IEC 62489-2

Edition 2.0 2014-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Electroacoustics – Audio-frequency induction loop systems for assisted hearing –
Part 2: Methods of calculating and measuring the low-frequency magnetic field emissions from the loop for assessing conformity with guidelines on limits for human exposure

Électroacoustique – Systèmes de boucles d'induction audiofréquences pour améliorer l'audition –
Partie 2: Méthodes de calcul et de mesure des émissions de champ magnétique basse fréquence à partir de la boucle pour l'évaluation de la conformité aux instructions sur les limites d'exposition humaine

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International Standard IEC 62489-2 has been prepared by IEC technical committee 29: Electroacoustics.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: it reflects several updates to the ICNIRP Guide [1][1] to which it makes frequent

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1 Numbers in square brackets refer to the Bibliography.

reference. The most significant change is that the underlying metric in the Guide has been changed from tissue current density to induced electric field.

The text of this standard is based on the following documents:

FDIS	Report on voting
29/847/FDIS	29/854/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62489 series, published under the general title *Electroacoustics – Audio-frequency induction loop systems for assisted hearing*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

A revision of IEC 62489-2 is necessary because, while the standard does not call up any particular set of exposure limits, it has numerous references to the ICNIRP Guide, which has profoundly changed between the 1998 and 2010 editions. This has resulted in a change in the physical quantity on which the basic restrictions are established, from tissue current density to induced electric field, resulting in changes to the reference levels and a considerable simplification of the application of the guidelines.

The recommendations of the new Guide have not yet been adopted at the regulatory level in the European Union. However, since the references to the Guide in IEC 62489-2 are purely informative, it does not appear that this revision should be unacceptable in Europe.

ELECTROACOUSTICS – AUDIO-FREQUENCY INDUCTION LOOP SYSTEMS FOR ASSISTED HEARING –

Part 2: Methods of calculating and measuring the low-frequency magnetic field emissions from the loop for assessing conformity with guidelines on limits for human exposure

1 Scope

This part of IEC 62489 applies to audio-frequency induction-loop systems for assisted hearing. It may also be applied to such systems used for other purposes, as far as it is applicable. The standard is intended for assessment of human exposure to low-frequency magnetic fields produced by the system, by calculation and by in-situ testing.

This standard does not deal with other aspects of safety, for which IEC 60065 applies, or with EMC.

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.

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

IEC 60268-1:1985, *Sound system equipment – Part 1: General*

IEC 60268-2:1987, *Sound system equipment – Part 2: Explanation of general terms and calculation methods*

IEC 60268-10:1991, *Sound system equipment – Part 10: Peak programme level meters*

3 Rated values

The term "rated" means "the value stated by the manufacturer". Rated values are of two kinds: rated conditions, which are fundamental values that cannot be verified by measurement, and others that can be so verified. For a full explanation, see IEC 60268-2.

4 Situation regarding current standards

Current published and draft IEC standards on EMF exposure can be ambiguous in their guidance on the approach that should be taken by product committees. The differences between the signals that are of concern and those considered in depth in EMF exposure standards are the following:

- wide relative bandwidth, i.e. the ratio of highest to lowest frequency present, 5 kHz and 100 Hz;
- no predominant frequency within the band;

- rapidly varying amplitude;
- high ratio of peak amplitude to average r.m.s. amplitude (at least 4).

5 Configurations of loops

5.1 Main types of configuration

There are four main types of configuration:

a) large area loops, with the smallest dimension larger than 1 m, usually installed at floor level in a room;

b) medium-area loops, with dimensions of the order of 1 m, often oriented in a vertical plane, installed at service desks and similar positions;

c) small area loops, with the largest dimension less than 1 m;

d) solenoid antennas, including the ear-hook.

NOTE Examples of small-area loops are portable systems, clipboards, neck loops, cushion loops (including those for use in vehicles) and chair loops.

5.2 General considerations

All loops produce strong fields close to the loop conductor(s). This is shown by the relationship between current I in a long, straight wire and the magnetic field strength H produced at a distance R from the centre of the wire, where R is greater than the radius r of the wire:

$$H = I/2\pi R \tag{1}$$

NOTE 1 Within the wire, the field strength decreases linearly from $I/2\pi r$ at the surface to zero at the centre.

NOTE 2 For n parallel conductors very close together (i.e. a multi-turn loop), the magnetic field strength is n times that produced by a single conductor.

For calculations of field strengths in the high field strength regions, very close to the conductor(s), the 'long, straight wire' approximation is almost always sufficiently accurate, except for solenoids, which need a completely different treatment (see 6.2).

5.3 Large-area loops

The occupants of a room are likely to come close to the loop conductor only by stepping on the floor at a point below which the conductor is installed. Such proximity is normally transient. However, in places of worship, devotional postures can bring parts of the body other than the feet into proximity. This can also apply in hospitals, treatment rooms and gymnasia.

Maintenance staff might come into closer contact and for longer periods, but it is unlikely that the system would then be operating.

5.4 Medium-area loops

For these, there are three considerations.

a) The hearing-aid user is normally at a distance from the loop comparable to its dimensions. Thus the loop current required to produce a maximum r.m.s. field strength of 400 mA/m (in compliance with IEC 60118-4) at the hearing-aid is much larger than the current required to produce it at the centre of the plane of the loop.

b) Nevertheless, the separation ensures that the hearing-aid user is not exposed to the high fields strengths near the loop conductor.

c) However, staff can come into close proximity of the loop conductor while the system is working unless steps are taken to maintain a minimum separation.

NOTE These loops often have more than one turn, so that the loop current can be kept reasonably small.

5.5 Small-area loops

For these, again, there are three considerations.

a) The separation for portable loops is very much greater than the loop dimensions, but for other types, the separation distance can be small or very small unless steps are taken to maintain a minimum separation.
b) The current apparently required is quite large, because of the large separation.
c) Both users and staff can come into close proximity of the loop, even that of a portable system.

NOTE These loops usually have many turns, so that the actual current is not so large.

5.6 Solenoid antennas

One example that is commercially available is the ear-hook. This device is typically as shown in Figure 1. A very small solenoid is incorporated in the stem of the device.

Figure 1 – An ear-hook induction transducer, with a BTE (behind the ear) hearing aid body for scale

6 Calculations

6.1 General

Calculation of the field strength can be reliably made using Equation (1) in almost all cases, except where the loop is very small or is a solenoid of length which is not very small compared with its plan dimensions, such as for the ear-hook device. It is necessary to calculate the current required in the loop to produce a field strength of 400 mA/m at the hearing-aid position, taking into account the orientation of the pick-up coil in the hearing-aid relative to the plane of the loop. In general, this calculation is not easy, but simple, approximate methods give sufficiently accurate results when used with insight. Proprietary calculation software, based on published mathematical analyses, exists. General-purpose mathematics software can also be used.

Translating the calculated field strengths into a form comparable with exposure guidelines or limits is considered in Clause 8.

6.2 Solenoid antennas

There is no simple expression for the field strength at a point outside a cylindrical solenoid. A solenoid may be treated as a stack of loops, or as a magnetic dipole, or the field strength can be calculated by means of a rather complex equation (see [2]).

7 Measurements

7.1 General

In the audio-frequency range, exposure time is irrelevant, because the predominant physiological effect, if it occurs, is nerve stimulation, which operates over a time-scale of a few milliseconds. It is therefore appropriate to use a quasi-peak measurement of field strength. Furthermore, exposure limits and guidelines are given in r.m.s. values, so the quasi-peak meter should be scaled to read r.m.s. values with a sinusoidal signal. This type of meter, the peak programme meter (PPM), is further described in IEC 60118-4 and IEC 60268-10 (type II) already.

It is also necessary to consider the type of magnetic field pick-up coil or sensor. Sensors may be single-axis, with just one coil, or three-axis, with three orthogonal coils. For use with a PPM, the single-axis sensor is most convenient, and if it is properly constructed, it is not difficult to orient it for maximum reading, especially as the likely direction of the field can usually be predicted from text-book field patterns.

The first measurement that shall be made is that the field strength is correct at the point or points where it is intended to be 400 mA/m (or the agreed lower value if adjusted to reduce loudness, as specified in IEC 60118-4).

NOTE IEC 60118-4 specifies the use of either a PPM or an r.m.s. meter with a 125 ms integration time for the measurement of magnetic field strength. However, for the purpose of this standard, the 125 ms integration time is incompatible with the requirement to measure field strengths over times of the order of a few milliseconds.

The instrument specified for measurements on other equipment and systems, such as in IEC 62233 [3], has an averaging time specified only as an upper limit of 1 s, which is also too slow for the assessment of fields due to audio-frequency signals.

7.2 Input signal

The input signal for the amplifier shall be the simulated programme signal described in IEC 60268-1, with additional filtering, –3 dB at 100 Hz and 5 kHz relative to the 1 kHz level, with ultimate attenuation slopes of at least 12 dB/octave.

7.3 Measuring instrument

It is unlikely that a suitable complete instrument is commercially available at present, since the application is extremely specialized. However, the design of an adapter for use with widely-available audio test equipment, or that itself provides the PPM function, is not very difficult. The elements are the following.

- The pick-up coil, which, because the field strengths of interest are high, needs few turns and no magnetic core material. Because the fields are highly inhomogeneous, the coil should be of small dimensions to minimize averaging. A coil covering four faces of a 1 cm cube of insulating material is convenient.
- A frequency-response correction circuit, which produces a constant output from a magnetic field that varies with frequency in the same way as the guidelines or limits, with bandwidth control so as to discard out-of band interference signals.
- Amplification of the signal such that the maximum permissible field strength produces an output voltage of 0,775 V for connection to the audio test equipment.
- Optionally, a quasi-peak detector substantially as specified in IEC 60268-10 (type II) and means to display its output with a resolution of 1 dB.

8 Comparison of calculated or measured results with guidelines or limits

The basic restrictions are based on the induced electric field. Table 1 gives the values for the 100 Hz to 5 kHz frequency range of audio-frequency induction-loop systems, where the head is exposed to the magnetic field.

Table 1 – Basic restrictions

Frequency (*f*) Hz	**Internal electric field strength** mV/m	
	Occupational	**General public**
100 to 400	2*f*	–
100 to 1 000	–	0,4*f*
400 to 3 000	800	–
1 000 to 3 000	–	400
3 000 to 5 000	0,27*f*	0,135*f*

The reference levels for exposure to magnetic fields given in the ICNIRP Guide are based on conversion factors between electric field strength and magnetic flux density established by research. They are shown in Figure A.1.

9 Meeting limits or guidelines

The field strength near the loop conductor is fixed by the current, which in turn is fixed by the field strength required at the hearing-aid position. It is clearly not possible to meet exposure requirements by reducing the current. It is also obvious that any form of shielding is unlikely to be practicable in most cases.

However, what can be done is to insert a physical barrier between the loop conductor and the person who might otherwise come too close to it. This barrier can be of any non-magnetic, non electrically conducting material.

10 Measurement uncertainty

The total measurement uncertainty includes sensor position and orientation, operating conditions and, for in-situ measurements, magnetic background noise (although if the system complies with IEC 60118-4, the effect of noise is negligible).