BS EN 62822-2:2016

BSI Standards Publication

Electric welding equipment — Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz)

Part 2: Arc welding equipment

bsi.

National foreword

This British Standard is the UK implementation of EN 62822-2:2016. It is identical to IEC 62822-2:2016.

The UK participation in its preparation was entrusted to Technical Committee WEE/6, Electric arc welding equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2016

ISBN 978 0 580 80431 1
ICS 25.160.01; 25.160.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2016.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62822-2

September 2016

ICS 25.160; 25.160.30

English Version

Electric welding equipment - Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz) - Part 2: Arc welding equipment (IEC 62822-2:2016)

Matériels de soudage électrique - Évaluation des restrictions relatives à l'exposition humaine aux champs électromagnétiques (0 Hz à 300 GHz) - Partie 2: Matériels de soudage à l'arc (IEC 62822-2:2016)

Bewertung Elektrischer Schweisseinrichtungen in Bezug auf Begrenzungen der Exposition von Personen gegenüber Elektromagnetischen Feldern (0 Hz - 300 GHz) - Teil 2: Grundnorm für Lichtbogenschweißeinrichtungen (IEC 62822-2:2016)

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 26/584/FDIS, future edition 1 of IEC 62822-2, prepared by IEC/TC 26 "Electric welding" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62822-2:2016.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017-03-16
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2019-09-16

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The text of the International Standard IEC 62822-2:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 62226-1	NOTE	Harmonized as EN 62226-1.
IEC 62226-2-1:2004	NOTE	Harmonized as EN 62226-2-1:2005 (not modified).
IEC 62311	NOTE	Harmonized as EN 62311.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60050-851	2008	International Electrotechnical Vocabulary - Part 851: Electric welding	-	-
IEC 60974-1	-	Arc welding equipment - Part 1: Welding power sources	EN 60974-1	-
IEC 60974-6	-	Arc welding equipment - Part 6: Limited duty equipment	EN 60974-6	-
IEC 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	EN 61786-1	-
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	EN 61788-2	-
IEC 62822-1	-	Electric welding equipment - Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz) - Part 1: Product family standard	EN 62822-1	-

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRIC WELDING EQUIPMENT – ASSESSMENT OF RESTRICTIONS RELATED TO HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS (0 Hz to 300 GHz) –

Part 2: Arc welding equipment

FOREWORD

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International Standard IEC 62822-2 has been prepared by IEC technical committee 26: Electric welding.

The text of this standard is based on the following documents:

FDIS	Report on voting
26/584/FDIS	26/591/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62822 series, published under the general title *Electric welding equipment – Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

ELECTRIC WELDING EQUIPMENT – ASSESSMENT OF RESTRICTIONS RELATED TO HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS (0 Hz to 300 GHz) –

Part 2: Arc welding equipment

1 Scope

This part of IEC 62822 applies to equipment for arc welding and allied processes designed for occupational use by professionals and for use by laymen.

NOTE 1 Typical allied processes are electric arc cutting and arc spraying.

This standard specifies procedures for the assessment of human exposure to magnetic fields produced by arc welding. It covers non-thermal biological effects in the frequency range from 0 Hz to 10 MHz and defines standardized test scenarios.

NOTE 2 The general term “field” is used throughout this document for “magnetic field”.

NOTE 3 For the assessment of exposure to electric fields and thermal effects, the methods specified in the Generic Standard IEC 62311 apply.

This standard does not define methods for workplace assessment regarding the risks arising from electromagnetic fields (EMF). However, the EMF data that results from the application of this standard can be used to assist in workplace assessment.

Other standards may apply to products covered by this standard. In particular this standard cannot be used to demonstrate electromagnetic compatibility with other equipment. It does not specify any product safety requirements other than those specifically related to human exposure to electromagnetic fields.

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.

IEC 60050-851:2008, *International Electrotechnical Vocabulary – Part 851: Electric welding*

IEC 60974-1, *Arc welding equipment – Part 1: Welding power sources*

IEC 60974-6, *Arc welding equipment – Part 6: Limited duty equipment*

IEC 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 61786-2, *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*

IEC 62822-1, *Electric welding equipment – Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz) – Part 1: Product family standard*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-851 on electric welding, in IEC 60974-1 and IEC 60974-6, as well as the following, apply.

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

3.1.2
exposure index
EI
result of the evaluation of exposure to (both sinusoidal and non-sinusoidal) EMF, expressed as a fraction or percentage of the permissible values

Note 1 to entry: Fractions higher than 1 (100 %) represent exceeding the permissible values.

3.1.3
general public
individuals of all ages and of varying health conditions

Note 1 to entry: Varying ages and health conditions can increase the individuals susceptibilities to EMF.

3.1.4
general public exposure
the exposure of members of the general public to EMF

Note 1 to entry: In many cases, members of the general public are unaware of their exposure to EMF.

3.1.5
health effects
adverse effects, such as thermal heating or stimulation of nerve and muscle tissue as a result of human exposure to EMF

3.1.6
intracorporeal
situated or occurring within the body

3.1.7
layman
operator who does not weld in the performance of his profession and may have little or no formal instruction in welding

[SOURCE: IEC 60050-851:2008, 851-11-14, modified – "arc welding" was replaced by "welding"]

3.1.8
non-thermal effects
the stimulation of muscles, nerves or sensory organs as a result of human exposure to EMF

3.1.9
occupational exposure
the exposure of workers to EMF at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job activities

Note 1 to entry: A worker is any person employed by an employer, including trainees and apprentices.

3.1.10
reference levels
action levels
directly measurable quantities, derived from basic restrictions, provided for practical exposure assessment purposes

Note 1 to entry: 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.

3.1.11
sensory effects
transient disturbed sensory perceptions and minor changes in brain functions as a result of human exposure to EMF

3.2 Quantities and units

The internationally accepted SI units are used throughout this document.

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

3.3 Constants

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

4 Requirements

Equipment shall be assessed as defined in Clause 7, using the methods given in Clause 5 and the conditions defined in Clause 6. The results shall be reported as specified in Clause 7.

5 Assessment methods

5.1 General considerations

5.1.1 Time averaging

Time averaging of exposure is not permitted for non-thermal effects unless the applied national or international requirements explicitly specify time averaging procedures.

5.1.2 Spatial averaging of external field values

Reference levels are typically based on spatial averaging over the relevant part of the body. If spatial averaging of exposure is not excluded and no specific procedures are defined in applicable national and international requirements, the procedures detailed in the relevant subclauses of 6.1 shall be applied.

5.1.3 Spatial averaging of intracorporeal values

If spatial averaging of exposure is not excluded and no specific procedures are specified in applicable national and international requirements, the procedures detailed in the relevant subclauses of 5.3 and 6.1 shall be applied.

5.1.4 Equipment with pulsed or non-sinusoidal welding current

5.1.4.1 General

Several methods for the assessment of pulsed and non-sinusoidal fields are available. For the purpose of this standard, only the weighted peak methods as given in 5.1.4.2 and 5.1.4.3 are applicable. For additional information, see IEC 61786-2. The result of these calculation methods is the exposure index (EI).

NOTE Applications of the weighted peak method in time domain or frequency domain are mathematically equivalent and give exactly the same results, if applied correctly. For some cases, e.g. when large numbers of spectral components have to be considered for the complete analysis of a signal, the application of the time domain method can be less complex.

Phase angles used for the weighted peak methods are given in Table 1.

Table 1 – Phase angles of weighting function or summation function

proportionality p_A [a]	$1/f^2$	$1/f$	f^0 (constant)	f
phase angle φ_l [b]	180°	90°	0°	-90°

[a] p_A is the proportionality factor defining the variation of the basic restriction/reference level as specified in the applicable national and international requirements.

[b] φ_l is the phase angle of the weighting function or summation function.

5.1.4.2 Weighted peak method in the time domain

For time domain evaluation, an evaluation system which incorporates a weighting function is applicable. The evaluation shall be based on the peak value of the weighted signal. This method can be used for both external field levels and intracorporeal metrics.

For comparison with the given exposure levels, the weighting function shall have a frequency response which matches the applicable national and international requirements, so that the weighting and summation of spectral components occurs in the time domain.

Further information on this method is given in IEC 62311.

The attenuation and phase angles of the weighting functions can be approximated with electronic or digital filters. The attenuation shall not deviate more than 3 dB and the phase angles not more than 90° from the piecewise linear frequency response. The piecewise linear values for phase angles are given in Table 1.

5.1.4.3 Weighted peak method in the frequency domain

For frequency domain evaluation, a phase corrected summation of the weighted spectral components of the signal is applicable. The evaluation shall be based on the peak value of the weighted signal as given in Equation (1).This method can be used for both external field levels and intracorporeal metrics.

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, as defined in 5.1.5.4.

$$\left| \sum_i \frac{A_i}{L_i} \cos(2 \times \pi \times f_i \times t + \theta_i + \varphi_i) \right| \leq 1 \tag{1}$$

where

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

L_i is the applicable limit at frequency f_i

f_i is the frequency of the spectral component i;

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

φ_i is the phase angle of the summation function at frequency f_i, see Table 1.

The amplitudes and phase angles of the limit values can be approximated with electronic or digital filters. The amplitudes shall not deviate more than 3 dB and the phase angles not more than 90° from the piecewise linear frequency response. The piecewise linear values for phase angles are given in Table 1.

Approximation of the piecewise linear values of limits L_i at frequencies f_i shall be done using complex functions such as Equation (2). The initial amplitude V_0, the number of corner frequencies and the position of the relevant terms are dependent on the applicable limits.

$$L_i = \left| V_0 \frac{(1 + s_i/\omega_1)(1 + s_i/\omega_2)(1 + s_i/\omega_3)}{(1 + s_i/\omega_4)(1 + s_i/\omega_5)(1 + s_i/\omega_6)} \right| \tag{2}$$

where

s_i is calculated as $j\ 2\ \pi\ f_i$;

ω_n is ω at the n^{th} corner frequency $f_{c\ n}$;

$f_{c\ n}$ is the n^{th} corner frequency.

An example for a piecewise linear limit and the derived approximation is shown in Figure 1. The example shows the combined reference levels for sensory and health effects in the head as specified in the European EMF Workers Directive 2013/35/EU [2][1].

1 Numbers in square brackets refer to the Bibliography.

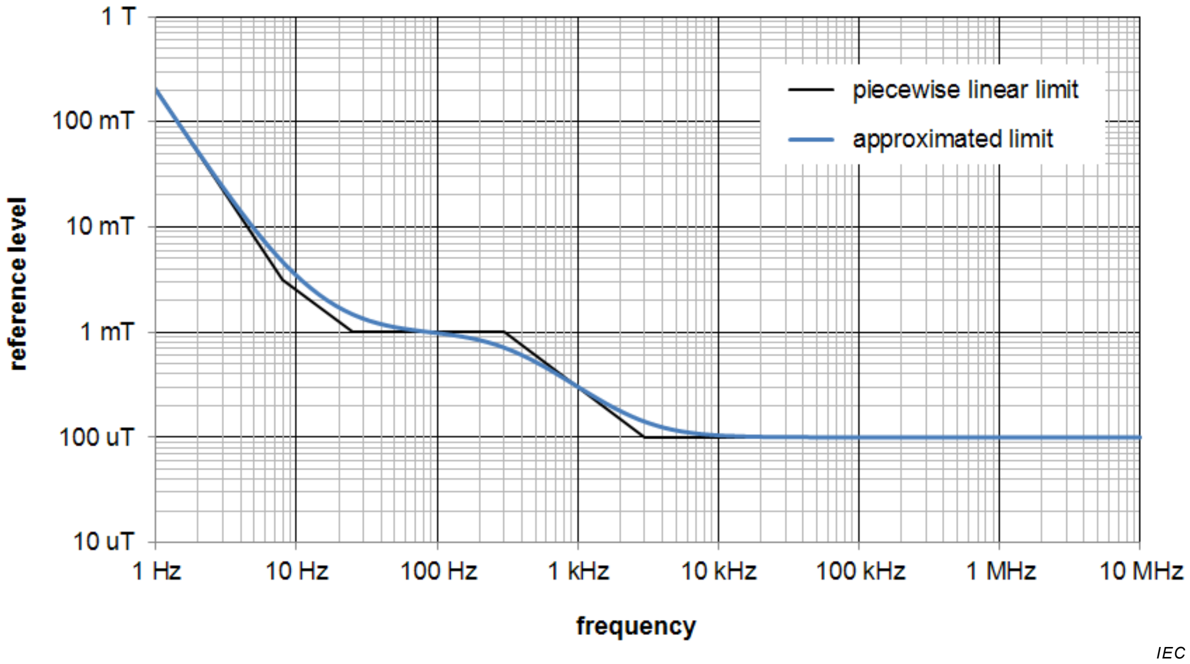


Figure 1 – Piecewise linear and approximated limit amplitudes

The phase angles φ_i of the summation function shall be calculated from the complex function for the approximated amplitudes. An example for piecewise linear phase angles and the phase angles of the derived approximation is shown in Figure 2, an example for the effect of this approximation is given in Annex C. The example in Figure 2 shows the phase angle of the combined reference levels for sensory and health effects in the head as specified in the European EMF Workers Directive 2013/35/EU [2].

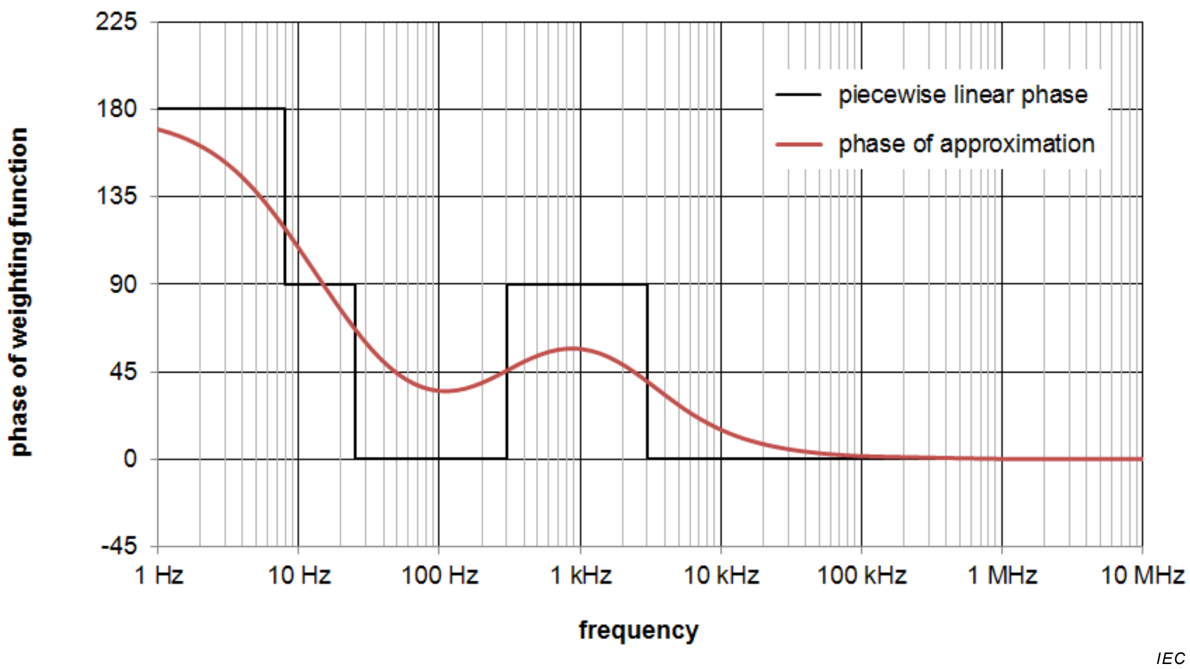


Figure 2 – Piecewise linear and approximated summation function phase angles

5.1.5 Considerations for spectral analysis

5.1.5.1 Validation

The results of spectral analyses, i.e. the amplitudes and phase angles of the spectral components of the assessed welding current or magnetic field, shall be validated. An example for validation by spectral synthesis is given in Figure 3.

NOTE The purpose of the validation is to check if major mistakes were made when performing spectral analysis (e.g. 90° errors in the phase angles) rather than checking for small deviations due to sampling rates or digitizing.

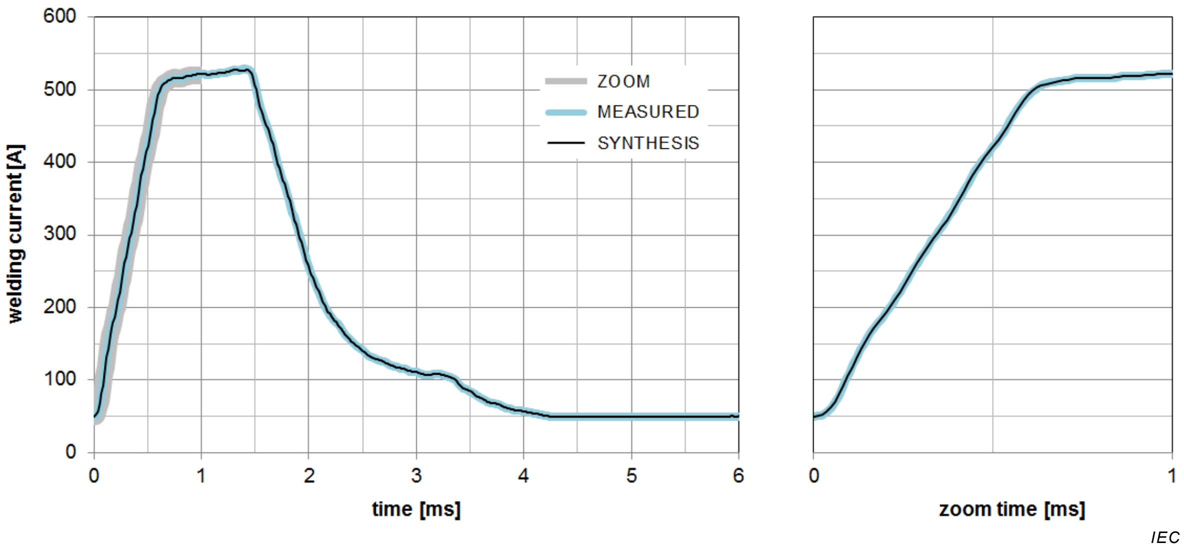


Figure 3 – Spectral synthesis for the validation of the analysis

5.1.5.2 Analysis of repetitive signals

Spectral analysis of repetitive signals (e.g. pulsed welding, a.c. welding or the welding current ripple) shall be based on one full cycle of the signal, where the amplitude at the beginning and the end of the assessment time-frame shall be equal. The number of spectral components to be calculated, i.e. the highest frequency covered by the spectral components, shall comply with the requirements given in 5.1.5.4.

5.1.5.3 Analysis of non-repetitive signals

In order to simplify the spectral analysis of non-repetitive signals (e.g. the maximum rate of change of current with respect to time (di/dt) capability of the welding power source), the constant part after the change can be replaced by a slope with a weighted value that is considerably lower than that of the change to be assessed, and does not influence the resulting value of the exposure index EI. The repetition time shall be sufficiently long to allow the EI curve to decay to zero before the end of the artificial cycle. By this, the non-repetitive signal is replaced by a repetitive signal that can be assessed as given in 5.1.5.2. See Figure 4.

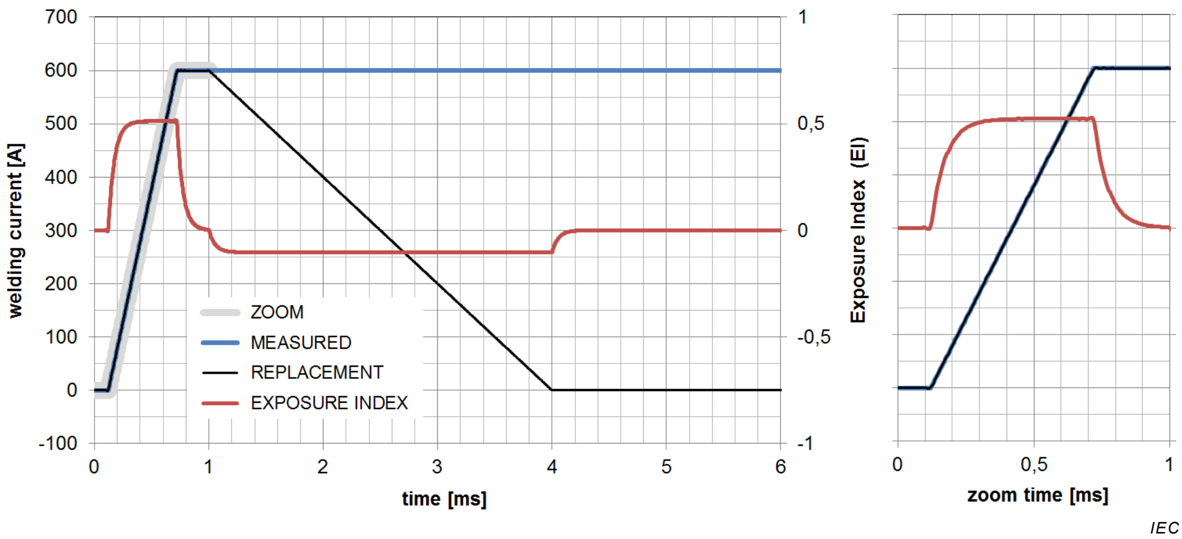


Figure 4 – Equivalent waveform for non-repetitive signals

5.1.5.4 Frequency range limitations

Assessment, dependent on the type of welding current waveform, shall be made in the relevant frequency range from 0 Hz (d.c., as applicable) to an upper frequency defined as the highest applicable value of

- 1 kHz for single phase transformer-rectifier types;
- 3 kHz for three phase transformer-rectifier types;
- 10 kHz for thyristor controlled types;
- 10 times the ripple frequency for inverter types;
- 10 times the a.c. welding current frequency;
- the frequency f_{max} defined by the minimum rise or fall time $\tau_{p\ min}$ of the maximum welding current (10 % to 90 %, from 0 A to $I_{2\ max\ pos}$ or $I_{2\ max\ neg}$).

$$f_{max} = 10 \times \frac{1}{4 \times \tau_{p\ min}} \quad (3)$$

The maximum upper frequency within the scope of this standard is 10 MHz.

The manufacturer, based on his knowledge of the process or special techniques used in the apparatus, shall select a higher upper frequency if applicable. An example for such a case is an a.c. square-wave power source.

If the output-current ripple-amplitude meets the exclusion criteria given in IEC 62822-1, the upper frequency range boundary based on ripple frequency can be neglected.

5.1.6 Uncertainty of assessment

The expanded uncertainty of the assessment shall be calculated as defined in IEC 61786-2.

If the expanded uncertainty is higher than the value specified IEC 62822-1, and the assessment is not proven to provide conservative results (i.e. overestimates the exposure), the method to calculate penalties given in IEC 62822-1 shall be applied.

5.2 Measurement of external field levels

5.2.1 General

This method is based on field measurements and can be used to show compliance without the need for complex calculation or modelling procedures related to basic restrictions. Reference levels typically include additional margins and are derived from the basic restrictions by using assumptions with regard to the properties of the field and the coupling conditions. Therefore this method represents a conservative approach and generally overestimates exposure.

The results shall be compared to the limits that are applicable to the relevant parts of the body as specified in IEC 62822-1.

Field measurements shall be made with straight welding cables carrying the relevant test current I_t. Return cables shall be routed in a way that eliminates or minimizes the influence of the return current on the measured field.

In the case of a metallic floor, the welding cables shall be placed on a non-metallic support with a minimum height of 0,8 m. Any other metallic objects, which could distort the magnetic field, should be at a horizontal distance of at least 2 m from the measurement points.

Measurements of background levels are recommended to establish the presence of external fields.

If necessary the influence of external field sources should be minimized. For medium and high frequency ranges this can be achieved by measurements in shielded enclosures, which shall be of sufficient size to avoid field distortion. Generally, increasing the distance to external sources of magnetic fields will dramatically decrease the background field strength.

5.2.2 Measurement equipment

The field probes(s) used for measurement shall comply with the requirements of IEC 61786-1, the probe(s) shall be of an area of 3 $cm^2 \pm 0{,}6\ cm^2$.

5.3 Calculation of external field levels

5.3.1 General

This method is based on analytical field calculations using welding current parameters and other data (e.g. source models and assessment configuration) and can be used to show compliance without the need for extensive field measurement campaigns or complex calculation or modelling procedures related to basic restrictions. Reference levels typically include additional margins and are derived from the basic restrictions by using assumptions with regard to the properties of the field and the coupling conditions. Therefore this method represents a conservative approach and generally overestimates exposure.

The results shall be compared to the limits that are applicable to the relevant parts of the body as specified in IEC 62822-1.

5.3.2 Source model and calculation equation

The model of an infinite single straight wire shall be used. Reference levels are typically applicable to field levels B_{AV} that are averaged over the relevant part of the body, therefore Equation (4), which includes averaging of the maximum and minimum values over the assessment range covered, shall be applied.

$$B_{AV} = \frac{\mu_0 \times I_t}{4 \times \pi} \times \left(\frac{1}{d_1} + \frac{1}{d_2} \right) \tag{4}$$

where

d_1 is the smallest distance between the body part and the virtual welding cable;

d_2 is the largest distance between the body part and the virtual welding cable;

I_t is the value of a spectral component or the total value of the welding current.

NOTE Equation (4) can be used for any type of current values. The type of current values for the above equation needs to match the type of limit used for assessment (for example, r.m.s. current values will result in r.m.s. field values).

Simplified versions of Equation (4), considering the standardized distances to and dimensions of relevant body parts, are given in the relevant subclauses of 6.1.

If spatial averaging is not allowed, Equation (4) shall be used with d_2 equal to d_1.

5.4 Calculation of intracorporeal levels

5.4.1 General

Analytical and numerical calculations of body internal metrics shall be based on the external field generated by the welding circuit and its coupling to body models. External field strengths shall be calculated, to obtain realistic results the use of anatomical body models should be combined with numerical calculation of the field-distribution.

The results for the relevant tissues and/or parts of the body shall be compared to the applicable limits as specified in IEC 62822-1.

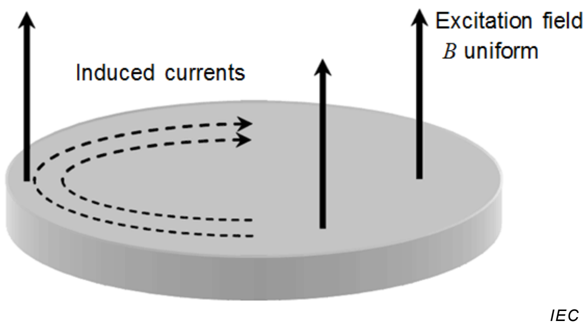
5.4.2 Source model

The model of an infinite single straight wire shall be used.

5.4.3 Body model for analytical calculations

5.4.3.1 General

The simplest analytical model used in EMF health guidelines is based on the hypothesis of coupling between a uniform external magnetic field at a single frequency, and a homogeneous disk of given conductivity, used to represent the part of the body under consideration. This is illustrated in Figure 5.



NOTE The source of this figure is Figure 1 of IEC 62226-2-1:2004.

Figure 5 – Conducting disk in a uniform magnetic flux density

The effects (current density and electric field strength) induced in the disk by a non-uniform magnetic field from a localised source are always lower than the effects that would be induced by a uniform magnetic field whose magnitude is equal to the magnitude of the non-uniform field at the edge of the disk closest to the localised source. This reduction of induced effects for non-uniform fields is quantified using the coupling factor K.

More information on the 2D disk model and the coupling factor K is given in IEC 62226-2-1.

5.4.3.2 Parameters for 2D disk models

The radii of the disks which shall be used for calculations with regard to head, trunk and limbs of the welder´s body are given in Table 2, together with the coupling factors applicable to the respective standardized assessment distances.

Table 2 – Radii and coupling factors for 2D disk models

	head	trunk	limbs	
			hand	thigh
Disk radius R	100 mm	200 mm	30 mm	100 mm
Coupling factor K [a)]	0,682 at 100 mm	0,556 at 100 mm	0,629 at 30 mm	0,432 at 30 mm

a) The coupling factor K is dependent on both the radius of the disk and the distance to the welding cable. The values given here are applicable to the standardized distances as defined in 6.1.2.3, 6.1.3.3 and 6.1.4.3. Correction factors for other distances, if needed, can be found in Table D.1 or be derived based on the information given in IEC 62226-2-1.

5.4.3.3 Conductivity for 2D disk models

The value of the electrical parameters to be used for human body modelling is of critical importance with regard to the computation of induced current densities. Average values of electrical conductivity σ for a human body are given in Figure 6. These average values shall only be used for assessment procedures using simplified body models with homogeneous electrical conductivity.

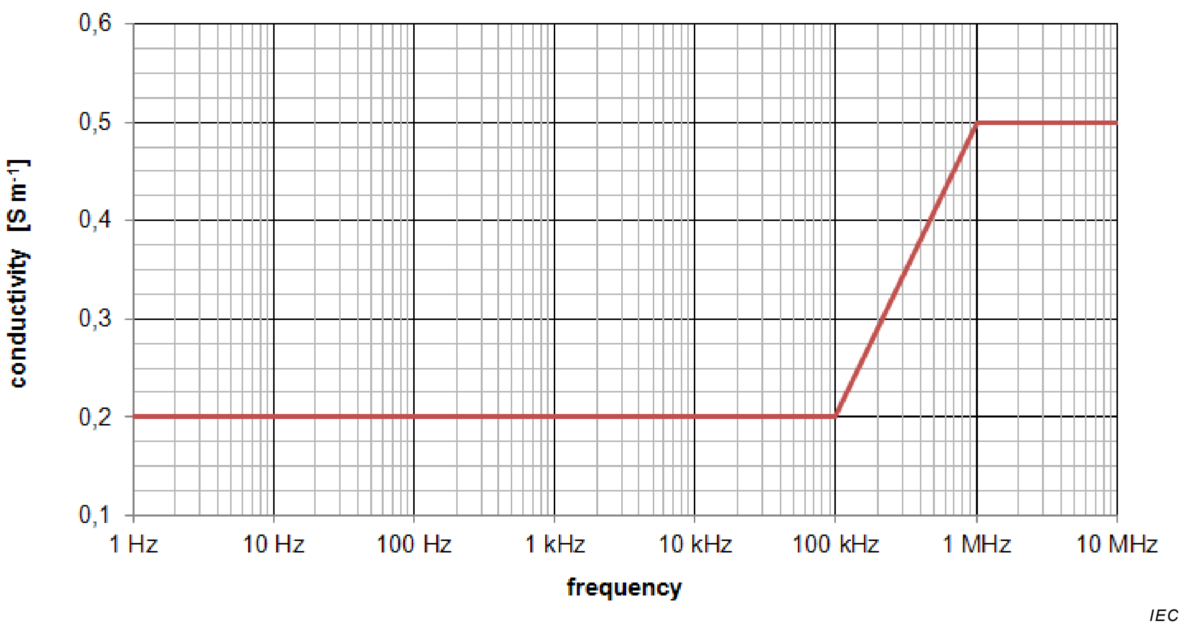


Figure 6 – Electrical conductivity for homogeneous body models

The average values in Figure 6, combined with the application of homogeneous body models, provide a conservative approach to the assessment of exposure. Therefore the uncertainty for these values shall be taken as 0 %.

5.4.3.4 Calculation equations for 2D disk models

The induced current density J and the internal electric field E_{i} in a disk with the conductivity σ are closely linked by the simple relation given in Equation (5).

$$J = \sigma \times E_{\text{i}} \tag{5}$$

It is assumed that the part of the body exposed is a circular section of radius R. The calculation of the maximum electric field $E_{\text{i MAX u}}$ at the circumference of this disk under maximum coupling conditions, i.e. with a uniform magnetic field perpendicular to this disk, is based on Equation (6).

$$E_{i\,\text{MAX u}} = \pi \times R \times f \times B \tag{6}$$

where

f is the frequency of a spectral component of the welding current;

B is the magnetic flux density of the uniform field.

Considering the coupling factor K for a non-uniform field around an infinite single straight wire and the model for the magnetic field around such a field source, the maximum electric field $E_{\text{i MAX}}$ in a disk shall be calculated as given in Equation (7).

$$E_{i\,\text{MAX}} = K \times \pi \times R \times f \times \mu_0 \times \frac{I_{(f)}}{2 \times \pi \times d} \tag{7}$$

where

K is the coupling factor for non-uniform magnetic fields as given in Table 2;

R is the radius of the disk;

f is the frequency of a spectral component of the welding current;

$I_{(\text{f})}$ is the amplitude of a spectral component of the welding current;

d is the distance between the single wire and the disk.

NOTE Equation (7) can be used for any type of current values. The type of current values for the above equation needs to match the type of limit used for assessment (for example, r.m.s. current values will result in r.m.s. electric field values).

Combined and simplified versions of Equations (5) and (7), considering the standardized distances to and dimensions of disks, are given in the relevant subclauses of 6.1.

There is a phase shift between the welding current creating the magnetic field and the induced electric field or current density in the disk, which is important for summation procedures considering phases. The phase angle of induced effects $\theta_{Ei,J}$ shall be calculated in accordance with Equation (8).

$$\theta_{Ei,J} = \theta_I + 90^\circ \tag{8}$$

where

θ_I is the phase angle of the spectral welding current component.

5.4.4 Anatomical body models for numerical calculations

Induced current density or intracorporeal electric field-strength may be derived by numerical simulation using a 3D body model where the dielectric properties of the various tissues are taken into account.

The body model shall represent relevant parts of the body (i.e. head, trunk or limbs) or the whole body, as applicable based on the relevant applicable national and international requirements setting limits.

Induced current densities and intracorporeal electric fields are calculated at the resolution of the model used. Because these models are anatomically based, it is possible to obtain results for particular tissue types, for example for Central Nervous System (CNS) tissues (the brain and/or the spinal cord), or other types as appropriate for the type of exposure assessment and the exposure requirements being used.

Such assessment involves the use of sophisticated millimetre resolution body models. These models are often derived from MRI data or from photographs of the anatomical sectional diagrams, and include accurate tissue conductivities, including those for CNS tissues, such as the brain and the spinal cord. This standard does not specify any individual method, model or technique, as several are equally applicable and accurate. Research is continuing in this area and new methods and information will become available. Additional information is given in IEC 62311.

If such simulation techniques are used, appropriate validation is required. This can be provided by peer review, appropriate published reference citations or comparison against other reviewed or referenced models.

6 Assessment conditions

6.1 Assessment configurations

6.1.1 General

Typically, different permissible values and coupling models need to be applied for different parts of the human body. This differentiation is based on the variety of tissue types, anatomic shapes or dimensions and distances to the source of electromagnetic fields that are applicable for various parts of the body.

Standardized assessment configurations, reflecting the normal operator position for manual welding, are defined below. One of the assessment options given below shall be applied for the head, trunk, and limbs of the welder.

If applicable national and international requirements exclude configurations specified in 6.1.2, 6.1.3 or 6.1.4 (e.g. if the assessment of the exposure of limbs is not required), these configurations may be omitted.

If applicable national and international requirements specifically call for the application of exposure configurations that are not specified in 6.1.2, 6.1.3 or 6.1.4, the manufacturer shall derive suitable assessment configurations following the underlying principles in 6.1.2, 6.1.3 and 6.1.4.

If applicable national and international requirements specifically exclude averaging of external field levels, measurements shall only be made at the distance d and analytical calculations shall be based on Equation (4) with $d = d_1 = d_2$.

6.1.2 Exposure of the head

6.1.2.1 Measurement of external field levels

Measurements shall be made in accordance with Figure 7. The standardized distance d from the axis of the welding cable to the closest surface of the field probes is 0,1 m.

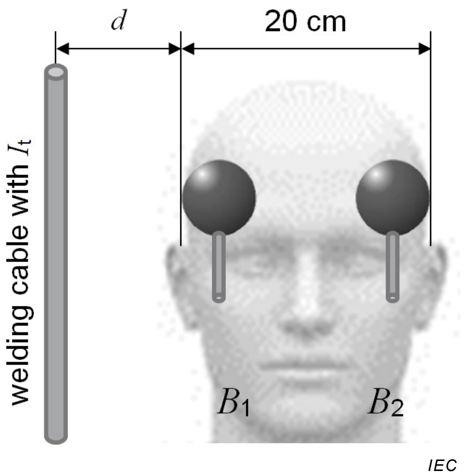


Figure 7 – Field measurement at head position

The average field level for the head $B_{AV\ head}$ shall be calculated as given in Equation (9).

$$B_{AV\,head} = \frac{B_1 + B_2}{2} \tag{9}$$

where

B_1 is the measured value at the position closest to the welding cable;

B_2 is the measured value at the position furthest from the welding cable.

6.1.2.2 Analytical calculation of external field levels

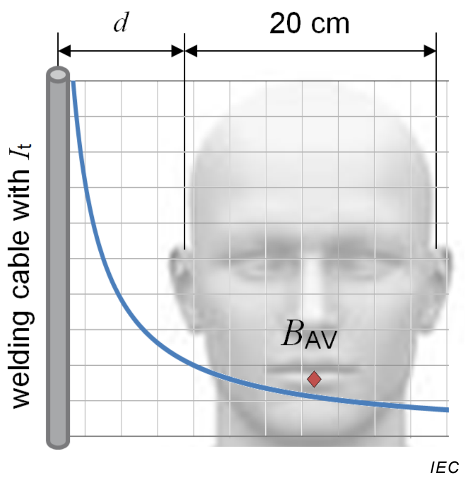


Figure 8 – Field calculation at head position

For the standardized value of d = 0,1 m and a calculation range of 0,2 m, as shown in Figure 8, the averaged external magnetic flux-density for the head $B_{AV\ head}$ shall be calculated as given in Equation (10).

$$B_{AV\,head} = 1{,}333 \times 10^{-6} \times I_t T \tag{10}$$

where

I_t is the value of a spectral component or the total value of the welding current.

6.1.2.3 Analytical calculation of intracorporeal levels

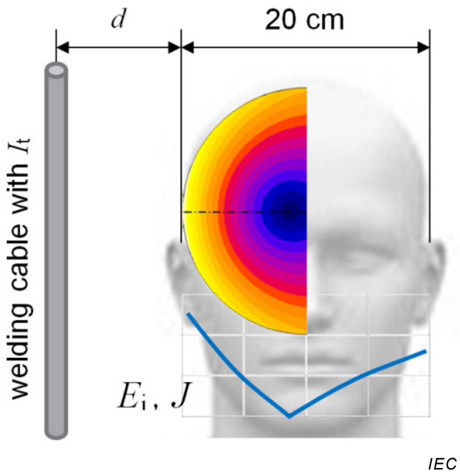


Figure 9 – Analytical calculation of intracorporeal metrics for the head

For the standardized value of d = 0,1 m and the standardized disk radius R = 0,1 m, as shown in Figure 9, the maximum intracorporeal electric field strength in the head $E_{i(f)\ MAX\ head}$ shall be calculated as given in Equation (11).

$$E_{i\,(f)MAXhead} = 4{,}285 \times 10^{-7} \times f \times I_{(f)}\ V\,m^{-1} \quad (11)$$

where

f is the frequency of a spectral component of the welding current;

$I_{(f)}$ is the amplitude of a spectral component of the welding current.

For the standardized value of d = 0,1 m and the standardized disk radius R = 0,1 m, as shown in Figure 9, the maximum induced current density in the head $J_{(f)\ MAX\ head}$ shall be calculated as given in Equation (12).

$$J_{(f)MAXhead} = 4{,}285 \times 10^{-7} \times \sigma_{(f)} \times f \times I_{(f)}\ A\,m^{-2} \quad (12)$$

where

$\sigma_{(f)}$ is the conductivity of the disk at the frequency f as given in Figure 6;

f is the frequency of a spectral component of the welding current;

$I_{(f)}$ is the amplitude of a spectral component of the welding current.

Other configurations can be calculated based on the information given in IEC 62226-2-1.

6.1.2.4 Numerical calculation of intracorporeal levels

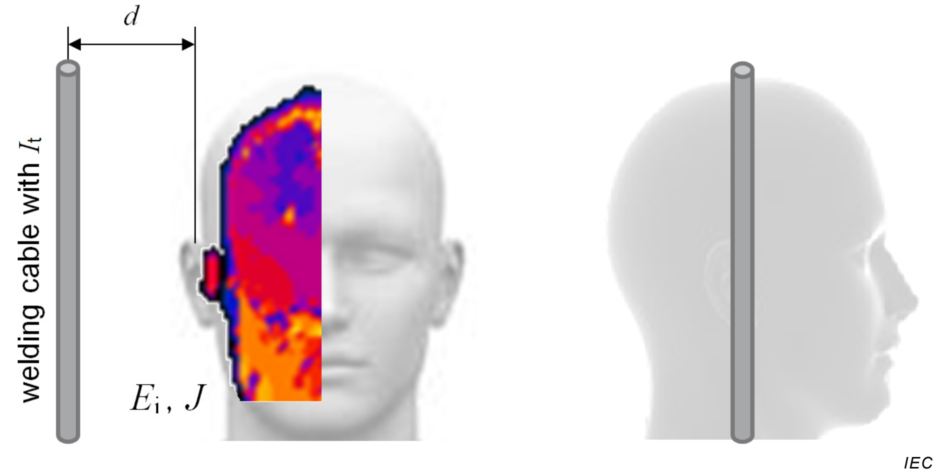


Figure 10 – Numerical calculation of intracorporeal metrics for the head

The standardized value for the distance d between the virtual welding cable and the model for the head, as defined in 5.4.4, is 0,1 m, as shown in Figure 10.

The relevant induced electric field value shall be the 99th percentile value of the vectorial averages within small contiguous tissue volumes of 2 mm^3 × 2 mm^3 × 2 mm^3.

The relevant induced current density value shall be the maximum of planar averages including only central nervous system tissues, excluding other types of tissue. The averaging area shall be perpendicular to the induced current flow and shall be smaller than or equal to 1 cm^2.

6.1.3 Exposure of the trunk

6.1.3.1 Measurement of external field levels

Measurements shall be made in accordance with Figure 11. The standardized distance d from the axis of the welding cable to the closest surface of the field probes is 0,1 m.

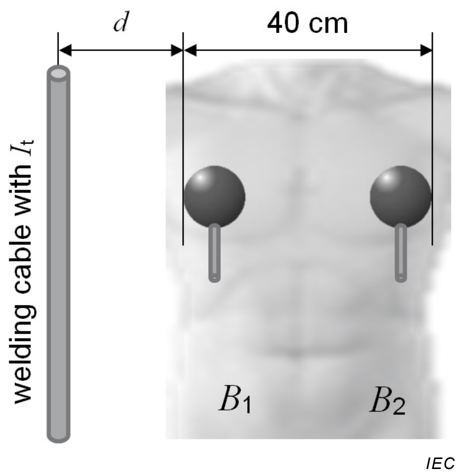


Figure 11 – Field measurement at trunk position

The average field level for the trunk $B_{AV\ trunk}$ shall be calculated as given in Equation (13).

$$B_{\text{AV trunk}} = \frac{B_1 + B_2}{2} \tag{13}$$

where

B_1 is the measured value at the position closest to the welding cable;

B_2 is the measured value at the position furthest from the welding cable.

6.1.3.2 Analytical calculation of external field levels

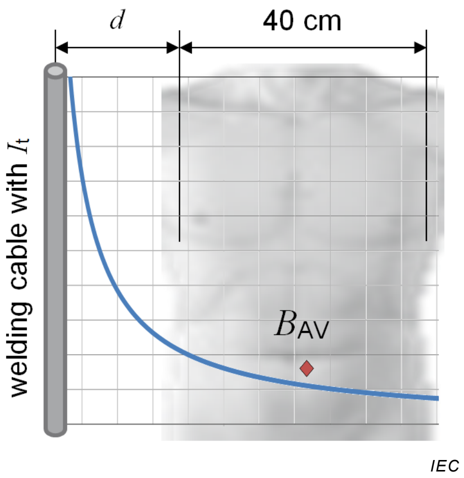


Figure 12 – Field calculation at trunk position

For the standardized value of d = 0,1 m and a calculation range of 0,4 m, as shown in Figure 12, the averaged external magnetic flux-density for the trunk $B_{\text{AV trunk}}$ shall be calculated as given in Equation (14).

$$B_{\text{AV trunk}} = 1{,}200 \times 10^{-6} \times I_t\ T \tag{14}$$

where

I_t is the value of a spectral component or the total value of the welding current.

6.1.3.3 Analytical calculation of intracorporeal levels

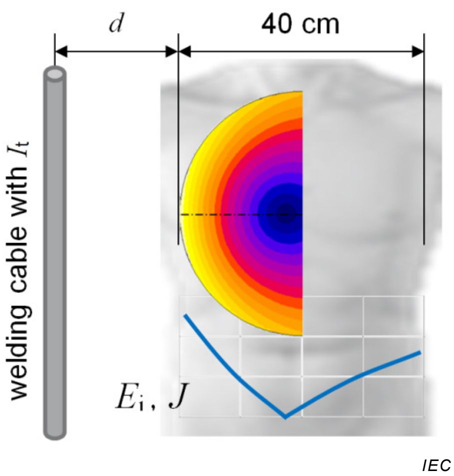


Figure 13 – Analytical calculation of intracorporeal metrics for the trunk

For the standardized value of d = 0,1 m and the standardized disk radius R = 0,2 m, as shown in Figure 13, the maximum intracorporeal electric field strength in the trunk $E_{i(f)\ MAX\ trunk}$ shall be calculated as given in Equation (15).

$$E_{i\,(f)MAX\,trunk} = 6{,}987 \times 10^{-7} \times f \times I_{(f)}\,V\,m^{-1} \quad (15)$$

where

f is the frequency of a spectral component of the welding current;

$I_{(f)}$ is the amplitude of a spectral component of the welding current;

d is the distance to the virtual welding cable.

For the standardized value of d = 0,1 m and the standardized disk radius R = 0,2 m, as shown in Figure 13, the maximum induced current density in the trunk $J_{(f)\ MAX\ trunk}$ shall be calculated as given in Equation (16).

$$J_{(f)MAX\,trunk} = 6{,}987 \times 10^{-7} \times \sigma_{(f)} \times f \times I_{(f)}\,A\,m^{-2} \quad (16)$$

where

$\sigma_{(f)}$ is the conductivity of the disk at the frequency f as given in Figure 6;

f is the frequency of a spectral component of the welding current;

$I_{(f)}$ is the amplitude of a spectral component of the welding current.

Other configurations can be calculated based on the information given in IEC 62226-2-1.

6.1.3.4 Numerical calculation of intracorporeal levels

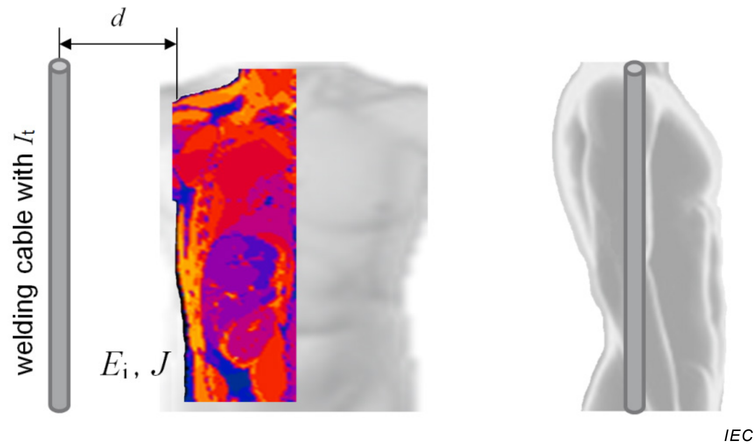


Figure 14 – Numerical calculation of intracorporeal metrics for the trunk

The standardized value for the distance d between the virtual welding cable and the model for the trunk, as defined in 5.4.4, is 0,1 m, see Figure 14.

The relevant induced electric field value shall be the 99th percentile value of the vectorial averages within small contiguous tissue volumes of 2 mm^3 × 2 mm^3 × 2 mm^3.

The relevant induced current density value shall be the maximum of planar averages including only central nervous system tissues, excluding other types of tissue. The averaging area shall be perpendicular to the induced current flow and shall be smaller than or equal to 1 cm^2.

6.1.4 Exposure of limbs

6.1.4.1 Measurement of external field levels

The highest localized exposure of limbs during manual electric welding operation is to be expected at the hand holding the welding gun and at the thigh, which may be close to the welding cable. Therefore the configurations as defined in Figure 15 shall be applied. The standardized distance d from the axis of the welding cable to the closest surface of the field probe(s) is 0,03 m.

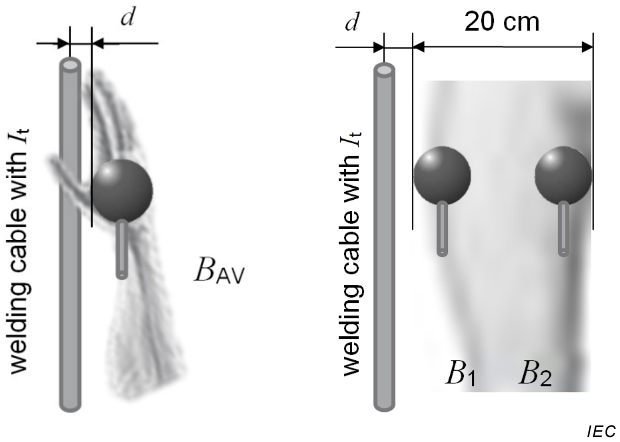


Figure 15 – Field measurement at limb positions, hand and thigh

Based on the intrinsic averaging effect due to the physical dimension of the field-probe, no additional averaging is applicable for the hand.

The average field level for the thigh $B_{AV\ thigh}$ shall be calculated in accordance with Equation (17).

$$B_{AV\,thigh} = \frac{B_1 + B_2}{2} \qquad (17)$$

where

B_1 is the measured value at the position closest to the welding cable;

B_2 is the measured value at the position furthest from the welding cable.

6.1.4.2 Analytical calculation of external field levels

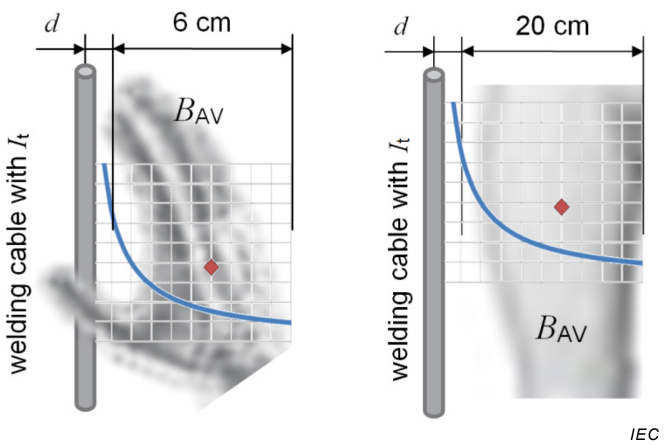


Figure 16 – Field calculation at limb positions, hand and thigh

For the standardized value of d = 0,03 m and a calculation range of 0,06 m, as shown in Figure 16, the averaged external magnetic flux-density for the hand $B_{AV\ hand}$ shall be calculated as given in Equation (18).

$$B_{\mathrm{AV\,hand}} = 4{,}444 \times 10^{-6} \times I_t T \tag{18}$$

where

I_t is the value of a spectral component or the total value of the welding current.

For the standardized value of d = 0,03 m and a calculation range of 0,2 m, as shown in Figure 16, the averaged external magnetic flux-density for the thigh $B_{AV\ thigh}$ shall be calculated as given in Equation (19).

$$B_{\mathrm{AV\,thigh}} = 3{,}768 \times 10^{-6} \times I_t T \tag{19}$$

where

I_t is the value of a spectral component or the total value of the welding current.

6.1.4.3 Analytical calculation of intracorporeal levels

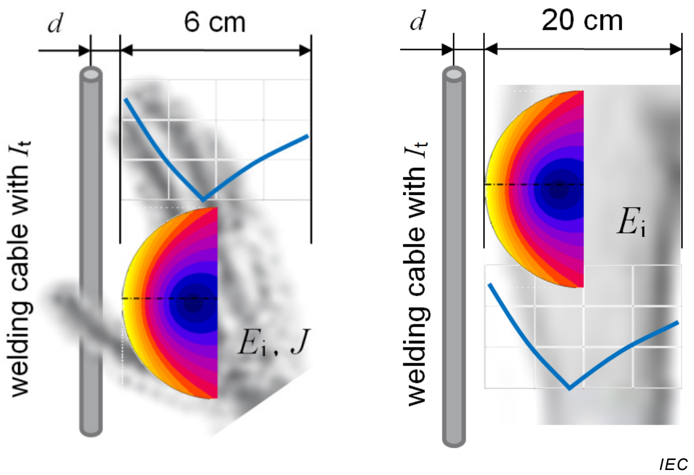


Figure 17 – Analytical calculation of intracorporeal metrics for hand and thigh

For the standardized value of d = 0,03 m and the standardized disk radius R = 0,03 m, as shown in Figure 17, the maximum intracorporeal electric field strength in the hand $E_{(i(f)\ MAX\ hand}$ shall be calculated as given in Equation (20).

$$E_{\mathrm{i\,(f)MAX\,hand}} = 3{,}952 \times 10^{-7} \times f \times I_{(f)}\ V\,m^{-1} \tag{20}$$

where

f is the frequency of a spectral component of the welding current;

$I_{(f)}$ is the amplitude of a spectral component of the welding current.

For the standardized value of d = 0,03 m and the standardized disk radius R = 0,1 m, as shown in Figure 17, the maximum intracorporeal electric field strength in the thigh $E_{(i(f)\ MAX\ thigh}$ shall be calculated as given in Equation (21).

$$E_{\mathrm{i\,(f)MAX\,thigh}} = 9{,}048 \times 10^{-7} \times f \times I_{(f)}\ V\,m^{-1} \tag{21}$$

where

f is the frequency of a spectral component of the welding current;

$I_{(f)}$ is the amplitude of a spectral component of the welding current.

Typically induced current density limitations apply to central nervous system tissues only. As there is no central nervous system tissue in limbs, the calculation of induced current densities in limbs is not applicable.

Other configurations can be calculated based on the information given in IEC 62226-2-1.

6.1.4.4 Numerical calculation of intracorporeal levels

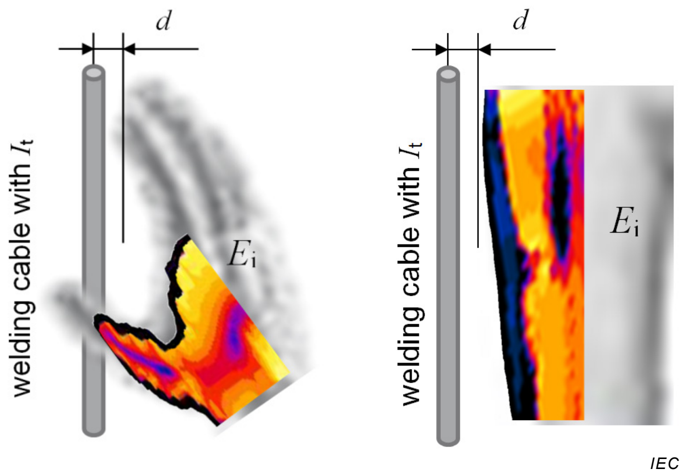


Figure 18 – Numerical calculation of intracorporeal metrics for hand and thigh

The standardized value for the distance between the virtual welding cable and the model for the limbs, as defined in 5.4.4, is 0,03 m, see Figure 18.

The relevant induced electric field value shall be the 99th percentile value of the vectorial averages within small contiguous tissue volumes of 2 mm^3 × 2 mm^3 × 2 mm^3, restricted to skin tissue.

Typically the relevant induced current density value is the maximum of planar averages including only central nervous system tissues, excluding other types of tissue. As there is no central nervous system tissue in limbs, assessment based on induced current densities in limbs is not applicable.

6.2 Welding current conditions

6.2.1 General

6.2.1.1 Procedure

The manufacturer shall select at least one of the assessment conditions given in 6.2.2, 6.2.3 and 6.2.4.

If the output-current ripple-amplitude, analysed as specified in 6.2.5, does not meet the exclusion criteria given in IEC 62822-1, the current ripple shall be included in the wave-shape to be assessed.

The wave-shape of the welding current shall be established by measurements or, if applicable, based on other data, e.g. pre-programmed welding current parameters of digitally controlled welding power sources.

6.2.1.2 Measurement of the current wave-shape

A conventional load as specified in IEC 60974-1 may be used. It is not necessary to set the load to the value corresponding to the conventional load voltages as specified in IEC 60974-1, provided that there is no influence on the selected waveform of the welding current. The load shall be connected to the welding power-source by two welding cables of appropriate cross-section.

NOTE 1 Influence on the welding current waveform could occur when short-circuit protection functions, special control routines or other functions are implemented in the welding power-source under test.

If realistic welding current waveforms cannot be achieved with a conventional load or the manufacturer prefers not to use a conventional load, measurements may be performed with constant voltage loads or under real arc conditions.

For the measurement of the welding current wave-shape, the inductance of the welding circuit including welding cables and load, as applicable, shall be less than 10 μH within the relevant frequency range.

Instruments (current transducer and oscilloscope) used for the measurement of the welding current shall have capabilities over the relevant frequency range and in terms of resolution and peak current.

Resistive shunts are not recommended for such measurements.

The sampling rate of the oscilloscope shall be set high enough to allow spectral analysis of the highest relevant frequency component.

Measurement results shall be validated in order to exclude noise or artefacts that are based on measurement errors. A possible method for validation is to derive the maximum realistic di/dt rate of the power-source before processing the data.

6.2.1.3 Current wave-shape based on other data

Current wave-shapes or the maximum di/dt capability of the power source may be derived by using parameters of the included welding programs or design parameters of the power source.

The relevant conditions given in 6.2.1.2 also apply, as applicable.

6.2.2 Single operating mode

Equipment shall be evaluated using the settings and conditions that lead to the highest exposure for the applied limits.

NOTE The highest exposure settings can be different depending on the applied limits (i.e. for EU Directive basic restrictions for sensory and health effects).

The selection of the relevant assessment conditions shall be based on the manufacturers´ technical knowledge of the welding equipment and, at least, the following parameters:

– rate of change of the welding current with respect to time (di/dt);
– welding current amplitude;
– pulse repetition rate, if applicable;
– a.c. frequency, if applicable.

The application of this concept allows the assessment of the worst case setting of the welding equipment at the time of testing. If new options for setting or use (e.g. new welding programs) are added after the assessment, the assessment shall be repeated.

6.2.3 Multiple operating modes

Equipment shall be assessed in multiple operation modes as specified by the manufacturer. The specification of assessment conditions shall be based on the manufacturers´ technical knowledge of the welding equipment and shall include the settings that lead to the highest exposure.

The application of this concept allows the provision of multiple sets of EMF data for the users, reducing overestimation of exposure for operating modes with EMF lower than the worst case mode (e.g. d.c. TIG welding, compared to a.c. square-wave TIG welding). Therefore unnecessary restrictions for workplaces where only lower EMF operating modes are used can be avoided. If new options for setting or use (e.g. new welding programs) are added after the assessment, the assessment shall be repeated.

NOTE The range of complexity for the differentiation of operating modes is broad, from providing data sets for each available process (e.g. MMA, MIG, TIG a.c., TIG d.c.) to providing a database for all implemented welding programs.

6.2.4 Worst case power source capability

Equipment shall be assessed using the current waveform that includes the maximum di/dt capability of the welding power source.

NOTE 1 For d.c. equipment, the current change is assessed from 0 to I_{2max} or from I_{2max} to 0. For a.c. equipment between $I_{max\ neg}$ and $I_{max\ pos}$.

This worst case exposure capability is determined by the design of the welding power source including related control systems (controlling the power circuit) and is independent from pre-programmed or otherwise pre-defined current wave-shapes (controlling the welding process).

NOTE 2 It might be appropriate to override standard operating modes to perform this assessment.

The application of this concept represents the assessment of the worst case technical di/dt capability of the welding power source. If new options for setting or use (e.g. new welding programs) are added after the assessment, there is no need to repeat the assessment.

6.2.5 Current ripple

In order to identify if the output-current ripple-amplitude meets the exclusion criteria given in IEC 62822-1, it shall be analysed at the rated welding current at 100 % duty cycle. If no rated current is specified for 100 % duty cycle (e.g. for equipment within the scope of IEC 60974-6), the analysis shall be made at 50 % of $I_{2\ max}$.

7 EMF data sheet and assessment report

The contents of the EMF datasheet are based on the mandatory compliance criteria and the required EMF data for the user, as specified in IEC 62822-1 and the decision of the manufacturer to provide additional data, exceeding the mandatory amount of information.

The minimum information to be collected during the assessment is given in the list below:

– a confirmation of compliance with the applicable basic restrictions at the standardized configurations for head, trunk and limbs – or a statement that the equipment does not comply at the standardized configurations;
– the exposure indices at the standardized configurations for head (for sensory effects and health effects, as applicable), trunk and limbs;
– the distances between the welding cable and the head, trunk and limbs with regard to the standardized configurations;
– required minimum distances for head, trunk and limbs at which compliance is ensured;

– if compliance could not be shown at all standardized configurations – the distances from the welding cable where compliance is reached for head, trunk and limbs.
– the distance from the welding cable where the exposure index falls below 20 %, based on the applicable basic restriction or reference level.
– for professional equipment – the distance from the welding cable where the exposure index falls below 100 %, based on the basic restriction or reference level for the general public.
– as applicable – if reference levels are exceeded at the standardized configurations for head, trunk and limbs;
– as applicable – if the basic restrictions for sensory effects are exceeded at the standardized configurations for the head.

NOTE 1 All distances refer to the centre of the welding cable.

NOTE 2 If applicable national and international requirements exclude parts of the body (e.g. limbs), information regarding these parts may not be required.

An example for additional information that may be collected during the assessment is given below:

– data for multiple operation modes.

The information collected shall be presented in an EMF datasheet. Examples of EMF data sheets based on the scenarios above are included in Annexes A and B.

Requirements for the assessment report are given in IEC 61786-2.

Annex A
(informative)

Example for EMF data sheet structure

EMF DATA SHEET FOR ARC WELDING POWER SOURCE

Issued by	I company name I	I responsible person I	
Valid from	I 20XX-YY-ZZ I	Revision	I A I

Equipment information

Brand name	I brand name I
Model name(s)	I model name 1, model name 2, … I
Model number(s)	I model number 1, model number 2, … I
Intended use	☐ for occupational use ☐ for use by laymen

Basic information

Applied regulation	I Directive 2006/95/EC I
Referenced limits	I Directive 2013/35/EU, Recommendation 1999/519/EC I
Applied standard(s)	I EN 62822-1:20XX, EN 62822-2:20XX I

Non- thermal effects need to be considered for workplace assessment ☐ YES ☐ NO

Thermal effects need to be considered for workplace assessment ☐ YES ☐ NO

☐ Data is based on maximum power source capability (valid unless firmware / hardware is changed)

☐ Data is based on worst case setting / program (only valid until setting options / welding programs are changed)

☐ Data is based on multiple settings / programs (only valid until setting options / welding programs are changed)

Compliance information summary

Compliance with the exposure limit values for health effects at the standardized configurations ☐ YES ☐ NO
(if NO, specific required minimum distances apply)

Compliance with the exposure limit values for sensory effects at the standardized configurations ☐ n.a. ☐ YES ☐ NO
(if applicable and NO, specific measures may be needed)

All values below the action levels at the standardized configurations ☐ n.a. ☐ YES ☐ NO
(if applicable and NO, specific signage may be needed)

EMF data for non-thermal effects

Exposure indices (EI) and distances to welding circuit (for each operation mode, as applicable)

	Head		Trunk	Limb hand	Limb thigh
	sensory effects	health effects			
Standardized distance	I 10 cm I	I 10 cm I	I10 cm I	I 3 cm I	I 3 cm I
EI at standardized distance	I XX I	I XX I	I XX I	I XX I	I XX I
Required minimum distance	I XX cm I	I XX cm I	I XX cm I	I XX cm I	I XX cm I

Distance where all EIs fall below 20 % I XX cm I

Distance where compliance with general public limits is reached (as applicable) I XX cm I

Annex B
(informative)

Assessment example for maximum power-source capability

B.1 Equipment description

The welding power-source is a multi-process, inverter type equipment for d.c. welding applications. It is built in accordance with IEC 60974-1. The maximum rated welding current is 600 A. Apart from the switched mode power-circuit, the equipment does not contain EMF relevant field sources.

B.2 Welding current measurement and spectral analysis

The manufacturer decided to assess the equipment based on the worst case power source condition, as described in 6.2.4. As a first step, the current ripple due to the inverter power circuit was measured as defined in 6.2.5. The result is shown in Figure B.1 it gives a peak-peak amplitude of 20 A at a ripple frequency of 100 kHz. Based on IEC 62822-1, the current ripple is therefore excluded from EMF assessment, both for non-thermal and thermal effects.

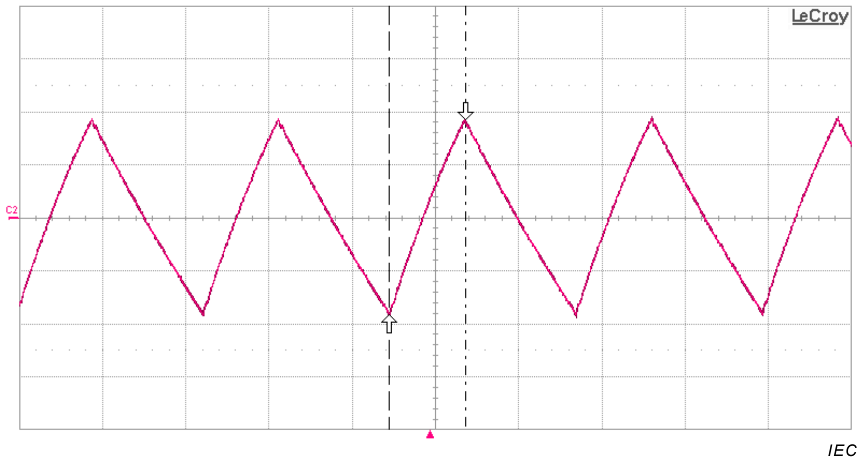


Figure B.1 – Example 1 – Current ripple

The maximum *di/dt* capability of the welding power source was identified and measured as defined in 6.2.4, the result is shown in Figure B.2.

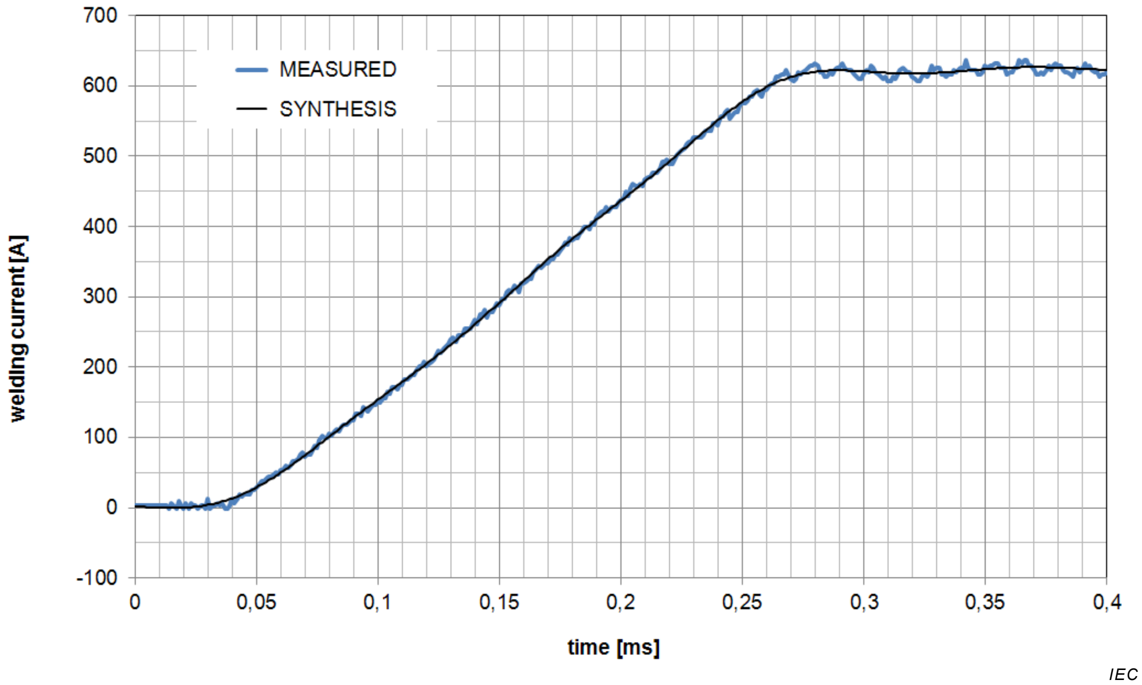


Figure B.2 – Example 1 – Maximum power-source capability

Based on the rise time of approximately 0,2 ms (and the identified non-relevance of the current ripple), the upper frequency range limitation for EMF assessment, as defined in 5.1.5.4, was calculated as 12,5 kHz. This means that thermal effects need not be considered.

An FFT analysis of the measured welding current was performed, before that the current slope was transformed to an equivalent repetitive signal as defined in 5.1.5.3.

The validation of the FFT (by synthesis of the identified spectral components up to the upper frequency) is included in Figure B.2.

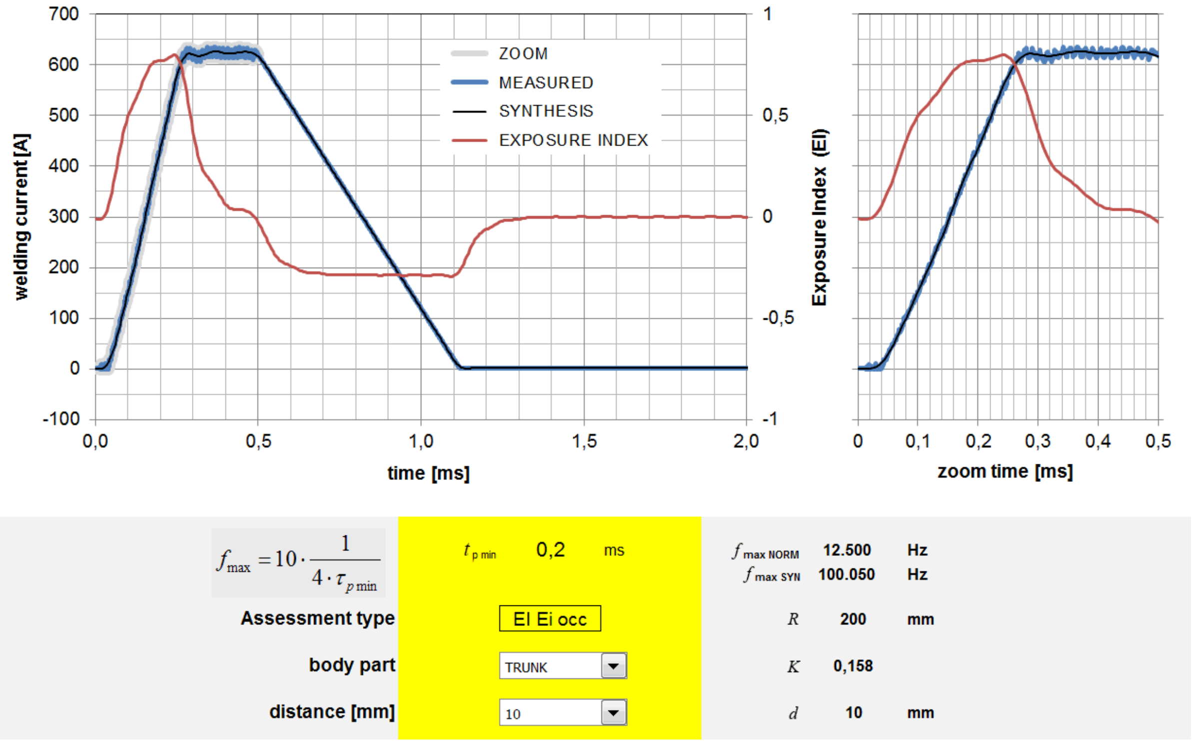
B.3 Assessment of non-thermal effects

The calculated spectral components (including phase information) were used to compute EI by using the weighted peak method in the frequency domain, as given in 5.1.4.3, for the standardized assessment configurations as defined in 6.1.

EIs were calculated based on the resulting external magnetic flux-densities (in comparison to the respective action levels) and the induced internal electric fields and current densities in conductive disks (in comparison to the respective exposure limit values). No numerical calculations were utilized for this assessment.

In addition, EIs for non-standardized distances between 10 mm and 5 000 mm were computed using an automated tool based on a spreadsheet. This was applied in order to define the minimum distances (lower that the standardized distances) for all parts of the body and the distances where the EIs fall below a value of 20 %. EI values were calculated for general public and occupational exposure.

The result of one of the assessment elements, the occupational EI for a conductive disk representing the trunk of the welder at a distance of 10 mm, is shown in Figure B.3.



IEC

Figure B.3 – Example 1 – EI calculation element

The results of all EI calculations were collected in a table and summarized in the graph as shown in Figure B.4. This graph can be used to identify all information necessary for the EMF datasheet presented in Figure B.5

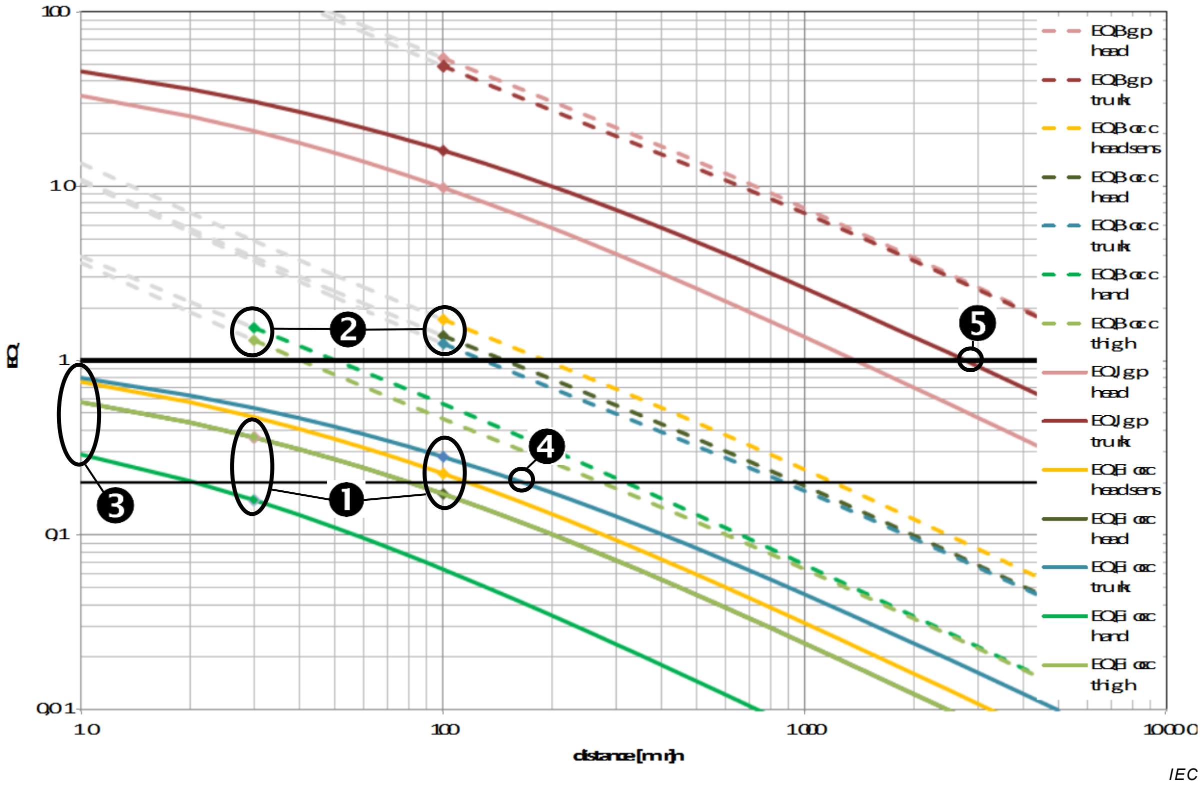


Figure B.4 – Example 1 – EI calculation summary

The main information contained in Figure B.4 is marked by the numbers in black circles. The respective conclusions are summarized below.

The results marked with ❶ show that all EIs based on the exposure limit values for occupational exposure, including the one for sensory effects, are below 1 (100 %) at the standardized configurations and distances.

The results marked with ❷ show that all EIs based on the action levels for occupational exposure are higher than 1 (100 %) at the standardized configurations and distances. I.e., assessment based on external field levels cannot be used. It further means that, based on the contents of Directive 2013/35/EU, signage of the workplaces where the equipment is used might be required even though compliance with the exposure limit values is shown.

The results marked with ❸ show that all EI lines based on exposure limit values for occupational exposure are below 1 (100 %), even at a distance of 1 cm (the lowest distance calculated) for all configurations.

The result marked with ❹ shows that the highest EI line based on the exposure limit value for occupational exposure (the configuration for the trunk) falls below 0,2 (20 %) at a distance of 19 cm.

The result marked with ❺ shows that the higher EI line based on the exposure limit value for general public exposure (the configuration for the trunk) only falls below 1 (100 %) at a distance of approximately 3 m.

EMF DATA SHEET FOR ARC WELDING POWER SOURCE

Issued by	Compaweld Ltd	Daniel Tester
Valid from	2016-06-30	revision A

Equipment information

Brand name	Compaweld	
Model name(s)	Superwelder 2016	
Model number(s)	12-3456-000-789	
Intended use	**X** for occupational use	☐ for use by laymen

Basic information

Applied regulation	Directive 2006/95/EC
Referenced limits	Directive 2013/35/EU, Recommendation 1999/519/EC
Applied standard(s)	EN 62822-1:2015, EN 62822-2:2015

Non- thermal effects need to be considered for workplace assessment	**X** YES	☐ NO
Thermal effects need to be considered for workplace assessment	☐ YES	**X** NO

X Data is based on maximum power source capability (valid unless firmware / hardware is changed)

☐ Data is based on worst case setting / program (only valid until setting options / welding programs are changed)

☐ Data is based on multiple settings / programs (only valid until setting options / welding programs are changed)

Compliance information summary

Compliance with the exposure limit values for health effects at the standardized configurations		**X** YES	☐ NO
	(if NO, specific required minimum distances apply)		
Compliance with the exposure limit values for sensory effects at the standardized configurations	☐ n.a.	**X** YES	☐ NO
	(if applicable and NO, specific measures may be needed)		
All values below the action levels at the standardized configurations	☐ n.a.	☐ YES	**X** NO
	(if applicable and NO, specific signage may be needed)		

EMF data for non-thermal effects

Exposure indices (EI) and distances to welding circuit (for each operation mode, as applicable)

	Head		Trunk	Limb hand	Limb thigh
	sensory effects	health effects			
Standardized distance	10 cm	10 cm	10 cm	3 cm	3 cm
EI at standardized distance	0,23	0,18	0,28	0,16	0,36
Required minimum distance	1 cm	1 cm	1 cm	1 cm	1 cm

Distance where all EIs fall below 20 %	19 cm
Distance where compliance with general public limits is reached (as applicable)	300 cm

IEC

Figure B.5 – Example 1 – EMF data sheet

Annex C
(informative)

Summation with approximated and piecewise linear limit values

The example for frequency domain evaluations of a pulsed welding current wave-shape given in Figure C.1 was calculated with the limit parameters (magnitudes and phase angles of the weighting function) for health effects as specified in the European EMF Workers Directive 2013/35/EU. Both the piecewise linear limit parameters and the approximated parameters, derived using a complex function as defined in 5.1.4.3, were used for calculation. It can be clearly seen that oscillations (bottom graph) at the corner frequency of the limit line (3 kHz), caused by the piecewise linear parameters, are eliminated when using the approximation approach (top graph).

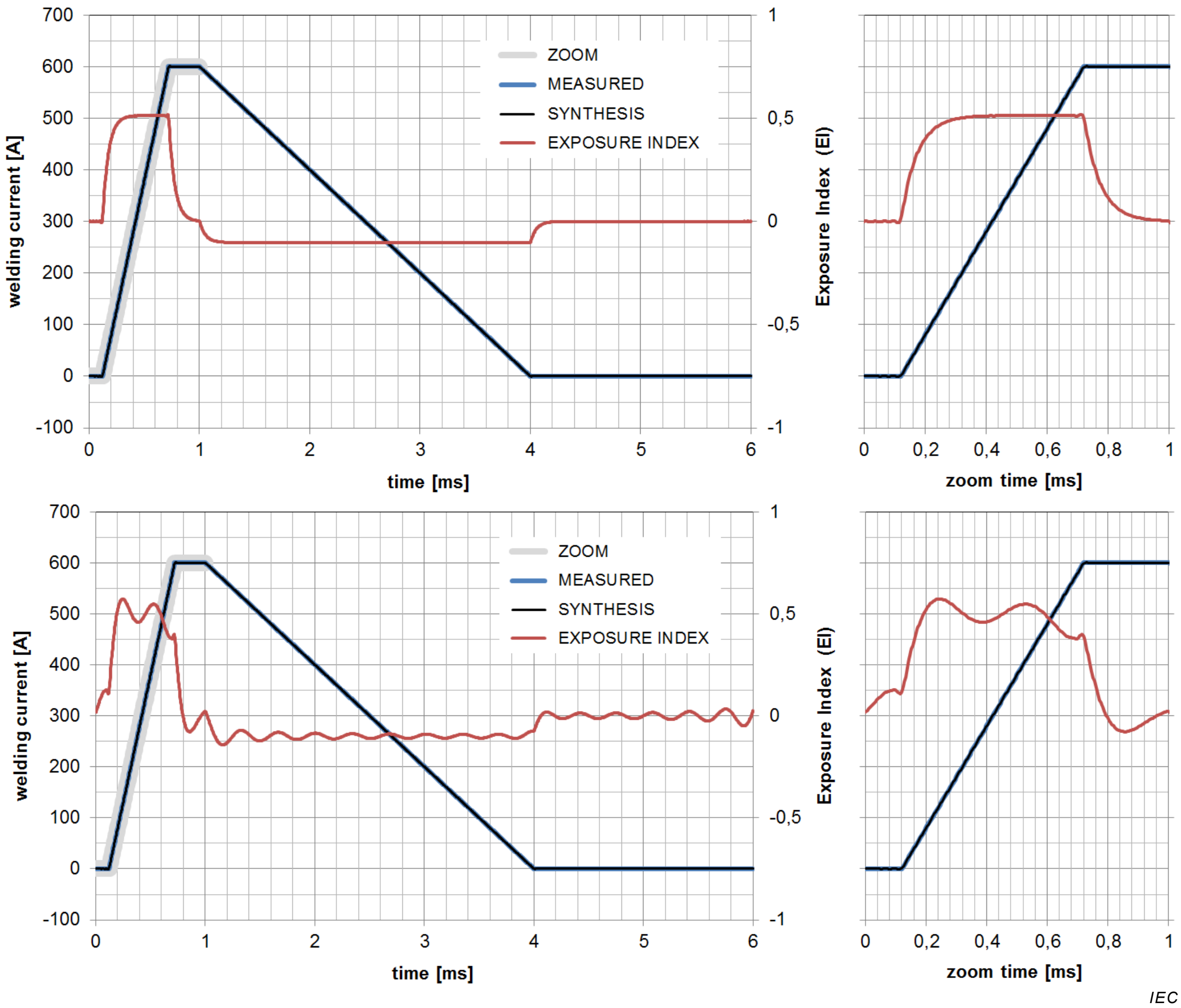


Figure C.1 – EI comparison with approximated and piecewise linear values

For this example, the maximum value of the EI is higher with the piecewise linear limit parameters. Comparing the EI wave-shape with the response of a real RC filter (which is the basis for the applied limit), is it obvious that the approximation approach leads to more realistic results than the piecewise linear approach.

Annex D
(informative)

Coupling factors for various distances and disk radii

Table D.1 – Coupling factors for various distances and disk radii

Distance *d* between the single wire and the disk mm	Coupling factors *K* for disk radii *R*		
	R = 30 mm	*R* = 100 mm	*R* = 200 mm
10	0,383	0,229	0,158
20	0,539	0,350	0,250
30	0,629	0,432	0,318
40	0,689	0,492	0,371
50	0,732	0,540	0,415
60	0,764	0,579	0,451
70	0,789	0,611	0,483
80	0,810	0,638	0,510
90	0,826	0,661	0,535
100	0,840	0,682	0,556
130	0,871	0,730	0,610
160	0,892	0,765	0,651
190	0,907	0,792	0,683
220	0,919	0,813	0,710
260	0,930	0,835	0,739
300	0,939	0,852	0,762
350	0,947	0,869	0,785
388	0,952	0,879	0,800
426	0,956	0,888	0,813
464	0,959	0,896	0,825
503	0,962	0,903	0,835
579	0,967	0,914	0,851
656	0,971	0,922	0,865
732	0,974	0,929	0,876
809	0,976	0,935	0,885
886	0,978	0,940	0,893
1 000	0,981	0,946	0,903
1 115	0,982	0,951	0,911
1 230	0,984	0,955	0,918
1 345	0,985	0,958	0,924
1 460	0,987	0,961	0,929
1 575	0,988	0,964	0,933
1 881	0,990	0,969	0,942
2 500	0,992	0,979	0,961
3 000	0,994	0,982	0,967
4 000	0,995	0,987	0,975
5 000	0,996	0,989	0,980

NOTE 1 The *K* values for *R* = 100 mm and *R* = 200 mm are copied from IEC 62226-2-1, the *K* values for *R* = 30 mm were calculated based on the procedures defined in IEC 62226-2-1.

NOTE 2 Coupling factors between successive values of *d* are derived by linear interpolation.

NOTE 3 An approximated coupling factor of 1 applies at distances larger than 5 m.

Bibliography

[1] *Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)*, Official Journal L 199, 30.07.1999, p.59-70

[2] *Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields),* 20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC and repealing Directive 2004/40/EC, Official Journal L 179, 29.06.2013, p.1-21

[3] Practical guides to Directive 2013/35/EU2

[4] International Commission on Non-Ionising Radiation Protection, *Guidelines on Limits of Exposure to Static Magnetic Fields, Health Physics*, Volume 96, Number 4, 2009, p.504-514

[5] International Commission on Non-Ionising Radiation Protection, *Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz),* Health Physics, Volume 99, Number 6, 2010, p.818-836

[6] International Commission on Non-Ionising Radiation Protection, *Guidance on Determining Compliance of Exposure to Pulsed and Complex Non-Sinusoidal Waveforms below 100 kHz with ICNIRP Guidelines*, Health Physics, Volume 84, Number 3, March 2003, p.383-387

[7] IEEE Std C95.1-2005, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz,* The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, New York, NY 10016-5997, USA

[8] IEEE Std C95.6-2002*, IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz,* The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, New York, NY 10016-5997, USA

[9] IEEE Std C95.3.1-2010, *IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz,* The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, New York, NY 10016-5997, USA

[10] IEC 62226-1, *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*

[11] IEC 62226-2-1:2004, *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*

[12] IEC 62311, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)*

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2 To be published

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