BRITISH STANDARD

BS EN ISO 4869-2:1995

Incorporating amendment no. 1 and corrigendum no. 1

Acoustics — Hearing protectors —

Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn

ICS 13.140; 13.340.20

British Standards

National foreword

This British Standard is the UK implementation of EN ISO 4869-2:1995, incorporating corrigendum June 2007. It is identical with ISO 4869-2:1994, incorporating corrigendum September 2006.

The UK participation in its preparation was entrusted to Technical Committee EPC/1, Acoustics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Board and comes into effect on 15 March 1995

ISBN 978 0 580 59311 6

Amendments issued since publication

Amd. No.	Date	Comments
8935	December 1995	Renumbers BS ISO 4869-2:1995 as BS EN ISO 4869-2:1995
17353 Corrigendum No. 1	28 September 2007	Correction to equation (2) and addition of note to Table 2

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 4869-2

June 1995

ICS 13.140

Incorporating corrigendum June 2007

Descriptors: Acoustics, safety devices, hearing protectors, tests, performance tests, acoustic tests, determination, sound pressure, attenuation, rules of calculation

English version

Acoustics — Hearing protectors — Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn

(ISO 4869-2:1994)

Acoustique — Protecteurs individuels contre le bruit — Partie 2: Estimation des niveaux de pression acoustique pondérés A en cas d'utilisation de protecteurs individuels contre le bruit (ISO 4869-2:1994)

Akustik — Gehörschützer — Teil 2: Abschätzung der beim Tragen von Gehörschützern wirksamen A-bewerteten Schalldruckpegel (ISO 4869-2:1994)

This European Standard was approved by CEN on 1995-04-27. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN ISO 4869-2:1995 E

Foreword

The text of the International Standard from ISO/TC 43, Acoustics, of the International Organization for Standardization (ISO) has been taken over as a European Standard by the Technical Committee CEN/TC 211, Acoustics.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 1995, and conflicting national standards shall be withdrawn at the latest by December 1995.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

INTERNATIONAL STANDARD

ISO 4869-2

First edition
1994-09-01

Acoustics — Hearing protectors —

Part 2:
Estimation of effective A-weighted sound pressure levels when hearing protectors are worn

Acoustique — Protecteurs individuels contre le bruit —

Partie 2: Estimation des niveaux de pression acoustique pondérés A en cas d'utilisation de protecteurs individuels contre le bruit

Reference number
ISO 4869-2:1994(E)

Contents

Descriptors: Acoustics, safety devices, hearing protectors, tests, performance tests, acoustic tests, determination, sound pressure, attenuation, rules of calculation.

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.

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.

International Standard ISO 4869-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 4869 consists of the following parts, under the general title *Acoustics — Hearing protectors*:

— *Part 1: Subjective method for the measurement of sound attenuation;*

— *Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn;*

— *Part 3: Simplified method for the measurement of insertion loss of ear-muff type protectors for quality inspection purposes;*

[Technical Report]

— *Part 4: Methods for the measurement of sound attenuation of amplitude-sensitive hearing protectors.*

Annex A, Annex B, Annex C, Annex D and Annex E of this part of ISO 4869 are for information only.

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Introduction

Ideally, the A-weighted sound pressure level effective when a hearing protector is worn should be estimated on the basis of both the octave-band sound attenuation data of the hearing protector (measured in accordance with ISO 4869-1) and the octave-band sound pressure levels of the noise. It is recognized, however, that in many situations information on the octave-band sound pressure levels of the noise might not be available. Therefore, for many practical purposes, there is a need for simpler methods to determine the effective A-weighted sound pressure levels which are only based on the A- and C-weighted sound pressure levels of the noise. This part of ISO 4869 addresses both of these situations by specifying an octave-band calculation method as well as two alternative simplified procedures, the HML method and the SNR method.

The octave-band method is a straightforward calculation method involving the workplace octave-band sound pressure levels and the octave-band sound attenuation data for the hearing protector which is being assessed. Although it can be thought of as an "exact" reference method, it has its own inherent inaccuracies, since it is based upon *mean* sound attenuation values and standard deviations and not the specific sound attenuation values for the individual person in question.

The HML method specifies three attenuation values, H, M and L, determined from the octave-band sound attenuation data of a hearing protector. These values, when combined with the C- and A-weighted sound pressure levels of the noise, are used to calculate the effective A-weighted sound pressure level when the hearing protector is worn.

The SNR method specifies a single attenuation value, the single number rating reduction, determined from the octave-band sound attenuation data of a hearing protector. This value is subtracted from the C-weighted sound pressure level of the noise to calculate the effective A-weighted sound pressure level when the hearing protector is worn.

Due to the large spread of the sound attenuation provided by hearing protectors when worn by individual persons, all three methods are nearly equivalent in their accuracy in the majority of noise situations. Even the simplest method, the SNR method, will provide a reasonably accurate estimate of the effective A-weighted sound pressure level to aid in the selection and specification of hearing protectors. In special situations, for example especially high- or low-frequency noises, it may, however, be advantageous to use either the HML or the octave-band method.

Depending on the choice of a certain parameter in the calculation process, various protection performances can be obtained. It should be noted that the protection performance values for all three methods are only valid when:

- — the hearing protectors are worn correctly and in the same manner as they were worn by subjects when carrying out the ISO 4869-1 test;
- — the hearing protectors are properly maintained;
- — the anatomical characteristics of the subjects involved in the ISO 4869-1 test are a reasonable match for the population of actual wearers.

Thus, the principal source of potential inaccuracy in use of the three methods described in this part of ISO 4869 is the basic ISO 4869-1 input data. If the input data do not accurately describe the degree of protection achieved by the target population, then no calculation method will provide sufficient accuracy.

NOTE 1 Differences of 3 dB or less in the determination of the effective sound pressure level for comparable hearing protectors are insignificant for the purposes of distinguishing between the hearing protectors.

NOTE 2 Caution should be exercised to avoid the selection of hearing protectors which provide unnecessarily high attenuation. Such devices might cause communication difficulties or be less comfortable than ones with lower sound attenuation and therefore they might be worn for less of the time.

1 Scope

This part of ISO 4869 describes three methods (the octave-band, HML and SNR methods) of estimating the A-weighted sound pressure levels effective when hearing protectors are worn. The methods are applicable to either the sound pressure level or the equivalent continuous sound pressure level of the noise. Although primarily intended for steady noise exposures, the methods are also applicable to noises containing impulsive components. These methods are not suitable for use with peak sound pressure level measurements.

The octave-band, H, M, L or SNR values are suitable for establishing sound attenuation criteria for selecting or comparing hearing protectors, and/or setting minimum acceptable sound attenuation requirements.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 4869. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 4869 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4869-1:1990, *Acoustics — Hearing protectors — Part 1: Subjective method for the measurement of sound attenuation.*

IEC 651:1979, *Sound level meters.*

3 Definitions

For the purposes of this part of ISO 4869, the definitions given in ISO 4869-1 and the following definitions apply.

3.1

protection performance

the percentage of situations for which the A-weighted sound pressure level effective when the hearing protector is worn is equal to or less than the predicted value

the value is designated by adding a subscript to the attenuation values according to the different methods, e.g. H_{80}, M_{80}, L_{80}, SNR_{80}

NOTE 3 The value of protection performance is often chosen to be 84 % [corresponding to the constant $\alpha = 1$ (see clause **5**)]. In this case, the subscripts to the attenuation values may be omitted.

NOTE 4 A situation is a combination of a particular individual wearing a given hearing protector in a specific noise environment.

3.2

effective A-weighted sound pressure level, L'_{Ax}

for a specified protection performance, x, and a specific noise situation, the A-weighted sound pressure level effective when a given hearing protector is worn, calculated in accordance with any of the three methods specified in this part of ISO 4869

3.3

predicted noise level reduction, PNR_x

for a specified protection performance, x, and a specific noise situation, the difference between the A-weighted sound pressure level of the noise, L_A, and the effective A-weighted sound pressure level, L'_{Ax}, when a given hearing protector is worn

3.4

high-frequency attenuation value, H_x

for a specified protection performance, x, and a given hearing protector, a value representing the predicted noise level reduction, PNR_x, for noises with $(L_C - L_A) = -2$ dB

3.5

medium-frequency attenuation value, M_x

for a specified protection performance, x, and a given hearing protector, a value representing the predicted noise level reduction, PNR_x, for noises with $(L_C - L_A) = +2$ dB

3.6

low-frequency attenuation value, L_x

for a specified protection performance, x, and a given hearing protector, a value representing the predicted noise level reduction, PNR_x, for noises with $(L_C - L_A) = +10$ dB

3.7
single number rating, SNR_x

for a specified protection performance, *x*, and a given hearing protector, the value which is subtracted from the measured C-weighted sound pressure level, L_C, in order to estimate the effective A-weighted sound pressure level, L'_{Ax}

3.8
pink noise

noise whose power spectral density is inversely proportional to frequency

NOTE 5 A consequence of this property of pink noise is that its unweighted octave-band sound pressure levels are the same for all octave bands.

4 Measurement of sound attenuation of hearing protectors

The one-third-octave band attenuation values of the hearing protector to be used in the calculation methods specified in this part of ISO 4869 shall be measured in accordance with ISO 4869-1.

5 Calculation of the assumed protection value, APV_{fx}, of a hearing protector for a selected protection performance

The calculation begins with the selection of the desired protection performance, *x*, and the associated constant α (see Table 1).

The assumed protection value, APV_{fx}, of the hearing protector is calculated for each octave band, in the range 63 Hz to 8 000 Hz, using the following equation:

$$APV_{fx} = m_f - \alpha s_f \quad \text{... (1)}$$

where

subscript f represents the centre frequency of the octave band;
subscript x represents the selected protection performance;
m_f is the mean sound attenuation determined in accordance with ISO 4869-1;
s_f is the standard deviation determined in accordance with ISO 4869-1;
α is a constant, having the values given in Table 1.

NOTE 6 If any values are not available at 63 Hz, then the values of m_f and s_f for 125 Hz should be used.

Table 1 — Values of α for various protection performances *x*

Protection performance *x*, %	Value of α
75	0,67
80	0,84
84	1,00
85	1,04
90	1,28
95	1,64

An example of the calculation of the assumed protection values, APV_{fx}, is given in Annex A.

6 Octave-band method

This method requires octave-band sound pressure levels of the noise and assumed protection values, APV_{fx}. Since the method is noise specific, the calculation shall be made for each noise situation.

The A-weighted sound pressure level effective when the hearing protector is worn, L'_{Ax}, is calculated using the following equation:

$$L'_{Ax} = 10 \lg \sum_{k=1}^{8} 10^{0,1(L_{f(k)} + A_{f(k)} - APV_{f(k)x})} dB \quad \text{... (2)}$$

where

subscripts $f(k)$ represent the octave-band mid-frequency;

$f(1)$ = 63 Hz; $f(2)$ = 125 Hz; $f(3)$ = 250 Hz ...

$f(8)$ = 8 000 Hz;

$L_{f(k)}$ is the sound pressure level of the noise in the octave band;

$A_{f(k)}$ is the frequency weighting A in accordance with IEC 651 at the octave-band mid-frequencies (see Table B.1).

NOTE 7 If 63 Hz octave-band data for the noise are not available, then the summation in equation (2) begins at 125 Hz.

The resulting L'_{Ax} value shall be rounded to the nearest integer.

An example of the calculation of the A-weighted sound pressure level effective when a given hearing protector is worn in a specific noise is given in Annex B.

7 HML method

This method requires C- and A-weighted sound pressure levels of the noise and H, M and L values.

7.1 Calculation of H, M and L values

Calculation of the H_x, M_x and L_x values is based on eight reference noise spectra with different ($L_C - L_A$) values (see Table 2) and the assumed protection values, APV_{fx}, of the hearing protector. The values are independent of the actual noise situation to which they are applied, and are calculated using the following equations:

$$H_x = 0,25 \sum_{i=1}^{4} PNR_{xi} - 0,48 \sum_{i=1}^{4} d_i PNR_{xi} \quad \text{... (3)}$$

$$M_x = 0,25 \sum_{i=5}^{8} PNR_{xi} - 0,16 \sum_{i=5}^{8} d_i PNR_{xi} \quad \text{... (4)}$$

$$L_x = 0,25 \sum_{i=5}^{8} PNR_{xi} + 0,23 \sum_{i=5}^{8} d_i PNR_{xi} \quad \text{... (5)}$$

where

$$PNR_{xi} = 100 \text{ dB} - 10 \lg \sum_{k=1}^{8} 10^{0,1(L_{Af(k)i} - APV_{f(k)x})} \text{ dB} \quad \text{... (6)}$$

$L_{Af(k)i}$ and d_i values are given in Table 2;

subscript i represents the number of the reference noise spectrum.

NOTE 8 In equation (6), the value of 100 dB represents the total A-weighted sound pressure level of each of the noises in Table 2.

The resulting H_x, M_x and L_x values shall be rounded to the nearest integer.

An example of the calculation of the H, M and L values is given in Annex C.

Table 2 — A-weighted octave-band sound pressure levels, $L_{Af(k)i}$, of eight reference noises normalized to an A-weighted sound pressure level of 100 dB, ($L_C - L_A$) values and constants d_i

Values in decibels

i	Octave-band centre frequency, Hz								($L_C - L_A$)	d_i
	63	125	250	500	1 000	2 000	4 000	8 000		
1	51,4	62,6	70,8	81,0	90,4	96,2	94,7	92,3	– 1,2	– 1,20
2	59,5	68,9	78,3	84,3	92,8	96,3	94,0	90,0	– 0,5	– 0,49
3	59,8	71,1	80,8	88,0	95,0	94,4	94,1	89,0	0,1	0,14
4	65,4	77,2	84,5	89,8	95,5	94,3	92,5	88,8	1,6	1,56
5	65,3	77,4	86,5	92,5	96,4	93,0	90,4	83,7	2,3	– 2,98
6	70,7	82,0	89,3	93,3	95,6	93,0	90,1	83,0	4,3	– 1,01
7	75,6	84,2	90,1	93,6	96,2	91,3	87,9	81,9	6,1	0,85
8	77,6	88,0	93,4	93,8	94,2	91,4	87,9	79,9	8,4	3,14

NOTE 1 d_i is an empirically derived number [2], [3].

NOTE 2 The value of 100 dB for the total A-weighted sound pressure level, L_A, is arbitrary and was chosen for computational simplicity.

7.2 Application of HML method for estimation of the effective A-weighted sound pressure level

The effective A-weighted sound pressure level, L'_{Ax}, is calculated in two steps as follows.

a) The predicted noise level reduction, PNR_x, is calculated from the H_x, M_x and L_x values and the C- and A-weighted sound pressure levels of the noise. The calculations are as follows.

For noises with ($L_C - L_A$) values ⩽ 2 dB

$$PNR_x = M_x - \frac{H_x - M_x}{4}(L_C - L_A - 2\text{ dB}) \quad \text{... (7)}$$

For noises with ($L_C - L_A$) values ⩾ 2 dB

$$PNR_x = M_x - \frac{M_x - L_x}{8}(L_C - L_A - 2\text{ dB}) \quad \text{... (8)}$$

b) L'_{Ax} is calculated from the following equation:

$$L'_{Ax} = L_A - PNR_x \quad \text{... (9)}$$

The resulting L'_{Ax} value shall be rounded to the nearest integer.

NOTE 9 The difference ($L_C - L_A$) may be determined from sound pressure level measurements, or may be provided in tabulated form for typical noise situations.

NOTE 10 Instead of the C-weighted sound pressure level, the unweighted sound pressure level may be used. For very low frequency noises, this procedure can result in higher values of L'_{Ax}.

An example of the calculation of the A-weighted sound pressure level effective when a given hearing protector is worn in a specific noise is given in Annex C.

8 SNR method

This method requires the C-weighted sound pressure level of the noise and the SNR value.

8.1 Calculation of SNR values

Calculation of SNR_x values is based on a pink noise spectrum (see Table 3) and the assumed protection values, $APV_{f(k)x}$, of the hearing protector. SNR_x is independent of the actual noise spectrum to which it is applied and is calculated using the following equation:

$$SNR_x = 100\text{ dB} - 10\lg\sum_{k=1}^{8}10^{0,1(L_{Af(k)} - APV_{f(k)x})}\text{ dB} \quad \text{... (10)}$$

where $L_{Af(k)}$ is given in Table 3.

NOTE 11 In equation (10) the value of 100 dB represents the total C-weighted sound pressure level of the reference pink noise in Table 3.

The resulting SNR_x value shall be rounded to the nearest integer.

An example of the calculation of SNR is given in Annex D.

8.2 Application of SNR method for estimation of the effective A-weighted sound pressure level

L'_{Ax} is calculated from SNR_x and the C-weighted sound pressure level of the noise using the following equation:

$$L'_{Ax} = L_C - SNR_x \qquad \text{... (11)}$$

When only the total A-weighted sound pressure level of a given noise is available, SNR may still be used if the difference ($L_C - L_A$) is known (see notes 12 and 13). L'_{Ax} is then given by:

$$L'_{Ax} = L_A + (L_C - L_A) - SNR_x \qquad \text{... (12)}$$

NOTE 12 The difference ($L_C - L_A$) can be estimated from sound pressure level measurements, or may be provided in tabulated form for typical noise situations.

NOTE 13 Instead of the C-weighted sound pressure level, the unweighted sound pressure level may be used. For very low frequency noises, this procedure can result in higher values of L'_{Ax}.

An example of the calculation of the A-weighted sound pressure level effective when a given hearing protector is worn in a specific noise is given in Annex D.

Table 3 — A-weighted octave-band sound pressure levels, $L_{Af(k)}$, of a pink noise which has a C-weighted sound pressure level of 100 dB

Octave-band centre frequency, *f*, Hz	63	125	250	500	1 000	2 000	4 000	8 000
$L_{Af(k)}$, dB	65,3	75,4	82,9	88,3	91,5	92,7	92,5	90,4

NOTE The values in this table are derived from a pink noise with an overall C-weighted sound pressure level of 100 dB. The magnitude of the level was chosen for computational simplicity and does not affect the resulting SNR. Frequency weighting C is defined in IEC 651.

Annex A (informative)
Example of the calculation of the assumed protection values, APV_{fx}

In this example, the APV_{f80} values for a hearing protector are calculated; i.e. a protection performance of 80 % is selected, with a corresponding constant α = 0,84 (see Table 1). These APV_{f80} values are then used in calculations for all illustrative examples.

Table A.1 — Calculation of APV_{f80}

Values in decibels

	Octave-band centre frequency, *f*, Hz							
	63	125	250	500	1 000	2 000	4 000	8 000
m_f	7,4	10,0	14,4	19,6	22,8	29,6	38,8	34,1
s_f	3,3	3,6	3,6	4,6	4,0	6,2	7,4	5,2
αs_f (α = 0,84)	2,8	3,0	3,0	3,9	3,4	5,2	6,2	4,4
$APV_{f80} = m_f - \alpha s_f$	4,6	7,0	11,4	15,7	19,4	24,4	32,6	29,7

Annex B (informative)
Example of the calculation of L'_{Ax} according to the octave-band method

In this example, a protection performance of 80 % is selected. The APV_{f80} values are taken from Table A.1.

Table B.1 — Calculation of L'_{A80} using the octave-band method

Values in decibels

	Octave-band centre frequency, *f*, Hz							
	63	125	250	500	1 000	2 000	4 000	8 000
Measured octave-band sound pressure level of the noise, L_f	75,0	84,0	86,0	88,0	97,0	99,0	97,0	96,0
Frequency weighting A (according to IEC 651)	– 26,2	– 16,1	– 8,6	– 3,2	0	+ 1,2	+ 1,0	– 1,1
A-weighted octave-band sound pressure level of the noise, $L_f + A_{f(k)}$	48,8	67,9	77,4	84,8	97,0	100,2	98,0	94,9
APV_{f80} from Table A.1	4,6	7,0	11,4	15,7	19,4	24,4	32,6	29,7
$L_f + A_{f(k)} - APV_{f80}$	44,2	60,9	66,0	69,1	77,6	75,8	65,4	65,2

L'_{A80} is calculated by substituting the values from the last row of Table B.1 into equation (2):

$$L'_{A80} = 10 \lg(10^{0,1 \times 44,2} + ... + 10^{0,1 \times 65,2}) \text{ dB} = 80,6 \text{ dB}$$

After rounding, L'_{A80} = 81 dB.

It can then be stated that the effective A-weighted sound pressure level will be less than or equal to 81 dB in 80 % of the situations when the hearing protector is properly worn by various people in this noise environment.

NOTE 14 The difference between L_A and L'_{A80} is the predicted noise level reduction, PNR_{80}, which in this example is equal to 23 dB.

Annex C (informative)
Example of calculation and use of H, M and L values

C.1 Calculation of H, M and L values for a particular hearing protector

Using the APV_{f80} values from Annex A and the A-weighted octave-band sound pressure levels, $L_{Af(k)i}$, from Table 2, ($L_{Af(k)i} - APV_{f80}$) is calculated as shown below.

Table C.1 — Calculation of the difference between $L_{Af(k)i}$ and APV_{f80}

Values in decibels

	Octave-band centre frequency, *f*, Hz							
	63	125	250	500	1 000	2 000	4 000	8 000
$L_{Af(k)1}$	51,4	62,6	70,8	81,0	90,4	96,2	94,7	92,3
$L_{Af(k)2}$	59,5	68,9	78,3	84,3	92,8	96,3	94,0	90,0
$L_{Af(k)3}$	59,8	71,1	80,8	88,0	95,0	94,4	94,1	89,0
$L_{Af(k)4}$	65,4	77,2	84,5	89,8	95,5	94,3	92,5	88,8
$L_{Af(k)5}$	65,3	77,4	86,5	92,5	96,4	93,0	90,4	83,7
$L_{Af(k)6}$	70,7	82,0	89,4	93,5	95,6	93,0	90,1	83,0
$L_{Af(k)7}$	75,6	84,2	90,1	93,6	96,2	91,3	87,9	81,9
$L_{Af(k)8}$	77,6	88,0	93,4	93,8	94,2	91,4	87,9	79,9
APV_{f80} from Table A.1	4,6	7,0	11,4	15,7	19,4	24,4	32,6	29,7
$L_{Af(k)1} - APV_{f80}$	46,8	55,6	59,4	65,3	71,0	71,8	62,1	62,6
$L_{Af(k)2} - APV_{f80}$	54,9	61,9	66,9	68,6	73,4	71,9	61,4	60,3
$L_{Af(k)3} - APV_{f80}$	55,2	64,1	69,4	72,3	75,6	70,0	61,5	59,3
$L_{Af(k)4} - APV_{f80}$	60,8	70,2	73,1	74,1	76,1	69,9	59,9	59,1
$L_{Af(k)5} - APV_{f80}$	60,7	70,4	75,1	76,8	77,0	68,6	57,8	54,0
$L_{Af(k)6} - APV_{f80}$	66,1	75,0	77,9	77,6	76,2	68,6	57,5	53,3
$L_{Af(k)7} - APV_{f80}$	71,0	77,2	78,7	77,9	76,8	66,9	55,3	52,2
$L_{Af(k)8} - APV_{f80}$	73,0	81,0	82,0	78,1	74,8	67,0	55,3	50,2

The eight $PNR_{i(80)}$ values are calculated by substituting the differences from Table C.1 into equation (6) as follows:

$$PNR_{1(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 46,8} + ... + 10^{0,1 \times 62,6}) = 24,5 \text{ dB}$$

$$PNR_{2(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 54,9} + ... + 10^{0,1 \times 60,3}) = 22,7 \text{ dB}$$

$$PNR_{3(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 55,2} + ... + 10^{0,1 \times 59,3}) = 21,1 \text{ dB}$$

$$PNR_{4(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 60,8} + ... + 10^{0,1 \times 59,1}) = 19,6 \text{ dB}$$

$$PNR_{5(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 60,7} + ... + 10^{0,1 \times 54,0}) = 18,2 \text{ dB}$$

$$PNR_{6(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 66,1} + ... + 10^{0,1 \times 53,3}) = 16,9 \text{ dB}$$

$$PNR_{7(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 71,0} + ... + 10^{0,1 \times 52,2}) = 15,9 \text{ dB}$$

$$PNR_{8(80)} = 100 \text{ dB} - 10 \lg(10^{0,1 \times 73,0} + ... + 10^{0,1 \times 50,2}) = 13,9 \text{ dB}$$

The H_{80}, M_{80} and L_{80} values are calculated using equations (3), (4) and (5), and the $PNR_{i(80)}$ values above and the constants d_i from Table 2 as shown below, and the values are rounded to the nearest integer:

$$H_{80} = 0,25(24,5 + ... + 19,6) - 0,48(-1,20 \times 24,5 + ... + 1,56 \times 19,6) \text{ dB} = 25 \text{ dB}$$

$$M_{80} = 0,25(18,2 + ... + 13,9) - 0,16(-2,98 \times 18,2 + ... + 3,14 \times 13,9) \text{ dB} = 18 \text{ dB}$$

$$L_{80} = 0,25(18,2 + ... + 13,9) + 0,23(-2,98 \times 18,2 + ... + 3,14 \times 13,9) \text{ dB} = 13 \text{ dB}$$

C.2 Use of H_{80}, M_{80} and L_{80} values to estimate L'_{A80} for a particular hearing protector in a specific noise situation

The effective A-weighted sound pressure level, L'_{A80}, for a hearing protector with given H_{80}, M_{80} and L_{80} values (from Table C.1) and a specific noise situation can be estimated in two steps as follows.

a) The difference ($L_C - L_A$) is calculated. Using the noise spectrum from Annex B gives ($L_C - L_A$) = – 1 dB. The predicted noise level reduction, PNR_{80}, is calculated using equation (7) as follows:

$$PNR_{80} = 18 \text{ dB} - \frac{25 - 18}{4}(-1 - 2) \text{ dB} = 23,3 \text{ dB}$$

b) The A-weighted sound pressure level, L_A, of the noise spectrum from Annex B is equal to 104 dB. The effective A-weighted sound pressure level, L'_{A80}, is calculated using equation (9) as follows:

$$L'_{A80} = 104 \text{ dB} - 23,3 \text{ dB} = 80,7 \text{ dB}$$

This value is rounded to the nearest integer. It can then be stated that the effective A-weighted sound pressure level will be less than or equal to 81 dB in 80 % of the situations when the hearing protector is properly worn by various people in this noise environment.

Annex D (informative) Example of the calculation and use of SNR values

D.1 Calculation of the SNR value for a particular hearing protector

In this example, a protection performance of 80 % is selected. Using the APV_{f80} values from Annex A and the $L_{\text{A}f(k)}$ values from Table 3, the SNR value is calculated (Table D.1).

Table D.1 — Calculation of the difference between $L_{\text{A}f(k)}$ and APV_{f80}

Values in decibels

	Octave-band centre frequency, *f*, Hz							
	63	125	250	500	1 000	2 000	4 000	8 000
$L_{\text{A}f(k)}$ from Table 3	65,3	75,4	82,9	88,3	91,5	92,7	92,5	90,4
APV_{f80} from Annex A	4,6	7,0	11,4	15,7	19,4	24,4	32,6	29,7
$L_{\text{A}f(k)} - \text{APV}_{f80}$	60,7	68,4	71,5	72,6	72,1	68,3	59,9	60,7

SNR_{80} is calculated using equation (10) and rounded to the nearest integer:

$$\text{SNR}_{80} = 100\ \text{dB} - 10\ \lg(10^{0,1 \times 60,7} + 10^{0,1 \times 68,4} + ... + 10^{0,1 \times 60,7})\ \text{dB} = 22\ \text{dB}$$

D.2 Use of the SNR_{80} value to estimate L'_{A80} for a particular hearing protector in a specific noise situation for which L_{C} is known

The effective A-weighted sound pressure level, L'_{A80}, for a hearing protector with a given SNR_{80} (from **D.1**) can be estimated from the measured C-weighted sound pressure level of a specific noise. Using the noise spectrum from Annex B, gives $L_{\text{C}} = 103$ dB.

L'_{A80} is calculated using equation (11) as follows:

$$L'_{\text{A80}} = 103\ \text{dB} - 22\ \text{dB} = 81\ \text{dB}$$

It can then be stated that the effective A-weighted sound pressure level, L'_{A80}, will be less than or equal to 81 dB in 80 % of the situations when the hearing protector is properly worn by various people in this noise environment.

D.3 Use of the SNR_{80} value to estimate L'_{A80} for a particular hearing protector in a specific noise situation in which the A-weighted sound pressure level has been measured and a reasonable estimate of ($L_{\text{C}} - L_{\text{A}}$) is available

The effective A-weighted sound pressure level, L'_{A80}, for a hearing protector with a given SNR_{80} (from **D.1**) can be estimated from the measured A-weighted sound pressure level, L_{A}, and the estimated or measured ($L_{\text{C}} - L_{\text{A}}$) value of a specific noise. Using the noise spectrum from Annex B, gives $L_{\text{A}} = 104$ dB and $(L_{\text{C}} - L_{\text{A}}) = -1,0$ dB.

L'_{A80} is calculated using equation (12) as follows:

$$L'_{\text{A80}} = 104\ \text{dB} + (-1,0)\ \text{dB} - 22\ \text{dB} = 81\ \text{dB}$$

It can then be stated that the effective A-weighted sound pressure level, L'_{A80}, will be less than or equal to 81 dB in 80 % of the situations when the hearing protector is properly worn by various people in this noise environment.

Annex E (informative) Bibliography

[1] WAUGH, R. Simplified hearing protector ratings — An international comparison, *J. Sound Vib.*, **93**(2), 1984, pp. 289–305.

[2] LUNDIN, R. *Three methods for calculating the attenuation index of a hearing protector — A presentation and a comparison*, Bilsom AB, S-260 50 Billesholm, 1988.

[3] LUNDIN, R. New Nordic draft for calculating three attenuation parameters for hearing protectors and how to use them in practice. *Proceedings InterNoise 86*, Vol. 1, 1986.

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Annex ZA (normative)
Normative references to international publications with their relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

Publication	Year	Title	EN	Year
ISO 4869-1	1990	*Acoustics — Hearing protectors — Subjective method for the measurement of sound attenuation*	EN 24869-1	1992

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