SLOVENSKI STANDARD

SIST EN 50357:2002

01-januar-2002

Evaluation of human exposure to electromagnetic fields from devices used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications

Evaluation of human exposure to electromagnetic fields from devices used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications

Ermittlung der Exposition von Personen gegenüber elektromagnetischen Feldern von Geräten, die in der elektronischen Artikelüberwachung (en: EAS), Hochfrequenz-Identifizierung (en: RFID) und ähnlichen Anwendungen verwendet werden

Evaluation de l'exposition humaine aux champs électromagnétiques (EMFs) émis par les dispositifs utilisés pour la surveillance électronique des objets (EAS), l'identification par radiofréquence (RFID) et les applications similaires

Ta slovenski standard je istoveten z: **EN 50357:2001**

ICS:

13.280	Varstvo pred sevanjem	Radiation protection

SIST EN 50357:2002 **en**

EUROPEAN STANDARD **EN 50357**

NORME EUROPÉENNE

EUROPÄISCHE NORM October 2001

ICS 13.280; 33.100.01

English version

Evaluation of human exposure to electromagnetic fields from devices used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications

Evaluation de l'exposition humaine aux champs électromagnétiques (EMFs) émis par les dispositifs utilisés pour la surveillance électronique des objets (EAS), l'identification par radiofréquence (RFID) et les applications similaires

Ermittlung der Exposition von Personen gegenüber elektromagnetischen Feldern von Geräten, die in der elektronischen Artikelüberwachung (en: EAS), Hochfrequenz-Identifizierung (en: RFID) und ähnlichen Anwendungen verwendet werden

This European Standard was approved by CENELEC on 2001-07-03. 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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 50357:2001 E

Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 106X (former TC 211), Electromagnetic fields in the human environment.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50357 on 2001-07-03.

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)	2002-07-01
- latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2004-07-01

Annexes designated "informative" are given for information only.
In this standard, annexes A and B are informative.

Contents

Foreword **1**

Introduction **4**

1 Scope **5**

2 Physical quantities, units and constants **5**

2.1 Quantities 5
2.2 Constants 6

3 Terms and definitions **6**

3.1 General 6
3.2 Specific for EAS, RFID and similar applications 11

4 Measurements and calculations for equipment compliance **14**

4.1 Simple measurements to show compliance with derived reference levels 14
4.2 Measurements and analysis to show compliance with basic restrictions 23
4.3 Numerical modelling to show compliance with basic restrictions 27
4.4 Measurement of limb and contact currents 29

5 Measurements for field monitoring **29**

5.1 Field measurements 29
5.2 Additional evaluation 30

6 Exposure from sources with multiple frequencies or complex waveforms **30**

7 Uncertainty **30**

7.1 Evaluating uncertainties 31
7.2 Examples of typical uncertainties 31
7.3 Overall uncertainties 32

Annex A (informative) **Characteristics of equipment** **35**

A.1 EAS Equipment 35
A.2 EAS desktop and activation/deactivation equipment 39
A.3 RFID equipment 39

Annex B (informative) **Information for numerical modelling** **45**

B.1 Introduction 45
B.2 Anatomical models 45
B.3 Electrical properties of tissue 46
B.4 Comparison of induced currents, modelled using different sizes of prolate spheroid 49

Introduction

This document presents procedures for the evaluation of human exposure to electromagnetic fields (EMF's) from Devices used in electronic article surveillance (EAS), radio frequency identification (RFID) and similar applications. The work has been carried out in response to:

- The ICNIRP [1)] Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz) [1];
- European Council Recommendation 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields 0-300 GHz (the EC Recommendation) [2];
- European Council Directive 73/23/EEC on the harmonisation of the laws of member states relating to electrical equipment designed for use within certain voltage limits (the LV Directive) [3];
- European Council Directive 1999/5/EC on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (the R&TTE Directive) [4].

The techniques presented in this document may also be used to demonstrate compliance to other National or International requirements.

Electromagnetic fields interact with the human body and other biological systems through a number of physical mechanisms. The main mechanisms of interaction are based on nervous system effects and heating. These effects are dependent on frequency and are defined by biologically relevant quantities such as magnetic flux density, induced current density and specific absorption rate. These quantities are not directly measurable so they must be determined either, by calculation for each case, or by measuring a reference quantity which has a pre-derived relationship to them.

The examples used in this document are taken from the EC Recommendation and from the ICNIRP Guidelines. They each contain a series of Basic Restrictions for magnetic flux density, induced current density, power density and specific absorption rate as well as a series of derived Reference Levels

In any particular exposure situation, measured or calculated values can be compared to the appropriate reference level. The reference levels are generally obtained from the basic restriction by mathematical modelling and laboratory experimentation at specific frequencies. They reflect maximum coupling of the fields to the exposed human being, thereby providing maximum protection. Respect of the reference level will ensure respect of the relevant basic restriction. If the measured value exceeds the reference level, it does not necessarily follow that the basic restriction is also exceeded. Under those circumstances, more detailed evaluation techniques will be necessary which are specific to that type of equipment and exposure.

This document adopts a staged approach to compliance assessment. The first stage is a simple measurement against the appropriate derived Reference Levels. If the device meets these, there is no requirement for further assessment. Stage 2 is a more complex series of measurements, coupled with analysis techniques. Again, if the device meets the appropriate levels, there is no requirement for further assessment. Stage 3 requires detailed modelling and analysis to show compliance with the Basic Restrictions. Device compliance can be shown using any one of the stages; it is not necessary to use more than one, unless an assessment using Stages 1 or 2 fails to demonstrate compliance.

The devices covered by this document normally have non-uniform field patterns. Often these devices have a very rapid reduction of field strength with distance and operate under near-field conditions where the relationship between electric and magnetic fields is not constant. This, together with typical exposure conditions for different device types, is detailed in annex A.

Measurements and methods are derived with reference to:

1. Work carried out within CENELEC
2. Notes and explanatory text from the EC Recommendation and the ICNIRP Guidelines
3. Similar techniques proposed or adopted by IEC [2)], especially in the case of desktop equipment [5].
4. Other, specifically referenced techniques.

---

1) International Commission on Non-Ionising Radiation Protection

2) International Electrotechnical Committee

1 Scope

This European Standard applies to devices used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications. The objective of the Standard is to specify, for such equipment, the methods for demonstration of compliance with basic restrictions or reference levels related to human exposure to electromagnetic fields.

The Council Directive 1999/5/EC [4], Article 3.1(a), defines essential requirements for equipment that is either radio equipment or telecommunications equipment or both; with regard to the protection of the health and safety of the user and any other person. This document may be used for demonstration of compliance to the Council Directive with reference to human exposure to electromagnetic fields (EMF's). There are additional requirements covered by Article 3.1(a), which are not included in this document.

The Council Directive 73/23/EEC [3], Article 2, stipulates that the Member States take all appropriate measures to ensure that electrical equipment may be placed on the market only if, having been constructed in accordance with good engineering practice in safety matters in force in the Community, it does not endanger the safety of persons, domestic animals or property when properly installed and maintained and used in applications for which it was made. The principal elements of those safety objectives are listed in annex I clause 2b. This document may be used for demonstration of compliance to the Council Directive only with reference to human exposure to electromagnetic fields (EMF's). There are additional requirements covered by Article 2 and annex I clause 2b, which are not included in this document.

The Council Recommendation 1999/519/EC [2] provides Basic Restrictions and derived Reference Levels for exposure of the general public in the areas where they spend significant time. This document may be used for demonstration of equipment compliance to the Council Recommendation on this basis, but there may be additional specific National or International requirements which are not included.

The ICNIRP Guidelines [1] provide Basic Restrictions and derived Reference Levels for both occupational and general public exposure. This document may be used for demonstration of equipment compliance to ICNIRP Guidelines on this basis, but there may be additional specific National or International requirements which are not included.

Other Standards can apply to products covered by this document. In particular this document is not designed to assess the electromagnetic compatibility with other equipment, medical or otherwise. It does not reflect any product safety requirements other than those specifically related to human exposure to electromagnetic fields.

It is also possible to use this document as a basis to demonstrate compliance to other National and International Guidelines or Requirements with regard to human exposure from EMF's. In these cases, other Restrictions and Levels may be used.

2 Physical quantities, units and constants

2.1 Quantities

The internationally accepted SI units are used throughout this document

Quantity	Symbol	Unit	Dimension
Current density	J	ampere per square metre	Am^{-2}
Electric field strength	E	volt per metre	Vm^{-1}
Electric flux density	D	coulomb per square metre	Cm^{-2}
Electric conductivity	σ	siemens per metre	Sm^{-1}
Frequency	f	hertz	Hz

Magnetic field strength	H	ampere per metre	Am^{-1}
Magnetic flux density	B	tesla (Vs/m^2)	T
Mass density	ρ	kilogram per cubic metre	kgm^{-3}
Permeability	μ	henry per metre	Hm^{-1}
Permittivity	ε	farad per metre	Fm^{-1}
Power density	S	watt per square metre	Wm^{-2}
Specific absorption rate	SAR	watt per kilogram	Wkg^{-1}
Wavelength	λ	metre	m
Temperature	T	kelvin	K

2.2 Constants

Physical Constant	Symbol	Magnitude
Velocity of light	c	$2{,}997 \times 10^{8}$ ms^{-1}
Permittivity of free space	ε_0	$8{,}854 \times 10^{-12}$ Fm^{-1}
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ Hm^{-1}
Impedance of free space	Z_0	120π (or 377) Ω

3 Terms and definitions

3.1 General

3.1.1
average (temporal) absorbed power (P_{avg})
the time – averaged rate of energy transfer defined by:

$$P_{avg} = \frac{1}{t_2 - t_1} \int_{t1}^{t2} P(t)dt$$

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)

3.1.2
averaging time (t_{avg})
the appropriate time over which exposure is averaged for purposes of determining compliance

3.1.3
Basic Restrictions
restrictions are the restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects

3.1.4
conductivity (σ)
the ratio of the conduction – current density in a medium to the electric field strength

3.1.5
contact current
current flowing into the body by touching a conductive object in an electromagnetic field

3.1.6
current density (J)
the electromagnetic field induced current per unit area inside the body

3.1.7
dielectric constant (ε)
see permittivity

3.1.8
duty factor (or duty cycle)
the ratio of pulse duration to the pulse period of a periodic pulse train. Also, may be a measure of the temporal transmission characteristic of an intermittently transmitting RF source such as a paging antenna by dividing average transmission duration by the average period for transmissions. A duty factor of 1,0 corresponds to continuous operation

3.1.9
electric field strength (*E*)
the magnitude of a field vector at a point that represents the force (*F*) on an infinitely small charge (*q*) divided by the charge

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

3.1.10
electric flux density (*D*)
the magnitude of a field vector that is equal to the electric field strength (*E*) multiplied by the permittivity (ε)

$$D = \varepsilon E$$

3.1.11
energy density
the energy impinging per unit area normal to the direction of the electromagnetic wave propagation

3.1.12
exposure
exposure occurs whenever and wherever a person is subjected to electric, magnetic or electromagnetic fields or to contact current other than those originating from physiological processes in the body and other natural phenomena

3.1.13
exposure level
The value of the quantity used when a person is exposed to electromagnetic fields or contact currents

3.1.14
exposure, direct effect of
result of a direct interaction in the exposed human body from exposure to electromagnetic fields

3.1.15
exposure, partial body
partial body exposure results when fields are substantially non-uniform over the body. Fields that are non-uniform over volumes comparable to the human body may occur due to highly directional sources, standing waves, re-radiating sources or in the near field

3.1.16
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 “exposure, partial body”

3.1.17
far-field region
that region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In this region (also called the free space region), the field has a predominantly plane-wave character, i.e. locally uniform distribution of electric field strength and magnetic field strength in planes transverse to the direction of propagation

3.1.18
induced current
current induced inside the body as a result of direct exposure to electromagnetic fields

3.1.19
intrinsic impedance of free space (Z_0)
the ratio of the electric field strength to the magnetic field strength of a propagating electromagnetic wave in free space. This does not apply in the near-field region

3.1.20
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

$$B = \mu H$$

3.1.21
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 velocity (*v*)

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

[or magnetic flux density divided by permeability of the medium, see “magnetic flux density”]

3.1.22
multiple frequency fields
the superposition of two or more electromagnetic fields of differing frequency

3.1.23
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 two sub-regions. The **reactive near-field region** is closest to the radiating structure and contains most or nearly all of the stored energy. The **radiating near-field region** is where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complicated in structure

3.1.24
permeability (μ)
the property of a material which defines the relationship between magnetic flux density *B* and magnetic field strength *H*. It is commonly used as the combination of the permeability of free space and the relative permeability for specific dielectric materials

$$\mu = \mu_R \mu_0 = B/H$$

where μ is the permeability of the medium expressed in henry per metre (Hm^{-1})

3.1.25
permittivity, (ε)
the property of a dielectric material (e.g. biological tissue) which defines the relationship between electrical flux density *D* and electrical field strength *E*. It is commonly used as the combination of the permittivity of free space and the relative permittivity (or dielectric constant) for specific dielectric materials

$$\varepsilon = \mu_R \mu_0 = D/H$$

where ε is the permittivity of the medium expressed in farads per metre (Fm^{-1})

3.1.26
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. 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 electric vector is designated right – hand polarisation and counter clockwise sense rotation is designated left-hand polarisation

3.1.27
power density (*S*)
power per unit area normal to the direction of electromagnetic wave propagation. For plane waves the power density (*S*), electric field strength (*E*) and magnetic field strength (*H*) are related by the impedance of free space, i.e. 377 ohms

NOTE Although many survey instruments indicate power density units, the actual quantities measured are *E* or *H*, or the square of those quantities.

$$S = \frac{E^2}{377} = 377H^2 = EH$$

In particular where *E* and *H* are expressed in units of Vm^{-1} and Am^{-1}, respectively, and *S* in Wm^{-2}.

It should be noted that the value of 377 Ω is only valid for free space, far field measurement conditions (and does not apply for inductive devices operating in the reactive near field).

3.1.28
power density, average (temporal)
the instantaneous power density integrated over a source repetition period. This averaging is not to be confused with the measurement averaging time

3.1.29
power density, plane-wave equivalent
commonly used term associated with any electromagnetic wave, equal in magnitude to the power density of a plane wave having the same electric (*E*) or magnetic (*H*) field strength

3.1.30
root-mean-square (rms)
the effective value or the value associated with joule heating, of a periodic electromagnetic wave. The rms value is obtained by taking the square root of the mean of the squared value of a function

NOTE Although many survey instruments indicate rms, the actual quantity measured is root-sum-square (rss) (equivalent field strength). The value rss is obtained from three individual rms field strength values, measured in three orthogonal directions combined disregarding the phases. The measured rss value is the maximum possible (worse case) and can be quite different from the true root-mean-square (rms) value.

3.1.31
root-sum-square (rss)
the effective value or the value associated with joule heating, of a periodic electromagnetic wave. The rss value is obtained by taking the square root of the sum of the squared value of a function

$$X = \sqrt{\sum_{1}^{n} (X_n)^2}$$

3.1.32
scattered radiation
an electromagnetic field resulting from currents induced in a secondary, conducting or dielectric object by electromagnetic waves incident on that object from one or more primary sources. The scattering object is sometimes called a “re-radiator” or “secondary radiator”

3.1.33
specific absorption rate (SAR)
the time derivative of the incremental electromagnetic energy *(dW)* absorbed by (dissipated in) an incremental mass *(dm)* contained in a volume element *(dV)* of given mass density (ρ)

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)$$

SAR is expressed in units of watts per kilogram (Wkg^{-1}).

NOTE SAR can be calculated by:

$$SAR = \frac{\sigma E_i^2}{\rho}$$

$$SAR = c_i \left.\frac{dT}{dt}\right|_{\text{at } t_0}$$

where

E_i: rms value of the electric field strength in the tissue in V/m
σ: conductivity of body tissue in S/m
ρ: density of body tissue in kg/m^3
c_i: heat capacity of body tissue in J/kg K
$\frac{dT}{dt}$: initial time derivative of temperature in body tissue in K/s

3.1.34
wavelength
the wavelength (λ) of an electromagnetic wave is related to the frequency (*f*) and velocity (*c*) by the expression

$$\lambda = \frac{c}{f}$$

3.2 Specific for EAS, RFID and similar applications

3.2.1
active tags
tags which use batteries as a partial or complete source of power. They are further differentiated by separating them into those with replaceable batteries and those with batteries that are sealed for life as an integral part of the tag

3.2.2
activator
a device which changes inactive transponders so that they are able to transpond

3.2.3
air interface
the conductor-free medium, usually air, between a transponder and the reader through which data communication is achieved by means of a modulated inductive, capacitive or propagated electromagnetic field

3.2.4
antenna
antennas are conductive elements that radiate, and/or receive energy in the radio frequency spectrum

3.2.5
bandwidth
the range or band of frequencies in the electromagnetic spectrum within which a system is capable of receiving and transmitting

3.2.6
capacitive coupling
systems using electric fields as a means of transferring data or power are said to use capacitive coupling. This is sometimes also referred to as electrostatic coupling

3.2.7
carrier
the frequency used to carry data by appropriate modulation of the carrier waveform

3.2.8
CEPT
Conférence Européenne des Postes et des Télécommunication. The body responsible for European (not only EC) efficient utilisation of spectrum and regulatory matters

3.2.9
deactivator
a device which changes transponders so that they no longer transpond

3.2.10
electromagnetic coupling
systems using electromagnetic waves (hertzian waves) as a means of transferring data or power are said to use electromagnetic coupling

3.2.11
electronic article surveillance (EAS)
a system which detects the presence of transponders, which is often used for anti-theft purposes

3.2.12
electrostatic coupling
systems using the induced voltage on a plate as a means of transferring data or power are said to use electrostatic coupling

3.2.13
ERP
effective radiated power (normally expressed in watts.) is the product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction

3.2.14
EIRP
equivalent isotropic radiated power (normally expressed in watts) is the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain)

3.2.15
frequency
the number of times per second that a signal executes a complete cycle

3.2.16
harmonics
multiples of a principal frequency, invariably exhibiting lower amplitudes

3.2.17
inductive coupling
systems using magnetic fields as a means of transferring data or power are said to use inductive coupling

3.2.18
ITU
International Telecommunication Union. The body responsible for world-wide utilisation of the spectrum

3.2.19
memory card
a read/write or re-programmable tag with the size of a credit card

3.2.20
modulation, amplitude (AM)
data superimposed on a carrier by means of changes in its amplitude

3.2.21
modulation, phase (PM)
data superimposed on a carrier by means of changes in its phase

3.2.22
modulation, frequency (FM)
data superimposed on a carrier by means of changes in its frequency

3.2.23
modulation, frequency shift keyed (FSK)
the transmission of data by switching between two frequencies of carrier

3.2.24
modulation, pulse duration (PDM)
the transmission of data by means of the duration of pulses of a carrier

3.2.25
modulation, pulse position (PPM)
the transmission of data by the position of pulses relative to a reference point

3.2.26
nominal range
the range at which a system will provide reliable operation, taking account of the normal variability of the environment in which it is used

3.2.27
omni-directional
capability of a tag to operate in any orientation

3.2.28
orientation
see alignment

3.2.29
orientation sensitivity
the extent to which range is reduced by non-optimal orientation

3.2.30
passive tags
tags that contain no internal power source. Typically, they derive their power from the carrier signal radiated by the scanner

3.2.31
penetration
term used to indicate the ability of electromagnetic waves to propagate into or through the body or materials

3.2.32
proximity sensor
a device that detects and signals the presence of a tag at or near the sensor's location

3.2.33
RFID
radio frequency identification

3.2.34
range
the distance at which successful reading and/or writing can be accomplished

3.2.35
read
the decoding, extraction and presentation of data from formatting, control and error management bits sent from a tag

3.2.36
read rate
the rate at which data is read from a tag expressed in bits or bytes per second

3.2.37
read/write
tags that are capable of having their data repeatedly modified are called read/write tags

3.2.38
reader
a device that activates an adjacent tag and then receives, decodes and verifies the returned data. The verified data may then be passed via an interface to a host system

3.2.39
tag
the transmitter/receiver pair and data storage contained within a single package is referred to as a tag, transponder, electronic label, code plate and various other terms

3.2.40
transponder
see tag