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REDLINE VERSION

INTERNATIONAL STANDARD

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Arc welding equipment –
Part 1: Welding power sources

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Arc welding equipment –
Part 1: Welding power sources

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ARC WELDING EQUIPMENT –

Part 1: Welding power sources

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60974-1 has been prepared by IEC technical committee 26: Electric welding. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2017 and Amendment 1:2019. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Table 1 with an alphabetical cross-reference listing of terms added;
b) CLEARANCE and CREEPAGE DISTANCE reference document changed to IEC 60664-1:2020;
c) 6.1.2 and 6.1.3 modified to follow IEC 60664-1 BASIC INSULATION dimensioning for mains supply with rationalized voltages;
d) abnormal capacitor test of 6.2.2 moved to new Subclause 9.5;
e) 6.2.5 and 6.3.6 modified to use TOUCH CURRENT measuring network weighted for letgo-immobilization and supply voltage tolerance requirement added;
f) 16.3 new structure and accuracy requirement for displayed voltage value;
g) Annex A changed to normative and Table A.2 and Table A.3 added;
h) Annex L editorial update to standardized symbols;
i) redraft of efficiency and IDLE STATE power measurement in Annex M based on IEC 62301:2011;
j) Annex N measurement network weighted for letgo-immobilization added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
26/724/FDIS	26/727/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

In this document, the following print types are used:

– *conformity statements*: in *italic* type.
– terms used throughout this document which have been defined in Clause 3: ~~in **bold** type~~ SMALL ROMAN CAPITALS.

A list of all parts of the IEC 60974 series can be found, under the general title *Arc welding equipment*, on the IEC website.

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- reconfirmed,
- withdrawn,
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ARC WELDING EQUIPMENT –

Part 1: Welding power sources

1 Scope

This part of IEC 60974 is applicable to power sources for arc welding and allied processes designed for INDUSTRIAL AND PROFESSIONAL USE, and supplied by a voltage not exceeding 1 000 V, BATTERY supplied or driven by mechanical means.

This document specifies safety and performance requirements of WELDING POWER SOURCES and PLASMA CUTTING SYSTEMS.

This document is not applicable to limited duty arc welding and cutting power sources which are designed mainly for use by laymen and designed in accordance with IEC 60974-6.

This document includes requirements for battery-powered WELDING POWER SOURCES and BATTERY packs, which are given in Annex O.

This document is not applicable to testing of power sources during periodic maintenance or after repair.

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

NOTE 2 AC systems having a nominal voltage between 100 V and 1 000 V are given in Table 1 of IEC 60038:2009.

NOTE 3 This document does not include electromagnetic compatibility (EMC) requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* (available at: http://www.electropedia.org)

IEC 60050-851, *International Electrotechnical Vocabulary (IEV) – Part 851: Electric welding* (available at: http://www.electropedia.org)

IEC 60245-6, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 6: Arc welding electrode cables*

IEC 60417, *Graphical symbols for use on equipment* (available at: http://www.graphical-symbols.info/equipment)

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1:~~2007~~2020, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

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IEC 60664-3, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60974-7, *Arc welding equipment – Part 7: Torches*

IEC 60974-10, *Arc welding equipment – Part 10: Electromagnetic compatibility (EMC) requirements*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61558-2-4, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 62133-1:~~—[1]~~2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems*

IEC 62133-2:~~—[2]~~2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

IEC 62301:2011, *Household electrical appliances – Measurement of standby power*

ISO 7010:~~2011~~2019, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-151, IEC 60050-851, IEC 60664-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

Table 1 provides an alphabetical cross-reference listing of terms.

~~[1] Under preparation. Stage at the time of publication: IEC CDV 62133-1:2015.~~

~~[2] Under preparation. Stage at the time of publication: IEC CDV 62133-2:2015.~~

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Table 1 – Alphabetical list of terms

Term	Term number	Term	Term number	Term	Term number
active power	3.3.3	explosion	3.2.23	rated reduced no-load voltage	3.1.27
apparent power	3.3.4	fixed installation	3.1.62	rated supply current	3.1.30
basic insulation	3.1.50	flat characteristic	3.1.9	rated supply frequency	3.3.1
basic protection	3.2.18	fully charged cell	3.2.10	rated supply voltage	3.1.29
battery	3.2.1	fully discharged cell	3.2.11	rated switched no-load voltage	3.1.28
battery system	3.2.5	functional insulation	3.1.65	rated value	3.1.21
battery voltage class A	3.2.19	general purpose batteries	3.2.12	rating plate	3.1.22
battery voltage class B	3.2.20	hazard reducing device	3.1.47	reinforced insulation	3.1.53
C_5 rate	3.2.6	idle state	3.1.66	remote control	3.1.60
cell	3.2.7	industrial and professional use	3.1.2	routine test	3.1.6
charger	3.2.8	instructed person	3.1.4	safety extra-low voltage	3.1.56
charging system	3.2.9	integral battery	3.2.2	separable battery pack	3.2.4
charring	3.2.21	load voltage	3.1.14	single-fault condition	3.1.61
class I equipment	3.1.48	material group	3.1.42	specified operating region	3.2.14
class II equipment	3.1.49	maximum charging current	3.2.13	specified operating region for charging	3.2.14.1
class of insulation	3.1.64	maximum effective supply current	3.1.33	static characteristic	3.1.10
clearance	3.1.38	micro-environment	3.1.41	supplementary insulation	3.1.51
consecutive operating cycle	3.2.22	no-load voltage	3.1.15	supply circuit	3.1.57
control circuit	3.1.12	plasma cutting power source	3.1.55	temperature rise	3.1.43
conventional load	3.1.18	plasma cutting system	3.1.54	thermal equilibrium	3.1.44
conventional load voltage	3.1.20	pollution degree	3.1.40	thermal protection	3.1.45
conventional value	3.1.16	power factor	3.3.5	total harmonic distortion	3.3.6
conventional welding condition	3.1.17	protective circuit	3.1.63	touch current	3.1.59
conventional welding current	3.1.19	rated idle speed	3.1.36	type test	3.1.5
creepage distance	3.1.39	rated load speed	3.1.34	upper limit charging voltage	3.2.15
detachable battery pack	3.2.3	rated maximum supply current	3.1.32	venting	3.2.16
double insulation	3.1.52	rated maximum welding current	3.1.24	visual inspection	3.1.7
drooping characteristic	3.1.8	rated minimum welding current	3.1.25	welding circuit	3.1.11

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Term	Term number	Term	Term number	Term	Term number
duty cycle	3.1.37	rated no-load speed	3.1.35	welding current	3.1.13
electronic component	3.2.17	rated no-load supply current	3.1.31	welding power source	3.1.1
environment with increased risk of electric shock	3.1.46	rated no-load voltage	3.1.26	welding power source efficiency	3.3.2
expert	3.1.3	rated output	3.1.23	working voltage	3.1.58

3.1 General terms and definitions

3.1.1
welding power source
arc welding power source
equipment for supplying current and voltage and having the required characteristics suitable for arc welding and allied processes

Note 1 to entry: A WELDING POWER SOURCE can also supply services to other equipment and auxiliaries for example auxiliary power, cooling liquid, consumable arc welding electrode and gas to shield the arc and the welding area.

Note 2 to entry: This entry revises IEC 60050-851:2008, 851-13-01, which will be updated.

3.1.2
industrial and professional use
use intended only for EXPERTS or INSTRUCTED PERSONS

[SOURCE: IEC 60050-851:2008, 851-11-12]

3.1.3
expert
competent person
skilled person
person who can judge the work assigned and recognize possible hazards on the basis of professional training, knowledge, experience and knowledge of the relevant equipment

Note 1 to entry: Several years of practice in the relevant technical field can be taken into consideration in assessment of professional training.

[SOURCE: IEC 60050-851:2008, 851-11-10]

3.1.4
instructed person
person informed about the tasks assigned and about the possible hazards involved in neglectful behaviour

Note 1 to entry: If necessary, the person has undergone some training.

[SOURCE: IEC 60050-851:2008, 851-11-13]

3.1.5
type test
test of one or more devices made to a given design to check if these devices comply with the requirements of the standard concerned

[SOURCE: IEC 60050-851:2008, 851-12-05]

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3.1.6
routine test
test made on each individual device during or after manufacture to check if it complies with the requirements of the standard concerned or the criteria specified

[SOURCE: IEC 60050-851:2008, 851-12-06]

3.1.7
visual inspection
inspection by eye to verify that there are no apparent discrepancies with respect to provisions of the standard concerned

[SOURCE: IEC 60050-851:2008, 851-11-11]

3.1.8
drooping characteristic
external STATIC CHARACTERISTIC of a WELDING POWER SOURCE which, in its normal welding range, is such that the negative slope is greater than or equal to 7 V/100 A

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-12-34, which will be updated.

3.1.9
flat characteristic
external STATIC CHARACTERISTIC of a WELDING POWER SOURCE which, in its normal welding range, is such that, as the current increases, the voltage either decreases by less than 7 V/100 A or increases by less than 10 V/100 A

[SOURCE: IEC 60050-851:2008, 851-12-35]

3.1.10
static characteristic
relationship between the voltage and the current at the output terminals of a WELDING POWER SOURCE when connected to a CONVENTIONAL LOAD

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-12-32, which will be updated.

3.1.11
welding circuit
conductive material through which the WELDING CURRENT is intended to flow

Note 1 to entry: In arc welding, the arc is a part of the WELDING CIRCUIT.

Note 2 to entry: In certain arc welding processes, the welding arc can be established between two electrodes. In such a case, the workpiece is not necessarily a part of the WELDING CIRCUIT.

[SOURCE: IEC 60050-851:2008, 851-14-10]

3.1.12
control circuit
internal or external circuit for the operational control of the equipment or for protection of the power circuits, or both

EXAMPLE 1 CONTROL CIRCUITS intended for interface between the WELDING POWER SOURCE and external equipment designed by the manufacturer.

EXAMPLE 2 CONTROL CIRCUITS intended for interface between the WELDING POWER SOURCE and other types of ancillary equipment.

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-14-11, which will be updated.

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3.1.13
welding current
current delivered by a WELDING POWER SOURCE during welding

3.1.14
load voltage
voltage between the output terminals when the WELDING POWER SOURCE is delivering WELDING CURRENT

[SOURCE: IEC 60050-851:2008, 851-12-04]

3.1.15
no-load voltage
voltage, exclusive of any arc striking or arc stabilizing voltage, between the accessible output terminals of a WELDING POWER SOURCE when the WELDING CIRCUIT is open but energized

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-12-24, which will be updated.

3.1.16
conventional value
standardized value that is used as a measure of a parameter for the purposes of comparison, calibration, testing, etc.

Note 1 to entry: CONVENTIONAL VALUES do not necessarily apply during the actual welding process.

[SOURCE: IEC 60050-851:2008, 851-12-07]

3.1.17
conventional welding condition
condition of the WELDING POWER SOURCE in the energized and thermally stabilized state defined by a CONVENTIONAL WELDING CURRENT driven by the corresponding CONVENTIONAL LOAD VOLTAGE through a CONVENTIONAL LOAD at RATED SUPPLY VOLTAGE and frequency or speed of rotation

[SOURCE: IEC 60050-851:2008, 851-12-26]

3.1.18
conventional load
practically non-inductive constant resistive load having a POWER FACTOR not less than 0,99

[SOURCE: IEC 60050-851:2008, 851-12-27]

3.1.19
conventional welding current
I_2
current delivered by a WELDING POWER SOURCE to a CONVENTIONAL LOAD at the corresponding CONVENTIONAL LOAD VOLTAGE

Note 1 to entry: The values of I_2 are given as RMS values for AC and arithmetic mean values for DC.

3.1.20
conventional load voltage
U_2
LOAD VOLTAGE of a WELDING POWER SOURCE having a specified linear relationship to the CONVENTIONAL WELDING CURRENT

Note 1 to entry: The values for U_2 are given as RMS values for AC and arithmetic mean values for DC.

Note 2 to entry: The specified linear relationship varies in accordance with the process (see 11.2).

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Note 3 to entry: This entry revises IEC 60050-851:2008, 851-12-30, which will be updated.

3.1.21
rated value
assigned value, generally by the manufacturer, for a specified operating condition of a component, device or equipment

3.1.22
rating plate
name plate
plate, permanently affixed on an electric device, which indelibly states the rating and other information as required by the relevant standard

[SOURCE: IEC 60050-151:2001, 151-16-12]

3.1.23
rated output
RATED VALUES of the output of the equipment

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-12-17, which will be updated.

3.1.24
rated maximum welding current
I_{2max}
maximum value of the CONVENTIONAL WELDING CURRENT that can be obtained at the CONVENTIONAL WELDING CONDITION from a WELDING POWER SOURCE at its maximum setting

[SOURCE: IEC 60050-851:2008, 851-12-14]

3.1.25
rated minimum welding current
I_{2min}
minimum value of the CONVENTIONAL WELDING CURRENT that can be obtained at the CONVENTIONAL WELDING CONDITION from a WELDING POWER SOURCE at its minimum setting

[SOURCE: IEC 60050-851:2008, 851-12-15]

3.1.26
rated no-load voltage
U_0
NO-LOAD VOLTAGE at RATED SUPPLY VOLTAGE and frequency or RATED NO-LOAD SPEED of rotation

Note 1 to entry: If a WELDING POWER SOURCE is fitted with a HAZARD REDUCING DEVICE, this is the voltage measured before the HAZARD REDUCING DEVICE has performed its function.

3.1.27
rated reduced no-load voltage
U_r
NO-LOAD VOLTAGE of a WELDING POWER SOURCE, fitted with a voltage reducing device immediately after the device acts to effect a reduction in the voltage

3.1.28
rated switched no-load voltage
U_s
DC NO-LOAD VOLTAGE of a WELDING POWER SOURCE, fitted with an AC to DC switching device

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3.1.29
rated supply voltage
U_1
RMS value of supply voltage for which the equipment is designed

3.1.30
rated supply current
I_1
RMS value of supply current to the WELDING POWER SOURCE at a rated CONVENTIONAL WELDING CONDITION

3.1.31
rated no-load supply current
I_0
RMS value of supply current to the WELDING POWER SOURCE at RATED NO-LOAD VOLTAGE

3.1.32
rated maximum supply current
I_{1max}
maximum value of the RATED SUPPLY CURRENT

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-12-13, which will be updated.

3.1.33
maximum effective supply current
I_{1eff}
maximum value of the effective supply current, calculated from the RATED SUPPLY CURRENT (I_1), the corresponding DUTY CYCLE (X) and the supply current at no-load (I_0) by the formula:

$$I_{1eff} = \sqrt{I_1^2 \times X + I_0^2 \times (1 - X)}$$

Note 1 to entry: The MAXIMUM EFFECTIVE SUPPLY CURRENT is not always at the DUTY CYCLE corresponding to the RATED MAXIMUM SUPPLY CURRENT.

[SOURCE: IEC 60050-851:2008, 851-12-39, modified – Addition of Note 1 to entry.]

3.1.34
rated load speed
n
speed of rotation of an engine-driven WELDING POWER SOURCE when operating at RATED MAXIMUM WELDING CURRENT

Note 1 to entry: This entry revises IEC 60050-851:2008, 851-12-12, which will be updated.

3.1.35
rated no-load speed
n_0
speed of rotation of an engine-driven WELDING POWER SOURCE when the external WELDING CIRCUIT is open

Note 1 to entry: If an engine is fitted with a device to reduce the speed when not welding, n_0 will be measured before the speed reduction device has operated.

Note 2 to entry: This entry revises IEC 60050-851:2008, 851-12-16, which will be updated.

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3.1.36
rated idle speed
n_i
reduced no-load speed of an engine driven WELDING POWER SOURCE

[SOURCE: IEC 60050-851:2008, 851-12-18]

3.1.37
duty cycle
X
SUPERSEDED: duty factor
ratio, for a given time interval, of the uninterrupted on-load duration to the total time

Note 1 to entry: This ratio, lying between 0 and 1, is expressed as a percentage.

Note 2 to entry: For the purposes of this document, the time period of one complete cycle is 10 min. For example, in the case of a 60 % DUTY CYCLE, a continuous 6 min load period is followed by a no-load period of 4 min.

3.1.38
clearance
shortest distance in air between two conductive parts

[SOURCE: ~~IEC 60664-1:2007, 3.2~~ IEC 60050-581:2008, 581-27-76]

3.1.39
creepage distance
shortest distance along the surface of a solid insulating material between two conductive parts

[SOURCE: ~~IEC 60664-1:2007, 3.3~~ IEC 60050-151:2001, 151-15-50]

3.1.40
pollution degree
numeral characterizing the expected pollution of the MICRO-ENVIRONMENT

Note 1 to entry: For the purpose of evaluating CREEPAGE DISTANCES and CLEARANCES, the following four POLLUTION DEGREES in the MICRO-ENVIRONMENT are established in 4.5.2 of IEC 60664-1:~~2007~~2020.

a) POLLUTION DEGREE **1**: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

b) POLLUTION DEGREE **2**: Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

c) POLLUTION DEGREE **3**: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.

d) POLLUTION DEGREE **4**: ~~The pollution generates persistent conductivity caused by conductive dust or by rain or snow.~~ Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

[SOURCE: ~~IEC 60664-1:2007, 3.13~~ IEC 60050-581:2008, 581-21-07, modified – Modification of the Note to entry.]

3.1.41
micro-environment
<of an electrical system> ~~immediate environment of the insulation~~ ambient conditions which ~~particularly~~ immediately influences the dimensioning of the CLEARANCE and CREEPAGE DISTANCES

[SOURCE: IEC 60664-1:~~2007~~2020, ~~3.12.2~~ 3.1.23]

3.1.42
material group
materials separated into four groups by their comparative tracking index (CTI) values in accordance with IEC 60664-1

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Note 1 to entry: The following four groups are defined in 5.3.2.4 of IEC 60664-1:2020:

– MATERIAL GROUP I: 600 ≤ CTI;

– MATERIAL GROUP II: 400 ≤ CTI < 600;

– MATERIAL GROUP IIIa: 175 ≤ CTI < 400;

– MATERIAL GROUP IIIb: 100 ≤ CTI < 175.

3.1.43
temperature rise
difference between the temperature of a part of the equipment and that of the ambient air

3.1.44
thermal equilibrium
state reached when the observed TEMPERATURE RISE of any part of the equipment does not exceed 2 K/h

3.1.45
thermal protection
system intended to ensure the protection of a part, and hence the whole, of the equipment against excessive temperatures resulting from certain conditions of thermal overload

Note 1 to entry: It is capable of being reset (either manually or automatically) when the temperature falls to the reset value.

Note 2 to entry: This entry revises IEC 60050-851:2008, 851-15-03, which will be updated.

3.1.46
environment with increased risk of electric shock
environment where the probability of electric shock by arc welding is increased in relation to normal arc welding conditions

Note 1 to entry: Such environments are found, for example:

a) in locations in which freedom of movement is restricted, so that the operator is forced to perform the welding in a cramped (for example kneeling, sitting, lying) position with physical contact with conductive parts;

b) in locations which are fully or partially limited by conductive elements, and in which there is a high probability of unavoidable or accidental contact by the operator;

c) in wet or damp or hot locations where humidity or perspiration considerably reduces the skin resistance of the human body and the insulating properties of accessories.

3.1.47
hazard reducing device
device designed to reduce the hazard of electric shock that may originate from the NO-LOAD VOLTAGE

[SOURCE: IEC 60050-851:2008, 851-15-01]

3.1.48
class I equipment
equipment with BASIC INSULATION as provision for BASIC PROTECTION and protective bonding as provision for fault protection

[SOURCE: IEC 60050-851:2008, 851-15-10]

3.1.49
class II equipment
equipment with BASIC INSULATION as provision for BASIC PROTECTION, and SUPPLEMENTARY INSULATION as provision for fault protection, or in which basic and fault protection are provided by REINFORCED INSULATION

[SOURCE: IEC 60050-851:2008, 851-15-11]

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3.1.50
basic insulation
insulation of hazardous-live-parts which provides BASIC PROTECTION

[SOURCE: IEC 60050-851:2008, 851-15-04]

3.1.51
supplementary insulation
independent insulation applied in addition to BASIC INSULATION for fault protection

[SOURCE: IEC 60050-851:2008, 851-15-05]

3.1.52
double insulation
insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

[SOURCE: IEC 60050-851:2008, 851-15-06]

3.1.53
reinforced insulation
insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to DOUBLE INSULATION

Note 1 to entry: REINFORCED INSULATION may comprise several layers which cannot be tested singly as BASIC INSULATION or SUPPLEMENTARY INSULATION.

[SOURCE: IEC 60050-851:2008, 851-15-07]

3.1.54
plasma cutting system
combination of power source, torch, and associated safety devices for plasma cutting/gouging

[SOURCE: IEC 60050-851:2008, 851-13-03]

3.1.55
plasma cutting power source
equipment for supplying current and voltage and having the required characteristics suitable for plasma cutting/gouging and which may supply gas and cooling liquid

Note 1 to entry: A PLASMA CUTTING POWER SOURCE can also supply services to other equipment and auxiliaries, for example auxiliary power, cooling liquid and gas.

Note 2 to entry: This entry revises IEC 60050-851:2008, 851-13-04, which will be updated.

~~[SOURCE: IEC 60050-851:2008, 851-13-04]~~

3.1.56
safety extra-low voltage
SELV
voltage which does not exceed 50 V AC or 120 V ripple free DC between conductors, or between any conductor and earth, in a circuit which is isolated from the supply mains by such means as a safety isolating transformer

Note 1 to entry: Maximum voltage lower than 50 V AC or 120 V ripple free DC is specified in particular requirements, especially when direct contact with live parts is allowed.

Note 2 to entry: The voltage limit is not exceeded at any load between full load and no-load when the source is a safety isolating transformer.

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Note 3 to entry: "Ripple-free" is conventionally an RMS ripple voltage not more than 10 % of the DC component; the maximum peak value does not exceed 140 V for a nominal 120 V ripple-free DC system and 70 V for a nominal 60 V ripple-free DC system.

Note 4 to entry: This entry revises IEC 60050-851:2008, 851-15-08, which will be updated.

3.1.57
supply circuit
input circuit
conductive material in the equipment through which the supply current is intended to flow

3.1.58
working voltage
highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

Note 2 to entry: Both open circuit conditions and normal operating conditions are taken into account.

[SOURCE: IEC 60050-851:2008, 851-12-31]

3.1.59
touch current
electric current passing through a human body or through an animal body when it touches one or more accessible parts of an installation or of equipment

Note 1 to entry: TOUCH CURRENT is measured by using a measuring network that simulates the impedance of the human body.

[SOURCE: IEC 60050-195:1998~~/AMD1:2001~~, 195-05-21, modified – Addition of a note to entry.]

3.1.60
remote control
device or circuit external to the equipment used for monitoring or operational control

3.1.61
single-fault condition
condition in which one means for protection against hazard is defective

Note 1 to entry: If a SINGLE-FAULT CONDITION results unavoidably in another SINGLE-FAULT CONDITION, the two failures are considered as one SINGLE-FAULT CONDITION.

3.1.62
fixed installation
particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location

3.1.63
protective circuit
circuit intended to be bonded to protective earth to protect against electric shock

3.1.64
class of insulation
standard classification applied to an insulating material for use in electrical apparatus and machines and specifying the nature of the material and a recommended limiting temperature

[SOURCE: IEC 60050-811:~~1991~~2017, 811-13-33, modified – Deletion of the Note 1 to entry.]

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3.1.65
functional insulation
insulation between conductive parts, necessary for the proper functioning of the equipment

[SOURCE: IEC 60050-195:1998, 195-02-41]

3.1.66
idle state
operating state in which the power is switched on and the WELDING CIRCUIT is not energized

Note 1 to entry: For some types of equipment there is no IDLE STATE, but a welding state preceding arc striking.

Note 2 to entry: For a power source in a mechanised system, the configuration to achieve IDLE STATE is defined by the manufacturer.

Note 3 to entry: An IDLE STATE can include a low energy state in which a welding process cannot be started without automatic or manual reactivation.

3.2 Terms and definitions related to BATTERY SYSTEMS

3.2.1
battery
assembly of one or more CELLS intended to provide electrical current to the WELDING POWER SOURCE

3.2.2
integral battery
BATTERY which is contained within the battery-powered WELDING POWER SOURCE and is not removed from the WELDING POWER SOURCE for charging purposes

Note 1 to entry: A BATTERY that is ~~to be~~ removed from the battery-powered WELDING POWER SOURCE for disposal or recycling purposes only is considered to be an INTEGRAL BATTERY.

3.2.3
detachable battery pack
BATTERY which is contained in a separate enclosure from the battery-powered WELDING POWER SOURCE and is intended to be removed from the WELDING POWER SOURCE for charging purposes

3.2.4
separable battery pack
BATTERY which is contained in a separate enclosure from the battery-powered WELDING POWER SOURCE and is connected to the battery-powered WELDING POWER SOURCE by a cable

3.2.5
battery system
combination of a BATTERY, the CHARGING SYSTEM, the WELDING POWER SOURCE and the interfaces between them as existing during operation of the WELDING POWER SOURCE or during charging

3.2.6
C_5 rate
current, in amperes, at which a CELL or BATTERY can be discharged for 5 h to the voltage cut-off point specified by the CELL manufacturer

3.2.7
cell
basic functional unit consisting of an assembly of electrodes, electrolyte, container, terminals, and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

[SOURCE: IEC 60050-482:2004, 482-01-01]

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3.2.8
charger
part or all of the CHARGING SYSTEM contained in a separate enclosure

Note 1 to entry: As a minimum, the CHARGER includes some of the power conversion circuitry. Not all CHARGING SYSTEMS include a separate CHARGER as in the case where a WELDING POWER SOURCE ~~may~~ can be charged utilizing a mains supply cable or ~~may~~ can incorporate a plug for attachment to a mains receptacle.

3.2.9
charging system
combination of circuitry intended to charge, balance and/or maintain the state of charge of the BATTERY

3.2.10
fully charged cell
fully charged battery
CELL or BATTERY charged to the maximum state of charge permitted by the BATTERY CHARGING SYSTEM intended for use with the WELDING POWER SOURCE

3.2.11
fully discharged cell
fully discharged battery
BATTERY or CELL discharged until one of the following conditions occurs: discharge terminates due to protective circuitry or the BATTERY (or CELL) reaches a total voltage with an average voltage per CELL equal to the end-of-discharge voltage for the CELL chemistry being used unless a different end-of-discharge voltage is specified by the manufacturer of BATTERY/CELL

Note 1 to entry: The end-of-discharge voltages for common CELL chemistries are provided in ~~O.5.210~~ O.5.1.209.

3.2.12
general purpose batteries
general purpose cells
BATTERIES and CELLS available from a variety of manufacturers, through a variety of outlets intended for a variety of different manufacturers' products

Note 1 to entry: 12 V automotive BATTERIES and AA, C and D alkaline CELLS are examples of GENERAL PURPOSE.

3.2.13
maximum charging current
highest current that a CELL is permitted to pass during charging for a specified range of temperatures as specified by the CELL manufacturer and evaluated in accordance with IEC 62133-1:2017 or IEC 62133-2:2017

3.2.14
specified operating region
range of permissible operation of CELLS, expressed by CELL parameter limits

3.2.14.1
specified operating region for charging
conditions for voltage and current during charging in which the CELL is permitted to operate as specified by the CELL manufacturer and evaluated in accordance with IEC 62133-1:2017 or IEC 62133-2:2017

3.2.15
upper limit charging voltage
highest voltage that a CELL is permitted to attain during normal charging for a specified range of temperatures as specified by the CELL manufacturer and evaluated in accordance with IEC 62133-1:2017 or IEC 62133-2:2017

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3.2.16
venting
condition that occurs, when a CELL releases excessive internal pressure intended by design to preclude EXPLOSION

3.2.17
electronic component
part in which conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor, with the exclusion of neon indicators

Note 1 to entry: Examples of ELECTRONIC COMPONENTS are diodes, transistors, triacs and monolithic integrated circuits. Resistors, capacitors and inductors are not considered ELECTRONIC COMPONENTS.

3.2.18
basic protection
protection against electric shock under fault-free conditions

[SOURCE: IEC 60050-195:1998, 195-06-01]

3.2.19
battery voltage class A
classification of an electric component or circuit with a maximum BATTERY WORKING VOLTAGE of 60 V DC

3.2.20
battery voltage class B
classification of an electric component or circuit with a maximum BATTERY WORKING VOLTAGE between 60 V DC and 1 500 V DC

3.2.21
charring
blackening of the cotton caused by combustion

Note 1 to entry: Discolouration of the cotton caused by smoke is acceptable.

3.2.22
consecutive operating cycle
immediate on cycle after the thermal control device resets

3.2.23
explosion
<of an explosive atmosphere> sudden increase of pressure and temperature, due to oxidation or other exothermic reaction

[SOURCE: IEC 60050-426:2008, 426-02-13]

3.3 Terms and definitions related to efficiency and IDLE STATE power measurement

3.3.1
rated supply frequency
RMS value of supply frequency to the WELDING POWER SOURCE, as specified by the manufacturer

3.3.2
welding power source efficiency
the ratio, expressed as a percentage, by dividing the output ACTIVE POWER by the supply ACTIVE POWER of the welding power source at rated load conditions

Note 1 to entry: In Commission Regulation (EU) 2019/1784 the corresponding term is “power source efficiency”.

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3.3.3
active power
P
under periodic conditions, mean value, taken over one period T, of the instantaneous power p

$$P = \frac{1}{T}\int_0^T p\,\mathrm{d}t$$

Note 1 to entry: Under sinusoidal conditions, the ACTIVE POWER is the real part of the complex power S, thus P = Re S.

Note 2 to entry: The coherent SI unit for ACTIVE POWER is the watt, W.

[SOURCE: IEC 60050-131:2013, 131-11-42]

3.3.4
apparent power
S
product of the RMS voltage U between the terminals of a two-terminal element or two-terminal circuit and the RMS electric current I in the element or circuit

Note 1 to entry: Under sinusoidal conditions, the APPARENT POWER is the modulus of the complex power S, thus $S = |S|$.

Note 2 to entry: The coherent SI unit for APPARENT POWER is the voltampere, VA.

[SOURCE: IEC 60050-131:2013, 131-11-41]

3.3.5
power factor
λ
under periodic conditions, ratio of the absolute value of the ACTIVE POWER P to the APPARENT POWER S

$$\lambda = \frac{|P|}{S}$$

Note 1 to entry: Under sinusoidal conditions, the POWER FACTOR is the absolute value of the active factor.

[SOURCE: IEC 60050-131:2002, 131-11-46]

3.3.6
total harmonic ratio
total harmonic distortion
THD (abbreviation)
ratio of the RMS value of the HARMONIC CONTENT to the RMS value of the fundamental component or the reference fundamental component of an alternating quantity

Note 1 to entry: The TOTAL HARMONIC RATIO depends on the choice of the fundamental component. If it is not clear from the context which one is used an indication should be given.

Note 2 to entry: The TOTAL HARMONIC RATIO can be restricted to a certain harmonic order. This is to be stated.

[SOURCE: IEC 60050-551:2001, 551-20-13]

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4 Environmental conditions

WELDING POWER SOURCES shall be capable of delivering RATED OUTPUTS at rated DUTY CYCLES when the following environmental conditions prevail:

a) range of ambient air temperature:

during operation: −10 °C to +40 °C;

b) relative humidity of the air:

up to 50 % at 40 °C;

up to 90 % at 20 °C;

c) ambient air, free from abnormal amounts of dust, acids, corrosive gases or substances, etc. other than those generated by the welding process;

d) altitude above sea level up to 1 000 m;

e) base of the WELDING POWER SOURCE inclined up to 10°.

WELDING POWER SOURCES shall withstand storage and transport at an ambient air temperature of –20 °C to +55 °C without any damage to function and performance.

NOTE 1 Different environmental conditions can be agreed upon between the manufacturer and the purchaser and the resulting WELDING POWER SOURCE is marked accordingly (see 15.1). Examples of these conditions are: high humidity, unusually corrosive fumes, steam, excessive oil vapour, abnormal vibration or shock, excessive dust, severe weather conditions, unusual coastal or shipboard conditions, vermin infestation and atmospheres conducive to the growth of mould.

NOTE 2 CLEARANCE and CREEPAGE DISTANCE requirements in this document allow usage at altitude above sea level up to 2 000 m.

5 Tests

5.1 Test conditions

Tests shall be carried out on new, dry and completely assembled WELDING POWER SOURCES.

The heating test defined in 7.1 and the THERMAL PROTECTION test defined in 8.5 shall be carried out at ambient temperature of 40 °C, see tolerances in 7.1.2 e), with the exception of engine-driven power sources and FIXED INSTALLATION equipment, which shall be tested in accordance with the manufacturer's specifications.

Other tests shall be carried out at an ambient air temperature ~~given in Clause 4 a)~~ of (25 ± 10) °C.

Liquid-cooled WELDING POWER SOURCES shall be tested with liquid conditions as specified by the manufacturer.

Unless otherwise specified, the equipment shall be supplied by a RATED SUPPLY VOLTAGE with a tolerance of ±5 %.

5.2 Measuring instruments

The accuracy of measuring instruments shall be:

a) electrical measuring instruments: CLASS I (±1 % of full-scale reading), except for the measurement of insulation resistance and dielectric strength where the accuracy of the instruments is not specified, but shall be taken into account for the measurement;

b) thermometer: ±2 K;

c) tachometer: ±1 % of full-scale reading.

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All electrical measurements shall be made with a maximum measurement uncertainty of 5 %.

5.3 Conformity of components

~~Refer to Annex P for conformity of components.~~

Components and subassemblies which, due to failure, can create a hazard, such as power supplies and built-in information technology equipment, shall be used in accordance with their specified ratings unless a specific exception is made. They shall conform to one of the following:

a) applicable safety requirements of a relevant IEC standard. Conformity with other requirements of the component standard is not required. If necessary for the application, components shall be subjected to the tests of this document, except when those tests are identical or equivalent to the tests required to check conformity with the relevant component standard;

For example, if components meet the safety requirements of IEC 60950-1 but are rated for a less severe environment than the applicable environment of Clause 4 and 6.1.1, they shall also meet relevant additional requirements of this document.

b) the requirements of this document and, where necessary for the application, any additional applicable safety requirements of the relevant IEC component standard;

c) if there is no relevant IEC standard, the requirements of this document;

d) applicable safety requirements of a non-IEC standard which are at least as high as those of the relevant IEC standard, provided that the component has been approved to the non-IEC standard by a recognized testing authority.

NOTE Tests performed by a recognized testing authority which confirm conformity with applicable safety requirements are not repeated, even if the tests were performed using a non-IEC standard.

Figure 1 is a flow chart showing methods of conformity verification.

Conformity is checked by VISUAL INSPECTION *and, if necessary, by test.*

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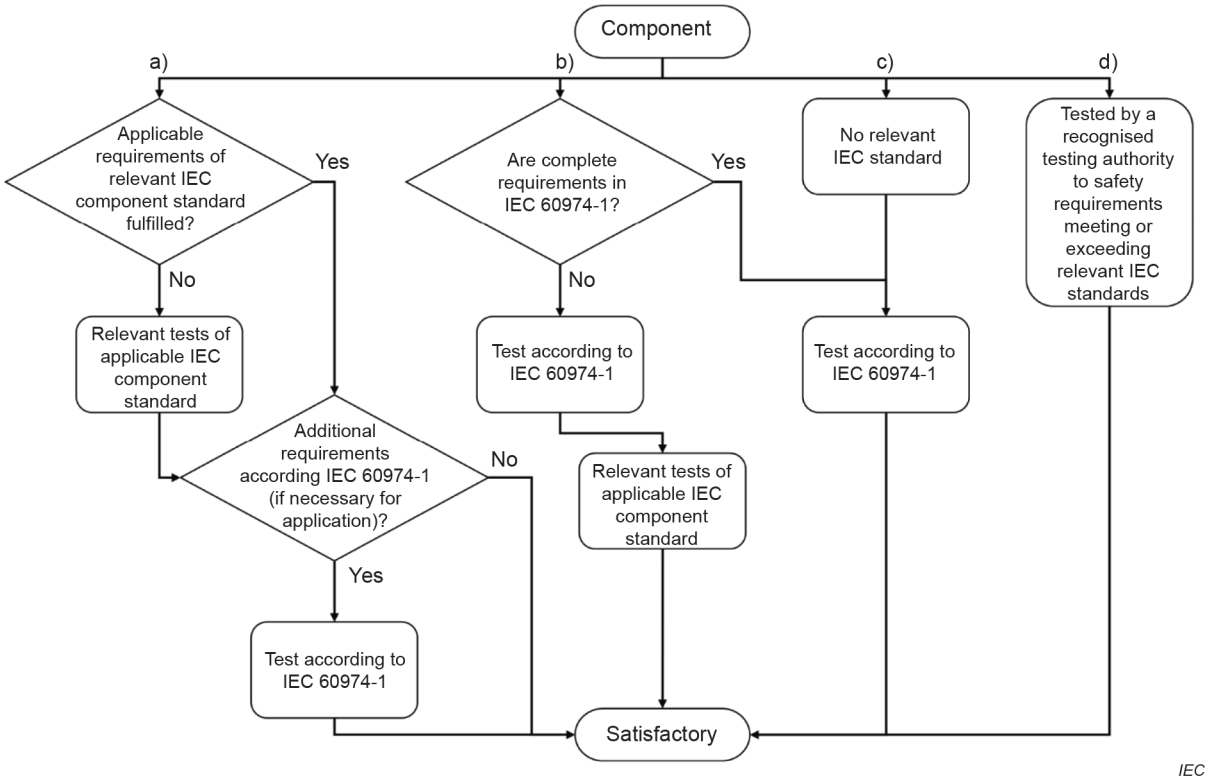

Figure 1 – Flow chart for conformity methods of 5.3

5.4 TYPE TESTS

Unless otherwise specified, the tests in this document are TYPE TESTS.

The WELDING POWER SOURCE shall be tested with any ancillary equipment fitted that could affect the test results.

All TYPE TESTS shall be carried out on the same WELDING POWER SOURCE except where it is specified that a test may be carried out on another WELDING POWER SOURCE.

As a condition of conformity, the TYPE TESTS given below shall be carried out in the following sequence with no drying time between f), g) and h):

a) general VISUAL INSPECTION, see 3.1.7;

b) insulation resistance, see 6.1.4 (preliminary check);

c) enclosure, see 14.2;

d) handling means, see 14.3;

e) drop withstand, see 14.4;

f) protection provided by the enclosure, see 6.2.1;

g) insulation resistance, see 6.1.4;

h) dielectric strength, see 6.1.5;

i) general VISUAL INSPECTION, see 3.1.7.

The other tests included in this document and not listed here shall be carried out, but ~~may~~ can be completed in any convenient sequence.

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5.5 ROUTINE TESTS

All ROUTINE TESTS shall be carried out on each WELDING POWER SOURCE. The following sequence is recommended:

a) VISUAL INSPECTION in accordance with the manufacturer's specifications;

b) continuity of the PROTECTIVE CIRCUIT, see 10.5.3;

c) dielectric strength, see 6.1.5;

d) NO-LOAD VOLTAGE:

   1) RATED NO-LOAD VOLTAGE, see 11.1 by measurement only; or

   2) if applicable, RATED REDUCED NO-LOAD VOLTAGE, see 13.2.1; or

   3) if applicable, RATED SWITCHED NO-LOAD VOLTAGE, see 13.2.2;

e) test to ensure rated minimum and maximum output values in accordance with 15.4 b) and 15.4 c). The manufacturer ~~may~~ can select CONVENTIONAL LOAD, short circuit load or other test conditions.

NOTE 1 In short circuit and other test conditions, the output values can differ from CONVENTIONAL LOAD values.

NOTE 2 If justified by the design, measured values can be compensated due to variations of the supply network.

6 Protection against electric shock

6.1 Insulation

6.1.1 General

The majority of WELDING POWER SOURCES fall within the overvoltage category III in accordance with IEC 60664-1; mechanically powered WELDING POWER SOURCES fall within overvoltage category II. All WELDING POWER SOURCES shall be designed for use in environmental conditions of POLLUTION DEGREE 3 as a minimum.

Components or subassemblies with CLEARANCES or CREEPAGE DISTANCES corresponding to POLLUTION DEGREE 2 are permitted if the MICRO-ENVIRONMENT of the component or subassembly is improved (by means such as filtering, coating, potting, moulding) so that only non-conductive pollution or occasional temporary conductivity caused by condensation occurs.

Components or subassemblies with CLEARANCES or CREEPAGE DISTANCES corresponding to POLLUTION DEGREE 1 are permitted, if they are completely coated, potted or moulded in accordance with IEC 60664-3.

See Table 3 for printed wiring material CREEPAGE DISTANCES.

CLASS I EQUIPMENT intended to be connected to an earthed three-phase three-wire system shall be designed with insulation based on line to line voltage values. CLASS I EQUIPMENT designed with insulation based on line to neutral voltage values shall be provided with a caution that such equipment shall only be used on a supply network that is either a three-phase, four-wire system with an earthed neutral or a single-phase, three-wire, system with an earthed neutral.

The application of insulation in many configurations is illustrated in Figure 2, but other configurations and solutions are possible. If a particular configuration is not represented in Figure 2, the required insulation shall be determined by considering the effect of a single fault.

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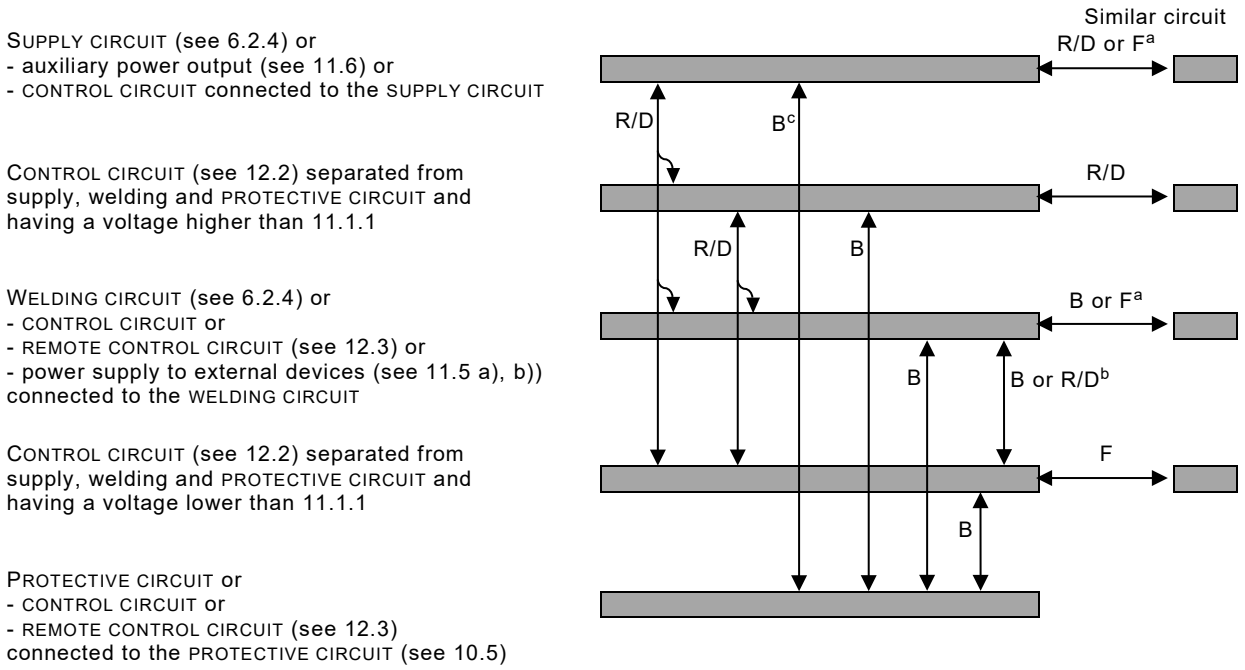

Key

R/D	Reinforced or DOUBLE INSULATION		Circuit
B	BASIC INSULATION	F	FUNCTIONAL INSULATION

[a] To be decided by the manufacturer with respect to the configuration.

[b] R/D if WELDING CIRCUIT higher than 11.1.1.

[c] CONTROL CIRCUITS connected to the PROTECTIVE CIRCUIT require R/D unless the CONTROL CIRCUIT meets the requirements of 10.5 under fault condition.

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Figure 2 – Example of insulation configuration for CLASS I EQUIPMENT

6.1.2 CLEARANCES

For circuits directly connected to the mains supply the voltage line-to-neutral shall be derived from Table A.1. For BASIC or SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, minimum CLEARANCES shall be in accordance with Table 2 for overvoltage category III. For other overvoltage categories, minimum CLEARANCES shall be in accordance with IEC 60664-1.

The values of Table 2 shall also apply to the WELDING CIRCUIT within the WELDING POWER SOURCE and to CONTROL CIRCUITS when separated from the SUPPLY CIRCUIT, for example by a transformer.

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Table 2 – Minimum CLEARANCES for overvoltage category III

Voltage line-to-neutral derived from nominal voltages AC or DC up to and including[a]	Basic or SUPPLEMENTARY INSULATION					REINFORCED INSULATION				
	Rated impulse test voltage	AC test voltage	POLLUTION DEGREE			Rated impulse test voltage	AC test voltage	POLLUTION DEGREE		
			2	3	4			2	3	4
			CLEARANCE					CLEARANCE		
V RMS	peak V	V RMS.	mm			peak V	V RMS	mm		
50	800	566	0,2	0,8	1,6	1 500	1 061	0,5	0,8	1,6
100	1 500	1 061	0,5			2 500	1 768	1,5		
150	2 500	1 768	1,5			4 000	2 828	3		
300	4 000	2 828	3			6 000	4 243	5,5		
600	6 000	4 243	5,5			8 000	5 657	8		
1 000	8 000	5 657	8			12 000	8 485	14		

NOTE 1 Values based on Tables F.1 and F.2 of IEC 60664-1:~~2007~~2020.

NOTE 2 For other POLLUTION DEGREES and overvoltage categories, see IEC 60664-1.

NOTE 3 If an autotransformer is connected to the SUPPLY CIRCUIT and provided as a part of a WELDING POWER SOURCE, the supply voltage determines the CLEARANCES.

[a] See Table A.1.

For determining CLEARANCES as to accessible non-conductive surfaces, such surfaces shall be considered to be covered by metal foil wherever they can be touched by the standard test finger in accordance with IEC 60529.

CLEARANCES shall not be interpolated.

For SUPPLY CIRCUIT terminals, see E.2.

CLEARANCES between parts of the WELDING POWER SOURCE (for example electronic circuits or components) which are protected by an overvoltage limiting device (for example metal oxide varistor) ~~may~~ can be rated in accordance with overvoltage category I (see IEC 60664-1).

~~The values of Table 1 shall also apply to the **welding circuit** within the welding power source and to **control circuits** when separated from the **supply circuit**, for example by a transformer.~~

If the CONTROL CIRCUIT is directly connected to the SUPPLY CIRCUIT, the values for the supply voltage shall apply.

Conformity shall be checked by measurement in accordance with 6.8 of IEC 60664-1:~~2007~~2020 or where this is not possible, by submitting the WELDING POWER SOURCE to an impulse test using the voltages given in Table 2.

For the impulse test, a minimum of three impulses of each polarity at the voltage given in Table 2 are applied with an interval of at least 1 s between impulses using a generator with an output waveform of 1,2/50 µs and an output impedance of less than 500 Ω.

Alternatively, either an AC test voltage as given in Table 2 ~~may~~ can be applied for three cycles or a ripple free DC voltage, the value of which is equal to the impulse voltage, ~~may~~ can be applied three times for 10 ms, for each polarity.

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6.1.3 CREEPAGE DISTANCES

The basis for the determination of a CREEPAGE DISTANCE is the long-term RMS value of the voltage existing across it. This voltage is the highest value of the steady-state WORKING VOLTAGE (as specified in IEC 60664-1:2020, 4.2.5), the rated insulation voltage or the rated voltage. For the determination of the rated insulation voltages Table A.2 and Table A.3 can be used.

CREEPAGE DISTANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION, shall be selected from Table 3.

CREEPAGE DISTANCES of DOUBLE INSULATION ~~shall be~~ are the sum of the values for the BASIC INSULATION and SUPPLEMENTARY INSULATION which ~~form~~ make up the DOUBLE INSULATION.

CREEPAGE DISTANCES for REINFORCED INSULATION shall be twice ~~those determined~~ the CREEPAGE DISTANCE for BASIC INSULATION.

When Table 3 is used, it is allowed to interpolate values for intermediate voltages. When interpolating, linear interpolation shall be used and values shall be rounded to the same number of digits as the values picked up from the table.

For the purpose of dimensioning CREEPAGE DISTANCES to accessible non-conductive surfaces, such surfaces shall be considered to be covered by metal foil wherever they can be touched by the standard test finger in accordance with IEC 60529.

~~**Creepage distances** are given for the highest rated voltage of each line of Table 2. In the case of a lower rated voltage, interpolation is allowed.~~

For SUPPLY CIRCUIT terminals, see E.2.

The values of Table 3 shall also be applicable to the WELDING CIRCUIT within the WELDING POWER SOURCE and to CONTROL CIRCUITS when separated from the SUPPLY CIRCUIT by, for example, a transformer.

A CREEPAGE DISTANCE cannot be less than the associated CLEARANCE, so the shortest possible CREEPAGE DISTANCE is equal to the required CLEARANCE.

If the CONTROL CIRCUIT is connected directly to the SUPPLY CIRCUIT, the values for the supply voltage shall apply.

Conformity shall be checked by linear measurement in accordance with 6.8 of IEC 60664-1:~~2007~~2020.

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Table 3 – Minimum CREEPAGE DISTANCES

Working voltage	CREEPAGE DISTANCES in mm								
	Basic or SUPPLEMENTARY INSULATION								
	Printed wiring material		POLLUTION DEGREE						
	POLLUTION DEGREE								
	1	2	1	2			3		
				MATERIAL GROUP			MATERIAL GROUP		
	a	b	a	I	II	III	I	II	III
V RMS	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,4	0,4	0,4	1	1	1
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5
400	1	2	1	2	2,8	4	5	5,6	6,3
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10
800	2,4	4	2,4	4	5,6	8	10	11	12,5
1 000	3,2	5	3,2	5	7,1	10	12,5	14	16
1 250			4,2	6,3	9	12,5	16	18	20
1 600			5,6	8	11	16	20	22	25
2 000			7,5	10	14	20	25	28	32
2 500			10	12,5	18	25	32	36	40
3 200			12,5	16	22	32	40	45	50
4 000			16	20	28	40	50	56	63
5 000			20	25	36	50	63	71	80
6 300			25	32	45	63	80	90	100
8 000			32	40	56	80	100	110	125
10 000			40	50	71	100	125	140	160

[a] MATERIAL GROUP I, II, IIIa and IIIb.

[b] MATERIAL GROUP I, II and IIIa.

NOTE In accordance with IEC 60664-1, the dimensions for CREEPAGE DISTANCE cannot be specified where permanently conductive pollution is present (POLLUTION DEGREE 4).

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6.1.4 Insulation resistance

The insulation resistance shall be not less than the values given in Table 4.

Table 4 – Insulation resistance

Measurement[a]			Resistance	Insulation
SUPPLY CIRCUIT	to	WELDING CIRCUIT	5,0 MΩ	Double or reinforced
WELDING CIRCUIT	to	PROTECTIVE CIRCUIT	2,5 MΩ	Basic
SUPPLY CIRCUIT	to	PROTECTIVE CIRCUIT	2,5 MΩ	Basic
SUPPLY CIRCUIT of CLASS II EQUIPMENT	to	accessible surfaces[b]	5,0 MΩ	Double or reinforced

[a] CONTROL CIRCUITS are tested together with the circuit to which they are galvanically connected. Accessible CONTROL CIRCUITS separated from all other circuits are tested according to the manufacturer's specification.

[b] For measurement to accessible non-conductive surfaces, such surfaces shall be considered to be covered by metal foil.

Any control or auxiliary circuit connected to the protective conductor terminal shall be considered as an exposed conductive part for the purpose of this test.

Conformity shall be checked by the stabilized measurement of the insulation resistance by application of a DC voltage of 500 V at room temperature.

During the measurement, torches shall be disconnected, solid-state ELECTRONIC COMPONENTS and their protective devices ~~may~~ can be short-circuited and liquid cooling units shall be tested without liquid.

6.1.5 Dielectric strength

The insulation shall withstand the following test voltages without any flashover or breakdown:

a) first test of a WELDING POWER SOURCE: test voltages given in Table 5;

b) repetition of the test of the same WELDING POWER SOURCE: test voltage 80 % of the values given in Table 5.

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Table 5 – Dielectric test voltages

Maximum rated voltage[a] V RMS	**AC dielectric test voltage** V RMS			
Supply[a], **welding**[b] **or control**[b] **circuits**	**All circuits to exposed conductive parts,** SUPPLY CIRCUIT **to all circuits except the** WELDING CIRCUIT		**All circuits except** SUPPLY CIRCUIT **to** WELDING CIRCUIT	SUPPLY CIRCUIT **to** WELDING CIRCUIT
	CLASS I EQUIPMENT	CLASS II EQUIPMENT		
Up to 50	500	1 000	500	1 000
220	1 100	2 200	1 100	2 200
450	1 875	3 750	1 875	3 750
700	2 500	5 000	2 500	5 000
1 000	2 750	5 500	2 750	5 500

NOTE 1 The maximum rated voltage is valid for earthed and unearthed systems.

NOTE 2 In this document, the dielectric strength test of CONTROL CIRCUITS is limited to any circuit that enters or exits the enclosure apart from the SUPPLY CIRCUIT and the WELDING CIRCUIT.

[a] For intermediate values, interpolation is allowed on all supply networks (SUPPLY CIRCUIT) operating outside the range of 220 V to 450 V and on all three-phase, three-wire earthed systems without voltage exemption (see Annex A).

[b] For intermediate values, interpolation is allowed on welding and CONTROL CIRCUITS.

The AC test voltage shall be of an approximate sine wave-form with a peak value not exceeding 1,45 times the RMS value, having a frequency of approximately 50 Hz or 60 Hz.

The maximum permissible setting of the tripping current shall be 100 mA. The high voltage transformer shall deliver the prescribed voltage up to the tripping current. Tripping is regarded as a flashover or a breakdown.

NOTE For the operator´s safety, the lowest setting of the tripping current (less than or equal to 10 mA) is typical.

Alternative test: A DC test voltage of 1,4 times the RMS test voltage ~~may~~ can be used.

Components or subassemblies shall not be disconnected or short-circuited unless the conditions of a), b) or c) below are met:

a) The components or subassemblies are designed and tested to relevant standards that specify a voltage lower than the test voltage level of this document. These components or subassemblies are not connected between supply and WELDING CIRCUITS and their disconnection or short-circuiting does not prevent a part of that circuit from being tested. Example: fan motors and pump motors.

b) The components or subassemblies are completely incorporated within either the supply or the WELDING CIRCUIT and their disconnection does not prevent a part of that circuit from being tested. Example: electronic circuits.

c) Interference suppression networks or protection capacitors between the supply or WELDING CIRCUIT and any exposed conductive part conform to the relevant standards.

CONTROL CIRCUITS connected to the protective conductor terminal shall not be disconnected during testing and they are then tested as exposed conductive parts.

At the discretion of the manufacturer, the test voltage may be slowly raised to the full value.

The test voltages between the SUPPLY CIRCUIT, the exposed conductive parts and the WELDING CIRCUIT ~~may~~ can be applied simultaneously. An example is given in Annex B.

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Engine-driven WELDING POWER SOURCES shall undergo the same test.

Conformity shall be checked by application of the test voltage for

a) 60 s (TYPE TEST);

b) 5 s (ROUTINE TEST);

or

c) 1 s (ROUTINE TEST with the test voltage increased by 20 %).

6.2 Protection against electric shock in normal service (direct contact)

6.2.1 Protection provided by the enclosure

WELDING POWER SOURCES specifically designed for indoor use shall have a minimum degree of protection of IP21S using IEC 60529 test procedures and conditions.

WELDING POWER SOURCES specifically designed for outdoor use shall have a minimum degree of protection of IP23S using IEC 60529 test procedures and conditions.

WELDING POWER SOURCES with degree of protection IP23S ~~may~~ can be stored, but are not intended to be used outside during precipitation unless sheltered.

Adequate drainage shall be provided by the enclosure. Retained water shall not interfere with the operation of the equipment or impair safety. The quantity of water that may enter the enclosure is not limited.

WELDING CIRCUIT connections shall be protected as specified in 11.4.1.

REMOTE CONTROLS for WELDING POWER SOURCES shall have a minimum degree of protection of IP2X using IEC 60529 test procedures and conditions.

Conformity shall be checked by the following test:

A WELDING POWER SOURCE shall be subjected to the appropriate water test without being energized. Immediately after the test, the WELDING POWER SOURCE shall be moved to a safe environment and subjected to the insulation resistance test, listed in 5.4 g) and dielectric strength test, listed in 5.4 h).

6.2.2 Capacitors

Each capacitor provided as part of a WELDING POWER SOURCE and connected either across a SUPPLY CIRCUIT or across a winding of a transformer providing WELDING CURRENT shall

a) not contain more than 1 l of flammable liquid;

b) be designed not to leak during normal service;

c) be contained within the WELDING POWER SOURCE enclosure or other enclosure which conforms to the relevant requirements of this document.

Conformity shall be checked by VISUAL INSPECTION.

~~Capacitors shall not cause the welding power source to exhibit hazardous electrical breakdown or present risk of fire in event of a failure.~~

~~*Conformity shall be checked by the following test:*~~

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~~The welding power source is operated at no-load at its **rated supply voltage** and with a supply fuse or circuit-breaker rated up to but not more than 200 % of the **rated maximum supply current** with all or any of the capacitors shorted until:~~

~~1) any fuse or over-current device in the welding power source has operated; or~~

~~2) the **supply circuit** fuse or circuit-breaker has cleared; or~~

~~3) the **supply circuit** components of the welding power source reach a steady state temperature, not higher than that allowed in 7.3.~~

~~If any undue heating or melting becomes apparent, the welding power source shall conform to the requirements of items a), c) and d) of 9.1.~~

~~There shall be no leakage of liquid during any of the **type tests** required by this document.~~

~~For interference suppression capacitors or capacitors having internal fusing or a circuit-breaker, this test is not required.~~

For capacitor short circuit test, see 9.5.

6.2.3 Automatic discharge of SUPPLY CIRCUIT capacitors

Each capacitor shall be provided with a means of automatic discharge which shall reduce the voltage across the capacitor to 60 V or less within the time necessary to give access to any current carrying part connected to the capacitor or an appropriate warning label shall be used. For any plug which has a voltage due to a capacitor, the access time is considered to be 1 s.

Capacitors having a rated capacitance not exceeding 0,1 µF are not considered to present a risk of electric shock.

Conformity shall be checked by VISUAL INSPECTION and by the following test.

The WELDING POWER SOURCE is operated at the highest RATED SUPPLY VOLTAGE. The WELDING POWER SOURCE is then disconnected from the supply network and the voltages are measured with instruments that do not significantly affect the values being measured.

6.2.4 Isolation of the WELDING CIRCUIT

The WELDING CIRCUIT shall be isolated from the SUPPLY CIRCUIT and from all other circuits having a voltage higher than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1 (for example auxiliary power SUPPLY CIRCUITS) by reinforced or DOUBLE INSULATION or equivalent means that meet the requirements of 6.1. If another circuit is connected to the WELDING CIRCUIT, the power of the other circuit shall be supplied by an isolating transformer or equivalent means.

The WELDING CIRCUIT shall not be connected internally to the connecting means for the external protective conductor, the enclosure, frame or core of the WELDING POWER SOURCE, except, if necessary, by an interference suppression network or protection capacitor.

Conformity shall be checked by tests given in 6.1.

6.2.5 WELDING CIRCUIT TOUCH CURRENT

The TOUCH CURRENT between the WELDING CIRCUIT connections and the protective conductor terminal shall not exceed 14,1 mA peak.

Conformity shall be checked by VISUAL INSPECTION and measurement of the TOUCH CURRENT with a circuit as shown in Figure 3 at the RATED SUPPLY VOLTAGE(S) and no-load condition.

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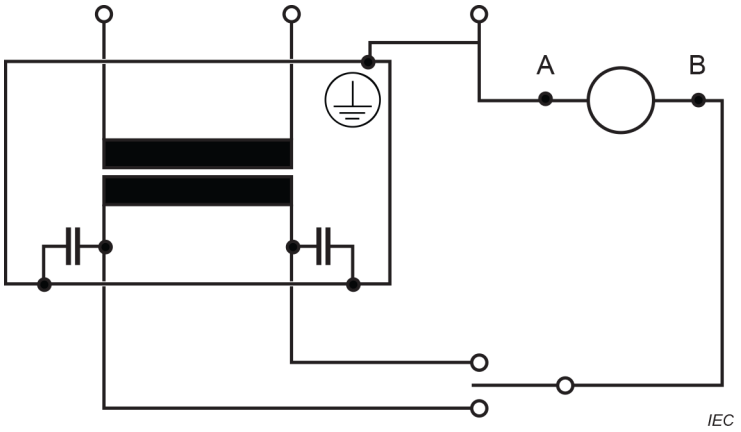
The measuring network specified in ~~Figure N.1~~ Figure N.2 shall be connected as shown in Figure 3.



Key

A, B Measuring network connections

NOTE For CLASS II EQUIPMENT, use the PE-terminal of earthed supply network.

Figure 3 – Measurement of WELDING CIRCUIT TOUCH CURRENT

6.2.6 TOUCH CURRENT in normal condition

The TOUCH CURRENT for accessible conductive surfaces, not connected to the PROTECTIVE CIRCUIT, shall not exceed 0,7 mA peak under normal conditions.

Conformity shall be checked by measurement of the TOUCH CURRENT with a circuit as shown in Figure 4 and the measurement network of Figure N.1, without simulating any fault and under the following conditions:

a) the WELDING POWER SOURCE is:
   - isolated from the ground plane;
   - supplied by the highest RATED SUPPLY VOLTAGE plus an appropriate working tolerance as specified by the manufacturer, at least +10 % for any supply, except +6 % for supply systems with 600 V or greater;

b) the WELDING CIRCUIT is in the no-load condition;

c) interference suppression capacitors are not disconnected.

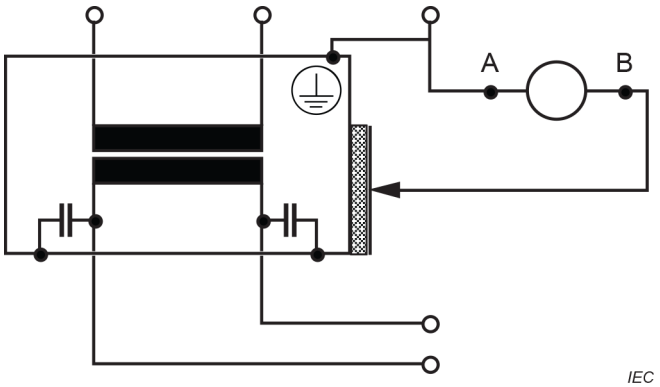


Figure 4 – Measurement of TOUCH CURRENT in normal condition

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6.3 Protection against electric shock in case of a fault condition (indirect contact)

6.3.1 Protective provisions

WELDING POWER SOURCES shall be CLASS I or CLASS II EQUIPMENT in accordance with IEC 61140, with the exception of the WELDING CIRCUIT.

6.3.2 Isolation between windings of the SUPPLY CIRCUIT and the WELDING CIRCUIT

Windings of the SUPPLY CIRCUIT and the WELDING CIRCUIT shall be isolated by

a) reinforced or DOUBLE INSULATION

or

b) BASIC INSULATION to a metal screen between them which is connected to the protective conductor.

Between the windings of the SUPPLY CIRCUIT and the WELDING CIRCUIT, there shall be insulation which conforms to the values given in Table 6. Alternatively, other means specified in IEC 61558-1 may be used provided that the complete requirements of IEC 61558-1 are satisfied.

Table 6 – Minimum distance through insulation

RATED SUPPLY VOLTAGE V RMS	Minimum distance through insulation mm	
	Single layer	Total of three or more separate layers
up to 440	1,3	0,35
441 to 690	1,5	0,4
691 to 1 000	2,0	0,5

Where there is a metal screen between the windings, the thickness of the insulation between each winding and the screen shall be at least half the values given in Table 6.

Conformity shall be checked by VISUAL INSPECTION and by measurement.

6.3.3 Internal conductors and connections

Internal conductors and connections shall be secured or positioned to prevent accidental loosening, which could cause electrical connection between

a) the SUPPLY CIRCUIT or any other circuit and the WELDING CIRCUIT so that the output voltage could become higher than the allowable NO-LOAD VOLTAGE;

b) the protective conductor, enclosure, frame or core and the WELDING CIRCUIT.

Where insulated conductors pass through metallic parts, they shall be provided with bushings of insulating material or the openings shall be smoothly rounded with a radius of at least 1,5 mm.

Bare conductors shall be so fixed that the CLEARANCE and CREEPAGE DISTANCE from each other and from conductive parts is maintained (see 6.1.2 and 6.3.2).

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Conductors of different circuits may be laid side by side, may occupy the same duct (for example conduit, cable trunking system), or may be in the same multiconductor cable provided that the arrangement does not impair the proper functioning of the respective circuits. Where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or shall be insulated for the highest voltage to which any conductor within the same duct can be subjected.

Conformity shall be checked by VISUAL INSPECTION *and by measurement.*

6.3.4 Additional requirements for PLASMA CUTTING SYSTEMS

The plasma cutting torch, parts (e.g. parts typically replaced due to wear) and PLASMA CUTTING POWER SOURCE, recommended by the manufacturer, shall form a safe system.

Plasma tips, which for technical reasons cannot be protected against direct contact, shall be considered sufficiently protected for normal use and SINGLE-FAULT CONDITION if the following requirements are fulfilled:

a) when no arc current is present:

the voltage between the plasma tip and the workpiece and/or earth is not higher than the values given in 11.1.1,

or

the PLASMA CUTTING POWER SOURCE is fitted with a HAZARD REDUCING DEVICE in accordance with Clause 13,

and

b) for manual systems, when an arc current is present:

the sides of a plasma tip cannot be touched by the standard test finger in accordance with IEC 60529 when it is placed on a flat surface with its centre line perpendicular to it,

or

the DC LOAD VOLTAGE between the plasma tip and the workpiece and/or earth is not higher than values given in 11.1.1.

NOTE A single-fault is an abnormal condition resulting from the electrode being in contact with the plasma tip because of missing insulators, sticking of the plasma tip to the electrode, conductive material between plasma tip and electrode, wrong parts, loose parts, electrode abrasion, parts inserted incorrectly, excessive load or incorrect gas flow.

Conformity shall be tested in accordance with 11.1 and by simulating a torch fault and testing in accordance with Clause 13. The torch shall be tested in accordance with IEC 60974-7.

6.3.5 Movable coils and cores

If movable coils or cores are used to adjust the WELDING CURRENT, the construction shall be such that the prescribed CLEARANCES and CREEPAGE DISTANCES are maintained, taking into account electrical and mechanical stresses.

Conformity shall be checked by operating the mechanism 500 times over its complete movement between minimum and maximum at the rate specified by the manufacturer and by VISUAL INSPECTION.

6.3.6 TOUCH CURRENT in fault condition

For CLASS I EQUIPMENT, the weighted TOUCH CURRENT in the case of an external protective conductor failure or disconnection shall not exceed 14,1 mA peak except for equipment with permanent connection by a reinforced protective conductor in accordance with IEC 61140.

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Equipment for permanent connection with a reinforced protective conductor may have a leakage current up to 5 % of the RATED SUPPLY CURRENT per phase.

Conformity shall be checked using the configurations as shown in Annex N with measurement network of Figure N.2 under the following conditions:

1) the WELDING POWER SOURCE is:
   - isolated from the ground plane;
   - fully assembled and ready for use in the maximum configuration;
   - supplied by the highest RATED SUPPLY VOLTAGE plus an appropriate working tolerance as specified by the manufacturer, at least +10 % for any supply, except +6 % for supply systems with 600 V or greater;
   - not connected to the protective earth except through measurement components;
2) the WELDING CIRCUIT is in the no-load condition;
3) interference suppression capacitors shall not be disconnected.

NOTE 1 When the TOUCH CURRENT is close to the limit value, effects of interference suppression capacitors tolerance are considered and special care is taken in measurement precision and calibration.

NOTE 2 Traditionally, TOUCH CURRENT was at its maximum at the highest supply voltage. Electronic WELDING POWER SOURCES will not always provide maximum TOUCH CURRENT under this supply condition. TOUCH CURRENT can be maximized at the lowest voltage, i.e. maximum current draw, or under some other condition. Electric shock protection is provided under the worst case operating condition.

7 Thermal requirements

7.1 Heating test

7.1.1 Test conditions

When placing the measuring devices, the only access permitted shall be through openings with cover plates, inspection doors or easily removable panels provided by the manufacturer. The ventilation in the test area and the measuring devices used shall not interfere with the normal ventilation of the WELDING POWER SOURCE or cause abnormal transfer of heat to or from it.

The WELDING POWER SOURCE is operated at RATED SUPPLY VOLTAGE, with constant current, at a cycle time of (10 ± 0,2) min:

a) with the rated WELDING CURRENT (I_2) at 60 % and/or 100 % DUTY CYCLE as appropriate;

b) with the RATED MAXIMUM WELDING CURRENT (I_{2max}) at the corresponding DUTY CYCLE.

If it is known that neither a) nor b) gives maximum heating, then a test shall be made at the setting within the rated range which gives the maximum heating.

In the case of a WELDING POWER SOURCE rated for AC tungsten inert-gas welding, an unbalanced load could cause maximum heating. In this case, a test shall be carried out as given in Annex C.

The ambient temperature condition of 5.1 shall be fulfilled.

NOTE 1 This maximum heating is possible at the no-load condition.

NOTE 2 The tests, if relevant, follow each other without having the WELDING POWER SOURCE returned to the ambient air temperature.

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7.1.2 Tolerances of the test parameters

During the last 60 min of the heating test in accordance with 7.1.3, the following tolerances shall be met:

a) LOAD VOLTAGE: $^{+10}_{-2}$ % of the appropriate CONVENTIONAL LOAD VOLTAGE;

b) WELDING CURRENT: $^{+10}_{-2}$ % of the appropriate CONVENTIONAL WELDING CURRENT;

c) supply voltage: ±5 % of the appropriate RATED SUPPLY VOLTAGE;

d) engine speed: ±5 % of the appropriate rated speed;

e) temperature: $^{+10}_{-2}$ K of the ambient temperature.

7.1.3 Duration of test

The heating test shall be carried out until the rate of the TEMPERATURE RISE does not exceed 2 K/h on any component for a period not less than 60 min.

7.2 Temperature measurement

7.2.1 Measurement conditions

The temperature shall be determined at the midpoint of the load time of the last cycle as follows:

a) for windings, by measurement of the resistance, or by surface or embedded temperature sensors;

NOTE 1 The surface temperature sensor method is not preferred.

NOTE 2 In the case of windings of low resistance having switch contacts in series with them, the resistance measurement can give misleading results.

b) for other parts, by surface temperature sensors.

7.2.2 Surface temperature sensor

The temperature is measured by a temperature sensor applied to accessible surfaces of windings or other parts in accordance with the conditions stipulated below.

NOTE 1 Typical temperature sensors are thermocouples, resistance thermometers, etc.

Bulb thermometers shall not be used for measuring temperatures of windings and surfaces.

Temperature sensors are placed at accessible spots where the maximum temperature is likely to occur. It is advisable to locate the predictable hot spots by means of a preliminary check.

NOTE 2 The size and spread of hot spots in windings depend on the design of the WELDING POWER SOURCE.

Efficient heat transmission between the point of measurement and the temperature sensor shall be ensured, and protection shall be provided for the temperature sensor against the effect of air currents and radiation.

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7.2.3 Resistance

The TEMPERATURE RISE of windings is determined by the increase in their resistance and is obtained for copper by the following formula:

$$t_2 - t_a = \frac{(235 + t_1)(R_2 - R_1)}{R_1} + (t_1 - t_a)$$

where

t_1 is the temperature of the winding at the moment when R_1 is measured (°C);

t_2 is the calculated temperature of the winding at the end of the test (°C);

t_a is the ambient air temperature at the end of the test (°C);

R_1 is the initial resistance of the winding (Ω);

R_2 is the resistance of the winding at the end of the test (Ω).

For aluminium, the number 235 in the above formula is replaced by the number 225.

The temperature t_1 shall be within ±3 K of the ambient air temperature.

7.2.4 Embedded temperature sensor

The temperature is measured by thermocouples or other suitable temperature measuring instruments of comparable size embedded at the hottest parts.

Thermocouples shall be applied directly to windings and coils. Any integrally applied insulation on the conductors themselves is not required to be removed.

A thermocouple applied to the hottest point of a single layer winding is considered as embedded.

7.2.5 Determination of the ambient air temperature

The ambient air temperature is determined by at least three measuring devices. These are spaced uniformly around the WELDING POWER SOURCE, at approximately one-half of its height and 1 m to 2 m from its surface. They are protected from draughts and abnormal heating. The mean value of the temperature readings is adopted as the temperature of the ambient air.

In the case of forced air-cooled WELDING POWER SOURCES, a single measuring device is placed where the air enters the cooling system. The mean of the readings taken at equal intervals of time during the last quarter of the duration of the test is adopted as the ambient air temperature.

7.2.6 Recording of temperatures

Where possible, temperatures are recorded while the equipment is in operation and after shutdown. On those parts where the recording of temperature is not possible while the equipment is in operation, temperatures are taken after shutdown as described below.

Whenever a sufficient time has elapsed between the instant of shutdown and the time of final temperature measurement to permit the temperature to fall, suitable corrections are applied to obtain as nearly as practicable the temperature at the instant of shutdown. This ~~may~~ can be done by plotting a curve in accordance with Annex D. A minimum of four temperature readings is taken within 5 min from shutdown. In cases where successive measurements show an increasing temperature after shutdown, the highest value is taken.

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To maintain the temperature during the stopping period, precautions shall be taken to shorten the stopping period of an engine-driven WELDING POWER SOURCE.

7.3 Limits of TEMPERATURE RISE

7.3.1 Windings, commutators and slip-rings

The TEMPERATURE RISE for windings, commutators and slip-rings shall not exceed the values given in Table 7, regardless of the method of temperature measurement used.

Table 7 – Temperature limits for windings, commutators and slip-rings

CLASS OF INSULATION	Maximum temperature	Maximum TEMPERATURE RISE K			
		Windings			Commutators
°C	°C	Surface temperature sensor	Resistance	Embedded temperature sensor	and slip-rings
105 (A)	150	55	60	65	60
120 (E)	165	70	75	80	70
130 (B)	175	75	80	90	80
155 (F)	190	95	105	115	90
180 (H)	210	115	125	140	100
200 (N)	230	130	145	160	Not determined
220 (R)	250	150	160	180	

NOTE 1 Surface temperature sensor means that the temperature is measured with non-embedded sensors at the hottest accessible spot of the outer surface of the windings.

NOTE 2 Normally, the temperature at the surface is the lowest. The temperature determined by resistance measurement gives the average between all temperatures occurring in a winding. The highest temperature occurring in the windings (hot spot) can be measured by embedded temperature sensors.

NOTE 3 Other classes of insulation having higher values than those given in Table 7 are available (see IEC 60085).

No part shall be allowed to reach any temperature that will damage another part even though that part might conform to the requirements in Table 7.

Furthermore, for tests at other than 100 % DUTY CYCLE, the temperature occurring during any full cycle shall not exceed the maximum temperatures given in Table 7.

Conformity shall be checked by measurement in accordance with 7.2.

7.3.2 External surfaces

The TEMPERATURE RISE for external surfaces shall not exceed the values given in Table 8. Limits of TEMPERATURE RISE are given for:

– an unintentional contact period of 1 s for enclosures,
– a contact period of 4 s for buttons and
– a contact period of 60 s for handles.

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Table 8 – Temperature limits for external surfaces

External surface	Maximum TEMPERATURE RISE K	Burn threshold for contact period[a] s
Uncoated metal enclosures	25	1
Painted metal enclosures	35	1
Plastic enclosures	45	1
Uncoated metal buttons	18	4
Painted metal buttons	22	4
Plastic buttons	35	4
Metal handles	10	60
Plastic handles	20	60
[a] Informative values in accordance with ISO 13732-1.		

For engine-driven WELDING POWER SOURCES, the limits of Table 8 ~~may~~ can be exceeded for surfaces that are:

a) recognizable by appearance or function; or

b) marked with the symbol IEC 60417-5041:2002-10; or

c) located or guarded to prevent unintentional contact during normal operation.

NOTE Surfaces that are recognizable by appearance or function include parts such as exhaust parts, silencers, spark arrestors, or cylinder heads.

Conformity shall be checked by measurement in accordance with 7.2 and VISUAL INSPECTION.

7.3.3 Other components

The maximum temperature of other components shall not exceed their rated maximum temperature, in accordance with the relevant standard.

7.4 Loading test

WELDING POWER SOURCES shall withstand repeated load cycles without damage or functional failure. This test ~~may~~ can be conducted on any WELDING POWER SOURCE that functions correctly.

Conformity shall be checked by the following tests and by establishing that no damage or functional failure to the WELDING POWER SOURCE occur during the tests.

Starting from the cold state, the WELDING POWER SOURCE is loaded at the RATED MAXIMUM WELDING CURRENT until one of the following occurs:

a) the THERMAL PROTECTION is actuated;

b) the maximum temperature limit of the windings is reached;

c) period of 10 min is reached.

Immediately after reset of the THERMAL PROTECTION in a), or after b) or c), one of the following tests is carried out.

1) In the case of a DROOPING CHARACTERISTIC WELDING POWER SOURCE, the controls are set to provide RATED MAXIMUM WELDING CURRENT. It is then loaded 60 times with a short circuit having an external resistance between 8 mΩ and 10 mΩ for 2 s, followed by a pause of 3 s.

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2) In the case of a FLAT CHARACTERISTIC WELDING POWER SOURCE, it is loaded once with 1,5 times the RATED MAXIMUM WELDING CURRENT at maximum available LOAD VOLTAGE for 15 s. For WELDING POWER SOURCES fitted with a protection device, which limits the WELDING CURRENT to a value lower than 1,5 times the RATED MAXIMUM WELDING CURRENT, the test is carried out at the maximum WELDING CURRENT available at corresponding LOAD VOLTAGE.

Immediately after test 1) or 2) is carried out, while equipment is still hot, the equipment shall be checked in accordance with 6.1.5.

7.5 Commutators and slip-rings

Commutators, slip-rings and their brushes shall show no evidence of injurious sparking or damage throughout the range of the engine-driven WELDING POWER SOURCE.

Conformity shall be checked by VISUAL INSPECTION during

a) the heating test in accordance with 7.1

and

b) the loading test in accordance with item 1) or 2) of 7.4.

8 THERMAL PROTECTION

8.1 General requirements

An electrically powered WELDING POWER SOURCE shall be fitted with THERMAL PROTECTION if the DUTY CYCLE at RATED MAXIMUM WELDING CURRENT is lower than

a) 35 % in the case of a DROOPING CHARACTERISTIC;

or

b) 60 % in the case of a FLAT CHARACTERISTIC.

NOTE A DROOPING CHARACTERISTIC is generally used for manual metal arc welding and tungsten inert gas welding, while a FLAT CHARACTERISTIC is generally used for metal inert/active gas welding.

If a WELDING POWER SOURCE is fitted with THERMAL PROTECTION, the THERMAL PROTECTION shall meet the requirements of 8.2 to 8.7.

Conformity shall be checked by VISUAL INSPECTION.

8.2 Construction

The THERMAL PROTECTION shall be designed to prevent alteration of the temperature setting or operation.

Conformity shall be checked by VISUAL INSPECTION.

8.3 Location

The THERMAL PROTECTION shall be permanently located within the WELDING POWER SOURCE to ensure that the heat transfer is reliable.

Conformity shall be checked by VISUAL INSPECTION.

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8.4 Operating capacity

The THERMAL PROTECTION shall be able to operate, when the WELDING POWER SOURCE delivers its RATED MAXIMUM WELDING CURRENT:

a) 100 times, in the case of a DUTY CYCLE of 35 % or higher

or

b) 200 times, in the case of a DUTY CYCLE lower than 35 %.

Conformity shall be checked with a suitable overload producing the required number of consecutive interruptions of a circuit having the same electrical characteristics, especially current and reactance, as the circuit in which the THERMAL PROTECTION is used.

After this test, the requirements of 8.5 and 8.6 shall be met.

8.5 Operation

The THERMAL PROTECTION shall prevent the WELDING POWER SOURCE windings from exceeding the maximum temperature limits given in Table 7.

The THERMAL PROTECTION shall not operate when the WELDING POWER SOURCE is loaded with the RATED MAXIMUM WELDING CURRENT at the corresponding rated DUTY CYCLE indicated on the RATING PLATE.

Conformity shall be checked during operation in accordance with 7.1, at RATED MAXIMUM WELDING CURRENT, at ambient temperature condition of 5.1 and without operation of the THERMAL PROTECTION. After that, the WELDING POWER SOURCE is overloaded in accordance with 9.4. Additionally, if the temperature condition of 5.1 does not give the maximum heating of windings, the test shall be carried out at ambient temperature that gives the maximum heating of windings.

8.6 Resetting

The THERMAL PROTECTION shall not reset automatically or manually until the temperature has dropped below that of the CLASS OF INSULATION given in Table 7.

Conformity shall be checked by operation and temperature measurement.

8.7 Indication

WELDING POWER SOURCES fitted with THERMAL PROTECTION shall indicate that the THERMAL PROTECTION has reduced or disconnected the WELDING POWER SOURCE output. When the THERMAL PROTECTION has an automatic reset, the indicator shall be either a yellow light (or yellow flag within an aperture), or an alphanumeric display on the WELDING POWER SOURCE, wire feeder or ancillary equipment showing symbols or words whose meanings are given in the instruction manual.

Conformity shall be checked by VISUAL INSPECTION.

9 Abnormal operation

9.1 General requirements

A WELDING POWER SOURCE shall not breakdown and increases the risk of electric shock or fire, under the conditions of operation of 9.2 to 9.5. These tests are conducted without regard to temperature attained on any part, or the continued proper functioning of the WELDING POWER SOURCE. The only criterion is that the WELDING POWER SOURCE does not become unsafe. These tests may be conducted on any WELDING POWER SOURCES that function correctly.

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WELDING POWER SOURCES, protected internally by, for example, circuit-breaker or THERMAL PROTECTION, meet this requirement if the protection device operates before an unsafe condition occurs.

Conformity shall be checked by the following tests:

a) A layer of dry absorbent surgical type cotton is placed under the WELDING POWER SOURCE, extending beyond each side for a distance of 150 mm.

b) Starting from the cold state, the WELDING POWER SOURCE is operated in accordance with 9.2 to 9.4.

c) During the test, the WELDING POWER SOURCE shall not emit flames, molten metal or other materials that ignite the cotton indicator.

d) Following the test and not more than 5 min after the test, the WELDING POWER SOURCE shall be capable of withstanding a dielectric test in accordance with 6.1.5 b).

9.2 Stalled fan test

A WELDING POWER SOURCE, which relies on motor-driven fan(s) for conformity with the tests of Clause 7, is operated at RATED SUPPLY VOLTAGE or RATED LOAD SPEED for a period of 4 h while the fan motor(s) is(are) mechanically stalled and the WELDING POWER SOURCE operated at the output condition of 7.1.

NOTE The intention of this test is to run the WELDING POWER SOURCE with the fan stationary to check the safety of both the fan and the WELDING POWER SOURCE.

9.3 Short circuit test

The WELDING POWER SOURCE is short circuited with the torch and the welding cables normally supplied by the manufacturer, or, if none are supplied, by a conductor 1,2 m in length and of the cross-section given in Table 9.

NOTE Cross sections for non-SI system are given in Table F.1.

The WELDING POWER SOURCE at the maximum output setting is connected to that RATED SUPPLY VOLTAGE that produces the highest RATED SUPPLY CURRENT at RATED MAXIMUM WELDING CURRENT. The SUPPLY CIRCUIT is protected by external fuses or a circuit-breaker with the rating and type as specified by the manufacturer.

Table 9 – Cross-section of the output short-circuit conductor

RATED MAXIMUM WELDING CURRENT A	Minimum cross-section[a] mm^2
Up to 199	25
200 to 299	35
300 to 499	50
500 and above	70
[a] See Annex F.	

The WELDING POWER SOURCE shall not clear the supply fuse or circuit-breaker when short circuited:

a) for 15 s in the case of a DROOPING CHARACTERISTIC;

b) three times for 1 s, within a period of 1 min, in the case of a FLAT CHARACTERISTIC.

The short circuit is then applied for 2 min or until the supply fuse or circuit-breaker clears.

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