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BS EN 50496:2008

BSI British Standards

Determination of workers' exposure to electromagnetic fields and assessment of risk at a broadcast site

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National foreword

This British Standard is the UK implementation of EN 50496:2008.

The UK participation in its preparation was entrusted to Technical Committee GEL/106, Human exposure to low frequency and high frequency electromagnetic radiation.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

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Determination of workers' exposure to electromagnetic fields and assessment of risk at a broadcast site

Détermination de l'exposition des travailleurs aux champs électromagnétiques et évaluation des risques sur un site de radiodiffusion

Ermittlung der Exposition von Arbeitnehmern gegenüber elektromagnetischen Feldern und Bewertung des Risikos am Standort eines Rundfunksenders

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 106X, Electromagnetic fields in the human environment.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50496 on 2008-09-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2009-09-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-09-01

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1 Scope

The object of this standard is to provide methods for assessing compliance with the requirements of the Directive 2004/40/EC [8] at a site operating one or more broadcast transmitters.

This standard covers the frequency range up to 40 GHz.

NOTE The Council and European Parliament Directive 2004/40/EC will be transposed into national legislation in all the EU member countries. It is recommended that users of this standard consult the national legislation related to this transposition in order to identify the national regulations and requirements. These national regulations and requirements may have additional requirements that are not covered by this standard.

2 Normative references

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

[1] EN 50413, Basic standard on measurement and calculation procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz - 300 GHz)

[2] EN 50420, Basic standard for the evaluation of human exposure to electromagnetic fields from a stand alone broadcast transmitter (30 MHz - 40 GHz)

[3] EN 50475, Basic standard for the calculation and the measurement of human exposure to electromagnetic fields from broadcasting service transmitters in the HF bands (3 MHz - 30 MHz)

[4] EN 50499, Procedure for the assessment of the exposure of workers to electromagnetic fields

[5] EN 62226-2-1, Exposure to electric or magnetic fields in the low and intermediate frequency range - Methods for calculating the current density and internal electric field induced in the human body - Part 2-1: Exposure to magnetic fields - 2D models (IEC 62226-2-1)

[6] IEEE C95.3, Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields

[7] Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (Official Journal L 199 of 30 July 1999)

[8] Directive 2004/40/EC of the Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (Electromagnetic fields) – Official Journal of 30 April 2004

[9] International Commission on Non-Ionizing Radiation Protection, Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), Health Physics Vol. 74, No 4, pp 494-522, 1998

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3 Terms and definitions

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

3.1
action values
the magnitude of directly measurable parameters, provided in terms of electric field strength (E), magnetic field strength (H), magnetic flux density (B), power density (S_{eq}), limb induced current (I_L) and contact current (I_C) at which one or more of the specified measures in [8] must be undertaken. Compliance with these values will ensure compliance with the relevant exposure limit values of [8]

3.2
AIMD
Active Implantable Medical Device

3.3
antenna
device that serves as a transducer between a guided wave (e.g. coaxial cable) and a free space wave, or vice versa

3.4
near-field region
region generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point. The near-field region is further subdivided into the reactive near-field region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complicated in structure

3.5
broadcasting service
radiocommunication service in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, television transmissions or other types of transmission e.g. data

3.6
broadcast site
site operating one or more broadcast transmitters

3.7
contact current
current flowing into the body resulting from contact with a conductive object in an electromagnetic field. This is the localised current flow into the body (usually the hand, for a light brushing contact). Shocks and burns can be the adverse indirect effects. Contact current relates to a short term effect and cannot be time-averaged

3.8
induced current
current flowing inside a human body resulting directly from an exposure to an electromagnetic field

3.9
employer
any natural or legal person who has an employment relationship with the worker and has responsibility for the undertaking and/or establishment (Directive 89/391/EEC)

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3.10
exposure limit values
limits on exposure to electromagnetic fields in [8] which are based directly on established health effects and biological considerations. Compliance with these limits will ensure that workers exposed to electromagnetic fields are protected against all known adverse health effects of electromagnetic fields

3.11
local safety Instruction
safety instructions relating to a specific broadcast site and containing the information specified in Clause 8:

- it must include all the necessary safety-related indications and, if applicable, point out the possible risk of exposure to electromagnetic fields where these are at levels above the worker action values;
- it could include all the necessary safety-related indications and, if applicable, point out the possible risk of exposure to electromagnetic fields where these are at levels above the limits for the general public

3.12
transmitter
device to generate the radio frequency broadcast signal which is fed into the antenna system

3.13
worker
any person employed by an employer, including trainees and apprentices but excluding domestic servants (Directive 89/391/EEC)

3.14
work place
location where workers have access as part of their duties;
particular place of work within the broadcast site as for example the area near a transmitter with an open enclosure, the area inside a transmitting antenna, on a ladder inside a broadcast mast / tower and platforms under and above the antennas, the area around feed lines, etc.

4 Assessment methods

4.1 Worker exposure assessment

The assessment should be done using the steps outlined below:

- collection of technical data (Clause 5);
- determination of exposure levels by calculation or measurement (Clause 6). This includes checking of operating procedures in the different exposure work places (Clause 8).

The results of the assessment process are:

- zoning of exposure work places (Clause 7);
- information and training (Clause 9);
- assessment report (Clause 10).

In the case of simultaneous exposure to multiple sources, the combined exposure shall be considered, referring to Annex A.

4.2 Use of public exposure assessment

If an evaluation has already been undertaken in accordance with the provisions of Council Recommendation 1999/519/EC [7], and the restrictions as specified therein are respected, then the exposure limit values for workers of [8] are also met.

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4.3 Assessment after technical modification

After technical modification like maintenance or repair of the installation or the environment, it is necessary to consider repeating or revising the assessment. This is particularly necessary if an additional transmitter or antenna is added to a site where there are already one or more transmitters.

5 Collection of technical data

Information on the following items may be needed:

- with regard to the surrounding area
  - information on the nature of the field from any external sources should be obtained from the operators of those sources. Examples of useful information are the frequency, the type of service, and whether the transmissions are intermittent. However, it should be noted that much of the detailed information may be commercially sensitive.
- with regard to the site
  - the area controlled e.g. information on property, fencing, where the controlled area is bounded,
  - the site map showing all facilities, e.g. buildings, towers, anchor cables, earth net…,
  - the several areas
    - where a public assessment has been done in compliance with [7] or national regulation,
    - where workers have access without specific care,
    - where workers have only access under specific circumstances.
- with regard to ELF emissions, the location of all 50 Hz site power supplies or transformers connected to low voltage networks.
- with regard to the radio-frequency emissions, for each relevant source
  - the mechanical configuration of the antennas, geometric dimensions, construction drawings, position in the mast, etc.,
  - radiation pattern, polarisation and gain of antennas,
  - maximum and nominal power transmitter,
  - frequency, type of modulation (AM, FM, COFDM, etc.), channel bandwidth,
  - feeder type and length, attenuation/meter,
  - additional losses (combiners, patch panels, antenna cables and power dividers).
- with regard to scheduling
  - transmitting time table (especially for short wave),
  - permitted operating configuration.

6 Determination of exposure levels by calculation or measurement

The collection of data permits to take into account the identification of sources of electromagnetic fields in or around the site during the assessment. However, this standard does not directly address product performance standards, which are intended to limit electromagnetic field (EMF) emissions under specified test conditions.

6.1 Methodologies

The work place is often in near field conditions where the situation is rather more complicated than in the far field. This is because the maxima and minima of the *E* and *H* fields do not occur together along the direction of propagation as they do in the far field. In the near field, the electromagnetic field structure may be highly inhomogeneous, and there may be substantial variations from the plane-wave impedance of 377 ohms; that is, there may be preponderant E fields in some regions and preponderant H fields in others. At 50 Hz, the E or the H- field may be very dominant, or both E and H field may be present.

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As a consequence, for each type of electromagnetic source, it is not possible to specify specific methodologies in this document. Therefore this standard refers to other appropriate standards to define the appropriate methodologies [1].

6.1.1 Exposure from power supplies

The annex on AC electricity supplies in EN 50499 [4] gives guidance for assessing 50 Hz power supplies and in particular criteria for power sources which are deemed to comply without any further assessment.

6.1.2 Exposure from transmitters from 9 kHz to 100 kHz

Methodologies of measurement and calculation are defined in EN 62226-2-1 [5] and IEEE 95.1 [6].

6.1.3 Exposure from transmitters from 100 kHz to 30 MHz

Methodologies of measurement and calculation are defined in:

- EN 50475 [3] for 3 MHz to 30 MHz;
- between 100 kHz and 3 MHz: under consideration in CENELEC/TC 106X WG3.

Information can also be found in ITU-R BS.1698.

6.1.4 Exposure from transmitters from 30 MHz to 40 GHz

Methodologies of measurement and calculation are defined in EN 50420 [2].

Information can also be found in ITU-R BS.1698.

Subclause 6.3 gives the process for use of a broadband field meter in a mast. Assessment of both the E and H fields may need to be performed.

6.2 Additional considerations

6.2.1 Use of action values

Compliance with the action values will ensure compliance with the relevant exposure limit values. If the measured or calculated value exceeds the action values, it does not necessarily follow that the exposure limit values will be exceeded.

6.2.2 Multiple exposure

With regard to simultaneous exposure to multiple frequency fields, it is important to identify multiple sources of exposure or simultaneous exposure to multiple frequency fields and to use appropriate methods of assessment, measurement and/or calculation capable of analysing the characteristics of the waveforms and nature of biological interactions (see flowchart in Figure 1).

Once identified, the combination of different frequency components should be carried out separately for thermal effects and electrical stimulation.

The formulae in Annex A apply to the relevant frequencies under practical exposure situations and have to be used to establish compliance to the action levels or exposure limits for all the frequencies together.

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6.2.3 Averaging

6.2.3.1 Time averaging

These following rules come from the ICNIRP Guidelines [9].

Exposure limit value

- For frequencies up to 10 GHz: all SAR values are to be averaged over any 6 min period.
- For frequencies between 10 GHz and 300 GHz: Power densities are to be averaged over any 20 cm^2 of exposed area and any $68/f^{1,05}$ min period (where *f* is in GHz) to compensate for progressively shorter penetration depth as the frequency increases.

Action value

- For frequencies between 100 kHz and 10 GHz: S_{eq}, E^2, H^2, B^2 and $I_L{}^2$ are to be averaged over any 6 min period.

  Particular case: For E^2, H^2, S_{eq} in case of specific modulation (like FM and digital OFDM emissions for instance), the field strength can be averaged over a lower period due to the constant power transmitted, because average value is equal to the instantaneous value in this case.
- For frequencies exceeding 10 GHz: S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1,05}$ min period (*f* in GHz).

6.2.3.2 Spatial averaging

In case of whole body exposure, from basic physics, spatial averaging in the typical situation like in a FM/TV mast, where a worker is moving in an EMF produced by a constant intensity source can be considered to be equivalent to time averaging on a stationary worker from source whose intensity varies with time.

The length of averaging path is given by the product of the averaging time, (6 min), and the velocity of movement of the worker along that path. An assessment of the appropriate speed needs to be made.

Consider, for example a worker who moves in a FM/TV mast with a velocity of 10 m per minute, then the integration path is 60 m. A typical use of this rule is the case when a worker climbs a ladder near several stages of antenna located between 2 platforms.

For instance, if the field strength is locally twice the action value between these platforms then the worker can be allowed to pass through this area if he will stay there no longer than ($6/2^2$=1,5 min). Therefore, he would have climbed a length around 15 m during this 1 min 30 s. This is possible, providing the fact that below and above this area, that means on the platforms, the exposure is negligible.

NOTE 1 The field strength can not exceed reasonably twice the action level because of the time necessary to climb between 2 platforms.

NOTE 2 Averaging is allowed providing local exposure is not exceeded. If the field strength does not exceed twice the action value, local exposure is under the exposure limit according the ration between whole body SAR and local SAR (factor of 25 if expressed in power and factor of 5 if expressed in field).

The workers shall be informed and the information shall be recorded in the assessment report (Clause 10).

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6.2.4 Polarisation

In the frequency range below 100 MHz, when the long axis of the human body is parallel to the electric field vector, and under plane-wave exposure conditions (i.e. far-field exposure), whole-body SAR reaches maximal values. In this frequency range, the action values are conservative for other coupling conditions.

6.3 Determination process

To ensure the safety of people carrying out measurements in unknown electromagnetic fields and to avoid damage of measuring instruments, it is necessary to assess expected field strengths before taking any action and then to decide the measurement plan and to select appropriate monitoring equipment. Furthermore this knowledge enables the choice of adequate measuring equipment (see EN 50413 [1] for selection of measurement equipment and safety issues for the personnel carrying out measurements).

Following the analysis of the data gathered from Clause 5, collection of technical data, the work place of investigation can be split in different sub-areas taking into account the field levels and frequencies expected.

Particular attention shall be paid to unintentional radiation coming from other equipments such as feed lines, filters, combiners especially at SW and MW broadcast site.

All sources that produce field strength of one fifth or more of the action value at the location being assessed should be included in the assessment.

The following flowchart defines the process to complete the assessment of the work place.

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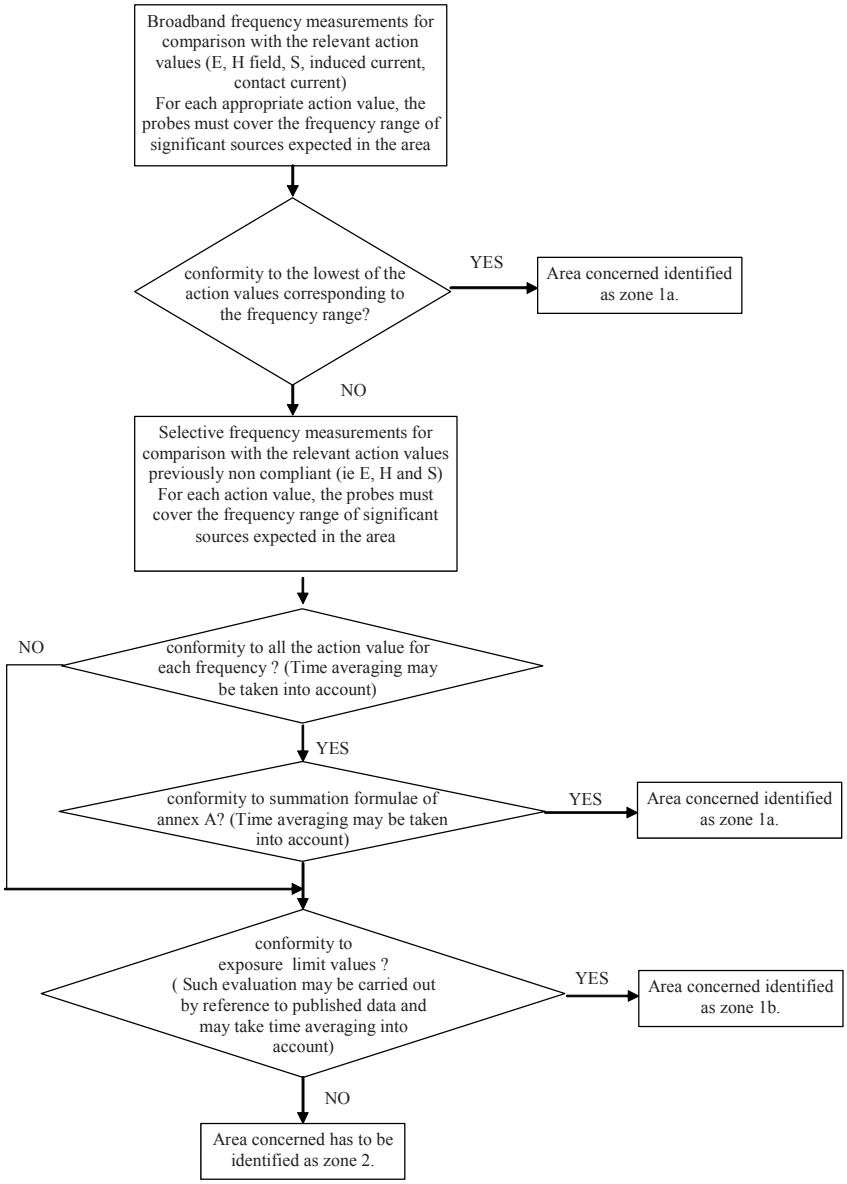

NOTE See Clause 7 for the definition of the zones.

Figure 1 - Work place assessment process

7 Zoning of exposure work place

If an employer wants to identify work places where exposures may exceed those recommended for the general public, a zoning concept can be used. To facilitate this, it is proposed a simple zoning of the workplace such as that described in the following paragraph could be applied.

These are not intended to be strict or “hard” boundaries corresponding to the exact locations that different exposure levels might be exceeded. Instead they might correspond, for example, existing areas of a work place:

– Zone 0: work place in which all exposure levels comply with the relevant general public limits.

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- Zone 1: work place where exposures may be greater than the general public limit but will be compliant with the worker exposure limit. It can be split into two sub-zones:
  - Zone 1a: compliance with the action values;
  - Zone 1b: compliance with the exposure limit values but not with the action values.
- Zone 2: work place where exposures may be greater than the worker exposure limit.

Various zones (as described above) are defined, but whether and where the exact zone boundaries are decided is a matter for the individual employer. What actions (if any) are to be taken at zone boundaries also is a matter for the employer.

8 Checking of operating procedures in the different exposure work places

Exposure in the work place shall be linked with information and training of people accessing the broadcast site. Consequently, it is necessary to identify general safety rules applicable to the site. These include the locations of the different work places and which information/training is adequate to people accessing those work places.

8.1 Work place access conditions

Work place access conditions are directly linked with the zoning concept.

8.1.1 Work place in Zone 0: access not limited by EMF restrictions

No access restrictions are required in relation to EMF exposures.

8.1.2 Work place in Zone 1: access limited due to EMF restrictions

Employers have to take the exposure of workers into consideration in organising the activity in the work place.

The employer shall make information available to its workers accessing the zone as detailed in 8.3.

If conformity to limit values has not been demonstrated for the work place then the work place needs to be considered as a Zone 2 area.

8.1.3 Work place in Zone 2: access prohibited without modifications to the transmitter or access conditions

Nobody is to be admitted into this work place, except for workers provided with adequate personal protection equipment. The personal protection equipment must ensure compliance with the exposure limits to its user. Alternatively, the Zone 2 work place may be temporarily changed into a Zone 1 work place (for example, by power reductions).

Access to a Zone 2 area must be prevented by either physical or management controls.

8.2 Signage and delimitation

The boundary between exposure Zones 1 and 2 must be clearly visible. This means that they can be seen from the surrounding and working pathways, or from any other possible access ways. Such signage may, however, be omitted when the sources are not normally accessible (e.g. for electrical safety reasons). An example of signage is presented in Annex B.

A typical use of this rule is the case when a worker climbs a ladder in a mast with broadcast antennas. Signage for Zone 2 needs to be on the access path itself but not outside this. In this latter region, training provides the worker with the information required to deal with the situation.

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8.3 Specific documentation

For each site, the following documentation must be compiled and maintained:

For Zone 1: General information including the results of the assessment of exposure in the work place demonstrating that the action values are not exceeded.

Additionally for Zone 1b: The values and concepts of the exposure limit values and action values and the associated potential risks:

- documentation demonstrating that the exposure limit values are not exceeded;
- documentation incorporating the conditions under which access is permitted. For example, if time-averaging is used a justification for a proposed occupancy duration shall be included;
- documentation detailing any other specific actions workers must take in order to manage exposure.

For Zone 2 areas: Documentation explaining the rationale for a classification in Zone 2 (normally associated with a potential risk that the exposure limit values are exceeded), giving boundaries of Zone 2 beginning and specific local safety instructions.

This documentation must be accessible throughout the facility's operating life.

8.4 Personal protective equipment

In specific cases, personal protective equipment can be used, with a view to avoid non-acceptable exposure. The user must be trained in the specific instructions for the use of such equipment and instructions related to the site. In particular, the equipment shall be assessed to ensure that the attenuation factor is such that protection is assured for the considered frequencies.

Attenuation assessment of such equipment shall be done following European directive 89/686/EEC on protective equipment following methodology like those described in German standard DIN 32780-100 Annex A (March 2002), for frequencies below 1 GHz.

8.5 Safety instructions

Where required, Safety instructions shall be established. They must include all the necessary safety-related indications and, if applicable, point out the possible risk of exposure to electromagnetic fields.

Typically, the equipment or facilities' operation manuals contain important indications for the preparation of the local safety instructions. They can be supplemented by specific provisions, and may be defined according to the commissioning, operation and maintenance conditions.

If necessary, excerpts from the local safety instructions shall be posted visibly on the site.

8.6 Maintenance work

Maintenance work has to be carried out in accordance with the local safety instructions.

The local safety instructions include the following provisions:

– if maintenance work is carried out when the facilities are shut down, it is sufficient that the local safety instructions include provisions that prohibit their restarting;

– the local safety instructions must demand that the necessary equipment be available for the safe performance of the maintenance and repair work, and that the workers be specifically briefed as to the work to be performed;

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– maintenance work in exposure work place 1b must not be performed before the adequate information has been given;

– if maintenance needs to be carried out at a workplace which is normally a Zone 2

  - exposure must be reduced below the limits,

  or

  - a protective suit must be used and the staff must be briefed prior to the beginning of work.

In cases where exposure work places are modified, special instructions on the various organisational stages shall be provided:

– temporary delimitation signs and placards to be installed,

– the power level reductions and the return to the normal conditions.

8.7 Inspections

Rules applicable to the performance of inspections shall be defined by the employer. These inspections are related to the correct application of the appropriate regulations, and the verification of equipment and exposure work places via measurement or computation of the EMF levels (engineering check).

8.8 Active implantable medical devices

The operation of active implantable medical devices (AIMD) can be influenced by electromagnetic fields.

Employer has to take care and to provide information and appropriate protective measures.

NOTE CENELEC/TC 106X WG15 is drafting a standard for assessing EMF risk for bearers of AIMD.

9 Information and training

The employer shall ensure that workers who are exposed to risks from electromagnetic fields at work and their representatives receive any necessary information and training relating to the outcome of the risk assessment.

Employer may need to advise workers representatives if basic restrictions from Council Recommendation 1999/519/EC [7] are exceeded in work place.

9.1 Information for workers

Information shall be given for sites where action values are exceeded, and, at a minimum, include the following items:

– suitable behaviour on the work site and especially with regard to Zone 1b and 2 areas;

– safety instructions;

– electromagnetic fields and their direct and indirect effects on human bodies;

– signage at the work site, protective measures.

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9.2 Training of workers

The basic training shall address the following issues:

- potential risks related to exposure to electromagnetic fields;
- prevention and protection measures to be implemented according to the work site;
- the evaluation of the exposure levels and classification of the exposure work place;
- the use of protective equipment to access Zone 2;
- the actions to be taken in the case of over-exposure.

Training courses shall be repeated at regular intervals, suitable for the specific constraints of the operations.

Special measures may be taken to suit company-specific requirements, for instance: the regular training sessions may be replaced by instructions given immediately before the start of activity in the work place involved.

10 Assessment report

The assessment report shall detail the following items:

- assessment reasons;
- installation situation;
- measurements equipment and methodologies;
- assessment uncertainty;
- limits and normative references;
- measurements reference points;
- EMF calculation;
- on site measurements results;
- conclusion.

An example form of a report can be seen in EN 50499 [4].

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Annex A
(normative)

Summation formulae

It is important to determine whether, in situations of simultaneous exposure to fields of different frequencies, these exposures are additive in their effects. Additivity should be examined separately for the effects of thermal and electrical stimulation, and the exposure limit value below should be met. The formulae below apply to relevant frequencies under practical exposure situations.

The following methods are based on ICNIRP Guidelines [9].

A.1 Frequency range from 1 Hz – 10 MHz

For investigation in the frequency domain, it is most realistic to include relative phase. This can be achieved by using a waveform capture approach with *post hoc* Fourier analysis. This procedure is applicable if there are only line spectra in the signal, for example for magnetic fields having a fundamental frequency and some harmonics.

In this frequency range the underlying exposure limit value is induced current density. The exposure limit based on summations may or may not include consideration of phase. The most conservative is to neglect phase information.

Therefore, as a worst case assumption multiple current densities at different frequencies should be evaluated according to the following formula:

$$\sum_{i=1\,\mathrm{Hz}}^{10\,\mathrm{MHz}} \frac{J_i}{J_{\mathrm{L},i}} \leq 1$$

where

J_i is the current density at frequency i;

$J_{\mathrm{L},i}$ is the current density exposure limit value at frequency i according [8].

When electric and magnetic field strengths are measured, the exposures should be summed according to these formulae:

$$\sum_{i=1\,\mathrm{Hz}}^{1\,\mathrm{MHz}} \frac{E_i}{E_{\mathrm{L},i}} + \sum_{i>1\,\mathrm{MHz}}^{10\,\mathrm{MHz}} \frac{E_i}{\mathrm{a}} \leq 1$$

and

$$\sum_{j=1\,\mathrm{Hz}}^{65\,\mathrm{kHz}} \frac{H_j}{H_{\mathrm{L},j}} + \sum_{j>65\,\mathrm{kHz}}^{10\,\mathrm{MHz}} \frac{H_j}{\mathrm{b}} \leq 1$$

where

E_i is the electric field strength at frequency i;

$E_{\mathrm{L},i}$ is the electric field strength action value at frequency i;

H_j is the magnetic field strength at frequency j;

$H_{\mathrm{L},j}$ is the magnetic field strength action value at frequency j;

a is 610 V/m;

b is 24,4 A/m (30,7 µT).

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This summation always results in an overestimation of the exposure and for broadband fields consisting of higher frequency harmonic components or noise, the limitation based on summation formula is very conservative because the components do not have the same phase.

With most measurement equipment the relative phases are not measured (for example if a spectrum analyser is used), but a summation of all frequency components can be undertaken. This will usually give a more realistic outcome than neglecting phase information completely. Examples for the r.m.s evaluation are:

$$H = \sqrt{\sum_{n=1}^{n=k} \left(\frac{H_n}{H_{\mathrm{L},n}} \right)^2} \quad \text{and} \quad E = \sqrt{\sum_{n=1}^{n=k} \left(\frac{E_n}{E_{\mathrm{L},n}} \right)^2}$$

where

H_n, E_n is the magnitude of the nth Fourier component of the exposure waveform in the same quantity as $H_{\mathrm{L},n}$, $E_{\mathrm{L},n}$;

$H_{\mathrm{L},n}$, $E_{\mathrm{L},n}$ is the maximum permissible exposure value of the *E*-field or *H*-field; with a single sinusoidal waveform at frequency f_n;

k is the maximum frequency to be considered.

The overestimation of the linear summation can be reduced by using the weighted peak approach presented in the ICNIRP guidelines [9].

A.2 Frequency range from 100 kHz – 300 GHz

In this frequency range, the limit exposure is based on the avoidance of thermal effects. The exposure limit value are on *SAR* and power density, and summation of these quantities should follow the formula

$$\sum_{i=100\,\mathrm{kHz}}^{10\,\mathrm{GHz}} \frac{SAR_i}{SAR_{\mathrm{L}}} + \sum_{i>10\,\mathrm{GHz}}^{300\,\mathrm{GHz}} \frac{S_i}{S_{\mathrm{L}}} \leq 1$$

where

SAR_i is the *SAR* caused by exposure at frequency *i*;

SAR_{L} is the *SAR* exposure limit value;

S_i is the power density at frequency *i*;

S_{L} is the power density exposure limit value.

NOTE *SAR* can be for the whole body or part of body. Partial-body *SARs* (local *SARs*) should be summed together; whole body *SARs* should be summed together. Partial body *SAR* should not be summed with whole body *SAR*.

Exposure field strengths can be compared to the action values on a squared basis:

$$\sum_{i=100\,\mathrm{kHz}}^{1\,\mathrm{MHz}} \left(\frac{E_i}{c} \right)^2 + \sum_{i>1\,\mathrm{MHz}}^{300\,\mathrm{GHz}} \left(\frac{E_i}{E_{\mathrm{L},i}} \right)^2 \leq 1$$

and

$$\sum_{j=100\,\mathrm{kHz}}^{1\,\mathrm{MHz}} \left(\frac{H_j}{d} \right)^2 + \sum_{j>1\,\mathrm{MHz}}^{300\,\mathrm{GHz}} \left(\frac{H_i}{H_{\mathrm{L},j}} \right)^2 \leq 1$$

where

E_i is the electric field strength at frequency i;

$E_{L,i}$ is the electric field strength action value at frequency i;

H_j is the magnetic field strength at frequency j;

$H_{L,j}$ is the magnetic field strength action value at frequency j;

c is 610/f V/m (f in MHz);

d is 1,6/f A/m (f in MHz).

Under this thermal summation regime, the relative phases of the spectral components can be neglected.

The summation formula for limb current is:

$$\sum_{k=10\,\mathrm{MHz}}^{110\,\mathrm{MHz}} \left(\frac{I_k}{I_{L,k}} \right)^2 \leq 1$$

where

I_k is the limb current component at frequency k;

$I_{L,k}$ is the action value for limb current.

Under this thermal summation regime, the relative phases of the spectral components can be neglected.

A.3 Contact currents in the frequency range 1 Hz – 110 MHz

For contact current in the frequency range 1 Hz – 110 MHz, the following requirements should be applied:

$$\sum_{n=1\,\mathrm{Hz}}^{110\,\mathrm{MHz}} \frac{I_n}{I_{C,n}} \leq 1$$

where

I_n is the contact current component at frequency n;

$I_{C,n}$ is the action value for contact current at frequency n.

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Annex B
(informative)

Marking

Marking shall be done in accordance to Directive 92/58/EEC and IEC 60417-5140.

The following marking indication is given as an example.

The pictogram shown below indicates the presence of one or more EMF radiating sources likely to generate conditions leading to a non-acceptable exposure.

Figure B.1 - Presence of electromagnetic field sources

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