



British Standard

Sound system equipment

Part 13. Guide for listening tests on loudspeakers

[IEC title : Sound system equipment. Part 13 : Listening tests on loudspeakers]

Equipements pour systèmes électroacoustiques
Partie 13. Guide pour essais d'écoute des haut-parleurs

Elektroakustische Geräte
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National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee and is identical with Publication 268-13 : 1985 'Sound system equipment' Part 13 'Listening tests on loudspeakers' published by the International Electrotechnical Commission (IEC).

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 (Previously BS 5428 : Part 9.)
- *Part 11. Specification for circular connectors for the interconnection of sound system components (Supersedes BS 5428 : Part 5 : Section 5.2.)
- *Part 12. Specification for circular 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 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 words 'this report' appear, referring to this standard, they should be read as 'this British Standard'.

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

Cross-references

International standard	Corresponding British Standard
IEC 268-1 : 1968 (superseded by IEC 268-1 : 1985)	BS 6840 Sound system equipment Part 1 : 1987 Specification for general requirements (Identical)
IEC 543 : 1976	BS 5877 : 1980 Guide for subjective listening tests for sound radio receivers (Technically equivalent)
IEC 651 : 1979	BS 5969 : 1981 Specification for sound level meters (Identical)
ISO 3382-1975	BS 5363 : 1976 Method for measurement of reverberation time in auditoria (Identical)

The Technical Committee has reviewed the provisions of ISO 384-1975, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. The related British Standard to ISO 389-1975 is BS 2497.

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

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1. General

1.1 Scope

The recommendations in this report apply to loudspeakers intended for household systems and environments. Although specifically designed for loudspeakers that are separate sound system components the procedures, with minor changes, are applicable also to other devices such as radio receivers and television sets.

1.2 Object

This report gives recommendations for the setting-up, performance and evaluation of listening tests on loudspeakers.

The tests described in this report are to be performed in a room having acoustical characteristics similar to those of an “average” living room. Recommendations about the room size, acoustical treatment and measurements, arrangement of loudspeakers and listeners, and environmental conditions are given.

Experimental procedures are described, including recommendations on the choice of music and speech programme material and the processing and presentation of the final data.

1.3 Explanation of terms

In this report, a number of special terms are used with the following meanings:

Stimulus

Reproduction of a certain programme section over a certain loudspeaker.

Programme section

A short piece of music or speech (approximately 30 s duration) that is presented without interruption over one loudspeaker at a time in a listening test.

Replication

Repeated application of the same stimulus in the test in order to increase the reliability of the ratings.

Reliability

- a) Intra-individual (“within listener”) reliability refers to the agreement between a certain listener’s repeated ratings of the same stimulus.
- b) Inter-individual (“between listeners”) reliability refers to the agreement between different listeners’ ratings of the same stimulus.

Interaction

An interaction between two variables means that the effects of one variable are different at different levels of the other variable. Applied to the ratings in a listening test, an interaction between loudspeakers and programmes may mean that the differences between the ratings of two (or more) loudspeakers are different for different programmes.

2. Physical conditions

2.1 Listening room

Ideally, the listening room should simulate a typical household listening environment in the geographical region where the test results apply. This report describes known principles of good listening room design to assist the user in approaching an optimum listening environment as closely as possible within the constraints of his situation and local context. Some more specific recommendations are given to describe an “international standard” listening room for use when test results are required to have the widest possible application.

2.1.1 Room dimensions

In rooms of household size, sound quality at low frequencies is significantly influenced by the frequency distribution of room eigentones and by the placement of loudspeakers and listeners in the pattern of standing-waves.

Because the distribution of eigentones in a rectangular room with flat, perfectly-reflecting walls is described by the ratio of room dimensions (height : length : breadth), the choice of optimum proportions is a natural consideration. In practice, however, such considerations must be modified by the fact that most room boundaries are neither perfectly-flat nor perfectly-reflecting at low frequencies.

The fact that the positioning of loudspeaker and listener affects the acoustical coupling into individual room modes means that audible colorations can be caused by the fortuitous enhancement of a small number of resonant modes in an otherwise acceptable room. There is even some evidence to suggest that axial modes may be of particular importance in this respect. As a result the frequency response of the transmission path through the listening room will be dependent upon several factors, not all of which are predictable.

It is therefore recommended that the final qualification of the listening room include an inspection of the acoustical transmission paths by means of swept-tone frequency-response measurements. (Measurements with poorer resolution may be made using pink noise filtered in 1/3 octave bands.) A good, broad-band loudspeaker should be positioned, in turn, at all loudspeaker test locations with a measuring microphone placed, in turn, at all listener head locations. All combinations should be explored and positional adjustments made to avoid those situations that clearly present difficulties. Large aberrations in frequency response tend to occur at frequencies below about 250 Hz.

The size of the room dictates both the specific eigentone frequencies and their density in the frequency domain. Large rooms offer greater potential for uniform frequency response but there is a practical upper limit on size.

The values given in Figure 1, page 71, indicate the acceptable ranges of room dimensions. Within those ranges, the recommended dimensions given below describe what is believed to be a good listening room falling within the range of typical dimensions for many geographical regions.

	Recommended dimension
Volume	80 m ³
Height	2.80 m
Length	6.70 m
Breadth	4.20 m

Note. — The recommended listening room dimensions come within the framework of those defined in IEC Publication 543: Informative Guide for Subjective Listening Tests.

2.1.2 Reverberation time

Reflected and reverberant sounds in the listening room have a major influence on overall sound quality and stereo perception. The amount and type of acoustical absorbing materials and the placement of the materials dictate the reverberation time, the uniformity of the reverberant sound field (degree of diffusion) and the interaction of the loudspeaker with adjacent room boundaries. In the household environment, regional and economic factors in structure and décor are significant factors in defining what is “typical” in these respects.

Technically, both the reverberation time, T , and the regularity of its variation as a function of frequency are important. Reverberation time shall be measured according to ISO Standard 3382 at 1/3 octave intervals, without listeners present.

Between 250 Hz and 4000 Hz the average value of T shall be within the range 0.3 s to 0.6 s. In that frequency range individual measurements of T should not deviate by more than 25% from the average value. Below 250 Hz and above 4000 Hz, T is permitted to deviate by more than 25% from the middle-frequency average value, but should not exceed 0.8 s below 250 Hz.

Where the results of the listening tests are of more than regional or other specific interest, it is recommended that the middle-frequency average, T , be 0.4 ± 0.05 s.

In physical arrangement the room should have a ceiling that is mostly sound reflecting and a floor that is mostly carpeted. The walls behind and immediately to the sides of the loudspeakers and the ceiling for approximately one-third of the room length should be mostly sound reflecting. Flutter echoes should be suppressed by means of sound absorbing and scattering objects arranged in such a manner that no reflecting surface is located opposite another parallel reflecting surface. The wall behind the listeners should be treated to prevent strong coherent reflections, particularly at middle and high frequencies.

The usefulness of the room will be substantially increased by the inclusion of some moveable sound-absorbing surfaces. These can be used to damp the walls acoustically, behind or beside the loudspeakers, or they can be distributed around the listening area, as the manufacturer or the experimenter requires. A convenient method of achieving this flexibility is to use floor-to-ceiling length drapes, in two or more sections, having a total length approximately equal to the width of the room. The drapes can be suspended from a rail near to the perimeter of the room and extending at least halfway around the room. The drapery material should be chosen for high sound absorption and should be in the place intended for a specific listening test during the reverberation-time measurements.

Note. — It should be noted especially that the quantity and arrangement of sound absorbing and scattering materials in the room are likely to influence the results of stereophonic tests. The listeners' perceptions of sound-image localization and their impressions of space may be differently affected by the strength and direction of reflected and reverberant sounds in the listening room.

2.1.3 Climatic conditions

The reliability of results may be affected by extremes of climatic conditions, therefore listening conditions should be as comfortable as possible. For test purposes the following requirements shall be met:

Ambient temperature:	18°C to 35°C, preferably 20°C
Relative humidity:	25% to 75%
Air pressure:	86 kPa to 106 kPa (860 mbar to 1 060 mbar).

The background noise level measured in the listening area of the room, in the absence of listeners, shall be below 35 dB (A-weighted, slow).

2.2 *Loudspeaker position and orientation*

The location of a loudspeaker with respect to the immediately adjacent room boundaries (floor, walls and ceiling) affects both the spectral and temporal aspects of sounds propagated into the listening room. The choice of loudspeaker location, therefore, is a factor of importance in the results of the listening tests.

In general, loudspeakers should be placed according to the recommendations of the manufacturers. However, most manufacturers offer only general guidance, if any, about optimum placement. Consequently, it is recommended that loudspeakers be auditioned in several different room locations. This is one reason why it is usually advisable to conduct two kinds of tests: monophonic tests, well suited to judgements of basic sound qualities and in which loudspeaker locations can be easily changed, and stereophonic tests that involve judgements of additional attributes of the reproduced sound and in which loudspeaker locations are rigorously controlled.

Unless the manufacturer gives specific indications to the contrary, the reference axis of each loudspeaker shall be horizontal, 1.25 m above the floor, and pointed towards a point near the centre of the listener seating area on the midline of the room. Loudspeakers shall be oriented so that the broadest dispersion of sound from the loudspeaker occurs in the horizontal plane passing through the reference axis.

The loudspeakers under test shall be rendered invisible to the listeners by an acoustically transparent screen separating the loudspeaker and listening areas (see Figure 1, page 71). The effect of the screen on the frequency response of the loudspeakers shall be less than 1 dB at any audio-frequency (measured with the screen midway between a loudspeaker and microphone spaced at 2 m).

2.2.1 *Monophonic tests*

Loudspeakers that by design (e.g. corner horns) or other considerations must be located according to a manufacturer's specification should, of course, be auditioned accordingly. The majority of loudspeakers, however, can be accommodated within a portion of the listening room, designated in Figure 1 as the "loudspeaker area", that is delineated by the restriction that the loudspeaker shall be at least 1 m from the side walls and at least 0.70 m from the back wall. These distances are measured to the reference point (the intersection of the reference axis and the front plane of the loudspeaker).

The different loudspeakers in a monophonic comparison should be separated by at least 0.50 m. The chosen locations should be noted and, if possible, the loudspeakers should be interchanged during the tests so as to avoid biasing the overall results by associating particular loudspeakers with particular room positions.

The test report should include a description of the loudspeaker locations used for each listening session.

Note. — Mechanical devices that substitute the different loudspeakers in the same room location suffer through a lack of flexibility in loudspeaker placement, but may be useful in some applications.

2.2.2 *Stereophonic tests*

The main purpose of stereophonic listening tests is to judge the ability of loudspeakers to reproduce the illusion of sound images localized in azimuth, elevation and depth, as well as the acoustical ambience of an original performance. Since more than one pair of loudspeakers cannot, at one time, occupy the same room position, judgements of this type tend to be confounded by the switching of source locations. A mechanical substitution device may be a satisfactory solution for use with many popular loudspeaker configurations.

Under normal circumstances, therefore, it is recommended that stereophonic listening tests be conducted using one pair of loudspeakers at a time. Comparative tests that do not involve positional substitution of loudspeakers should be treated with caution.

The loudspeakers should be separated by at least 2 m. In smaller rooms it may be necessary to move the loudspeakers to within 0.5 m of the side walls to achieve the separation necessary for good stereophonic perspective. The nearest listener should be no less than 2 m, measured perpendicularly, from an imaginary line joining the loudspeakers. In general, the minimum listening distance should be 1.0 to 0.8 times the distance between the loudspeakers, i.e. the loudspeakers should subtend an angle of 55° to 65° at the nearest listener position. For good stereophonic reproduction the arrangement of loudspeakers and listeners should be symmetrical about the major axis of the room.

Unless the manufacturer gives specific instructions to the contrary, the loudspeakers should be oriented so that the reference axes intersect on the major axis of the room at a point near the centre of the line of listeners.

2.3 *Listener position*

Listeners shall be seated in the area of the room specified in Figure 1, page 71. For the purpose of averaging over the directional properties of the loudspeakers and the acoustical coupling properties of the room it is advantageous to use several listening positions in the course of a test. In stereophonic tests it is essential that listeners be arranged in a line on the axis of symmetry of the loudspeaker array. Listeners from front-to-rear of the line arrangement should be progressively elevated to give each head a clear acoustical "view" of all the loudspeakers under test. In monophonic tests only one listener position need be on the room axis; the others can be placed at random within the suggested area.

Each listener should be placed at least 0.40 m from the side walls and at least 1 m from the back wall. The distance between listeners should be at least 0.60 m.

Chairs for listeners should have backs no higher than shoulder level to prevent acoustical interference with normal perception of the total room sound field.

Although there can be any number of listener positions the number of listeners at any session should be limited. The most critical tests may involve only single listeners, occupying the different positions at different times. In large rooms a maximum of five listeners may be used simultaneously.

With multiple listeners it is difficult to avoid mutual communication that encourages group rather than individual responses. Visual communication can be reduced by a visual separation of listeners using acoustically transparent screens. In any event, listeners should be given specific instructions emphasizing the importance of independent responses.

2.4 *Programme material*

The selection of music or speech passages for programme material in a listening test can have a very strong effect on the results of the test. Often there are interactions between specific loudspeakers and particular types of programme to such an extent that the ratings of the various systems will depend on the passages of music or speech presented. The programme material should therefore be treated as a separate independent variable.

The programme sections should differ from each other in a way that brings out different aspects (dimensions) of the perceived sound quality of the loudspeakers.

Note. — If it should prove feasible to isolate specific aspects of perceived sound quality, each section of programme material could be selected to measure that aspect alone. A collection of programmes chosen arbitrarily is liable to be partially redundant, since several programmes may have the same characteristics and hence increase the test length without adding any new information.

Such redundancy can be reduced by examining the test results from a variety of programmes and eliminating some of the sections that yield essentially identical results. By this procedure the listening test is made more efficient.

There is also a risk that the test may be incomplete, which means that certain aspects of sound quality are not covered by any of the programmes. Inspection of the perceptual dimensions given in Sub-clause 3.3 may give certain clues for selecting programmes which together will extend over most aspects of perceived sound quality.

At least five different programme sections should be included. It is recommended that one section consists of speech, preferably a male voice at normal conversation level. Part of the recorded test instruction can be used for this purpose. The speech shall be recorded in an anechoic room with no perceptible source of sound other than the speaker. The microphone shall be of the omnidirectional type, placed in the same horizontal plane as the speaker's mouth at a distance of 0.50 m from the latter and to one side, the line joining microphone and mouth forming an angle of 30° with the sagittal plane of the speaker's head.

Another section should be a full symphony orchestra playing fortissimo, which is known to differentiate strongly between loudspeakers. Other music sections should contain combinations of small numbers of instruments, such as:

- piano, violin and cello,
- woodwind and strings,
- brass instruments,
- percussion instruments,
- solo voice and instrumental accompaniment,
- chorus of voices.

The preceding music sections are intended to test the accuracy of sound reproduction and, therefore, they rely on music of the classical or jazz repertoire which can be compared with an acoustical "original", for example in the concert hall. Recordings of popular music tend to be studio creations, incorporating artificial compression, colorations and spatial effects. Certain types of popular music, such as rock and disco, when reproduced at high sound levels, stress speakers in ways that classical music cannot. In evaluating products for the general public it is important to include some tests of their ability to satisfactorily reproduce this kind of musical material.

The music sections should demonstrate a variety of musical types and sound levels, but the variations of timbre and loudness within each section should be as small as possible.

The recorded programme material shall be of high technical quality. Ideally there should be no frequency or amplitude distortions in the recording and reproduction chain, and background noises should be minimized. Original recordings made under strict control are desirable but carefully-selected commercial recordings are acceptable. Furthermore, no manual or automatic amplitude compression shall be used at one end of the chain without the corresponding expansion at the other end.

In the monophonic tests special care should be taken in the selection of programme material to ensure that audible colorations do not occur due to the combination of two stereophonic channels into one. Such a requirement will eliminate many commercial stereophonic recordings.

Note. — Because uncontrolled variations exist in commercial recordings (the number of microphones used, their type and placement, equalization, added reverberation, etc.) it is sometimes advisable to use musically redundant sections from a variety of sources (different recording companies, studios, engineers, etc.). The music and its sources should always be quoted in the test report.

The preparation of an internationally recognized standard programme tape is under consideration. Such a tape would facilitate the comparison of listening tests done at different places.

Where the musical programme is to be used to test other than high fidelity system components (e.g., a.m. receivers), band limiting is permitted. The precise frequency weighting function must be specified in these instances.

Programme sections should be of approximately equal durations, in the range 20 s to 40 s. For pair-wise comparisons identical sections are used in a pair. Sections of music should as far as possible form complete musical phrases.

It is often convenient to record the programme sections on magnetic tape in an order suited to the test procedure. The length of silent periods between sections will also depend on the test procedure and must be long enough to permit the writing down of the test score. Five seconds to 15 s is normally sufficient for the scoring, but a longer interval may be necessary for the experimenter to rewind the tape. The pause between repeated sections in a paired comparison should be about 1 s and not longer than 2 s.

The programme tape shall also contain necessary frequency-response and sound-level calibration signals.

2.5 *Level setting*

2.5.1 *Listening levels for programmes*

For each programme section, the reproduced sound level should, in principle, be the preferred listening level for the average listener. There is some experimental evidence that the preferred sound level is often fairly close to the level of the original speech or music at a typical listener's position during the live performance. The task of making fidelity ratings (see Sub-clause 3.4 and Appendix A) of reproduced sounds would probably also be more easily done if the relative listening levels for different programme sections reflected the relative levels of the original performances.

Alternatively, the preferred average listening level may be assessed by listening tests on each programme section, carried out in the listening room using a high quality loudspeaker.

It is often desirable to include more than one listening level in a test for two reasons. One reason is that there are large differences between the preferred listening levels of the individual listeners, and some listeners may prefer considerably lower levels than the average. Another reason is that some small loudspeakers may be overloaded by levels which are preferred for bigger loudspeakers. If additional listening levels are used, they should be chosen in steps of 10 dB below the primary level. However, in order to limit the total test length, it is not generally necessary to repeat all programme sections at each listening level. Instead, only those one or two programme sections having the highest level in the test might be reproduced at a level 10 dB or 20 dB lower.

2.5.2 *Relative levels for loudspeakers*

To avoid biasing the test results, it is essential that each individual programme section should sound equally loud over all of the loudspeakers. In general, this is achieved by adjusting the gain controls in the loudspeaker selection system using the following measurement procedure:

- a) Test signal: Continuous noise with a spectrum representing properties of the average of all types of programme material according to IEC Publication 268-1: Sound System Equipment. Part 1: General.
- b) Measuring instrument: Sound level meter according to IEC Publication 651: Sound Level Meters, weighting curve A, Class 1, time characteristic S.

The sound level is measured in the listening room at ear level in the middle of the seating area when the loudspeakers are fed with the test signal, and the gain is adjusted until the meter reads the same for all loudspeakers.

Occasions may arise, depending on the spectrum of the programme and the spectral balance of the loudspeakers, when the loudness balances achieved by measurement are not adequate. In these cases, careful balancing by subjective methods is advised. In very critical situations, it may be necessary to do individual subjective loudness balances for every programme section.

2.6 *Electrical requirements*

If the listening test is to be a valid indicator of differences between loudspeakers it is essential that careful consideration be given to certain electrical requirements.

2.6.1 *Power amplifier*

The power amplifier shall be capable of driving all test loudspeakers at the highest sound level without clipping, instability or triggering of protective circuitry. It is good practice to monitor the amplifier output, during at least preliminary tests, using an oscilloscope or peak power indicator. The complex impedance of some loudspeaker and connecting wire combinations can cause problems with certain power amplifiers.

2.6.2 *Switching system*

It is commonplace in listening tests to use a switching system to select the different loudspeakers under test. Such a system shall not compromise the performance of either the loudspeakers or the power amplifier. Switch contact resistance, especially in the amplifier output circuit, shall be very low and shall be checked periodically for deterioration (see Sub-clause 2.6.3). Level settings (see Sub-clause 2.5) shall be accomplished by means of potentiometers positioned before the input to the power amplifier.

Power amplifier input and output earth connections shall be electrically isolated from each other by using separate input and output switching. A common earth connection through the switching system can, with some amplifiers, result in frequency-response modifications related to loudspeaker impedance characteristics.

It should be confirmed by measurement that the interconnection of the apparatus has not introduced significant changes in important performance parameters, such as frequency-response or background noise.

2.6.3 *Connecting wires*

Wires from the power amplifier output to the loudspeakers should be as short as possible and in any event shall be of sufficient gauge that the total resistance of any loudspeaker circuit (measured from the power amplifier output, through all selector switch contacts to the short-circuited loudspeaker terminals) does not exceed $0.2\ \Omega$ or $1/40$ of the lowest rated impedance of the loudspeakers under test, whichever is less.