

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

Basisnorm für die Evaluierung der beruflichen Exposition gegenüber elektrischen und magnetischen Feldern ausgehend von Komponenten und

# Norme fondamentale pour l'évaluation de l'exposition des travailleurs aux champs électriques et magnétiques produits par les équipements et

06/2017



## National Foreword

This European Standard EN 50647:2017 was adopted as Luxembourgish Standard ILNAS-EN 50647:2017.

Every interested party, which is member of an organization based in Luxembourg, can participate for FREE in the development of Luxembourgish (ILNAS), European (CEN, CENELEC) and International (ISO, IEC) standards:

- Participate in the design of standards
- Foresee future developments
- Participate in technical committee meetings

<https://portail-qualite.public.lu/fr/normes-normalisation/participer-normalisation.html>

### **THIS PUBLICATION IS COPYRIGHT PROTECTED**

Nothing from this publication may be reproduced or utilized in any form or by any mean - electronic, mechanical, photocopying or any other data carries without prior permission!

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**

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

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

This European Standard was approved by CENELEC on 2017-04-10. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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**

<b>Contents</b>	<b>Page</b>
European foreword.....	4
3.1 Terms and definitions .....	6
3.2 Physical quantities and units .....	8
3.3 Abbreviations .....	8
6.1 General.....	11
6.2 Exposure assessment regarding external fields.....	11
6.2.1 General.....	11
6.2.2 Harmonics of magnetic field.....	12
6.2.3 Harmonics of electric field.....	12
6.3 Numerical calculation of induced electric fields inside the human body.....	13
8.1 General.....	13
8.2 Simplified criteria for compliance with action levels .....	15
8.2.1 General.....	15
8.2.2 Magnetic fields .....	15
8.2.3 Electric fields .....	16
8.3 Assessment using measurements or calculations .....	17
8.3.1 General.....	17
8.3.2 Magnetic fields .....	17
8.3.3 Electric fields .....	18
9.1 General.....	19
9.2 Simplified criteria for compliance with exposure limit values .....	19
9.2.1 General.....	19
9.2.2 Magnetic fields .....	20
9.2.3 Electric fields .....	21
9.3 Assessment using dosimetry and considerations for non-uniform fields .....	21
13.1 Workers at particular risk .....	23
13.2 Other requirements .....	23
Annex A (informative) Assessment of harmonics in magnetic fields.....	24
A.1 Introduction .....	24
A.2 Assessment Method using TEI .....	24
A.3 Assessment using the weighted peak function .....	26
A.4 Simplified assessment procedure for public grids .....	28
Annex B (normative) 50 Hz magnetic field sources in the environment of equipment and installations for production, transmission and distribution of electricity .....	29
B.1 General.....	29
B.2 Currents in single conductors .....	29
B.3 Currents in circuits .....	31
B.4 Assessing magnetic fields exposures .....	31
B.5 Check list for assessing compliance for magnetic fields .....	33
Annex C (informative) Examples of application of the different assessment criteria.....	34

C.1	Assessment for air-cored reactors: Simplified calculation of the magnetic field under a vertical air-cored self-inductance .....	34
C.2	Assessment for insulated cables: Calculation of compliance distances for typical XLPE cables.....	36
C.3	Assessment for exposure to electric fields considering different coupling conditions .....	38
Annex D (informative) Method for deriving Exposure-Limit-Equivalent-Fields (LEFs) .....		41
D.1	Introduction.....	41
D.2	Method .....	41
D.3	Selection of the reference model:.....	42
D.4	Reference organs and data .....	42
D.5	Uncertainty assessment .....	43
D.6	Deriving the Exposure-Limit-Equivalent-Field (LEF) .....	44
Annex E (informative) Considerations about DC magnetic fields in electrical companies.....		45
E.1	Introduction.....	45
E.2	Exposure of workers to DC magnetic field in electrical companies .....	45
E.3	Attention points .....	45
Annex F (informative) contact currents .....		46
F.1	Introduction.....	46
F.2	Influence of electric fields .....	46
F.2.1	General .....	46
F.2.2	Person isolated (at floating potential), capacitive coupling to ground .....	46
F.2.3	Person at earth potential, isolated object.....	47
F.2.4	Spark discharges.....	48
F.3	Influence of magnetic fields .....	48
F.3.1	General .....	48
F.3.2	Working adjacent to live circuits .....	48
F.4	Summary .....	49
Annex G (informative) Exposure during transient and fault conditions .....		50
G.1	Introduction.....	50
G.2	Faults .....	50
G.2.1	Overview.....	50
G.2.2	Short-circuit currents during faults.....	50
G.2.3	Prevention and protection against faults.....	50
G.2.4	Magnetic field exposures during faults.....	51
G.3	Switching transients .....	51
G.4	Lightning strikes.....	51
G.5	Inrush currents .....	51
G.6	Compliance of short-duration events with the Directive.....	52
Bibliography.....		53

## 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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

## 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 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]