
**Acoustics — Statistical distribution of
hearing thresholds as a function of age**

*Acoustique — Distribution statistique des seuils d'audition en fonction de
l'âge*

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 7029 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

This second edition cancels and replaces the first edition (ISO 7029:1984). This edition presents the same data as the first edition so does not differ technically from that. At present data are not available to extend the tables beyond the age of 70.

Annexes A to C of this International Standard are for information only.

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Introduction

It is well known that the sensitivity of human hearing usually falls progressively with age and that the impairment of hearing develops more rapidly for sound at high frequencies than at low frequencies. Moreover, the magnitude of this effect varies considerably among individuals.

When testing the hearing of persons markedly over 18 years of age, part of any observed hearing loss will probably be associated with age, and it is important to be aware of this when estimating the amount of hearing loss attributable to other causes under investigation.

It should be noted that a decrease in hearing ability may not necessarily be caused by ageing itself, but by many injurious influences during life time, which are not known in detail.

This International Standard is based on a thorough examination of literature data on the change of hearing with age for populations of otologically normal persons as defined herein. Distinction is made between males and females since the difference is found to be of significance in the case of older age groups. The data have been derived from investigations using pure tones transmitted to the ear from an earphone, but no evidence is known that disqualifies their use for noise band stimuli or for sound transmitted to the ear from an external sound field.

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Acoustics — Statistical distribution of hearing thresholds as a function of age

1 Scope

This International Standard provides descriptive statistics of the hearing threshold for populations of various ages. It specifies the following, for the range of audiometric frequencies from 125 Hz to 8 000 Hz and for populations of otologically normal persons of a given age within the age limits of 18 years to 70 years inclusive:

- a) the expected median value of hearing thresholds given relative to the median hearing threshold at the age of 18 years;
- b) the expected statistical distribution above and below the median value.

The data are applicable for estimating the amount of hearing loss caused by a specific agent in a population. Such a comparison is valid if the population under study consists of persons who are otologically normal except for the effect of the specific agent. Noise exposure is an example of a specific agent and for this application selected data from this International Standard are referred to as "Data Base A" in ISO 1999.

The data may also be used to assess an individual's hearing in relation to the distribution of hearing thresholds which is normal for the person's age group. However, it is not possible to determine for an individual precisely which part of an observed hearing loss is attributable to an accumulation of detrimental effects on the hearing which increase with age, and which part has been caused by other factors such as noise.

The *hearing threshold deviation* as defined herein and the *hearing threshold level* as defined in other standards (ISO 389-1, ISO 8253-1, ISO 8253-2, IEC 60645-1) express the hearing threshold of an individual or an individual ear relative to, respectively,

- a) the median hearing threshold of a population of 18-year-old persons, or
- b) a reference zero level specified in various parts of ISO 389.

To the extent that the reference zero level represents the median of the 18-year-old population, the values of the two terms will be the same.

2 Terms and definitions

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

2.1

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 canals, and who has no history of undue exposure to noise

NOTE This definition is the one that was used to select subjects for the data presented in this International Standard. A stricter definition of an otologically normal person is presently used in hearing threshold standards (also excluding persons with a history of exposure to potentially ototoxic drugs and familial hearing loss).

2.2 hearing threshold deviation

ΔH
 threshold of hearing of an individual minus the median threshold of hearing of a population of 18-year-old otologically normal persons of the same sex

3 Specifications

3.1 General

The statistical distribution of hearing threshold deviations for otologically normal persons of a specific age Y and a specific sex is given in terms of the median value (see 3.2) and the distribution around the median (see 3.3).

3.2 Median

The median value $\Delta H_{md,Y}$ shall be given by the following equation:

$$\Delta H_{md,Y} = \alpha (Y - 18 \text{ years})^2 \tag{1}$$

Values of the coefficient α for males and females are given in Table 1. The range of Y for which equation (1) is valid is from 18 years to 70 years inclusive.

Table 1 — Values of the coefficient α

Frequency Hz	Values of α 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

3.3 Distribution around the median

The distribution around the median shall be approximated by the upper and lower halves, respectively, of two Gaussian distributions, each with their standard deviation s_u and s_l , given by the following equations:

$$s_u = b_u + 0,445 \Delta H_{md,Y} \tag{2}$$

$$s_l = b_l + 0,356 \Delta H_{md,Y} \tag{3}$$

where b_u and b_l have the values given in Table 2.

Table 2 — Values of parameters b_u and b_l

Frequency Hz	Value of b_u		Value of b_l	
	dB		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

3.4 Application of data

The hearing threshold deviation ($\Delta H_{Q,Y}$) which can be expected to be exceeded by a given fraction (Q) of an otologically normal population of given age (Y) and given sex, is given by equation (4) or (5):

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

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

Equation (4) applies when $0,05 \leq Q \leq 0,50$, whereas equation (5) applies when $0,50 < Q \leq 0,95$. Values of the multiplier k correspond to the Gaussian distribution. For information, these values are given in Table A.1.

Due to uncertainties in the experimental data on which this International Standard is based, tails of the statistical distributions are only reliable within the range $0,05 \leq Q \leq 0,95$.

The constants given in equations (2) and (3) and the data given in Tables 1 and 2 are the outcome of comprehensive statistical analyses. The accuracy provided is for calculation only, and the final results should be rounded to the nearest integer of a decibel.

An example of a calculation is given in annex B. Calculated values for a range of parameters are given in Table C.1.

Annex A
(informative)

Selected values of the Gaussian distribution

Table A.1 — Values of the multiplier k corresponding to the Gaussian distribution

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

Annex B (informative)

Numerical example to illustrate the procedure

B.1 Example

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

B.2 Calculation

Step 1: Table 1, males, 4 000 Hz, gives $\alpha = 0,016$ dB/year².

Step 2: Equation (1), $Y = 60$ years, $\alpha = 0,016$ dB/year², gives $\Delta H_{\text{md},60} = 28,2$ dB.

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, $\Delta H_{\text{md},60} = 28,2$ dB gives $s_u = 20,89$ dB.

Step 5: Table A.1, $Q = 0,25$ (25 %), gives $k = 0,675$.

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

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

Annex C
(informative)

Selected values of the statistical distribution of hearing threshold deviations

Table C.1 — Hearing threshold deviation (ΔH) which can be expected to be exceeded by a given fraction (Q) of an otologically normal population ^a

Frequency Hz	Age years	Males					Females				
		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	9	16	23	-1	4	9	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
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

Table C.1 (continued)

Frequency Hz	Age years	Males					Females				
		0,9	0,75	0,5	0,25	0,1	0,9	0,75	0,5	0,25	0,1
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
8000	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

^a Values are rounded to the nearest decibel.

NOTE Reference [25] contains further tables for a more extensive range of parameters.