International Standard 1996/1

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Acoustics — Description and measurement of environmental noise — Part 1 : Basic quantities and procedures

Acoustique — Caractérisation et mesurage du bruit de l'environnement — Partie 1 : Grandeurs et méthodes fondamentales

First edition — 1982-09-15

UDC 534.61 **Ref. No. ISO 1996/1-1982 (E)**

Descriptors : acoustics, acoustic measurement, noise (sound), sound pressure, quantities, units of measurement.

Price based on 5 pages

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1996/1 was developed by Technical Committee ISO/TC 43, *Acoustics*, and was circulated to the member bodies in November 1980.

It has been approved by the member bodies of the following countries :

Australia	Germany, F. R.	New Zealand
Austria	Greece	Norway
Belgium	Hungary	Romania
Canada	India	South Africa, Rep. of
China	Ireland	Spain
Czechoslovakia	Israel	Sweden
Denmark	Italy	Switzerland
Finland	Japan	United Kingdom
France	Netherlands	USSR

The member body of the following country expressed disapproval of the document on technical grounds :

USA

This International Standard cancels and replaces ISO Recommendation R 1996-1971, of which it constitutes a technical revision.

Acoustics — Description and measurement of environmental noise — Part 1 : Basic quantities and procedures

0 Introduction

This International Standard is the first in a series of documents replacing ISO Recommendation R 1996, *Acoustics — Assessment of noise with respect to community response.* The present list of parts of ISO 1996 is as follows :

Part 1 : Basic quantities and procedures;

Part 2 : Acquisition of data pertinent to land use;

Part 3 : Application to noise limits.

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 International 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 shall always be 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 ISO 1996 series is to provide authorities with material for the description of noise in community environments. Based on the principles described in this International Standard, acceptable limits of noise can be specified and compliance with these limits can be controlled.

This International Standard does not specify limits for environmental noise.

1 Scope and field of application

This part of ISO 1996 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 International Standard forms the basis for further parts in the ISO 1996 series.

2 References

ISO 1999, *Acoustics — Determination of occupational noise exposure and estimation of noise-induced hearing impairment.* [1]

ISO 3891, *Acoustics — Procedure for describing aircraft noise heard on the ground.*

IEC Publication 651, *Sound level meters.*

IEC Publication 804, *Integrating-averaging sound level meters.*

3 Definitions

For the purpose of this International Standard and other parts in the series the following definitions apply :

3.1 A-weighted sound pressure, in pascals : The root mean square sound pressure determined by use of frequency-weighting network "A" (see IEC Publication 651).

3.2 sound pressure level, in decibels : The 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;

p_0 is the reference sound pressure (20 μPa).

1) At present at the stage of draft. (Revision of ISO 1999-1975.)

3.3 A-weighted sound pressure level, in decibels : Sound pressure level of A-weighted sound pressure is given by the formula

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

3.4 percentile level : The A-weighted sound pressure level obtained by using time-weighting "F" (see IEC Publication 651) that is exceeded for N % of the time interval considered. Symbol : $L_{AN,T}$; for example $L_{A95,1\,h}$ 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. It is given by the formula

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

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_o is the reference sound pressure (20 μPa);

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

NOTES

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, $L_{A,1h}$.

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

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

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_o is the reference sound pressure (20 μPa);

t_o is the reference duration (1 s).

NOTE — L_{AE} is given in 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 : The time interval to which an equivalent continuous A-weighted sound pressure level can be referred. 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 : A specified time interval for which the results of the noise measurement are representative. 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 : The 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. Averaging is to be carried out as described in ISO 1996/2.

3.11 rating level : The 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 : The average over the long term time interval of the rating levels for a series of reference time intervals. Averaging is to be carried out as described in 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 : A 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 : The ambient noise prevailing in an area before any modification of the existing situation.

3.14 symbols : Symbols for sound levels are given in the table.

Table — 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	$L_{Aeq,LT}$	dB	Time interval shall be stated
Rating level	$L_{Ar,T}$	dB	Time interval shall be stated
Long term average rating level	$L_{Ar,LT}$	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 comply with the specifications for sound level meters preferably of type 1 but at least of type 2 as given in IEC Publication 651. Integrating averaging sound level meters shall be of category P as specified in IEC Publication ... Alternative instrumentation, if used, shall provide equivalent performance in respect of frequency and time weightings and tolerances.

The instrumentation may comprise

a) integrating-averaging sound level meter set to frequency-weighting "A";

b) sound exposure level meter for measurements of sound exposure level of discrete events;

c) sound level meter set to frequency-weighting "A" and time-weighting "S";

d) data logger for sampling the running value of A-weighted sound pressure level using time-weighting "F";

e) 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.

NOTES

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.

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 International Standard may be used for the purposes described in detail in the relevant International 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 International Standards shall also be given.

NOTES

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 4.1 a) and b) is used.

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

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

5.2.1 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 to 1,5 m above the ground. Other measurement heights may be specified in pertinent standards.

5.2.2 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 to 2 m from the façade and 1,2 to 1,5 m above each floor level of interest.

5.2.3 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 to 1,5 m above the floor and about 1,5 m from windows.

5.3 Meteorological effects

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.

5.3.1 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).

5.3.2 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 5.3.1 by applying a correction to the values obtained by using the method of 5.3.2.

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 International 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 International Standards. Four cases can be distinguished for which different instrumentation is best suited, see 4.1. These cases are described in 5.4.2 to 5.4.5.

NOTE — The use of integrating-averaging instrumentation described in 4.1 a) and b) 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 4.1 d) and e).

5.4.2 Fluctuating noise

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.

5.4.2.1 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, $L_{\mathrm{Aeq},T}$, is derived using the formula

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

where

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

$L_{p\mathrm{A}i}$ is the sampled values of the pressure level, in decibels;

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.

5.4.2.2 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, $L_{\mathrm{Aeq},T}$, is derived using the formula

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

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.

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 complying with IEC Publication 651, 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

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

where

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

$L_{p\mathrm{A}i}$ 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 :

$$L_{\mathrm{Aeq},T} = 10 \lg \left[\frac{t_0}{T} \sum_{i=1}^{n} 10^{0,1 \, L_{\mathrm{AE}i}} \right]$$

where

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

$t_0 = 1$ 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 4.1 b), and the reading then converted to equivalent continuous A-weighted sound pressure level, in decibels, by the formula

$$L_{\mathrm{Aeq},T} = L_{\mathrm{AE}} + 10 \lg n - 10 \lg \left(\frac{T}{t_0} \right)$$

where

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

$t_0 = 1$ s.

5.5 Adjustments

The measurements described in this International 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, $L_{\mathrm{Ar},T}$.

6 Information to be recorded

In addition to the results of the acoustic measurements the information in 6.1 shall be recorded and kept for reference purposes. The information in 6.2 and 6.3 should also be recorded, if relevant.

6.1 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.

6.2 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.

6.3 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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