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Specification for

● Sound level meters



(Implementation of CENELEC HD 425)

Spécification pour sonomètres

Spezifikation für Schallpegelmesser

British Standards Institution

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National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee and is identical with IEC Publication 651 'Sound level meters' published in 1979 by the International Electrotechnical Commission (IEC). IEC Publication 651 supersedes IEC Publications 123 : 1962 and 179 : 1973. This standard is also in agreement with the Harmonization Document 425 published by the European Committee for Electrotechnical Standardization (CENELEC).

Additional information is given in HD 425 to define the transfer functions for direct calculation of the values given in Table IV. These functions are defined in national appendix Z.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards.

Where page numbers are quoted in the text, they refer to IEC page numbers.

In some of the titles of the tables italic type has been used for unit symbols which, by convention, should be in roman type.

Attention is drawn to 2.3.3 of the IEC text and in particular to the sentence 'standardization of the I time weighting characteristic does not imply that the relationship between loudness or hearing damage risk of impulsive sounds and the physical characteristics of sounds is thereby precisely represented'.

For the purposes of this British Standard the above should be regarded as warning that reliance cannot be placed on the I time weighting characteristic for use in connection with noise measurement to determine loudness of the sounds and for assessing the risk of hearing impairment.

For information on the sound level meter characteristics to be used in any given noise measurement situation, reference should be made to the relevant standard(s), e.g. BS 5330 : 1976 'Method of test for estimating the risk of hearing handicap due to noise exposure'.

Cross-references

International standard

Corresponding British Standard

IEC 537 : 1976

BS 5721 : 1979 Specification for frequency weighting for the measurement of aircraft noise (D-weighting)
(Identical)

ISO 266-1975

BS 3593 : 1963 Recommendation on preferred frequencies for acoustical measurements
(Technically equivalent)

NOTE. In table VIII, the tolerance on 'F' for the Type 1 instrument should read ' ± 1 ' and not '+1' as printed. This error derives from a printer's error in IEC Publication 651 : 1979 and the IEC has been informed.

British Standard Specification for

Sound level meters

1. Scope

1.1 General

This standard describes instruments (sound level meters) for the measurement of certain frequency and time weighted sound pressure levels.

1.2 Types

This standard specifies sound level meters of four degrees of precision, designated Types 0, 1, 2 and 3.

1.3 Tolerances

The specifications for Types 0, 1, 2 and 3 sound level meters have the same centre values and differ only in the tolerances allowed. Tolerances generally broaden as the type number increases and differ for the various types to a degree which affects manufacturing costs significantly.

1.4 Characteristics specified

This standard specifies the following characteristics of sound level meters:

- a) directional characteristics;
- b) frequency weighting characteristics;
- c) time weighting, detector and indicator characteristics;
- d) sensitivity to various environments.

1.5 Tests specified

This standard specifies electrical and acoustical tests to verify compliance with the characteristics specified (see Sub-clause 1.4). It also describes the method for absolute sensitivity calibration.

2. Object and general requirements

2.1 Object

Owing to the complexity of operation of the human ear, it is not possible at present to design an objective noise measuring apparatus to give results which are absolutely comparable, for all types of noise, with those obtained by subjective methods. However, it is considered essential to standardize an apparatus by which sounds can be measured under closely defined conditions so that results obtained by users of such apparatus are always reproducible within stated tolerances.

The object of this standard is to ensure specified accuracy and stability of a particular sound level meter in practice, and to reduce to the practical minimum any differences in equivalent measurements taken with devices of various makes and models which satisfy the requirements of this standard.

2.2 Applications

The Type 0 sound level meter is intended as a laboratory reference standard. Type 1 is intended especially for laboratory use, and for field use where the acoustical environment can be closely specified and/or controlled; the measurement accuracy possible with such an instrument will generally not be realized under ordinary conditions. The Type 2 sound level meter is suitable for general field applications. Type 3 is intended primarily for field noise survey applications to determine whether an established noise limit has been significantly violated.

Sound level meters intended for field use have to meet rigorous environmental specifications. Other sound level meters are only used in laboratories where the environment is controlled, and it is not justifiable to require such instruments to meet the design constraints imposed on field instruments. The distinction is provided for in Sub-clauses 8.5 and 8.6 which specify additional requirements for instruments intended for field use.

2.3 Weighting characteristics

2.3.1 Frequency weighting

A sound level meter shall have one or more frequency weighting characteristics designated A, B and C. Optional weighting characteristics which may be included are:

- i) a characteristic designated Lin for which the response is constant as a function of frequency;
- ii) a characteristic designated D as specified in IEC Publication 537, Frequency Weighting for the Measurement of Aircraft Noise (D-weighting).

2.3.2 Time weighting

A sound level meter shall have one or more time weighting characteristics designated S, F and I. A Peak characteristic may also be included.

2.3.3 Significance of weighting characteristics

In the past, frequency weighting and time weighting have been associated with certain characteristics of the ear. However, recent work has not substantiated these historical associations so that frequency and time weighting characteristics of sound level meters may be considered to be conventional. The A weighting characteristic is now frequently specified for rating sounds irrespective of level and is no longer restricted to low level sounds. Furthermore, standardization of the I time weighting characteristic does not imply that the relationship between loudness or hearing damage risk of impulsive sounds and the physical characteristics of sounds is thereby precisely represented. However, a wide dynamic range, overload indication, and a high crest factor capability are necessary for the accurate measurement of short-duration sounds, and these characteristics are specified in this standard for sound level meters which incorporate the I time weighting characteristic.

2.4 Optional features

This standard is intended to allow special features in a sound level meter such as wide indicator range, digital display, recording display and automatic range changing.

2.5. Method of use

It is recognized that sound level meters are used to measure many types of sound, under different conditions, and for a variety of reasons. For each application, the measurement technique should be chosen and controlled carefully to obtain valid and consistent results. It is important to note that the method of use has at least as much effect on a measurement as the quality of the instrument itself; errors will often result if the effect of the environment, and (especially for portable instruments) the presence of the observer, are ignored.

3. Definitions

3.1 For the definitions of terms used in this standard, reference should be made to the International Electrotechnical Vocabulary (I.E.V.), Chapter 801, Acoustics and Electroacoustics (in preparation). Certain additional terms are defined below.

3.2 *Weighted sound pressure level* in decibels (dB) is 20 times the logarithm to the base ten of the ratio of a weighted sound pressure to the reference sound pressure. The sound pressure is weighted in accordance with one of the frequency weightings A, B or C, and is time weighted in accordance with characteristics S, F, I, or Peak, the frequency and time weightings being as specified in this standard. The reference sound pressure is 20 μPa (20 $\mu\text{N/m}^2$) and does not depend on the frequency or time weighting. When quoting the weighted sound pressure level, the frequency weighting and time weighting shall be indicated.

Note. — The term “weighted sound pressure level”, used throughout this standard, is often abbreviated to “weighted sound level” or “sound level” in English-speaking countries.

3.3 *Crest factor* of a signal is the ratio of the peak value to the r.m.s. value measured over a specified time interval, the instantaneous values of the signal being measured with respect to the arithmetic mean value. The relation between crest factor and pulse duty factor for sequences of rectangular pulses and for tone bursts is given in Appendix A.

3.4 *Primary indicator range* of a sound level meter is a specified range of the indicator for which the sound level meter readings are within particularly close tolerances on level linearity as specified in Sub-clauses 7.9 and 7.10.

3.5 *Level linearity* means that the reading of the sound level meter is a linear function of the level of the input signal, within stated tolerances.

3.6 *Reference direction* is the direction of sound incidence specified by the manufacturer to be used for testing the absolute sensitivity, the directional characteristics and the frequency weighting of a sound level meter.

3.7 *Reference frequency* is a frequency specified by the manufacturer in the range 200 Hz to 1 000 Hz used for calibration of the absolute sensitivity of a sound level meter.

Note. — A reference frequency of 1 000 Hz is preferred.

3.8 *Reference sound pressure level* is a sound pressure level specified by the manufacturer used for calibrating the absolute sensitivity of the sound level meter.

Note. — A reference sound pressure level of 94 dB is preferred or, if this level is not within the measuring range of the instrument, 84 dB or 74 dB.

- 3.9 *Reference range* of a sound level meter is a range specified by the manufacturer for calibration purposes. The reference sound pressure level shall be included in this range.

4. General characteristics

- 4.1 A sound level meter is generally a combination of a microphone, an amplifier with controlled frequency weighting, and a detector-indicator device with controlled time weighting characteristics. In Clauses 5, 6 and 7, specifications are given for these parts of the sound level meter and tolerances are given for four types of sound level meters. Any additional items necessary to meet any of the requirements (such as extension rods or cables and random-incidence correctors) are regarded as integral parts of the sound level meter.
- 4.2 The reading of the sound level meter under the reference conditions as defined in Sub-clauses 9.1 and 9.2.1 shall be accurate to within ± 0.4 dB, ± 0.7 dB, ± 1.0 dB, ± 1.5 dB for Types 0, 1, 2 and 3 instruments respectively, after any warm-up period specified by the manufacturer. A means shall be available to check and maintain calibration at the reference frequency.
- 4.3 Ideally, a sound level meter is equally responsive to sounds arriving at any angle of incidence. The microphone and instrument case shall satisfy the requirements of Clause 5 for directional characteristics.
- 4.4 The output signal of the microphone is frequency weighted to produce one or more of the three characteristics designated A, B and C. Weighting and amplifier circuits shall satisfy the requirements of Clause 6.
The Lin response, when provided, allows the sound level meter to measure sound pressure level (unweighted) or to function as a preamplifier for an auxiliary device. When the Lin response is provided the manufacturer shall specify its frequency range and tolerances. The tolerances shall not be greater than those for the frequency weighting characteristics (see Table V, page 19).
- 4.5 The frequency weighted signal is detected and indicated in accordance with one or more of the characteristics designated S, F, I and Peak specified in Clause 7 and in Sub-clauses 9.4.3 and 9.4.4. Sound level meters with the time weighting characteristics I or Peak shall also include at least one of the characteristics F or S. When provided, the Peak characteristic allows the sound level meter to indicate the absolute peak of the acoustical signal.
- 4.6 Although the frequency weighting characteristic and detector-indicator characteristic are usually associated with particular circuits within the sound level meter, the tests to determine compliance with Clause 9 of this standard shall be made on the complete instrument. In this way, any interaction between the various elements of the instrument will be taken into account.
- 4.7 The manufacturer shall provide the means to substitute an electrical signal for the microphone for the purpose of performing tests on the complete instrument without the microphone.
- 4.8 If the sound level meter is battery operated, suitable means shall be provided to check that a battery voltage adequate to operate the instrument according to the specifications is maintained.
- 4.9 After a warm-up period to be specified by the manufacturer, but less than 10 min in duration, the reading shall not change within 1 h of continuous operation under constant test conditions by more than the values shown in Table I.

TABLE I

*Maximum change of reading, in decibels,
during 1 h of operation*

Type 0	Type 1	Type 2	Type 3
0.2	0.3	0.5	0.5

5. Directional characteristics of the microphone and instrument case

- 5.1 The manufacturer shall specify a reference direction of incidence for which the frequency weighting characteristics given in Clause 6 apply. The total spread of the change in sensitivity of the equipment within an angle of $\pm 30^\circ$ from the reference direction shall not exceed the values given in Table II. The total spread of the change in sensitivity within an angle of $\pm 90^\circ$ from the reference direction shall not exceed the values given in Table III. The tables shall apply when the microphone is mounted as specified by the manufacturer for normal use and with the observer not disturbing the sound field at the microphone. The values in both tables shall be checked using the same microphone configuration.

TABLE II

*Maximum change in sensitivity within an angle of $\pm 30^\circ$
from the reference direction, in decibels*

Frequency (Hz)	Type 0	Type 1	Type 2	Type 3
31.5– 1 000	0.5	1	2	4
1 000– 2 000	0.5	1	2	4
2 000– 4 000	1	1.5	4	8
4 000– 8 000	2	2.5	9	12
8 000–12 500	2.5	4	—	—

TABLE III

*Maximum change in sensitivity within an angle of $\pm 90^\circ$
from the reference direction, in decibels*

Frequency (Hz)	Type 0	Type 1	Type 2	Type 3
31.5– 1 000	1	1.5	3	8
1 000– 2 000	1.5	2	5	10
2 000– 4 000	2	4	8	16
4 000– 8 000	5	8	14	30
8 000–12 500	7	16	—	—

6. Frequency weighting and amplifier characteristics

- 6.1 The complete instrument comprising the microphone, amplifier, weighting network and detector-indicator shall have one or more of the frequency weighting characteristics with tolerances given in

Tables IV and V, and in IEC Publication 537, when measured in the reference direction. For sound level meters of given type, the tolerances are identical for all weighting characteristics, including the D weighting when provided.

TABLE IV
Frequency weighting characteristics
Relative free-field frequency response in the reference direction, in decibels

Nominal frequency* (Hz)	Exact frequency* (Hz)	A weighting	B weighting	C weighting
10	10.00	-70.4	-38.2	-14.3
12.5	12.59	-63.4	-33.2	-11.2
16	15.85	-56.7	-28.5	-8.5
20	19.95	-50.5	-24.2	-6.2
25	25.12	-44.7	-20.4	-4.4
31.5	31.62	-39.4	-17.1	-3.0
40	39.81	-34.6	-14.2	-2.0
50	50.12	-30.2	-11.6	-1.3
63	63.10	-26.2	-9.3	-0.8
80	79.43	-22.5	-7.4	-0.5
100	100.0	-19.1	-5.6	-0.3
125	125.9	-16.1	-4.2	-0.2
160	158.5	-13.4	-3.0	-0.1
200	199.5	-10.9	-2.0	-0.0
250	251.2	-8.6	-1.3	-0.0
315	316.2	-6.6	-0.8	-0.0
400	398.1	-4.8	-0.5	-0.0
500	501.2	-3.2	-0.3	-0.0
630	631.0	-1.9	-0.1	-0.0
800	794.3	-0.8	-0.0	-0.0
1 000	1 000	0	0	0
1 250	1 259	+ 0.6	- 0.0	- 0.0
1 600	1 585	+ 1.0	- 0.0	- 0.1
2 000	1 995	+ 1.2	- 0.1	- 0.2
2 500	2 512	+ 1.3	- 0.2	- 0.3
3 150	3 162	+ 1.2	- 0.4	- 0.5
4 000	3 981	+ 1.0	- 0.7	- 0.8
5 000	5 012	+ 0.5	- 1.2	- 1.3
6 300	6 310	- 0.1	- 1.9	- 2.0
8 000	7 943	- 1.1	- 2.9	- 3.0
10 000	10 000	- 2.5	- 4.3	- 4.4
12 500	12 590	- 4.3	- 6.1	- 6.2
16 000	15 850	- 6.6	- 8.4	- 8.5
20 000	19 950	- 9.3	-11.1	-11.2

* Nominal frequencies are as specified in ISO Standard 266. Exact frequencies are given above to four significant figures and are equal to $1\,000 \cdot 10^{n/10}$, where n is a positive or negative integer.

6.2 The values given in Table IV correspond to pole-zero specifications as follows:

The C weighting characteristic is ideally realized with two poles in the complex frequency plane situated on the real axis at 20.6 Hz ($10^{1.31}$ Hz) to provide the low frequency roll-off and two poles on the real axis at 12 200 Hz ($10^{4.09}$ Hz) to provide the high frequency roll-off. The lower frequency half-power or 3 dB down point with respect to the 1 kHz response is at 31.62 Hz