SIST

SLOVENSKI STANDARD
SIST EN 50505:2008

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Osnovni standard za oceno izpostavljenosti ljudi elektromagnetnim sevanjem opreme za uporovno varjenje in sorodne procese

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

Grundnorm für die Bewertung der menschlichen Exposition gegenüber elektromagnetischen Feldern von Einrichtungen zum Widerstandsschweißen und für verwandte Verfahren

Norme de base destinée à l’évaluation de l’exposition humaine aux champs électromagnétiques émanant du matériel de soudage par résistance et des techniques connexes

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

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This European Standard was approved by CENELEC on 2008-03-01. 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

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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 26B, Electric resistance welding.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50505 on 2008-03-01.

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)	2009-03-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-03-01

This European Standard shall 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.

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1 Scope

This European Standard applies to equipment for resistance welding and allied processes designed for use in industrial or domestic environments.

NOTE 1 Typical allied processes are resistance hard and soft soldering or resistance heating achieved by means comparable to resistance welding equipment.

This European Standard establishes a suitable evaluation method for determining the electromagnetic fields in the space around the equipment and defines standardized operating conditions and measuring distances. It provides a method to show conformity with guidelines or requirements concerning human exposure to electromagnetic fields.

The Directive 2006/95/EC of the European Parliament and the Council [1], 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 is was made. The principal elements of those safety objectives are listed in Annex I Clause 2.b. This standard may be used in conjunction with EN 50445 for demonstration of conformity to the Council Directive with reference to human exposure to electromagnetic fields (EMF). There are additional requirements covered by Article 2 and Annex I Clause 2.b, 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. This standard may be used for demonstration of resistance welding equipment conformity to the Council Recommendation on this basis, but there may be additional specific national or international requirements which are not included.

The ICNIRP Guidelines [3], on limits of exposure to static magnetic fields as well as for limiting exposure in time varying electric, magnetic and electromagnetic fields, provide Basic restrictions and Derived reference levels for both occupational and general exposure. This standard may be used for demonstration of equipment conformity to ICNIRP Guidelines on this basis, but there may be additional national or international requirements which are not included.

It is also possible to use this document as a basis to demonstrate conformity of resistance welding equipment to other national and international guidelines or requirements with regard to human exposure from EMF, for example Council Directive 2004/40/EC [4] on the minimum health and safety requirements regarding the exposure of workers to the risk arising from physical agents (electromagnetic fields), or the requirements of the Directive 98/37/EC [5]. In these cases, other restrictions and levels than those referenced above may be used.

Other standards may apply to equipment 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.

The frequency range covered is 0 Hz to 300 GHz.

NOTE 2 Procedures to demonstrate conformity are not specified for the whole frequency range.

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	2004	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	2008	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 61566	1997	Measurement of exposure to radio-frequency electromagnetic fields – Field strength in the frequency range 100 kHz to 1 GHz (IEC 61566:1997)
EN 62226-1	2005	Exposure to electric or magnetic fields in the low and intermediate frequency range – Methods for calculating the current density and internal electric field induced in the human body – Part 1: General (IEC 62226-1:2004)
EN 62226-2-1	2005	Exposure to electric or magnetic fields in the low and intermediate frequency range – Methods for calculating the current density and internal electric field induced in the human body – Part 2-1: Exposure to magnetic fields – 2D models (IEC 62226-2-1:2004)
EN ISO/IEC 17025	2005	General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)
IEC 61786	1998	Measurement of low-frequency magnetic and electric fields with regard to exposure of human beings – Special requirements for instruments and guidance for measurements
ISO 669	2000	Resistance welding – Resistance welding equipment – Mechanical and electrical requirements

3 Definitions

3.1 General

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

3.1.1
averaging time (t_{avg})
appropriate time over which exposure is averaged for purposes of determining conformity

3.1.2
basic restrictions
restrictions on exposure to electric, magnetic and electromagnetic fields that are based directly on established health effects and biological considerations

3.1.3
compliance boundary
spatial border outside which any point of investigation is deemed to be compliant

3.1.4
conductivity (σ)
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
coupling factor (*K*)
used to enable exposure assessment for complex exposure situations, such as non-uniform magnetic field or perturbed electric field

NOTE The coupling factor *K* has different physical interpretations depending on whether it relates to electric or magnetic field exposure. The value of the coupling factor *K* depends on the model used for the field source and the model used for the human body.

3.1.7
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

3.1.8
EMF
electric, magnetic or electromagnetic field

3.1.9
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

3.1.10
exposure level
value of the quantity evaluated when a person is exposed to electromagnetic fields or contact currents

3.1.11
exposure, non-uniform
results when fields are non-uniform over volumes comparable to the whole human body

3.1.12
induced current density (*J*)
electromagnetic field induced current per unit area inside the body

3.1.13
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 ($\vec{v}$)

$$\vec{F} = q(v \times \mu \vec{H}) \tag{1}$$

or magnetic flux density divided by permeability of the medium

3.1.14
magnetic flux density (*B*)
magnitude of a field vector that is equal to the magnetic field strength (*H*) multiplied by the permeability (μ) of the medium

$$B = \mu H \tag{2}$$

3.1.15
permeability (μ)
property of a material which defines the relationship between magnetic flux density (B) and magnetic field strength (H)

NOTE 1 It is commonly used as the combination of the permeability of free space (μ_0) and the relative permeability for specific dielectric materials (μ_R).

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

NOTE 2 Permeability is expressed in henry per metre (H m^{-1}).

3.1.16
point of investigation (POI)
location in space at which the value of the 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.

3.1.17
root-mean-square (r.m.s.)
effective value or the value associated with joule heating, of a periodic signal

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

$$x_{\mathrm{rms}} = \sqrt{\frac{1}{T}\int_0^T x^2(t)\mathrm{d}t} \quad \text{(expression in time domain)} \tag{4}$$

where $x(t)$ is the signal at time t, T is the signal period or multiples of it

$$x_{\mathrm{rms}} = \sqrt{\sum_n x_n^2} \quad \text{(expression in frequency domain)} \tag{5}$$

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

3.1.18
reference levels
directly measurable quantities, derived from basic restrictions, provided for practical exposure assessment purposes

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

3.1.19
response time
time required for field strength indicated by a measurement instrument to reach 90 % of its final value when the instrument is exposed to a defined step function of field strength

NOTE This step function is defined as a change in field strength from less than 1 % of the full scale deflection (fsd) of the measurement instrument to 100 % of fsd occurring in a time of 1/4 of the period of the waveform at the frequency of interest.

3.2 Specific for resistance welding and similar applications

3.2.1
conventional load
load condition with the electrodes short-circuiting as defined in ISO 669:2000

3.2.2
current flow time
duration defined from the start time of current conduction to the time when its current has decreased to 10 % level of the measured welding current value

3.2.3
duty factor (X)
ratio for a given interval of the on-load duration to the total time

NOTE This ratio, lying between 0 and 1, may be expressed as a percentage.

3.2.4
equipment for resistance welding and allied processes
equipment associated with carrying out the processes of resistance welding or allied processes consisting of e.g. power source, electrodes, tooling and associated control equipment, which may be a separate unit or part of a complex machine

3.2.5
hand-held integrated transformer gun
resistance welding equipment with built-in transformer and all conductors carrying their welding current, which is intended to be held in the hand during use

3.2.6
hand-held separated transformer gun
resistance welding equipment with separate transformer, which is intended to be held in the hand during use

3.2.7
maximum short-circuit current output (I_{2cc})
equipment rated output current with conventional load as defined in ISO 669:2000, Clause 10

3.2.8
phase control
typical current control technique in resistance welding, e.g. by changing the firing angle in each half-weld cycle of a.c. current

3.2.9
processes allied to resistance welding
processes which are carried out on machines comparable to resistance welding equipment

NOTE Typical allied processes are resistance hard and soft soldering or resistance heating achieved by means comparable to resistance welding equipment.

3.2.10
stationary resistance welding equipment
resistance welding equipment which is stationary, the operator handle the piece to be welded

3.2.11
suspended integrated transformer gun
resistance welding equipment with built-in transformer and all conductors carrying their welding current, which is intended to be suspended and hand-guided by the operator to position the equipment in the correct welding position

3.2.12
suspended separated transformer gun
resistance welding equipment with separate transformer, which is intended to be suspended and hand-guided by the operator to position the equipment in the correct welding position

3.2.13
weld time
current flow time given as a number of cycles of the mains frequency or as time duration

3.2.14
welding cable(s)
flexible conductor(s) used to connect the power source and the welding tool in some types of resistance welding equipment

NOTE Typical examples of these equipments are the car-body production and repair welding-station.

3.2.15
welding circuit
circuit that includes all conductive material through which the welding current is intended to flow

3.2.16
welding current
current value accumulated over the weld time and indicated by the r.m.s. value, which is applicable for a.c. and d.c. current

NOTE In the case of pulsed current, e.g. a capacitor discharged current, the welding current is indicated by the peak value.

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	$4\pi \times 10^{-7}$ H m^{-1}

5 Assessment procedures

5.1 General

This European Standard defines, as far as possible, suitable points of investigation for different types of equipment that represent the highest exposure positions during practical use. These points of investigation are based on previous experience and measurement, taking into account typical operator positions, and have been selected to protect against effects on central nervous system tissues in the head and trunk of the body.

NOTE 1 Equipment complying with the basic restriction or reference levels at the points of investigation defined in this European Standard are considered to be compliant with the requirements of the reference document that contains limits.

NOTE 2 Equipment that does not comply with these tests needs to be carefully evaluated to quantify the exposure in all relevant operator positions. This evaluation shall define compliance boundaries that describe all the operator positions that are in conformity with the requirements. The equipment use shall be restricted according to the established compliance boundaries.

5.2 Resistance welding equipment EMF emission description

The main source of EMF in a resistance welding equipment is the welding current flowing through the welding circuit, generating a low frequency magnetic field, this has the greatest influence on the exposure level.

The emission is a non homogeneous field at the proximity of equipment.

The parameters of the welding current (e.g. amplitude and waveform), and the welding circuit characteristics (e.g. dimensions), are determined by the equipment only. External factors e.g. characteristics of the workpiece have influence on the magnetic field, but are not taken into account by this standard.

The emission is present only during welding process, therefore only assessment in operator position during welding is required, no assessment is required in positions used for equipment programming or set-up.

Therefore assessment shall be based on these parameters and the configuration of the welding circuit as specified in this standard.

NOTE The fact that magnetic field in the surrounding space of a resistance welding equipment is non-homogeneous shall be taken into account.

5.3 Assessment conditions

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

5.4 Averaging

5.4.1 General

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

Specific criteria for resistance welding equipment given in 5.4.2 and 5.4.3 shall be used if no or less detailed averaging procedures are provided by the document containing the limits.

5.4.2 Time averaging

For occupational exposure the d.c. component of the magnetic flux density or field strength values should be averaged over a time interval of 8 h, taking into account the duty cycle of the equipment and the welding current output sequence, as applicable. The reduction factor shall be calculated:

– for constant d.c. current as

$$V_{\mathrm{rdc}} = \sqrt{\frac{X}{100}} \qquad (6)$$

where

X is the duty cycle of the welding equipment, expressed in %, calculated by

$$X = \frac{I_{\mathrm{2p}}{}^{2}}{I_{\mathrm{2cc}}{}^{2}} \cdot 100 \qquad (7)$$

– for welding current output sequences as

$$V_{\mathrm{rdcs}} = \sqrt{\frac{X}{100}\,\frac{1}{t_{cs}}\sum_{i=1}^{n} I_n \cdot t_n} \qquad (8)$$

where

X is the duty cycle of the welding equipment, expressed in %;
t_{cs} is the sequence cycle time;
I_n is the d.c. level during time interval n;
t_n is the duration of interval n.

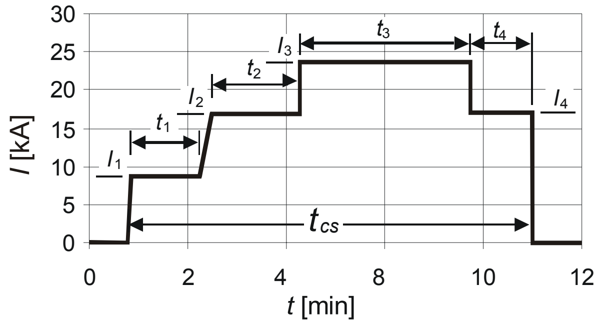

Figure 1 – Example for parameters of a welding current sequence

For general public exposure of d.c. component or exposure to time varying magnetic fields, time averaging shall be performed according the relevant document containing limits.

5.4.3 Spatial averaging of magnetic field

Generally reference levels are intended to be spatially averaged values over the entire body of the exposed individual, but with the important proviso that the basic restrictions on localized exposure are not exceeded.

This European Standard is used to assess mainly the exposure generated from the welding circuit, creating stimulation effects. The maximum exposure is localized on the part of the body nearest to the source. In this type of situation an approach based on the spatial averaging of non uniform field distributions underestimates the exposure and is not able to ensure that the localized exposure does not exceed the basic restrictions for induced current densities. Therefore spatial averaging shall not be applied to reference level based exposure assessment of stimulation effects due to fields generated from welding circuit.

For evaluation of exposure generated from sources other than the welding circuit (for example from microprocessors, radio communication systems, ancillary equipment) spatial averaging of the field may be appropriate.

5.5 Pulsed or non-sinusoidal welding current

5.5.1 General

Welding current of resistance welding equipment are typically pulsed current, therefore the generated magnetic field is of pulsed type. Some type of resistance welding equipment (i.e. seam welders) generates sustained field. The waveform of the welding current depends from the welding technology used by the equipment.

For pulsed or non-sinusoidal (including a d.c. component) welding current a separate evaluation 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.

Different frequency ranges of the signal (e.g. due to rise and fall time of welding pulse or welding current ripple) may be evaluated separately. In this case the results of each evaluation shall be added linearly. Care must be taken to ensure that no applicable frequency band is disregarded, and that overlapping frequency ranges do not lead to an overestimation of exposure.

The a.c. component may consist of a number of spectral components, typically a fundamental frequency (e.g. the mains frequency or, ripple frequency for rectifiers) and harmonics.

It is important to determine whether, in situations of simultaneous exposure to fields of different frequencies, these exposures are additive in their effects. Additivity is generally applicable to thermal effects and should be examined separately for electrical stimulation.

These spectral components shall be summed for assessment of exposure, summation shall take into account 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 5.5.2 and 5.5.2.4.

Only spectral components up to the upper frequency defined in 5.7 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 5.5.3, 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" [6].

5.5.2 Summation for basic restriction assessment

5.5.2.1 Summation of currents density components without phase information

For summation of induced current density Equation (9) may be applied.

$$J_{\mathrm{t}} = \sum_{i=1\,\mathrm{Hz}}^{10\,\mathrm{MHz}} \frac{J_i}{J_{\mathrm{L},i}} \qquad (9)$$

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 5.5.2.2 may be applied.

5.5.2.2 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 (9) provides a conservative approach to the assessment of the exposure. Therefore Equation (10) may be used for a more realistic summation whenever the phases of the spectral components are available.