
British Standard

Sound system equipment

Part 4. Methods for specifying and measuring the characteristics of microphones

[IEC title: Sound system equipment Part 4: Microphones]

Equipements pour systèmes électroacoustiques

Partie 4. Méthodes d'établissement et de mesure des caractéristiques des microphones

Elektroakustische Geräte

Teil 4. Verfahren zur Festlegung und Messung von Mikrofonkennwerten

National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee and is identical with IEC 268-4 : 1972 'Sound system equipment' Part 4 'Microphones' published by the International Electrotechnical Commission (IEC). The text of this Part of BS 6840 is unchanged from the text of BS 5428 : Part 3 : 1977 which is now withdrawn.

All Parts and Sections of BS 5428 will be published as Parts of BS 6840 in order to achieve consistency of numbering between the corresponding Parts of the IEC Publication and the British Standard, with harmonization in view.

BS 6840 consists of the following Parts:

- Part 1. Methods for specifying and measuring general characteristics used for equipment performance (Supersedes part of BS 5428 : Part 1.)
- *Part 2. Guide for explanation of general terms (Supersedes part of BS 5428 : Part 1.)
- *Part 3. Methods for specifying and measuring the characteristics of sound system amplifiers (Supersedes BS 5428 : Part 2.)
- Part 4. Methods for specifying and measuring the characteristics of microphones (Previously BS 5428 : Part 3.)
- *Part 5. Methods for specifying and measuring the characteristics of loudspeakers (Supersedes BS 5428 : Part 11 and Part 11 : Supplement 1.)
- Part 6. Methods for specifying and measuring the characteristics of auxiliary passive elements (Previously BS 5428 : Part 4.)
- *Part 7. Methods for specifying and measuring the characteristics of headphones and headsets (New.)
- Part 8. Methods for specifying and measuring the characteristics of automatic gain control devices (Previously BS 5428 : Part 7.)
- Part 9. Methods for specifying and measuring the characteristics of artificial reverberation, time delay and frequency shift equipment (Previously BS 5428 : Part 8.)
- *Part 10. Specification for programme level meters (Supersedes BS 5428 : Part 9.)
- *Part 11. Specification for applications of connectors for the interconnection of sound system components (Supersedes BS 5428 : Part 5 : Section 5.2.)
- *Part 12. Specification for applications of connectors for broadcast and similar use (Supersedes BS 5428 : Part 5 : Section 5.3.)
- Part 13. Guide for listening tests on loudspeakers (New.)
- Part 14. Guide for circular and elliptical loudspeakers: outer frame diameters and mounting dimensions (Previously BS 5428 : Part 5 : Section 5.1.)
- *Part 15. Specification for matching values for the interconnection of sound system components (Supersedes BS 5428 : Part 10.)
- *Part 16. Guide to the RASTI method for the objective rating of speech intelligibility in auditoria (New.)

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Wherever the word 'Recommendations' or 'Publication' appears, referring to this standard, it should be read as 'British Standard'.

Cross-references

International standard	Corresponding British Standard
IEC 225 : 1966	BS 2475 : 1964 Specification for octave and one-third octave band-pass filters (Technically equivalent)
IEC 268-1 : 1985	BS 6840 Sound system equipment Part 1 : 1987 Methods for specifying and measuring general characteristics used for equipment performance (Identical)
ISO 354:1985†	BS 3638 : 1987 Method for measurement of sound absorption in a reverberation room (Identical)

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

*In preparation.

†ISO R 354 is now superseded by ISO 354:1985.

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British Standard

Sound system equipment

Part 4. Methods for specifying and measuring the characteristics of microphones

1. Scope

These recommendations apply to sound system microphones in both professional and domestic applications.

The microphones shall be understood to include devices, if any, such as transformers, pre-amplifiers, or other elements which form an integral part of the microphone, up to the output terminals specified by the manufacturer.

For stereo microphones the data for both sections should be given.

2. Object

This publication gives recommendations relative to the characteristics to be specified and the methods of measurement for sound system microphones, such as wide band microphones, microphones used normally for speech and close talking microphones.

In general, the methods of measurement recommended are those which are seen to be the most directly related to the characteristics.

This does not exclude the use of other methods, which will give equivalent results.

Methods for securing absolute primary calibration are under consideration.

SECTION ONE — CONDITIONS FOR SPECIFICATION AND MEASUREMENT

3. General conditions

3.1 General

Reference is made to IEC Publication 268-1, Sound system equipment, Part 1: General, as concerns:

- Units and system of measurement;
- Frequencies of measurement;
- Quantities to be specified and their accuracy (see also Sub-clause 4.7);
- Marking (see also Sub-clause 6.1);
- Ambient conditions (see also Clause 16);
- Filters, networks and measuring instruments for noise specification and measurement;
- Individual specification and type specification;

- Graphical presentation;
- Scales for graphical presentation;
- Personal safety and prevention of spread of fire;
- Method of producing a uniform alternating magnetic field;
- Search coil for measuring the magnetic field strength.

3.2 *Rated and normal working conditions*

3.2.1 *Introduction*

For convenience in specifying how microphones are to be set up for measurement or verification, certain sets of conditions have been defined in this Recommendation under the titles of rated conditions and normal working conditions, respectively.

Four ratings are basic to the formulation of these concepts:

- rated impedance;
- rated load impedance;
- rated power supply;
- rated sensitivity.

To obtain the correct conditions for measurement, the above-mentioned ratings shall be taken from the manufacturer's specification. These ratings themselves are not subject to measurement but they constitute the basis for measuring the other characteristics.

The prefix "rated" applied to other characteristics relates to the specification or measurement of the particular characteristic under rated conditions or under conditions unambiguously connected to them. This applies to the following two characteristics:

- rated output voltage;
- rated equivalent sound pressure level due to inherent noise.

Measuring methods are specified for the electrical impedance, sensitivity, directional response pattern, dynamic range and external influences.

For obtaining the sensitivity of a microphone, the secondary calibration method, using a calibrated laboratory standard pressure microphone, is described.

3.2.2 *Rated conditions*

The microphone will be understood to be working under rated conditions when the following conditions are fulfilled:

- microphone connected to rated load impedance;
- if the microphone needs a power supply, this should be the rated power supply.
- the microphone (except the close-talking microphone) should be placed in a plane-wave-free sound field, the waves having zero degree incidence with respect to the reference direction;
- the undisturbed sound pressure (in the absence of the microphone) in the sound field at the reference point of the microphone, shall be adjusted to a sinusoidal pressure of 0.2 Pa (pressure level of 80 dB);

- for close-talking microphones, the microphone shall be placed at a stated distance, no more than 50 mm from the artificial mouth, as referred to in this Recommendation (Sub-clause 10.3.3), the undisturbed sound-pressure being sinusoidal and adjusted to 3 Pa (a pressure level of 104 dB) at the reference point of the microphone;
- controls, if any, set to such position that the most flat frequency response and maximum sensitivity is obtained;
- in the absence of a clear reason to the contrary, the frequency shall be the standard frequency of 1 000 Hz (see IEC Publication 268-1);
- the ambient pressure, the relative humidity and the ambient temperature should be within the limits given in IEC Publication 268-1 and Clause 16 and should be stated.

3.2.3 *Normal working conditions*

Unless otherwise stated, the measurements shall be made under normal working conditions.

The microphone will be understood to be working under “normal working conditions”, when the following conditions are fulfilled:

- connections, impedances, ambient conditions and sound fields as for rated conditions;
- the sound pressure level shall correspond to a sinusoidal sound pressure and shall be 10 dB below the sound pressure level for rated conditions;
- the sound pressure level shall be adjusted at the frequency specified for rated conditions, unless otherwise stated;
- setting of the controls as for rated conditions, unless otherwise specified;
- the angle of incidence shall be zero degrees as for rated conditions, unless otherwise specified.

4. **Particular conditions**

4.1 *Pre-conditioning*

A microphone having a preamplifier shall be switched on for the period of time specified by the manufacturer, before measurements are made, to allow the components to reach the temperature for normal working conditions. If no period is specified, then a period of one hour shall be allowed for stabilisation.

4.2 *Sound source*

The sound source shall be capable of producing at the microphone position the sound pressure level as defined for either rated or normal working conditions. Unless otherwise specified, measurement shall be made under one of these conditions as appropriate. Amplitude non-linearity of the sound field shall be held to such a value that the effect on the measured response shall not exceed 0.5 dB; if conditions of measurement preclude the possibility of securing sufficiently low distortion, a narrow-band filter may be used, following the microphone terminals, which will allow the response to the fundamental frequency to be measured.

For field calibrations it is recommended that the sound source (loudspeaker) be contained in an enclosure which radiates sound from one well-defined opening only.

4.3 *Standard microphone*

A calibrated laboratory standard pressure microphone shall be used to measure the sound pressure.

4.3.1 *Accuracy of standard microphone*

The standard microphone should be calibrated with an accuracy of ± 1 dB, or better.

4.4 *Voltage measuring system*

The electromotive force (e.m.f.) generated by the microphone, when in a sound field, may be determined by one of the following methods:

- a) by measuring the open-circuit voltage of the microphone using a voltmeter with an input impedance of at least 30 times the rated impedance of the microphone; or
- b) in case of a high impedance microphone, by using the insert voltage technique.

Note. — The insert voltage technique (also referred to as the substitution method) is used to determine the open-circuit voltage of a microphone when it is electrically loaded. Let a microphone, having a certain open-circuit voltage, be connected to a load impedance. To measure the open-circuit voltage, an impedance, small compared with the load impedance, is connected in series with the microphone, and a calibrating voltage applied across it. Let a sound pressure and a calibrating voltage of the same frequency be applied alternately. When the calibrating voltage is adjusted until it gives the same voltage across the load impedance as results from the sound pressure on the microphone, the open-circuit voltage will be equal in magnitude to the calibrating voltage.

4.5 *Acoustical environment*

4.5.1 *General*

The microphone can be measured in different acoustical ambient conditions:

— Placed in an acoustic field:

a) *In free field*

- spherical waves, or
- plane waves, or
- waves produced by specified sound source (artificial mouth);

b) *In diffuse field*

— Coupled to a sound source by means of a small cavity (coupler).

4.5.2 *Microphone placed in an acoustic field*

a) Free-field conditions

A free-field sound wave is always divergent in character. In certain circumstances it may approximate an ideal plane wave.

Free-field conditions can be obtained:

- in open air, ambient noise and wind permitting, or
- in an anechoic room, or
- in a duct.

A sound source of small dimensions with respect to the wave-length produces a spherical wave in this environment.

The spherical wave can be approximated to a plane wave in a region of measurement located at a sufficient distance from the source.

At low frequencies, it becomes difficult to realize plane wave conditions in an anechoic room. A plane wave at low frequencies, below the cut-off frequency of the anechoic room, may therefore better be realized in a duct.

A region around the microphone can be defined where the errors due to the departure from either plane or spherical waves do not exceed ± 1 dB compared with the ideal conditions.

Spherical waves

The sound pressure generated in a free-field by an omnidirectional sound source varies inversely with the distance from the acoustic centre of the source.

The response of the microphone will vary inversely with the distance between the source and the microphone when the relevant dimensions of both are small compared with the wave-length, allowing the results from the measurements made at a certain distance r to be computed to the reference distance.

When either the circumference of the radiating surface of the source or the circumference of the principal acoustic entry of the microphone exceeds the wave-length, this computation applies only when the measuring distance complies to:

$$r \geq d$$

$$r \geq \frac{d^2}{\lambda}$$

where: r = distance from the source to the measuring point
 d = effective diameter of the sound source
 λ = sound wave-length

Spherical waves can be used to measure pressure microphones but it is necessary to use almost perfect plane waves in the low frequency range for the measurement of pressure gradient microphones.

For microphones responding both to pressure and to pressure gradient, having a flat frequency response in a plane-wave free sound field (i.e. at a sufficient distance from the source), the response as a function of frequency f , distance from a centre of spherical diverging waves r and of angle of incidence θ of the waves at the microphone, can be given in a complex form:

$$(1 - B) + B \left(1 + \frac{1}{jkr} \right) \cos \theta$$

where: $1 - B$ = contribution of pressure component

B = contribution of pressure gradient component

$k = 2\pi/\lambda$ or $2\pi f/c$

$B = 0$ for the omnidirectional pressure type

$B = 0.5$ for the cardioid type

$B = 1$ for the bidirectional pressure gradient type

The response, expressed in decibels, of a cardioid type microphone as a function of the parameter kr and the angle θ can be taken from the following table:

TABLE I

$\theta \backslash kr$	0.1	0.2	0.5	1.0	2.0	5.0	10	∞
0°	+14.2	+8.6	+3.0	+1.0	+0.3	+0.0	+0.0	0
45°	+11.1	+5.8	+0.9	-0.7	-1.2	-1.4	-1.4	-1.4
90°	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0
135°	+10.9	+4.9	-2.8	-8.4	-12.7	-15.6	-16.2	-16.5
180°	+14.0	+8.0	0	-6.0	-12.0	-20.0	-26.0	$-\infty$

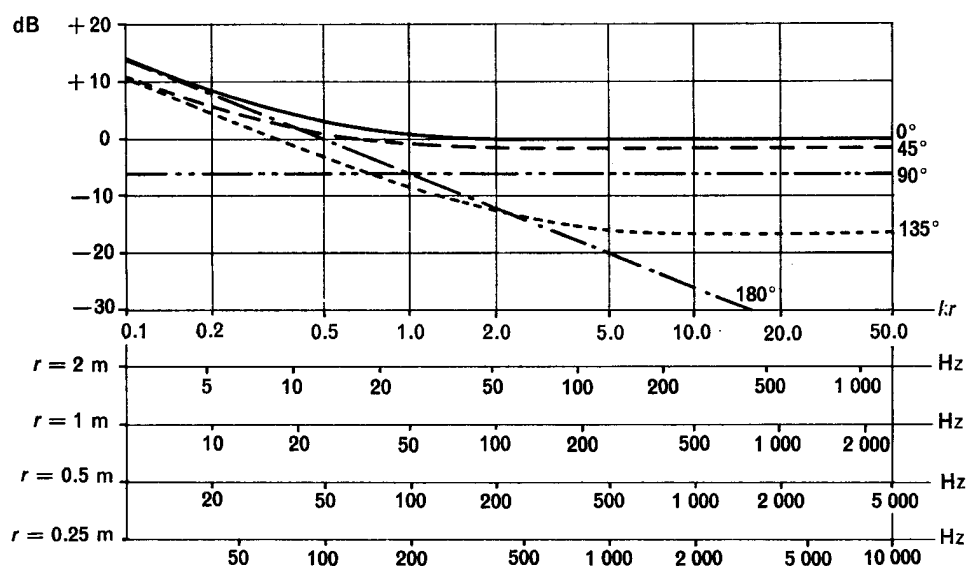


FIGURE 1

Plane progressive waves

A plane progressive wave can be obtained either in a duct or in a free field.

1. *In a duct*

It must be noted that there are many problems to be solved such as the design of the terminating impedance, the avoidance of cross-modes, the shape of the original wave front and the relative dimensions of the duct and the microphone.

2. *In a free field*

A spherical wave at a distance of at least half the wave-length from the centre of curvature at the lowest frequency of measurement is a practical approximation to a plane progressive wave.

Use of an artificial mouth

In order that the conditions of test may be similar to those of actual use, it is necessary to introduce an obstacle in the shape of a human head when measuring close talking microphones by means of an artificial mouth.

The artificial mouth used for the measurements and the conditions required for its use are under consideration.

b) Diffuse field

Some measurements can be made in a diffuse field in which sound waves are propagated with random incidence. In this case, bands of noise of third octave width shall be used as the signal.

A diffuse sound field can be approximately realized in a reverberant room characterized by a sufficiently long duration of reverberation at a sufficiently large distance from the source and the walls, and above a limiting frequency (see also ISO Publication R 354, Measurement of absorption coefficients in a reverberant room).

The reverberation time T of the empty room shall exceed

at	5 s	5 s	5 s	4.5 s	3.5 s	2 s
at	125 Hz	250 Hz	500 Hz	1 000 Hz	2 000 Hz	4 000 Hz

For the determination of the lower frequency limit, the following equation can be used:

$$f > 125 \left(\frac{180}{V} \right)^{\frac{1}{3}} \text{ Hz}$$

where: V = the volume of the room in cubic metres.

The region of measurement shall be chosen at such a distance from the source that the direct sound of the source is negligible.

When an omnidirectional source is used, the minimum distance r from the source to the measuring points is given by:

$$r \gg 0.06 \left(\frac{V}{T} \right)^{\frac{1}{2}} \text{ m}$$

where: V = the volume of the room in cubic metres

T = the Sabine reverberation time at the frequency f .

4.5.3 *Microphone coupled to a sound source by means of a small cavity coupler*

To determine the pressure sensitivity of a microphone, a rigid cavity is used to couple the sound source to the microphone.

For normal use this method is most useful for obtaining the pressure sensitivity of a microphone by comparison with the sensitivity of a calibrated reference microphone.

In order to obtain a sufficiently uniform sound pressure inside the cavity, this method shall only be used inside the limits of the frequency range where the linear dimensions of the cavity are less than one-tenth of the wavelength. At low frequencies care must be taken to eliminate air leakage.

For absolute pressure calibration of a microphone, reference is made to the appropriate IEC Publications.

Note. — If the sound source consists of a small vibrating part of the inner surface of the cavity, and the exact vibrating movement of the vibrating part is known, the device is commonly called a pistonphone.

4.6 *Methods of taking frequency response curves*

4.6.1 *Point-by-point or automatic method*

Response curves may be prepared point-by-point or automatically.

a) Point-by-point method

Great care is needed to ensure that all significant peaks and troughs of the frequency response curve are explored.

Note. — The graph should clearly indicate the points taken.

b) Automatic method

The rate of traversing the frequency range shall be slow enough to ensure that the resulting curve does not deviate from that which would be obtained under steady state conditions.

Notes 1. — Stopping the trace at any instant should not change the indicated response by more than ± 1 dB.

2. — The following additional apparatus may be used:

- equipment capable of automatically maintaining the requisite sound pressure level over the frequency range concerned;
- an automatic level recorder as output indicator.