SLOVENSKI STANDARD
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Human exposure to electromagnetic fields - High frequency (10 kHz to 300 GHz)

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English version

Human exposure to electromagnetic fields
High frequency (10 kHz to 300 GHz)

This European Prestandard (ENV) was approved by CENELEC on 1994-11-30 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CENELEC will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

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CENELEC
European Committee for Electrotechnical Standardization
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Foreword

This European Prestandard has been prepared by SC 111B, High-frequency EM radiation, of Technical Committee CENELEC TC 111, Electromagnetic fields in the human environment.

The text of the draft was voted and accepted during the combined meeting of CENELEC TC 111 and its SCs on 1994-11-30.

The following date was fixed :

- latest date of announcement of the ENV at national level (doa) 1995-03-01

Documents referred to in this Prestandard are indicated by a number between square brackets and are listed in 5.6, References, and in the relevant annexes.

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1 INTRODUCTION

This Prestandard, which is divided into two parts, deals with the exposure of persons to electromagnetic fields and radiation at all frequencies from 0 kHz up to 300 GHz (Part. 1: 0 to 10 kHz and Part 2: 10 kHz to 300 GHz). Electromagnetic fields interact with the human body and other biological systems through a number of physical mechanisms. This Prestandard is based on well-established short-term effects which, depending on frequency, include stimulation of electrically-excitable cells in nerve and muscle tissue and heating.

Basic restrictions are given to prevent any adverse consequences of these effects. They are specified in terms of biologically relevant quantities, typically induced current density and specific absorption rate. These quantities cannot be determined directly, so the standard specifies a set of more-readily-measurable reference levels, in terms of external electric and magnetic field strengths and power density, derived from the basic restrictions.

Pulsed electromagnetic fields may produce other effects, such as the auditory perception of microwaves pulses, in addition to those associated with continuous wave radiation. For these, restrictions in terms of specific energy absorption and energy density are given.

Electromagnetic fields can also interact indirectly when a person touches a conductive object in a field. If the field is sufficiently intense, the person may experience a shock or burn. To control these effects, limits are specified for the contact current.

This Prestandard has a two-tier structure in which lower levels are specified for the general public than for workers. For the general public, allowance has to be made for all likely activities and for all ages and states of health. Such persons may be unaware of some of the effects of exposure to electromagnetic fields, whereas appropriate information and training can be provided for workers.

There are reports that electromagnetic fields of lower intensity than the reference levels specified in this standard may have long-term effects on health. Currently available research however has not established adverse effects and does not provide a basis for restricting exposure.

Cardiac pacemakers and other active implantable devices are designed to cope with the typical levels of electromagnetic interference encountered in daily life. However, some devices - and also some metallic prosthetic implants - may be affected below the reference levels given in this Prestandard. When necessary, advice should be sought from the manufacturer of the device and from the medical authority which implanted it. A CENELEC Standard concerning interference and implantable cardiac pacemakers is available [EN 50061:1988/A1:1995].

This Prestandard sets basic restrictions and reference levels that have been derived in a documented way. It is recognised that additional considerations may lead some countries to regard the reference levels as minimum requirements in certain frequency ranges and add further margins.

This Prestandard is issued as a prospective standard for provisional application so as to gain experience in its use. It may be modified in the light of that experience or new scientific data before conversion to a full standard, or it may be withdrawn.

The present document is regarded as a basic standard. Further standardisation work should include the development of product and product family standards, based on this document, which define precisely the measurement method in each case. This additional work should be done in the coming years in parallel with the review of ENV 50166.

2 SCOPE

This part of the Prestandard deals with the prevention of adverse short-term effects of human exposure to electromagnetic fields in the frequency range of 10 kHz to 300 GHz. The rationale is set out in Annex A.

This Prestandard does not apply to the deliberate exposure of persons to electric or magnetic fields during medical research, diagnosis or treatment.

Safety hazards which may be associated with the ignition of flammable materials or the triggering of explosive devices in strong fields are not covered.

Compliance with this Prestandard may not exclude interference with or effects on some examples of implants such as cardiac pacemakers.

3 TERMS and DEFINITIONS

For the purpose of this standard the following terms and definitions will apply:

3.1 Physical Quantities and Units

The international accepted SI-units are used throughout the standard.

Quantity	Symbol	Unit	Symbol
Current density	J	Ampere per square metre	A/m^2
Electric field strength	E	Volt per metre	V/m
Electric flux density	D	Coulomb per square metre	C/m^2
Electric Conductivity	σ	Siemens per metre	S/m
Frequency	f	Hertz	Hz
Magnetic field strength	H	Ampere per metre	A/m
Magnetic flux density	B	Tesla ($8 \cdot 10^{-5}$ A/m)	T
Permeability	μ	Henry per metre	H/m
Permittivity	ε	Farad per metre	F/m
Power density	S	Watt per square metre	W/m^2
Specific absorption rate	SAR	Watt per kilogram	W/kg
Wavelength	λ	Metre	m
Energy Density		Joule per square metre	J/m^2

3.1.1 Physical constants

Physical constant		Magnitude
Velocity of light	c	$2{,}997 \times 10^8$ m/s
Permittivity of free space	ε_0	$8{,}854 \times 10^{-12}$ F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ H/m
Impedance of free space	Z_0	120π or 377 Ω

3.2 Definitions and Terms

3.2.1 Average (temporal) absorbed power (Pavg). The time-averaged rate of energy transfer defined by:

$$\bar{P}_{avg} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} P(t)dt$$

where t_1 and t_2 are the start and stop time of the exposure. The period $t_2 - t_1$ is the exposure duration time.

3.2.2 Averaging time (t_{avg}) The appropriate time over which exposure is averaged for purposes of determining compliance with the limits.

3.2.3 Basic restriction. The basic restriction is the ceiling level that should not be exceeded under any conditions. The basic restriction includes the necessary safety margins.

3.2.4 Conductivity. (σ) The ratio of the conduction-current density in a medium to the electric field strength. Conductivity is expressed in units of siemens per metre (S/m).

3.2.5 Continuous exposure. Exposure for durations exceeding the corresponding averaging time. Exposure for less than the averaging time is called short-term exposure.

3.2.6 Contact current. Current flowing into the body by touching a conductive object in an electromagnetic field.

3.2.7 Current density. The electromagnetic field induced current per unit area inside the body. The current density is expressed in units of ampere per square metre (A/m^2).

3.2.8 Dielectric constant (ε), see Permittivity.

3.2.9 Duty factor (duty cycle). The ratio of pulse duration to the pulse period of a periodic pulse train. A duty factor of unity corresponds to continuous-wave operation.

3.2.10 Electric field strength (E). The magnitude of a field vector at a point that represents the force (F) on a positive small charge (q) divided by the charge.

$$E = \frac{F}{q}$$

Electric field strength is expressed in units of volts per metre (V/m).

3.2.11 Electric flux density (D). The magnitude of a field vector that is equal to the electric field strength (E) multiplied by the permittivity (ε)

$$D = \varepsilon E$$

Electric flux density is expressed in units of coulomb per square metre (C/m^2).

3.2.12 Energy Density. The energy impinging per unit area normal to the direction of the electromagnetic wave propagation. It is usually expressed in units of joule per square metre (J/m^2).

3.2.13 Exposure. Exposure occurs wherever a person is subjected to electric, magnetic or electromagnetic fields or to contact currents other than those originating from physiological processes in the body and other natural phenomena.

3.2.14 Exposure level. The value of the quantity used when a person is exposed to electromagnetic fields or contact currents.

3.2.15 Exposure, direct effect of. Result of a direct interaction in the exposed human body from exposure to electromagnetic fields.

3.2.16 Exposure, indirect effect of. Result of an indirect interaction occurring when human body comes into contact with metallic objects in electromagnetic fields.

3.2.17 Exposure, partial-body. Partial-body exposure results from concentrated deposition of the energy.

3.2.18 Exposure, non uniform. Non uniform exposure levels result when fields are non uniform over volumes comparable to the whole human body. This may occur due to standing-waves, scattered radiation or in the near field. *See* **RF "hot spot"** and **"exposure, partial body".**

3.2.19. Far field region. In this region, the field has a predominantly plane-wave character, i.e., locally uniform distributions of electric and magnetic field strengths in planes transverse to the direction of propagation.

3.2.20 General Public. All non-workers (see definition of workers in this document).

3.2.21 Induced Current. Current induced inside the body as a result of direct exposure to electromagnetic fields.

3.2.22 Intrinsic impedance (of free space). The ratio of the electric field strength to the magnetic field strength of a propagating electromagnetic wave. The intrinsic impedance of a plane wave in free space is approximately 377 ohms.

3.2.23 Magnetic flux density (B). The magnitude of a field vector that is equal to the magnetic field H multiplied by the permeability (μ) of the medium.

$$B = \mu H$$

Magnetic flux density is expressed in units of tesla (T).

3.2.24 Magnetic field strength (H). The magnitude of a field vector in a point that results in a force (F) on a charge q moving with the velocity v.

$$F = q(v \times \mu H)$$

The magnetic field strength is expressed in units of ampere per metre (A/m)

3.2.25 Multiple frequency fields. The superposition of two or more phase incoherent electromagnetic fields of differing frequency.

3.2.26 Near-field region. A 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 the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field, but lacks substantial planewave character and is complicated in structure.

Note: For many antennas, the outer boundary of the reactive near field region is commonly taken to exist at a distance of one-half wavelength from the antenna surface. (See 3.2.19.)

3.2.27 Permeability, (μ). The magnetic permeability of a material is defined by the magnetic flux density B divided by the magnetic field:

$$\mu = \frac{B}{H},$$

where μ is the permeability of the medium expressed in henry per metre (H/m)

3.2.28 Permittivity, (ε). The property of a dielectric material (e.g. biological tissue) defined by the electrical flux density D divided by the electrical field E.

$$\varepsilon = \frac{D}{E}$$

The permittivity is expressed in units of farads per metre (F/m)

3.2.29 Polarisation. That property of electromagnetic fields describing the time-varying direction and amplitude of the electric field vector; specifically, the figure traced as a function of time by the extremity of the E-field vector at a fixed location in space, as observed along the direction of propagation.

NOTE: In general, the figure is elliptical and it is traced in a clockwise or counter clockwise sense. The commonly referenced circular and linear polarisations are obtained when the ellipse becomes a circle or a straight line, respectively. Clockwise sense rotation of the