SLOVENSKI STANDARD
SIST EN 50444:2008

01-junij-2008

Osnovni standard za oceno izpostavljenosti ljudi elektromagnetnim sevanjem opreme za oblọ no varjenje in sorodne postopke

Basic standard for the evaluation of human exposure to electromagnetic fields from equipment for arc welding and allied processes

Grundnorm zur Ermittlung der Exposition von Personen gegenüber elektromagnetischen Feldern von Einrichtungen zum Lichtbogenschweißen und artverwandten Prozessen

Norme de base pour l'évaluation de l'exposition des personnes aux champs électromagnétiques d'un équipement pour le soudage à l'arc et les techniques connexes

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This European Standard was approved by CENELEC on 2008-02-01. 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, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the 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

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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 26A, Electric arc welding equipment.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50444 on 2008-02-01.

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)	2009-02-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-02-01

This European Standard is to be read in conjunction with EN 50445.

This European Standard has been prepared under mandates M/305 and M/351 given to CENELEC by the European Commission and the European Free Trade Association.

Contents

Figures

Tables

1 Scope

This European Standard applies to equipment for arc welding and allied processes designed for use in industrial or domestic environments, including welding power sources, wire feeders and ancillary equipment, e.g. torches, liquid cooling systems and arc striking and stabilising devices.

NOTE Allied processes are for example electric arc cutting and arc spraying.

This standard specifies procedures for assessment of electromagnetic fields produced by arc welding equipment and defines standardized operating conditions and test set-ups.

This standard may be used as a basis to demonstrate compliance to national and international guidelines or requirements with regard to human exposure to EMF from arc welding equipment [1] [2].

Other standards may apply to products covered by this standard. In particular this standard can not be used to demonstrate electromagnetic compatibility with other equipment; nor does it specify any product safety requirements other than those specifically related to human exposure to electromagnetic fields.

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.

EN 50392	Generic standard to demonstrate the compliance of electronic and electrical apparatus with the basic restrictions related to human exposure to electromagnetic fields (0 Hz – 300 GHz)
EN 50445	Product family standard to demonstrate compliance of equipment for resistance welding, arc welding and allied processes with the basic restrictions related to human exposure to electromagnetic fields (0 Hz – 300 GHz)
EN 60974-1	Arc welding equipment – Part 1: Welding power sources (IEC 60974-1)

3 Terms and definitions

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

3.1 General

3.1.1
basic restrictions
restrictions on exposure to electric, magnetic and electromagnetic fields that are based directly on established health effects and biological considerations

3.1.2
conductivity (*σ*)
ratio of the conduction current density in a medium to the electric field strength

3.1.3
contact current
current flowing into the body by touching a conductive object in an electromagnetic field

3.1.4
effective reference level ($B_{L,eff}$)
level, provided for practical exposure assessment purposes using a broadband measurement, derived from frequency dependent reference levels considering the spectral content of the field

3.1.5
EMF
electric, magnetic or electromagnetic field

3.1.6
exposure
situation that occurs when 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

3.1.7
exposure level
value of the quantity evaluated when a person is exposed to electromagnetic fields or contact currents

3.1.8
induced current density (J)
electromagnetic field induced current per unit area inside the body

3.1.9
magnetic flux density (B)

magnitude of a field vector that is equal to the magnetic field H multiplied by the permeability μ of the medium

$$B = \mu H \tag{1}$$

3.1.10
magnetic field strength (H)
magnitude of a field vector in a point that results in a force $\vec{F}$ on a charge q moving with velocity $\vec{v}$

$$\vec{F} = q\,(\vec{v} \times \mu\,\vec{H}) \tag{2}$$

or magnetic flux density divided by permeability of the medium

3.1.11
permeability (μ)
property of a material which defines the relationship between magnetic flux density B and magnetic field strength H

NOTE It is commonly used as the combination of the permeability of free space μ_0 and the relative permeability μ_R for specific dielectric materials

$$\mu = \mu_R\,\mu_0 \tag{3}$$

where

μ is the permeability of the medium expressed in Henry per metre (H m^{-1}).

3.1.12
point of investigation (POI)
location in space at which the value of E-field, H-field or power density is evaluated

NOTE This location is defined in Cartesian, cylindrical or spherical co-ordinates relative to the reference point on the EUT.

3.1.13
root-mean-square (r.m.s.)
effective value or the value associated with joule heating, of a periodic electromagnetic wave

NOTE The r.m.s. value is obtained by taking the square root of the mean of the squared value of a function.

Expression in time domain

$$X_{\text{r.m.s.}} = \sqrt{\frac{1}{T}\int_0^T X^2(t)dt} \quad (4)$$

where

$X(t)$ is the signal at time t;

T is the signal period or multiples of it.

Expression in frequency domain

$$X_{\text{r.m.s.}} = \sqrt{\sum_n X_n^2} \quad (5)$$

where

Xn is the magnitude of spectral component at nth frequency, expressed as r.m.s. value.

3.1.14
reference levels
directly measurable quantities, derived from basic restrictions, provided for practical exposure assessment purposes

NOTE Respect of the reference levels will ensure respect of the relevant basic restriction. If the reference levels are exceeded, it does not necessarily follow that the basic restriction will be exceeded.

3.2 Specific for arc welding and similar applications

3.2.1
arc welding power source
equipment for supplying current and voltage and having the required characteristics suitable for arc welding and allied processes

NOTE 1 An arc welding power source may also supply services to other equipment and auxiliaries e.g. auxiliary power, cooling liquid, consumable arc welding electrode and gas to shield the arc and the welding area.

NOTE 2 In the following text, the term “welding power source” is used.

3.2.2
industrial and professional use
use intended only for experts or instructed persons

3.2.3
expert (competent person, skilled person)
person who can judge the work assigned and recognize possible hazards on the basis of professional training, knowledge, experience and knowledge of the relevant equipment

NOTE Several years of practice in the relevant technical field may be taken into consideration in assessment of professional training.

3.2.4
instructed person
person informed about the tasks assigned and about the possible hazards involved in neglectful behaviour

NOTE If necessary, the person has undergone some training.

3.2.5
rated maximum welding current (I_{2max})
maximum value of the conventional welding current that can be obtained at the conventional welding condition from a welding power source at its maximum setting

4 Physical quantities, units and constants

4.1 Quantities and units

The internationally accepted SI units are used throughout this document.

Quantity	Symbol	Unit	Dimension
Current density	J	Ampere per square metre	A m^{-2}
Electric conductivity	σ	Siemens per metre	S m^{-1}
Frequency	f	Hertz	Hz
Magnetic field strength	H	Ampere per metre	A m^{-1}
Magnetic flux density	B	Tesla	T (Vs m^{-2})
Permeability	μ	Henry per metre	H m^{-1}

4.2 Constants

Physical Constant	Symbol	Magnitude
Permeability of free space	μ_0	$4\pi \cdot 10^{-7}$ H m^{-1}

5 Assessment procedures

5.1 Arc welding equipment components to be tested

The main source of EMF is the welding current, delivered by the power source, flowing through the welding circuit. The parameters of the current e.g. amplitude and waveform, which are determined by the welding power source only, have the greatest influence on the exposure level. Therefore assessment shall be based on these parameters and the configuration of the welding circuit as specified in this standard.

However, direct emissions from components of the welding system e.g. wire feeders may also contribute to the total EMF and shall be considered. Care shall be taken not to add emissions assessed at short distances (less than 1 m), as the welder will not be close to those components at the same time.

5.2 Assessment conditions

Test configurations, distances, operating conditions and other parameters, which are valid for all evaluation procedures, are specified in Annex A.

5.3 Averaging

Time and spatial averaging shall be made in accordance with the relevant document containing limits.

5.4 Pulsed or non-sinusoidal welding current

5.4.1 General

For pulsed or non-sinusoidal (including a d.c. component) welding current a separate assessment for a.c. and d.c. components shall be made. Only the a.c. component shall be used to assess compliance with restrictions for time varying fields. The d.c. component shall be used to assess compliance with restrictions for static fields.

The a.c. component may consist of a number of spectral components, typically a fundamental frequency (e.g. the pulse repetition rate for a pulsed MIG process or the switching frequency for inverter power sources) and harmonics.

These spectral components shall be summed for assessment of exposure, considering the biological effects caused by the individual components (e.g. stimulation effects in the frequency range from 1 Hz to 10 MHz and thermal effects in the frequency range above 100 kHz). Summation of frequency components causing stimulation and thermal effects shall be made separately. Summation procedures are given in 5.4.2 and 5.4.3.

Different frequency ranges of the field (e.g. due to pulsed welding current or ripple current) may be evaluated separately. In this case the results of each evaluation shall be added linearly.

Only spectral components up to the upper frequency defined in 5.6 shall be considered. Harmonic components with an amplitude of less than 3 % of the amplitude of the corresponding fundamental frequency are insignificant and are disregarded.

NOTE 1 A complex signal may consist of several fundamental frequencies (e.g. the pulse and the ripple current frequencies) and associated harmonics.

For a simplified conservative assessment of induced current densities with non-sinusoidal or pulsed waveforms the procedure given in 5.4.4, based on the determination of an equivalent frequency, may be applied.

NOTE 2 Further guidance may be found in the ICNIRP statement “Guidance on determining compliance of exposure to pulsed and complex non-sinusoidal waveforms below 100 kHz with ICNIRP guidelines” [3].

5.4.2 Summation for basic restriction assessment

5.4.2.1 Summation of current density components without phase information

For summation of induced current density Equation (6) may be applied.

$$J_t = \sum_{i=1Hz}^{10MHz} \frac{J_i}{J_{L,i}} \tag{6}$$

where

- J_t is the total relative induced current density, expressed as a fraction of the permissible value
- J_i is the induced current density component at frequency f_I;
- $J_\mathrm{L,i}$ is the corresponding current density limit at frequency f_i;

The sum of the weighted spectral components shall not exceed 1.

As no phase information is used in this summation formula, this method can lead to significant overestimation of exposure. When information on the phase-angles of spectral components is available, the procedure given in 5.4.2.2 may be applied.

5.4.2.2 Summation of currents density components including phase information

As the spectral components of a pulsed or non-sinusoidal signal are typically not in phase (i.e. they do not reach their maximum value at the same time in the time domain), Equation (6) provides a conservative approach to the assessment of exposure. Therefore Equation (7) may be used for a more realistic summation whenever the phases of the spectral components are available.

The sum of the weighted spectral components shall not exceed 1 at any time t within the evaluation interval, which shall be one period of the pulsed or non-sinusoidal signal. The time increments used for evaluation shall be less than or equal to 1/10 of the period of the highest relevant spectral component.

$$\left| \sum_i \frac{J_i}{J_{L,i}} \cos(2\pi f_i t + \theta_i + \varphi_i) \right| \le 1 \quad (7)$$

where

J_i is the induced current density spectral component at frequency f_i;

$J_{L,i}$ is the corresponding current density limit at frequency f_i, see Annex F;

f_i is the frequency of the spectral component i (components up to 10 MHz maximum) ;

θ_i is the phase angle of the spectral component at frequency f_i;

φ_i is the phase angle of the weighting function at frequency f_i, see Annex F.

5.4.2.3 Summation of specific absorption rate (*SAR*) components

Thermal effects due to EMF will be negligible for most types of arc welding equipment. If relevant spectral components (see 5.4.1) in the frequency range (see 5.6) above 100 kHz exist, Equation (8) shall be applied for summation of *SAR* spectral components.

$$SAR_t = \sum_{i=100kHz}^{10GHz} \frac{SAR_i}{SAR_{L,i}} \quad (8)$$

where

SAR_t is the total *SAR*, expressed as a fraction of the permissible value;

SAR_i is the *SAR* spectral component at frequency f_i;

$SAR_{L,i}$ is the corresponding *SAR* limit at frequency f_i.

5.4.3 Summation for reference level assessment

5.4.3.1 Summation for stimulation effects without phase information

For summation of magnetic field strength spectral components with respect to stimulation effects, Equation (9) may be applied.

$$H_t = \sum_{i=1Hz}^{f_{sco}} \frac{H_i}{H_{L,i}} + \sum_{f_{sco}}^{10MHz} \frac{H_i}{b} \quad (9)$$

where

H_t is the total relative magnetic field strength, expressed as a fraction of the permissible value;

f_{sco} is the summation cut off frequency in accordance with the reference document for the limit values;

H_i is the magnetic field strength component at frequency f_i;

$H_{L,i}$ is the corresponding magnetic field strength reference level at frequency f_i;

b is the permissible magnetic field strength value defined in the reference document for the limit values.

For summation of magnetic flux density spectral components with respect to stimulation effects, Equation (10) may be applied

$$B_t = \sum_{i=1Hz}^{f_{sco}} \frac{B_i}{B_{L,i}} + \sum_{f_{sco}}^{10MHz} \frac{B_i}{b} \qquad (10)$$

where

- B_t is the total relative magnetic flux density, expressed as a fraction of the permissible value;
- f_{sco} is the summation cut off frequency in accordance with the reference document for the limit values;
- B_i is the magnetic flux density component at frequency f_i;
- $B_{L,i}$ is the corresponding magnetic flux density reference level at frequency f_i;
- b is the permissible magnetic flux density value defined in the reference document for the limit values.

An example for a summation without phases is given in B.8.

5.4.3.2 Effective reference level method

The assessment is performed by measuring the total r.m.s. magnetic flux density value using a broadband probe. For evaluation of exposure the result of the broadband measurement is compared to the calculated effective reference level $B_{L,eff}$.

The spectral content of the field shall be derived, e.g. by Fast Fourier Transformation (FFT) of the measured field or, alternatively in case of field measurements around welding cables, the measured welding current. The contribution of each spectral component is calculated as a fraction of the total a.c. r.m.s. flux density or welding current value.

The r.m.s. effective reference level is obtained using Equation (11)

$$B_{L,eff} = \frac{1}{\sum_i \frac{F_i}{B_{L,i}}} \qquad (11)$$

where

- $B_{L,i}$ is the corresponding r.m.s. magnetic flux density reference level at frequency f_i;
- F_i is the fractional contribution of the spectral component *i*, defined as

$$F_i = \frac{B_{r.m.s.,i}}{B_{r.m.s.}} \qquad (12)$$

where

- $B_{r.m.s.}$ is the total r.m.s. magnetic flux density value,
- $B_{r.m.s.,i}$ is the r.m.s. value of the spectral component *i*;

or

$$F_i = \frac{I_{r.m.s,i}}{I_{r.m.s}} \qquad (13)$$

where

- $I_{r.m.s.}$ is the total r.m.s. welding current value,
- $I_{r.m.s.,i}$ is the r.m.s. value of the spectral component *i*.

NOTE Further guidance may be found in the NRPB document W24 “Occupational Exposure to Electric and Magnetic Fields in the Context of the ICNIRP Guidelines” [4].

An example using this method is given in B.10.

5.4.3.3 Summation for stimulation effects including phase information

As the spectral components of a pulsed or non-sinusoidal signal are typically not in phase (i.e. they do not reach their maximum value at he same time in the time domain), the procedure in accordance with 5.4.3.1 provides a conservative approach to the assessment of exposure. Therefore Equation (14) may be used for a more realistic summation whenever the phases of the spectral components are available. Equation (14) may be used for evaluation of *B* or *H* values.

The sum of the weighted spectral components must not exceed 1 at any time *t* within the evaluation interval, which shall be one period of the pulsed or non-sinusoidal signal. The time increments used for evaluation shall be less than or equal to 1/10 of the period of the highest relevant spectral component.

$$\left| \sum_i \frac{A_i}{L_i} \cos(2\pi f_i t + \theta_i + \varphi_i) \right| \le 1 \qquad (14)$$

where

A_i is the amplitude of the spectral component at frequency f_i;

L_i is the applicable limit at frequency f_i, or above f_{sco} the value *b* as given in the reference document for the limit values, see Annex F;

f_i is the frequency of the spectral component *i* (components up to 10 MHz maximum);

θ_i is the phase angle of the spectral component at frequency f_i;

φ_i is the phase angle of the weighting function at frequency f_i, see Annex F.

Examples for summation including phase information are given in B.8 and B.9.

5.4.3.4 Summation for thermal effects

Thermal effects due to EMF will be negligible for most types of arc welding equipment. If relevant spectral components (see 5.4.1) in the frequency range (see 5.6) above 100 kHz exist, Equation (15) shall be applied for summation of magnetic flux density spectral components.

$$B_t = \sum_{i=100kHz}^{f_{sco}} \left(\frac{B_i}{d} \right)^2 + \sum_{f_{sco}}^{300GHz} \left(\frac{B_i}{B_{L,i}} \right)^2 \qquad (15)$$

where

B_t is the total relative magnetic flux density, expressed as a fraction of the permissible value;

f_{sco} is the summation cut off frequency according to the reference document for the limit values;

B_i is the magnetic flux density component at frequency f_i;

$B_{L,i}$ is the corresponding magnetic flux density reference level at frequency f_i;

d is the magnetic flux density value defined in the reference document for the limit values.

5.4.4 Equivalent frequency of induced current density waveforms

If the reference document contains frequency dependent limits, the peak value of the induced current density may be compared to the corresponding limit for a equivalent frequency f_e, which is calculated as defined in Equation (16)

$$f_e = \frac{1}{2\tau_p} \qquad (16)$$

where

τ_p is the pulse duration of the induced current density waveform.