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Methods for

Specifying and measuring the characteristics of sound system equipment

Part 11. Loudspeakers

Méthodes de spécification et de mesure des caractéristiques des équipements pour systèmes électroacoustiques
Partie 11. Haut-parleurs

Verfahren zur Bestimmung und Messung der Eigenschaften von Schall-Aufnahme und Wiedergabegeräten
Teil 11. Lautsprecher

Foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee and it supersedes BS 2498 : 1954, which is therefore now withdrawn. This standard is identical with Publication 268-5 : 1972 'Sound system equipment' Part 5 'Loudspeakers' published by the International Electrotechnical Commission (IEC).

Terminology. The text of the IEC Publication has been accepted as suitable for publication, without deviation, as a British Standard. Certain terminology is used, however, that is not identical with that used in British Standards. Attention is therefore drawn to the following.

Wherever the words 'Recommendations' or 'Publication', relating to this publication, appear, they should be interpreted as 'British Standard'.

Cross references. For each of the following references to other international standards that are given in the text, there is an equivalent British Standard; these are as listed below:

Reference to international standard	Equivalent British Standard
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IEC Publication 268-1 : 1968	BS 5428 Methods for specifying and measuring the
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Sound system equipment	characteristics of sound system equipment
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Part 1 General	Part 1 : 1977 General
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IEC Publication 225 : 1966 Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations	Substantially agrees with BS 2475 : 1964 Octave and one-third octave band-pass filters
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NOTE 1. There is as yet no equivalent British Standard for IEC Publication 268-14 : 1971, referred to in this standard, but it is envisaged that one will be produced in the future.

NOTE 2. References to page numbers relate to the IEC page numbers given in brackets at the bottom of each page.

CONTENTS

FOREWORD	Inside front cover
--------------------	--------------------

Clause

1. Scope	3
2. Object	3

SECTION ONE — CONDITIONS FOR SPECIFICATIONS AND MEASUREMENTS

3. General conditions	3
3.1 General	3
3.2 Rated and normal working conditions	4
3.3 Free-field conditions	4
4. Particular conditions of measurement	4
4.1 Acoustical environment	4
4.2 Noise	4
4.3 Accuracy	5
4.4 Mounting and acoustic loading	5
4.5 Pre-conditioning	5
4.6 Method of taking response curves	5
4.7 Measuring apparatus	6
4.8 Measuring distance	6

SECTION TWO — CHARACTERISTICS TO BE SPECIFIED AND THE RELEVANT METHODS OF MEASUREMENT

5. Type description (acoustical behaviour)	7
5.1 Principle of the transducer	7
5.2 Type of loudspeaker	7
6. Terminals and controls	7
6.1 Marking	7
7. Impedance	7
7.1 Rated impedance	7
7.2 Impedance curve	7
8. Voltage	8
8.1 Rated voltage	8
9. Power	8
9.1 Rated power	8
9.2 Rated damage limited power	8
9.3 Power handling capacity	8
10. Reference point and axis	10
10.1 Reference point	10
10.2 Reference axis	10
11. Frequency	10
11.1 Rated frequency range	10
11.2 Effective frequency range	10
11.3 Resonance frequency	11
12. Response	11
12.1 Frequency response	11
13. Directional characteristics	12
13.1 Directional response pattern	12
13.2 Directivity index	12

Clause

14. Sound pressure	13
14.1 Characteristic sound pressure	13
14.2 Rated characteristic sound pressure	13
14.3 Characteristic sensitivity / Reference characteristic sound pressure	13
14.4 Method of measurement	13
15. Efficiency	14
15.1 Rated efficiency	14
16. Distortion	15
16.1 Amplitude non-linearity	15
16.2 Transient distortion	19
17. Ambient conditions	19
17.1 Temperature range	19
17.2 Relative humidity range	20
18. Magnetic stray field	20
18.1 Interfering stray field	20
19. Physical characteristics	20
19.1 Dimensions	20
19.2 Weight	20
19.3 Cable assemblies	20
20. Design data	20

SECTION THREE — CLASSIFICATION

21. Classification of the characteristics to be specified	21
21.1 Characteristics to be specified	21
APPENDIX: Notes on the test for power handling capacity	23
FIGURES	24

British Standard Method for

Specifying and measuring the characteristics of sound system equipment

Part 11. Loudspeakers

1. Scope

These recommendations apply to sound system loudspeakers in both professional and domestic applications, treated as entirely passive elements.

Unless otherwise stated, the loudspeaker shall be understood to include both loudspeaker elements and loudspeaker systems comprising one or more loudspeaker elements and such relevant devices as built-in cross-over filters, transformers, and any other passive elements.

2. Object

- 2.1 This Publication gives recommendations relative to the characteristics to be specified and the relevant measuring methods for sound system loudspeakers.
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.

- 2.2 Care shall be taken to avoid measuring the frequency response of any multi-radiator system in the near field where diverse path lengths may give rise to local irregularities.

In such cases, a mean curve, derived from a family of curves measured at different distances, may give the best results.

Note. — All the relevant conditions laid down in this Publication must be met for all distances.

- 2.3 Although the importance of active elements is recognized, this will be referred to a later edition.

Measurements under non free-field conditions and measurements with a special test signal are also referred to a later edition.

SECTION ONE — CONDITIONS FOR SPECIFICATIONS AND MEASUREMENTS

3. General conditions

3.1 General

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

- units and system of measurement;
- frequencies of measurement;
- quantities to be specified and their accuracy (see also Sub-clause 4.3);
- marking and symbols for marking;
- ambient conditions (see also Clause 17);
- individual specification and type specification;
- graphical presentation;
- scales for graphical presentation;
- personal safety and prevention of spread of fire;
- probe coil for measuring the magnetic field.

3.2 *Rated and normal working conditions*

3.2.1 *Rated conditions*

The loudspeaker shall be understood to be working under rated conditions when:

- the voltage across the loudspeaker terminals is chosen in accordance with the expression:

$$U^2 = PR$$

where: U = the voltage

P = the rated power

R = the rated impedance

- the volume controls, if any, have to be set to such a position that the minimum attenuation is introduced;
- in the absence of a clear reason to the contrary, the rated conditions shall imply a sinusoidal voltage with a frequency of 1 000 Hz;
- the loudspeaker is working under free-field conditions;
- the loudspeaker is mounted in its own enclosure, specified enclosure, or on the standard baffle (Figures 1, 2 and 3, page 52).

3.2.2 *Normal working conditions*

The loudspeaker will be understood to be working under normal working conditions when:

- the voltage at the terminals is adjusted 10 dB below that voltage chosen for rated conditions;
- if a constant-current method is used, the value of the current shall be such that the voltage reaches normal working conditions at the frequency of maximum impedance;
- the volume controls, if any, are set for rated conditions unless otherwise stated;
- the loudspeaker is working under free-field conditions;
- the loudspeaker is mounted as for rated conditions.

3.3 *Free-field conditions*

Conditions which approach acoustically those of free space. Anechoic rooms in which the $1/r$ law moving off from a point source is followed within ± 1 dB at the positions that will be occupied by the loudspeaker system and the microphone during the measurement, are considered to be satisfactory.

4. *Particular conditions of measurement*

4.1 *Acoustical environment*

Acoustical measurements shall be made under free-field conditions as specified in Sub-clause 3.3.

4.2 *Noise*

Since the presence of noise may obscure low level signals, it must be kept at the lowest possible level. Data relating to signals which are less than 10 dB above the noise level must be discarded.

4.3 Accuracy

In view of the inevitable errors under practical measuring conditions, the range over which the total errors do not exceed ± 2 dB shall be stated with an indication of the permissible upper limit. Particular attention is drawn to the contribution which harmonics may make to the output, especially at low frequencies.

4.4 Mounting and acoustic loading

The performance of a loudspeaker, *per se*, depends on the properties of the loudspeaker unit and also on the acoustic loading presented to it, which in turn is greatly influenced by the way it is mounted.

Hence an unambiguous description of the mounting used for the tests shall always be included in the presentation of results.

Three types of mounting are considered:

- a) A particular baffle or enclosure;
- b) A standard baffle;
- c) Without a baffle or enclosure (only applicable to loudspeaker units).

In choosing the mounting conditions appropriate to an actual measurement the testing authority shall give consideration to the particular purpose of the measurement, and his decision may also be influenced by a knowledge of how the designer intended the units to be used. Thus if a loudspeaker be designed to be used with a specified enclosure, the measurements shall be made with it so mounted.

4.4.1 Standard baffle

The baffle shall be made with a plane front surface which is acoustically reflecting; it shall be of a suitable rigid material with high internal damping and of an adequate thickness to assure negligible vibration. (See Figures 1, 2 and 3, page 52.)

The baffle shall have the dimension shown in Figure 1. The cone rim shall be substantially flush with the front surface of the baffle and care shall be taken to avoid a resonant cavity behind the baffle. This may be achieved by means of a chamfer as shown in Figure 2, or by the use of a thin rigid sub-baffle as shown in Figure 3. The thickness of the baffle or sub-baffle in the neighbourhood of the rim shall be kept as small as possible and not greater than one tenth of the loudspeaker nominal diameter, or in the case of an elliptical loudspeaker, one tenth of the nominal minor axis.

4.5 Pre-conditioning

Permanent changes may take place in a loudspeaker as a result of motion of the diaphragm. It is therefore desirable to subject it for a period of at least 1 h to pre-conditioning by applying the rated power of a signal of the type discussed in Sub-clause 9.3.

The period of pre-conditioning shall be followed by a recovery period of at least 1 h, during which the loudspeaker shall be disconnected before proceeding with the measurement.

4.6 Method of taking response curves

It is recommended that the response curve be taken by an automatic method giving a continuous curve. Care should be taken to avoid simple errors such as those due:

- to the rate of traversing the frequency range;
- to the writing speed of the level recorder;
- to the finite impedance of the actual source.

These errors should not contribute more than ± 0.5 dB each.

4.7 *Measuring apparatus*

Measurements shall be made with a pressure microphone, having a known free-field calibration, mounted at an adequate distance from the reference point of the loudspeaker. The normal procedure is to feed the loudspeaker with a constant voltage. The amplifier supplying the signal to the loudspeaker and the measuring equipment in conjunction with the microphone shall have an amplitude response independent of frequency over the effective frequency range of the loudspeaker and negligible amplitude non-linearity (harmonic distortion less than 0.3%) under test conditions.

4.8 *Measuring distance*

For single unit loudspeakers, measurements shall be made with a pressure microphone, having a known free-field calibration, mounted at a distance of 50 cm from the reference point on the reference axis. The results shall be referred to a distance of 1 m.

Note. — For loudspeakers of greater diameter than 25 cm, a larger measuring distance is to be preferred (see note following), but it should be recognized that the effect of the baffle, if used at low frequencies, will then be greater.

For multi-unit loudspeakers the field at short distances is so complex, due to interference patterns produced by the various elements, that it is necessary to measure at a much greater distance, though it is recommended that the results be referred to a distance of 1 m. In these cases the note which follows may help in the choice of the required measuring distance. (See Sub-clause 2.2.)

These recommendations are in the nature of a compromise enabling measurements to be made which are admittedly subject to theoretical and practical difficulties, but will at least enable comparisons to be made between similar types of devices. Further work on this subject is under consideration for possible use in future recommendations.

Note. — Characteristics measured according to this Publication will be understood to refer to loudspeakers under free-field conditions. The response and the directivity of a loudspeaker element or loudspeaker system vary with the distance from the reference point. A possible definition of these quantities is to refer these characteristics to a point very far from the source. As the dimensions of practical anechoic rooms are small, it is necessary to make measurements at a practical distance taking into account the errors introduced.

For a predetermined tolerable error in the frequency response measurement, the measuring distance r shall exceed the minimum value.

Figures 5 and 6, page 54, either for a homogeneous straight line source or for a homogeneous flat disk source, show the errors a_l and a_d (dB) which occur during the measurement of the frequency response as a function of u ,

$$u = \frac{l^2}{r\lambda} \text{ for a homogeneous straight line source, and}$$

$$u = \frac{d^2}{r\lambda} \text{ for a homogeneous flat disk source,}$$

where: r = the measuring distance
 d = the diameter of the disk
 l = the length of the line source
 λ = the wavelength

For a loudspeaker column with a number of sources larger than three, the length l is defined as $l = nb$ where n = number of point sources and b = distance between the sources.

From these curves the minimum distance at which to place the microphone can be calculated so that errors in the frequency response measurements do not exceed the predetermined value.

For practical purposes, the relevant characteristics of sound system loudspeakers are those valid at a large distance from the source. Therefore, characteristics measured according to this Publication will be understood to refer to measuring distances complying with the expressions mentioned above.

To permit comparison between loudspeakers of different sizes and consequently measured at different distances, the characteristics for measurement are given for a distance of 1 m and are computed from measured characteristics according to the expression:

$$p(r_0) = p(r) \frac{r}{r_0}$$

where: r = measuring distance
 r_0 = reference distance of 1 m

A simple method of checking the errors in the response curve at distances of 1 m is to make three measurements. Each measurement is made at twice the distance of the previous one. If free-field conditions are present, the curves should be alike and 6 dB apart.

SECTION TWO — CHARACTERISTICS TO BE SPECIFIED AND THE RELEVANT METHODS OF MEASUREMENT

5. Type description (acoustical behaviour)

Characteristics to be specified

5.1 Principle of the transducer

e.g. electrostatic, electrodynamic or piezoelectric shall be specified by the manufacturer.

5.2 Type of loudspeaker

e.g. horn or direct radiating type, single or multiple unit, column or line, etc., shall be specified by the manufacturer.

6. Terminals and controls

Characteristics to be specified

6.1 Marking

Recommendations for marking the terminals and controls are given in IEC Publication 268-1, Clause 6, with the addition of the following requirement:

— the polarity shall be indicated by a mark, preferably a coloured dot, at that input terminal at which a positive instantaneous voltage produces an outward movement of the diaphragm.

7. Impedance

7.1 Rated impedance

Characteristic to be specified

The rated impedance of a loudspeaker or loudspeaker system is that value of a pure resistance which is to be substituted for the loudspeaker or system when defining the available electric power of the source. This is to be specified by the manufacturer.

Note. — The rated impedance specified by the manufacturer normally represents the lowest value of the modulus of the impedance in that part of the rated frequency range, where the maximum power is to be expected, and is normally not more than 20% higher than the lowest value of the modulus of the impedance at any frequency within the rated frequency range.

7.2 Impedance curve

Characteristic to be specified

Description, usually presented in the form of a graph, of the modulus of the impedance as a function of frequency, measured under normal working conditions.