
British Standard

Sound system equipment

Part 5. Methods for specifying and measuring the
characteristics of loudspeakers

Equipements pour systèmes électroacoustiques

Partie 5. Méthodes de spécification et de mesure des caractéristiques des hauts-parleurs

Elektroakustische Geräte

Teil 5. Verfahren zur Festlegung und Messung der Kennwerte von Lautsprechern

National foreword

This Part of BS 6840 has been prepared under the direction of the Electronic Equipment Standards Policy Committee and is identical with Publication 268-5 : 1989 'Sound system equipment' Part 5 'Loudspeakers', published by the International Electrotechnical Commission (IEC). This standard supersedes BS 5428 : Part 11 : 1977 and Part 11 : Supplement 1 : 1981 which are now withdrawn.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.

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. Glossary of general terms and calculation methods (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 (Will supersede BS 5428 : Part 9)
- Part 11. Specification for application 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)

Cross-references

International standard	Corresponding British Standard
IEC 50 (151) : 1978	BS 4727 Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms Part 1. Terms common to power, telecommunications and electronics Group 02 : 1980 Electrical and magnetic devices terminology (Technically equivalent)
IEC 225 : 1982 (second impression)	BS 2475 : 1964 Specification for octave and one-third octave band-pass filters (Technically equivalent)
IEC 263 : 1982	BS 6397 : 1983 Specification for scales and sizes for plotting frequency characteristics and polar diagrams (Identical)
IEC 268-1 : 1985	BS 6840 Sound system equipment Part 1 : 1987 Methods for specifying and measuring general characteristics used for equipment performance (Identical)
IEC 268-2 : 1987	Part 2 : 1988 Glossary of general terms and calculation methods (Identical)

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Sound system equipment
Part 5. Methods for specifying and measuring the
characteristics of loudspeakers

NOTE. This amendment is being published to effect the implementation of CENELEC HD 483.5 S1.

Revised text

AMD 6414
August 1991

Front cover

Underneath the title, insert the following:
'(Implementation of CENELEC HD 483.5 S1)'.

AMD 6414
August 1991

National foreword

Insert the following sentence at the end of paragraph 1.

'This British Standard is also in agreement with Harmonization Document HD 483.5 S1, published by the European Committee for Electrotechnical Standardization (CENELEC).'

In the list of Parts of BS 6840, insert the following new Part 17.

'Part 17. Methods for specifying and measuring the characteristics of standard volume indicators (New)'

IEC 268-11 : 1987	Part 11 : 1988 Specification for application of connectors for the interconnection of sound system components (Identical)
IEC 268-12 : 1987	Part 12 : 1987 Specification for applications of connectors for broadcast and similar use (Identical)
IEC 268-14 : 1980	Part 14 : 1987 Guide for circular and elliptical loudspeakers; outer frame diameters and mounting dimensions (Identical)
IEC 651 : 1979	BS 5969 : 1981 Specification for sound level meters (Identical)
ISO 3741-1988	BS 4196 Sound power levels of noise sources Part 1 : 1981 Precision methods for determination of sound power levels for broad-band sources in reverberation rooms (Identical)
ISO 3743 - 1976	Part 3 : 1981 Engineering methods for determination of sound power levels for sources in special reverberation test rooms (Identical)
ISO 3744-1981	Part 4 : 1981 Engineering methods for determination of sound power levels for sources in free-field conditions over a reflecting plane (Identical)
ISO 3745 - 1977	Part 5 : 1981 Precision methods for determination of sound power levels for sources in anechoic and semi-anechoic rooms (Identical)

IEC 65 : 1985, to which reference is made in the text, has been harmonized by CENELEC under HD 195 and is implemented by BS 415 : 1990 which is a related British Standard. A further related British Standard to IEC 50 (151) : 1978 is BS 4727 Part 1, Group 01 : 1983.

Typographical error. In table 1 the title of clause 16.2 should be read as 'Impedance curve'.

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

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SOUND SYSTEM EQUIPMENT

Part 5: Loudspeakers

1. Scope

This standard applies to sound system loudspeakers, treated as entirely passive elements. Loudspeakers with built-in amplifiers are excluded.

Note. – The term “loudspeaker” used in this standard relates to loudspeaker drive units themselves and also to loudspeaker systems which comprise one or more loudspeaker drive units provided with a baffle, enclosure or horn and such relevant devices as built-in cross-over filters, transformers and any other passive element.

2. Object

The purpose of this standard is to give the characteristics to be specified and the relevant methods of measurement for loudspeakers using sinusoidal or specified noise signals.

The methods of measurement given in this standard are those which are seen to be most directly related to the characteristics.

Notes 1. – If equivalent results can be obtained using other methods of measurement, details of the methods used should be presented with the results.

2. – The following items are under consideration:

- loudspeakers with built-in amplifiers;
- measurements under conditions other than free-field, half space free-field and diffuse field;
- measurements with signals other than sinusoidal or noise.

SECTION ONE – GENERAL

3. Conditions

3.1 General conditions

This standard is to be used in conjunction with the following standards:

- IEC 268-1 (1985): Sound system equipment, Part 1: General.
- IEC 268-2 (1987): Part 2: Explanation of general terms and calculation methods.
- ISO 3741 (1988): Acoustics – Determination of sound power levels of noise sources – Precision methods for broad-band sources in reverberation rooms.

3.2 *Conditions for the measurement*

3.2.1 *Introduction*

For convenience in specifying how loudspeakers are to be set up for measurement, normal measuring conditions are defined in this standard. To obtain the correct conditions for measurement, some values (known as “rated conditions”) shall be taken from the manufacturer’s specification.

These values themselves are not subject to measurement but they constitute the basis for measuring the other characteristics.

The following values are of this type, and shall be stated by the manufacturer:

- rated impedance;
- rated sinusoidal voltage or power;
- rated noise voltage or power;
- rated frequency range;
- reference plane;
- reference point;
- reference axis.

A full explanation of the term “rated” is given in IEC 268-2. See also term 151-04-03 in IEC 50 (151).

3.2.2 *Normal measuring conditions*

A loudspeaker shall be understood to be working under normal measuring conditions when all the following conditions are fulfilled:

- a) the loudspeaker to be measured is mounted in accordance with Clause 10;
- b) the acoustical environment is specified and is selected from those given in Clause 5;
- c) the loudspeaker is positioned with respect to the measuring microphone and the walls in accordance with Clause 7;
- d) the loudspeaker is supplied with a specified test signal (see Clause 4) of a stated voltage U , within the rated frequency range (see 19.1). If required, the input power P can be calculated from the equation: $P = U^2/R$, where R is the rated impedance (see 16.1);
- e) attenuators, if any, shall be set to their “normal” position as stated by the manufacturer. If other positions are chosen, for example those providing a maximally flat frequency response or maximum attenuation, these shall be specified;
- f) measuring equipment suitable for determining the wanted characteristics is connected (see Clause 8).

4. **Test signals**

4.1 *Sinusoidal signal*

The sinusoidal signal shall not exceed the rated sinusoidal voltage at any frequency (see 17.3). The voltage across the input terminals of the loudspeaker under test is kept constant for all frequencies unless otherwise stated.

4.2 *Broadband noise signal*

This term is explained in IEC 268-2.

For practical reasons, a noise source with a crest factor between 3 and 4 is recommended, to avoid overload of amplifiers.

A true r.m.s. voltmeter having a time constant at least as long as the “slow” constant of the sound level meter, specified in IEC 651, shall be used.

4.3 *Narrow band noise signal*

This term is explained in IEC 268-2.

For measurement using narrow-band noise, constant relative bandwidth filters (see IEC 225) are used with a pink-noise generator, the relative bandwidth being usually $\frac{1}{3}$ octave.

5. **Acoustical environment**

Acoustical measurements shall be made under one of the following conditions, the choice being indicated with the results.

5.1 *Free-field conditions*

Acoustical conditions which approach those of free space. Any environment is considered satisfactory (for example, an anechoic room) in which the sound pressure decreases with the distance (r) from a point source according to a $1/r$ law with an accuracy of $\pm 10\%$ in the region that will be occupied by the sound field between the loudspeaker system and the microphone during the measurements. The minimum conditions exist if this requirement is met along the axis joining the measuring microphone and the reference point on the loudspeaker.

Free-field conditions shall exist over the whole frequency range of measurement.

5.2 *Half space free-field conditions*

Acoustical conditions in which the free-field exists in a half space. These conditions are satisfactorily met with a reflecting plane of sufficient size such that the sound pressure from a point source mounted in the surface of that plane decreases in the manner specified in 5.1.

5.3 *Diffuse sound field conditions* (with band noise measurements only)

Diffuse sound field conditions for measurements with $\frac{1}{3}$ octave band limited noise are defined and specified in ISO 3741. The lower limiting frequency shall be determined as specified in ISO 3741, Appendix A.

Notes 1. – While ISO 3741 provides details of measuring instruments in section 5: “Instrumentation”, it should be clearly understood that both space averaging and time averaging are required in loudspeaker power determination. This may be achieved as stated in the standard or alternatively by using continuous space and time averaging techniques.

2. – The precision of the measurement depends on a number of factors including the room volume, the room reverberation time, the degree of diffusion.

3. – For measurement below 125 Hz a room volume greater than 200 m³ is desirable.

6. Unwanted acoustical and electrical noise

Unwanted acoustical and electrical noise shall be kept at the lowest possible level as its presence may obscure low level signals.

Data related to signals which are less than 10 dB above the noise level in the frequency band considered shall be discarded.

7. Positioning of loudspeaker and measuring microphone

7.1 *Measuring distance under free-field and half space free-field conditions*

Ideally measurements under free-field and half space free-field conditions should be carried out in the far field of the loudspeaker, in order to obtain consistent results. The approximation to far field conditions improves as the distance between loudspeaker and measuring microphone is increased, but imperfections of the measuring environment room and the effects of background noise set an upper limit to the distance that can be used in practice.

To simulate likely conditions of use, measurements should be made at a distance similar to that of the listener(s), for example 2 m to 3 m for household sound systems and more than 10 m for sound reinforcement systems, but these distances may still be too large for existing measuring environments, if the difficulties mentioned above are to be avoided. Reducing the measuring distance to overcome these difficulties may result in the microphone being placed in the near field, so that, for example, small changes in microphone position result in large, frequency-dependent changes in sound pressure, due to interference phenomena. These can occur in any multiple-source loudspeaker where the spacing between sources radiating the same frequency is comparable with the measuring distance. If the chosen measuring distance, together with the directional characteristics of the loudspeaker, results in the measurement being made in the near field, where the sound pressure does not vary inversely with the measuring distance, then referring results to another distance, assuming the $1/r$ relationship, may cause significant error. Such calculations may be used, however, for comparison of loudspeakers having very similar directional characteristics, and to facilitate these comparisons it is recommended that the measuring distance should be 0,5 m or an integral number of metres, and that result should be referred to a standard distance of 1 m.

Note. – The calculation of errors due to finite source size and small measuring distance is not often useful, since calculated and observed errors rarely agree.

7.1.1 *Single drive unit loudspeaker*

For this type of loudspeaker, a measuring distance of 1 m from the reference point shall be used, unless there is a good reason to use another value; in any case the distance used shall be stated.

7.1.2 *Multi-unit loudspeaker systems*

Loudspeaker systems in which two or more loudspeaker units reproduce the same frequency band create problems of acoustical interference at the measuring point due to the interaction of the sounds radiated by the units. This situation exists whether all units operate over the entire frequency band under test or whether some units operate over parts of this band (for example cross-over regions). In such cases the measuring distance shall be chosen so as to minimize the errors due to this phenomenon.