BRITISH STANDARD

BS EN 60651:1994
IEC 60651:1979
Incorporating Amendment No. 1

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

ICS 17.140.50

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:

Austria	Italy
Belgium	Luxembourg
Denmark	Netherlands
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom

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Contents

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BS EN 60651:1994 replaces BS 5969:1981 which is withdrawn.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

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

For the B-weighting:

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

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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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EUROPEAN STANDARD

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EUROPÄISCHE NORM

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Descriptors: Sound level meters, precision, requirements, testing, properties, definitions

English version

Sound level meters

(including amendments A1:1994 and A2:2001)

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

Sonomètres
(inclut les amendments A1:1994 et A2:2001)
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(enthält Änderungen A1:1994 und A2:2001)
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CENELEC

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

Central Secretariat: rue de Stassart 35, B-1050 Brussels

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.

Contents

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 $\mu N/m^2$) 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 ±0,4 dB, ±0,7 dB, ±1,0 dB, and ±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 ±30° 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 ±90° 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 ±30° 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 ± 90° 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 Table IV and Table 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[a] (Hz)	Exact frequency[a] (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

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

Relative frequency response levels for the A-, B-, and C- frequency weightings in Table IV are given as rounded values to the nearest tenth of a decibel.

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

A practical realization of the frequency weightings specified in Table IV may be derived from the equations given in Appendix D for the zeros and pole frequencies specified below.

The C-weighting characteristic is realized with two zeros at the origin in the complex frequency plane plus two poles situated on the real axis at a frequency of 20,6 Hz to provide the low frequency roll-off and two poles on the real axis at a frequency of 12,2 kHz 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 and the upper-frequency half-power or 3 dB-down point is at 7 943 Hz. Attenuation rates approach 12 dB per octave at both low and high frequencies.

The B-weighting characteristic is realized by adding one zero at the origin and a pole on the real axis at a frequency of 158,5 Hz to the C-weighting characteristic.

The A-weighting characteristic is realized by adding two zeros at the origin and two poles on the real axis, at frequencies of 107,7 Hz and 737,9 Hz, to the C-weighting characteristic.

6.3 When a level range control is included, it shall introduce errors less than those given in Table VI for all settings with reference to a range setting specified by the manufacturer as the reference range. The reference range shall include the reference sound pressure level defined in Sub-clause **3.8** and the test shall be performed on the basis of this level.

Table V — Tolerances[a] on frequency weighting characteristics given in Table IV for each instrument type, in decibels

Nominal frequency (Hz)	Type 0	Type 1	Type 2	Type 3
10	+2; −∞	+3; −∞	+5; − ∞	+5; −∞
12.5	+2; −∞	+3; −∞	+ 5; − ∞	+5; −∞
16	+2; −∞	+3; −∞	+ 5; − ∞	+5; −∞
20	±2	±3	± 3	+5; −∞
25	±1.5	±2	± 3	+5; −∞
31.5	±1	±1.5	± 3	±4
40	±1	±1.5	± 2	±4
50	±1	±1.5	± 2	±3
63	±1	±1.5	± 2	±3
80	±1	±1.5	± 2	±3
100	±0.7	±1	± 1.5	±3
125	±0.7	±1	± 1.5	±2
160	±0.7	±1	± 1.5	±2
200	±0.7	±1	± 1.5	±2
250	±0.7	±1	± 1.5	±2
315	±0.7	±1	± 1.5	±2
400	±0.7	±1	± 1.5	±2
500	±0.7	±1	± 1.5	±2
630	±0.7	±1	± 1.5	±2
800	±0.7	±1	± 1.5	±2
1 000	±0.7	±1	± 1.5	±2
1 250	±0.7	±1	± 1.5	±2.5
1 600	±0.7	±1	± 2	±3
2 000	±0.7	±1	± 2	±3
2 500	±0.7	±1	± 2.5	±4
3 150	±0.7	±1	± 2.5	±4.5
4 000	±0.7	±1	± 3	±5
5 000	±1	±1.5	± 3.5	±6
6 300	+1; –1.5	+1.5; –2	± 4.5	±6
8 000	+1; –2	+1.5; –3	± 5	±6
10 000	+2; –3	+2; –4	+ 5; − ∞	+6; −∞
12 500	+2; –3	+3; –6	+ 5; − ∞	+6; −∞
16 000	+2; –3	+3; −∞	+ 5; − ∞	+6; −∞
20 000	+2; –3	+3; −∞	+ 5; − ∞	+6; −∞

[a] Tolerances are the same for all weighting characteristics. The tolerance shall be zero at the reference frequency (see Sub-clause **3.7**).

Table VI — Tolerances on level range control accuracy in various frequency ranges, in decibels

Frequency (Hz)	Type 0	Type 1	Type 2	Type 3
31.5 – 8 000	±0.3	±0.5	±0.7	±1.0
20 – 12 500	±0.5	±1.0	—	—

6.4 When a manual level range control is included in a sound level meter, ranges shall overlap by at least 5 dB if the step of the level range control is 10 dB and by at least 10 dB if the step is greater.

6.5 The instrument shall be capable of meeting the crest factor requirements of **7.2**. For Type 0 instruments, overload detectors shall be placed in the amplifier chain and shall comply with the requirements of **9.3.1**.

NOTE It is recommended that overload detectors should also be used in Type 1 and Type 2 instruments.

When the I characteristic is included in any instrument, overload detectors shall be provided.

6.6 If signals are available at filter connections and at an a.c. output, the total harmonic distortion for sinusoidal input test signals in the frequency range 31.5 Hz to 8 000 Hz shall be less than 1 % when the level of the test signal is at least 10 dB below the equivalent upper limit of the weighted sound pressure level which the instrument is designed to measure.

At the upper limit of sound pressure level to be stated by the manufacturer, the total harmonic distortion generated between the sound input and the signal output, where the latter is provided, shall be less than 10 % at any frequency in the range 200 Hz to 1 000 Hz.

6.7 In order to minimize the chance of overload and to permit the widest dynamic range at high sound pressure levels, dual independently adjustable range controls that operate attenuators situated before and after the weighting circuits may be used.

NOTE When dual controls are used, an instruction plate that clearly describes the method of operation of the controls should be affixed to the instrument.

If an automatic range control system is used, its settling time shall be specified.

7 Detector and indicator characteristics

7.1 The indication of the sound level meter with either the F or S time weightings selected shall be the level of the exponential time average of the frequency weighted signal, the time constants being specified differently for F and S (see Figure 1). When the I time weighting is in use, the indication of the sound level meter is related to the maximum of the short-time r.m.s. value of the signal; this characteristic is achieved by means of an r.m.s. detector with a short averaging time and a peak detector with a long fall time (see Figure 2).

7.2 In principle, an instrument possessing the F and S detector-indicator characteristics corresponds to the following block diagram:

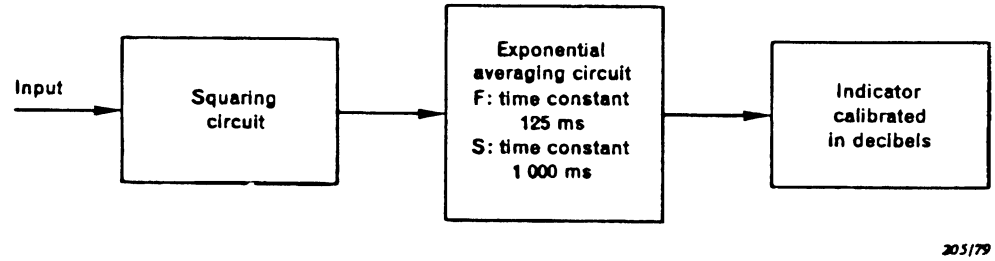

Figure 1

Tests for r.m.s. accuracy and time weighting characteristics are given in Sub-clause **9.4**. Allowable errors for various signal crest factors are shown in Table VII, below. The time weighting characteristics of the detector-indicator shall be such that it will respond to tone bursts as specified in Table VIII, page 11, and to a suddenly applied signal, or step in signal amplitude, with overshoot as specified in Table IX below.

When the applied signal is suddenly turned off, the meter indicator shall decay by 10 dB in a time of 0.5 s or less for F and 3.0 s or less for S.

NOTE Where no tolerance is specified in Table VIII, the manufacturer should state the design centre response and tolerances.

Table VII — Maximum error, in decibels, for tests of crest factor (CF) capability

Type	Crest factor		
	1 ≤ CF ≤ 3	3 < CF ≤ 5	5 < CF ≤ 10
0 I	±0.5	±0.5	±1
0			
1 I	±0.5	±1	±1.5
1		—	—
2 I	±1	±1	—
2		—	—
3	±1.5	—	—

NOTE 1 The designation "Type 0 I" refers, for example, to an instrument of Type 0 that includes the I characteristic.

NOTE 2 For Type 3 I, see Sub-clauses **7.3** and **9.4.3**.

Table VIII — Response to tone bursts

Detector-indicator characteristic	Duration of test tone burst (ms)	Maximum response to test tone burst referred to response to continuous signal (see Appendix C) (dB)	Tolerances on maximum response for each instrument type (dB)			
			0	1	2	3
	Continuous	0				
F	200	–1.0	±0.5	±1	+1 –2	+1 –3
	50	–4.8	±2	—	—	—
	20	–8.3	±2	—	—	—
	5	–14.1	±2	—	—	—
S	2 000	–0.6	±0.5	—	—	—
	500	–4.1	±0.5	±1	±2	±2
	200	–7.4	±2	—	—	—
	50	–13.1	±	—	—	—

Table IX — Maximum overshoot, in decibels

Detector-indicator characteristic	Type 0	Type 1	Type 2	Type 3
F	0.5	1.1	1.1	1.1
S	1.0	1.6	1.6	1.6

7.3 In principle, an instrument possessing the I detector-indicator characteristic corresponds to the following block diagram:

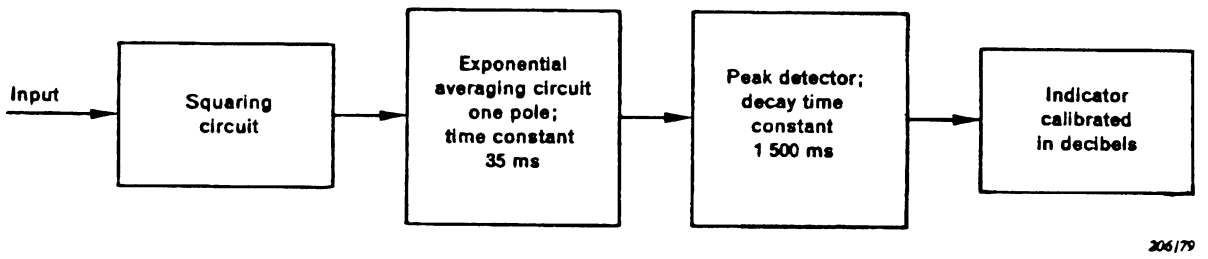

Figure 2

The components of the I detector-indicator are similar to those of the F and S detector-indicators except that a peak detector is introduced into the chain. The time constant of the exponential averaging circuit is equal for charge and discharge. The peak detector has the effect of storing the voltage fed to it for a sufficient time to allow it to be displayed by the indicator.

The onset time constant of the peak detector shall be small compared with the 35 ms time constant of the averaging circuit, and its decay rate shall be 2.9 dB/s with a tolerance of ±0.5 dB/s for Types 0 and 1 instruments or ±1.0 dB/s for Types 2 and 3 instruments. This decay rate corresponds approximately to a time constant of (1 500 ± 250) ms for Types 0 and 1 instruments and (1 500 ± 500) ms for Types 2 and 3 instruments. The accuracy of the I indication for single sinusoidal bursts and for a continuous sequence of bursts is tested as described in Clause **9**. Responses with tolerances are given in Table X and Table XI. If a Type 3 instrument includes the I characteristic, it shall satisfy the burst tests for a Type 2 instrument.

Table X — Response to a single burst

Duration T (ms)	**Maximum response to test tone burst referred to response to a continuous signal** (see Appendix C) (dB)	**Tolerance in decibels**	
		Types 0 and 1	**Type 2**
Continuous	0		
20	–3.6	±1.5	±2
5	–8.8	±2	±3
2	–12.6	±2	No test

Table XI — Response to a continuous sequence of bursts

Repetition frequency f_p (Hz)	**Maximum response to test tone burst referred to response to a continuous signal** (see Appendix C) (dB)	**Tolerance in decibels**	
		Types 0 and 1	**Type 2**
Continuous	0		
100	–2.7	±1	±1
20	–7.6	±2	±2
2	–8.8	±2	±3

7.4 Indications in the S, F and I detector-indicator modes shall not differ by more than 0.1 dB for Types 0, 1 and 2 and 0.2 dB for Type 3 instruments for steady-state sinusoidal signals in the frequency range 315 Hz to 8 000 Hz. When tested with a single short burst or a continuous sequence of bursts with low repetition rate, the I detector will generally give an indication that is higher than either F or S.

7.5 Optionally, the sound level meter may be equipped for measuring peak values. In the peak mode, the onset time of the detector shall be specified by the manufacturer. A Type 0 instrument shall be such that a single pulse of 50 μs duration produces a deflection no more than 2 dB below that produced by a pulse having a duration of 10 ms and equal peak amplitude. This requirement shall be met for electrical pulses of both polarities.

NOTE For other types, the onset time should be such that a single pulse of either polarity of 100 μs duration produces a deflection no more than 2 dB below the deflection produced by a pulse having a duration of 10 ms and equal peak amplitude.

7.6 The range of the indicator, whether analogue or digital, shall be at least 15 dB. At least 10 dB shall be specified as the primary indicator range by the manufacturer.

7.7 When an analogue indicator (meter or recorder) is provided, its scale shall be graduated in steps not greater than 1 dB over a range of at least 15 dB. Each decibel step shall be at least 1 mm wide.

7.8 When a digital indicator or other indicator with discontinuous display (e.g. lamps with level steps) is provided, the sound level meter shall include a mode in which the maximum weighted sound pressure level in a measuring interval is held (stored) in the display. Additional modes in which the display is held automatically in fixed intervals or on command may also be included.

When results in digital format are made available at an electrical output, the output rate shall be stated.

A digital display shall have a resolution of 0.1 dB or better.

When a discontinuous analogue display is used, reduced resolution is permitted. Resolution shall be equal to or better than 0.2 dB for Types 0 and 1 instruments, 1 dB for Type 2 instruments and 3 dB for Type 3 instruments. Because of the low resolution, special test methods will be required in order to demonstrate that all requirements of this standard are met.

7.9 The level linearity of the system, including any manual or automatic level range controls, shall satisfy the requirements of Table XII. The reference level for testing linearity is the reference sound pressure level.

NOTE In previous standards for sound level meters based only on analogue indicating instruments, the level linearity tolerance was given by the sum of the tolerances of the level range control and the meter scale graduation. Since this standard permits various other indicating systems, level linearity is specified in a different manner intended to produce equivalent results.

Table XII — Tolerances on level linearity referred to the reference sound pressure level in the frequency range 31.5 Hz to 8 000 Hz (20 Hz to 12 500 Hz for Type 0), in decibels

Readings	Type 0	Type 1	Type 2	Type 3
Inside primary indicator range	±0.4	±0.7	±1.0	±1.5
Outside primary indicator range	±0.6	±1.0	±1.5	±2.0

7.10 The instrument shall satisfy a test for differential level linearity in addition to the test given in Sub-clause **7.9**. On a specified level range and without changing the level range control, differential level linearity error is measured between any two arbitrarily chosen points which are up to 10 dB apart, in the range of the indicator. The maximum error, both inside and outside the primary indicator range, permitted for each type of sound level meter for points separated by 1 dB and for points separated by up to 10 dB is given in Table XIII.

Table XIII — Tolerances on differential level linearity in the frequency range 31.5 Hz to 8 000 Hz (20 Hz to 12 500 Hz for Type 0), in decibels

Readings	Type 0	Type 1	Type 2	Type 3
Inside primary indicator range, points separated by 1 dB	±0.2	±0.2	±0.3	±0.3
Inside primary indicator range, points separated by 1 dB to 10 dB	±0.4	±0.4	±0.6	±1.0
Outside primary indicator range, points separated by 1 dB	±0.3	±0.3	±0.4	±0.4
Outside primary indicator range, points separated by 1 dB to 10 dB	±0.6	±1.0	±1.5	±2.0

8 Sensitivity to various environments

All sound level meters shall meet the requirements in Sub-clauses **8.1** to **8.6**, with the exception that parts of Sub-clauses **8.5** and **8.6** apply only to sound level meters intended for field use.

NOTE Instruments suitable for laboratory use only are distinguished by the marking "L" (see Sub-clause **11.1**).

8.1 For a variation of ±10 % in static pressure, the sensitivity of the complete instrument shall not change by more than ±0.3 dB for Types 0 and 1 instruments, nor more than ±0.5 dB for Types 2 and 3 instruments, when tested at a frequency between 200 Hz and 1 000 Hz.

8.2 When the microphone is replaced by an equivalent electrical impedance and the sound level meter is placed in a sound field arriving in the reference direction, the response of the sound level meter shall be at least 20 dB below that which would be obtained in normal operation. This condition shall be fulfilled using a sinusoidal sound signal at a test level of 100 dB or at the upper limit of sound pressure level which the instrument is designed to measure, whichever is lower, and for all frequencies in the range 31.5 Hz to 8 000 Hz. The frequency sweep rate, where used, shall not exceed 0.1 octave/s.

8.3 The influence of mechanical vibrations on the operation of the sound level meter shall be reduced as far as practical. The effect of vibrations between 20 Hz and 1 000 Hz shall be indicated by the manufacturer; in cases where the microphone is not intended to be mounted on an extension cable for normal use, this information shall apply to the complete apparatus; in other cases it shall be given at least for the microphone assembly. The unit shall be vibrated sinusoidally at an acceleration of 1 m/s^2. A reference sound level meter that is not being vibrated shall be used to ensure that any sound produced by the vibrations does not affect the test result. The readings of both the sound level meter under test and the reference sound level meter shall be reported. The sound produced by the vibration exciter and the vibrated sound level meter shall be measured with a second sound level meter that is not vibrated. The microphone of the non-vibrated sound level meter shall be placed within 0,2 m of the microphone of the sound level meter which is attached to the vibration exciter. The sound pressure levels indicated by the two sound level meters shall be reported. If there are two possible mounting methods, the test shall be performed with both. If there is no tripod mount, the manufacturer shall specify the method of mounting the sound level meter for the test. In this case and for adjustable mountings, the vibration shall be applied in a direction perpendicular to the plane of the microphone diaphragm.

8.4 The effects of magnetic and electrostatic fields shall be reduced as far as practical. Sound level meters with attached microphones shall be tested in a magnetic field of strength 80 A/m (1 œrsted) at 50 Hz or 60 Hz. The apparatus shall be oriented in a direction which gives maximum indication, and this indication shall be stated for each of the weighting characteristics provided. For instruments using an extension cable between the microphone and indicating unit, the test shall also be performed on the microphone unit. The test frequency shall be stated.

8.5 The temperature range over which the calibration of the complete instrument, including the microphone, is not affected by more than 0.5 dB for Types 0, 1 and 2 and 1 dB for Type 3 instruments referred to the indication at 20 °C shall be specified by the manufacturer. If the change in calibration of an instrument intended for field use exceeds ±0.5 dB in the temperature range –10 °C to +50 °C, correction information shall be provided by the manufacturer. The test shall be performed at a frequency between 200 Hz and 1 000 Hz.

NOTE The relative humidity at which the test is carried out should be specified (see Sub-clause **8.6**).

8.6 The manufacturer shall state the range of humidity over which the complete instrument, including the microphone, is intended to operate continuously. In instruments intended for field use, the sensitivity shall not change by more than ±0.5 dB for Types 0, 1 and 2 and ±1 dB for Type 3 instruments referred to the indication at 65 % when the relative humidity varies from 30 % to 90 %. The test shall be conducted at a temperature of 40 °C at a frequency between 200 Hz and 1 000 Hz.

9 Calibration and verification of the basic characteristics of the sound level meter

9.1 The tests described in Sub-clauses **9.2**, **9.3** and **9.4** shall be used to check that the requirements of Clauses **4**, **5**, **6** and **7** are met. All tests shall be made at or referred to the standard reference conditions of 20 °C, 65 % relative humidity and 1.013×10^5 Pa (N/m^2) (1 013 mbar) atmospheric pressure. If not otherwise stated, the test shall be performed using low distortion sinusoidal signals. If rectangular test signals are used, the rise and fall times shall be between 3 μs and 10 μs.

During these tests, the sound field shall not be significantly disturbed by the presence of the observer.

NOTE The observer should preferably not be present in the sound field, for example, by reading the meter remotely. If this is not possible, the type of instrument and the corresponding tolerances should be taken into account in determining compliance with the requirement.

9.2 Calibration procedure and tests related to the complete sound level meter are described in Sub-clauses **9.2.1**, **9.2.2** and **9.2.3**. The tests may be carried out partly as acoustical and partly as electrical tests if no loss in accuracy results.

NOTE The manufacturer should provide basic information as to how the tests are performed.

9.2.1 The complete instrument shall be calibrated in absolute sensitivity at the reference frequency. The sound field shall consist of plane progressive waves arriving at the microphone in the reference direction of incidence at the reference sound pressure level. Before this test is performed, the sound level meter shall be adjusted and checked according to the specifications of the manufacturer. If an external reference sound source is prescribed for this adjustment, it shall be considered as part of the sound level meter.

9.2.2 The frequency weighting of the sound level meter shall be tested in a sound field consisting of plane progressive waves arriving at the microphone in the reference direction of incidence. At the reference frequency, the unweighted sound pressure level shall be the reference sound pressure level or in a range not more than 20 dB below this level.

These tests may be partly carried out by using an electrical signal and an equivalent electrical impedance substituted for the microphone. In this case, the measured frequency response error of the microphone and instrument case shall be applied as a correction to the frequency response of the electrical circuits in determining compliance with Sub-clause **6.1**.

NOTE These tests do not apply to the Peak response.

9.2.3 The variation in sensitivity as a function of angle of incidence shall be measured at a sufficient number of angles and frequencies to ensure that the requirements of Clause **5** are met.

9.3 Tests of the amplifier characteristics are described in Sub-clauses **9.3.1** to **9.3.3.**

9.3.1 When overload detectors are included (see Sub-clause **6.5**), they shall meet the requirements of the following tests:

The first test applies only to instruments that have the frequency weighting characteristic A. The instrument shall be set to A weighting and the microphone cartridge replaced by an electrical impedance equal to that of the microphone. A sinusoidal signal of frequency 1 000 Hz shall be applied to the instrument through this impedance with an amplitude which gives a reading of 5 dB below that of the maximum A weighted sound pressure level which the instrument is designed to measure. When applicable, dual independently adjustable level range controls shall be set according to the manufacturer's instructions. The frequency of the input signal shall then be lowered in steps to 20 Hz while simultaneously the amplitude is raised by multiples corresponding to the inverse of the A weighting characteristic given in Table IV, page 8. If, at any frequency, the indication of the instrument deviates from its initial value at 1 000 Hz by more than the tolerance (in practice, the lower tolerance) given in Table V, page 9, for the corresponding frequency, then a clear overload indication shall occur.

If a Lin (flat) response is provided, an overload indication shall also occur for rectangular pulses when the indication of the instrument deviates by more than the tolerances given in Table VII for the test signals with various crest factor (see Appendix A). The manufacturer's recommended maximum electrical input signal shall not be exceeded. The testing shall be performed 2 dB below the upper limit of the primary indicator range.

The overload detectors shall be equally responsive within 2 dB to single rectangular pulses of either polarity and a duration in the range from 200 μs to 10 ms.

9.3.2 When a level range control is included, it shall be tested to verify compliance with the requirements of Table VI, page 10.

9.4 Tests of the detector and indicator characteristics are described in Sub-clauses **9.4.1** to **9.4.4**. The linearity of the detector-indicator and range controls shall be tested and shall meet the requirements of Sub-clauses **7.9** and **7.10**.

NOTE These tests may be carried out by using an electrical signal and an equivalent electrical impedance substituted for the microphone.

9.4.1 Tests of time weighting characteristics F and S: The onset transient characteristics of F and S detector-indicators shall be tested using single sinusoidal bursts at a frequency in the range 1 000 Hz to 2 000 Hz. For a single burst with a duration *T* and an amplitude that produces an indication 4 dB below the upper limit of the primary indicator range when the signal is continuous, the indication for the burst signal is given in Table VIII, page 11. The requirements shall be met for all level ranges of the sound level meter. For test signals of short duration, it may be necessary to increase the level of the input signal by 10 dB to obtain a reading in the range of the indicator.

NOTE It is recommended that the onset transient characteristics also be tested for an indication of the steady level 5 dB above the lower limit of the indicator range with tone burst durations of 200 ms for F and 500 ms for S.

The overshoot for the F and S detector-indicators shall be tested using a signal that is suddenly applied and thereafter held constant. The maximum readings shall not exceed the final steady reading by more than the amounts given in Table IX, page 11, when the test signal has a frequency between 100 Hz and 8 000 Hz.

When the range of the indicator is 20 dB or less, the requirement shall be satisfied for a steady-state level corresponding to 4 dB below the upper limit of the primary indicator range.

NOTE It is recommended that the requirement also be satisfied at other levels.

When the range of the indicator is more than 20 dB, the tests of onset transient characteristic and overshoot shall be conducted using signals that step (i.e. suddenly increase) in amplitude by 20 dB. The tests shall be performed at 4 dB below the upper limit of the primary indicator range and at intervals of 10 dB below this level for all signals that produce an indication.

NOTE For sound level meters having a digital indicator, it is recommended that these tests be performed with the instrument set to the "maximum hold" mode.

The decay time for F and S detector-indicators shall be tested by suddenly turning off the signal used to test overshoot.

9.4.2 Test of r.m.s. performance: The r.m.s. accuracy of the detector-indicator system shall be tested by comparing the indication for a continuous sequence of rectangular pulses and for a sequence of tone bursts with that for a reference sinusoidal signal (see Appendix A).

For each rectangular test pulse, the duration shall be 200 μs and the rise and fall times shall be between 3 μs and 10 μs. The electrical tone burst test signals shall consist of an integral number of sine waves starting and ending at zero crossings. The repetition frequency shall be 40 Hz.

NOTE It is recommended that the sinusoidal signal have a frequency of 2 000 Hz.

The test signals shall be such that when compared with the reference sinusoidal signal using a device that introduces frequency weighting corresponding to that in the sound level meter being tested within the tolerances given in Table V, page 9, the r.m.s. values shall be equal. The C weighting or Lin characteristic, if any, shall be used. If the instrument has only A or B weighting, then only the tone burst test shall be performed.

The test signal is fed to the electrical input of the sound level meter, and the test is performed for the S detector-indicator characteristic or for the F characteristic if S is not available in the sound level meter being tested. If microphone correction networks are used such that the response at the electrical input is not within the tolerances in Table V, page 9, the frequency response of these networks shall be stated by the manufacturer.

The rectangular pulse test shall be performed using both positive going and negative going pulses. The test shall be performed at 2 dB below the upper limit of the primary indicator range and at intervals of 10 dB below this level down to the lowest level that produces an indication of more than 3 dB above the lower limit of the primary indicator range.

The tolerances in Table VII, page 11, shall be met over the entire range of weighted sound pressure levels which the instrument is designed to measure.

If a Type 3 instrument includes the I characteristic, it shall be verified that its response to tone bursts complies with the requirements for Type 2 instruments (see Sub-clause **7.3**).

9.4.3 Test of time weighting characteristic I: For a single sinusoidal burst with a frequency of 2 000 Hz, a duration *T* and an amplitude that produces a full range indication when the signal is continuous, the indication relative to the indication for the continuous signal shall be as given in Table X, page 12, with tolerances for Types 0, 1 and 2 instruments. If an I detector is included in a Type 3 instrument, it shall satisfy the requirements for the Type 2 instrument.

When the burst duration is held constant at 2 ms and the amplitude is increased by 10 dB, the indication of the sound level meter shall increase by (10 ± 1) dB, for instruments of Types 0 and 1. For Types 2 and 3 instruments, the test shall be performed with a burst duration of 5 ms and an amplitude step of 5 dB.

The decay rate for the time weighting I, specified in **7.3**, shall be tested by suddenly turning off a continuous 2 kHz sinusoidal electrical signal providing an indication at the upper end of the primary indicator range and observing the decay.

For a continuous sequence of sinusoidal bursts having a frequency of 2 000 Hz, a duration of 5 ms, a repetition frequency f_p and an amplitude that produces a full range indication when the signal is continuous, the indication of the sound level meter relative to that for the continuous signal shall be as stated in Table XI, page 12, with tolerances for Types 0, 1 and 2 instruments.

For the continuous sequence of bursts (see Sub-clause **7.3**), when the repetition frequency is held constant at 2 Hz and the amplitude is increased by 5 dB, the indication of the sound level meter shall increase by (5 ±1) dB.

The above requirements shall be met for all level ranges of the sound level meter.

When the range of the indicator is more than 20 dB, the requirements of the tests with a single burst and a continuous sequence of bursts shall be met at intervals of 10 dB below full scale down to the lowest level that produces an indication.

9.4.4 If the sound level meter is equipped with a means to indicate Peak sound pressure level, the rise time shall be tested by comparing the response of a short-duration rectangular electrical pulse with that for a reference electrical pulse of 10 ms duration. For each rectangular pulse, the rise and fall times shall be between 3 μs and 10 μs. The onset time to be specified by the manufacturer is equal to the duration of the pulse that produces an indication 2 dB below that of the 10 ms reference pulse. Both pulses shall have the same peak amplitude. The amplitude of the 10 ms reference pulse shall be such as to produce an indication 1 dB below the upper limit of the primary indicator range. The test shall be repeated with both positive going and negative going pulses.

NOTE 1 It is recommended that the test should also be performed at other input signal levels that produce a reading in the primary indicator range.

NOTE 2 The “maximum S”, “maximum F”, and “maximum I” responses are not the same as the Peak response.

10 Provision for use with auxiliary equipment

10.1 If the sound level meter can be used with a cable between the microphone and the amplifier, the corrections corresponding to this method of use shall be stated by the manufacturer.

NOTE Corrections due to the use of other available accessories should be stated. These accessories include windscreens, rain protectors, etc.

10.2 If the sound level meter is provided with one or more outputs for use in driving headphones, analysers and other equipment the following requirements shall apply:

i) if connection of external equipment having a specified impedance would affect the indicator by more than 0.1 dB for Type 0, 0.2 dB for Type 1, 0.5 dB for Type 2 and 1 dB for Type 3 instruments, then the indicator shall be automatically muted or disconnected;

ii) full details relating to the output characteristics of the signal shall be given.

NOTE It is recommended that when an output signal is provided, it should be possible to terminate the output in any impedance without affecting either the meter indication or the linear operation of the output circuits.

10.3 If connections are provided to permit insertion of an external filter, the instructions provided with the sound level meter shall state clearly how these connections are to be used.

NOTE It is recommended that the sound level meter should have sufficient dynamic range to avoid overload when an external filter is used e.g. by having dual attenuators.

10.4 If a d.c. output is provided, the manufacturer shall provide full details in the instruction manual concerning the characteristics of the output signals, including time and frequency weightings.

11 Rating information and instruction manual

11.1 A sound level meter that complies with this standard shall be marked to show the number of this standard and the instrument Type (see **1.2**). Moreover, if the instrument is intended for laboratory use only, it shall be marked additionally with the letter "L" (e.g. "TYPE 2 L"). It shall also be marked with the name of the manufacturer, the model number and the serial number. If the sound level meter consists of several separate units, each principal unit or component shall be marked, if practical, with the name of the manufacturer, model number, serial number, and a designation of its function. All principal units or components constituting the sound level meter shall be identified.

11.2 An instruction manual shall be supplied with the sound level meter; it shall include at least the information listed below.

1) The kind of microphone (piezoelectric, condenser, etc.) and method of mounting in order to attain the tolerances required for that particular type of sound level meter.

2) The reference direction of incidence as defined in Sub-clause **3.6**.

3) The range of sound levels or weighted sound pressure levels which the complete instrument is designed to measure within the tolerances specified in this standard. The range shall be stated separately for each frequency-weighting characteristic.

4) The reference value of sound pressure level as defined in Sub-clause **3.8**.

5) The nominal frequency weighting characteristics specified in Table IV, page 8, and (if applicable) the weighting characteristic D specified in IEC Publication 537.

6) A description of the detector-indicator characteristics F, S, I and Peak (as applicable) specified in Clauses **7** and **9**.

7) The effect of vibrations on the operation of the sound level meter as tested in accordance with Sub-clause **8.3**.

8) The effect of magnetic fields as tested in accordance with Sub-clause **8.4**.

9) The effects of temperature as tested in accordance with Sub-clause **8.5**.

10) The effect of the presence of the operator on a free field measurement.

11) The effects of humidity as tested in accordance with Sub-clause **8.6**.

12) The limits of temperature and humidity beyond which permanent damage to the sound level meter may result.

13) Any correction to calibration required when a microphone extension cable is used.

14) The effect on the performance of the instrument caused by the use of recommended microphone accessories such as windscreens, etc.

15) The calibration procedure necessary to maintain the accuracy as specified in Sub-clause **4.2**.

16) The position of the instrument case and observer relative to the microphone in order to minimize their influence on the measured sound field.

17) A procedure to ensure optimum operating conditions when the sound level meter is used with external filters or analysers if applicable.

18) The limitations on the electrical impedance that may be connected to the output connector if one is provided.

19) The reference frequency as defined in Sub-clause **3.7**.

20) The reference range as defined in Sub-clause **3.9**.

21) The warm-up time before valid readings can be made as defined in Sub-clause **4.9**.

22) For Type 0 instruments, continuous frequency response curves.

23) For Types 0, 1, and 2 instruments, correction information between the sensitivity in a diffuse field and that in the reference direction, as a function of frequency. These data shall be given for the frequencies in Table IV, page 8, at least up to 10 000 Hz (see Appendix B).

24) The directional response of the sound level meter at various frequencies including at least 1 000 Hz, 2 000 Hz, 4 000 Hz and 8 000 Hz (for Types 2 and 3 instruments) and additionally 12 500 Hz for Types 0 and 1 instruments.

25) The electrical impedance which shall be substituted for the microphone for testing purposes.

26) The primary indicator range as required by Sub-clause **7.6**.

27) For sound level meters with automatic range control, the settling time (see Sub-clause **6.8**).

28) The manufacturer should state how the instrument may be mounted for testing compliance with the requirements of this standard.

NOTE It is recommended that the following information also be provided in the instruction manual.
i) The sensitivity of the sound level meter as a function of frequency for the reference direction specified by the manufacturer for one or all of the frequency weighting characteristics.
ii) The behaviour of the sound level meter when tested with tone bursts in accordance with Sub-clauses **7.2** and **7.3**.

29) the sound level at which the sound level meter conforms to the specifications of clause **12** (74 dB or less);

30) the approved cables and accessories as included in the tests of **12.5.2.6** and **12.5.4.4**;

31) the configuration for the normal mode of operation;

32) any specified degradation in performance or loss of functionality following the application of electrostatic discharges;

33) the configuration for the reference orientation, and method of securing the microphone cable, if appropriate;

34) the setting and configuration for greatest radio-frequency emissions;

35) the mode of operation and connecting devices that produce minimum immunity to power- and radio-frequency fields.

12 Electromagnetic and electrostatic compatibility requirements and test procedures

12.1 Field of application

12.1.1 This clause specifies requirements for sound level meters with respect to their immunity to power- and radio-frequency fields and to electrostatic discharge, and the permitted radio-frequency emissions, together with test procedures to demonstrate conformance to the specifications of this standard. Sound level meters are available in many different configurations and may be powered by batteries or from external power supply systems. The technical requirements in this clause are for three configurations of sound level meters that incorporate a sound level measurement facility according to this standard: first, for self-contained instruments that are designed primarily for battery operation; second for self-contained instruments that are operated from public power supply systems; third, for sound level meters that are formed by interconnection of two or more items of equipment.

12.1.2 The electromagnetic and electrostatic compatibility requirements are equally applicable for sound level meters used in residential, commercial and light-industrial environments, or industrial sites. The requirements of this clause are additional to those contained in previous clauses and do not alter any of the specifications for sound level meters contained therein. The requirements do not apply to sound level meters complying with this standard prior to the publication of this amendment.

12.2 Emission limits

12.2.1 The upper limits on radio-frequency emissions from any apparatus are defined for compatibility with many different standards, with the limits laid down in Table 1 of CISPR 61000-6-3 forming the basic requirements for sound level meters in groups X, Y or Z. These are summarized in Appendix E.

12.2.2 Sound level meters in groups Y or Z powered from a public power supply system shall also comply with the limits for disturbance to the public supply system specified in CISPR 22. For sound level meters, the requirements are summarized in Appendix E.

12.2.3 The instruction manual shall state the mode of operation of, and the connecting devices (if any) to, the instrument that produce the greatest radio-frequency emissions.

12.3 Electrostatic discharges

12.3.1 Sound level meters in groups X, Y or Z shall withstand electrostatic discharges of specified magnitudes. The requirements are those specified in **1.4** of Table 1 in IEC 61000-6-1 and are summarized as follows.

— Contact discharges up to 4 kV and air discharges up to 8 kV with both positive and negative voltages. The polarity of the electrostatic voltage is with respect to earth ground.

12.3.2 IEC 61000-6-1 specifies performance criterion B during and after electrostatic discharge tests, given as:

"The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended. In some cases the performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is however allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer then either of these may be derived from the product description and documentation and what the user may reasonably expect from the apparatus if used as intended."

The term "apparatus" means any sound level meter conforming with this standard.

12.3.3 After each and every electrostatic discharge test is complete, the sound level meter shall be fully operational and in a configuration identical to that established before the start of the electrostatic discharge tests. Previously stored data (if any) shall remain unchanged.

12.4 Immunity to power- and radio-frequency fields and conducted disturbances

12.4.1 Sound level meters in groups X, Y and Z shall exhibit a minimum degree of immunity over a range of power- and radio-frequencies and field strengths. The requirements are those specified in **1.1** of Table 1 in IEC 61000-6-1 and **1.2** of Table 1 in IEC 61000-6-2 with minor amendments. These amendments extend the range of radio-frequency fields to cover from 27 MHz to 1000 MHz, and increase the field strength for the power-frequency field to 80 A/m, as already specified in **8.4**.

The requirements are summarized as follows.

— Frequency range from 27 MHz to 1000 MHz. Root-mean-square electric field strength up to and including 10 V/m (unmodulated) with 80 % sinusoidal amplitude modulation at 1 kHz, except for the frequencies from 87 MHz to 108 MHz, from 174 MHz to 230 MHz and from 470 MHz to 790 MHz as specified in note 3 of Table 1 in IEC 61000-6-2, where the root-mean-square electric field strength is up to and including 3 V/m (unmodulated) with 80 % sinusoidal amplitude modulation at 1 kHz.

— Uniform root-mean-square alternating magnetic field of 80 A/m strength at 50 Hz or 60 Hz.

12.4.2 For sound level meters in groups Y or Z that are connected to a public power supply, the instruments shall also conform to additional requirements. These requirements are specified in Table 4 in IEC 61000-6-2.

12.4.3 For sound level meters in group Z, and where any interconnecting cable between any two parts of the system exceeds 3 m in length, the instruments shall also conform to the requirements of Table 2 in IEC 61000-6-2.

12.4.4 For all grounds of sound level meters, the immunity of any instrument to power and radio-frequency fields shall be demonstrated by applying an acoustic source of pink noise, band limited to 1/1 octave of 1 kHz (from 700 Hz to 1,4 kHz) with a roll-off rate of at least 12 dB per octave below and above these frequencies, respectively, at a frequency weighted sound level of 74 dB ± 1 dB as indicated by the sound level meter under test, suitably calibrated. The acoustic signal shall be applied to the microphone in such a manner that causes no interference with either the applied electromagnetic field or the normal operation of the sound level meter, or of the susceptibility of the instrument to radio-frequency radiation. The sound level meter shall be positioned in the reference orientation relative to the source of radio-frequency emissions.

12.4.5 During testing, the sound level meter shall be set for the normal mode of operation as described in the instruction manual. It shall be turned on, powered by its preferred supply, and set to read A-frequency-weighted and F-time-weighted sound level. If frequency weighting A is not provided, then frequency weighting C shall be selected. If time weighting F is not provided, then time weighting S shall be selected. If any of these choices is not provided, then the nearest equivalent setting should be selected. The level range control shall be set (if applicable) to cover the range from 70 dB to 80 dB in the primary indicator range. If a choice of ranges covering these sound levels exists, the selected range shall be the one for which the lowest measured sound level within the primary indicator range is closest to, but not greater than, 70 dB.

12.4.6 When the power- or radio-frequency field as specified in **12.4.1** is applied, the change in the indication of the sound level meter shall not exceed ±1 dB for a type 0 or 1 sound level meter, or ±2 dB for a type 2 or 3 sound level meter.

12.4.7 The specifications of **12.4.6** also apply to the additional requirements in **12.4.2** and **12.4.3**. No power- or radio-frequency field is applied during the testing of these additional requirements.

12.4.8 If the instruction manual states that a sound level meter conforms with the specifications of this clause for F-time-weighted, A-frequency-weighted sound levels (or the alternatives described in **12.4.5**) down to a sound level less than 74 dB, then the sound level meter shall conform within the tolerance limits of **12.4.6** for all sound levels between 74 dB and the stated lower sound level on all possible level ranges (if any) for all tests relevant to its group. The lower level shall be stated to 1 dB resolution and shall apply to all modes of operation of the instrument.

12.4.9 The instruction manual shall state the mode of operation and the connecting devices (if any) that produce the minimum immunity to power- and radio-frequency fields.

12.5 Test procedures

12.5.1 ***General***

12.5.1.1 The tests described in this subclause shall be carried out unless the particular configuration of the sound level meter renders them inappropriate, in which case equivalent tests shall be substituted if equivalence to these tests can be demonstrated. Unless stated otherwise, these tests apply to all sound level meters in groups X, Y and Z.

12.5.1.2 During testing, the instrument under test shall be set in the configuration for the normal mode of operation as described in the instruction manual. The instrument shall be turned on, powered by its preferred source of supply, and set to measure A weighted sound level with time weighting F (or the alternatives described in **12.4.5**).

12.5.1.3 Full details of equipment required to perform the tests and the methods of executing them are mostly contained in other standards with the additional requirements for sound level meters specified in this clause. Other standards listed in the preface shall be referred to for all relevant tests.

12.5.2 ***Emission measurements***

12.5.2.1 The instrument under test shall be configured and set according to the specification in the instruction manual to produce the greatest emissions in the frequency range being investigated.

12.5.2.2 Measurements of emissions shall be as described in clause **6** and clause **10** of CISPR 22. All results from measurements of radiated emissions shall conform to the requirements for enclosure ports given in Table 1 of CISPR 61000-6-3.

12.5.2.3 The instrument under test shall initially be tested in the reference orientation. For instruments with microphones attached by a cable, the microphone shall be positioned centrally above the case of the meter at a height of 250 mm, or as close to this distance as is practical. If the cable is longer than 250 mm, then it may be folded back on itself in a figure-of-eight configuration with an even number of folds of equal length, and all parts secured closely together at each end of the folds, and in their centre.

12.5.2.4 Maintaining the configuration of **12.5.2.3**, the instrument under test shall be tested for emissions in at least one other plane, each approximately orthogonal to the reference orientation, within the limits of suitable positioning for the measuring system employed.

12.5.2.5 Any fixtures and fittings used to maintain the position of the instrument under test (including the microphone and cable if appropriate) shall be such as to have no significant influence on the measurement of any emissions from the instrument.

12.5.2.6 If the instrument under test is fitted with a connection device that allows interface or interconnection cables to be attached to it, then all tests of emissions shall be carried out with cables connected to all available connection devices. All cables shall be left unterminated and arranged as described in clause **8** of CISPR 22, unless the manufacturer of the sound level meter also supplies the device connected to the sound level meter by this cable, in which case all items shall be tested together.

12.5.2.7 Where several connections can be made to the same connecting device, emissions shall be measured only with the configuration that produces the greatest emissions. Other configurations emitting similar or lower levels of emissions may be included in the instruction manual in a list of complaint configurations without further testing, provided the tested configuration fully conforms to the limits of **12.2**.

12.5.2.8 For sound level meters in groups Y and Z connected to a public power supply, disturbances conducted to the public power supply shall be measured as described in CISPR 22 and shall conform to the requirements of clause **5** of that standard for class B equipment.

12.5.3 ***Tests for electrostatic discharge***

12.5.3.1 Equipment required and methods of testing are described in IEC 61000-4-2.

12.5.3.2 If the instrument under test is fitted with connection devices that are not required as part of the configuration for the normal mode of operation, then no cables shall be fitted during the electrostatic-discharge test. Discharges shall not be made to pins on connectors that are recessed behind the surface of either the connector or sound level meter.

12.5.3.3 Any supports or other items used to maintain the position of the instrument under test during testing shall not obscure any part of the sound level meter required for access for static discharge, nor shall they affect the testing of the sound level meter.

12.5.3.4 Contact and air discharges of all required polarities and voltages shall be applied 10 times each to all appropriate parts of the instrument under test.

NOTE Care should be taken to ensure that the sound level meter under test is fully discharged from any effects of each test before repeating the application of a discharge.

12.5.3.5 If the instruction manual specifies a performance degradation or loss of function after the electrostatic discharge tests, this degradation or loss of function shall not allow any reduced operation, change of configuration or corruption or loss of any stored data.

12.5.4 ***Tests for immunity to power- and radio-frequency fields and conducted disturbances***

12.5.4.1 The equipment required and the test methods needed to test for radio-frequency fields are described in IEC 61000-4-3.

12.5.4.2 Testing shall first be made in the reference orientation with any microphone cables arranged as described in **12.5.2.3**. The signal from the acoustic source described in **12.4.4** shall be applied to the microphone.

12.5.4.3 Tests for immunity to radio-frequency fields may be performed at discrete frequencies in accordance with clause **8** of IEC 61000-4-3, but increments of up to 4 % for frequencies less than 500 MHz and up to 2 % for all other frequencies may be substituted for the 1 % specified therein. Dwell time at each frequency shall be appropriate to the sound level meter under test. Testing at a limited number of discrete frequencies does not negate the need to meet the requirements of **12.4** at all frequencies within the specified range.

12.5.4.4 If the instrument under test is fitted with a connection device that allows interface or interconnection cables to be attached to it, then all tests for immunity to power- and radio-frequency fields shall be performed with cables connected to all available connection devices. All cables shall be left unterminated and shall be arranged as described in clause **8** of CISPR 22 unless the supplier of the sound level meter also supplies the device connected to the sound level meter by this cable, in which case all items shall be tested together.

12.5.4.5 Where several connections can be made to the same connecting device, tests shall be performed only with the configuration specified in the instruction manual as producing minimum immunity. Other configurations that are equally or more immune may be included in the instruction manual in a list of conforming configurations without further testing, provided the tested configuration fully conforms to the limits of **12.4**.

12.5.4.6 Tests of immunity to radio-frequency fields shall be performed as described in clause **8** of IEC 61000-4-3.

12.5.4.7 Power-frequency testing shall be as specified in **8.4** with the acoustic source of **12.4.4** applied to the microphone in a manner that has no influence on the power-frequency field.

12.5.4.8 Maintaining the configuration of **12.5.4.2** and **12.5.4.4**, the instrument under test shall be tested in at least one other plane, each approximately orthogonal to the reference orientation, within the limits of suitable positioning for the radio-frequency transmitting system employed.

12.5.4.9 During testing, the instrument under test shall remain fully operational and in the same configuration as it was before testing commenced.

12.5.4.10 If the instruction manual states that the instrument conforms to the specifications of this clause at a sound level less than 74 dB, the tests for immunity to power- and radio-frequency fields shall be repeated in steps of not greater than 5 dB on all applicable level ranges from a sound level of 74 dB down to the lower sound level stated in the instruction manual for conformance with the specifications of this clause to the nearest decibel. The specified acoustic source shall continue to be used for these tests, with its output signal level reduced as required.

12.5.4.11 For sound level meters in groups Y and Z operating from a public power supply, tests shall be performed to demonstrate conformance to additional specifications given in **12.4.2**.

12.5.4.12 For sound level meters in group Z using or specifying interconnecting cables longer than 3 m, tests shall be performed to demonstrate conformance to the additional specifications given in **12.4.3**.

Appendix A
Tests of the overload and detection characteristics

Tests of the overload and detection characteristics of the instrument for compliance with Clause **7** are carried out with rectangular pulse sequences and with tone bursts as described in Clauses **A.1** and **A.2** respectively.

A.1 Rectangular pulse test

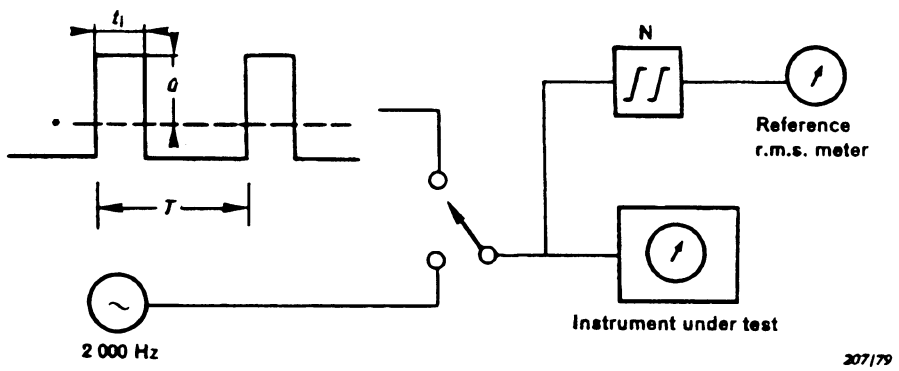

Figure A.1

Apply the 2 000 Hz sinusoidal signal to the instrument under test and simultaneously to a reference system having a true r.m.s. response and a frequency weighting network N, corresponding to that in the sound level meter being tested within the tolerances given in Table V, page 9. Note the indication of the reference meter.

Apply the rectangular pulse sequence and adjust its amplitude to give an indication on the reference r.m.s. meter identical to that for the sinusoidal signal. The instrument under test shall then give an indication within the tolerances specified in this standard.

For the rectangular pulse shown, the relation between crest factor ($\hat{u}/u$) and pulse duty factor (t_i/T) is given by:

$$(\hat{u}/u) = \sqrt{(T/t_i) - 1}$$

where

$\hat{u}$ is the peak value of the signal, the instantaneous value being measured with reference to the arithmetic mean (see Sub-clause **3.3**);

u is the r.m.s. value of the signal, the instantaneous value being measured with reference to the arithmetic mean (see Sub-clause **3.3**);

T is the fundamental period of the signal;

t_i is the time during which the signal is at its peak value $\hat{u}$.

A.2 Tone burst test

The rectangular pulse generator in Clause **A.1** is replaced by a tone burst generator and the procedure described above is repeated using the appropriate crest factor. The relation between crest factor and pulse duty factor for this case is given by:

$$(\hat{u}/u) = \sqrt{2T/t_i}$$

where

$\hat{u}$, u and T are as defined above, and where t_i is the time during which the signal has a non-zero value.

Appendix B
Diffuse field sensitivity

The sensitivity S of the complete instrument in a diffuse sound field is defined as the r.m.s. value of the sensitivities for all orientations in a free field. For this purpose, it will generally suffice to measure the sensitivity at angles of incidence of 0°, 30°, 60°, 90°, 120°, 150° and 180° from an axis of symmetry of the microphone and to obtain S from the following formula which takes account, for each orientation, of the area of the corresponding surface element:

$$S = \sqrt{K_1 S_0^2 + K_2 S_{30}^2 + K_3 S_{60}^2 + \ldots + K_7 S_{180}^2}$$

where

S_0, S_{30}, S_{60} ... S_{180} are the sensitivities expressed in linear units, (for example, millivolts per pascal) at the respective angles;

$K_1 = K_7 = 0.018$;

$K_2 = K_6 = 0.129$;

$K_3 = K_5 = 0.224$;

$K_4 = 0.258$.

Appendix C
Theoretical response to tone bursts

The values given in Table VIII, Table X and Table XI, pages 11, and 12, are obtained using the following formulae.

For the single burst in Table VIII and Table X:

$$\Delta L = 10 \log_{10} \{1 - \exp(-t_i/\tau)\} \text{ dB}$$

For the continuous sequence of bursts given in Table XI:

$$\Delta L = 10 \log_{10} \left\{ \frac{1 - \exp(-t_i/\tau)}{1 - \exp(-T/\tau)} \right\} \text{ dB}$$

where

t_i is the burst duration in seconds;

τ is the time constant of the exponential averaging circuit as specified in Figure 1 and Figure 2, pages 10 and 12;

$T = 1/f_p$ in seconds, where f_p is the repetition frequency of the bursts in hertz.

Appendix D (normative)
Equations for design-goal frequency weightings

Analytical expressions for the non-dimensional C-, B-, and A weighting relative frequency response R in terms of poles and zeros are given by the following equations as continuous functions of frequency f in hertz.

For the C-weighting:

$$R_C(f) = \frac{12\,200\, f^2}{(f^2 + 20{,}6^2)\,(f^2 + 12\,200^2)} \qquad \text{(D1)1)}$$

For the B-weighting:

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

For the A weighting:

$$R_A(f) = \frac{12\,200^2\, f^4}{(f^2 + 20{,}6^2)\,(f^2 + 12\,200^2)\,(f^2 + 107{,}7^2)^{1/2}\,(f^2 + 737{,}9^2)^{1/2}} \qquad \text{(D3)}$$

Corresponding expressions for the C-, B-, and A-weighting relative frequency response levels, in decibels relative to the response at 1 000 Hz, are given by:

$$C(f) = 20 \lg[R_C(f)/R_C(1\,000)] \qquad \text{(D4)}$$

$$B(f) = 20 \lg[R_B(f)/R_B(1\,000)] \qquad \text{(D5)}$$

$$A(f) = 20 \lg[R_A(f)/R_A(1\,000)] \qquad \text{(D6)}$$

For calculation of the design-goal C-, B-, and A weightings in Table IV: frequency f is an exact frequency calculated from (1 000) ($10^{0,1n}$) where n is an integer: positive, negative, or zero.

1) See National foreword.

Appendix E (informative)
Emission limits

Table E.1 — Limits for radiated disturbance of class B ITE at a measurement distance of 10 m

Frequency range MHz	**Quasi-peak limits** dB (μV/m)
30 to 230	30
230 to 1000	37
NOTE 1 The lower limit applies at the transition frequency.	
NOTE 2 Additional provisions may be required for cases where interference occurs.	
NOTE 3 The characteristics of a quasi-peak receiver are specified in **4.1.2** of CISPR 16-1.	

For mains-powered equipment, the following is also required.

Table E.2 — Limits for conducted disturbance at the mains ports of class B ITE

Frequency range MHz	**Limits** dB (μV/m)	
	Quasi-peak	**Average**
0,15 to 0,50	66 to 56	56 to 46
0,50 to 5	56	46
5 to 30	60	50
NOTE 1 The lower limit applies at the transition frequency.		
NOTE 2 The limit decreases linearly with the logarithm of the frequency in the range 0,15 MHz to 0,50 MHz.		

Annex ZA (normative)
Other international publications quoted in this standard with the references of the 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.

NOTE When the international publication has been modified by CENELEC common modifications, indicated by (mod), the relevant EN HD applies.

IEC publication	Date	Title	EN/HD	Date
60537	1976	*Frequency weighting for the measurement of aircraft noise (D-weighting)*	—	—
60942	1988	*Sound calibrators*	HD 556 S1	1991
IEC 61000-4-2	1995	*Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*	EN 61000-4-2	1995
IEC 61000-4-3 (mod)	1995	*Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test*	EN 61000-4-3	1996
IEC 61000-6-1	1997	*Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments*	—	—
IEC 61000-6-2	1999	*Part 6-2: Generic standards — Immunity for industrial environments*	EN 61000-6-2	1999
IEC 61000-6-3	1996	*Part 6-3: Generic standards — Emission standard for residential, commercial and light-industrial environments*	—	—
CISPR 16-1	1999	*Specification for radio disturbance and immunity measuring apparatus and methods — Part 1: Radio disturbance and immunity measuring apparatus*	—	—
CISPR 22 (mod)	1997	*Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement*	EN 55022 + corr. August	1998 1999

National annex NA (informative)
Committees responsible

The United Kingdom participation in the preparation of this European Standard was entrusted by the Electronic Equipment Standards Policy Committee (EEL/-) to Technical Committee EEL/24 upon which the following bodies were represented:

British Association of Otolaryngologists
British Hearing Aid Industry Association
British Hearing Aid Manufacturers' Association
British Medical Association
British Telecommunications plc
Confederation of British Industry
Department of Health
Department of Trade and Industry (National Physical Laboratory)
Health and Safety Executive
Institute of Acoustics
Institute of Sound and Vibration Research
Institution of Electrical Engineers
Medical Research Council
Ministry of Defence
National Health Services
Royal Aeronautical Society
Royal National Institute for Deaf People
Society of Environmental Engineers
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BS EN 60651:1994 IEC 60651:1979

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