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BSI Standards Publication

Code of practice for audio-frequency induction-loop systems (AFILS)

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 September 2011. 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This British Standard supersedes BS 7594:1993, which is withdrawn.

Relationship with other publications

The performance of induction loop systems is specified in BS EN 60118-4:2006, whereas this standard gives recommendations and guidance for their design, planning, installation, testing, operation and maintenance. Provisions for components of a system are given in BS EN 62489-1. Methods of calculation and measurement of the magnetic field, in the context of human exposure, are given in BS EN 62489-2.

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.

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.

Section 1: General

1 Scope

This British Standard gives recommendations for and guidance on the design, planning, installation, testing, operation and maintenance of an audio frequency induction loop system (AFILS) intended for communicating speech, music and/or other signals. It is mainly concerned with AFILS for hearing enhancement, in which the signals are communicated to users of hearing aids equipped with magnetic pick-up coils. However, most of the standard also applies to AFILS used for other purposes, and some additional information on these purposes is given in Section 3.

This standard does not apply to induction-loop systems which use a carrier frequency, nor to other systems for hearing enhancement purposes which do not use magnetic induction.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, the latest edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 60065, *Audio, video and similar electronic apparatus – Safety requirements*

BS EN 60118-4:2006/IEC 60118-4:2006, *Electroacoustics – Hearing aids – Part 4: Induction loop systems for hearing aid purposes – Magnetic field strength*

BS EN 61672-1:2003/IEC 61672-1:2003, *Electroacoustics – Sound level meters – Part 1: Specifications*

BS EN 62489-1/IEC 62489-1, *Electroacoustics – Audio-frequency induction loop systems for assisted hearing – Part 1: Methods of measuring and specifying the performance of system components*

BS 7671, *Requirements for Electrical Installations – IEE Wiring Regulations Seventeenth Edition*¹⁾

3 Terms, definitions, signs and symbols

3.1 Terms and definitions

For the purposes of this standard, the following definitions apply.

3.1.1 audio-frequency induction-loop system (AFILS)

system including amplifier(s), microphones and/or other signal sources, in which magnetic fields are created by the flow of audio-frequency current in a conductor arranged in the form of a loop or coil

3.1.2 AFILS for hearing enhancement

AFILS in which the intended receivers are hearing aids or specially designed listening devices equipped with coils acting as magnetic antennas

¹⁾ Informative dated reference also made to BS 7671:2008+A1:2010.

3.1.3 direct-to-reverberant ratio

ratio at a given point in the sound field, of the sound pressure due to the wanted sound source to the sound pressure due to reverberation

3.1.4 hearing aid

personal amplification system, worn entirely on the listener, which is designed to enable a person with impaired hearing to hear more easily

3.1.5 induction-loop listener

listening device which is designed to give an audible output in response to signals transmitted by an AFILS

3.1.6 induction-loop monitor receiver

equipment designed to verify the performance of an AFILS by audio and visual means:

- a) providing visible indication that it is powered and when the strength of the magnetic field produced by the loop falls within a specified range; and
- b) providing an audio-frequency output by which the sound quality of the AFILS transmissions can be assessed

NOTE Other facilities may be included (see Annex A).

3.1.7 magnetic field strength

magnitude of the magnetic field, at a stated point in space and in a stated direction, generated by the flow of alternating current in an AFILS

3.1.8 listening plane

plane of the listeners' telecoils in their hearing aids

NOTE As most hearing aid users are standing or sitting, only the vertical component of the magnetic field of an area-coverage loop system is useful and the listening plane is horizontal. However, if the user is lying down, the horizontal component of the magnetic field is useful. The listening plane for seated listeners is conventionally taken as 1.2 m above floor level and that for standing listeners as 1.7 m above floor level. Where a single plane height is required for design purposes, it should be taken as being 1.45 m above floor level, and the resultant design checked for heights of 1.2 m and 1.7 m.

3.1.9 useful magnetic field volume

volume within which the system provides hearing-aid users with a signal of acceptable quality

[From BS EN 60118-4:2006.]

3.1.10 system designer

technically competent person who takes responsibility for the technical specification, design and performance of the system

3.1.11 simple installation

AFILS that is neither large nor complex and does not require specialist skills in order to achieve a satisfactory result

3.1.12 counter system**ticket office system**

small area AFILS designed to assist communication between (usually) two persons, sometimes through a transparent screen

NOTE For example at a ticket office, bank, or a social security office.

3.1.13 large area installation

AFILS that has an approximate coverage area greater than 400 m²

NOTE Such installations are likely to require specialized design knowledge in order to obtain a satisfactory result (see 4.3).

3.1.14 complex installation

AFILS needed when:

- it is required to operate close to another AFILS, which could lead to co-interference;
- it is required that a certain area is not covered by the AFILS, in case it might interfere with sensitive electronic equipment, e.g. electric guitars or dynamic microphones;
- it is required that the system operates on a number of different listening planes;
- an unconventional layout of loop conductors is indicated;
- there is metal in the building's structure and this causes irregularity in the field strength when using a perimeter loop

NOTE See Clause 10.

3.1.15 direction of magnetic field

resultant direction of the magnetic field at a point in three dimensional space, arising from the phasor sum of components of the field derived by integration over all elements of the induction-loop

NOTE See also Annex G.

3.1.16 reference magnetic field strength level

0 dB reference for magnetic field strength levels, which is 400 mA/m

NOTE See BS EN 60118-4, 3.1.

3.1.17 overspill

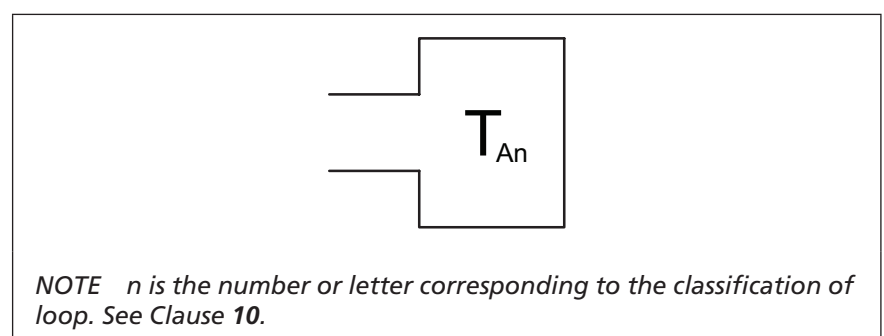
magnetic field of usable strength that is present outside the volume in which it is required

NOTE This volume is larger than the useful magnetic field volume because a field of usable strength can be weaker than the minimum specified in BS EN 60118-4 for the useful magnetic field volume.

3.2 Signs and symbols**3.2.1 Symbol for an induction-loop**

The symbol shown in Figure 1 should be used on circuit diagrams to indicate an AFILS.

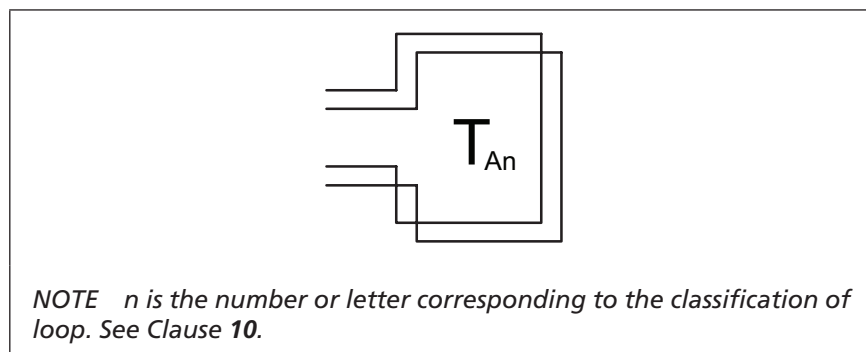
Figure 1 **Symbol for use on diagrams**



3.2.2 Symbol for multiple loops

The symbol shown in Figure 2 should be used on circuit diagrams to indicate a complex or low-spill AFILS.

Figure 2 Symbol for multiple loops for use on diagrams



3.2.3 Sign for display in premises where an AFILS is installed and for AFILS equipment identification

Signs for display should be produced on a durable material.

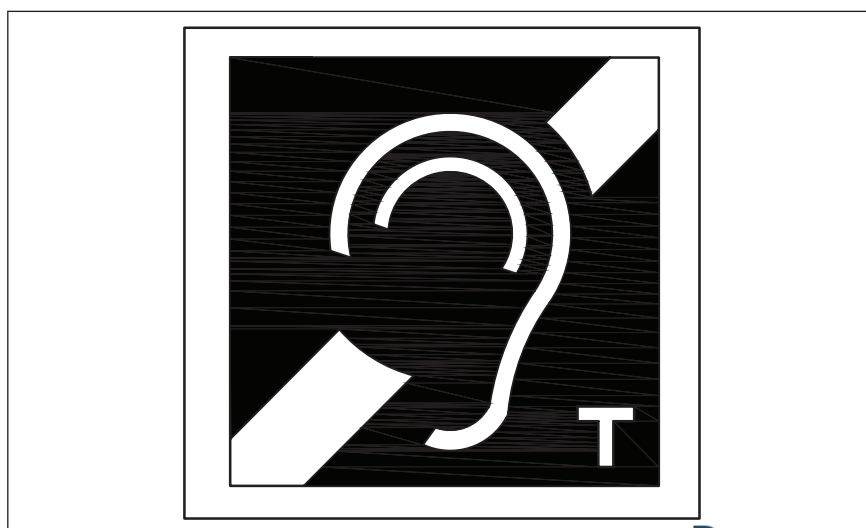
Areas where the reception of the AFILS is satisfactory should be clearly indicated at visible positions by means of the sign shown in Figure 3, which is based on the one originally adopted by the World Federation of the Deaf, should be used. The sign should indicate T as shown. The background colour should be Pantone reference 661 or 662 (blue) and the printing should be in white.

NOTE Signs of other colours are found in use.

Normally the dimensions of the display signs should be a minimum of 100 mm × 100 mm, when used on equipment they may be of any convenient size.

The sign should appear at a position visible in normal use on AFILS equipment, on loop cable junction boxes and adjacent to the loop cable itself where it would be helpful to maintenance personnel or help to prevent accidental disturbance.

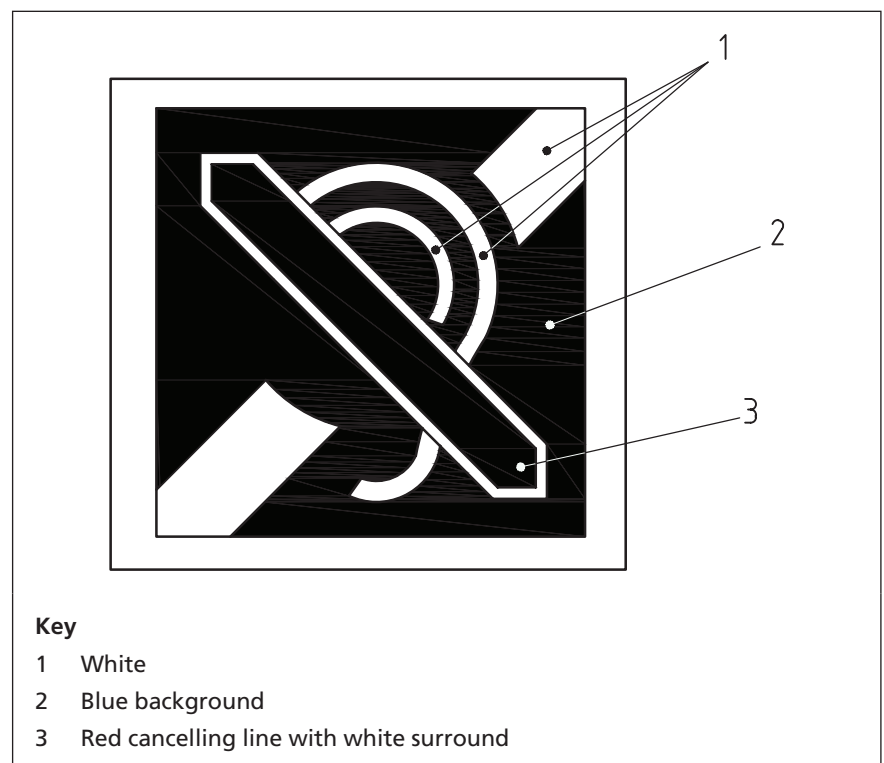
Figure 3 Sign for display in premises to indicate that an AFILS is installed and for AFILS equipment identification



3.2.4 Identification of areas where reception of the AFILS is not satisfactory

Areas where the reception of the AFILS is not satisfactory should be clearly indicated on a plan of the space by means of the sign shown in Figure 4. The plan should be placed where it can be seen by both hearing-aid users and staff. This sign should also be placed visibly in the unsatisfactory area and/or on all seats in that area.

Figure 4 Sign to show seating areas where AFILS reception is not satisfactory



4 General

4.1 Object

The recommendations of this standard are intended to lead to the following.

- a) Prospective purchasers clearly understand the functions and limitations of an AFILS (see Annex B).
- b) The design, installation and setting-up of the AFILS allows compliance with the appropriate requirements for safety and electromagnetic compatibility and all relevant regulations relating to electrical installations.
- c) Users wearing hearing aids equipped with a magnetic pick-up coil receive signals transmitted by the AFILS that are intelligible and free from undue distortion and interference even when all non-AFILS equipment normally used in the environment is in operation.
- d) The reception of such signals is possible in any part of the space; where, by force of circumstance, the reception in some parts is limited, this is clearly defined and identified (see 3.2.4).

- e) Visual indication is given to prospective users that an AFILS is installed.
- f) Means are provided for the building management to easily verify that an AFILS is working satisfactorily (see Annex A).
- g) The AFILS can be satisfactorily operated and maintained by properly trained and competent personnel.
- h) Where necessary, the AFILS is arranged for minimum extraneous coverage. It should be understood, however, that even if an AFILS is designed to limit extraneous coverage, it might be possible for a determined person outside the intended area of coverage to receive what might be confidential information.
- i) Guidance is given on means to reduce possible effects of the magnetic field produced by the loop on other nearby equipment.

4.2 How to use this code of practice

This standard is divided into sections, with recommendations intended primarily for:

- a) purchasers of AFILS (Section 1 and Section 2);
- b) designers of AFILS and AFILS equipment (Section 3 and Section 5);
- c) installers of AFILS (Section 4 and Section 5);
- d) those responsible for commissioning, testing, operation and maintenance (see Section 5, Section 6 and Section 7);
- e) those responsible for day-to-day operations, ensuring that the facilities are accessible to as many people as is reasonably possible.

4.3 Specialist advice

Except for home 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. Professional bodies such as the Institute of Sound and Communications Engineers may be approached for lists of such specialists.

4.4 Safety aspects

It is essential that an AFILS, even if temporary, is installed in a safe manner and in accordance with safe work practices (see Clause 13).

4.5 Conforming to existing performance standards

The performance standard for AFILS is BS EN 60118-4:2006, the requirements of which have been incorporated (where applicable) as recommendations in this standard.

Section 2: Purchasing an AFILS, placing a contract for its installation, or obtaining independent assessment of the performance of an installation

5 Technical advice

5.1 Complying with this standard

Significant problems can arise with poorly designed or installed AFILS. Purchasers should stipulate that the design and installation are to comply with this code of practice and that the system should conform to BS EN 60118-4:2006. Operation and maintenance procedures should also be in accordance with this code of practice.

NOTE For small self-install systems intended for home use, it is expected that the manufacturer has ensured that the basic requirements of this standard will be met if the user follows the installation instructions carefully.

It is recommended that contracts include a specific variation clause under which parties agree to the terms of the contract and document any agreed variations.

5.2 Seeking technical advice

NOTE While many successful AFILS have been installed to date, compliance with this standard should greatly increase the probability that satisfactory results will be obtained. Its provisions, however, cannot be properly applied without adequate technical knowledge and experience, and each design presents individual challenges.

Wherever possible, technical advice should be sought during the early planning stages of an AFILS. Such advice should cover:

- a) the suitability of an AFILS for a particular venue and/or application (see Clause 10);
- b) factors that may adversely affect the performance of an AFILS;
- c) factors that may add to the cost of installing an AFILS;
- d) the need for, and scope of, an initial site assessment (see Clause 12);
- e) details of the audio source(s);
- f) where microphones are to be used, their positioning to minimize extraneous noise and reverberation.

In all cases, the responsibility for the correct performance of the system at the time of commissioning should lie with the system designer, when one is involved (see Section 3). It should be understood, however, that the system designer cannot be held responsible for the parts of the system outside their control.

Where the AFILS is to be installed as part of other electrical works, it is especially important that all aspects of the design are clearly specified, especially regarding microphones, required coverage and overspill (see 3.1.17 and 9.2).

5.3 The nature of the advice

Advice sought will depend on the particular installation requirements for each AFILS, but should generally be covered by the following categories:

- a) advice from the designer/installer direct to the client on all aspects, from initial quotations for the task in the planning stages through to installation, commissioning and maintenance of the AFILS;
- b) advice from the designer to a technician who lacks experience with AFILS installations but who has the task of installing the system (e.g. systems in new buildings where installation is to be carried out by electrical contractors; systems installed by in-house staff);
- c) advice from an appropriate organization or professional body such as the Institute of Sound and Communications Engineers.

5.4 Professional (consultancy) advice

Professional advice from a specialist consultant should be sought when installations are to be undertaken in extra-large buildings, prestigious buildings and those posing special difficulties.

The advice of an independent consultant may also be sought in the event of a dispute between the purchaser and supplier or manufacturer.

NOTE Such advice can often provide the most economical resolution of the dispute.

6 Objective of the system

Before approaching a supplier, it is important to write down, in non-technical terms, what the users of the system require it to do and the environment it is to be used in. 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:

- the room(s) and three dimensional space(s) to be covered;
- what sounds or audio signals are to be reproduced and where they are to come from (all the sources and places);
- whether the audio information needs to be confidential (e.g. a court);
- known/likely interference from other equipment (e.g. power transformers, air-conditioning equipment, other AFILS, and some fluorescent lighting);
- building construction, such as structural steel work and metal sheeting in walls, floors and ceilings, particularly close to the looped area;
- any metal construction within the space (e.g. tiered seating or metal suspended ceiling grids);
- architectural considerations or restrictions (e.g. listed building status); and
- how continuing satisfactory operation of the system can be ensured, for instance by regular testing by trained staff, or by the installation of a fixed monitor receiver (see Annex A).

7 Choosing the system supplier

7.1 General

Possible procedures for acquiring an AFILS are recommended in 7.2, 7.3 and 7.4. The choice of procedure should depend on the size of the space to be covered and any special complications which might be involved.

7.2 Approaching a contractor

Particularly for simple AFILS, 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). 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 AFILS correctly, should rest with the contractor.

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

7.3 Approaching a manufacturer of AFILS equipment

NOTE Some manufacturers of AFILS equipment are willing to produce the site survey for the proposed installation, design a system and, perhaps, recommend a competent installation contractor. Manufacturers who are unable to provide this service themselves may offer contact with appropriate designers/installers who can undertake such projects. Names of manufacturers can be obtained from business directories and trade associations such as the Institute of Sound and Communications Engineers.

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

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

7.4 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 AFILS, choice of equipment and for helping to assess installers' proposals. Where necessary, the consultant should also liaise with architects and construction contractors on matters affecting the AFILS. Names of consultants who specialize in this work may be obtained from business directories and trade associations.

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

8 Contractual provisions

8.1 Performance specification

The purchase contract should include an agreed performance specification, prepared by the system designer, to which the system is contractually required to conform at the commissioning stage. A guide to the preparation of a specification is given in Annex D. Where 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 reservation about the suitability of such equipment should be clearly explained to the purchaser in writing.

8.2 Verifying that the completed system delivers its intended performance

Tests of the completed installation to verify that the AFILS performs satisfactorily should be specified in the contract and should cover:

- a) checks of the system using a calibrated meter designed to measure field strength in conformity with BS EN 60118-4:2006;
- b) subjective tests using persons with normal hearing listening through suitable receiving units;
- c) subjective tests by hearing aid users, with their hearing aids set to T;
- d) provision of either field-strength meters for use by trained staff or a fixed monitor receiver.

If the subjective tests are conducted correctly and do not provide confirmation of positive instrumentation checks, the system designer should be held responsible for identifying measures necessary to achieve satisfactory results. The contract should, therefore, include adequate provisions for properly defining the system designer's responsibility with regard to the preparation of any required remedial proposals and their implementation.

NOTE The emphasis is on satisfactory results, as determined by the users of the system, rather than achieving particular objective results from technical tests. See BS EN 60118-4:2006, 6.4.2.

The system designer should advise on methods of eliminating interference by the AFILS with other nearby electronic equipment, and modifications to the AFILS should be agreed with the system designer; it is advisable for the contract to specify how the costs of such remedial work are to be apportioned.

COMMENTARY ON 8.2

The need for specific measures to eliminate interference by the AFILS with other nearby electronic systems (e.g. multiple grounding, legacy equipment with inadequate immunity, unforeseen proximity of loop cabling to other cabling, see Clause 9) might be impossible to predict before the AFILS is installed and tested.

Remedial work has to be carried out by the body having technical responsibility for the appropriate system (telephone systems, etc.).

The tests in 17b) are to determine the perceived sound quality of the system and its adequate freedom from noise, reverberation and distortion. They are not intended to demonstrate that the needs of any particular hearing-aid user are met.

8.3 Arbitration

It is recommended that provision is made in the contract for arbitration in the event that problems arise.

Where possible, an arbitration body should be identified.

9 Factors to be considered at the design stage

9.1 External factors

9.1.1 Magnetic noise interference

COMMENTARY ON 9.1.1

Magnetic fields radiated from mains cables and overhead and underground power lines or cables and equipment can be picked up in most buildings on a hearing aid switched for use with a loop system (T position). Where the field is at a low level of intensity it is not normally troublesome. However, under certain circumstances the field strength can be sufficiently high to interfere with the signal picked up from the induction-loop, causing annoyance to the listener and in some cases making it impossible to use the loop system. Examples of sources of magnetic interference are fluorescent and other types of discharge lamps, electronic lamp dimming systems and faulty or incorrectly routed wiring (see Clause 13).

For the limits on magnetic noise level, see BS EN 60118-4:2006.

Serious magnetic interference can be caused by the separation of live and neutral conductors (or of phase conductors) of mains circuits, which is particularly found in old buildings where numerous changes have been made to electrical installations. Magnetic interference is also a problem in newer buildings where loop circuits have been installed in rooms with suspended ceilings and the fluorescent lighting circuits have an interlinked neutral instead of each lighting circuit having an individual neutral.

Such wiring is not in accordance with BS 7671:2008+A1, 444.4.2.1(iii).

9.1.2 Effect of metal in the building structure and within the coverage area

NOTE 1 *The performance of the AFILS can be seriously degraded if there is metal (which might be concealed) in the building. Local degradation of the performance can also occur near large metal objects or constructions within the coverage area.*

NOTE 2 *For new builds, the building designers should provide detailed drawings and information regarding structural metal and sheet metal in the vicinity of all AFILS.*

While these effects are difficult to predict, the customer should be made aware of their likely or potential impact. The outcome of site measurements of the effect of metal in the building structure on magnetic fields should be considered as part of the objectives and the design procedure, and any anticipated detrimental effects reported to the customer.

9.2 Magnetic field overspill

Care should be taken to ensure that confidential information is not fed into the AFILS as it can be possible to hear this information with a suitable receiver some distance outside the loop. Special designs of loop system may be considered, which can help to reduce the overspill field. (See also 3.1.17)

While certain AFILS rely on magnetic fields extending beyond the loop for their correct operation, this extended field can potentially interfere with any other communication system, including another AFILS. For example, an AFILS installed in a theatre auditorium might interfere with the intelligibility of an AFILS installed at the box office (interference in the other direction is much less likely). Since the magnetic field produced by an induction loop is not confined to the area within the loop, signals can often be picked up on a suitably equipped hearing aid or receiver outside the room or the building in which the loop is installed, or even in an adjacent public road or area. This can cause difficulties when two or more loop systems in close proximity to each other are in operation simultaneously, as listeners to one of the loops may also hear overspill signals from the other.

It is not practicable to recommend limits on overspill field strength as the acceptable strength depends on many site-specific factors. It is recommended that the requirements for overspill be specified contractually in each case in which it is necessary.

Section 3: AFILS system design

10 Classification of systems

NOTE 1 Because of the diversity of use for AFILS the following classifications are intended to group similar applications, providing minimum performance characteristics for each group based on the intended use; for example the permissible magnetic noise and overspill with adjacent counter loops can be considerably higher than that of a theatre system as the user is only in contact with the counter system for a small period of time.

AFILS should be assessed by a competent person and assigned one of the following classifications for operation and performance.

NOTE 2 Classifications start A (AFILS) to prevent confusion with fire systems L classifications.

- **A1: Portable or hand held self contained equipment.** This equipment is designed for mobile/temporary use only to assist one-to-one communication. It is not intended to be used on counters or left permanently installed in a location. It is intended, for example, for use by travelling professionals such as doctors or lawyers.
- **A2: Small volume system for use in counters, signage, intercom, emergency voice communication system (EVCS).** Coverage is required within a small defined volume (generally not more than 2 m × 2 m × 0.5 m), where the user is in a fixed position and use is transitory, e.g. counter systems for a ticket office or GP surgery, help points. For counter systems where confidentiality is important the design of the AFILS may be required to attenuate the magnetic field outside a designated space (usually the useful magnetic field volume) to a level at which speech cannot be understood. But there is no requirement for the magnetic attenuation to exceed the acoustic attenuation.
- **A3: Perimeter loop for coverage of a single volume where other AFILS are not present in the vicinity and where security, overspill or overcoming significant metal losses is of no importance,** e.g. church/stone building remote from other buildings containing AFILS.
- **A4: Multi-loop systems,** specifically designed to control the horizontal and vertical field components for AFILS installed in close proximity and/or to overcome significant metal content, e.g. classrooms or cinemas with multiple AFILS, an auditorium with a box office AFILS in same building, reinforced concrete construction, or an office space with a raised steel computer floor. The techniques involved depend entirely on the individual application: from as simple as a figure 8 loop, to the use of two separate arrays of loops in conjunction with a phase shifter or similar device. Consultation of a specialist in AFILS antenna design is essential to ensure that the correct solution is applied. Professional bodies such as the Institute of Sound and Communications Engineers may be approached for lists of such specialists.
- **A5: Loop systems designed for purposes other than assistive listening** such as stage direction or observational counselling.

- **A6: Personal loops, hand held or worn on the body.**
- **A7: Specialist loops** which fall into none of the above categories, such as systems for lifts, which generally require detailed design work by a competent AFILS specialist.

NOTE 3 Table 1 gives the required features, performance and indications for different loop classes and covers the desired and minimum features of classes A1 to A4; by their nature the other classes have specific requirements beyond the scope of this standard.

Table 1 Required features, performance and indications for different loop classes

Type	Allowable background noise dB L ^{A)}	Field variation in the useful magnetic field volume dB	Loop separation ^{B)}	User controls (minimum)	Indications
<i>A1: Portable or hand held self contained equipment</i>	–32, –22 for short time periods	12	2 m		Power, loop current
<i>A2: Small volume system for use in counters, signage, emergency voice communication system (EVCS).</i>	–32, –22 for short time periods	12	Width of loop ×2 e.g. 2 m for counters using 1 m wide loop	Input gain, loop drive	Power, loop current, input signal present or automatic gain control active
<i>A3: Area coverage systems for a single volume where other AFILS are not present in the vicinity and where security or overspill or overcoming significant metal losses is of no importance</i>	–32, –22 for short time periods	6	Width of loop ×2 e.g. 10 m for 5 m wide loop	Input gain, loop drive.	Power, loop current, input signal present or automatic gain control active
<i>A4: Low overspill loop systems</i>	–32, –22 for short time periods	6	As recommended by designer, typically 2 m	Input gain, loop drive.	Power, loop current, input signal present or automatic gain control active

^{A)} dB L is “decibels with respect to 400 mA/m”.

^{B)} Separation between two adjacent loops in the plane of the loops to minimize the pick up of signals from one loop by a hearing-aid user using the other loop. Where loops are installed one above the other the situation is more complex and requires specialist knowledge to minimize interference.

11 Signal sources

COMMENTARY ON CLAUSE 11

The prime objective of an AFILS is the improvement in the signal to noise ratio and direct-to-reverberant ratio, in order to improve the intelligibility for the hearing aid user. As such the choice of the audio source and the choice and positioning of microphones are of paramount importance.

For Type A1 systems the microphone is usually contained within the device.

For Type A2 systems microphones are used for counter systems, with particular attention to counters where the server and customer are separated by glass and the need for the hearing aid user to hear a proportion of their own voice to help regulate their speech; for EVCS, help points and signage the audio source is usually taken directly from the loudspeaker or public address/voice alarm system (see 11.2).

Where several microphones are used in a space or the talkers move to set locations within a space (such as places of worship) the use of several open microphones increases the background noise lowering the intelligibility of the system.

For theatres, cinemas and places of worship, it is advisable to consider an audience-response microphone for ambience between events and to reassure users the AFILS is in operation. This ambient input may be passed through a "ducking circuit" to prevent the performance system audio being picked up by this ambient input and thus reducing the intelligibility.

11.1 Audio sources

Type A2, A3 and A4 AFILS may be required to reproduce voice alarm signals and messages whilst overriding other input signals.

Type A3 and A4 systems can have a variety of sources from microphones and line level systems. In these arrangements particular care has to be taken in the choice of source, particularly for multi-function venues. If there is no fixed position for a talker in the space, it is advisable to consider wireless microphones or multiple microphones and suitable audio processing such as manual switching, noise gates or automatic mixers to minimize noise.

For type A5 and type A6 systems the audio sources are application specific although the general recommendations still apply.

When positioning talkers and their associated microphones, it is essential to avoid mechanical noise entering the system from local sources such as air conditioning, AV projector fans and the suchlike.

11.2 Interconnection with sound reinforcement systems

COMMENTARY ON 11.2

Where the room configuration is constant, it may be satisfactory to derive the signal for the AFILS from a sound reinforcement system. If so, it should preferably be derived from a low-level output on the mixer or amplifier of the sound reinforcement system, but it is also possible to derive the signal from a loudspeaker distribution system.

If the input to the AFILS is to be taken from a low level output of a sound reinforcement system, then it should be confirmed that any adjustment of the output of the sound system itself does not affect the signal being fed to the AFILS, and that the AFILS signal is not subject to equalization for the room characteristic. It should be made difficult to switch off inadvertently, or to fade down the feed to the AFILS.

Makeshift methods, such as placing a microphone in front of a loudspeaker, should not be used in a permanent installation. This does not exclude the use of properly designed attachments, for example for television receivers, or use of the microphone and loudspeaker technique in a temporary installation provided that satisfactory operation can be achieved.

11.3 Interconnection with a voice alarm system

Where the AFILS is used as a supplementary alarm device to reproduce messages or signals from a voice alarm system, provision should be made to silence or override all other input signal inputs for the duration of the voice alarm message. Some AFILS amplifiers have this feature built-in while others require additional equipment for this purpose. A voice alarm system should provide both an audio signal connection and a control connection (usually a switched DC voltage) to the AFILS.

The AFILS should also provide an indication to the voice alarm system that the amplifier is working correctly and that current is flowing in the loop. This is usually provided by volts-free contacts that open when a fault is detected.

11.4 Use and siting of microphones

Where the talker position is predictable, the microphone should be securely fixed and maintained in position.

In other cases, and especially where the room configuration changes, it may be necessary to provide one or more microphones, and a mixer or mixing amplifier, specifically for the AFILS. Such microphones should be chosen and sited, in liaison with the occupier of the building, architect, etc., 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.

NOTE 1 Directional microphones normally give the best results; 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 is almost always required in order to achieve adequate intelligibility.

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.

It is not advisable to use very inexpensive microphones, such as those intended for household use. Microphones requiring batteries should not be used, because of the inconvenience of replacing them; an exception is made for wireless microphones. Microphones vary greatly in their susceptibility to picking up the magnetic field of the loop. Dynamic microphones should be tested for magnetic pick-up unless the manufacturer provides adequate assurance of immunity.

Where questions or comments from an audience are to be relayed via the AFILS, highly directional microphones may 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.

NOTE 2 It is usually necessary to provide a separate pre-amplification channel for each of these microphones, and for an operator to control the channel gains when the microphones are in use.

NOTE 3 Alternative positions may require evaluation with a trial loop and an induction-loop monitor receiver.

NOTE 4 The use of appropriate equalization on an individual microphone channel can considerably help to reduce unwanted room effects and low frequency acoustic noise transmission.

11.5 Microphone accessories

AFILS microphones should be mounted on surfaces or structures that are solid or not vulnerable to vibration, impact or similar disturbance (either accidental or deliberate), and not mounted on floor stands, because floor noise, kicks, clicks and handling noise can be very disturbing to a hearing aid user. Microphones are very susceptible to accidental damage and vandalism, so they should be secured against unauthorized access, especially when the AFILS is left unattended.

AFILS microphones should not normally be provided with a switch accessible to the microphone user, because of the likelihood of incorrect operation. An exception may be made if only properly trained persons use the microphones, and the switch is not built into or mounted directly on the microphone (as this often results in noise when the switch is operated).

11.6 Use of several microphones

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

NOTE 1 In general, 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 preamplifiers which 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 (see 11.6) 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, who should not be located more than 45° off-axis of at least one microphone.

In Type A2 counter systems, microphones should be provided on both the staff and customer sides where the parties are separated by a glass screen or other obstruction.

11.7 Distance between the microphone and the source of sound

It is essential that the signal delivered to hearing aid users is as free from reverberation and noise (as well as other forms of degradation) as possible; this is because the single-channel nature of the AFILS prevents the listener using the mechanisms of the ear-brain system to distinguish wanted sounds from unwanted.

Microphones should be positioned as close to the original source(s) of sound as possible, and the output signal of each microphone should be checked by listening for sufficiently low levels of reverberation and noise at an early stage, so that any unsatisfactory performance can be corrected.

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

For talker-to-microphone distances larger than 3 m, use of a 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.

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

NOTE 1 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 help maintain an acceptable signal to noise ratio, the maximum microphone distance should be limited to approximately 6 m to 10 m, even in quiet auditoriums with trained speakers and assuming a microphone having a cardioid directional response. The use of a highly directional "shotgun" microphone may be used to extend the range up to 15 m maximum.

NOTE 2 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 greater than 0 dB is necessary (normal unimpaired listeners). For hearing impaired listeners, a direct-to-reverberant sound pressure level ratio of at least +4 dB to +6 dB is usually necessary 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.

NOTE 3 For example in an auditorium with a volume of 3000 m³ 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.

The direct-to-reverberant sound pressure level ratio K may 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 m³);

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

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

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

NOTE 4 Except for large auditoriums 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 seconds for lecture theatres and similar sized rooms. (primary school classrooms should have an RT value of 0.6 s or less, 0.8 for secondary school classrooms and open plan areas/seminar rooms and 0.8s to 1.2 s for assembly halls. Lecture theatres should have RT values < 1.0 s and 0.8 s for small rooms (<50 people).

It should be realized that this 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.

COMMENTARY ON 11.7

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.

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 (somewhat idealized) of some common types of microphone are shown in Figures 5 to 11. 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 Figures 9 to 11), and they might therefore pick up considerable low-frequency reverberation: this can be reduced by the careful use of equalization.

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 omni-directional, 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 12 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. It is important to minimize the actual distance in all cases, 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 5 Figures 13 to 16 show typical examples of good and bad microphone positioning.

The sound wave reflected from a desk top can interfere with the direct sound (as shown in Figure 17) which should be taken into consideration. This effect can cause considerable unevenness in the frequency response above 1 kHz, which may be minimized by positioning the microphone at least 150 mm above the surface. It may be helpful to cover the part of the desk top around the microphone with a layer of soft material, preferably at least 25 mm thick.

Figure 5 Horizontal directional response of an omni-directional microphone with its axis vertical: decibel scale

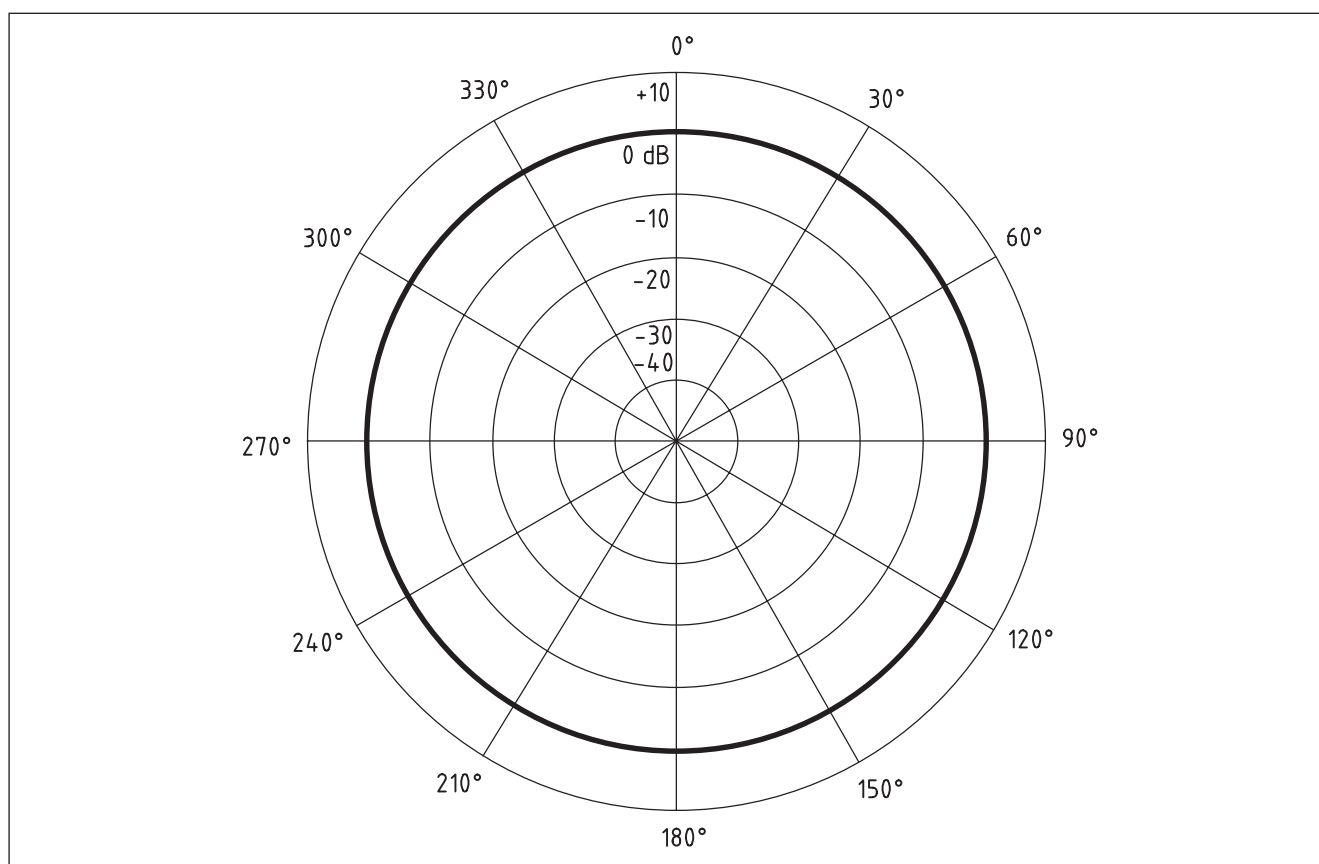


Figure 6 Directional response of a cardioid microphone: decibel scale

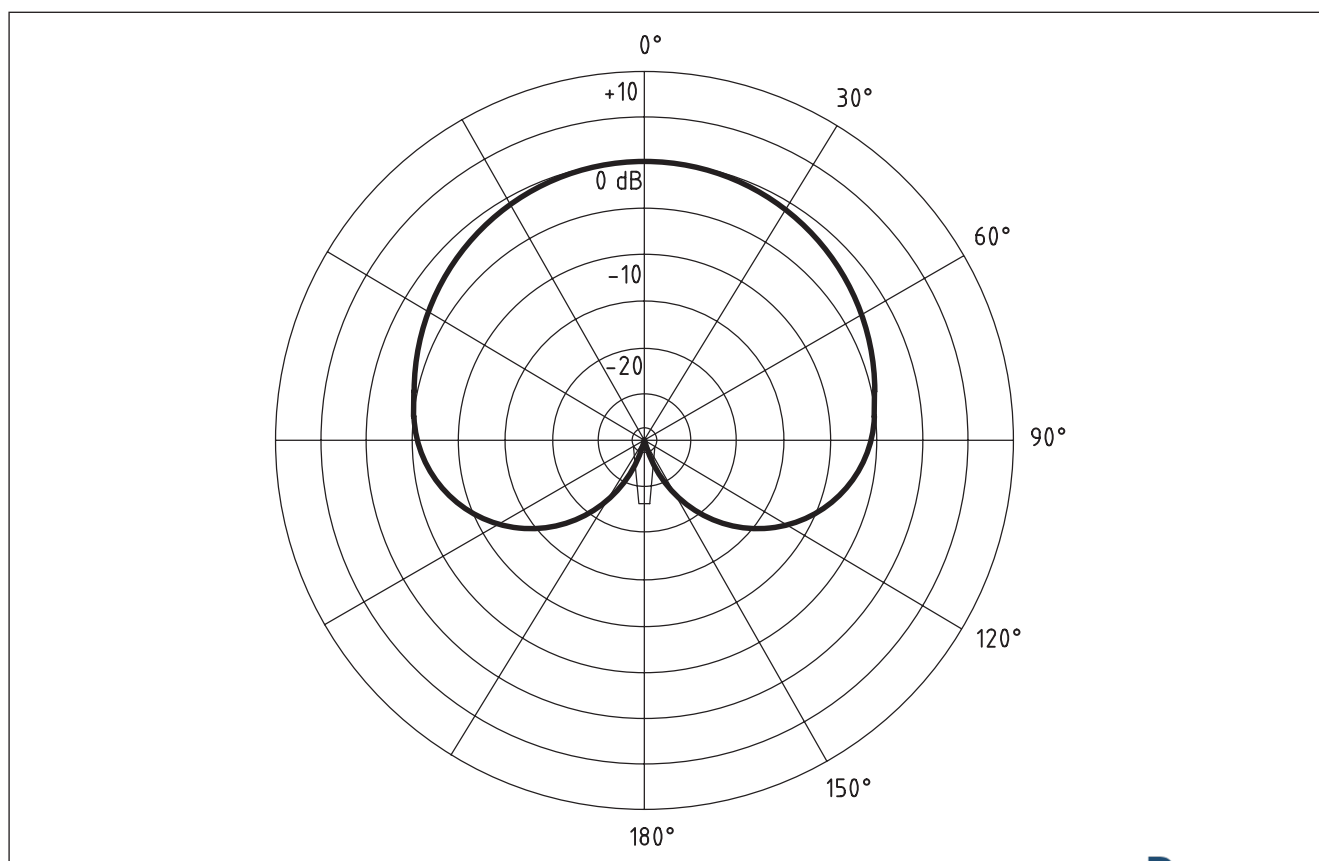


Figure 7 Directional response of a supercardioid microphone: decibel scale

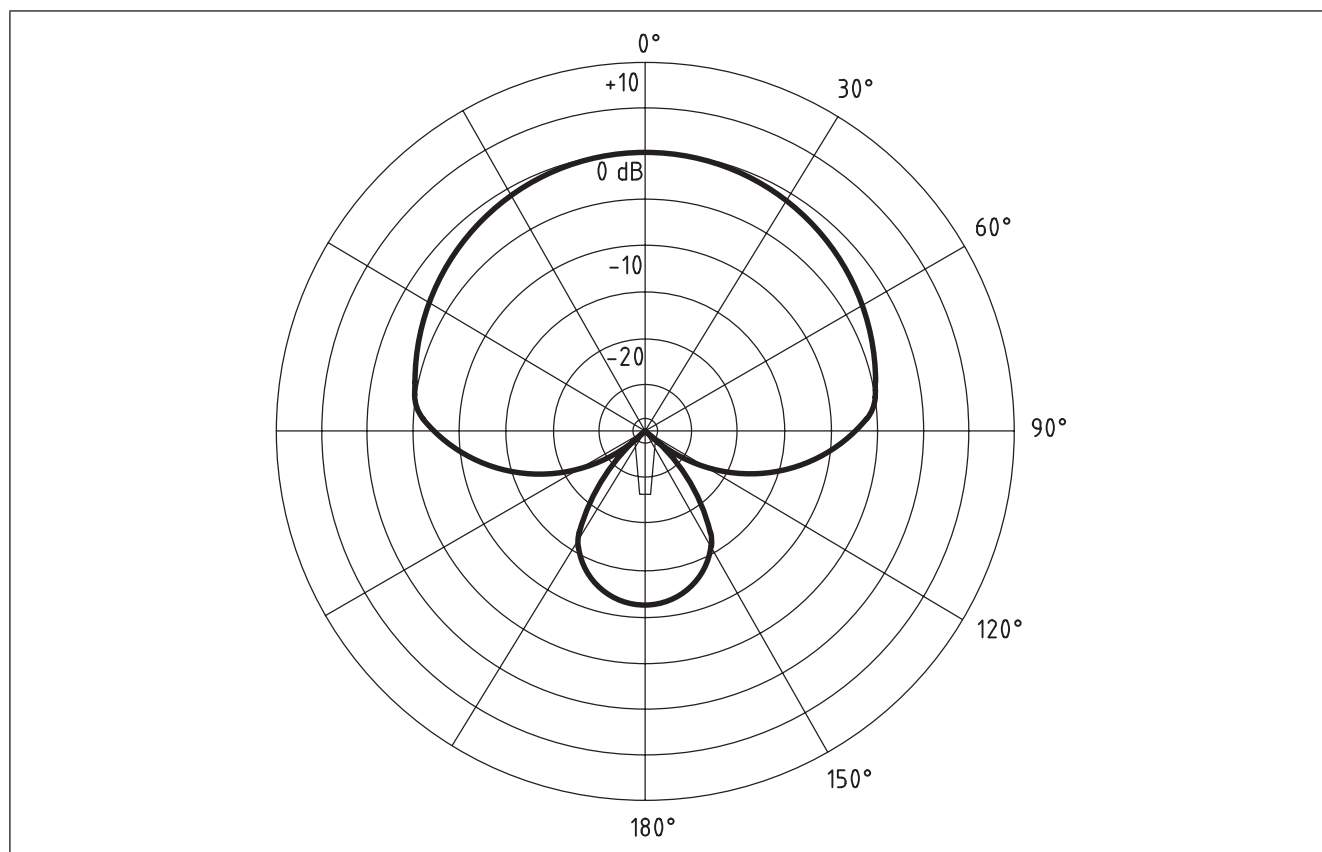


Figure 8 Directional response of a hypercardioid microphone: decibel scale

