INTERNATIONAL STANDARD

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Acoustics — Frequency-weighting characteristic for infrasound measurements

Acoustique — Pondération fréquentielle pour le mesurage des infrasons

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 7196 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annexes A and B of this International Standard are for information only.

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Introduction

Methods have already been standardized for the description and assessment of noise from various sources and with respect to various effects on human subjects (risk of hearing damage, annoyance reactions, loudness, perceived noisiness, interference with speech communication). These methods are described in outline in ISO 2204 and in detail in other International Standards, including ISO 226, ISO 1996-1, ISO 1999, ISO/TR 3352 and ISO 3891. In all these cases, the bandwidth of the noise is either considered to lie within the conventional audio frequency limits from 20 Hz to 20 000 Hz or within a specified narrower band (for example, 45 Hz to 11 200 Hz in the case of perceived noisiness of aircraft). The band limits of 20 Hz and 20 000 Hz also define the frequency range for which the characteristics of sound level meters are fully specified (see IEC 651).

In practice, some noises consist of, or contain components at, frequencies below 20 Hz. At present, there are no standardized methods for sound pressure measurements of these noises, nor for their description and assessment with respect to human response. Although research in this field is comparatively sparse, there is evidence of infrasonic effects which are potentially harmful or unpleasant to human subjects and some authorities may desire to extend their regulations or codes of practice governing noise emissions to cover sources of infrasound. For this reason, it is considered to be highly desirable to standardize measurement and description methods in order to facilitate the exchange of information and to avoid proliferation of incompatible procedures.

Many types of human response can be distinguished and, correspondingly, different description methods are, in principle, appropriate. The method described in this International Standard corresponds to the direct perception of infrasound. At present, this is the only human response for which there is an ample research base. Some literature on annoyance from infrasound suggests that annoyance may be closely related to the direct perception. On that precondition, levels measured according to this International Standard would reflect the annoyance as well as the direct perception.

The perception of infrasound, although apparently achieved through the auditory mechanism, differs in some respects from that usually understood by hearing. The normal threshold of perception is considerably higher than at audio frequencies (about 100 dB relative to 20 μPa at 10 Hz), whilst toleration for high levels is not raised correspondingly, that is, the dynamic range is smaller and the rate of growth of sensation with sound pressure level is much more rapid. In the frequency range 1 Hz to 20 Hz, sounds that are just perceptible to an average listener will yield weighted sound pressure levels close to 100 dB when measured in accordance with this International Standard. A very loud noise will yield a weighted level in the order of 120 dB, only 20 dB above. Weighted sound pressure levels which fall below about 90 dB will not normally be significant for human perception.

Attention should be paid to the fact that, due to the combined effect of individual differences in perception threshold and the steep rise in sensation above the threshold, the same infrasonic noise may appear loud and annoying to some people while others can hardly perceive it.

Publication of this International Standard is not intended to inhibit research into infrasonics, for which methods of physical measurement other than those specified here may be appropriate, for example frequency analysis.

The specification of measuring equipment for use in conjunction with this International Standard is expected to be undertaken by Technical Committee IEC/TC 29. This International Standard contains an informative annex A outlining requirements for instrumentation to measure weighted levels, which may be used until a suitable IEC standard has been issued.

It should be emphasized that the measurement and description of a wide-band noise, containing infrasonic components, in accordance with this International Standard shall be considered as being independent of, and supplementary to, the measurement, description and assessment of the same noise by the methods defined in existing International Standards.

A bibliography is given for information in annex B.

Acoustics — Frequency-weighting characteristic for infrasound measurements

1 Scope

This International Standard specifies a frequency-weighting characteristic, designated G, for the determination of weighted sound pressure levels of sound or noise whose spectrum lies partly or wholly within the frequency band from 1 Hz to 20 Hz.

NOTES

1 In the case of wide-band noises whose spectrum embraces both the infrasonic and audio-frequency ranges, use of this International Standard to determine the infrasonic weighted sound pressure level is supplementary to the description of the same noise by methods already standardized which cover the audio-frequency range only, for example the description in terms of A-weighted sound pressure level. The numerical value of the results will, in general, differ from the G-weighted result. No significance should be attached to this difference since the respective results relate to different parts of the noise spectrum with little overlap.

2 The G-weighting can also be used in connection with the determination of sound power levels and sound intensity levels. When measured with the G-curve, these are symbolized respectively as L_{WG} and L_{IG}.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 651:1979, *Sound level meters.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 infrasound: Sound or noise whose frequency spectrum lies mainly in the band from 1 Hz to 20 Hz.

3.2 audio-frequency sound: Sound or noise whose frequency spectrum lies mainly in the band from 20 Hz to 20 000 Hz.

3.3 wide-band sound: Sound or noise which consists partly of infrasound and partly of audio-frequency sound.

3.4 G frequency weighting: Frequency weighting of a signal by means of the frequency-response characteristic as defined in clause 4.

3.5 G-weighted sound pressure level: Sound pressure level given by the formula:

$$L_{pG} = 10 \lg \frac{\overline{p^2}}{p_0^2} \text{ dB}$$

where

$\overline{p^2}$ is the mean-square value of the G-weighted sound pressure;

p_0 is the reference sound pressure (20 µPa).

Sound pressure levels are expressed in decibels.

NOTE 3 When there is no possibility of misunderstanding (for example with the expressions in clause 1, note 2), L_{pG} may be abbreviated to L_G.

4 Specification of frequency-weighting characteristic G

The G frequency response is obtained with a combination of poles and zeros in the complex frequency plane, as given in table 1. The relative frequency response corresponding to this pole-zero configuration is given in table 2 and shown graphically in figure 1.

The G-weighting curve is so defined that it has a gain of 0 dB at 10 Hz, that is, the G-weighted sound pressure level of a pure tone at 10 Hz is equal to the unweighted sound pressure level. Between 1 Hz and 20 Hz the curve approximates a straight line with a slope of 12 dB per octave. In this way, each frequency is weighted in accordance with its relative contribution to the perception.

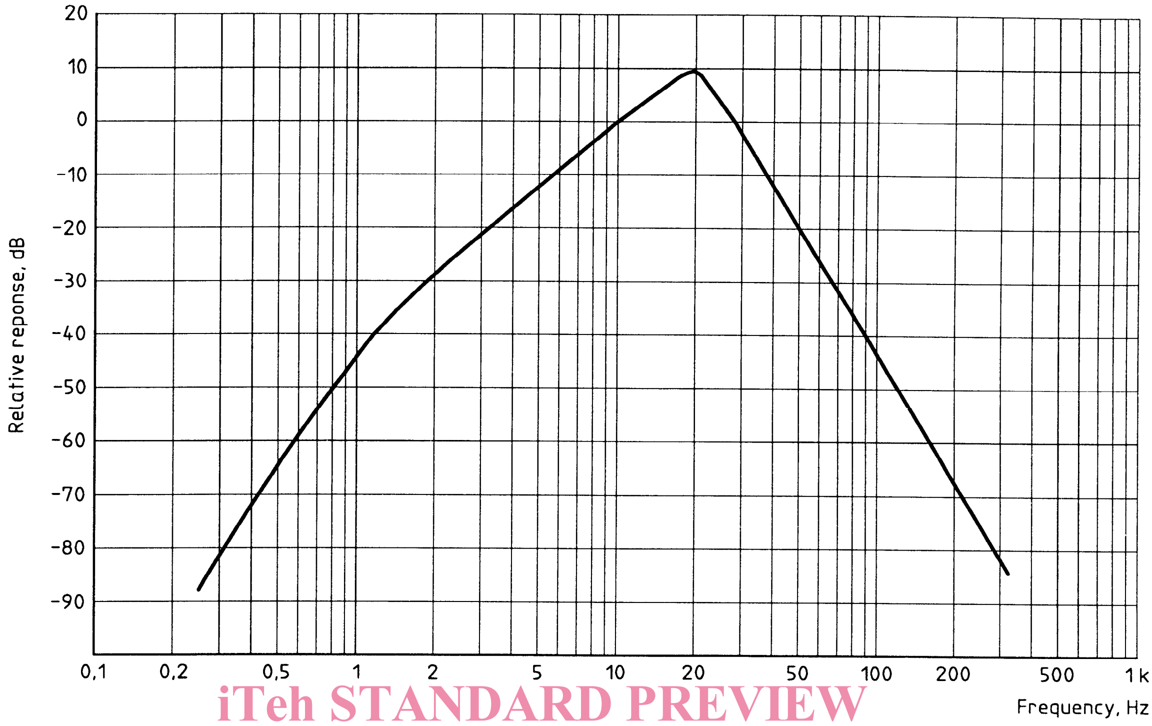
Below 1 Hz and above 20 Hz, the curve has cut-offs with rates of 24 dB per octave.

Table 1 — Nominal coordinates of the poles and zeros of the transfer function, in the complex frequency plane

Poles Hz	**Zeros** Hz
– 0,707 + j 0,707	0 + j 0
– 0,707 – j 0,707	0 + j 0
– 19,27 + j 5,16	0 + j 0
– 19,27 – j 5,16	0 + j 0
– 14,11 + j 14,11	
– 14,11 – j 14,11	
– 5,16 + j 19,27	
– 5,16 – j 19,27	

Table 2 — Nominal frequency response

Nominal one-third-octave frequency Hz	**Relative response** dB
0,25	– 88,0
0,315	– 80,0
0,4	– 72,1
0,5	– 64,3
0,63	– 56,6
0,8	– 49,5
1,00	– 43,0
1,25	– 37,5
1,6	– 32,6
2,0	– 28,3
2,5	– 24,1
3,15	– 20,0
4,0	– 16,0
5,0	– 12,0
6,3	– 8,0
8,0	– 4,0
10,0	0,0
12,5	4,0
16,0	7,7
20,0	9,0
25,0	3,7
31,5	– 4,0
40	– 12,0
50	– 20,0
63	– 28,0
80	– 36,0
100	– 44,0
125	– 52,0
160	– 60,0
200	– 68,0
250	– 76,0
315	– 84,0



NOTE — The G-weighting characteristic can be physically realized to a close approximation by simple inductor/resistor/capacitor networks.

Figure 1 — Nominal frequency response

5 Reporting of results

When measuring the sound pressure level applying G-weighting using appropriate instrumentation, for example that given in annex A, results shall be accompanied by the following data:

a) the calibration of the measuring system, including frequency response;

b) the integration time;

c) the characteristics of the detector;

d) the estimated uncertainty of the measured levels;

e) all relevant details of place, time and conditions prevailing during the measurements.

Annex A
(informative)

Outline requirements for equipment for measuring infrasound

A.1 General

The frequency weighting is designed to be introduced into an instrumentation system having an otherwise constant frequency response. Alternatively, part of the frequency weighting can be omitted from the weighting filter and included elsewhere in the instrumentation system, so that the entire system exhibits the same performance. The system should be designed to indicate the level of the root-mean-square sound pressure in decibels relative to 20 μPa.

A.2 Microphone

The microphone should have a substantially constant or well-defined frequency response over at least the frequency range from 0,25 Hz to 160 Hz, preferably the range 0,25 Hz to 315 Hz.

NOTE 4 There is no practical limit on the dimensions of the microphone since directional effects will be negligible in the infrasonic frequency range.

A.3 Amplifier and frequency-weighting circuit

The amplifier and frequency-weighting circuit of the instrumentation system should be designed to avoid overload and, in conjunction with the microphone, to produce the overall frequency-weighting characteristic G. Relative to the gain at 10 Hz, the response of the system should conform as closely as possible to the characteristic specified in clause 4. Because of the steep rise in sensation with sound pressure level, accuracy is crucial and more important than at audio frequencies. For the frequency range 1 Hz to 20 Hz, the tolerance range should not exceed ± 1 dB, and for frequencies below 1 Hz and above 20 Hz, a tolerance range of $-\infty$ to + 1 dB can be applied to the nominal values.

A.4 Detector

The detector should deliver an output which is proportional to the square of the electrical signal at its input within a specified accuracy and over a specified dynamic range. The characteristics should be stated when reporting the results of noise measurements and should not be less stringent than those specified for sound level meters of type 1 having the F or S time-weighting characteristics (see 9.4.2 of IEC 651:1979).

A.5 Integrator-indicator

The integrator-indicator should display, in decibels, the mean value of the detector output signal. The integrator may have a rectangular time window or be of the RC-type, having an exponential time window. The integrating time constant chosen should be sufficiently long for the observed value to be representative of the noise being measured. Usually, this will be the case for an integration time/time constant of 10 s. When frequencies in the upper part of the 1 Hz to 20 Hz band mainly contribute, a value as low as 1 s may be used.

For fluctuating noise, a rectangular time window of at least 1 min is recommended. In this case the reported value is denoted equivalent G-weighted sound pressure level, L_{pGeq}.

The indicator may be of the analog, discontinuous-analog (series of lamps) or digital type, as specified for sound level meters. A digital indicator is not recommended in connection with an RC-type integrator.

A.6 Calibration

The overall instrumentation system, from microphone to indicator display, should be calibrated for sinusoidal inputs over at least the frequency range from 0,5 Hz to 160 Hz, and preferably the range from 0,25 Hz to 315 Hz, at the frequencies given in table 2.

The gain of the system should be adjusted so that, for an input signal at 10 Hz, the indicator reads the true sound pressure level, in decibels relative to 20 μPa.

The calibration should be carried out at a level within the linearity range of the instrumentation system and comparable with that of the noises which the apparatus is intended to measure.

The calibration may be partly acousto-electrical and partly electrical, provided that no loss of accuracy ensues.

A.7 Method for approximate determination of G-weighted sound pressure level

An approximate determination of the G-weighted sound pressure level may be made by band analysis of the signal using bandwidths no greater than one-third octave and application of the weighting values given in table 2.