

Specification for Sound level meters

The European Standard EN 60651:1994, with the incorporation of amendments A1:1994 and A2:2001, has the status of a British Standard

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Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

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National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Policy Committee and is the English language version of EN 60651:1994 *Sound level meters*, including amendments A1:1994 and A2:2001, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 60651:1979 including amendments 1:1993 and 2:2000, published by the International Electrotechnical Commission (IEC).

Amendment A1 was incorporated with the original BS EN 60651:1994. Amendment A2 has therefore been incorporated into BS EN 60651 as Amendment No. 1.

BS EN 60651:1994 replaces BS 5969:1981 which is withdrawn.

It should be noted that IEC 651 amendment 1:1993 contains an error which has been notified to IEC. Until such time as the error is corrected the following information applies to BS EN 60651:1994. In Appendix D (normative): Equations for design-goal frequency weightings equations (D1) and (D2) are to be read as follows.

For the C-weighting:

$$R_c(f) = \frac{12\,200^2 f^2}{(f^2 + 20,6^2)(f^2 + 12\,200^2)} \quad (\text{D1})$$

For the B-weighting:

$$R_B(f) = \frac{12\,200^2 f^3}{(f^2 + 20,6^2)(f^2 + 12\,200^2)(f^2 + 158,5^2)^{1/2}} \quad (\text{D2})$$

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 29 and a back cover.

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English version

Sound level meters

(including amendments A1:1994 and A2:2001)

(IEC 60651:1979 + A1:1993 + A2:2000)

Sonomètres
(inclut les amendements A1:1994 et A2:2001)
(CEI 60651:1979 + A1:1993 + A2:2000)

Schallpegelmesser
(enthält Änderungen A1:1994 und A2:2001)
(IEC 60651:1979 + A1:1993 + A2:2000)

This European Standard was approved by CENELEC on 1993-12-08. CENELEC 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 CENELEC 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 CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

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

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Foreword

As a consequence of the IEC-CENELEC Agreement, HD 425 S1:1983 (IEC 651:1979) was submitted to the CENELEC voting procedure for conversion into a European Standard.

The text of the International Standard was approved by CENELEC as EN 60651 on 8 December 1993.

The following dates were fixed.

- latest date of publication of an identical national standard (dop) 1994-12-01
- latest date of withdrawal of conflicting national standards (dow) —

Annexes designated “normative” are part of the body of the standard. In this standard, Appendix A, Appendix B, Appendix C and Annex ZA are normative.

Foreword of EN 60651/A1:1994

The text of document 29(CO)203, as prepared by IEC Technical Committee No. 29: Electroacoustics, was submitted to the IEC-CENELEC parallel vote in March 1993.

The reference document was approved by CENELEC as amendment A1 to EN 60651 on 8 December 1993.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1994-12-01
- latest date of withdrawal of conflicting national standards (dow) 1994-12-01

Annexes designated “normative” are part of the body of the standard. In this standard, Appendix D and Annex ZA are normative.

Foreword to amendment A2

The text of document 29/458/FDIS, future amendment 2 to IEC 60651:1979, prepared by IEC TC 29, Electroacoustics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 60651:1994 on 2000-11-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2001-08-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2003-11-01

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given for information only. In this standard Annex ZA is normative and Annex E is informative. Annex ZA has been added by CENELEC.

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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; sound level*: Logarithm of the ratio of a given sound pressure to the reference sound pressure of 20 μPa , the sound pressure being obtained with a standard frequency weighting and with standard exponentially weighted time-averaging. Sound level in decibels is twenty times the logarithm to the base ten of that ratio. 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.

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.

The following definitions apply in addition to those specified in IEC 61000-4-2, IEC 61000-4-3, IEC 61000-6-1, IEC 61000-6-2 and CISPR 61000-6-3.

3.10 Reference orientation (of a sound level meter): orientation of a sound level meter with respect to the principal direction of an emitter or receiver of radio-frequency fields such that for sound level meters with the microphone directly attached, the reference orientation specified for the instrument is directly in line with the principal direction of this same emitter or receiver. For instruments that do not have the microphone directly attached, the configuration for the reference orientation is specified in the instruction manual.

3.11 Group X sound level meter: self-contained instrument that includes sound level measurement facilities according to this standard and which specifies internal battery power for the normal mode of operation, requiring no external connections to other apparatus to measure sound levels.

3.12 Group Y sound level meter: self-contained instrument that includes sound level measurement facilities according to this standard and which specifies connection to a public power supply system for the normal mode of operation, requiring no external connections to other apparatus to measure sound levels.

3.13 Group Z sound level meter: instrument that includes sound level measurement facilities according to this standard requiring two or more items of equipment to be connected together by some means for the normal mode of operation, with operation either from batteries or from a public power supply. The configuration for the normal mode of operation is specified in the instruction manual.

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 9.1 and 9.2.1 shall be accurate to within $\pm 0,4$ dB, $\pm 0,7$ dB, $\pm 1,0$ dB, and $\pm 1,5$ dB for types 0, 1, 2, and 3 instruments respectively, after any warm-up period specified by the manufacturer and after following the manufacturer's recommended field checking/calibrating procedure. A means shall be available (for example, a sound calibrator meeting the requirements of IEC 942) to check and maintain calibration such that the tolerances specified above are met for the reading under reference conditions.

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 9).

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.

NOTE The “maximum S”, “maximum F” and “maximum I” responses (if provided) are not the same as the Peak response.

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	—	—