SIST

SLOVENSKI STANDARD
SIST EN 50647:2017

01-september-2017

Osnovni standard za ocenjevanje izpostavljenosti delavcev elektromagnetnim sevanjem, ki jih oddajajo oprema in inštalacije za proizvodnjo, prenos in razdeljevanje električne energije

Basic standard for the evaluation of workers' exposure to electric and magnetic fields from equipment and installations for the production, transmission and distribution of electricity

Basisnorm für die Evaluierung der beruflichen Exposition gegenüber elektrischen und magnetischen Feldern ausgehend von Komponenten und Anlagen zur Erzeugung, Übertragung und Verteilung elektrischer Energie

Norme fondamentale pour l’évaluation de l’exposition des travailleurs aux champs électriques et magnétiques produits par les équipements et installations de production, transport et distribution d’électricité

Ta slovenski standard je istoveten z: EN 50647:2017

ICS:

13.100	Varnost pri delu. Industrijska higiena	Occupational safety. Industrial hygiene
17.220.01	Elektrika. Magnetizem. Splošni vidiki	Electricity. Magnetism. General aspects

SIST EN 50647:2017 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50647

June 2017

ICS 17.220.20; 17.240

English Version

Basic standard for the evaluation of workers' exposure to electric and magnetic fields from equipment and installations for the production, transmission and distribution of electricity

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 50647:2017 E

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European foreword

This document [EN 50647:2017] has been prepared by CLC/TC 106X “Electromagnetic fields in the human environment”.

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2018-04-10
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2020-04-10

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1 Scope

This European Standard provides a general procedure to assess workers' exposure to electric and magnetic fields (EMF) in work places associated with the production, transmission and distribution of electric energy, and to demonstrate compliance with exposure limit values and action levels as stated in the Council and European Parliament "EMF" Directive 2013/35/EU [11].

NOTE 1 The Council and European Parliament Directive 2013/35/EU will be transposed into national legislation in all the EU member countries. It is important 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

It has the role of a specific workplace standard. It takes into account the non-binding application guide for implementing the EMF Directive [10] and it defines the assessment procedures and compliance criteria applicable to the electric industry.

The frequency range of this standard covers from DC to 20 kHz, which is sufficient to include the power frequency used for electric power supply systems throughout Europe (50 Hz) and the various harmonics and inter-harmonics occurring in the supply system. In this extremely low frequency range, electric and magnetic fields are independent and, therefore, they both have to be addressed in the exposure assessment.

NOTE 2 Electrical companies also use radio frequency transmissions to operate and maintain their networks and power plants. Similarly, other exposures to EMF may occur during maintenance operations, for instance, due to the use of hand-held electrical tools. All these EMF sources are outside the scope of this standard.

NOTE 3 Regarding EMF in the low frequency range, the scientific basis of the EMF directive is the ICNIRP health guidelines published in 2010 [13]. Reference is made to this scientific basis when necessary for justifying or clarifying some of the technical statements of the present document.

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.

EN 61786-1, *Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings - Part 1: Requirements for measuring instruments (IEC 61786-1)*

EN 50527-1, *Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices - Part 1: General*

EN 50527-2-1, *Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices - Part 2-1: Specific assessment for workers with cardiac pacemakers*

IEC 61786-2, *Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings - Part 2: Basic standard for measurements*

3 Terms, definitions, physical quantities, units and abbreviations

3.1 Terms and definitions

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

3.1.1
action level
AL
operational level established for the purpose of simplifying the process of demonstrating compliance with the relevant exposure limit value or, where appropriate, to take relevant protection or prevention measures

Note 1 to entry: "Reference levels" as defined in the European Recommendation 1999/519/EC [3] for limiting the exposure of the public and in ICNIRP Health Guidelines [13] are based on the same approach as Action Levels and the two terms are defined to achieve the same objective.

Note 2 to entry: For electric fields, "Low ALs" and "High ALs" are levels which relate to the specific protection or prevention measures specified in the EMF Directive [11].

Note 3 to entry: The Low AL for external electric field is based both on limiting the internal electric field below ELVs and on limiting spark discharges in the working environment. Below the High AL, the internal electric field does not exceed ELVs and annoying spark discharges are prevented, provided that the relevant protection measures are taken.

Note 4 to entry: For magnetic fields, "Low ALs" are levels which relate to the sensory effects ELVs and "High ALs" to the health effects ELVs.

Note 5 to entry: Compliance with the ALs will ensure compliance with the relevant ELVs. If the assessed exposure values are higher than the ALs, it does not necessarily follow that the ELVs have been exceeded, but a more detailed analysis is necessary to demonstrate compliance with the ELVs.

Note 6 to entry: ALs may not provide adequate protection to workers at particular risks, for whom a particular risk assessment shall be performed.

3.1.2
compliance distance
distance from a source of field that ensures respect of the relevant exposure limit values or action levels

Note 1 to entry: Working at distances smaller than compliance distances requires a specific assessment.

3.1.3
contact current
current between a person in established contact with a conductive object, resulting from the inductive or capacitive coupling between the field and the person and/or object, and expressed in amperes (A)

Note 1 to entry: The EMF directive [11] specifies limits for the steady-state value of the contact current.

3.1.4
electric field
constituent of an electromagnetic field which is characterized by the electric field strength ***E*** together with the electric flux density ***D***

Note 1 to entry: In French, the term "champ électrique " is also used for the quantity electric field strength.

[SOURCE: IEV, ref 121-11-67]

3.1.5
exposure index
EI
assessed exposure divided by the relevant action level or exposure limit value

3.1.6
exposure-limit-equivalent field
LEF
magnitude of uniform external electric or magnetic field that exposes the person to the sensory or health effects ELV

Note 1 to entry: The numerical values of LEFs are derived from dosimetry.

3.1.7
exposure limit value
ELV
limit which is based directly on established health effects and biological considerations

Note 1 to entry: In the frequency range covered by the present standard, ELVs are expressed in terms of induced electric fields except between 0 Hz and 1 Hz where the ELV is given in terms of external magnetic field.

Note 2 to entry: "Basic restrictions" as defined in the European Recommendation 1999/519/EC [3] for limiting the exposure of the public and in ICNIRP Health Guidelines [13] are based on the same approach as Exposure Limit Values and the two terms are defined to achieve the same objective.

3.1.8
exposure limit values for sensory effects (sensory effects ELVs)
ELVs above which workers might be subject to transiently disturbed sensory perceptions, i.e. retinal phosphenes and minor changes in brain functions

Note 1 to entry: The sensory effects relate only to the central nervous system of the head. Exceeding sensory effects ELVs is allowed under controlled conditions for informed workers.

3.1.9
exposure limit values for health effects (health effects ELVs)
ELVs above which workers might be might be subject to adverse health effects, such as stimulation of nerve and muscle tissue

Note 1 to entry: Compliance with health effects ELVs will ensure that workers exposed to electric and magnetic fields are protected against all established adverse health effects.

Note 2 to entry: The threshold for muscle excitation is far higher than for nerve excitation, and therefore the directive [11], consistently with its scientific basis [13], considers limits to prevent only nerve excitation, as they are conservative with regard to muscle excitation. As a result, the health effects relate to the peripheral nervous system, i.e. the whole body.

3.1.10
induced electric field
electric field inside a human body resulting directly from an exposure to an external source of electric or magnetic field

3.1.11
magnetic field
constituent of an electromagnetic field which is characterized by the magnetic field strength ***H*** together with the magnetic flux density ***B***

Note 1 to entry: In French, the term "champ magnétique" is also used for the quantity magnetic field strength.

Note 2 to entry: In this document, the term magnetic field is used for magnetic flux density.

[SOURCE: IEV ref 121-11-69]

3.1.12
total exposure index
TEI
sum of all exposure indexes (e.g. at different frequencies, or from different sources) of either electric or magnetic field

Note 1 to entry: If the total exposure index is less than one, the exposure is compliant.

Note 2 to entry: Using the arithmetic sum makes the TEI a conservative assessment of exposure.

3.1.13
unperturbed field
field at a point that would exist in the absence of persons or in the absence of movable objects which are not necessary for the work progress

Note 1 to entry: All limits expressed in terms of fields external to the human body refer to the unperturbed field.

[SOURCE: EN 61786-1:2014, 3.3.1]

3.2 Physical quantities and units

For the purposes of this document, the physical quantities and units given in Table 1 apply.

Table 1 — Physical quantities and units

Quantity	Symbol	Unit	Comments
Electric field strength	E	V/m	
Magnetic flux density	B	T	μT is more usually used at 50 Hz
Contact current	I_c	A	

3.3 Abbreviations

AL	action level
CNS	central nervous system
DC	direct current
EI	exposure index
ELV	exposure limit value
GIS	gas insulated substation
HV	high voltage
LEF	exposure limit equivalent field
PNS	peripheral nervous system
TEI	total exposure index
WPR	worker at particular risk
rms	root mean square

4 Assessment procedure

According to Article 4 of EU Directive 2013/35/EU [11] "...the employer shall assess all risks for workers arising from electromagnetic fields at the workplace and, if necessary, measure or calculate the levels of electromagnetic fields to which workers are exposed......In workplaces open to the public it is not necessary for the exposure assessment to be carried out if an evaluation has already been undertaken in accordance with the provisions on the limitation of exposure of the general public to electromagnetic fields, if the restrictions specified in those provisions are respected for workers and if the health and safety risks are excluded. Where equipment intended for the public use is used as intended and complies with Union law on products that establishes stricter safety levels than those provided for by this Directive, and no other equipment is used, these conditions are deemed to be met."

Electrical equipment for the production, transmission and distribution of electricity is highly standardized and a few general assessments may cover many sites which have similar equipment and work positions. Therefore, a systematic and thorough assessment of every site containing electrical equipment is not necessary. For a given site, the risk assessment should be limited to any specific equipment or work positions not covered by the general assessments.

The exposure assessment shall be updated if any modification to the installation, the working environment or the work practice significantly affects the EMF exposure conditions.

In electrical companies, many workplaces are exposed simultaneously to electric and magnetic fields. The internal electric fields induced simultaneously by external electric and magnetic fields are vectors, which most often are neither collinear in space nor coincident in phase. ICNIRP's position [13] is that situations where these field vectors are collinear and in phase "*are judged to be very infrequent taking into account the great difference in the distribution of the electrically and magnetically induced electric fields*".

Therefore, when assessing compliance with the Directive according to the present standard, exposure to low frequency electric and magnetic fields shall be considered separately and not additively.

This clause gives a general procedure for the exposure assessment of a work place, which is presented in Figure 1 as a flowchart. It shows all the possible methods to demonstrate compliance with the EMF directive [11]. The different steps of this flowchart are developed in Clauses 5, 7, 8, 9, 10 and 13.

Compliance can be demonstrated using any of the possible methods. For example, in some cases it might be more simple and efficient to demonstrate compliance using measurements (e.g. subclause 8.3) rather than identifying all the electrical equipment and checking whether it meets the criteria for simplified assessment (e.g. subclause 8.2).

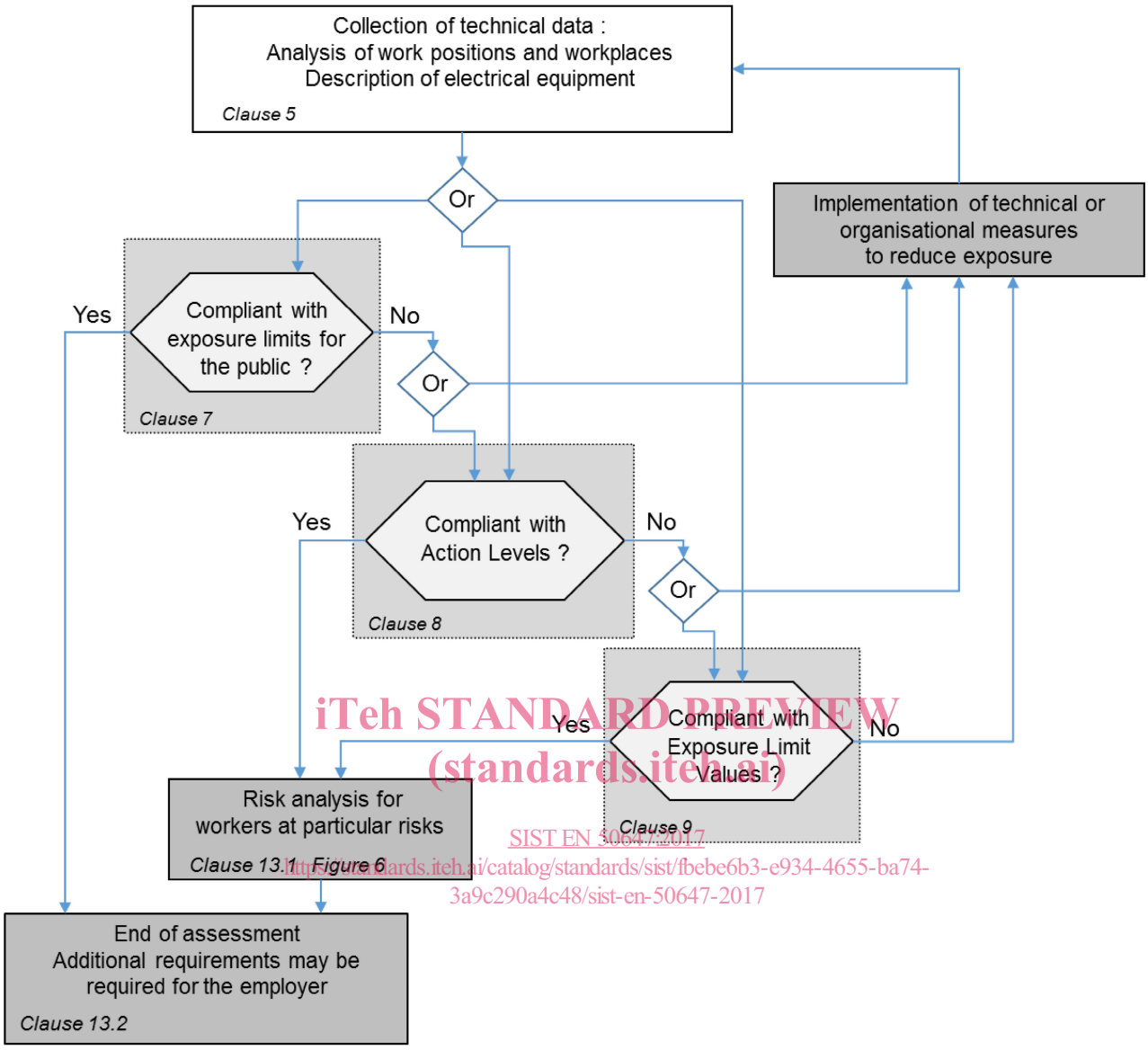

Figure 1 — General flowchart of the compliance assessment procedure

5 Collection of technical data

For assessing compliance, it is necessary to characterize the workplace in terms of EMF sources and of work positions in relation to them, and of the work practices involved. In terms of the scope of this standard, relevant field sources are energized electrical conductors and electrical equipment for producing and distributing electricity.

A simple identification is sufficient for the equipment covered by simplified procedures and general assessments (see Clause 7 and 8.2).

For the specific electrical equipment which may need a particular assessment, the following technical data may be useful to characterize the workplaces being assessed:

— type of equipment;

— rated characteristics (e.g. voltage, current);

— whether the equipment is insulated or not;

— whether any screens or shields are present;

— extent of any harmonics;

— distance of the energized parts of the equipment to workers;

— etc.

6 Methods for assessing exposure of workers

6.1 General

When assessing exposure in a particular area, it is normally sufficient to identify only the main EMF sources that affect that area. If the workers are very close to - or in contact with - one EMF source, any other sources located further away can generally be neglected (examples: HV live-line working, GIS inspection, etc.).

For working environments where different sources are at comparable distances to the workers (examples: low voltage environments, where the three phases are close to each other), the simultaneous contribution of all such sources should be considered.

The worst case exposure of workers shall be determined. As the exposure may vary as a function of the operating conditions, it may be necessary to extrapolate the exposure to worst case exposure conditions. Magnetic fields are generated by currents in electric equipment, such as lines, cables, coils and windings. The current may vary significantly over time and thus so will the magnetic field. This means that extrapolations of measured or calculated values will often be relevant when considering magnetic fields. Electric fields are generated by non-shielded electric equipment, such as overhead lines or busbars in substations. The voltage does not vary significantly over time and neither does the electric field at a given point, provided it remains unperturbed i.e. not affected by any moving object. Therefore, extrapolations of measured or calculated values are not normally relevant when considering power frequency electric fields, except under special circumstances such as a change in maximum operating voltage.

Waveforms of electric and magnetic fields at 50 Hz are not always purely sinusoidal but may contain significant harmonic components, which have to be taken into account in the exposure assessment when relevant. See 6.2.2 and 6.2.3.

6.2 Exposure assessment regarding external fields

6.2.1 General

External fields may be assessed by measurements and/or calculations.

Field meters shall be compliant with EN 61786-1.

This standard does not specify any specific measurement protocol, because of the diversity of the exposure situations experienced by workers. The measurement protocol shall be compliant with IEC 61786-2.

For small distances to a magnetic field source, where the magnetic field is highly non uniform, the size of the measuring probe may introduce an averaging bias and therefore may underestimate the actual field. Therefore the size of the probe shall be appropriate to the spatial variation of the field. Guidance is given in the measurement standard IEC 61786-2.

Magnetic field measurements should not be performed for assessing compliance for distances to field sources smaller than the measuring probe.

Measurements and calculations of electric fields are much more complex than for magnetic fields, as the electric field is perturbed by all conducting objects, even poorly conducting objects, and particularly by metallic structures. This is known as the “peak effect” and it results in strong local enhancements of the electric field. The strongly non-uniform field resulting from the peak effect is not representative of the exposure of a worker. That is why, in order to measure the unperturbed field, IEC 61786-2 recommends:

— a minimum distance of 2 m between the operator and the E field probe;

— to remove movable objects if possible;

— a minimum distance of 1 m to permanent objects if possible.

To overcome this effect, it is recommended to remove any movable object not necessary for the work in progress that might disturb the measurements during electric fields measurements.

Similarly, the peak effect also affects E-fields measurements close to fixed metallic structures, and a minimum distance to such structures should be respected in order to perform reliable and reproducible measurements. IEC 61786-2 recommends a minimum distance of 1 m when possible. However, a measuring distance of 1 m is not applicable to many work situations which involve contact to metallic structures, such as workers climbing in lattice steel electrical towers. In this case, a minimum distance of 20 cm shall be maintained between conducting objects and the measurement probe to reduce the peak effect measurement bias.

6.2.2 Harmonics of magnetic field

For transmission and distribution systems it is acceptable to perform a simplified assessment of harmonics, except around supplies for industry operating high power converters and rectifiers. Annex A proposes different approaches for assessing harmonics.

For simplified assessment of harmonics, the total exposure index is allocated partly to the exposure index for 50 Hz and partly to the sum of exposure indexes of harmonics. A total exposure index, including the fundamental and all harmonics, below 1 demonstrates compliance. Criteria for the 50 Hz exposure index, depending on the nominal voltage, are given in order to demonstrate that the total exposure index remains lower than 1. Alternative values may be used if based on specific assessment of harmonics.

— ***Criterion for voltage range ≥ 60 kV***

Based on available field measurements and current measurements, the harmonics of magnetic field at voltage levels higher than 60 kV can be neglected because the maximum harmonic content of currents in transmission and distribution systems is limited during normal operations.

NOTE Circumstances where significant harmonics can occur, such as resulting from saturation of transformers during energizing or during geomagnetic storms, are too rare to need considering further.

— ***Criterion for voltage range 1 kV to 60 kV***

Based on available field measurements and current measurements from medium voltage distribution and transmission systems, the harmonics up to the 50th might be relevant, but the exposure is compliant if the exposure index for 50 Hz is below 0,8 (see Annex A). The same criterion can be applied for broadband measurements.

— ***Criterion for low voltages (<1kV)***

Based on available field measurements and current measurements from low voltage distribution systems, the harmonics up to the 50th might be relevant, but the exposure is compliant if the exposure index for 50 Hz is below 0,7 (see Annex A). The same criterion can be applied for broadband measurements.

For power plants, assessment of harmonics may be limited to the excitation unit.

6.2.3 Harmonics of electric field

The harmonics of electric field at any voltage level can be neglected because the maximum harmonic content of voltage in transmission and distribution systems, which is limited by voltage quality requirements, usually increases the total exposure index only within the range of the expected uncertainty of assessment.

6.3 Numerical calculation of induced electric fields inside the human body

Numerical computations of induced electric fields inside the human body can be performed using different numerical methods, such as Finite Elements Method, Finite Integration Technique, Finite Difference Time Domain, and Scalar Potential Finite Difference. (See [7] and [8]).

Sophisticated models for calculating induced currents in the body have been used and are the subject of a number of scientific publications. These models use numerical 3D electromagnetic field computation codes and detailed models of the internal structure with specific electrical characteristics of each tissue within the body. Such scientific models can be used to assess compliance to ELVs.

7 Assessment against exposure limits for the public

At many workplaces, EMF levels will remain below the reference levels or basic restrictions for the public, such as those established in the Council Recommendation 1999/519/EC [3]. For such workplaces, when compliance to these values has already been demonstrated, no further assessment is needed.

The Application Guide [10] of the EMF Directive [11] gives a non-exhaustive list of workplaces where it should not be necessary to carry out a specific assessment as there is expected to be no risk from EMFs. The corresponding sources (Table 2) are not expected to give rise to exposures in excess of the reference levels of the Council Recommendation [3] under any conditions of normal operations.

Table 2 — Equipment or work places deemed to comply with reference levels for public exposure, i.e. 100 µT or 5 kV/m at 50 Hz (from Table 3.2 of the application guide [10])

Type of equipment or workplace	Type of exposure
Overhead bare conductors of any voltage	Magnetic fields
Electrical installations or electrical circuits within an installation, with a phase current rating of 100 A or less for the individual circuit (includes wiring, switchgear, transformers, etc.)	Magnetic fields
Any underground or insulated cable circuit, rated at any voltage	Electric fields
Any overhead bare circuit in substations above the work place rated at a voltage up to 110 kV	Electric fields
Any overhead bare circuit in substations with a grounded shield, rated at any voltage	Electric fields
Any overhead line above the work place rated at a voltage up to 150 kV	Electric fields
Any overhead lines at any voltage over-sailing the workplace building where the workplace is indoors	Electric fields

8 Assessment against Action Levels

8.1 General

Action Levels may not provide sufficient protection for workers at particular risk, as defined in the EMF directive [11], and a separate assessment is required for those categories of workers (see 13.1).

The rms values for Low and High ALs are given in Figure 2 (magnetic field) and Figure 3 (electric field). At 50 Hz the corresponding values are given in Table 3.