 3, $Q = 0{,}25$ (25 %), gives $k = 0{,}675$

Step 6 : Equation (4), $H_{md,60} = 28{,}2$ dB, $k = 0{,}675$, $s_u = 20{,}89$ dB, gives the required hearing threshold level, $H_{25,60} = 42{,}3$ dB

Step 7 : The result should be rounded to the nearest integer, 42 dB.

Annex B

Selected values of median threshold shift and of statistical distribution

(This annex does not form an integral part of the standard.)

Values of the median threshold deviation [see 4.1, equation (1)] and of the statistical distribution [see 4.2.2.1, equation (4) and 4.2.2.2, equation (5)] are given in table 4 below for selected values of the parameters.

NOTE — Reference [18] contains more extensive tables derived from the same equations.

Table 4 — Values, rounded to the nearest whole decibel, of hearing threshold deviation at frequencies from 125 to 8 000 Hz, expressed relative to the median hearing threshold level at 18 years of age, that can be expected to be exceeded by fractions from 0,1 to 0,9 (10 to 90 %) of otologically normal groups of males and females, at intervals of 10 years of age from 20 to 70 years

Frequency	Age	Males					Females				
in Hz	in years	0,9	0,75	0,5	0,25	0,1	0,9	0,75	0,5	0,25	0,1
125	20	−7	−4	0	5	9	−7	−4	0	5	9
	30	−7	−4	0	5	10	−7	−3	0	5	9
	40	−7	−3	2	7	12	−6	−2	2	6	11
	50	−6	−2	3	9	14	−5	−1	3	9	13
	60	−4	0	5	12	18	−4	0	5	11	17
	70	−3	2	8	15	22	−2	3	8	15	21
250	20	−7	−4	0	5	9	−6	−3	0	4	8
	30	−7	−3	0	5	9	−6	−3	0	5	9
	40	−6	−2	2	6	11	−5	−2	2	6	10
	50	−5	−1	3	9	13	−5	−1	3	8	13
	60	−4	0	5	11	17	−3	1	5	11	16
	70	−2	3	8	15	21	−2	3	8	15	21
500	20	−6	−3	0	4	8	−6	−3	0	4	8
	30	−6	−3	1	5	9	−6	−3	1	5	9
	40	−5	−2	2	6	11	−5	−2	2	6	11
	50	−4	−1	4	9	14	−4	−1	4	9	14
	60	−3	1	6	12	18	−3	1	6	12	18
	70	−1	4	10	16	23	−1	4	10	16	23
1 000	20	−6	−3	0	4	8	−6	−3	0	4	8
	30	−6	−3	1	5	9	−6	−3	1	5	9
	40	−5	−2	2	7	11	−5	−2	2	7	11
	50	−4	0	4	9	14	−4	0	4	9	14
	60	−2	2	7	13	19	−2	2	7	13	19
	70	0	5	11	18	25	0	5	11	18	25
1 500	20	−7	−4	0	5	9	−7	−4	0	5	9
	30	−6	−3	1	6	10	−6	−3	1	5	10
	40	−5	−2	3	8	13	−5	−2	2	8	12
	50	−4	1	6	12	17	−4	0	5	11	17
	60	−2	4	10	17	24	−2	3	9	16	22
	70	1	8	15	24	32	1	7	14	22	30

Table 4 (*concluded*)

Frequency	Age	Males					Females				
in Hz	in years	0,9	0,75	0,5	0,25	0,1	0,9	0,75	0,5	0,25	0,1
2 000	20	−7	− 4	0	5	9	−7	−4	0	5	9
	30	−7	− 3	1	6	11	−6	−3	1	6	10
	40	−6	− 1	3	9	15	−5	−1	3	8	13
	50	−3	2	7	14	21	−3	1	6	13	18
	60	−1	6	12	21	29	−1	4	11	18	25
	70	3	11	19	30	39	2	9	16	26	34
3 000	20	− 8	− 4	0	5	10	− 7	− 4	0	5	9
	30	− 7	− 3	2	7	13	− 7	− 3	1	6	11
	40	− 5	0	6	13	19	− 5	− 1	4	10	15
	50	− 2	5	12	21	29	− 3	2	8	15	21
	60	3	11	20	32	42	0	6	13	22	30
	70	9	19	31	46	59	4	12	20	31	41
4 000	20	− 8	− 4	0	6	11	− 8	− 4	0	5	10
	30	− 7	− 3	2	9	14	− 7	− 3	1	7	12
	40	− 4	1	8	16	23	− 6	− 1	4	11	17
	50	0	8	16	27	36	− 3	3	9	17	24
	60	7	17	28	42	55	1	8	16	26	35
	70	15	28	43	62	79	5	14	24	37	48
6 000	20	−10	− 5	0	7	12	− 9	− 5	0	6	12
	30	− 8	− 3	3	10	16	− 8	− 3	2	8	14
	40	− 5	2	9	18	26	− 6	0	6	14	21
	50	0	9	18	30	41	− 2	5	12	22	31
	60	8	19	32	48	62	2	11	21	34	45
	70	17	32	49	70	> 80	9	20	32	48	62
8 000	20	−11	− 6	0	7	14	−11	− 6	0	7	14
	30	− 9	− 3	3	11	19	−10	− 4	2	10	17
	40	− 5	2	11	21	30	− 7	0	7	17	25
	50	1	11	23	36	49	− 3	6	15	27	38
	60	10	24	39	58	75	4	14	27	42	55
	70	22	40	60	> 80	> 80	11	25	41	60	77

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