BS 6259:2015

BSI Standards Publication

Code of practice for the design, planning, installation, testing and maintenance of sound systems

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Contents

List of tables

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 60, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited under licence from The British Standards Institution and came into effect on 31 March 2015. It was prepared by Technical Committee EPL/100, *Audio, video and multimedia systems and equipment*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 6259:1997, which is withdrawn.

Information about this document

This is a full revision of the standard, updating all aspects.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

The recommendations of this British Standard are intended to enable a clear understanding, including understanding by non-technical users, of the functions and limitations of a proposed sound system.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Section 1: General

1 Scope

This British Standard gives recommendations for the design, planning, installation, testing and maintenance of sound systems intended for communicating speech, music and/or other signals, including systems conveying emergency messages or signals that are not connected to a fire detection system.

NOTE 1 For systems used for conveying emergency messages, recommendations are given in BS 5839-8.

This standard is intended for use by clients, designers, installers and those responsible for commissioning, testing, operation and maintenance of sound systems.

This standard is not applicable to:

a) voice alarm systems within the scope of BS 5839-8 or BS EN 54-16 or BS EN 54-24;

b) emergency voice communication systems within the scope of BS 5839-9;

c) emergency sound systems within the scope of BS 7827;

d) simultaneous interpretation systems (see ISO 2603);

e) some of the aspects associated with recording studios, and applies only to some types of broadcasting studio;

f) home entertainment systems;

g) systems intended only to modify the perceived acoustic characteristics of the space;

h) manual fire detection systems; or

i) audio conferencing systems.

This standard is not applicable to cinema sound systems.

NOTE 2 Cinema sound technology is evolving very rapidly at present, due partly to the elimination of film stock in favour of digital distribution and the increased practicability of multichannel sound systems with tens of channels. Existing standards such as BS 5550-3.4.9 are likely to be replaced by completely new standards within a few years. It is therefore not at present practicable to give advice on these systems in this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7671:2008+A3:2015, *Requirements for electrical installations – IET Wiring Regulations (Seventeenth edition)*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

NOTE A glossary of technical words and phrases is given in Annex A.

3.1 Acoustics

3.1.1 acoustic feedback

energizing of a microphone by the acoustic output of a loudspeaker of the same sound reinforcement system

NOTE As the effect increases so does the distortion, which might become intolerable, and eventually the system might oscillate continuously at some frequency, usually audible, at which the microphone to loudspeaker gain exceeds the loss in the feedback path. The system is then said to "howl round".

3.1.2 average sound pressure level (L_p)

twenty times the logarithm to base ten of the ratio of the r.m.s. sound pressure under consideration, p, to the reference r.m.s. sound pressure, p_o

NOTE 1 The average sound pressure level, L_p, expressed in decibels, is calculated as follows:

$$L_p = 20 \lg \frac{p}{p_o}$$

NOTE 2 The standard reference sound pressure p_o is 20 μPa in air.

3.1.3 echo

sound heard as a repetition of a first hearing

NOTE Repetition of a sound can occur in three ways:

a) if a sound is reflected from an object more than about 10 m away;

b) if sound travels to a distant listener by more than one route and the path length difference is more than 10 m; and

c) if electronically delayed signals are intentionally generated.

3.1.4 reverberation time (of an enclosure for a sound of a given frequency or frequency band)

time that would be required for the sound pressure level in the enclosure to decrease by 60 dB, after the source has been stopped

3.2 Intelligibility

3.2.1 audibility

property of a sound which allows it to be distinguished from other sounds

NOTE The property may include intensity, spectral distribution and variation with time.

3.2.2 clarity

property of a sound which allows its information bearing components to be distinguished by the listener

NOTE Clarity is related to the freedom of the sound from distortion of all kinds.

3.2.3 intelligibility

measure of the proportion of the content of a speech message that can be correctly understood

NOTE Intelligibility requires sufficient audibility and sufficient clarity. These can be related to the mathematical basis of the objective method of determining intelligibility though the use of the speech transmission index (STI), but clarity in that case is limited to freedom from reverberation.

3.2.4 speech transmission index
STI
metric ranging between 0 and 1 representing the transmission quality of speech with respect to intelligibility by a speech transmission channel

[SOURCE: BS EN 60268-16:2011]

3.3 People

3.3.1 client
person, group or organization that commissions the design and installation of the sound system

NOTE The client is usually, but not always, the purchaser of the system.

3.3.2 contractor
person or company that enters into a written agreement with the purchaser to supply a sound system

NOTE The contractor might also undertake the system design and/or the installation. In major building projects the sound system may be the subject of a written agreement between the main building contractor and the specialist supplier.

3.3.3 installer
person, group or organization responsible for the installation of the sound system as specified by the system designer

3.3.4 operator
person who controls the sound system manually when it is in use

3.3.5 system designer
person responsible to the client for the design and specification of the sound system

3.3.6 user
person, group or organization who supervises the operation of the equipment in use

NOTE The needs of the user are important factors in the design of a sound system. There might be more than one user and the user might not be the client or owner of the system when a room is hired with a sound system.

3.4 System features

3.4.1 channel
signal path between input and output of a system

3.4.2 control point
place where controls for the operation of the system are located

NOTE A control point can have controls for operating the system only under special conditions, for example a police or fire control point. There can be more than one control point.

3.4.3 line-level voltage

voltage of 0.775 V r.m.s. (corresponding to a power of 1 mW in 600 Ω)

NOTE When this voltage is used as a reference level ("line level") in decibels (0 dB), it is written as 0 dB (0.775 V) or 0 dBu. Although the reference level is derived from a system having a characteristic impedance of 600 Ω, such systems are rarely used now (see BS EN 61938).

3.4.4 mixer

specialized amplifier whose output is at line-level voltage, with facilities to allow input signals from several sources to be controlled or combined or both

3.5 System types

3.5.1 sound system

system including amplifiers, loudspeakers and sources of speech, music or tone signals, which is intended to present the signals to people outside the household environment

3.5.2 sound reinforcement system

sound system intended to reinforce sound signals from actors, musicians, etc.

NOTE In these systems the microphones are exposed to the sound produced by the loudspeakers.

Section 2: Exchange of information and definition of responsibilities

4 Technical advice and performance specification

4.1 General

NOTE Except for basic systems sold as a complete kit, the engagement of a skilled system designer is advisable and is considered to be essential whenever large or complex installations are involved.

If prospective purchasers wish the sound system to be in accordance with this British Standard, then a reference to the standard should be included in written agreements relating to the installation, modification and extension of the sound system.

4.2 Purpose of the system

Before approaching a supplier, the client should write down, in non-technical terms, what the users of the system require it to do and the environment in which it is to be used. Care should be taken that this is as comprehensive as possible. Anything left out at this stage can result in extra expenditure later. Factors that should be considered include:

a) the room(s) and other three dimensional space(s) to be covered, their dimensions and the nature of their surfaces and their acoustic characteristics;

b) the various usages of each space and the background noise associated with them;

c) what audio signals are to be reproduced and their sources (e.g. microphones, alert signals and recorded messages), including all the sources and places;

d) methods of controlling the sound system, both manual and automatic;

e) presentation of user interfaces (e.g. volume control, touch-screen, paging panel);

f) interconnection with other audio systems [e.g. audio frequency induction loop systems (AFILS) and infrared systems];

g) priorities of input sources if applicable;

h) the need to avoid unwanted broadcast of audio information to adjacent environments (e.g. noise pollution in a public space, or confidentiality in a court, where the audio information needs to be kept confidential); and

i) architectural considerations or restrictions (e.g. listed building status).

4.3 Obtaining technical advice

Wherever possible, technical advice should be obtained during the early planning stages of a sound system. Such advice should cover:

a) the suitability of a sound system for a particular venue and/or application;

b) factors that might adversely affect the performance of a sound system;

c) factors that might add to the cost of installing a sound system; and

d) the need for, and scope of, an initial site assessment.

NOTE For a small sound system, the cost of a formal initial survey might not be justified, but many contractors conduct an informal survey as a matter of course.

4.4 The nature of the advice

Advice to be obtained depends on the particular installation requirements for each sound system, but should generally include the following:

a) advice from the contractor to the client on all aspects, from initial quotations for the task in the planning stages through to installation, commissioning and maintenance of the sound system;

b) advice from the designer to a technically competent installer (e.g. in the case of systems in new buildings where installation is to be carried out by electrical contractors; systems installed by in-house staff); and

c) advice from an appropriate organization or professional body, such as the Institute of Sound and Communications Engineers.

4.5 Professional (consultancy) advice

Professional advice from a specialist consultant should be obtained when installations are to be undertaken in extra-large or prestigious buildings and those posing special difficulties, such as very reverberant spaces, areas with high ambient noise levels and multi-purpose spaces.

NOTE The advice of an independent consultant or a professional body might also be useful in the event of a dispute between the client and supplier or manufacturer. Such advice can often provide the most economical resolution of a dispute.

4.6 Choosing the system supplier

4.6.1 General

Possible procedures for acquiring a sound system are recommended in **4.6.2**, **4.6.3** and **4.6.4**. The choice of procedure should depend on the size of the space to be covered and any special complications which might be involved.

4.6.2 Approaching a contractor

For a small and uncomplicated sound system, a contractor may be asked to design, supply and install suitable equipment and all cabling, based on the objective of the system (see Clause **6**).

NOTE Names of contractors who specialize in this work may be obtained from business directories and trade associations.

Responsibility for choosing appropriate equipment (microphones, amplifier, etc.) and for installing and setting up the sound system correctly should rest with the contractor.

For some sound systems, the installation contractor may call in a manufacturer to provide detailed technical advice on areas of uncertainty or particular difficulty. On these occasions the agreed obligations of the installation contractor and the manufacturer to the prospective purchaser should be clearly documented, preferably in a single document.

4.6.3 Approaching a manufacturer of sound system equipment

Some manufacturers of sound system equipment are willing to produce the site survey for the proposed installation, design a system and, perhaps, recommend an installation contractor. Manufacturers who are unable to provide this service themselves might offer contact with appropriate designers/installers who can undertake such projects.

NOTE Names of manufacturers can be obtained from business directories and trade associations.

Responsibility for choosing appropriate equipment (microphones, amplifier, etc.) and commissioning the system should rest with the selected manufacturer or designer. The contractor should be responsible to the manufacturer for the correct installation of the sound system and commissioning (where this is also undertaken).

4.6.4 Approaching a specialist consultant

When it is appropriate to engage a specialist consultant, this should be done at the earliest opportunity. The consultant should be responsible for the initial survey, design and commissioning of the sound system, choice of equipment and helping to assess installers' proposals. Where necessary, the consultant should also liaise with architects and construction contractors on matters affecting the sound system.

NOTE Such a consultant might be independent or might be a suitably competent person employed by a manufacturing or contracting organization.

4.7 Performance specification

A performance specification should be prepared by the system designer and agreed with the client. It is this performance to which the system is required to conform at the commissioning stage. If the choice of equipment to be used is not completely under the control of the system designer (for example, if some existing microphones are to be used), any reservations about the suitability of such equipment should be clearly explained to the client in writing.

4.8 Specification for tests of completed installation

Tests of the completed installation to verify that the sound system performs satisfactorily should be specified in writing and should cover:

a) intelligibility within the covered space, assessed both subjectively and objectively – this may consist of a "walk test" and STI measurements, or a much more intensive assessment using, for example, PB word scores (see BS EN 60268-16)];

b) quality of installation;

c) functionality of inputs;

d) correct operation of controls and priorities;

e) accuracy of documentation;

f) correct implementation of loudspeaker zones (if any); and

g) unwanted coverage and noise pollution.

The specification should include documented provisions regarding remedial action in case the system does not pass the test.

NOTE The system designer would normally be responsible for detailing required remedial proposals and their implementation.

Section 3: Sound system design

5 System-level considerations

5.1 Classification of systems

5.1.1 General

Sound systems can be classified into the three categories given in **5.1.2** to **5.1.4**.

NOTE Classifications start with the letter S (standing for "sound system") to avoid confusion with fire systems which have L and P classifications, audio frequency induction loops (AFILS) which have A classifications and voice alarm systems which have V classifications.

5.1.2 Category S1

Category S1 systems aim mainly at the reproduction of speech with good intelligibility, but not necessarily a high degree of naturalness. They are suitable for broadcasting emergency messages. Music, if reproduced at all, would be of an acceptable quality but not necessarily of artistic merit. Where acoustic conditions are bad, for example because noise levels are high or reverberation is excessive, these systems can be expected to provide the best results that can be achieved.

5.1.3 Category S2

Category S2 systems are most commonly used. The aim is to produce intelligible and natural sounding speech and/or music of a quality that the average listener considers pleasant. It is desirable that the listening conditions are either already fairly good acoustically or can be made so by suitable acoustic treatment.

5.1.4 Category S3

Category S3 systems aim at the highest possible quality of reproduction. This category is appropriate when the audience is expected to be critically interested in the programme for its own sake and not merely as a background. It is essential that the listening conditions are acoustically very good, and that the input to the system is of adequately high quality, as any defects can sound more objectionable. Signal quality from an amplitude modulated broadcast receiver, for example, can cause the reproduction from a category S3 system to be less satisfactory than that obtained from a category S2 system using similar inputs.

5.2 Provisions for conveying emergency messages

The operation of the system under emergency conditions should be documented in an overall plan for handling emergencies at the site. Priority should be given to emergency messages over all other functions of the system.

6 Planning

The project should be planned over all phases. The detail required depends on the size and complexity of the installation. Table 1 gives a detailed overall plan, which might need to be supplemented by detailed planning tables for some stages.

Table 1 **Overall view of planning stages**

Stage	Purpose of work and decisions to be reached	Tasks to be undertaken	People directly involved	Usual terminology
A. Inception	To prepare general outline of requirements and plan future action	Identify client organization for briefing. Consider requirements, appoint project team leader	Client organization, Project team leader	Briefing
B. Feasibility	To provide an appraisal and recommendation in order to allow the client to determine the form in which the project is to proceed, ensuring that it is feasible and functional – technically and financially	Carry out studies of use requirements, site conditions, planning, statutory obligations, design, and cost, etc., as necessary to reach decisions	Client's representatives, Project team leader, Building and system acoustic consultant, System electronic designer, according to the nature of the project	
C. Outline proposals	To determine general approach to layout, design and construction in order to get authoritative approval for the client on the outline proposals and accompanying report	Develop the brief further. Carry out studies on the user requirements, technical problems, planning, design and cost, as necessary to reach decisions	Client's representatives, Project team leader, Building and system acoustic consultant, System electronic designer, as required	Sketch plans
D. Scheme design	To complete the brief and decide on particular proposals, including outline specification, and cost, and to obtain all approvals	Final development of the brief, full design of the project by project team leader, preliminary system schematic using BS/ISO standard symbols, prepare cost plan and full explanation report. Submission of proposals for all approvals	Client's representatives, Project team leader, Building and system acoustic consultant, System electronic designer, all statutory and other approving authorities	
Brief should not be modified after this point.				
E. Detailed design	To obtain final decision on all matters related to design, specification, construction and cost	Full design or selection of all parts and components of the sound system. Complete cost checking of design	Project team leader, Building and system acoustic consultant, System electronic designer, Sound system installer (if appointed)	Working drawings
Any further changes in location, size, shape or cost after this point will result in abortive work.				
F. Bills of quantity	To prepare and complete all information and arrangements for obtaining tender	Preparation of Bills of Quantities and tender documentation	Project team leader, Sound system installer (if appointed)	

Table 1 **Overall view of planning stages**

Stage	Purpose of work and decisions to be reached	Tasks to be undertaken	People directly involved	Usual terminology
G. Works planning	To enable the contractor to programme the work in accordance with the written agreement	Prepare workshop drawings for approval by project team leader	Project team leader, Contractor, Subcontractor sound system installer	Site operations
H. Sound system installation	To follow the plan through to practical completion of the sound system installation	Off-site assembly and testing, installation and testing by the installer	Project team leader, Contractor, Subcontractor sound system installer	
I. Complet-ion	To hand over the sound system to the project team leader for use by the client, remedy any defects, settle the final account, and complete all work in accordance with the written agreement	Project team leader commissioning: agree and carry out any remedial works as required	Project team leader, Contractor, Subcontractor sound system installer	

7 System design

7.1 Overview

When designing a sound system, the following factors should be taken into account:

a) loudness, which is controlled by amplifier power and loudspeaker sensitivity and siting;

NOTE 1 An increase of 3 dB in loudness requires a doubling of amplifier power. An increase of 10 times in amplifier power is required to produce an apparent doubling of loudness.

NOTE 2 Loudspeakers vary considerably in sensitivity (maximum sound pressure produced by a given amplifier power). Details of loudspeakers and associated system components are given in Annex B.

b) frequency range; and

c) echoes and reverberation, whose effects are minimized by the siting and selection of microphones.

NOTE 3 Details of microphones are given in Annex C.

Microphones should be used and sited in accordance with Annex D.

NOTE 4 A sound system consists essentially of the following four basic components:

1) microphone(s) and other signal source(s);

2) pre-amplifier (control unit);

3) power amplifier(s); and

4) loudspeakers (normally more than one).

NOTE 5 In order to obtain the maximum performance from a system, to maintain an adequate signal-to-noise ratio and provide an appropriate frequency response, a number of other additional elements may be added, such as compressors and equalizers. Additionally, loudspeaker zoning or group switching might be required.

7.2 Loudspeaker siting

Good siting of loudspeakers is very important for uniform sound coverage. A position above audience listening can help to establish a clear line-of-sight path to every listener and also helps to equalize the distances between loudspeakers and listeners. Difficult compromises might have to be reached to accommodate objections to the visibility of the loudspeakers.

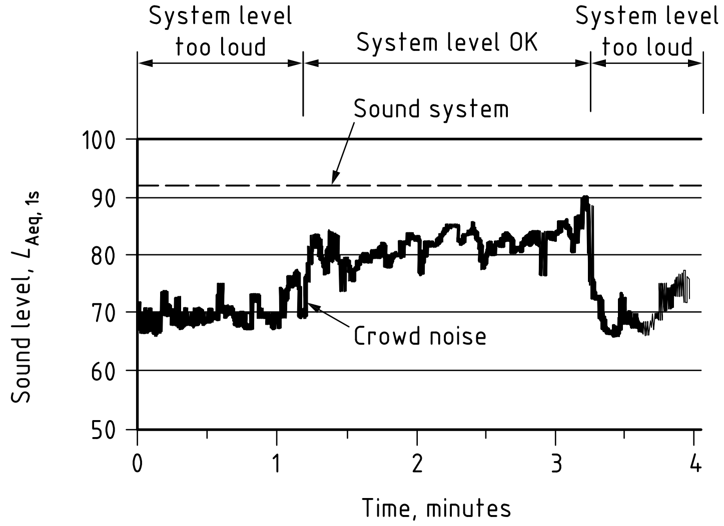
NOTE Fewer, more costly, loudspeakers of high sensitivity might reduce aesthetic difficulties over their visibility.

The relationship between the power supplied to the loudspeaker and the sound level achieved depends on the sensitivity of the loudspeaker, the distance from the loudspeaker to the listener and the acoustics of the room. Near to the loudspeaker, the sound pressure is proportional to the voltage input to the loudspeaker; as the distance between listener and loudspeaker increases, so the sound reflected from the room boundaries becomes more important. At a certain ("critical") distance from the loudspeaker, the sound level stops decreasing with distance because of the addition of reflected sounds.

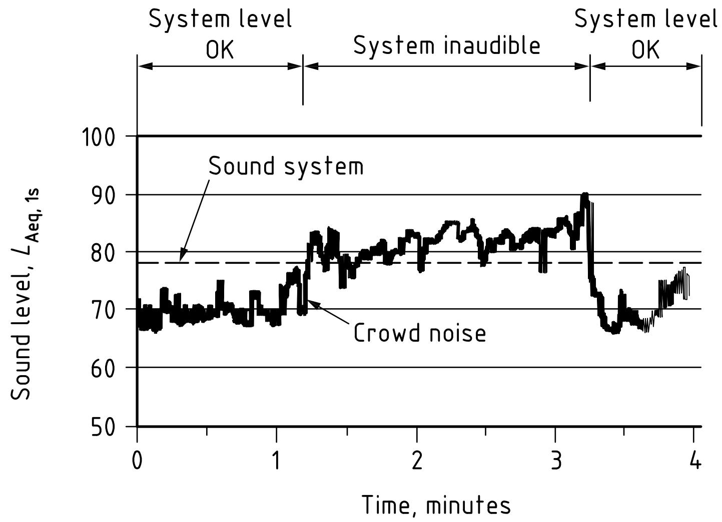
7.3 Ambient noise level sensing

In many locations, for example sports stadia, railway stations and airports, the background noise level is not constant. It might fluctuate over long or short periods, or both. A sound system having a fixed output level might be too loud when the noise is least, or inaudible when the noise is greatest. (See Figure 1 for examples.) The technique of ambient noise level sensing should be considered and may be applied to overcome this defect. It can also eliminate or mitigate noise nuisance.

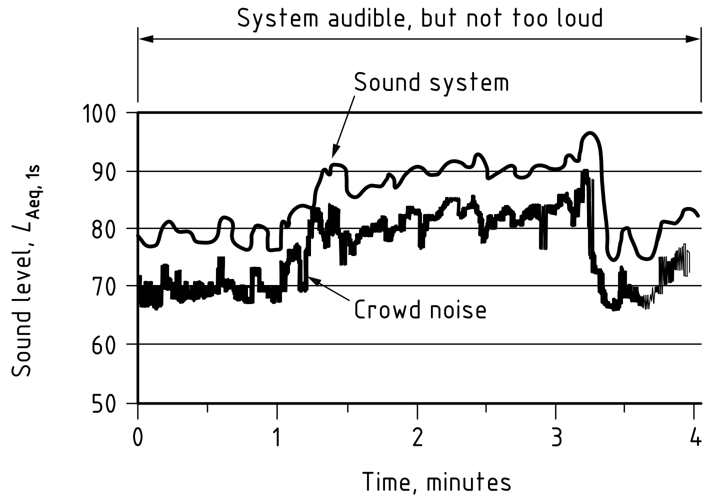
Figure 1 **Effect of ambient noise sensing**



a) System level fixed above maximum noise level – too loud in quiet periods



b) System level fixed below maximum noise level – too quiet in loud periods



c) System level varied by sensing noise level – acceptable in all periods

7.4 Frequency range

Historical limitations of frequency range have largely been eliminated in modern equipment, but there is a cost penalty (and possibly unnecessary technical difficulties) if the design is based on an excessively wide range. The following factors should be taken into account:

a) extended low-frequency reproduction requires large loudspeakers or high amplifier power, or both; and

b) high frequencies are absorbed by the atmosphere over long path lengths, and this effect varies greatly with the humidity.

7.5 Speech intelligibility and quality of reproduction

The intelligibility (which depends on both audibility and clarity) of speech signals, the audibility of any warning tones, and the desired quality of reproduction of any music signals are of prime importance. The quality of reproduction of music signals depends on factors additional to audibility and clarity.

Audibility is related to loudness, but excessive loudness results in a reduction of intelligibility. Clarity is related to freedom from echoes and reverberation. Non-linearity distortion is very seldom an issue with modern equipment, but has much less effect on speech than on the quality of music reproduction. On the other hand, the quality of music reproduction is little affected by reverberation, and echo may even be used for artistic effect.

Several methods currently exist of objectively measuring speech intelligibility, one of which is STI (see BS EN 60268-16). However, no objective method is absolutely reliable, so a subjective assessment should be also carried out.

NOTE Annex E gives examples of STI qualification bands and typical applications.

7.6 Electronic equipment and wiring

7.6.1 Electronic equipment

Electronic equipment should be sited where it is accessible to authorized people but not others. Responsibility for providing any housing, support or other accessories should be agreed and documented. Care should be taken that the equipment is sited so that it will not overheat or become excessively damp. The equipment should conform to the appropriate safety standard for the environment in which it is used.

7.6.2 Wiring

The installation of mains wiring and protective devices should conform to BS 7671. Microphone and other signal cables are Category 2 circuits as defined in BS 7671 and should be segregated from mains and other cables in Category 1 circuits.

Section 4: Installing a sound system

8 Installation

8.1 General

One organization should be responsible for the installation of the sound system and this responsibility should be agreed prior to the start of the work.

NOTE It is not, in general, the responsibility of the installer to verify whether the design of the system is in accordance with the recommendations of this standard, unless the installer is also the designer.

The responsibility of the installer should be to install the system in accordance with the requirements of the design specification and to follow good practice in the installation work. However, in practice, compliance with a number of these recommendations impacts on both design and installation, and may, therefore, be delegated by the designer to the installer, provided the responsibility for compliance is clearly documented, that the installer is competent to address the issues and that the responsibility is accepted by the installer.

8.2 Installation of cables

NOTE The designer may delegate decisions regarding cable routes to the installer, by simple reference in the design to compliance with this clause. At the design stage, the designer might have inadequate information to enable compliance with all the relevant recommendations. For example, drawings on which the design is based might not show sufficient information about structural features or final fittings of the building.

The installer should ensure that all wiring and cable types conform to the design documentation. All cables should be clearly identified, at least at each end and at all the joints on the route. These should be accurately recorded for future reference.

Cables should be installed without external joints wherever practicable. All terminations and other connectors should be such as to minimize the probability of early failure. Other than in the case of joints at or within system components such as amplifiers and microphones, terminals and connectors used to joint cables should be constructed of materials that will withstand a similar environment and be of similar durability to that of the cable. All joints, other than those within system components, should be enclosed within junction boxes, labelled with the words "Sound system" to avoid confusion with other services.

Care should be taken to ensure the electrical continuity of electromagnetic screens, including those of microphone cables.

Cables that are directly fixed to surfaces should be neatly run and securely fixed at suitable intervals, in accordance with the recommendations of the cable manufacturer. Cables should not be supported by suspended ceilings. Where new conduit, trunking or tray is installed, its capacity should be in accordance with the requirements of BS 7671.

Where a cable passes through an internal wall, a small clearance hole should be provided. If additional mechanical protection is necessary, a smooth-bore sleeve should be sealed into the wall. Where a cable passes through an external wall, it should be contained in a smooth-bore sleeve of metal or other non-hygroscopic material sealed into the wall. This sleeve should slope downwards towards the outside and should be plugged with a suitable non-hardening waterproof compound to prevent the entry of rain, dust or vermin. Care should be taken to ensure that the ends of any sleeves are free from sharp edges which might damage cables during installation. Where a cable passes through a floor, the recommendations above should be applied. The sleeve should extend as far above floor level as is required to provide adequate protection of the cable, but not less than 300 mm.

Penetration of construction (e.g. for the passage of cables, conduit, trunking or tray) should be made good to prevent the free passage of fire or smoke, regardless of whether the construction has a recognized degree of fire resistance.

8.3 Inspection and testing of wiring

Continuity of all circuits should be tested. Insulation resistance between conductors, between each conductor and earth, and between each conductor and any screen, should be at least 2 MΩ. Care should be taken not to measure the insulation resistance with a voltage high enough to damage the equipment. Alternatively, any such equipment should be disconnected before applying the test, but this latter procedure is less reliable.

8.4 As-fitted drawings

As-fitted drawings should be produced, which include at least:

a) the positions of all sound system equipment;

b) the positions of all cables, including the type, sizes and actual routes of cables;

c) the position(s) of microphone(s); and

d) the positions of all equipment that might require routine attention or adjustment.

The cable routes shown should be a reasonable representation of the routes followed, to enable any cable to be located in the event of a fault or need for modification or extension of the system.

NOTE A simple schematic showing the sequence in which devices are wired is unlikely to be sufficient, other than in small, simple systems.

In the case of extensions or alterations, existing as-fitted drawings should be updated. Where necessary, in complex buildings, a cabling schedule cross-referencing the drawings should be produced in order to help explain the cable routes.

8.5 Check list

The installer should ensure that:

a) adequate space is provided around the equipment for access;

b) the structure can accept the weight of the equipment;

c) adequate cooling or ventilation is provided to keep the equipment within its rated temperature range; and

d) the installation of microphones and loudspeakers is strictly in accordance with the design specification.

To facilitate safe maintenance work, the installer should ensure that all sound system equipment that is likely to need routine attention is sited in accessible locations.

All metallic parts of the installation, including conduit, trunking, ducting, cabling and enclosures, should be separated from any metalwork forming part of a lightning protection system.

NOTE 1 Further guidance is given in BS EN 62305.

On completion of the installation work the installer should issue an installation certificate.

NOTE 2 An example of a model installation certificate is given in Annex F.

Where a designer makes variations from any of the preceding recommendations of this subclause, they should communicate this in the form of specific written requirements (e.g. within a specification). In this case, the installer should record the relevant variations within the installation certificate.

9 Commissioning

The system should be commissioned by a person who has access to the requirements of the designer (i.e. the system specification) and any other relevant documentation or drawings, and possesses a thorough knowledge and understanding of the standard.

At commissioning, the entire system should be inspected and tested to ensure that it operates satisfactorily and that, in particular:

a) intelligibility and signal-to-noise ratios conform to the system specification;

b) an acceptable level of intelligibility is achieved throughout the covered volume;

c) no changes to the building since the time of the agreed design have compromised the performance of the system (e.g. by erection of new structures that affect the effectiveness of the sound system);

d) mains power supplies are appropriately rated; and

e) all relevant documentation has been provided to the user or purchaser.

On completion of the commissioning a certificate should be issued. All inspection and test results obtained during the commissioning process should be clearly documented.

NOTE An example of a model commissioning certificate is given in Annex F.

10 Documentation

10.1 General

On completion of the commissioning, all records and other documentation relating to the system should be provided to the user or purchaser.

NOTE The user and purchaser might, or might not, be the same organization.

The responsibility for provision of the documentation may rest with more than one organization. Priority should be given to the preparation and accuracy of as-fitted drawings (see **8.4**) and operation and maintenance manuals. The manuals should be adequately specific to the system. Without these drawings and manuals, maintenance or future modification of the system is very likely to be difficult.

10.2 Documentation for the project as a whole

Documentation of the project should be as set out in Table 2.

Table 2 **Documentation**

Project stage	Personnel involved
a) the initial consultation to determine the client's needs and what is possible or not within the available technology or budget	Consultant Client
b) design to produce a workable design based on a)	Consultant Client Designer
c) installation and project management to implement the design of b)	Consultant Client Designer Contractor
d) testing and commissioning to prove the design is working and achieves the objectives and performance of a) and b)	Consultant Client Designer
e) certification where appropriate, affirming that the appropriate standards have been met according to their individual responsibilities	Consultant Client Designer Contractor
f) maintenance	Consultant Client Maintenance contractor

10.3 Documentation of software

Documentation of software should be such that, where relevant:

a) the system can be maintained and updated as and when necessary;

b) in the event of the absence of the software author(s), the system can still be maintained and adjusted as necessary;

c) the operation of the system is transparent and that new operators/maintainers can be trained without problems; and

d) it is made clear that, in the event of a "commissioned work", i.e. where the client has paid for the software, the copyright is transferred to the client and they are entitled to all source code and similar documentation.

10.4 Documentation for the client

The following documentation should be provided to the client:

a) certificates for design, installation and commissioning of the system;

b) a comprehensive operation and maintenance manual for the system, which should provide information specific to the system in question, including the following:

- a list of equipment provided and its configuration (e.g. schematic diagram);
- use and operation of the system;
- service and maintenance of the system;
- the importance of ensuring that changes to the building, such as new structures, do not affect the standard of coverage in the space; and
- the need to update the "as-fitted" drawings after extensions or alterations;

c) as-fitted drawings indicating at least the following:

- the positions of all sound system equipment;
- the positions of all microphones, loudspeakers and inputs; and
- the type, sizes and actual routes of cables;

d) a record of any agreed variations from the original design specification; and

e) a logbook in which to record periodic testing of the system, and repairs and changes.

10.5 Logbook

The following information should be recorded in the logbook:

a) the name of the responsible person;

b) details of the maintenance organization;

c) brief details of maintenance arrangements;

d) dates, times and types of all tests;

e) dates, times and types of all faults and defects; and

f) dates and types of all maintenance (e.g. maintenance visit or non-routine attention).

NOTE It is important to ensure that the logbook is updated to reflect any changes of responsible person, maintenance organization or maintenance arrangements.

11 Certification

This standard does not prescribe a certification scheme, but Annex F gives examples of certificates that might be used in such a scheme or without the support of such a scheme.

On completion of design, installation and commissioning, a separate certificate should be issued for each of these three processes, confirming compliance with the recommendations of this standard for the stage in question (i.e. design, installation or commissioning) or identifying variations. Three separate certificates should be independently issued, i.e. the issue of one should not depend on the issue of another. The person(s) who sign(s) these certificates should be competent to verify whether the recommendations of this standard in respect of the process to which the certificate refers have, or have not, been satisfied.

The client should be asked to complete an acceptance certificate provided by the organization, bearing overall responsibility for the system. Before accepting a system, the client should ensure, at least, that:

a) all installation work appears to be satisfactory;

b) the system is capable of giving intelligible broadcasts;

c) the following documents have been provided to the purchaser or user:
   - as-fitted drawings;
   - operating and maintenance instructions;
   - certificates of design, installation and commissioning; and
   - a logbook to record the periodic testing of the system;

d) sufficient representatives of the user have been adequately trained in the operation of the system, including, if applicable, all means of broadcasting emergency signals and the correct use of emergency microphones (if installed);

e) the nominated responsible person has been advised of their responsibilities and how these might be discharged; and

f) all relevant tests, defined in the system specification, have been witnessed.

Where modifications are carried out to a system, the client should require that the organization responsible for the work issues a new commissioning certificate.

The purchaser or user might decide that there is a need for independent verification of compliance of the installed system with this standard as a result of one or more of the following:

1) the division of work elements between different organizations;

2) the evolution of the building design during construction; and

3) the lack of detailed information at the time of design.

The person responsible for verification should be familiar with this standard and with the relevant installation practices. The scope and extent of the verification process should be agreed between the purchaser or user and the organization responsible for verification. On completion, a verification certificate should be issued.

12 Lifetime activities

12.1 Regular testing

The mechanical components of the system, for example connectors, connecting leads and switches, are less reliable than the electronic equipment. Regular tests should be carried out to ensure that there has not been any failure of the sound system, or, if there has been a failure, that repairs can be carried out before the system is required for use.

On a weekly basis, the responsible person should ensure that operation of the system in the areas where coverage is required is checked. The performance of these tests, the results and any user complaints should be recorded in the system logbook (**10.5**).

12.2 Inspection and maintenance

The system should be periodically inspected, so that faults are identified, preventive measures are taken to ensure the continued reliability of the system, and the user is made aware of any changes to the building that might affect the performance afforded by the system. Periodic inspection and maintenance should be carried out by a person with appropriate knowledge of sound systems, adequate access to spare parts and sufficient information regarding the system.

Where maintenance is carried out by a third party, there should be an agreement for call-out to deal with any fault or damage that occurs to the system, and this agreement should be such that a technician of the maintenance organization can normally attend the premises in an acceptable period after a call from the user. The name and telephone number of the party responsible for maintenance of the system should be prominently displayed.

During inspections, the following processes should be carried out:

a) the system logbook should be examined to check that any faults recorded have received appropriate attention;

b) a visual inspection should be made to check whether structural or occupancy changes have affected the system, with particular care taken to check whether:

- any new or relocated partitions have been erected affecting the volume to be covered;
- any changes to the use or occupancy of an area makes the existing sound system design unsuitable, for example increase of acoustic ambient noise; and
- any building alterations or extensions require the installation of additional sound system equipment;

c) any structural or occupancy changes that have been found as a result of the inspection should be reported to the responsible person so that appropriate design and implementation of corrective works can be commissioned;

d) all controls and visual indicators at control and indicating equipment should be checked for correct operation;

e) all further checks and tests recommended by the manufacturer of the sound system equipment and other components of the system should be carried out; and

f) the following physical checks should be made:

- ensure that the amplifier ventilation holes are clear and no unauthorized articles are stacked on it;
- check mains leads, microphone leads and wiring (where accessible) for fraying, damage or incorrect location which could affect safety;
- for temporary or modified systems, clean any connectors that appear to be tarnished before they are inserted;
- clean dust and grime from the system equipment;

- check and remake as necessary all leads that are heavily used, to improve reliability, noting that leads with moulded plugs can fail with little or no warning, as their internal condition cannot be accurately assessed;
- the intelligibility should be checked to see that it meets the design minimum within the space; and
- the signal-to-noise ratio should be checked when all the electrical equipment normally used in the environment is functioning.

Following the work carried out above, any outstanding defects should be reported to the responsible person (see Clause **13**) and the system logbook should be completed.

Following repair or modification, the system should be recommissioned to the extent needed, all documentation should be brought up to date to reflect the new status, and a modification certificate should be issued. On successful completion of any remedial works, an inspection and servicing certificate should be issued.

12.3 Non-routine attention

12.3.1 Overview

The recommendations given in **12.1** and **12.2** are intended to maintain the system in operation under normal circumstances. However, from time to time, the sound system is likely to require non-routine attention, including special maintenance. Non-routine maintenance should include:

a) a special inspection of an existing sound system when a new organization takes over maintenance of the system;

b) repair of faults or damage;

c) modification to take account of extensions, alterations or changes in occupancy; and

d) inspection and test of the system following a user complaint.

12.3.2 Special inspection on appointment of a new maintenance organization

The following should be undertaken on appointment of a new maintenance organization:

a) for an existing system, a special inspection should be carried out and records should be studied in order to produce a plan for effective maintenance of the system;

b) if any of the following are found during the inspection, they should be reported to the responsible person and action taken to resolve them:

   - areas of non-coverage;
   - areas of unacceptable coverage or intelligibility; and
   - inadequate standards of electrical safety; and

c) if no logbook exists, a suitable logbook should be provided by the maintenance organization.

12.3.3 Documentation of repairs

All faults or damage should be recorded in the system logbook, and repairs should be carried out as soon as possible.

12.3.4 Modifications to the system

The following recommendations apply to all modification work:

a) responsibility for modification of a sound system should rest, ultimately, with a person who is conversant with this standard and the installed system, and has access to the as-fitted drawings;

NOTE This person may, for example, be the original designer, or may be a representative of the user or maintenance organization.

b) on completion of the modifications, all as-fitted drawings and other relevant system records should be updated as appropriate; and

c) on commissioning of the work and completion of the tests, a modification certificate (see Annex F) should be issued, confirming that the work has been carried out in accordance with the recommendations of this standard, or identifying any variations.

13 Responsible person

A single, named responsible person should be appointed to supervise all matters pertaining to the sound system. The responsible person should be given sufficient authority to carry out the duties described in this section and should normally be the keeper of the documentation. The responsible person should ensure that the sound system is checked at least once a week, or before each use if the sound system is used less frequently than once a week, to confirm that there are no faults on the system.

The responsible person should ensure that arrangements are in place for testing and maintenance of the system in accordance with the recommendations of this standard. The responsible person should ensure that the system logbook is kept up to date and is available for inspection by any authorized person.

The responsible person should ensure that authorized operators of the sound system are instructed in the proper use of the system. Particular care should be taken to ensure that operators are able to interpret fault indications and are adequately familiar with the appropriate controls and the circumstances in which these should, and should not, be used.

The responsible person should establish a liaison between those responsible for changes in, or maintenance of, the building fabric (including redecoration) to ensure that the work does not unnecessarily compromise the performance of the system or create system faults. If structural or occupancy changes occur or are planned, the responsible person should ensure that any necessary changes to the sound system are considered at an early stage.

When changes are made to the system, the responsible person should ensure that operating instructions and "as-fitted" drawings are updated.

The responsible person should ensure that any stock of spare parts agreed between the user and the organization responsible for the maintenance of the system is held within the premises.

Section 5: Operation and maintenance

14 System components: Application of standards

NOTE 1 The system components are microphones, amplifiers (including mixers), loudspeakers and dynamics processors. Detailed explanations, except for amplifiers, are given in Annexes B, C, D and G).

The manufacturer's specifications of all components of a sound system should be based on the provisions of the relevant Part of the IEC, CENELEC and British Standard Sound system equipment.

Table 3 explains the functions of the Parts of the IEC, CENELEC and British standard "Sound system equipment". Because the Parts of the underlying IEC standard have been revised at different times, during which CENELEC and BSI have changed their standards adoption policies and numbering systems, a key to the Parts is essential for good understanding.

NOTE 2 Dated references are not given, as they might change during the life of this publication.

Table 3 **Sound system equipment**

IEC Part reference IEC 60268	BSI reference	Title (all titles begin "Sound system equipment")	Function
1	BS 6840-1	Methods for specifying and measuring general characteristics used for equipment performance	Methods of measuring and specifying
2	BS 6840-2	Glossary of general terms and calculation methods	Reference material
3	BS EN 60268-3	Amplifiers	Methods of measuring and specifying
4	BS EN 60268-4	Microphones	Methods of measuring and specifying
5	BS EN 60268-5	Loudspeakers	Methods of measuring and specifying
6	BS 6840-6	Methods for measuring and specifying the characteristics of auxiliary passive elements	Methods of measuring and specifying (long out-of-date)
7	BS EN 60268-7	Headphones and earphones	Methods of measuring and specifying
8	BS 6840-8	Methods for specifying and measuring the characteristics of automatic gain control devices	Methods of measuring and specifying (long out-of-date)
9	BS 6840-9	Methods for specifying and measuring the characteristics of artificial reverberation, time delay and frequency shift equipment	Methods of measuring and specifying (long out-of-date)
10	BS 6840-10	Peak programme level meters	Methods of measuring and specifying, and performance requirements

Table 3 **Sound system equipment**

IEC Part reference IEC 60268	BSI reference	Title (all titles begin "Sound system equipment")	Function
11	BS 6840-11	Specification for application of connectors for the interconnection of sound system components	Application data (for consumer and "semi-pro" applications)
12	BS EN 60268-12	Application of connectors for broadcast and similar use	Application data
13	BS 6840-13	Listening tests on loudspeakers	Subjective testing (mainly applicable to cabinet loudspeakers)
14	BS 6840-14	Guide for circular and elliptical loudspeakers, outer frame diameters and mounting dimensions	Obsolete, to be withdrawn
15	—	BS EN 61938	Electrical interface values
16	BS EN 60268-16	Objective rating of speech intelligibility by speech transmission index	Methods of measuring and specifying
17	BS 6840-17	Methods for specifying and measuring the characteristics of standard volume indicators	Methods of measuring and specifying and performance requirements
18	BS 6840-18	Peak programme level meters. Guide for digital audio level meter	Methods of measuring and specifying, and performance requirements

Annex A (informative) Explanation of technical words and phrases

Discussions and communications regarding sound systems often involve the use of technical and quasi-technical words and phrases in addition to those defined in Clause **3**. They are therefore defined in this annex.

A.1 sound distribution system

sound system intended to distribute signals from one or more locations to a number of other locations through a multiplicity of loudspeakers

NOTE In these systems, the microphones are not normally exposed to the sound produced by the loudspeakers.

A.2 sound reproduction system

sound system intended for the reproduction in one (or a small number of) location(s) of sound signals generated in another location, usually through a small number of loudspeakers

NOTE In these systems, the microphones are not exposed to the sound produced by the loudspeakers.

A.3 voltage line principle

principle for designing and specifying audio amplifiers in terms of (maximum) output voltage and power and loudspeakers in terms of (maximum) input voltage and power, where the voltage is the same for all products and only the power varies

NOTE This has the following objectives:

a) to simplify the connection and matching of several loudspeakers to one amplifier;

b) to minimize power losses in cables;

c) to facilitate interchangeability; and

d) to provide a simple means of adjusting the sound level produced by an individual loudspeaker in a system, without incurring power losses and affecting the rest of the system.

A.4 100 V line system

sound system in which the amplifiers and loudspeakers are specified by the voltage line principle and the system voltage is 100 V

A.5 matching

correct coupling of a source to a load, for example a microphone to an amplifier, or an amplifier to a loudspeaker system

NOTE Formally, matching involves a condition of maximum power transfer from source to load, but the word is widely used informally for any condition that enables units to work together satisfactorily. A future edition of BS EN 61938 is expected to use the term "interoperability", which is not widely used in this context at present.

A.6 sound power level (L_w)

ten times the logarithm to base ten of the ratio of the sound power under consideration, W, to a reference sound power, W_{ref}

NOTE 1 The sound power level, L_w, expressed in decibels, is calculated as follows:

$$L_W = 10\lg\frac{W}{W_{ref}}$$

NOTE 2 The standard reference sound power, W_{ref}, is 10^{-12} W (1 pW).

A.7 long path delay

time interval between the generation of a sound and its perception at a distant point, due to the finite velocity of propagation of sound waves (approximately 340 $m \cdot s^{-1}$ in air at 20 °C)

A.8 confidence signal

response, audible to an announcer, which confirms that their speech is being delivered by the system

A.9 equalizer

equipment used in a sound system to adjust the overall frequency response, i.e. that of the total signal path including the room or space

NOTE The performance of a sound system can often be most effectively improved by the provision of appropriate equalization. The setting of an equalizer is, at least, semi-permanent, and is not intended change the "tone" of the system, or to compensate for deficiencies in input signals.

A.10 foldback

provision to a performer, by headphone or loudspeaker, of a signal selected to assist coordination with other performers or signals

A.11 functional surveillance

continuous automatic monitoring that audio equipment is functioning correctly

A.12 graphic equalizer

bank of band filters, each of whose loss or gain can be varied by means of a continuously variable control (usually a sliding control)

A.13 parametric equalizer

set of one or more filters in which the centre frequency, response shape and, sometimes, the symmetry of each filter can be adjusted in addition to its loss or gain

NOTE Adjustable band limiting filters may also be provided.

A.14 pre-set control

device for varying some characteristic of the equipment, the use of which is not required during the normal functioning of the equipment

NOTE 1 Such controls are used only for setting up the equipment and are usually arranged to be inaccessible to unauthorized persons

NOTE 2 "User pre-sets" can be adjusted by the user in accordance with the manufacturer's instructions. "Factory pre-sets", however, are intended to be adjusted only by the manufacturer or authorized service agents.

A.15 screened wiring

wiring in which the insulated conductor or conductors are enclosed within a continuous electrically conducting screen

A.16 user control

device usually operated manually, for varying some characteristic that might require adjustment or selecting a particular programmable configuration during the normal functioning of the equipment

Annex B (informative) Loudspeakers and associated system components

B.1 Loudspeakers

B.1.1 General

It is essential for successful sound system design that the right type of loudspeaker is chosen. A good choice takes into account not only the characteristics of the loudspeaker (sensitivity, maximum sound pressure level, axial and directional frequency responses and directivity index), but also the acoustic characteristics of the environment in which it is to be used.

The choice of loudspeakers is influenced by the following:

a) functional requirements relating to the required sound pressure level and the programme content, for example speech only, or music with extended bass;

b) operational requirements relating to the use to which the system is to be put, for example hotel paging system, performance system or emergency evacuation system;

c) architectural constraints relating to the acoustics of the space and any limitation it imposes on the system, for example extended reverberation time, presence of echoes, curved surfaces and aesthetic conditions; and

d) environmental conditions relating to any matter which would affect the operation or performance requirements of the loudspeaker, for example high noise levels, high temperature and humidity, atmospheric pollution and hazardous conditions.

A shortlist of relevant characteristics and references to standard methods of measurement is therefore given in **B.2.3**, and manufacturers are encouraged to provide at least this minimum of reliable data.

B.1.2 Characterization of loudspeakers

Loudspeakers can be characterized by the following:

a) directionality;

b) sensitivity;

c) frequency response;

d) power handling;

e) impedance;

f) distortion; and

g) size.

There can be no rules with regard to the selection of the loudspeaker as there might be a large number of factors to be considered. The following are, however, some basic guidelines.

As the reverberation time of the space increases, the loudspeaker is generally required to be more directional, so as to reduce the acoustic power radiated into the reverberant space.

If high ambient noise levels are encountered or if high sound levels are required, then the loudspeakers need to be more directional, more sensitive and more powerful. This inevitably means a larger loudspeaker.

If improved system quality is required, this implies wider, flatter frequency response and lower distortion. This generally necessitates a reduction in sensitivity.

The directional properties of most types of loudspeaker are very much a function of frequency, and this is important for comparisons between different products. The variation in directionality is also important at the design stage. Loudspeakers can be divided into eight types, with different directional characteristics:

1) "constant-directivity" devices, normally large horns;
2) column devices relying on wave interference for their means of operation, which means that their directional properties can be very frequency dependent;
3) re-entrant or folded-horn devices which are directional but where directionality is frequency dependent;
4) straight, circular or rectangular horn devices;
5) bi-directional devices, based on the use of the radiation from both sides of a diaphragm or a pair of diaphragms;

   NOTE 1 Such devices may be of the horn-loaded or direct-radiator types.

6) cabinet loudspeakers, which have an identifiable "front", and radiate middle and high frequencies mainly into the front hemisphere;
7) omnidirectional loudspeakers that usually employ a circular cone drive unit with its axis vertical; for example, ceiling loudspeakers; and

   NOTE 2 Although described as "omnidirectional", the directional response in the vertical plane is often more nearly a hemisphere, although more truly omnidirectional devices are available.

8) resonant pipe enclosures.

B.1.3 Types of loudspeaker and their uses

B.1.3.1 Cabinet loudspeakers

The term "cabinet loudspeaker" refers to one or more moving-coil direct radiator units mounted in an enclosure. Small types are used for low-level sound reinforcement or distribution. Larger types that may incorporate horn-loaded midrange and/or high-frequency units are used for music reproduction, for example, in nightclubs, and in other high-level systems in small auditoria. Another variant is the "bass bin", which, as the name implies, contains one or more large direct radiator units designed for low-frequency reproduction only, the higher frequencies being supplied by other, often horn-loaded, radiators.

Small cabinet loudspeakers are suitable for music, speech, and paging systems in areas where the floor-to-ceiling height is typically 4 m or less. The useful coverage is normally restricted to a cone of 60° to 90° apex angle.

B.1.3.2 Ceiling loudspeakers

Ceiling loudspeakers consist of a moving-coil direct radiator unit (preferably mounted in a closed-back enclosure) designed for mounting in a ceiling. A device may be incorporated which is intended to widen the directional response pattern. This is a particularly important characteristic at high frequencies (above 3 kHz), in determining the number of loudspeakers required to cover an area evenly with good intelligibility. The use of ceiling loudspeakers with open-backed enclosures is often unsatisfactory, due to the excitation of reverberation in the ceiling void. Some of the available ceiling loudspeakers are unsatisfactory in other ways, for example, frequency response. These loudspeakers are used for low-level sound reinforcement or distribution.

Recessed ceiling loudspeakers may be used in areas with ceiling heights up to 5 m to 6 m. The coverage from a ceiling-mounted loudspeaker is generally less than that from a wall-mounted cabinet, because the throw is limited by the ceiling height. When calculating the area covered by a ceiling loudspeaker, the height of the listener’s ears above floor level is an important parameter. A high-density ceiling loudspeaker installation can form the basis of a high quality sound reinforcement system with very uniform coverage. When designing a high quality sound reinforcement system, the coverage angle at 4 kHz is used; typically, this is 60° for a 200 mm cone loudspeaker.

B.1.3.3 Column or “line-source” loudspeakers

Column or line-source loudspeakers consist of a series of moving-coil direct radiator units arranged in a linear array in an enclosure. There may be a complementary array of high-frequency units in the same enclosure. The rear of the enclosure may be rigid, or may consist of a porous structure acting as an acoustic phase-shift network, tending to minimize the amount of rear radiation. Such an array, set up with the long axis vertical, can have a broad directional response pattern 90° to 120° apex angle in the horizontal plane and a narrow pattern 15° to 20° apex angle in the vertical plane. However, designing to achieve these characteristics is not simple, and many examples fall short of expectations. Nevertheless, column loudspeakers can provide an economical solution for low- and high-level systems in auditoria, and outdoors if naturalness of reproduction is required without high sound pressure levels. It is also possible to use the line-source principle with horn-loaded compression driver units. Such assemblies can provide very high sound pressure levels over a wide area hundreds of metres from the source.

It is important to orient the column loudspeakers correctly so that the beams of sound produced are directed at the listeners. Column loudspeakers ought not usually to be mounted flat against a wall, but provided with suitable angle brackets allowing correct alignment.

By directing the axis of each column loudspeaker towards the centre of the area to be covered, a fairly uniform coverage is obtained as the nearer listeners are located out of the main beam of sound which extends towards the rear of the area. When using repeater columns, for example, in long churches, the repeater units can be located within 12 m to 15 m of the primary or any other supplementary loudspeakers, unless signal delay lines are employed.

B.1.3.4 Straight, circular or rectangular exponential horns

The loudspeaker consists of a moving-coil compression driver (or more than one) attached to a horn flare of circular cross section, which might transform to rectangular towards the mouth. This type is capable of high sensitivity and high sound pressure levels, but unless very large has limited low-frequency response. The high-frequency response is also somewhat uneven and restricted, but this is usually tolerable. The directional pattern is narrow, but depends strongly on frequency. At high sound pressure levels, amplitude non-linearity is usually evident, but can be prevented from compromising intelligibility by good design and attention to the spectral distribution (frequency response) of the applied signal. Straight horns are typically used for high-level sound reinforcement and distribution outdoors. Derivative types also exist, such as units equipped with two horns facing in opposite directions, which are used where this bi-directional distribution is thought to be required, for example, on railway station platforms. Another derivative type has a basically square mouth divided into two rows of more or less square sections, and the name “multicellular” is applied to this as well as to the rather different types described in **B.1.3.7** and **B.1.3.8**.

B.1.3.5 Constant-directivity (CD) horns

The loudspeaker employs one or more compression drivers connected to horns of arcane shape, which are claimed to give exceptionally wide and/or frequency invariant directional response patterns. In some designs, the angles of distribution in orthogonal planes may differ, so that the product may be specified for example as a “90° × 40° CD horn”. They are used in high-level systems, both indoors and out.

CD horns are becoming increasingly popular in high quality sound systems applications, or where high sound pressure levels are required. Their many advantages over re-entrant or other horn types include the following.

a) They are extremely sensitive, typically exhibiting a 1 W/1 m sensitivity of around 113 dB SPL for a 60° × 40° horn.

b) They can provide extremely uniform coverage as they exhibit a reasonably constant directivity with frequency, for example within ±10° over their operational range of 500 Hz to 16 kHz plus, for a well-designed large-format device.

c) They exhibit considerably lower distortion characteristics than a re-entrant horn.

d) They provide a very much smoother and uniform frequency response. CD horns may be used for high quality sound systems in theatres and concert halls, as well as large stadia or reverberant exhibition halls. A CD horn usually operates over the range 500 Hz to 15 kHz plus (or from 800 Hz for the small types). An associated low-frequency loudspeaker is therefore required to form a complete system operating from well below 100 Hz, for example 50 Hz, to over 15 kHz. A crossover unit is therefore employed to block low frequencies being fed to the horn and high frequencies to the bass driver. The crossover may either be active or passive, depending on the particular application and system configuration desired.

e) The controlled dispersion of a CD horn ensures that high-frequency beaming and “hot spots” do not occur, but instead a uniform distribution of sound is created at all frequencies within the working range of the horn. The controlled radiation of the CD horn also enables it to work well in acoustically difficult and reverberant spaces, allowing the sound to be directed onto the absorbing audience or congregation and away from the reflective room surfaces.

B.1.3.6 Concentric folded or "re-entrant" horns

The inconvenient length of a straight exponential horn is reduced by "folding" the axis. This results in a loss of bandwidth and uniformity of frequency response and, often, an increase in amplitude non-linearity which is important at the design stage. Even so, such products can be very effective, especially for systems mounted on vehicles, and can also be used for speech-only reinforcement and distribution in noisy situations both indoors and outdoors. They are often used for emergency sound systems. Extreme restriction of the spectral distribution of the applied signal, so as to follow broadly the measured frequency response of the loudspeaker, is very advantageous in reducing distortion and making best use of the output capability of the amplifier.

NOTE Restriction of the frequency response, as described above, is intended to prevent damage to the loudspeakers. Equalization to widen the system bandwidth is thus not appropriate. However, equalization within the effective frequency range of the loudspeakers can be employed with advantage, in order to combat irregularities in the frequency response.

Re-entrant horn loudspeakers have a restricted frequency response and are used mainly for speech. They are more efficient than either the cabinet or column loudspeaker and are therefore suitable for use in areas with high background noise levels, large enclosed areas, and outdoors. The coverage angles of horn loudspeakers vary considerably but typically are between 40° and 80°.

B.1.3.7 Radial horns

A radial horn loudspeaker has the moving-coil driver(s) attached to a horn flare which is of constant dimension in one direction, but flares in the perpendicular direction. Various advantages, which include ease of manufacture, are claimed for this principle, and such units are typically used in high level reinforcement and distribution systems. The directional response pattern in the plane perpendicular to the parallel faces of the horn flare tends to be broad, but might degenerate into several narrow lobes at high frequencies, due to wave interference effects across the mouth of the horn. This effect can be reduced by dividing the mouth into a number of sections.

B.1.3.8 Multicellular horns

In most cases, and particularly in describing American products, the term "multicellular horn" is applied to horns that have a rectangular mouth aperture of large aspect ratio, divided into two or more "cells" by partitions. Claims are made for the width and uniformity of the directional response pattern of these devices, which are used in high-level systems.

B.1.3.9 Folded horn cabinets

Folded horn cabinets are distinguished from the more modest (and less costly) cabinet type described in **B.1.3.1**. They consist of one or more horn-loaded drivers mounted in an enclosure. The low-frequency driver is horn-loaded by structures forming part of the enclosure (designs differing widely in detail), while mid-range and high-frequency drivers are provided with discrete or integral horn flares. Such systems are used for very high level reinforcement in large auditoria and stadia, and have higher sensitivities than direct-radiator types.

Both two-way and three-way designs are available in a range of sizes, power handling capabilities, frequency ranges, and dispersion patterns. Power ratings range from around 100 W to 400 W. Some models employ dedicated control units, which may incorporate equalization filters, crossover networks and signal limiters to avoid potential loudspeaker overloads.

These loudspeakers may either be portable, transportable or permanently installed. Weather-resistant models are also available for outdoor use. The loudspeakers may be used in almost any high-quality sound system for both speech and music purposes, where highly uniform or directional control across a wide frequency range, for example from 500 Hz upwards, is not required. They therefore find application in clubs, discotheques, theatres, auditoria, assembly halls and leisure centres. Care is needed, however, when employing them in reverberant spaces, for example, concert halls. Their directional characteristics generally make them less suitable for use in highly reverberant spaces, unless located close to the listener or arrayed to provide additional directional control.

B.1.3.10 Resonant pipe enclosures

Resonant pipe enclosures have recently enjoyed some popularity. A large drive unit is mounted approximately one-third the way along a circular tube. Such a device can offer high sensitivity and high sound pressure levels over a restricted range of low frequencies, provided that the drive conditions are carefully adjusted. The manufacturer normally provides full information on this. Such products are used in large auditoria and stadia.

B.1.3.11 Bi-directional enclosures and horns

Bi-directional and wedge loudspeakers may either be directly mounted on a wall or ceiling or suspended below a high ceiling by a chain or wire. The loudspeaker produces two cones of sound (60° to 90°). A dead spot, where the sound pressure level is very low at some frequencies, can occur directly under the loudspeaker.

B.1.3.12 Loudspeakers with digitally-controllable characteristics

Loudspeakers with digitally-controllable characteristics allow system performances to be achieved that are impossible or impracticable otherwise. Most manufacturers provide comprehensive documentation and technical support for the use of their products.

B.1.4 Performance

Objective measurements, in accordance with BS EN 60268-5, of loudspeakers are of irreplaceable value, but have limitations. The evaluation of results requires special knowledge and experience in order to determine their subjective significance. Measurement of large enclosures and horns in an anechoic chamber might be impracticable due to the limited number of very large chambers and the high cost of using them. Open air measurements are more practicable than is generally realized.

Major irregularities in the frequency response characteristics, both on axis and off axis, ought not to be accepted. Large variations of the input impedance as a function of frequency ought not to be accepted, especially reductions below the rated value, since these increase line losses and can affect the system frequency response.

It is essential that objective measurements of loudspeakers are supplemented by listening tests, under as near practical operating conditions as possible. The relative importance of naturalness, intelligibility, high sound pressure level and high sensitivity vary with the application, and positive decisions on these are best made before the tests are conducted, so as to provide a firm base for the measurements. Loudspeakers are affected by the acoustic environment and peaks in their response, coupled with the room acoustic characteristics, can cause acoustic feedback in sound reinforcement systems.

B.2 Loudspeaker volume controls and override circuits

B.2.1 Volume controls

It is often convenient or necessary to be able to control locally the sound level produced by one or a group of loudspeakers. This technique, however, might make the system difficult to operate, and the volume controls might be adjusted by unauthorized persons. In particular, it is important that a volume control is not sited where a person adjusting it cannot properly hear the loudspeaker(s) it controls.

There are two main types of loudspeaker volume controls, resistive and transformer. Resistive types can further be divided into continuously-variable and switched types. The use of a simple variable series resistor is not recommended, because this might lead to noticeable distortion at low volume levels.

A continuously-variable resistive control may be a simple potentiometer (of adequate power rating) or a special type with two resistive elements, forming a variable L-network. Such controls result in some power loss and some impedance mismatching, which could result in changes in frequency response. This is most noticeable with loudspeakers having large magnet systems and two-way (woofer/tweeter) and multi-way systems having simple dividing (crossover) networks. If used with loudspeakers having inexpensive magnet systems, an increase in distortion might occur at low volume levels. This effect is due to non-linearity of the driver system and can be reduced by adding a fixed resistor so as to prevent the volume being reduced too far, and adding a switch to the control if it is required to be able to silence the loudspeaker(s). In addition, or as an alternative, measures can be taken to reduce the level of signals below the main (bass) resonance frequency of the loudspeaker, which produce little useful sound output.

The resistance of the potentiometer is typically four times the rated impedance of the loudspeaker reflected through the line transformer if the attenuator is in the primary circuit. This gives a power loss of just under 1 dB at maximum setting, and a maximum source resistance (at 6 dB attenuation) equal to the rated impedance. The effects of this value of source resistance on distortion are usually negligible, but changes in the frequency response of multi-way systems can be very significant, in which case a transformer-type control might be used.

Switched resistive controls can be based on the same circuit configurations as continuously-variable controls, but it is also possible to use more complex configurations which cause less power loss and less impedance mismatching. Switched controls ought normally to have steps of approximately 3 dB (2:1 power ratio); smaller steps have little audible effect.

Transformer controls may employ a tapped autotransformer or line transformer. In the latter case, greater efficiency and reduced safety concerns arise if the secondary winding is tapped. While generally larger and more expensive than resistive controls, transformer controls give less power loss and better impedance matching, with less chance of distortion at low volume levels.

B.2.2 Override circuits

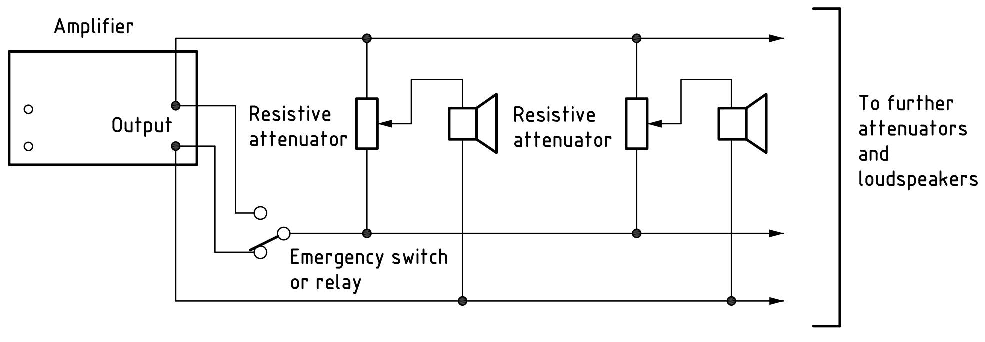
Where local volume controls are provided, it might be necessary to be able to override these from a remote point. This is often achieved by providing each volume control with a relay which switches the attenuation to a lower value or to minimum.

It is recommended that such systems use a fail-safe mode of operation, whereby the presence of a control current is necessary for the volume control to function. In this way, failure of the control voltage disables the volume controls (see Figure B.1). In order to reduce the standing current required to energize the relays, the control voltage may be applied through a parallel resistor-capacitor circuit, so designed that a large current is available to pull the relay in, while a smaller current, sufficient to hold the relay, flows continuously. With suitable relays, a reduction of standing current to 25% of pull-in current is possible. This technique may be applied individually to each relay, or to groups, or to all of them.

The relay power supply is normally tolerant of brief short-circuits (such as might happen during maintenance), and the technique mentioned earlier can help to achieve this. The continuous short-circuit current is limited, for conformity with safety standards, to a value which does not damage the power supply or cables. Failure of the power supply normally causes an indication at the control point.

Another technique which may be employed is a three-conductor system, in which the earthy ends of the volume controls (of the resistive type, but the technique is not applicable to volume controls using auto-transformers or tapped line transformers) are all connected to a return conductor separate from that to which the earthy ends of the loudspeaker voice-coils or the line transformer primary windings are connected. The separate return conductor is then connected to the earthy output terminal of the amplifier via the contacts of a switch, or the normally-open contacts of a single relay which is de-energized in the "override" mode. Each loudspeaker is thus connected in series with part of the volume control, and does not operate at true full volume. An improvement may be obtained if, instead of simply disconnecting the volume control return line from the amplifier earthy output terminal, it is connected instead, by means of a changeover switch, or contact set on the relay, to the live output terminal. This reduces the resistance in series with each loudspeaker, but cannot eliminate it completely. The use of attenuators of less than four times the (reflected) resistance of the loudspeakers entails greater power loss but reduces the residual series resistance.

Figure B.1 **Diagram showing the floating-return technique for disabling local loudspeaker attenuators in an emergency**



B.2.3 Characteristics in loudspeaker specifications, and methods of measurement

A comprehensive list of characteristics to be specified is included in BS EN 60268-5, and may sometimes be considered too long for convenience. The following extracted list is expected to be short enough for all manufacturers to use for all products. The order in which the characteristics are listed is that of perceived interest to the prospective purchaser, rather than that of the list in BS EN 60268-5. BS EN 60268-5 recommends that input voltages rather than input powers are specified. This is because the values of power quoted are purely notional, being related to the rated rather than the actual impedance, and this convention leads to abuses and complications which are causing increasing difficulty. For a transition period of several years, it is necessary to include both specifications, until the use of voltage values is sufficiently widely accepted.

The list of characteristics and methods of measurement to be included is as follows:

a) marking of terminals and controls (see BS 6840-2);

b) reference plane, reference point and reference axis (see BS EN 60268-5:2003+A1:2009, Clause **15**);

c) rated impedance (see BS EN 60268-5:2003+A1:2009, **16.1**);

d) for electrodynamic drive units only, total Q-factor, Q_t (see BS EN 60268-5:2003+A1:2009, **16.3**), equivalent air volume of a loudspeaker drive unit compliance, V_{as} (see BS EN 60268-5:2003+A1:2009, **16.4**), resonance frequency, f_r (see BS EN 60268-5:2003+A1:2009, **19.2**), and design data (see BS EN 60268-5:2003+A1:2009, Clause **28**);

   NOTE 1 The first three values in item d) are often known as the "Thiele-Small characteristics". While of greater importance for low-frequency drive units, their specification can also assist the design of filter networks for high-frequency drive units.

e) rated noise voltage or power (see BS EN 60268-5:2003+A1:2009, Clause **18**);

   NOTE 2 The rated noise power used to be called "power handling capacity".

f) characteristic sensitivity in a stated frequency band (see BS EN 60268-5:2003+A1:2009, **20.3**);

g) frequency response (curve) (see BS EN 60268-5:2003+A1:2009, **21.1**);

h) effective frequency range (see BS EN 60268-5:2003+A1:2009, **21.2**);

   *NOTE 3 This is not the same as the rated frequency range (see BS EN 60268-5+A1:2009, **19.1**), which is an arbitrary choice of the manufacturer, including the effect of any specified filter circuit.*

i) directional response patterns, for at least three frequencies within the effective frequency range, one near the lower bound, one central and one near the upper bound of the range (see BS EN 60268-5:2003+A1:2009, **23.1**);

j) directivity index (ratio) (see BS EN 60268-5:2003+A1:2009, **23.3**);

k) coverage angle (see BS EN 60268-5:2003+A1:2009, **23.4**);

l) rated ambient conditions (see BS EN 60268-5:2003+A1:2009, Clause **25**); and

m) physical characteristics covering dimensions, weight, and connector and cable data (see BS EN 60268-5:2003+A1:2009, Clause **27**).

Annex C (informative) Types of microphones

C.1 General

Numerous microphone types and characteristics are available. They may be classed by their directional response, type of generating element and physical characteristics. If a microphone is placed very close to a loud source of sound, it might be necessary to include an attenuator between the microphone and the pre-amplifier, in order to prevent the latter being overloaded. Such attenuators need careful design to preserve the correct impedances and circuit balance.

C.2 Directional responses

Microphones of the following types are available.

a) Omnidirectional microphones pick up sound equally from all directions, and are thus not suitable when discrimination is required against either reverberant sound pick-up, unwanted sound or noise pick-up.

b) Directional microphones do not pick up sound equally from all directions. They may therefore be used in situations where it is desirable or necessary to discriminate against sounds arriving from a particular direction or to reduce reverberant sound pick-up.

NOTE 1 Directional microphones normally give the best results. Selection and installation of highly directional microphones require considerable skill and experience in order to achieve consistent loudness, unless the signal levels are continuously monitored and adjusted. However, where a microphone has to be located at a distance from the source (on a balcony front in a theatre for example) a highly directional microphone might be required in order to achieve adequate intelligibility.

NOTE 2 Although the term "unidirectional" is used in describing microphones, no practicable microphone can really be described in this way, over the whole audio frequency range.

Idealized directional responses of omnidirectional microphones and a selection of directional microphones are shown in Figure C.1 to Figure C.7. The properties of the hypercardioid and supercardioid responses are given in Figure C.8.

C.3 Type of generating element

The two most widely used types of microphone element are the dynamic (moving coil) and the electret. Dynamic microphones are generally extremely robust and offer a wide range of performance characteristics which are little influenced by temperature and humidity, making them potentially suitable for both indoor and outdoor use.

NOTE Good quality moving coil microphones offer a wide frequency response, but this may be deliberately tailored to a particular characteristic to aid intelligibility, for example by applying low-frequency cut-off.

Electret microphones are capable of providing a very smooth and extended frequency response at a higher output level than the dynamic type. They need to have their own external power supply to operate and are generally not as robust as the dynamic microphone, but their higher sensitivity enables very small electret capsules to be made that can be employed in a number of special types of microphone. Some models have an internal battery, but these are best avoided in professional installations due to their continual maintenance requirements. They are, however, very convenient for portable use.

C.4 Physical characteristics

Lavalier microphones are small, usually dynamic, with an omnidirectional response, designed for speech pick-up from lecturers, etc., and are fitted with a neck cord, to be worn by the person speaking. Tie-clip microphones are small and lightweight, usually electret, and may be clipped to the clothing of the person speaking by a clip or lapel badge.

NOTE 1 These are generally omnidirectional but directional types are available.

Boundary-layer (pressure zone) microphones are based on a small, usually electret, capsule fitted onto a special mounting plate. They are most useful for recording purposes or sound pick-up of more than one person. The form and mounting arrangement can substantially reduce the reverberant sound pick-up of conventional microphones.

Noise-cancelling microphones are used in high-noise environments. These microphones are highly insensitive to indirect sound pick-up and need a close speaking distance.

NOTE 2 Generally, the frequency response is limited, and optimized for speech.

Radio microphones may be in the form of either a small tie-clip and pocket transmitter or an all-in-one, hand-held or stand-mounted unit. They need a separate receiver unit tuned to the microphone transmission frequency, but allow freedom of movement. They are not suitable for use where a secure transmission is required.

Figure C.1 **Horizontal directional response of an omnidirectional microphone with its axis vertical: decibel scale**

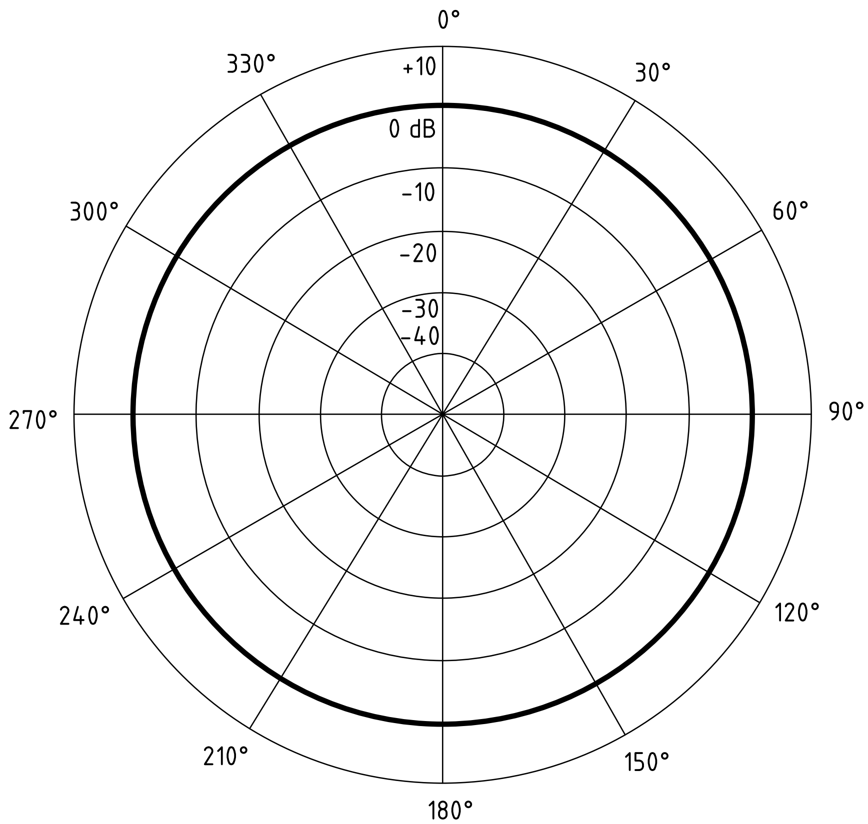


Figure C.2 **Directional response of a cardioid microphone: decibel scale**

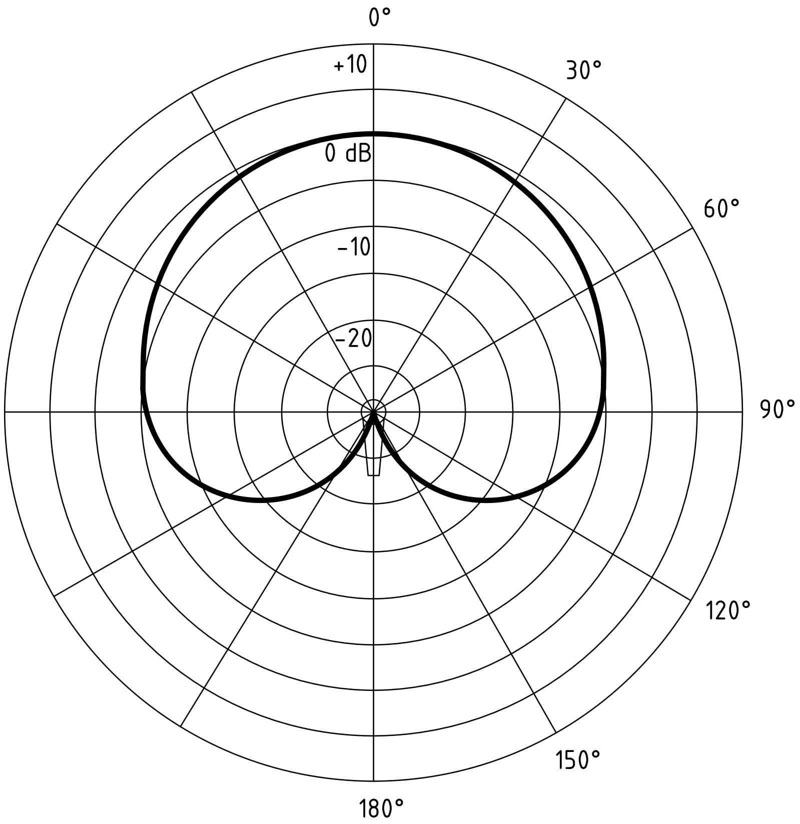


Figure C.3 **Directional response of a supercardioid microphone: decibel scale**

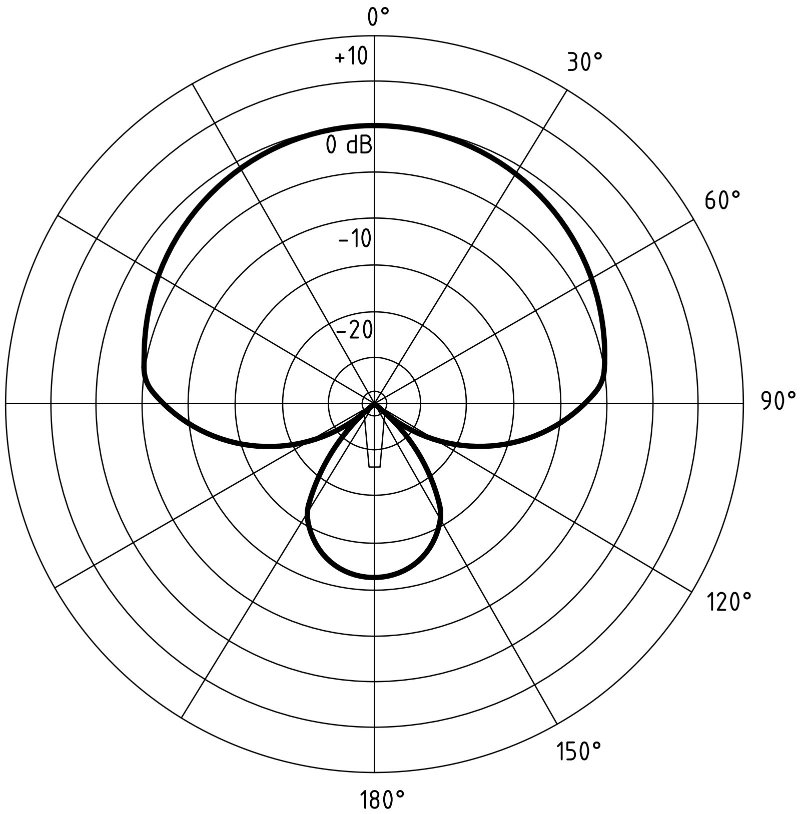


Figure C.4 **Directional response of a hypercardioid microphone: decibel scale**

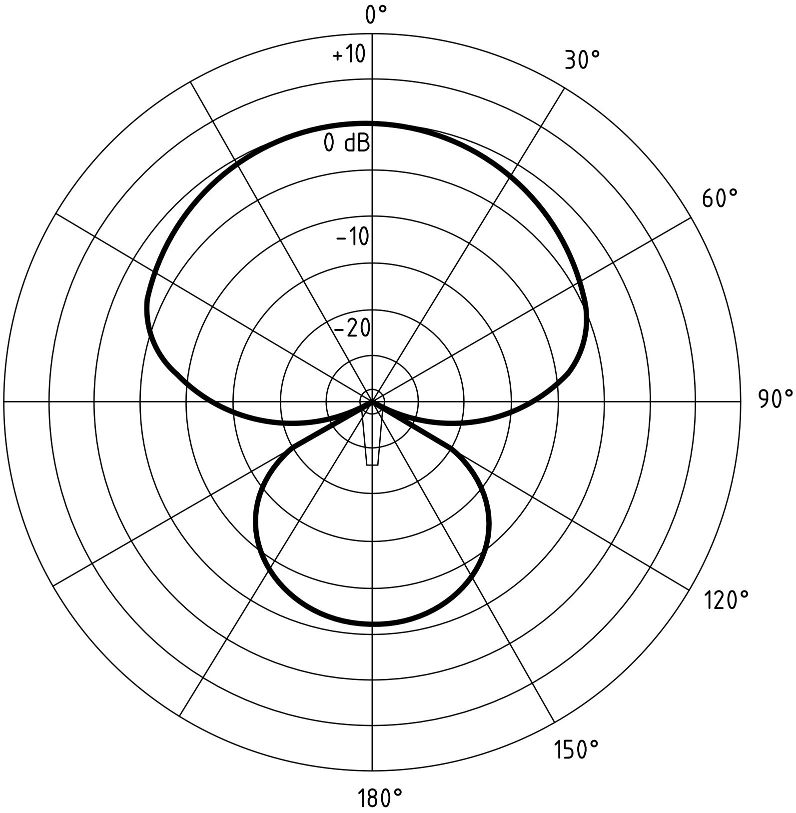
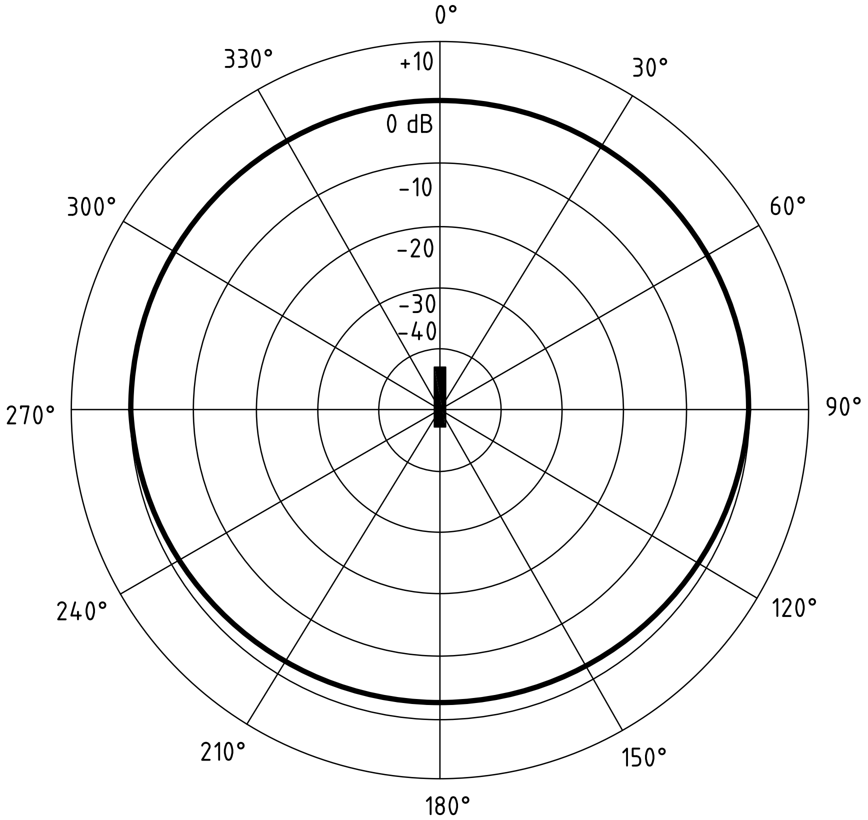


Figure C.5 **Directional response of a highly directional shotgun (rifle) microphone where *f* = 250 Hz and barrel length is 275 mm**



NOTE Some microphones of this type have an approximately cardioid response (see Figure C.8) at low frequencies.

Figure C.6 **Directional response of a highly directional shotgun (rifle) microphone where *f* = 2.5 kHz and barrel length is 275 mm**

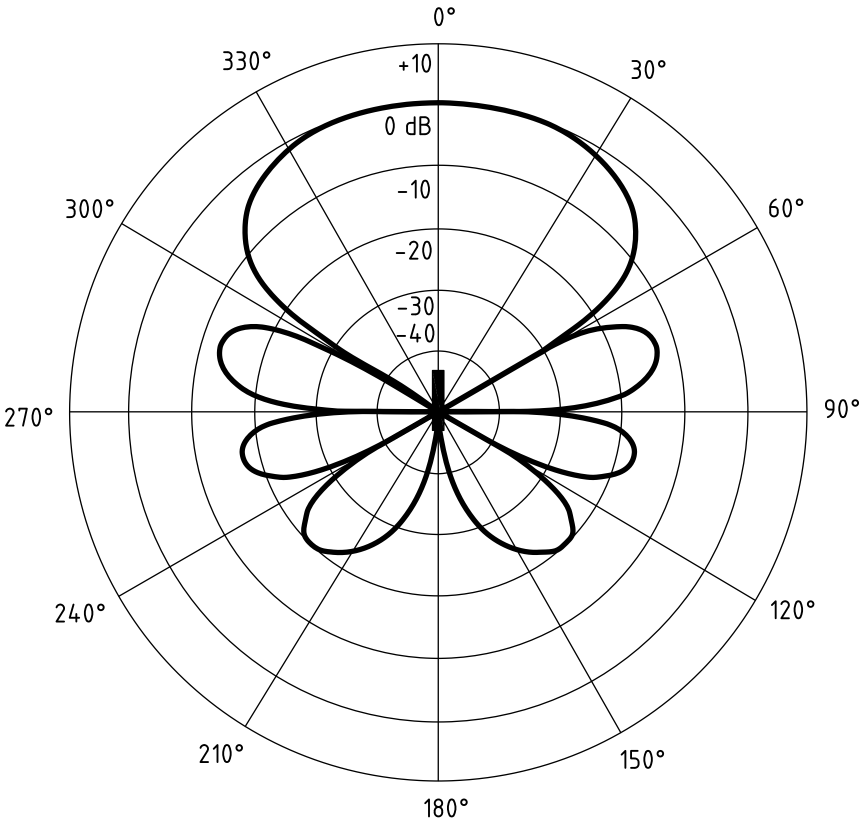


Figure C.7 **Directional response of a highly directional shotgun (rifle) microphone where *f* = 10 kHz and barrel length is 275 mm**

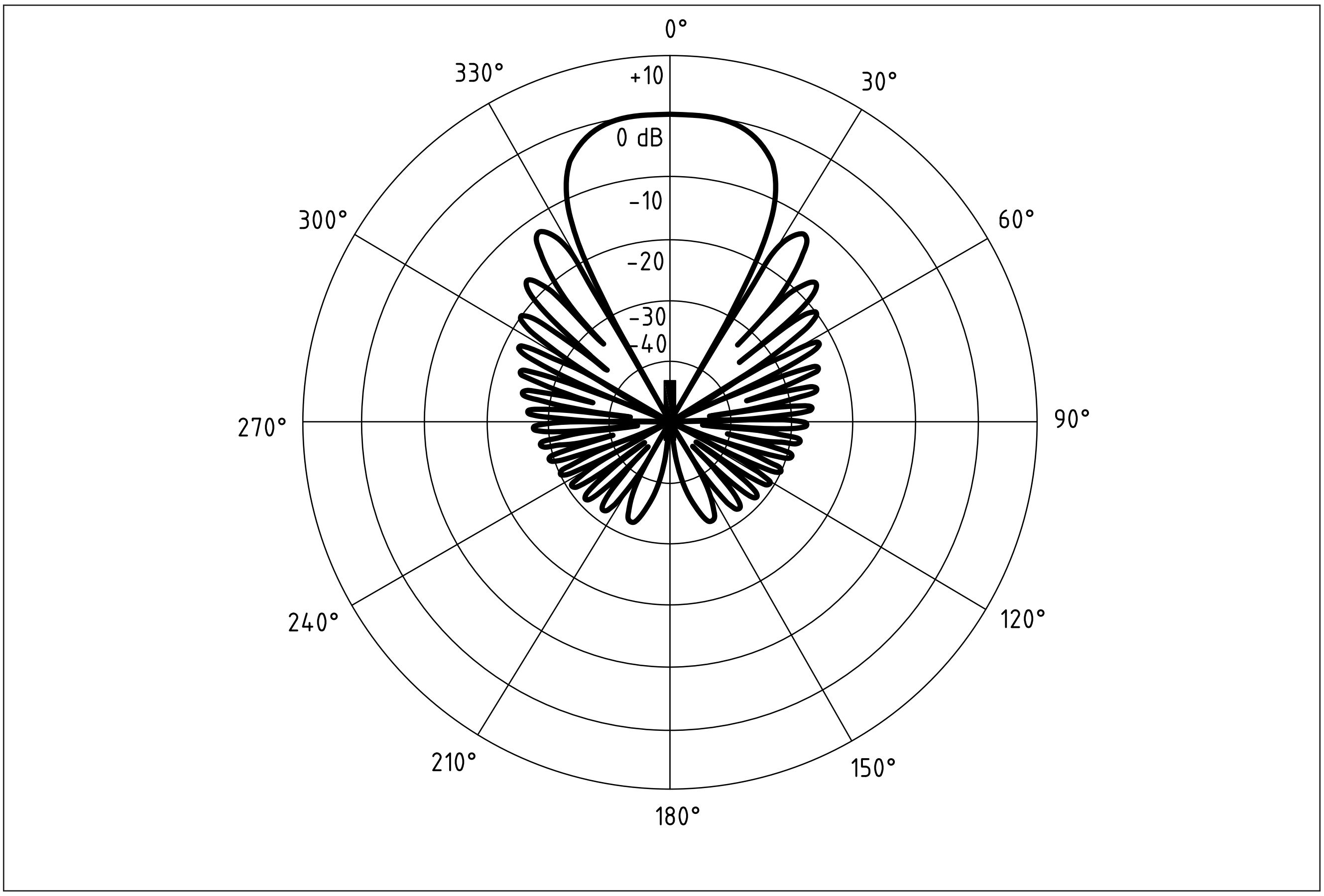
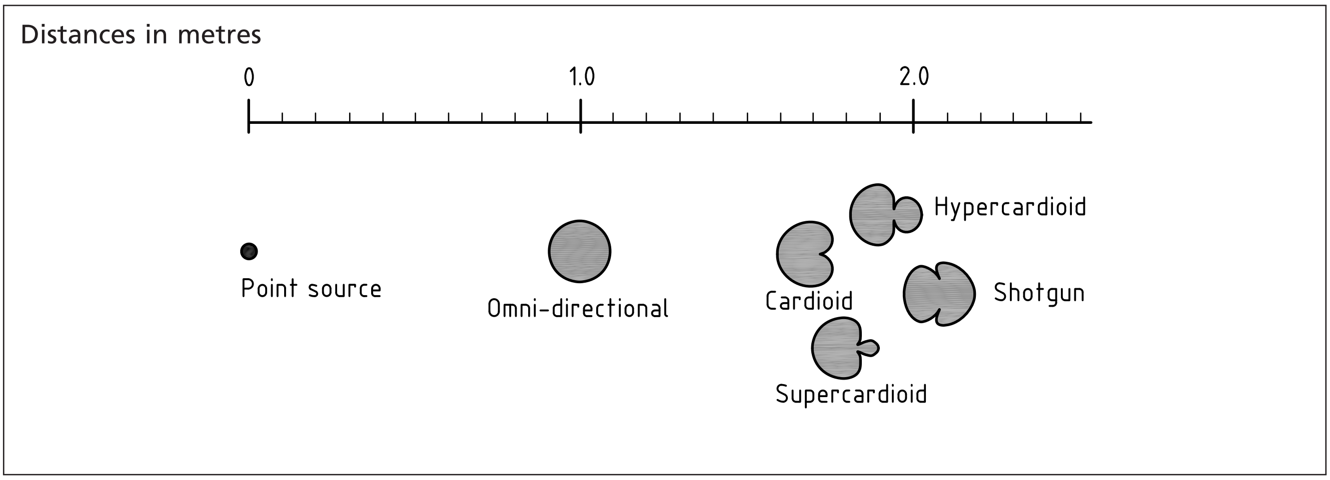


Figure C.8 **Relative operating distances of directional microphones for equal direct-to-reverberant signal ratios**



Annex D (normative) Use and siting of microphones

D.1 Distance between the microphone and the source of sound

When a directional microphone is used very close to the sound source, be that an orator or a singer, there is a bass frequency increase (proximity effect) which might or might not be desirable. Close talking or singing into a microphone increases the chances of the explosive phona (such as "P"s or "S"s), producing a popping effect. Careful choice of microphone can help in reducing the adverse effect and a certain amount of equalization might also be beneficial and specific to each user. A trained operator is usually needed under such circumstances if a poor or mediocre result is to be avoided.

It is not possible to give numerical design procedures for determining the maximum permissible distance between a microphone and the wanted source of sound. Two primary factors should be jointly taken into account, i.e. general noise and room reverberation.

The further a microphone is located away from the sound source, the weaker the wanted signal becomes. This effectively reduces the signal-to-noise ratio and also reduces the direct-to-reverberant sound pressure level ratio. In order to maintain an acceptable direct-to-reverberant signal ratio, the maximum microphone distance should be limited to approximately 6 m to 10 m, even in quiet auditoria with trained speakers and assuming a microphone having a cardioid directional response. The use of a highly directional "shotgun" microphone can extend the range up to 15 m for sound effects only. The effects of reverberation, however, are additive to noise, and tend to reduce the distance still further. For effective speech intelligibility, a direct-to-reverberant ratio of greater than 0 dB is necessary. For hearing impaired listeners, a direct-to-reverberant sound pressure level ratio of at least +4 dB to +6 dB is usually required, but this is highly dependent upon a number of factors, including size, shape, volume and reverberation time of the room, and the characteristics of any reflecting surfaces. In all cases the microphone should be located as close as possible to the wanted sound source.

NOTE 1 For example in an auditorium with a volume of 3 000 m^3 and a reverberation time of 1.5 s, the maximum acceptable distance with two cardioid microphones operating may be as little as 4 m to 5 m.

In other cases, and especially where the room configuration changes, one or more microphones should be provided together with a mixer or mixing amplifier, specifically for the sound system. Such microphones should be chosen and sited with a view to obtaining as much direct sound from the original sources as possible, and a uniform loudness balance if there are several sources. Adjacent microphones should not be closer together than three times the distance between the source of sound and the closest microphone. Where the talker position is predictable, the microphone should be securely fixed and maintained in position.

To avoid introducing audibly delayed signals, the difference in path lengths between any source and the two nearest active microphones should not exceed 5 m for music or 8 m for speech. Adjacent microphones should not be closer together than three times the distance between the microphone and the source of sound.

Inexpensive microphones, such as those intended for household use, should not be used. Except for tie-clip, lavalier, and wireless microphones, those requiring batteries should not be used, because of the inconvenience of replacing them. Where questions or comments from an audience are to be relayed via the sound system, highly directional microphones can be used. These should be positioned so that in spite of the very restricted coverage provided by each microphone, uniform pick-up from all audience positions is achieved. A separate pre-amplification channel should be used for each of these microphones, and an operator should control the channel gains when the microphones are in use.

Microphones should be located so as to have a clear "view" of the source they are intended to cover, and should be located away from air conditioning grilles, fans, strong air currents or other potential sources of acoustic noise pick-up, for example fluorescent or theatre lighting, and video projectors.

NOTE 2 The use of appropriate equalization on an individual microphone channel can considerably help to reduce unwanted room effects and low-frequency acoustic noise transmission.

D.2 Use of several microphones

Microphones that are not directly picking up the wanted signal should be switched off.

NOTE 1 The fewer the number of microphones in operation at any one time the better the clarity and intelligibility of the wanted signal becomes. Microphone mixers and pre-amplifiers that include voice switching or noise gating are extremely useful when more than one or two microphones are needed and a trained operator is not available.

NOTE 2 In small to medium-sized meeting rooms, a boundary-layer microphone located centrally on the meeting table or on the ceiling immediately above it can often prove more effective than four or five simultaneously operating cardioid table microphones, as a more uniform and less "coloured" sound pick-up is possible. However, the maximum distance over which such a device operates effectively is likely to be less than approximately 3 m from the talker.

At larger distances than 3 m, use of a greater number of local microphones should be considered to improve the direct-to-reverberant sound-pressure level ratio, with the absolute minimum number of microphones being in operation at any given time.

The direct-to-reverberant sound pressure level ratio, *K,* should be calculated from the following equation, if only a single microphone is used:

$$K = 10\lg\left[\frac{QV}{314D^2(RT)}\right]$$

where:

Q is the directivity index of the microphone;

V is the volume of the room, in cubic metres (m^3);

D is the distance between sound source and the microphone, in metres (m); and

RT is the reverberation time of the room, in seconds (s).

If more than one microphone is used, the subject becomes significantly more complicated and specialist advice should be sought.

Except for large auditoria and places of worship, *RT* for most medium to large rooms is likely to be between 1 s and 2 s. Small rooms generally have a shorter *RT*, e.g. around 0.5 s for well furnished (domestic) rooms and up to around 1 s to 1.2 s for lecture theatres and similar sized rooms. Primary school classrooms should have an *RT* value of 0.6 s or less, secondary schools 0.8 s, and open plan areas/seminar rooms and assembly halls 0.8 s to 1.2 s. Lecture theatres should have *RT* values <1.0 s and 0.8 s for small rooms (<50 people).

It should be taken into account that the equation assumes a diffuse, statistical sound field to exist and does not take into account the effects of local reflections, or non-exponential sound decay within the room. However, the equation may be used to obtain an initial estimate of the likely maximum usable microphone distances.

NOTE 3 The ratio K decreases by a factor of 3 dB each time the number of active microphones in operation is doubled. For example, using two microphones instead of one reduces the direct-to-reverberant sound pressure level ratio by approximately 3 dB.

NOTE 4 Since the equation for K includes the directivity index Q of the microphone, the directional characteristic of the microphone affects the distance from the source of sound at which a given direct-to-reverberant sound pressure level ratio is achieved. The directional characteristics of some common types of microphone are shown in Figure C.1 to Figure C.7. The hypercardioid characteristic gives the maximum rejection of reverberant sound of all simple microphones, while the supercardioid characteristic gives the maximum ratio of front to random energy efficiency. The directional characteristics of highly-directional or shotgun interference-tube rifle microphones vary considerably with frequency (see Figure C.2 to Figure C.7), and they might therefore pick up considerable low-frequency reverberation. This can be reduced by the careful use of equalization.

NOTE 5 A type of microphone which has low sensitivity to reverberant sound is the boundary-layer (pressure-zone) microphone, in which the microphone capsule is mounted very close to a plane reflecting surface, supplied as part of the microphone. These microphones are designed to be placed in contact with a large flat surface, and owe their reduced sensitivity to reverberation to the confinement (by the large flat surface) of the directional response in three dimensions to half-space, instead of the full-space which applies to other types of microphone. The basic directional characteristic of the microphone capsule may be omnidirectional, in which case the three-dimensional directional characteristic is a hemisphere, or a cardioid, giving a three-dimensional pattern in the form of a half-cardioid of revolution.

Figure C.8 shows the relative distances from the source of sound at which different types of microphone can be operated, for a given direct-to-reverberant sound pressure level ratio. The actual distance in all cases should be minimized, but with a minimum distance of approximately 300 mm, below which breath noise, coloration and large variations in signal level with small changes in distance can lead to degradation of intelligibility.

NOTE 7 Two methods of positioning microphones on a conference table are illustrated in Figure D.1, the 3 to 1 ratio for microphone positioning in Figure D.2 and Figure D.3 and typical examples of good and bad microphone positioning in Figure D.4.

The sound wave reflected from a desk top can interfere with the direct sound (as shown in Figure D.5) which should be taken into account. This effect can cause considerable unevenness in the frequency response above 1 kHz, which should be minimized by positioning the microphone at least 150 mm above the surface. The desk top around the microphone should be covered with a layer of soft material, preferably at least 25 mm thick.

D.3 Electrical characteristics

The output from a microphone is generally of the order of a few millivolts. A pre-amplifier with a considerable degree of gain, typically 60 dB to 70 dB, is therefore necessary.

Particular care should be taken to ensure that microphone circuits are not subjected to either RF or other forms of electrical interference. Microphone circuits should be low impedance and balanced, and cables should be segregated from other services by at least 300 mm or by the use of dedicated and compartmentalized trunking or conduit.

D.4 Microphone mountings

When mounting microphones on lecterns or table tops, shock/vibration isolating mounts should be used to reduce unwanted noise or vibration pick-up.

Figure D.1 **Two methods of positioning microphones on a conference table**

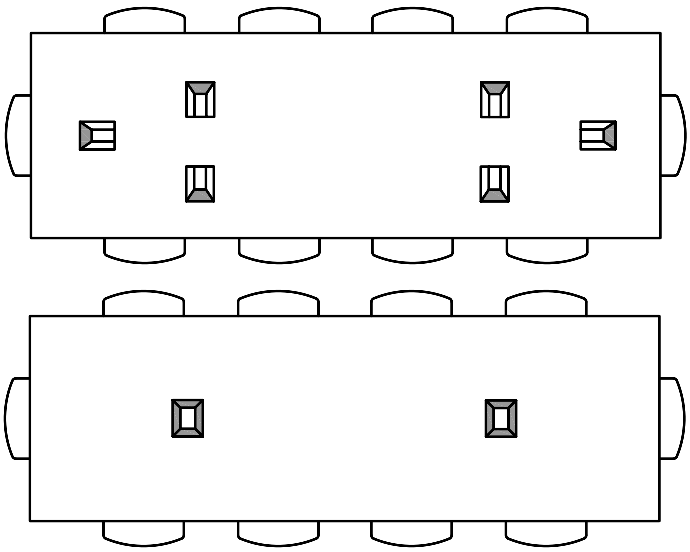


Figure D.2 **The 3 to 1 ratio for microphone positioning (normal)**

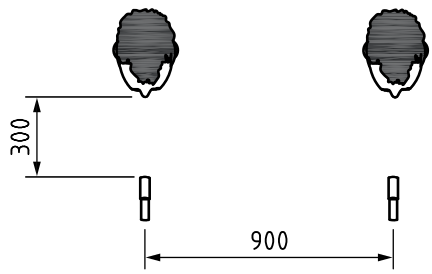


Figure D.3 **A reduced 3 to 1 ratio using angled microphones**

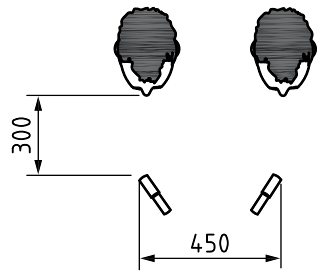


Figure D.4 **Illustrations of good and bad microphone placements**

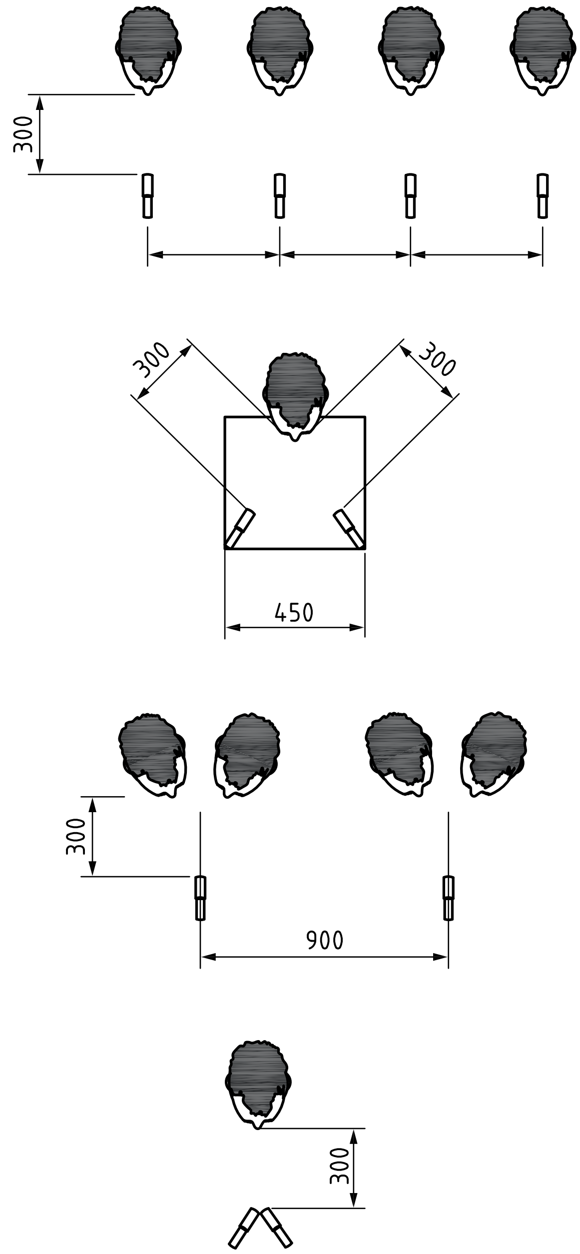
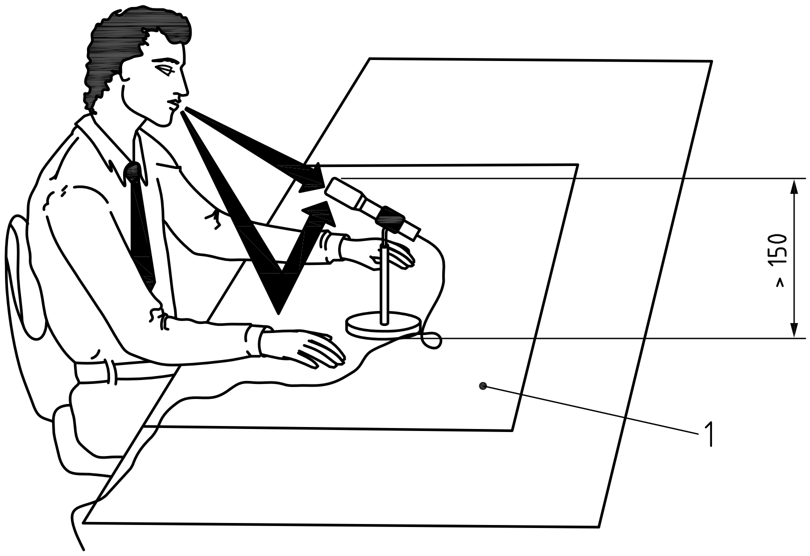


Figure D.5 **Optimization of the height of the microphone above the Table**

Dimension in millimetres



Key

1 Layer of soft material

Annex E (informative) STI qualification bands

Examples of STI qualification bands and typical applications are given in Table E.1.

Table E.1 **Examples of STI qualification bands and typical applications**

Category	Nominal STI value	Type of message information	Examples of typical uses (for natural or reproduced voice)	Comment
A+	>0.76	—	Recording studios	Excellent intelligibility but rarely achievable in most environments
A	0.74	Complex messages, unfamiliar words	Theatres, speech auditoria, parliaments, courts, assistive hearing systems (AHS)	High speech intelligibility
B	0.7	Complex messages, unfamiliar words	—	—
C	0.66	Complex messages, unfamiliar words	Theatres, speech auditoria, teleconferencing, parliaments, courts	High speech intelligibility
D	0.62	Complex messages, familiar words	Lecture theatres, classrooms, concert halls	Good speech intelligibility
E	0.58	Complex messages, familiar context	Concert halls, modern churches	High quality PA systems
F	0.54	Complex messages, familiar context	PA systems in shopping malls, public buildings offices, voice alarm (VA) systems, cathedrals	Good quality PA systems
G	0.5	Complex messages, familiar context	Shopping malls, public buildings offices, VA systems	Target value for VA systems
H	0.46	Simple messages, familiar words	VA and PA systems in difficult acoustic environments	Normal lower limit for VA systems
I	0.42	Simple messages, familiar context	VA and PA systems in very difficult spaces	—
J	0.38	—	Not suitable for PA systems	—
U	<0.36	—	Not suitable for PA systems	—

NOTE 1 These values are minimum target values.

NOTE 2 Perceived intelligibility relating to each category also depends on the frequency response at each listening position.

NOTE 3 The STI values refer to measured values in sample listening positions or as required by specific application standards.

Annex F (informative) Examples of certificates

F.1 Design certificate

Figure F.1 **Design certificate**

Certificate of design of the sound system at:

Address: ....

....

.... Postcode: ....

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the design of the sound system, particulars of which are set below, CERTIFY that the said design for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendation of Section 3 of BS 6259:2015 except for the variations, if any, stated in this certificate.

Name (in block letters): .... Position: ....

Signature: .... Date: ....

For and on behalf of: ....

Address: ....

....

.... Postcode: ....

Variations from the recommendations of Section 3 of BS 6259:2015:

....

....

....

Extent of system covered by the certificate:

....

....

....

Installation and commissioning

It is strongly recommended that installation and commissioning be undertaken in accordance with the recommendation of Section 4 of BS 6259:2015.

Verification

Verification that the system complies with BS 6259:2015 should be carried out, on completion, in accordance with Clause **11** of BS 6259:2015.

Yes ☐ No ☐ To be decided by the purchaser ☐

Maintenance

It is strongly recommended that, after completion, the system is maintained in accordance with Section **5** of BS 6259:2015.

User responsibilities

The user should appoint a responsible person to supervise all matters pertaining to the sound system in accordance with the recommendations of Clause **13** of BS 6259:2015.

F.2 Installation certificate

Figure F.2 **Installation certificate**

Certificate of installation of the sound system at:

Address: ……………………………………………………………………………………………………

………

………………………………………………………………………… Postcode: ……………………………

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the installation of the sound system, particulars of which are set below, CERTIFY that the installation work for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendation of Section 4 of BS 6259:2015 except for the variations, if any, stated in this certificate.

Name (in block letters): ……………………………… Position: ……………………………………………

Signature: ………………………………… ………………………… Date: …………………………

For and on behalf of: ……………………………………………………………………………………

Address: ……………………………………………………………………………………………………

………

………………………………………………………………………… Postcode: ……………………………

The extent of liability of the signatory is limited to the system described below.

Extent of system covered by the certificate:

………

………

………

………

Specification against which the system was installed:

………

………

………

………

Variations from the recommendation and/or Section 4 of BS 6259:2015:

………

………

………

………

Wiring has been tested in accordance with the recommendations of subclause **8.3** of BS 6259:2015. Test results have been recorded and provided to:

………

Unless supplied by others, the “as-fitted” drawings have been supplied to the person responsible for commissioning the system (see Clause **10** of BS 6259:2015).

F.3 Commissioning certificate

Figure F.3 **Commissioning certificate**

Certificate of commissioning of the sound system at:

Address: ....

....

.... Postcode: ....

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the commissioning of the sound system, particulars of which are set below, CERTIFY that the commissioning work for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendation of Section 4 of BS 6259:2015 except for the variations, if any, stated in this certificate.

Name (in block letters): .... Position: ....

Signature: .... Date: ....

For and on behalf of: ....

Address: ....

....

.... Postcode: ....

The extent of liability of the signatory is limited to the system described below.

Extent of system covered by the certificate:

....

....

....

....

Variations from the recommendation of Section 4 of BS 6259:2015:

....

....

....

....

☐ All equipment operates correctly.

☐ Installation work is, as far as can be reasonably ascertained, of an acceptable standard.

☐ The entire system has been inspected and tested in accordance with the recommendations of Clause **9** of BS 6259:2015.

☐ The system performs as required by the specification prepared by:

....

a copy of which I/we have given.

☐ The documentation described in Clause **10** of BS 6259:2015. has been provided to the user.

The following work should be completed before/after (delete as applicable) the system becomes operational:

....

F.4 Acceptance certificate

Figure F.4 **Acceptance certificate**

Certificate of acceptance of the sound system at:

Address: ....

....

.... Postcode: ....

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the acceptance of the sound system, particulars of which are set below, ACCEPT the system on behalf of:

....

....

....

Name (in block letters): .... Position: ....

Signature: .... Date: ....

For and on behalf of: ....

Address: ....

....

.... Postcode: ....

The extent of liability of the signatory is limited to the system described below.

Extent of system covered by the certificate:

....

....

....

....

☐ All installation work appears to be satisfactory.

☐ The system is capable of giving an audible and intelligible signal.

The following documents have been provided to the purchaser or user:

☐ "As-fitted" drawings.

☐ Operating and maintenance instructions.

☐ Certificate of design, installation and commissioning.

☐ A logbook.

☐ Sufficient representatives of the user have been properly instructed in the use of the system.

☐ All relevant tests, defined in the purchasing specification, have been witnessed. (Delete if not applicable.)

The following work is required before the system can be accepted:

....

....

F.5 Verification certificate

Figure F.5 **Verification certificate**

Certificate of verification of the sound system at:

Address: ....

....

.... Postcode: ....

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the verification of the sound system, particulars of which are set below, CERTIFY that the verification work for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendations Clause **11** of BS 6259:2015.

Name (in block letters): .... Position: ....

Signature: .... Date: ....

For and on behalf of: ....

Address: ....

....

....

.... Postcode: ....

The extent of liability of the signatory is limited to the system described below.

Extent of system covered by the certificate:

....

....

....

Scope and extent of the verification work:

....

....

....

....

☐ In my/our opinion, that as far as can reasonably be ascertained from the scope of work described above, the system complies with, and has been commissioned in accordance with, the recommendations of BS 6259:2015, other than in respect of variations already identified in the certificates of design, installation or commissioning.

The following non-compliances with the recommendations of BS 6259:2015 have been identified (other than those recorded as variations in the certificates of design, installation or commissioning):

....

....

....

....

F.6 Servicing certificate

Figure F.6 **Servicing certificate**

Certificate of servicing of the sound system at:

Address: ……………………………………………………………………………………………………

………

…………………………………………………………………… Postcode: ………………………………

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the servicing of the sound system, particulars of which are set below, CERTIFY that the servicing work for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendations Section 5 of BS 6259:2015 except for the variations, if any, stated in this certificate.

Name (in block letters): ………………………………. Position: ……………………………………………

Signature: ………………………………….. ………………………….. Date: ……………………………

For and on behalf of: ………………………………………………………………………………………

Address: ……………………………………………………………………………………………………

………

………

…………………………………………………………………… Postcode: ………………………………

The extent of liability of the signatory is limited to the system described below.

Extent of system covered by the certificate:

………

………

………

………

Variations from the recommendations of Section 5 of BS 6259:2015:

………

………

………

………

☐ Relevant details of the work carried out and faults identified have been entered in the system logbook.

………

………

………

………

F.7 Modification certificate

Figure F.7 **Modification certificate**

Certificate of modification of the sound system at:

Address: ....

....

.... Postcode: ....

I/we being the competent person(s) responsible (as indicated by my/our signatures below) for the modification of the sound system, particulars of which are set below, CERTIFY that the modifications for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendations Section 4 of BS 6259:2015 except for the variations, if any, stated in this certificate.

Name (in block letters): .... Position: ....

Signature: .... Date: ....

For and on behalf of: ....

Address: ....

....

....

.... Postcode: ....

The extent of liability of the signatory is limited to the system described below.

Extent of system covered by the certificate:

....

....

....

....

Variations from the recommendations of Section 4 of BS 6259:2015:

....

....

....

....

☐ Following the modifications, the system has been tested in accordance with the recommendations of Clause **12** of BS 6259:2015.

☐ Following the modifications, "as-fitted" drawings and other system records have been updated as appropriate.

I/we the undersigned confirm that the modifications have introduced no additional variations from the recommendations of BS 6259:2015 other than those recorded above:

Signed:...

Capacity:...

(e.g. maintenance organization, system designer, consultant or user representative)

Annex G (informative)

Dynamics processors (compressors and AGC)

It is important to recognize that the distinction between automatic gain control (AGC) and compression is not widely understood. AGC is characterized by sufficient gain in the control loop to hold the steady-state amplifier output current substantially constant for values of sinusoidal source e.m.f. above a threshold value, and a release time-constant in the control loop of 1 s or greater. AGC does not, when correctly implemented, change the subjective quality of the programme signals.

Similarly, compression (amplitude compression) is characterized by gain in the control loop set so that the steady-state amplifier output current increases with source e.m.f. less than proportionally for values of sinusoidal source e.m.f above a threshold value, and a release time-constant in the control loop of the order of milliseconds. Compression changes the subjective quality of the programme material.

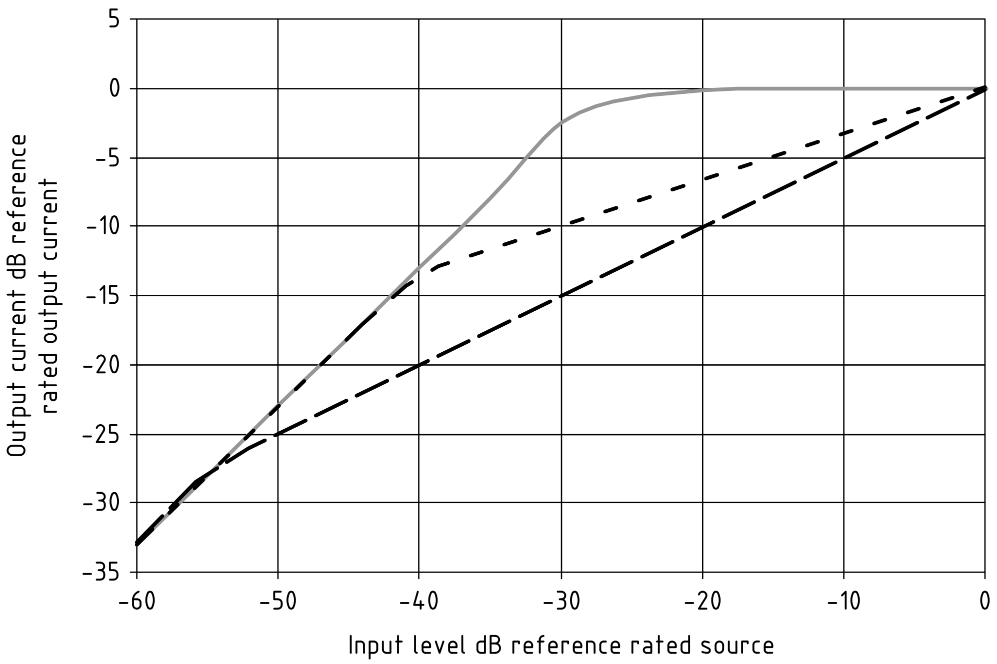
For both techniques, the attack time-constant in the control loop is usually of the order of milliseconds.

It is recognized that other definitions of automatic gain control, automatic volume control and compression are in use, but the earlier definitions are appropriate for this standard.

The compression ratio is the difference in decibels between an increment of level of source e.m.f. and the resulting 1 dB increment of level of output current. There is evidence that compression ratios in the region of 2 can improve speech intelligibility, while values above 3 tend to make the sound quality strident and unpleasant. Compression can depress speech levels undesirably in noisy situations.

Figure G.1 shows typical steady-state output/input characteristics.

Figure G.1 **Typical steady-state output/input characteristics**



Key

AGC

Compression 2

Compression 3

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