

Description and measurement of environmental noise —

Part 1: Guide to quantities and procedures

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Committees responsible for this British Standard

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Association of Noise Consultants
 Association of Professional Clay Target Shooting Grounds
 BRE – Building Research Establishment
 British Association for Shooting and Conservation
 British Measurement and Testing Association
 British Metals Federation
 British Occupational Hygiene Society
 Chartered Institute of Environmental Health
 Directorate of Airspace Policy
 Electricity Association
 HSE – Health and Safety Executive
 Institute of Acoustics
 Institute of Sound and Vibration Research
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 National Rifle Association
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Foreword

This part of BS 7445 has been prepared by Subcommittee EH/1/3. It supersedes BS 7445-1:1991 (dual numbered ISO 1996-1:1982), which is withdrawn.

This new edition of BS 7445-1 does not reflect a full review or revision of the standard, which will be undertaken in due course.

The previous edition of BS 7445-1 (1991) was identical with ISO 1996-1:1982 published by the International Organization for Standardization (ISO).

Following an extended period of international consultation Subcommittee 1, Noise, of ISO Technical Committee 43, Acoustics, prepared a revised version of ISO 1996-1. The UK and France voted against the adoption of the revised version as an ISO standard. The main reasons given for the negative votes included the fact that few, if any, of the innovations introduced in the revised standard could be supported by existing scientific or technical evidence. In addition, UK Subcommittee EH/1/3 had serious concerns over some of the definitions introduced in the revised ISO 1996-1.

UK Subcommittee EH/1/3, therefore, decided to re-issue the previous version of BS 7445-1 (dual numbered ISO 1996-1) as a new edition (BS 7445-1:2003) without making any changes to the technical content to distinguish it from the revised version of ISO 1996-1 published in 2003.

BS 7445 comprises the following parts:

- *Part 1: Guide to quantities and procedures;*
- *Part 2: Guide to the acquisition of data pertinent to land use* (identical with ISO 1996-2:1987);
- *Part 3: Guide to application to noise limits* (identical with ISO 1996-3:1987).

BS 7445-2 and -3 will be reviewed at such time that any revised versions of the identical ISO standards are published.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

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Introduction

Extensive research concerning the way in which human beings are affected by noise from a single kind of source such as rail or road vehicles, aircraft or industrial plants, has led to a variety of measures for assessment of different kinds of noise, many of which are in common use. Conversion from one measure to another is often beset with serious uncertainty.

If an acoustical environment were always dominated by a single kind of noise, the confusion caused by the existence of different measures would not be so severe. But often environmental noise is a composite of the sounds from many sources, and the distribution of the different kinds of noise is likely to change from moment to moment. The methods and procedures described in this British Standard are intended to be applicable to sounds from all sources, individually and in combination, which contribute to the total noise at a site. At the present stage of technology this requirement seems to be best met by adopting the equivalent continuous A-weighted sound pressure level as a basic quantity. Results are always expressed in terms of this quantity even if supplemented by corrections or other descriptors that, in certain cases, may be deemed appropriate.

The aim of the BS 7445 series is to provide authorities with material for the description of noise in community environments. Based on the principles described in this British Standard, acceptable limits of noise can be specified and compliance with these limits can be controlled.

This British Standard does not specify limits for environmental noise.

1 Scope

This part of BS 7445 defines the basic quantities to be used for the description of noise in community environments and describes basic procedures for the determination of these quantities.

This British Standard forms the basis for further parts in the BS 7445 series.

2 References

BS 5727 (ISO 3891), *Method for describing aircraft noise heard on the ground* [ISO 3981].

BS 7445-2 (ISO 1996-2), *Description and measurement of environmental noise — Part 2: Guide to the acquisition of data pertinent to land use*.

BS EN 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*.

BS EN 61672-2, *Electroacoustics — Sound level meters — Part 2: Pattern evaluation tests*.

ISO 1999, *Acoustics — Determination of occupational noise exposure and estimation of noise-induced hearing impairment*.

3 Definitions

For the purpose of this British Standard and other parts in the series the following definitions apply.

3.1

A-weighted sound pressure, in pascals

root mean square sound pressure determined by use of frequency-weighting network “A” (see BS EN 61672)

3.2

sound pressure level, in decibels

sound pressure level is given by the formula

$$L_p = 10 \lg \left(\frac{p}{p_0} \right)^2$$

where

p is the root mean square sound pressure, in pascals (Pa);

p_0 is the reference sound pressure (20 μ Pa)

3.3**A-weighted sound pressure level, in decibels**

sound pressure level of A-weighted sound pressure is given by the formula

$$L_{pA} = 10 \lg \left(\frac{p_A}{p_0} \right)^2$$

3.4**percentile level**

A-weighted sound pressure level obtained by using time-weighting “F” (see BS EN 61672) that is exceeded for N % of the time interval considered

Symbol: $L_{AN,T}$; for example $L_{A95,1\text{ h}}$ is the A-weighted level exceeded for 95 % of 1 h

NOTE Percentile levels as determined over a certain time interval cannot generally be extrapolated to other time intervals.

3.5**equivalent continuous A-weighted sound pressure level, in decibels**

value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval T , has the same mean square sound pressure as a sound under consideration whose level varies with time, given by the formula

$$L_{Aeq,T} = 10 \lg \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt \right]$$

where

$L_{Aeq,T}$ is the equivalent continuous A-weighted sound pressure level, in decibels, determined over a time interval T starting at t_1 and ending at t_2 ;

p_0 is the reference sound pressure (20 μPa);

$p_A(t)$ is the instantaneous A-weighted sound pressure of the sound signal

NOTE 1 Equivalent continuous A-weighted sound pressure level during time interval T is also called time interval average sound level, $L_{A,T}$, in decibels, with the averaging time interval usually indicated in the format, for example one-hour average sound level, $L_{A,1\text{h}}$.

NOTE 2 Equivalent continuous A-weighted sound pressure level is also used for assessment of occupational noise exposure (see ISO 1999).

3.6**sound exposure level, in decibels**

sound exposure level of a discrete noise event given by the formula

$$L_{AE} = 10 \lg \frac{1}{t_0} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt$$

where

$p_A(t)$ is the instantaneous A-weighted sound pressure;

$t_2 - t_1$ is a stated time interval long enough to encompass all significant sound of a stated event;

p_0 is the reference sound pressure (20 μPa);

t_0 is the reference duration (1 s)

NOTE L_{AE} is given in BS 5727 (ISO 3891) as L_{AX} (single-event exposure level).

3.7**measurement time interval**

that time interval over which the squared A-weighted sound pressure is integrated and averaged

3.8**reference time interval**

time interval to which an equivalent continuous A-weighted sound pressure level can be referred

NOTE It may be specified in national or international standards or by local authorities to cover typical human activities and variations in the operation of sound sources.

3.9**long-term time interval**

specified time interval for which the results of the noise measurement are representative

NOTE The long-term time interval consists of a series of reference time intervals and is determined for the purpose of describing the environmental noise and is generally designated by competent authorities.

3.10**long-term average sound level**

average over the long-term time interval of the equivalent continuous A-weighted sound pressure levels for a series of reference time intervals comprised within the long-term time interval, carried out as described in BS 7445-2 (ISO 1996-2)

3.11**rating level**

equivalent continuous A-weighted sound pressure level during a specified time interval, plus specified adjustments for tonal character and impulsiveness of the sound

3.12**long-term average rating level**

average over the long-term time interval of the rating levels for a series of reference time intervals, carried out as described in BS 7445-2 (ISO 1996-2)

3.13 categories of noise**3.13.1****ambient noise**

totally encompassing sound in a given situation at a given time usually being composed of sound from many sources near and far

3.13.2**specific noise**

component of the ambient noise which can be specifically identified by acoustical means and may be associated with a specific source

NOTE The ambient noise remaining at a given position in a given situation when one or more specified noises are suppressed is sometimes called the residual noise.

3.13.3**initial noise**

ambient noise prevailing in an area before any modification of the existing situation

3.14

symbols

symbols for sound levels are given in Table 1

Table 1 — Symbols for sound levels

| Quantity | Symbol | Unit | Remarks |
|---|---------------|------|---|
| Sound pressure level | L_p | dB | — |
| A-weighted sound pressure level | L_{pA} | dB | — |
| Percentile level | $L_{AN,T}$ | dB | Level exceeded for N % of time interval T |
| Sound exposure level | L_{AE} | dB | For noise events |
| Equivalent continuous A-weighted sound pressure level | $L_{Aeq,T}$ | dB | Time interval shall be stated |
| Long-term average sound level | $L_{Aeq,L T}$ | dB | Time interval shall be stated |
| Rating level | $L_{Ar,T}$ | dB | Time interval shall be stated |
| Long-term average rating level | $L_{Ar,L T}$ | dB | Time interval shall be stated |

4 Instrumentation

4.1 General

The instrumentation system shall be designed to determine equivalent continuous A-weighted sound pressure level, either directly or indirectly, and either in direct accordance with the definition in 3.5 or by some approximative process. The instrumentation shall conform to the specifications for sound level meters preferably of type 1 but at least of type 2 as given in BS EN 61672. Integrating averaging sound level meters shall be of category P as specified in BS EN 61672. Alternative instrumentation, if used, shall provide equivalent performance in respect of frequency and time weightings and tolerances.

The instrumentation may comprise:

- integrating-averaging sound level meter set to frequency-weighting “A”;
- sound exposure level meter for measurements of sound exposure level of discrete events;
- sound level meter set to frequency-weighting “A” and time-weighting “S”;
- data logger for sampling the running value of A-weighted sound pressure level using time-weighting “F”;
- statistical distribution analyser for sampling the running value as in d).

The instrumentation described in d) and e) could also be used to obtain values of percentile levels.

NOTE 1 Instrumentation of types a) and b) is preferred and will generally be used for noise of impulsive, fluctuating or cyclic character. Special care should be taken to ensure that the dynamic range is large enough and that the inherent electrical noise and overload capacity of these instruments are suitable for the applications.

NOTE 2 When using instrumentation described in e) the class interval should be chosen in relation to the overall range of sound pressure levels but should not exceed 5 dB.

Ways of determining the equivalent continuous A-weighted sound pressure level using the various kinds of equipment are described in 5.4.

4.2 Calibration

All equipment shall be calibrated and the configuration for calibration shall be in accordance with the manufacturer's instructions.

A comprehensive recalibration at certain time intervals (for example annually) may be prescribed by authorities responsible for the use of the measurement results.

A field check shall be made by the user at least before and after each series of measurements, preferably including an acoustic check of the microphone.

5 Measurements

5.1 General

The results of the measurements described in this British Standard may be used for the purposes described in detail in the relevant standards. It is important that pertinent details of the measurement instrumentation, measurement procedure and conditions prevailing during the measurements are carefully recorded and kept for reference purposes. Reference to the pertinent standards shall also be given.

NOTE 1 When the measured signals are recorded on magnetic tape for control and reference purposes it should be borne in mind that even with studio-quality (non-digital) recorders the dynamic range may fall short of that necessary when instrumentation of the types mentioned in 4.1a) and 4.1b) is used.

NOTE 2 In some circumstances the frequency-weighting network "A" is inadequate for filtering out high level infrasound which occurs near some industrial locations and some forms of transport as well as near buildings due to wind turbulence. This may cause overload and, if not detected, distortion produced at higher frequencies may be inaccurately attributed to audible sound.

5.2 Measurement positions

5.2.1 General

The choice of the actual measurement positions depends on the purpose of the measurements as specified in the pertinent standard.

5.2.2 Outdoor measurements

When it is desired to minimize the influence of reflections then measurements should, whenever possible, be carried out at least 3.5 m from any reflecting structure other than the ground. When not otherwise specified, the preferred measurement height is 1.2 m to 1.5 m above the ground. Other measurement heights may be specified in pertinent standards.

5.2.3 Outdoor measurements near buildings

These measurements shall be carried out at places where the noise to which a building is exposed is of interest. If not otherwise specified, the preferred measurement positions are 1 m to 2 m from the facade and 1.2 m to 1.5 m above each floor level of interest.

5.2.4 Measurements inside buildings

These measurements shall be carried out in enclosures where the noise is of interest. If not otherwise specified, the preferred measurement positions are at least 1 m from the walls or other major reflecting surfaces, 1.2 m to 1.5 m above the floor and approximately 1.5 m from windows.

5.3 Meteorological effects

5.3.1 General

Sound levels are affected by meteorological conditions, especially when the transmission distance is large. Where levels are likely to be affected by meteorological conditions they should be measured in one of the two ways described below.

5.3.2 Measurements averaged over a range of meteorological conditions

The measurement time intervals are chosen in such a way that the long-term average sound level is determined over the range of meteorological conditions found at the measurement position(s).

5.3.3 Measurements made under specific meteorological conditions

The measurement time intervals are chosen so that measurements are taken only under carefully specified meteorological conditions. Normally, the conditions chosen will be those which result in the most stable sound propagation, that is, with a significant positive wind component from source to measurement position(s).

NOTE In some cases it may be possible to determine a sound pressure level equivalent to that obtained under the conditions of 5.3.2 by applying a correction to the values obtained by using the method of 5.3.3.

5.4 Recommended procedures for the determination of equivalent continuous A-weighted sound pressure level

5.4.1 General recommended procedures

The environmental noise descriptors defined in this British Standard may be used for a variety of purposes; the wide range of circumstances makes it extremely difficult to specify in detail procedures for any particular case. Procedures for certain specific cases will be described in the relevant standards. Four cases can be distinguished for which different instrumentation is best suited, see 4.1. These cases are described in 5.4.2, 5.4.3, 5.4.4 and 5.4.5.

NOTE The use of integrating-averaging instrumentation described in 4.1a) and 4.1b) will yield correct results for all types of noise. For the simpler cases of 5.4.3 and 5.4.4 the sound level meter may be used; for the cases of 5.4.2 and 5.4.5 approximate results may be obtained by sampling methods using the equipment described in 4.1d) and 4.1e).

5.4.2 Fluctuating noise

5.4.2.1 General

For general use, and especially if the noise is fluctuating, the preferred instrument is the integrating-averaging sound level meter or the sound exposure level meter in which case the associated measurement time intervals shall be recorded. Alternatively, sampling or statistical distribution analysis can be used.

5.4.2.2 Sampling of the sound pressure level at a sampling rate $1/\Delta t$, over the time interval $t_2 - t_1$.

The A-weighted equivalent continuous sound pressure level, $L_{Aeq,T}$, is derived using the formula

$$L_{Aeq,T} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^N 10^{0,1L_{pAi}} \right]$$

where

N is the total number of samples $\left(N = \frac{t_2 - t_1}{\Delta t} \right)$;

L_{pAi} is the sampled values of the pressure level, in decibels (dB);

Δt is the time interval between two adjacent samples taken by the instrument.

The sampling period may greatly influence the accuracy of the result if not conveniently matched to the approximate time constant of the integration giving the sound pressure level. A sampling period less than the time constant of the complete instrumentation will generally give a good approximation to the results obtained with a true integration.

5.4.2.3 Use of statistical distribution by observing the readings of the A-weighted sound pressure level at intervals of time by a sampling technique.

Class intervals for the sound pressure levels should be chosen according to the character of the noise; in most cases an interval of 5 dB will be appropriate.

The A-weighted equivalent continuous sound pressure level, $L_{Aeq,T}$, is derived using the formula

$$L_{Aeq,T} = 10 \lg \left[\frac{1}{100} \sum_{i=1}^n f_i 10^{0,1L_i} \right]$$

where

n is the number of classes;

f_i is that percentage of the time interval for which the A-weighted sound pressure level is within the limits of class i ;

L_i is the A-weighted sound pressure level corresponding to the class-midpoint of class i , in decibels (dB).

5.4.3 Steady noise

If the noise is steady over the period of interest the measurements may be carried out with a sound level meter conforming to BS EN 61672, type 1 or 2. The frequency-weighting network “A” and the time-weighting “S” should be used.

The reading is taken as the average meter deflection. If the meter reading fluctuates over a range of more than 5 dB, then the noise cannot be considered steady.

5.4.4 Steady noise with stepwise variations of level

If the noise is steady but occurs at a number of clearly distinguishable values of sound pressure levels, then the separate levels can be measured as for steady noise and the durations associated with each level can be determined, thus permitting the calculation of the equivalent continuous A-weighted sound pressure level, in decibels, by the formula

$$L_{Aeq,T} = 10 \lg \left[\frac{1}{T} \sum T_i 10^{0,1L_{pAi}} \right]$$

where

$T = \sum T_i$ is the total time interval;

L_{pAi} is the A-weighted sound pressure level prevailing during the time interval T_i .

5.4.5 Separate noise events

When a noise environment is the result of a number of identifiable noise events, the equivalent continuous A-weighted sound pressure level, in decibels, may be calculated from the sound exposure levels of the individual events occurring within a time period T :

$$L_{Aeq,T} = 10 \lg \left[\frac{t_o}{T} \sum_{i=1}^n 10^{0,1L_{AEi}} \right]$$

where

L_{AEi} is the sound exposure level of the i 'th event in a series of n events in time period T , in seconds;

$t_o = 1$ s.

If the noise consists of a succession of similar discrete events (that is, having equal values of sound exposure level) it may be measured by any of the methods given in 5.4.2 over an integer number of complete cycles of the noise.

Alternatively, the sound exposure level of a cycle of the noise, L_{AE} , may first be measured by means of a sound exposure level meter, see 4.1b), and the reading then converted to equivalent continuous A-weighted sound pressure level, in decibels, by the formula

$$L_{Aeq,T} = L_{AE} + 10 \lg n - 10 \lg \left(\frac{T}{t_o} \right)$$

where

n is the number of cycles occurring in the time interval T ;

$t_o = 1$ s.

5.5 Adjustments

The measurements described in this British Standard are designed to give a reliable physical description of the environmental noise. For assessment of human reactions to noise it is sometimes necessary to make adjustments to the measured values in order to arrive at a more meaningful basis for the assessment.

When such adjustments are made to a value of equivalent continuous A-weighted sound pressure level it is termed rating level, $L_{Ar,T}$.

6 Information to be recorded

6.1 General

In addition to the results of the acoustic measurements the information in 6.2 shall be recorded and kept for reference purposes. The information in 6.3 and 6.4 should also be recorded, if relevant.

6.2 Measurement technique

- a) Type of instrumentation, measurement procedure and any calculation employed.
- b) Description of the time aspect of the measurements, i.e. the reference and measurement time intervals, including details of sampling, if used.
- c) Positions of measurements.

6.3 Conditions prevailing during measurements

- a) Atmospheric conditions: direction and speed of wind; rain; temperature at ground level and other levels; atmospheric pressure; relative humidity.
- b) Nature and state of the ground between noise source(s) and measurement position(s).
- c) Variability of emission of noise sources.

6.4 Qualitative data

Data such as the following may be significant for the interpretation of the results.

- a) Possibility of locating the origin of the noise.
- b) Possibility of identification of the sound source.
- c) Nature of the sound source.
- d) Character of the sound.
- e) Connotation of the sound.

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