

INTERNATIONAL STANDARD



**Arc welding equipment –
Part 1: Welding power sources**

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IEC 60974-1

Edition 6.0 2021-06
REDLINE VERSION

INTERNATIONAL STANDARD



**Arc welding equipment –
Part 1: Welding power sources**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 25.160.30

ISBN 978-2-8322-9962-3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ARC WELDING EQUIPMENT –

Part 1: Welding power sources

FOREWORD

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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.

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

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- withdrawn,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

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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*

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:—¹2017, *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:—²2017, *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.

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

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]

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.

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).

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

$I_{2\max}$

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

$I_{2\min}$

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

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** $I_{1\max}$

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** $I_{1\text{eff}}$

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:

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

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.

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

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

- MATERIAL GROUP I: $600 \leq \text{CTI}$;
- MATERIAL GROUP II: $400 \leq \text{CTI} < 600$;
- MATERIAL GROUP IIIa: $175 \leq \text{CTI} < 400$;
- MATERIAL GROUP IIIb: $100 \leq \text{CTI} < 175$.

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]

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.

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.]

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

C₅ 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]

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

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”.

3.3.3**active power** P

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

$$P = \frac{1}{T} \int_0^T p dt$$

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

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]

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: $-10\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$;
- b) relative humidity of the air:
up to 50 % at $40\text{ }^{\circ}\text{C}$;
up to 90 % at $20\text{ }^{\circ}\text{C}$;
- 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 $-20\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ 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 $40\text{ }^{\circ}\text{C}$, 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 $(25 \pm 10)\text{ }^{\circ}\text{C}$.

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 $\pm 5\text{ }%$.

5.2 Measuring instruments

The accuracy of measuring instruments shall be:

- a) electrical measuring instruments: CLASS I ($\pm 1\text{ }%$ 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: $\pm 2\text{ K}$;
- c) tachometer: $\pm 1\text{ }%$ of full-scale reading.

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.

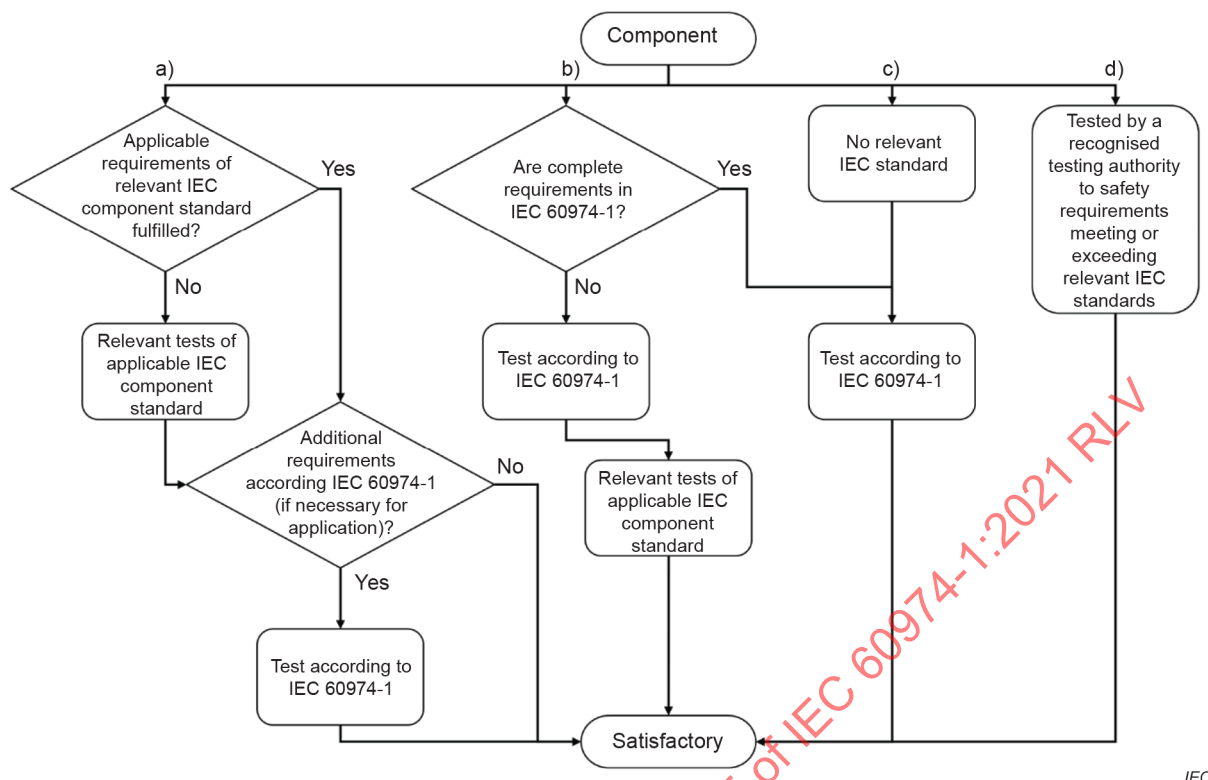


Figure 1 – Flow chart for conformity methods of 5.3

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):

- general VISUAL INSPECTION, see 3.1.7;
- insulation resistance, see 6.1.4 (preliminary check);
- enclosure, see 14.2;
- handling means, see 14.3;
- drop withstand, see 14.4;
- protection provided by the enclosure, see 6.2.1;
- insulation resistance, see 6.1.4;
- dielectric strength, see 6.1.5;
- 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.

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.

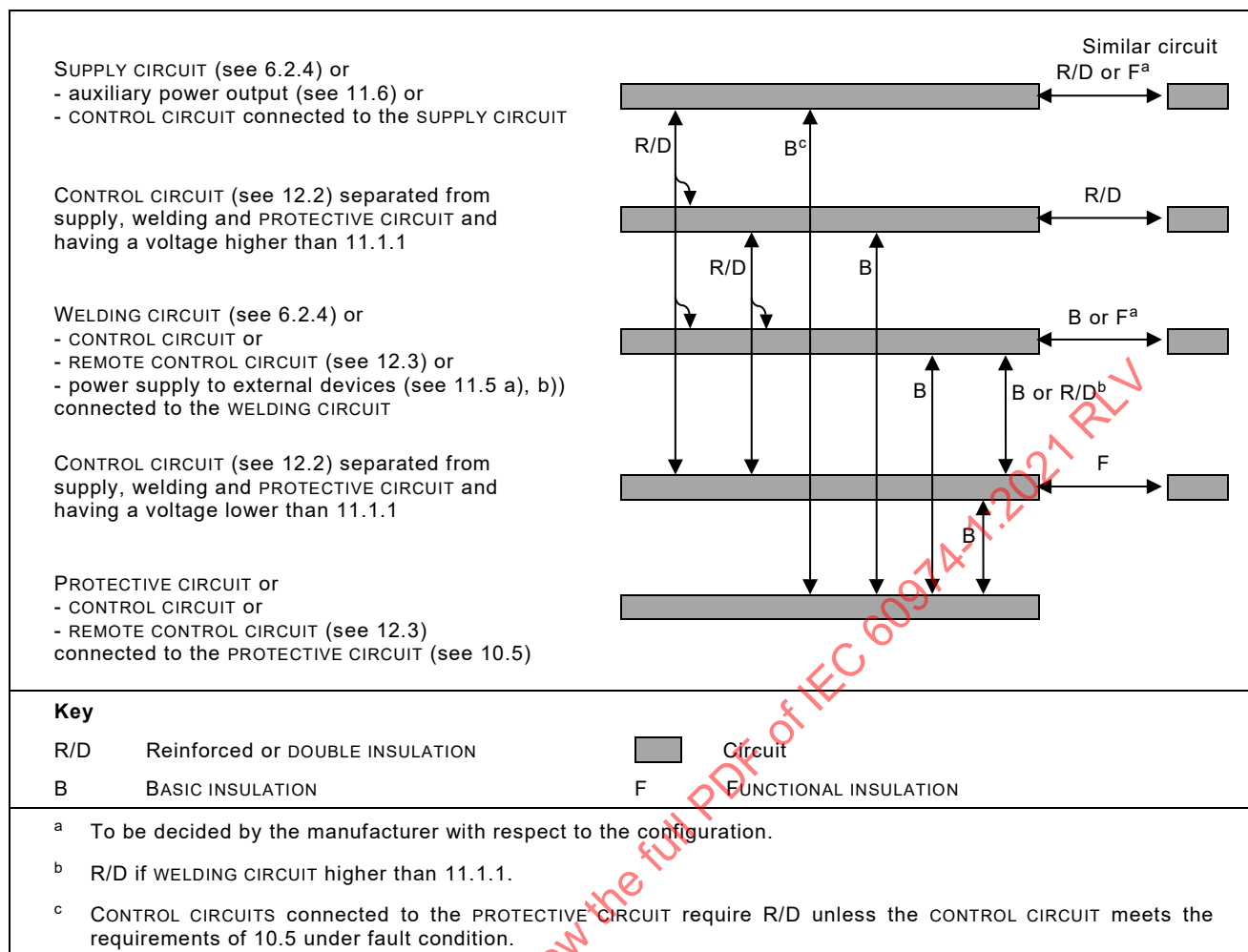
Components or subassemblies with CLEARANCES or CREEPAGE DISTANCES corresponding to POLLUTION DEGREE 2 are permitted if the MICRO-ENVIRONMENT of the component or subassembly is improved (by means such as filtering, coating, potting, moulding) so that only non-conductive pollution or occasional temporary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



IEC

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.

Table 2 – Minimum CLEARANCES for overvoltage category III

Voltage line-to-neutral derived from nominal voltages AC or DC up to and including ^a V RMS	Basic or SUPPLEMENTARY INSULATION					REINFORCED INSULATION				
	Rated impulse test voltage peak V	AC test voltage V RMS.	POLLUTION DEGREE			Rated impulse test voltage peak V	AC test voltage V RMS	POLLUTION DEGREE		
			2	3	4			2	3	4
			CLEARANCE					CLEARANCE		
			mm					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 60664-1:20072020.										
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 60664-1:20072020 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.

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.

Table 3 – Minimum CREEPAGE DISTANCES

Working voltage	CREEPAGE DISTANCES in mm								
	Basic or SUPPLEMENTARY INSULATION								
	Printed wiring material		POLLUTION DEGREE						
	POLLUTION DEGREE								
V RMS	1	2	1	2			3		
				MATERIAL GROUP			MATERIAL GROUP		
	a mm	b mm	a mm	I mm	II mm	III mm	I mm	II mm	III 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).

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:

- first test of a WELDING POWER SOURCE: test voltages given in Table 5;
- repetition of the test of the same WELDING POWER SOURCE: test voltage 80 % of the values given in Table 5.

Table 5 – Dielectric test voltages

Maximum rated voltage ^a V RMS	AC dielectric test voltage V RMS			
	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:

- 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.
- 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.
- 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.

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:*~~

~~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.

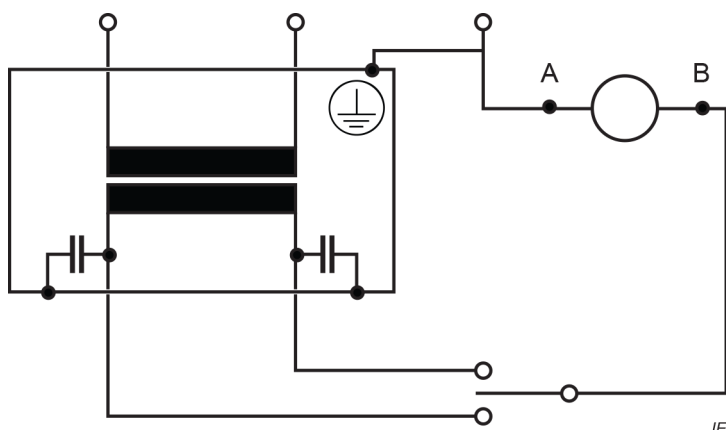
Conformity shall be checked by tests given in 6.1.

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.

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.

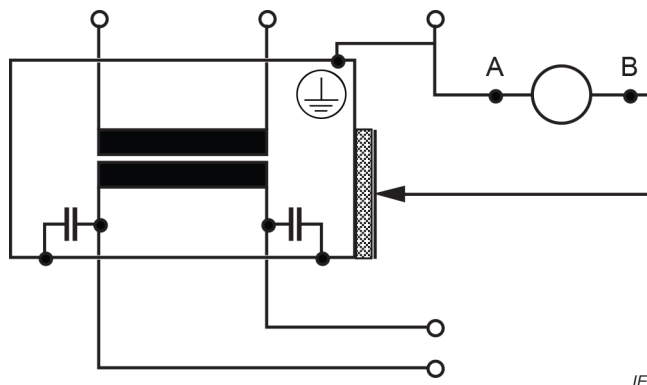


Figure 4 – Measurement of TOUCH CURRENT in normal condition

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).

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.

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 $(10 \pm 0,2)$ 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.

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:	$\begin{matrix} +10 \\ -2 \end{matrix}$ % of the appropriate CONVENTIONAL LOAD VOLTAGE;
b) WELDING CURRENT:	$\begin{matrix} +10 \\ -2 \end{matrix}$ % 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:	$\begin{matrix} +10 \\ -2 \end{matrix}$ 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.

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.

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 and slip-rings
°C	°C	Surface temperature sensor	Resistance	Embedded temperature sensor	
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.

Table 8 – Temperature limits for external surfaces

External surface	Maximum TEMPERATURE RISE	Burn threshold for contact period ^a
	K	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.

- 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.

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.

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 layer of dry absorbent surgical type cotton is placed under the WELDING POWER SOURCE, extending beyond each side for a distance of 150 mm.
- Starting from the cold state, the WELDING POWER SOURCE is operated in accordance with 9.2 to 9.4.
- During the test, the WELDING POWER SOURCE shall not emit flames, molten metal or other materials that ignite the cotton indicator.
- 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:

- for 15 s in the case of a DROOPING CHARACTERISTIC;
- 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.

The supply voltage shall not decrease by more than 10 % during this test.

Mechanically driven WELDING POWER SOURCES are short circuited for 2 min at maximum output setting and set for operation at RATED LOAD SPEED.

9.4 Overload test

The WELDING POWER SOURCE is operated for 4 h in accordance with 7.1.1 b) at 1,5 times the corresponding DUTY CYCLE.

If the WELDING POWER SOURCE is rated for more than 67 % DUTY CYCLE, this test is conducted at 100 % DUTY CYCLE.

If the WELDING POWER SOURCE is provided with output regulating taps, those taps producing the highest supply current shall be used.

If the DUTY CYCLE at the RATED MAXIMUM WELDING CURRENT is 100 %, the WELDING POWER SOURCE ~~need~~ shall not be tested.

9.5 Capacitors short circuit

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 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:

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 capacitor class X and class Y, or capacitors having internal fusing or a circuit-breaker, this test is not required.

10 Connection to the supply network

10.1 Supply voltage

WELDING POWER SOURCES shall be capable of operating at the RATED SUPPLY VOLTAGE ± 10 %. This ~~may~~ can give deviations from the RATED VALUES.

Conformity shall be checked by the following test:

The WELDING POWER SOURCE is connected to a CONVENTIONAL LOAD and adjusted to minimum and maximum output. Each setting is tested at RATED SUPPLY VOLTAGE ± 10 %. Verify presence of stable current flow in the WELDING CIRCUIT under these four conditions.

10.2 Multi-supply voltage

WELDING POWER SOURCES which are designed to operate from different supply voltages shall be fitted with one of the following:

- a) an internal voltage selection panel where the adjustment for the supply voltage is made by links. A marking shall indicate the arrangement of links for each supply voltage;
- b) an internal terminal box or panel in which the terminals are clearly marked with the supply voltages;
- c) a switch for tap selection which shall be fitted with an interlocking system which prevents the switch being moved to an incorrect position. The interlocking system shall be adjusted only by the use of a tool;
- d) two supply cables, each fitted with a different plug, and a selector switch which ensures that the pins of the plug not in use cannot become live;
- e) a system to automatically configure the WELDING POWER SOURCE in accordance with the supply voltage.

NOTE WELDING POWER SOURCES can be fitted with an external indication of the supply voltage selected.

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

In the case d), a selector switch is additionally tested in accordance with 10.8.

10.3 Means of connection to the SUPPLY CIRCUIT

Acceptable means of connection to the SUPPLY CIRCUIT are one of the following:

- a) terminals intended for the permanent connection of flexible supply cables;
- b) terminals intended for the connection of supply cables to a permanent installation;
- c) appliance inlets fitted to the WELDING POWER SOURCE.

NOTE This requirement can also be met by using terminals on a device such as a switch, contactor, etc.

The means of connection to the SUPPLY CIRCUIT shall be chosen in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT I_{eff} and the maximum supply voltage and meet the requirements of the relevant standards or be designed in accordance with Annex E.

Conformity shall be checked by VISUAL INSPECTION.

10.4 Marking of terminals

The terminal for the external protective conductor shall be marked with the symbol  (IEC 60417-5019:2006-08).

Optionally the following may be added:

- a) the letters: **PE**
or
- b) the twin colours: **green and yellow**.

Additionally, three-phase equipment terminals shall be clearly marked in accordance with IEC 60445 or other relevant component standards. The identifying marking notation shall be located on or adjacent to the corresponding terminal.

Conformity shall be checked by VISUAL INSPECTION.

10.5 PROTECTIVE CIRCUIT

10.5.1 Continuity requirement

The internal PROTECTIVE CIRCUIT shall be capable of withstanding currents likely to be encountered in the case of a fault.

CLASS I WELDING POWER SOURCES shall have a suitable terminal, adjacent to the phase-conductor terminals, dimensioned in accordance with Annex E and Table E.1, for the connection of the external protective conductor. This terminal shall not be used for any other purpose (such as for clamping two parts of the casing together).

On and inside the WELDING POWER SOURCE, if there is a neutral-conductor terminal, this shall not be in electrical contact with the terminal for the connection of the protective conductor.

Both inside and outside the WELDING POWER SOURCE, insulated protective conductors shall have the twin colours green and yellow. If the WELDING POWER SOURCE is supplied with a flexible multi-conductor supply cable, this shall have the protective conductor with the twin colours green and yellow.

In some countries, the single colour green is also used to identify the protective conductor and the protective conductor terminal.

If the WELDING POWER SOURCE is fitted with a protective conductor, it shall be connected in such a way that if the cable is pulled away from the terminals, the phase conductors break before the protective conductor.

Conformity shall be checked by VISUAL INSPECTION and the tests given in 10.5.2 and 10.5.3.

The method of securing conductive parts to the PROTECTIVE CIRCUITS, for example paint-piercing washers, paint-piercing screws or non-painted surfaces shall be considered during VISUAL INSPECTION.

10.5.2 TYPE TEST

A current of 200 % of the MAXIMUM EFFECTIVE SUPPLY CURRENT as given on the RATING PLATE is applied from an enclosure part, that is likely to become live, through the external protective conductor terminal for a period of time given in Table 10, using the smallest external protective conductor size given in Table 11.

NOTE The waveform of the test current is not defined as long as the effective value is used for comparison.

Table 10 – Current and time requirements for PROTECTIVE CIRCUITS

Current A	Time min
Up to 30	2
31 to 60	4
61 to 100	6
101 to 200	8
Above 200	10

Table 11 – Minimum cross-sectional area of the external protective copper conductor

Cross-sectional area of phase conductors supplying the equipment S mm^2	Minimum cross-sectional area of the external protective copper conductor S_p mm^2
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

During the test there shall be no melting of any metal, deterioration of the bond to the WELDING POWER SOURCE, nor heating likely to cause a fire, nor shall the measured voltage drop from the enclosure part to the terminal exceed 4 V RMS.

10.5.3 ROUTINE TEST

The test is to verify the continuity of the PROTECTIVE CIRCUIT by injecting a current of at least 10 A at 50 Hz or 60 Hz derived from a SELV source. The tests are to be made between the PE terminal and relevant points that are part of the PROTECTIVE CIRCUIT. The test time is 1 s.

The measured voltage between the PE terminal and the points of test shall not exceed the values given in Table 12:

Table 12 – Verification of continuity of the PROTECTIVE CIRCUIT

Minimum effective protective conductor cross-sectional area of the branch under test mm^2	Maximum measured voltage drop (values are given for a test current of 10 A) V
1,0	3,3
1,5	2,6
2,5	1,9
4,0	1,4
> 6,0	1,0

10.6 Cable anchorage

WELDING POWER SOURCES fitted with terminals for the connection of flexible supply cables shall be provided with a cable anchorage that relieves the electrical connection from strain.

The cable anchorage shall be so constructed that

- it is dimensioned for flexible cables having the range of cross-sectional area of conductor as specified in Table E.1;
- the method of anchorage can be easily recognized;
- the cable can be easily replaced;
- the cable cannot come into contact with conductive clamping screws of the cable anchorage if these screws are accessible or in electrical contact with exposed conductive parts;
- the cable is not retained by a metal screw which bears directly on it;
- at least one part of the cable anchorage is securely fixed to the WELDING POWER SOURCE;
- any screws that ~~need to~~ shall be loosened or tightened during cable replacement do not serve to fix any other component;

- h) when fitted to a CLASS II WELDING POWER SOURCE, it shall be made of insulating material or so insulated that, if there is a cable insulation fault, no exposed conductive parts shall become live.

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

A flexible supply cable, which has the minimum cross-sectional area of the conductor specified, is connected at the point of connection to the equipment. The cable anchorage is fitted to the cable and tightened.

It shall then not be possible to push the cable so far into the WELDING POWER SOURCE that either the cable itself or internal parts of the WELDING POWER SOURCE are likely to be damaged.

The cable anchorage is then loosened and retightened 10 times.

The cable is then subjected for 1 min to a pull as specified in Table 13 without jerking.

Table 13 – Pull

Nominal cross-sectional area of the conductor mm ²	Pull N
1,5	150
2,5	220
4,0	330
6 and above	440

At the end of the test, the cable shall not have been displaced by more than 2 mm and the ends of the conductors shall not have been noticeably displaced in the terminals. To measure the displacement, prior to the test, a mark is provided at a distance of 20 mm from the cable anchorage on the cable with the cable in the stressed condition.

After the test, the displacement of this mark in relation to the cable anchorage is measured, with the cable in the stressed condition.

During the test, no visible damage (for example nicks, cuts or tears in the sheath) shall be caused to the cable.

The test is then repeated with the maximum cross-sectional area of the conductor specified.

10.7 Inlet openings

Where the supply cable passes through metallic parts, it shall be provided with a bushing of insulating material, or the openings shall be smoothly rounded with a radius of at least 1,5 mm.

Conformity shall be checked by VISUAL INSPECTION.

10.8 SUPPLY CIRCUIT on/off switching device

Where a built-in SUPPLY CIRCUIT on/off switching device (for example switch, contactor or circuit-breaker) is provided, this shall:

- switch all ungrounded mains conductors, and
- plainly indicate whether the circuit is open or closed, and either

- c) be rated as follows:
 - voltage: not less than the values given on the RATING PLATE,
 - current: not less than the highest effective supply current as given on the RATING PLATE,
 - or
- d) be suitable for this application.

Conformity shall be checked by VISUAL INSPECTION; for c) in accordance with other relevant standards, and for d) by the following tests.

For the tests, the SUPPLY CIRCUIT on/off switching devices ~~may~~ can be mounted external to the power source.

A WELDING POWER SOURCE is connected for the RATED SUPPLY VOLTAGE that corresponds to the RATED MAXIMUM SUPPLY CURRENT and, in addition for CLASS I EQUIPMENT, a fuse of 10 A to 20 A is placed

- in the case of an earthed SUPPLY CIRCUIT, in the protective earth connection;
- in the case of an unearthed SUPPLY CIRCUIT, between a phase conductor and the PROTECTIVE CIRCUIT.

During the tests, the supply voltage shall be maintained at not less than at the RATED VALUE.

Overload: The output of the WELDING POWER SOURCE is short-circuited in accordance with 9.3. The switching device is operated for 100 cycles at the rate of 6 cycles/min to 10 cycles/min with a minimum on-time of 1 s.

A switching device ~~need~~ shall not be tested if its RATED VALUE exceeds twice the RATED MAXIMUM SUPPLY CURRENT of the WELDING POWER SOURCE.

Endurance: The output is connected to a CONVENTIONAL LOAD and adjusted to produce the rated WELDING CURRENT at 100 % DUTY CYCLE. The switching device is operated for 1 000 cycles at a rate of 6 cycles/min to 10 cycles/min with a minimum on-time of 1 s.

A WELDING POWER SOURCE with more than one RATED SUPPLY VOLTAGE is also tested at the rated maximum supply voltage.

There shall be no electrical or mechanical failure and, in addition for CLASS I EQUIPMENT, no clearing of the fuse.

NOTE A component having demonstrated that it passes these tests can be used in other similar applications if the other requirements are equal or less.

10.9 Supply cables

When supply cables are attached to the WELDING POWER SOURCE, they shall:

- a) be suitable for the application and meet national and local regulations;
- b) be dimensioned in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT $I_{1\text{eff}}$;
- and
- c) have a length of at least 2 m as measured from the exit point of the enclosure.

Conformity shall be checked by VISUAL INSPECTION.

NOTE Examples of local regulations are given in the Bibliography, e.g. EN 50525-2-21, Electrical code NFPA 70 (SE, SO, ST, STO or other extra hard usage cable) or CSA C22.1. PVC insulation has been proven not suitable for the application.

10.10 Supply coupling device (attachment plug)

If a supply coupling device is provided as a part of the arc welding equipment, its RATED VALUES shall be not less than:

- a) the rated current of the fuse required to comply with the tests specified in 9.3 regardless of whether or not a SUPPLY CIRCUIT switch is incorporated;
- b) the MAXIMUM EFFECTIVE SUPPLY CURRENT $I_{1\text{eff}}$.

For supply networks up to 125 V, the rated current shall, additionally, not be less than either c) or d):

- c) 70 % of the RATED MAXIMUM SUPPLY CURRENT for equipment incorporating a supply switch;
- d) 70 % of the supply current measured with the output short-circuited at maximum setting for equipment not incorporating a supply switch.

Furthermore, the coupling device shall be suitable for industrial purposes.

NOTE Example of coupling devices suitable for industrial purposes can be found in IEC 60309-1.

Conformity shall be checked by VISUAL INSPECTION, measurement and calculation.

11 Output

11.1 RATED NO-LOAD VOLTAGE

11.1.1 RATED NO-LOAD VOLTAGE for use in environments with increased risk of electric shock

If the WELDING POWER SOURCE is not fitted with a HAZARD REDUCING DEVICE in accordance with Clause 13, the RATED NO-LOAD VOLTAGE shall not exceed:

- a) DC 113 V peak;
- b) AC 68 V peak and 48 V RMS.

Such WELDING POWER SOURCES may be marked with symbol 84 of Annex L S.

Conformity shall be checked by measurement and by analysis of the circuit and/or by failure simulation in accordance with 11.1.5.

11.1.2 RATED NO-LOAD VOLTAGE for use in environments without increased risk of electric shock

If the WELDING POWER SOURCE is not fitted with a HAZARD REDUCING DEVICE in accordance with Clause 13, the RATED NO-LOAD VOLTAGE shall not exceed

- a) DC 113 V peak;
- b) AC 113 V peak and 80 V RMS.

Conformity shall be checked by measurement in accordance with 11.1.5.

11.1.3 RATED NO-LOAD VOLTAGE for the use with mechanically held torches with increased protection for the operator

The RATED NO-LOAD VOLTAGE shall not exceed

- a) DC 141 V peak;
- b) AC 141 V peak and 100 V RMS.

These values may only be used if the following requirements are fulfilled:

- 1) the torch shall not be hand-held;
- 2) the NO-LOAD VOLTAGE shall be switched off automatically when the welding is stopped;
and
- 3) the protection against direct contact with live parts shall be given by:
 - a minimum degree of protection of IP2X,
 - or
 - a HAZARD REDUCING DEVICE (see Clause 13).

Conformity shall be checked by measurement in accordance with 11.1.5, by operation and by VISUAL INSPECTION.

11.1.4 RATED NO-LOAD VOLTAGE for special processes for example plasma cutting

The RATED NO-LOAD VOLTAGE shall not exceed 500 V peak DC.

Conformity shall be checked by measurement in accordance with 11.1.5, by operation and by VISUAL INSPECTION, except that the series combination of the 200 Ω fixed and 5 k Ω variable resistors ~~may~~ can be replaced by a fixed resistance of 5 k Ω .

A RATED NO-LOAD VOLTAGE exceeding 113 V peak DC ~~may~~ can only be used if the following requirements are fulfilled.

- a) These PLASMA CUTTING POWER SOURCES with their corresponding torches shall prevent the output of NO-LOAD VOLTAGE if the torch is disassembled or disconnected from the PLASMA CUTTING POWER SOURCE.
- b) The NO-LOAD VOLTAGE shall be less than 68 V peak not later than 2 s after the CONTROL CIRCUIT (for example start switch) is opened.
- c) The voltage between the tip of the torch and the workpiece or earth shall be less than 68 V peak not later than 2 s after both pilot and main arcs are extinguished.

The conditions for complying with these requirements shall be given in the instructions.

Such PLASMA CUTTING POWER SOURCES may be marked with the symbol 84 of Annex L.

Conformity shall be checked by measurement by meter or oscilloscope in parallel with 5 k Ω minimum resistance.

11.1.5 Additional requirements

The RATED NO-LOAD VOLTAGE at all possible output settings shall not exceed the values given in 11.1.1 to 11.1.4, summarized in Table 14.

During measurement, the actual supply voltage shall not vary from the RATED SUPPLY VOLTAGE by greater than ± 6 %. If the NO-LOAD VOLTAGE varies with supply voltage, then for a variation of supply voltage greater than ± 1 %, the NO-LOAD VOLTAGE shall be linearly corrected in accordance with the actual supply voltage.

Table 14 – Summary of allowable RATED NO-LOAD VOLTAGES

Subclause	Working conditions	RATED NO-LOAD VOLTAGE
11.1.1	ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK	DC 113 V peak AC 68 V peak and 48 V RMS
11.1.2	Environment without increased risk of electric shock	DC 113 V peak AC 113 V peak and 80 V RMS
11.1.3	Mechanically held torches with increased protection for the operator	DC 141 V peak AC 141 V peak and 100 V RMS
11.1.4	Plasma cutting	DC 500 V peak

WELDING POWER SOURCES shall be

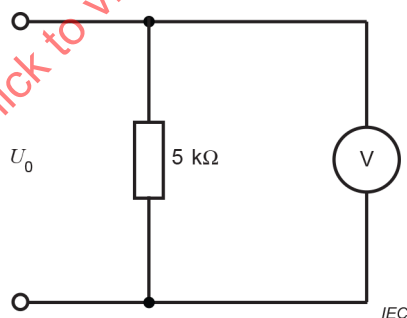
- designed to ensure that the output voltages given in Table 14 are not exceeded in the event of failure of any component (for example, open circuit or short circuit failure) or
- fitted with a protection system, which switches off the voltage at the output terminals within 0,3 s and shall not be reset automatically.

These values are not applicable to voltages for arc striking or arc stabilizing that could be superimposed.

Conformity shall be checked by measurement and by analysis of the circuit and/or by failure simulation.

11.1.6 Measuring circuits

For measuring RMS values, a true RMS meter shall be used together with a resistor of $(5 \pm 0,25) \text{ k}\Omega$, connected across the WELDING CIRCUIT terminals as shown in Figure 5.



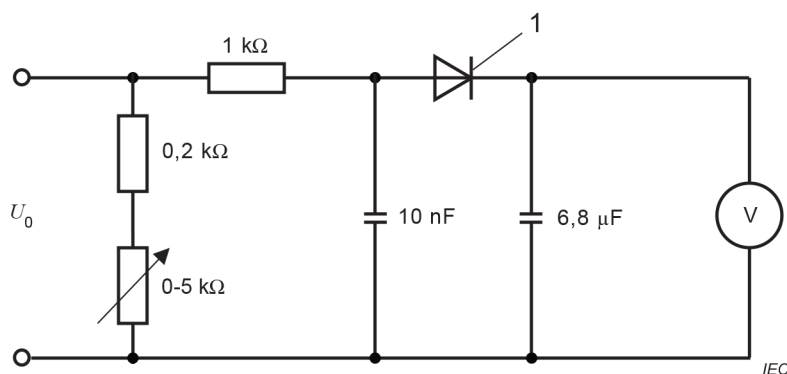
Key

U_0 NO-LOAD VOLTAGE

V True RMS voltmeter

Figure 5 – Measurement of RMS values

To obtain reproducible measurements of peak values, omitting impulses which are not dangerous, a circuit as shown in Figure 6 shall be used.



Key

U_0 NO-LOAD VOLTAGE

V Voltmeter

1 Diode 1N4007 or similar

Figure 6 – Measurement of peak values

The voltmeter shall indicate mean values. The measurement range chosen shall be as near as possible to the actual value of the NO-LOAD VOLTAGE. The voltmeter shall have an internal resistance of at least 1 MΩ.

The tolerance of the component values in the measurement circuit shall not exceed ±5 %.

For the TYPE TEST, the rheostat is varied from 0 Ω to 5 kΩ in order to obtain the highest peak value of the voltage measured with these loads of 200 Ω to 5,2 kΩ. This measurement is repeated with the two connections to the measuring apparatus reversed.

The rheostat resistance and connection that produces the highest value of the voltage ~~may~~ can be determined during the TYPE TEST. This resistance and lead polarity ~~may~~ can be used for the ROUTINE TEST.

11.2 TYPE TEST values of the CONVENTIONAL LOAD VOLTAGE

11.2.1 Manual metal arc welding with covered electrodes

I_2 up to 600 A: $U_2 = (20 + 0,04 I_2)$ V

I_2 over 600 A: $U_2 = 44$ V

11.2.2 Tungsten inert gas

I_2 up to 600 A: $U_2 = (10 + 0,04 I_2)$ V

I_2 over 600 A: $U_2 = 34$ V

11.2.3 Metal inert/active gas and flux cored arc welding

I_2 up to 600 A: $U_2 = (14 + 0,05 I_2)$ V

I_2 over 600 A: $U_2 = 44$ V

11.2.4 Submerged arc welding

I_2 up to 600 A: $U_2 = (20 + 0,04 I_2)$ V

I_2 over 600 A: $U_2 = 44$ V

11.2.5 Plasma cutting

I_2 up to 170 A: $U_2 = (80 + 0,4 I_2) \text{ V}$

I_2 between 170 A and 500 A: $U_2 = (131 + 0,1 I_2) \text{ V}$

I_2 above 500 A: $U_2 = 181 \text{ V}$

For plasma cutting, the manufacturer ~~may~~ can specify additional LOAD VOLTAGES as determined under typical cutting conditions.

NOTE The manufacturer-specified LOAD VOLTAGE is used due to the nature of the plasma process. Factors that can influence the voltage at which satisfactory performance occurs include the interaction of the plasma torch design, recommended plasma gas, and standoff distance.

11.2.6 Plasma welding

I_2 up to 600 A: $U_2 = (25 + 0,04 I_2) \text{ V}$

I_2 over 600 A: $U_2 = 49 \text{ V}$

11.2.7 Plasma gouging

I_2 up to 300 A: $U_2 = (100 + 0,4 I_2) \text{ V}$

I_2 over 300 A: $U_2 = 220 \text{ V}$

For plasma gouging, the manufacturer ~~may~~ can specify additional LOAD VOLTAGES as determined under typical gouging conditions.

NOTE The manufacturer-specified LOAD VOLTAGE is used due to the nature of the plasma process. Factors that can influence the voltage at which satisfactory performance occurs include the interaction of the plasma torch design, recommended plasma gas, and standoff distance.

11.2.8 Additional requirements

Throughout its range of adjustment, the electrically powered WELDING POWER SOURCES shall be capable of delivering CONVENTIONAL WELDING CURRENTS (I_2) at CONVENTIONAL LOAD VOLTAGES (U_2) in accordance with 11.2.1 to 11.2.7.

Conformity shall be checked by sufficient measurements (see Annex H).

11.3 Mechanical switching devices used to adjust output

A switch, contactor, circuit-breaker or other control device used to adjust or control the level of output from the WELDING POWER SOURCE shall have an endurance suitable for the application.

Conformity shall be checked by the following test.

The device is installed in a test WELDING POWER SOURCE and subjected to 6 000 cycles of operation over the complete range of mechanical movement with the output at the no-load condition. If the device is in the SUPPLY CIRCUIT, the WELDING POWER SOURCE is operated at the highest RATED SUPPLY VOLTAGE. Check that no electrical or mechanical failure of the device or damage to the WELDING POWER SOURCE occurs.

NOTE A component having demonstrated that it passes these tests can be used in other similar applications, if the other requirements are equal or less.

11.4 WELDING CIRCUIT connections

11.4.1 Protection against unintentional contact

WELDING CIRCUIT connections, with or without welding cables connected, shall be protected against unintentional contact by persons or by metal objects, for example vehicles, crane hooks, etc.

Examples of how such protection can be afforded.

- a) Any live part of a coupling device is recessed behind the plane of the access opening. Devices complying with IEC 60974-12 meet the requirement.
- b) A hinged cover or a protective guard is provided.

Conformity shall be checked by VISUAL INSPECTION.

11.4.2 Location of coupling devices

Uncovered coupling devices shall be located so that their openings are not tilted upwards.

NOTE Coupling devices fitted with an automatic closing device can have their openings tilted upwards.

Conformity shall be checked by VISUAL INSPECTION.

11.4.3 Outlet openings

Where welding cables pass through metallic parts, the edges of the opening shall be smoothly rounded with a radius of at least 1,5 mm.

Conformity shall be checked by VISUAL INSPECTION.

11.4.4 Three-phase multi-operator welding transformer

All welding output connections intended to be connected to the workpiece shall have a common interconnection within the WELDING POWER SOURCE.

Welding output connections of the same phase shall all be marked in the same way as each other.

Conformity shall be checked by VISUAL INSPECTION.

11.4.5 Marking

Connections designed specifically for attachment to the workpiece or to the electrode shall be so identified.

For DC WELDING POWER SOURCES, the polarity shall be clearly marked, either on the welding output connections or on the polarity selector. This requirement is not relevant for PLASMA CUTTING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION.

11.4.6 Connections for plasma cutting torches

The torch shall be connected to and disconnected from the PLASMA CUTTING POWER SOURCE:

- a) within the PLASMA CUTTING POWER SOURCE, by use of a tool, by screws or coupling devices;
- or

b) on the PLASMA CUTTING POWER SOURCE, by a coupling device which is:

- 1) designed to avoid connection of incompatible torches
or
- 2) operated by use of a tool.

When the coupling device is disconnected, no voltage higher than the limits of SELV accessible to the operator shall be present.

Conformity shall be checked by VISUAL INSPECTION and measurement.

11.5 Power supply to external devices connected to the WELDING CIRCUIT

When a WELDING POWER SOURCE supplies electrical power to an external device including a connection to the WELDING CIRCUIT, such power shall be supplied by one of the following:

- a) the WELDING CIRCUIT;
- b) a safety isolating transformer in accordance with IEC 61558-2-6 or equivalent means incorporated in the WELDING POWER SOURCE;
- c) an isolating transformer in accordance with IEC 61558-2-4 with a rated secondary voltage up to 120 V RMS if all exposed conductive parts of the external device, as recommended by the manufacturer, are connected to the protective earth conductor that is protected against the WELDING CURRENT, for example by a current sensing relay or by insulation of the relevant metal parts, for example by an enclosure.

External devices include wire feed units, arc striking and stabilizing devices, torches, seam trackers or other devices containing a connection to the WELDING CIRCUIT.

Conformity shall be checked by VISUAL INSPECTION and fault simulation.

11.6 Auxiliary power supply

In the case of WELDING POWER SOURCES designed to supply electrical power to external devices which are not a part of the WELDING CIRCUIT (for example for lighting, external cooling system or electric tools), these auxiliary circuits and accessories shall comply with the standards and regulations relating to the use of these external devices.

The WELDING CIRCUIT shall be isolated from such SUPPLY CIRCUITS in accordance with 6.2.4 and 6.3.2.

Near the socket-outlet of the auxiliary power supply, the available current, voltage, DUTY CYCLE if less than 100 %, AC or DC and the status of the neutral (for example earthed or unearthed) as appropriate, shall be clearly and indelibly marked.

Conformity shall be checked by VISUAL INSPECTION during the tests in accordance with 6.1.4, 6.1.5, 6.2.4 and 6.3.2 and by rubbing the marking in accordance with 15.1.

11.7 Welding cables

If a WELDING POWER SOURCE is supplied with welding cables, they shall meet the requirements of IEC 60245-6 or meet national and local regulations.

If a PLASMA CUTTING POWER SOURCE is supplied with welding cables, they shall meet the current and NO-LOAD VOLTAGE ratings suitable for the application and meet national and local regulations.

NOTE 1 Example or local regulations are given in the Bibliography, e.g. EN 50525-2-81:2011. Additional information about the current carrying capability of welding cables can be found in EN 50565-1:2014.

NOTE 2 PVC insulation has been proved not suitable for the application and is not recognised in welding cable product standards of IEC or CENELEC.

NOTE 3 The rated voltage of welding cables complying with IEC 60245-6 is typically not suitable for plasma cutting applications.

12 CONTROL CIRCUITS

12.1 General requirement

All inputs and outputs of CONTROL CIRCUITS shall be tested at the maximum load as specified by the manufacturer. REMOTE CONTROL CIRCUITS ~~may~~ can be tested without connection to the power source, provided that the power source can be simulated.

Conformity shall be checked by measurement or analysis, as appropriate.

12.2 Isolation of CONTROL CIRCUITS

A CONTROL CIRCUIT that leaves the enclosure that has a voltage lower than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1, and that is separated from the WELDING CIRCUIT and SUPPLY CIRCUIT shall be:

- a) insulated from the SUPPLY CIRCUIT by double or REINFORCED INSULATION,
- b) insulated from all other circuits having a voltage higher than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1 (e.g. auxiliary power SUPPLY CIRCUITS, plasma cutting circuit) by double or REINFORCED INSULATION, and
- c) insulated from the WELDING CIRCUIT having a voltage lower than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1 by BASIC INSULATION.

NOTE Example of insulation configuration for CLASS I EQUIPMENT is given in 6.1.1.

Conformity shall be checked by measurement or analysis, as appropriate.

12.3 WORKING VOLTAGES of remote CONTROL CIRCUITS

The WORKING VOLTAGES in REMOTE CONTROL CIRCUITS that are designed to be handheld shall not exceed 50 V AC or 120 V ripple free DC between conductors, or between any conductor and PROTECTIVE CIRCUIT, under normal operating conditions and after a single fault.

NOTE WORKING VOLTAGE requirements for local or wide area computer networks are contained in IEC 60950-1.

Conformity shall be checked by measurement or analysis, as appropriate.

13 HAZARD REDUCING DEVICE

13.1 General requirements

A HAZARD REDUCING DEVICE shall reduce the severity of the electric shock that can originate from NO-LOAD VOLTAGES exceeding the allowable RATED NO-LOAD VOLTAGE for a given environment. Types of HAZARD REDUCING DEVICES are given in 13.2.

Requirements are given in Table 15.

Table 15 – HAZARD REDUCING DEVICE requirements

Unreduced NO-LOAD VOLTAGE in accordance with subclause	Reduced NO-LOAD VOLTAGE in accordance with subclause	Operating time s
Between 11.1.3 and 11.1.2	11.1.1	0,3
Between 11.1.2 and 11.1.1	11.1.1	2
For DC WELDING POWER SOURCE above 113 V, an operating time of 0,3 s is required.		

13.2 Types of HAZARD REDUCING DEVICES

13.2.1 Voltage reducing device

A voltage reducing device shall have automatically reduced the RATED NO-LOAD VOLTAGE to a level not exceeding the values of 11.1.1 at the moment the resistance of the external WELDING CIRCUIT exceeds 200 Ω . The operating time is specified in Table 15.

Such WELDING POWER SOURCES may be marked with the symbol 84 of Annex L.

Conformity shall be checked by connecting a variable load resistor across the welding output connections of the WELDING POWER SOURCE. Voltage measurements and operating time are taken while the resistance is being increased.

13.2.2 Switching device for AC to DC

A switching device for AC to DC shall have automatically switched the rated AC NO-LOAD VOLTAGE to a rated DC NO-LOAD VOLTAGE not exceeding the values given in 11.1.1 at the moment the resistance of the external WELDING CIRCUIT exceeds 200 Ω . The operating time is specified in Table 15.

Such WELDING POWER SOURCES ~~may~~ can be marked with the symbol 84 of Annex L.

Conformity shall be checked in accordance with 13.2.1.

13.3 Requirements for HAZARD REDUCING DEVICES

13.3.1 Disabling the HAZARD REDUCING DEVICE

The design shall be such that the operator cannot disable or by-pass the HAZARD REDUCING DEVICE without the use of a tool.

Conformity shall be checked by VISUAL INSPECTION.

13.3.2 Interference with operation of a HAZARD REDUCING DEVICE

REMOTE CONTROLS, as specified by the manufacturer, and arc striking or arc stabilizing devices of the WELDING POWER SOURCE shall not interfere with the proper functioning of the HAZARD REDUCING DEVICE, i.e. NO-LOAD VOLTAGE limits shall not be exceeded.

Conformity shall be checked by repeating the tests of 13.2.1 with any of the devices that could interfere with the operation of the HAZARD REDUCING DEVICE.

13.3.3 Indication of satisfactory operation

A reliable device, for example a signal lamp, shall be provided which indicates that the HAZARD REDUCING DEVICE is operating satisfactorily. Where a signal lamp is used, it shall light when the voltage has been reduced or changed to DC.

Conformity shall be checked by VISUAL INSPECTION during the test in accordance with 13.1.

13.3.4 Fail to a safe condition

If the HAZARD REDUCING DEVICE fails to operate in accordance with 13.1, the voltage at the output terminals shall be reduced to a level not exceeding 11.1.1 in accordance with Table 15 and shall not be reset automatically.

Conformity shall be checked by simulating a fault of the HAZARD REDUCING DEVICE and measuring the time to reach a safe condition after failure of the HAZARD REDUCING DEVICE.

14 Mechanical provisions

14.1 General requirements

Equipment shall be constructed and assembled so that it has the strength and rigidity necessary to withstand the normal service to which it is likely to be subjected, without increasing the risk of electric shock or other hazards whilst maintaining the minimum CLEARANCES required. Equipment shall be provided with a case or cabinet that encloses all live and hazardous moving parts (such as pulleys, belts, fans, gears etc.) except that the following ~~need~~ shall not be fully enclosed:

- a) supply, control and welding cables;
- b) output terminals for the connection of welding cables.

After the tests in accordance with 14.2 to 14.5, the equipment shall comply with the provisions of this document. Some deformation of the structural parts or enclosure is permitted provided this does not reduce the level of safety protection.

Accessible parts shall have no sharp edges, rough surfaces or protruding parts likely to cause injury.

Conformity shall be checked by VISUAL INSPECTION after meeting the requirements of 14.2 to 14.5.

14.2 Enclosure

14.2.1 Enclosure materials

Non-metallic materials intended to protect from contact with live parts, except welding and SELV circuits, shall have a flammability classification of V-1 or better in accordance with IEC 60695-11-10.

Conformity is checked by inspection of non-metallic materials specification.

14.2.2 Enclosure strength

The enclosure, including air louvers, shall withstand an impact energy of 10 Nm in accordance with Annex I.

Handles, push buttons, adjustment dials etc. shall not be tested with the pendulum hammer.

Alternatively, the enclosure ~~may~~ can be constructed of sheet metal with a minimum thickness in accordance with Annex J.

Conformity shall be checked in accordance with a) or b) below.

- a) By an impact test using a pendulum impact hammer in accordance with I.1 or using a free fall weight in accordance with I.2 or equivalent means as follows:
 - 1) one sample is tested;
 - 2) the WELDING POWER SOURCE is not energized during the test;
 - 3) select one impact point on each side, where risk of electrical shock or malfunction is highest;
 - 4) apply three impacts to selected impact points.
- b) By measurement of the thickness of the sheet metal.

14.3 Handling means

14.3.1 Mechanised handling

If means for mechanical handling are provided (for example eyelet or lug) for the purpose of lifting an assembled equipment, these shall be capable of withstanding the mechanical stress of a static pull with a force calculated from the mass of the assembled equipment as follows.

- a) For equipment with a mass of up to 150 kg, a force calculated from 10 times the mass shall be used.
- b) For equipment with a mass of greater than 150 kg, a force calculated from four times the mass or at least 15 kN shall be used.

If only a single lifting means is provided, it shall be designed so that a torque applied during lifting cannot cause it to be loosened.

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

The equipment is fitted with all the associated attachments, (excluding gas cylinders, separate trailers, carts and wheel undercarriages) that are likely to be installed and, in the case of engine-driven WELDING POWER SOURCES, completely serviced and ready for operation. The equipment is anchored rigidly at its base and a chain or cable is attached to its lifting means, as recommended by the manufacturer, and an upward force is then exerted continuously for 10 s.

If two or more lifting means are provided, the chains or cables are arranged so that the force is equally shared between them and is applied at an angle not greater than 15° to the vertical.

14.3.2 Manual handling

If means for manual handling are provided for lifting or carrying (for example handles, straps), these shall be capable of withstanding the mechanical stress of a static pull with a force calculated from the mass of the assembled equipment as follows.

A force calculated from four times the mass or at least 600 N shall be used.

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

The equipment is fitted with all the associated attachments, (excluding gas cylinders, separate trailers, carts and wheel undercarriages) that are likely to be installed. The equipment is anchored rigidly at its base and a chain or cable is attached to its handles or strap, as recommended by the manufacturer, and an upward force is then exerted continuously for 10 s.

14.4 Drop withstand

Equipment shall be capable of withstanding a drop test. For this test, the equipment shall be equipped with all the associated attachments, cooling liquid and filler wire (excluding gas cylinders, separate trailers, carts and wheel undercarriages, unless these items are standard equipment and permanently affixed) that are recommended to be installed.

The heights for the drop test shall be as follows:

- a) equipment with a mass of up to 25 kg shall withstand a drop of 250^{+10}_0 mm;
- b) equipment with a mass of greater than 25 kg shall withstand a drop of 100^{+10}_0 mm.

NOTE 1 Mass of equipment includes mass of associated attachments, cooling liquid and filler wire.

Conformity shall be checked by dropping the equipment three times on a hard and rigid surface. This test is so arranged that a different bottom edge of the equipment is struck each time it drops.

NOTE 2 In practice, one corner will touch the impact surface first.

Engine-driven WELDING POWER SOURCES shall be filled up and be ready for immediate use.

14.5 Tilting stability

Equipment in its most unstable position shall not topple over when tilted up to 10°. Auxiliary items as specified by the manufacturer in accordance with the type of the equipment such as gas cylinders, wire feed unit or cooling device could affect the stability, and these shall be taken into account.

If the manufacturer specifies other auxiliary items, so that the requirement of this subclause cannot be met, then instructions shall be provided for anchorage or other means as necessary.

Conformity shall be checked by the following test.

The equipment is placed on a plane and tilted from the horizontal level.

15 RATING PLATE

15.1 General requirements

A clearly and indelibly marked RATING PLATE shall be fixed securely to or printed on each WELDING POWER SOURCE.

NOTE The purpose of the RATING PLATE is to indicate to the user the electrical characteristics, which enables the comparison and correct selection of WELDING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

After this test, the marking shall be easily legible. It shall not be easy to remove the RATING PLATE and it shall show no curling.

15.2 Description

The RATING PLATE shall be divided into sections containing information and data for the

- a) identification;
- b) welding output;
- c) energy supply.

The arrangement and sequence of the data shall comply with the principle shown in Figure 7 (for examples, see Annex K).

The dimensions of the RATING PLATE are not specified and ~~may~~ can be chosen freely.

It is permissible to separate the above sections from each other and affix them at locations more accessible or convenient for the user.

For WELDING POWER SOURCES to be used for several welding processes or for rotating WELDING POWER SOURCES, either one combined or several separate RATING PLATE(S) ~~may~~ can be used.

NOTE Additional information can be given. Further useful information, for example CLASS OF INSULATION, POLLUTION DEGREE or POWER FACTOR, can be given in technical literature supplied by the manufacturer (see 17.1).

a) Identification					
1)					
2)			3)		
4) Optional			5)		
b) Welding output					
6)		8)		10)	
		11)		11a)	
				11b)	
				11c)	
7)		9)		12)	
				12a)	
				12b)	
				12c)	
		13)		13a)	
				13b)	
				13c)	
c) Energy supply					
14)		15) or 18)		16)	
		or 19)		or 20) If applicable	
				or 21) If applicable	
22) Optional		23) If applicable			

IEC

Figure 7 – Principle of the RATING PLATE

15.3 Contents

The following explanations refer to the numbered boxes shown in Figure 7.

a) Identification

Box 1 Name and address of the manufacturer or distributor or importer and, optionally, a trademark and the country of origin, if required.

Box 2 Type (identification) as given by the manufacturer.

Box 3 Traceability of design and manufacturing data, for example serial number.

NOTE 1 National or local regulation (e.g. Commission Regulation (EU) 2019/1784) may require to provide the year of manufacture on the RATING PLATE. Alternative methods like decoding the traceability number or retrieving the year of manufacture by typing the traceability number into a web-tool provided by the manufacturer, is considered to fulfil the requirement.

Box 4 WELDING POWER SOURCE symbol (optional) for example:

	Single-phase transformer
	Three-phase transformer-rectifier
	Single- or three-phase static frequency converter-transformer-rectifier
	Inverter power source with AC and DC output
	Three-phase motor-generator
	Three-phase motor-generator-rectifier
	Three-phase rotating frequency converter
	Single-phase combined AC and DC power source
	Engine-AC generator
	Engine-generator-rectifier

Box 5 Reference to the standards confirming that the WELDING POWER SOURCE complies with their requirements.

b) Welding output

Box 6 Welding process symbol for example:

	Manual metal arc welding with covered electrodes
	Tungsten inert-gas welding
	Metal inert and active gas welding including the use of flux cored wire
	Self shielded flux cored arc welding
	Submerged arc welding
	Plasma cutting
	Plasma gouging
	Plasma welding

Box 7  Mark for WELDING POWER SOURCES which are suitable for supplying power to welding operations carried out in an ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK (if applicable).

NOTE 2 In addition, this symbol, of a suitable size, can be displayed on the front of the WELDING POWER SOURCE.

Box 8 WELDING CURRENT symbol for example:



Direct current

Alternating current, and additionally the rated frequency in hertz for example: ~50 Hz

Direct and alternating current at the same output, and additionally the rated frequency in hertz

Box 9 $U_0 \dots V$ RATED NO-LOAD VOLTAGE (see 11.1)

- 1) peak value in case of direct current;
- 2) RMS value in case of alternating current.

NOTE 3 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.

If several NO-LOAD VOLTAGES are adjustable, their range shall be given by the rated minimum and maximum NO-LOAD VOLTAGE.

Additionally, the following shall be given.

- 3) $U_r \dots V$ reduced RATED NO-LOAD VOLTAGE in case of a voltage reducing device;
- 4) $U_s \dots V$ switched RATED NO-LOAD VOLTAGE in case of an AC to DC switching device.

Box 10 $\dots A / \dots V$ to $\dots A / \dots V$ Range of output, minimum WELDING CURRENT and its corresponding CONVENTIONAL LOAD VOLTAGE or less, maximum WELDING CURRENT and its corresponding CONVENTIONAL LOAD VOLTAGE or greater.

Box 11 X DUTY CYCLE symbol.

Box 12 I_2 Rated WELDING CURRENT symbol.

Box 13 U_2 CONVENTIONAL LOAD VOLTAGE symbol.

Boxes 11a, 11b, 11c $\dots \%$ Values of the DUTY CYCLE at an ambient temperature of 40 °C.

12a, 12b, 12c $\dots A$ Values of the rated WELDING CURRENT.

13a, 13b, 13c $\dots V$ Values of the CONVENTIONAL LOAD VOLTAGE.

These boxes form a table with corresponding values of the three settings:

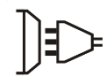
- 1) $\dots \%$ DUTY CYCLE at the RATED MAXIMUM WELDING CURRENT;
- 2) 60 % DUTY CYCLE;
- and
- 3) 100 % DUTY CYCLE as far as relevant.

Column a) ~~need~~ shall not be used if the DUTY CYCLE for the RATED MAXIMUM WELDING CURRENT is 60 % or 100 %.

Column b) ~~need~~ shall not be used if the DUTY CYCLE at the RATED MAXIMUM WELDING CURRENT is 100 %.

c) Energy supply

Box 14 Energy supply symbol, for example:



SUPPLY CIRCUIT, number of phases (for example 1 or 3), symbol for alternating current and the rated frequency (for example 50 Hz or 60 Hz)



Engine



Motor



Belt drive

Box	Electrically powered WELDING POWER SOURCES		Box	Mechanically powered WELDING POWER SOURCES	
15	$U_1 \dots V$	RATED SUPPLY VOLTAGE	18	$n \dots \text{min}^{-1}$	RATED LOAD SPEED
16	$I_{1\text{max}} \dots A$	RATED MAXIMUM SUPPLY CURRENT	19	$n_0 \dots \text{min}^{-1}$	RATED NO-LOAD SPEED
17	$I_{1\text{eff}} \dots A$	MAXIMUM EFFECTIVE SUPPLY CURRENT	20	$n_i \dots \text{min}^{-1}$	RATED IDLE SPEED, if applicable
Boxes 15 to 17 form a table with corresponding values.			21	$P_{1\text{max}} \dots \text{kW}$	Maximum power consumption, if applicable

Box 22 IP.. Degree of protection, for example IP21 or IP23.



Box 23 Symbol for CLASS II EQUIPMENT, if applicable.

Conformity shall be checked by VISUAL INSPECTION and by checking of complete data.

15.4 Tolerances

Manufacturers shall meet RATING PLATE values within the following tolerances by controlling component and manufacturing tolerances:

- U_0 RATED NO-LOAD VOLTAGE in V $\pm 5 \%$ measured in accordance with 11.1, but in no case shall the values summarized in Table 14 be exceeded;
- $I_{2\text{min}}$ RATED MINIMUM WELDING CURRENT in A;
 $U_{2\text{min}}$ minimum CONVENTIONAL LOAD VOLTAGE in V;
 The values of b) shall ~~not~~ be no greater than 102 % of those stated on the RATING PLATE.
- $I_{2\text{max}}$ RATED MAXIMUM WELDING CURRENT in A;
 $U_{2\text{max}}$ maximum CONVENTIONAL LOAD VOLTAGE in V;
 The values of c) shall ~~not~~ be no less than 98 % of those stated on the RATING PLATE.
- n_0 RATED NO-LOAD SPEED of rotation in $\text{min}^{-1} \pm 5 \%$;
- $P_{1\text{max}}$ maximum power consumption in kW $^{+10}_0 \%$;
- $I_{1\text{max}}$ RATED MAXIMUM SUPPLY CURRENT in A $\pm 10 \%$.

- g) The efficiency measured on any equipment connected to the supply network shall not be less than the reported value. The IDLE STATE power consumption shall not be greater than the reported value.

Conformity shall be checked by measuring under CONVENTIONAL WELDING CONDITIONS (see 3.17).

15.5 Direction of rotation

If necessary, the direction of rotation shall be indicated on rotating WELDING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION.

16 Adjustment of the output

16.1 Type of adjustment

If the WELDING POWER SOURCE has a means to adjust the output current, output voltage or both, the adjustment ~~may~~ can be continuous, step-by-step, or both.

In the case of a continuous adjustment with several ranges, there shall be no gap between the ranges.

Conformity shall be checked by measuring.

16.2 Marking of the adjusting device

The output of the WELDING POWER SOURCE corresponding to different control settings shall be clearly and indelibly marked either on or by the controls, or displayed digitally.

With the exception of WELDING POWER SOURCES that are set or adjusted with or by means of a digital read-out, the following shall apply.

- a) The setting indications on the scales or control tables shall take into account the relationship between the CONVENTIONAL LOAD VOLTAGE and the CONVENTIONAL WELDING CURRENT.
- b) Each position in the case of a step-by-step adjustment or each major graduation in the case of a continuous adjustment shall be clearly marked with
 - 1) a numerical indication of the controllable parameters;
or, where this is not possible,
 - 2) an alphanumeric marking.In case 2), a table on the apparatus or in the instructions shall indicate, for each control position, the nominal value of the (control) parameter.
- c) In the case of multiple range adjustment, maximum and minimum values for each range shall be given.
- d) WELDING POWER SOURCES designed for use with more than one process, for which the CONVENTIONAL LOAD VOLTAGE differs, shall be marked with a separate control scale for each process. If this is not possible, alphanumeric marks as given in b) shall be used.
- e) Where the WELDING POWER SOURCE is designed so that it can be supplied at several RATED SUPPLY VOLTAGES and where, for the same control position, the numerical values of the welding parameters are not the same, separate scales or a separate series of alphanumeric markings shall be fitted.

Conformity shall be checked by VISUAL INSPECTION.

16.3 Indication of current or voltage control

16.3.1 General

Where there is a voltage or current control, the output setting shall be indicated in volts, amperes or an arbitrary reference scale.

16.3.2 Set value

The accuracy of voltage or current indication shall be

- a) between 100 % and 25 % of the maximum setting ± 10 % of the true value;
- b) below 25 % of the maximum setting $\pm 2,5$ % of the maximum setting.

Conformity shall be checked by measurement and VISUAL INSPECTION.

16.3.3 Displayed value

If the manufacturer provides an analog ammeter or voltmeter on the equipment, this shall be of class 2,5 and be properly damped.

The accuracy of provided digital ammeters shall be equal or better than $\pm 2,5$ % of highest RATED VALUE for WELDING CURRENT according to RATING PLATE.

The accuracy of provided digital voltmeters shall be equal or better than $\pm 1,5$ V.

Conformity shall be checked by measurement and VISUAL INSPECTION.

NOTE Where a display is provided, Commission Regulation (EU) 2019/1784 requires to provide indication of the use of welding wire or filler material in g/min or equivalent standardised units of measurement, Providing the wire-feed speed in m/min, or optionally in inch/min, is considered to fulfil the requirement.

17 Instructions and markings

17.1 Instructions

Each WELDING POWER SOURCE shall be delivered with instructions which shall include the following (as applicable):

- a) general description;
- b) mass of the WELDING POWER SOURCE and its various parts and correct methods of handling them, for example by fork-lift or crane, and precautions to be taken with gas cylinders, wire feeders, etc.;
- c) the meaning of indications, markings and graphical symbols;
- d) information for selection and connection to the supply network (for example suitable supply cables, connection devices or attachment plugs, including the type and RATED VALUES for RCD, fuse or circuit-breaker, see also caution of 6.1.1) by qualified personnel in accordance with relevant national and local regulations;

NOTE Some national and local regulations require use of RCDs. Types of RCDs and their use are given in Annex B of IEC TR 60755:2008/2017. Only Type B" RCDs provide protection where SUPPLY CIRCUIT DC fault currents are likely to occur.

- e) correct operational use relating to the WELDING POWER SOURCES (for example cooling requirements, location, control device, indicators, fuel type);
- f) welding capability, STATIC CHARACTERISTIC (drooping and/or flat), DUTY CYCLE (DUTY FACTOR) limitations and explanation of THERMAL PROTECTION if relevant;
- g) limitations of use relating to the degree of protection provided, for example WELDING POWER SOURCES are not suitable for use in rain or snow;

- h) basic guidelines regarding protection against personal hazards for operators and persons in the work area (for example electric shock, fumes, gases, arc rays, hot metal, sparks, noise, back injury during manual handling);
- i) conditions under which extra precautions are to be observed when welding or cutting (for example ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK, flammable surroundings, flammable products, closed containers, elevated working positions, etc.);
- j) how to maintain the WELDING POWER SOURCE, such as recommended cycles for partial and complete test and other operation (for example cleaning);
- k) a list of parts typically replaced due to wear;
- l) information on supply of electrical power to external devices, for example for lighting or electric tools;
- m) precautions against toppling over, if the WELDING POWER SOURCE shall be placed on tilted plane;
- n) warning against the use of a WELDING POWER SOURCE for pipe thawing;
- o) type (identification) of plasma cutting torches that are specified for use with the PLASMA CUTTING POWER SOURCE;
- p) pressure, flow rate and type of plasma gas and if relevant, of cooling gas or cooling liquid;
- q) steps or range of the output current and the corresponding plasma gas as a set of values;
- r) EMC classification in accordance with IEC 60974-10;
- s) for an engine-driven WELDING POWER SOURCE, warning against the carbon monoxide component of engine exhaust (example of National Labelling Regulation is given in *US Code of Federal Regulations, Title 16, Parts 1407*).

Other useful information ~~may~~ can also be given, for example CLASS OF INSULATION, POLLUTION DEGREE, efficiency (see Annex M), etc.

Conformity shall be checked by reading the instructions.

17.2 Markings

Each WELDING POWER SOURCE shall be clearly and indelibly marked on or near the front panel or near the ON/OFF switching device with the following combination of symbols to signify "Caution! Read instruction manual":



This marking shall also be used near the torch connector of PLASMA CUTTING POWER SOURCES indicating that the operator should read the instruction manual before selecting and connecting a torch. A single marking readily visible within operator line of sight to the front panel, ON/OFF switching device and torch connector is permitted.

The following equivalent wording ~~may~~ can be used:

Warning: Read instruction manuals before operating and servicing this equipment.

For other additional markings, see Annex L.

NOTE Precautionary labels appearing on power sources can consist of text only, text and symbols, or symbols only. Symbols-only precautionary labels are specified in ISO 17846.

Conformity shall be checked by VISUAL INSPECTION and by testing in accordance with the durability test in 15.1.

Annex A

(informative normative)

Nominal voltages of supply networks

Table A.1 – Nominal voltages for supply networks with protective overvoltage control

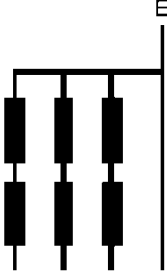
Voltage line-to-neutral derived from nominal voltages AC or DC up to and including ^c	Nominal voltages presently used in the world			
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems earthed or unearthed (E)	Single-phase two-wire systems AC or DC	Single-phase three-wire systems AC or DC
V				
50			12,5 24 25 30 42 48	30 to 60
100	66/115	66	60	
150	120/208 ^a , 127/220	115, 120, 127	100 ^b 110, 120	100 to 200 ^b , 110 to 220, 120 to 240
300	220/380, 230/400, 240/415, 260/440, 277/480	200 ^b , 220, 230, 240, 260, 277	220	220 to 440
600	347/600, 380/660, 400/690, 417/720, 480/830	347, 380, 400, 415, 440, 480 500, 577, 600	480	480 to 960
1 000		660, 690, 720, 830, 1 000	1 000	
NOTE 1 Values taken from Table B.2 of IEC 60664-1:2007/2020.				
NOTE 2 “E” means “earthed”.				
^a Common Practice in the United States of America and in Canada.				
^b Common Practice in Japan.				
^c Voltage line-to-neutral to be used in Table 2.				

Table A.2 – Single-phase three-wire or two-wire AC or DC systems

Nominal voltage of the mains supply	Voltage rationalized for Table 3	
	For insulation line-to-line ^a	For insulation line-to-earth ^a
	All systems	Three-wire systems mid-point earthed
V	V	V
12,5	12,5	
24 25	25	
30	32	
42 48 50 ^b	50	
60	63	
30 to 60	63	32
100 ^b	100	
110 120	125	
150 ^b	160	
200	200	
100 to 200	200	100
220	250	
110 to 220 120 to 240	250	125
300 ^b	320	
220 to 440	500	250
600 ^b	630	
480 to 960	1 000	500
1 000 ^b	1 000	

NOTE Values taken from Table F.3 of IEC 60664-1:2020.

^a Line-to-earth insulation level for unearthed or impedance-earthed systems equals that for line-to-line because the operating voltage to earth of any line can, in practice, approach full line-to-line voltage. This is because the actual voltage to earth is determined by the insulation resistance and capacitive reactance of each line to earth; thus, low (but acceptable) insulation resistance of one line can in effect earth it and raise the other two to full line-to-line voltage to earth.

^b These values correspond to the values given in Table A.1.

Table A.3 – Three-phase four-wire or three-wire AC systems

Nominal voltage of the mains supply	Voltages rationalized for Table 3		
	For insulation line-to-line	For insulation line-to-earth	
	All systems	Three-phase four-wire systems neutral-earthed ^b	Three-phase three-wire systems unearthed ^a or corner-earthed
V	V	V	V
60	63	32	63
110 120 127	125	80	125
150 ^c	160	–	160
200	200		200
208	200	125	200
220 230 240	250	160	250
300 ^c	320	–	320
380 400 415	400	250	400
440	500	250	500
480 500	500	320	500
575	630	400	630
600 ^c	630	–	630
660 690	630	400	630
720 830	800	500	800
960	1 000	630	1 000
1 000 ^c	1 000	–	1 000

NOTE Values taken from Table F.4 of IEC 60664-1:2020.

^a Line-to-earth insulation level for unearthed or impedance-earthed systems equals that for line-to-line because the operating voltage to earth of any line can, in practice, approach full line-to-line voltage. This is because the actual voltage to earth is determined by the insulation resistance and capacitive reactance of each line to earth; thus, low (but acceptable) insulation resistance of one line can in effect earth it and raise the other two to full line-to-line voltage to earth.

^b For equipment for use on both three-phase four-wire and three-phase three-wire supplies, earthed and unearthed, use the values for three-wire systems only.

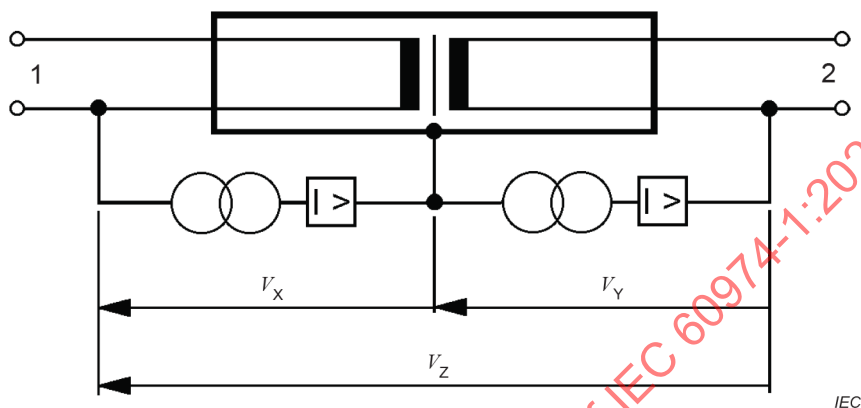
^c These values correspond to the values given in Table A.1.

Annex B (informative)

Example of a combined dielectric test

Two high voltage transformers may be connected in series, correctly phased.

The common connection is to exposed conductive parts (see Figure B.1).



Key



Current sensing tripping device

①

SUPPLY CIRCUIT

②

WELDING CIRCUIT

V_X SUPPLY CIRCUIT to exposed conductive parts

V_Y WELDING CIRCUIT to exposed conductive parts

V_Z SUPPLY CIRCUIT to WELDING CIRCUIT

Figure B.1 – Combined high-voltage transformers

Annex C (normative)

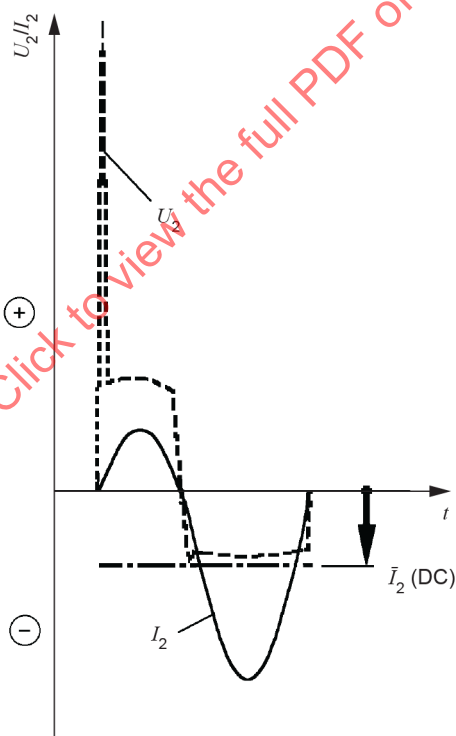
Unbalanced load in case of AC tungsten inert-gas WELDING POWER SOURCES

C.1 General

The difference in emissivity between the electrode and the workpiece in AC tungsten inert-gas welding causes an unbalanced welding voltage and a corresponding unbalance in the WELDING CURRENT.

This unbalance is called the DC component, and can cause saturation of the transformer of a transformer type WELDING POWER SOURCE. Such saturation will cause an abnormally high supply current that could cause severe over-heating.

Figure C.1 shows that the WELDING CURRENT has a DC component $\bar{I}_2$ that may overheat the winding of the WELDING POWER SOURCE.



IEC

Key

U_2 Welding voltage

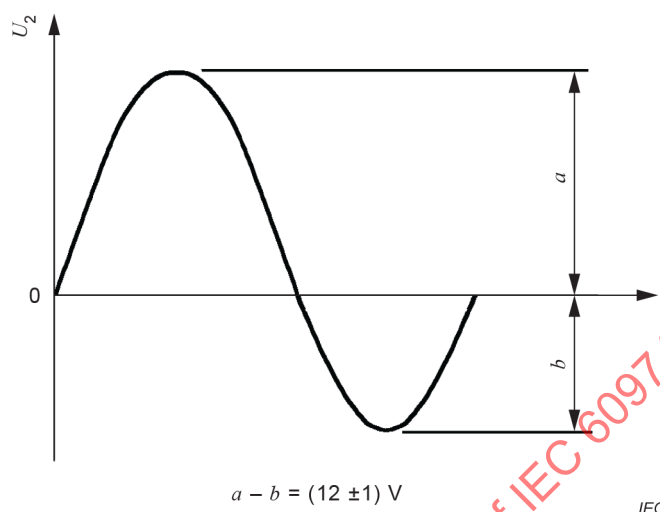
I_2 WELDING CURRENT

$\bar{I}_2$ Arithmetic mean value of the WELDING CURRENT

Figure C.1 – Voltage and current during AC tungsten inert-gas welding

C.2 Unbalanced load

To simulate the required WELDING CURRENTS for the heating test, a CONVENTIONAL LOAD shall be used with a partial rectifying characteristic, so that if the polarity of the electrode is negative, the half-cycle voltage shall be (12 ± 1) V less than the half-cycle voltage if the polarity of the electrode is positive (see Figure C.2).



Key

- a peak voltage value when the electrode is positive
- b peak voltage value when the electrode is negative

Figure C.2 – Unbalanced voltage during AC tungsten inert-gas welding

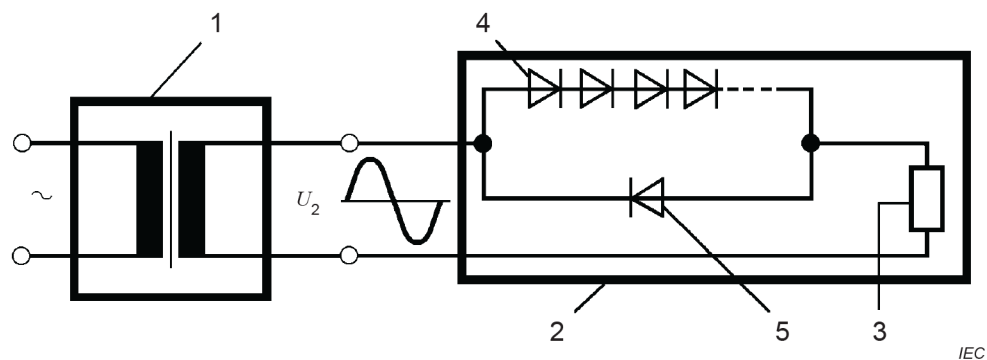
This difference of the half-cycle welding voltages is determined by passing a DC test current through the unbalanced load in both directions and measuring the DC LOAD VOLTAGE.

WELDING POWER SOURCES that incorporate a balance control are tested with a CONVENTIONAL LOAD, but with the balance control set to the condition producing the maximum unbalance, but not higher than 12 V.

C.3 Example for an unbalanced load

The rectifying characteristic of the load is achieved by a circuit of diodes in accordance with Figure C.3.

The required voltage difference between the half-cycle voltages is adjusted by the numbers of diodes in the string.



Key

- 1 Transformer
- 2 Unbalanced load

- 3 CONVENTIONAL LOAD
- 4 Series of diodes

- 5 Single diode

Figure C.3 – AC WELDING POWER SOURCE with unbalanced load

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Annex D

(informative)

Extrapolation of temperature to time of shutdown

When the temperature at the instant of shutdown cannot be recorded, it is necessary to use an extrapolation to obtain this temperature. The procedure for such extrapolation is as follows:

- a) the time is marked at the instant of shutdown;
- b) successive temperature readings are taken, and the elapsed time from shutdown noted for each;
- c) a minimum of four readings is taken for each temperature to be extrapolated;
- d) using logarithmic/linear graph paper, the readings are plotted so that the temperature is against the logarithmic scale, and the time from shutdown against the linear scale. A straight line extending back to $t = 0$ will give the extrapolated temperature at shutdown.

Alternative: A mathematical regression analysis can be used as an alternative to the graphical method. If a linear regression is chosen, then the logarithms of the temperatures are used with the linear values of the reading times from the instant of shutdown. The regression analysis is solved for the time $t = 0$ and the antilogarithm taken to find the true temperature.

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Annex E (normative)

Construction of SUPPLY CIRCUIT terminals

E.1 Size of terminals

The terminals shall be dimensioned in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT $I_{1\text{eff}}$ and it shall be possible to connect flexible conductors with cross-sectional areas as given in Table E.1. These values are based on wire rated at 60 °C.

**Table E.1 – Range of conductor dimensions to be accepted
by the SUPPLY CIRCUIT terminals**

MAXIMUM EFFECTIVE SUPPLY CURRENT A	Range of cross-sectional area of the conductor mm ²
10	1,5 to 2,5
16	1,5 to 4
25	2,5 to 6
35	4 to 10
50	6 to 16
63	10 to 25
80	16 to 35
100	25 to 50
125	35 to 70
160	50 to 95
200	70 to 120
250	95 to 150
315	120 to 240
400	150 to 300

Alternative cross-section ranges are permitted if the manufacturer indicates in the instructions the type and size of wire to be used.

Conformity shall be checked by calculation and measurement.

E.2 Connections at the terminals

Connections at the terminals shall be made by means of screws, nuts or other equivalent means and shall comply with the requirement given in 5.3.

NOTE Electrical quick-connect terminals are considered equivalent when fitted with two independent fixings, one clamping the insulation and the other clamping the conductor.

The terminal screws or nuts shall not be used to secure other parts or to connect other conductors.

Conformity shall be checked by VISUAL INSPECTION.

E.3 Construction of the terminals

Conductors or their lugs shall be clamped between metallic parts and shall not be able to escape when the clamping means are tightened.

Live parts that can turn and reduce the CLEARANCE shall not rely on friction between mounting surfaces to prevent turning. A suitable lock washer, properly applied, shall be acceptable. Leads or busbars that are secured by other means ~~need~~ shall not have a lock washer.

Iron or steel, plain or plated, shall not be used for current carrying parts.

Conformity shall be checked by VISUAL INSPECTION and by the temporary connection of conductors with the minimum and maximum cross-sectional area specified.

E.4 Fixing of the terminals

The terminals shall be securely fixed so that they cannot work loose when the clamping means are tightened or loosened. Furthermore, if friction alone is relied on to prevent turning or shifting of the terminals on the supporting surface, the CLEARANCES shall not be reduced below the values of Table 2 by shifting or turning. A pressure terminal connector ~~need~~ shall not be prevented from turning provided no CLEARANCES less than those required result when the terminals are turned 30° towards each other, or towards other uninsulated parts of opposite polarity, or towards grounded metal parts.

Conformity shall be checked by VISUAL INSPECTION and by tightening and loosening 10 times the clamping means holding a conductor of the maximum cross-sectional area specified.

The test shall be repeated using a conductor of the minimum cross-sectional area specified.

Annex F

(informative)

Cross-reference to non-SI units

Cross references to non-SI units for short-circuit test (see 9.3) are given in Table F.1.

Table F.1 – Cross-reference for mm² to American wire gauge (AWG)

mm ²	AWG
1,5	15
2,5	13
4	11
6	9
10	7
16	5
25	3
35	1
50	1/0
70	2/0
95	3/0
120	250 MCM
150	350 MCM
240	600 MCM
300	700 MCM

Annex G (informative)

Suitability of supply network for the measurement of the true RMS value of the supply current

The peak and RMS values of the supply current (I_1) can be substantially affected by the supply network impedance (R_s). To obtain valid measurements, the supply network impedance is 4 % or less than the input impedance of the WELDING POWER SOURCE:

$$R_s \leq 0,04 \frac{U_1}{I_1} (\Omega) \quad (G.1)$$

where

R_s is the impedance of the supply network in Ω ;

U_1 is the RATED SUPPLY VOLTAGE in V;

I_1 is the RATED SUPPLY CURRENT in A.

To determine the impedance of the supply network, it is loaded by a CONVENTIONAL LOAD that is able to reduce the supply voltage at least 1 % below the unloaded value.

NOTE 1 If the rated voltage of this CONVENTIONAL LOAD is lower than the supply voltage, a transformer can be used.

NOTE 2 Automatic supply network voltage regulators are turned off.

NOTE 3 If a transformer is used $I_{1 \text{ unloaded}}$ is the no-load current of that transformer, otherwise $I_{1 \text{ unloaded}} = 0 \text{ A}$.

The impedance of the supply network is calculated by the following formula:

$$R_s = \frac{U_{1 \text{ unloaded}} - U_{1 \text{ loaded}}}{I_{1 \text{ loaded}} - I_{1 \text{ unloaded}}} (\Omega) \quad (G.2)$$

where

R_s is the impedance of the supply network in Ω ;

$U_{1 \text{ loaded}}$ is the supply voltage in V when loaded by a CONVENTIONAL LOAD;

$U_{1 \text{ unloaded}}$ is the supply voltage in V when unloaded;

$I_{1 \text{ loaded}}$ is the supply current in A when loaded by a CONVENTIONAL LOAD;

$I_{1 \text{ unloaded}}$ is the supply current in A when unloaded.

Example:

Supply network:

$$U_{1 \text{ unloaded}} = 230 \text{ V}$$

$$I_{1 \text{ unloaded}} = 1 \text{ A}$$

$$U_{1 \text{ loaded}} = 227 \text{ V}$$

$$I_{1 \text{ loaded}} = 31 \text{ A}$$

$$R_s = \frac{230 - 227}{31 - 1} = 0,10 \Omega$$

WELDING POWER SOURCE: $U_1 = 230 \text{ V}$ $I_{1 \text{ max}} = 30 \text{ A}$

With these values, the condition in accordance with Formula (G.1) is fulfilled:

$$R_s = 0,10 \Omega \leq 0,04 \frac{230}{30} = 0,31 \Omega$$

Annex H (informative)

Plotting of STATIC CHARACTERISTICS

H.1 General

By varying the resistance of a CONVENTIONAL LOAD connected to the output terminals of the WELDING POWER SOURCE, a set of values of WELDING CURRENT (I_2) and corresponding LOAD VOLTAGE (U_2) ~~may~~ can be obtained for a given output setting of the WELDING POWER SOURCE. The STATIC CHARACTERISTIC is obtained by plotting these values on a graph with the WELDING CURRENT on the horizontal and the LOAD VOLTAGE on the vertical axis.

The slope of the STATIC CHARACTERISTIC is given by its tangent at the operating point.

H.2 Method

The number of values measured should be sufficient to enable a smooth curve to be plotted. In all cases, the NO-LOAD VOLTAGE and the RATED VALUES corresponding to each DUTY CYCLE (DUTY FACTOR) stated on the RATING PLATE should be recorded. For DROOPING CHARACTERISTIC WELDING POWER SOURCES, the short-circuit current should also be recorded.

If the WELDING POWER SOURCE has a step-by-step setting, values should be measured at each position of the control. If a WELDING POWER SOURCE is designed for several supply voltages, the measurement should be repeated at each supply voltage.

For each point, the following should also be recorded: supply voltage (U_1), supply current (I_1), power delivered to the WELDING POWER SOURCE (P_1).

For WELDING POWER SOURCES with no feedback circuitry (for example simple transformers), the values of U_2 and I_2 should be multiplied by a correction factor of (U_1/U_1') if the measured supply voltage (U_1') differs from the RATED SUPPLY VOLTAGE (U_1). The power (P_1) should be multiplied by (U_1/U_1')².

H.3 Analysis of the results

The series of curves obtained for the STATIC CHARACTERISTICS of a WELDING POWER SOURCE ~~may~~ can be used to confirm conformity to the relevant requirements of this document. If the negative slope at the operating point is greater than or equal to 7 V per 100 A, the STATIC CHARACTERISTIC is considered to be drooping.

Annex I
(normative)

Test methods for a 10 Nm impact

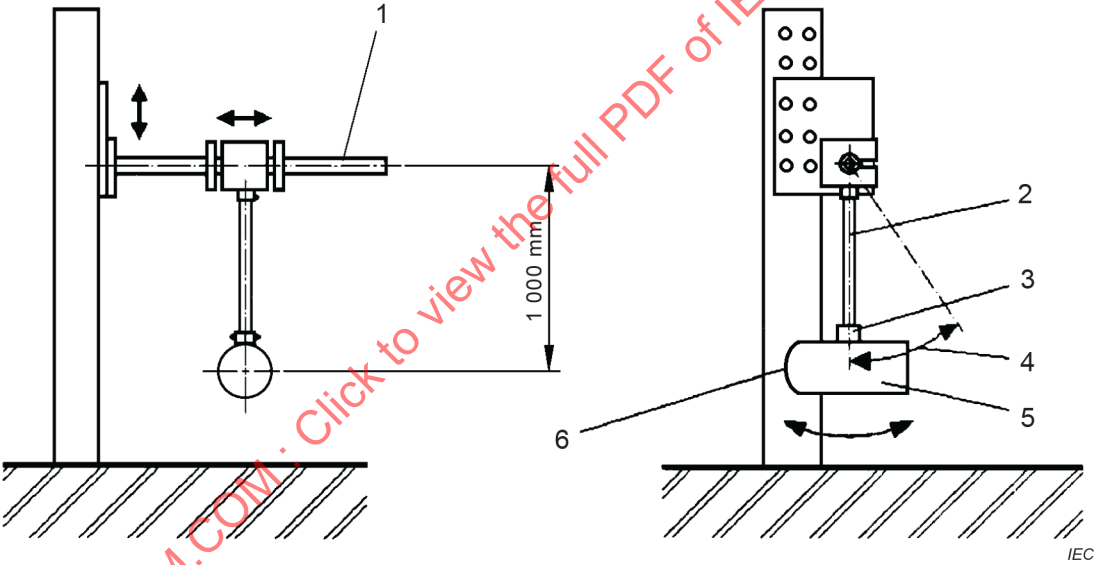
I.1 Pendulum impact hammer

The WELDING POWER SOURCE is placed against a rigid vertical surface and the impact is directed against the opposite side.

The angle of rotation θ (see Figure I.1) is adjusted (see Table I.1) to account for hammer and swing arm tolerances with the objective of delivering the required impact energy of 10 Nm.

Table I.1 – Angle of rotation θ to obtain 10 Nm impact

Hammer mass (kg)	1	1,5	2	2,5	3
Angle of rotation θ (°)	90	71	60	53	48



Key

- 1 Support shaft (should not deflect more than 1,5 mm)
- 2 Swing arm, steel tubing (its mass is negligible)
- 3 Hammer collar (mass up to 100 g)
- 4 Angle of rotation θ
- 5 Steel hammer
- 6 Radius (50 ± 2) mm

Figure I.1 – Test set-up

I.2 Free fall spherical steel weight

The WELDING POWER SOURCE is laid on a rigid horizontal surface. The mass of the free fall weight and the height of the free fall are given in Table I.2.

Table I.2 – Mass of the free fall weight and height of the free fall

Mass (kg)	0,50	0,75	1,00	1,25	1,50	1,75	2,00
Height (m)	2,04	1,36	1,02	0,82	0,68	0,58	0,51

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Annex J (normative)

Thickness of sheet metal for enclosures

The minimum thickness of sheet metal for enclosures shall be

- a) for steel, in accordance with Table J.1;
- b) for aluminium, brass or copper, in accordance with Table J.2.

The thickness values are based on a uniform deflection of the indicated sheet metal sizes, if loaded at the centre of their surface.

The thickness of an enclosure ~~may~~ can be less than that given in Table J.1 and Table J.2, if the enclosure shows the same deflection as an enclosure of the same size having the required thickness.

Table J.1 – Minimum thickness of sheet metal for steel enclosures

Minimum thickness of uncoated steel ^a	Without supporting frame ^b		With supporting frame ^c	
	Maximum width	Maximum length	Maximum width	Maximum length
mm	mm	mm	mm	mm
0,50	105 125	Not limited 150	160 175	Not limited 210
0,65	155 180	Not limited 225	245 255	Not limited 320
0,80	205 230	Not limited 300	305 330	Not limited 410
1,00	320 360	Not limited 460	500 535	Not limited 635
1,35	460 510	Not limited 635	690 740	Not limited 915
1,50	560 635	Not limited 790	840 890	Not limited 1 095
1,70	635 740	Not limited 915	995 1 045	Not limited 1 295
2,00	840 890	Not limited 1 200	1 295 1 375	Not limited 1 680
2,35	1 070 1 200	Not limited 1 500	1 630 1 730	Not limited 2 135
2,70	1 325 1 525	Not limited 1 880	2 035 2 135	Not limited 2 620
3,00	1 600 1 860	Not limited 2 290	2 470 2 620	Not limited 3 230

^a 1) For stainless steel, only 80 % of the given values are necessary.
2) For zinc-coated steel, the thickness shall be adjusted to take into account the coating thickness (usually 0,05 mm to 0,1 mm).

^b Constructions considered to be without a supporting frame are for example:
1) a single sheet with single formed flanges;
2) a single sheet that is corrugated or ribbed;
3) an enclosure surface loosely attached to a frame, for example with spring clips or latch;
4) an enclosure surface having an unsupported edge.

^c These two columns apply when the enclosure is strengthened by one of the following means:
1) a supporting frame that is a structural channel, angle, or folded rigid section that is at least equal to the metal thickness of the enclosure, and is rigidly attached to the enclosure;
2) a supporting frame other than metal that has an equivalent torsional rigidity to a sheet steel angle in accordance with 1) above, and is fire resistant;
3) all of the edges of the enclosure are turned through a 90° angle to produce a formed flange with a minimum width of 10 mm.

Table J.2 – Minimum thickness of sheet metal for enclosures of aluminium, brass or copper

Minimum thickness of metal mm	Without supporting frame ^a		With supporting frame ^b	
	Maximum width mm	Maximum length mm	Maximum width mm	Maximum length mm
0,55	80 90	Not limited 110	180 220	Not limited 245
0,70	105 130	Not limited 155	260 270	Not limited 345
0,90	155 165	Not limited 205	360 385	Not limited 460
1,10	205 245	Not limited 295	485 535	Not limited 640
1,45	305 360	Not limited 410	715 765	Not limited 940
1,90	460 510	Not limited 635	1 070 1 145	Not limited 1 400
2,40	635 740	Not limited 915	1 525 1 630	Not limited 1 985
3,10	940 1 070	Not limited 1 350	2 210 2 365	Not limited 2 900
3,85	1 325 1 525	Not limited 1 880	3 125 3 305	Not limited 4 065

^a Constructions considered to be without a supporting frame are for example:

- 1) a single sheet with single formed flanges;
- 2) a single sheet that is corrugated or ribbed;
- 3) an enclosure surface loosely attached to a frame, for example with spring clips or latch;
- 4) an enclosure surface having an unsupported edge.

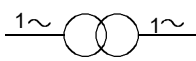
^b These two columns apply when the enclosure is strengthened by one of the following means:

- 1) a supporting frame that is a structural channel, angle, or folded rigid section that is at least equal to the metal thickness of the enclosure, and is rigidly attached to the enclosure;
- 2) a supporting frame other than metal that has an equivalent torsional rigidity to a sheet steel angle in accordance with a) above, and is fire resistant;
- 3) all of the edges of the enclosure are turned through a 90° angle to produce a formed flange with a minimum width of 10 mm.

Annex K (informative)

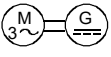
Examples of RATING PLATES

Examples of RATING PLATES are given in Figure K.1 to Figure K.7.

a) Identification					
1) Manufacturer		Trademark			
Address					
2) Type		3) Serial number			
4) 		5) IEC 60974-1 IEC 60974-10 Class A			
b) Welding output					
6) 	8) ~50 Hz	10) 15 A / 20,6 V to 160 A / 27 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7) 	9) $U_0 = 48 \text{ V}$	12) I_2	12a) 160 A	12b) 130 A	12c) 100 A
		13) U_2	13a) 26 V	13b) 25 V	13c) 24 V
c) Energy supply					
14)  1 ~ 50 Hz	15) $U_1 = 230 \text{ V}$		16) $I_{1\text{max}} = 37 \text{ A}$		17) $I_{1\text{eff}} = 22 \text{ A}$
	22) IP23		23) 		

IEC

Figure K.1 – Single-phase transformer

a) Identification					
1) Manufacturer Address		Trademark			
2) Type		3) Serial number			
4) 		5) IEC 60974-1 IEC 60974-10 Class A			
b) Welding output					
6) 	8) ~450 Hz	10) 60 A / 22,4 V to 500 A / 40 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7)	9) $U_0 = 78 \text{ V}$	12) I_2	12a) 500 A	12b) 400 A	12c) 320 A
		13) U_2	13a) 40 V	13b) 36 V	13c) 33 V
c) Energy supply					
14) 	18) $n = 2\,800 \text{ min}^{-1}$				
	3 ~ 50 Hz	15) $U_1 = 400 \text{ V}$	16) $I_{1\text{max}} = 68 \text{ A}$	17) $I_{1\text{eff}} = 40 \text{ A}$	
22) IP23		23)			

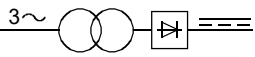
IEC

Figure K.2 – Three-phase rotating frequency converter

Distributor-related plate

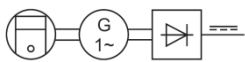
a) Identification	
1) Manufacturer Address	Trademark
2) Type	3) Serial number

Manufacturer-related plate

a) Identification	
4) 	5) IEC 60974-1 IEC 60974-10 Class A
b) Welding output	
6) 	8) 
10) 20 A / 20,8 V to 250 A / 30 V	
11) X	11a) 35 %
11b) 60 %	11c) 100 %
7) 	9) $U_0 = 105 \text{ V}$
12) I_2	12a) 250 A
12b) 200 A	12c) 160 A
13) U_2	13a) 30 V
13b) 28 V	13c) 27 V
c) Energy supply	
14)  1(3) ~ 50 Hz	15) $U_1 = 230 \text{ V}$ $U_1 = 400 \text{ V}$
16) $I_{1\max} = 57 \text{ A}$ $I_{1\max} = 34 \text{ A}$	17) $I_{1\text{eff}} = 34 \text{ A}$ $I_{1\text{eff}} = 20 \text{ A}$
22) IP23	23) 

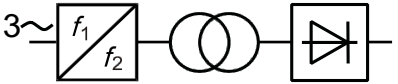
IEC

Figure K.3 – Subdivided RATING PLATE: single-/three-phase transformer rectifier

a) Identification					
1) Manufacturer Address		Trademark			
2) Type		3) Serial number			
4) 		5) IEC 60974-1			
b) Welding output					
6) 	8) 	10) 40 A / 21,6 V to 400 A / 36 V			
7) 	9) $U_0 = 110 \text{ V}$	11) X	11a) 35 %	11b) 60 %	11c) 100 %
		12) I_2	12a) 400 A	12b) 320 A	12c) 255 A
		13) U_2	13a) 36 V	13b) 33 V	13c) 30 V
c) Energy supply					
14) 	18) $n = 3\,150 \text{ min}^{-1}$				
	19) $n_0 = 3\,300 \text{ min}^{-1}$	20) $n_i = 980 \text{ min}^{-1}$	21) $P_{1\text{max}} = 34 \text{ kW}$		
22) IP23	23)				

IEC

Figure K.4 – Engine-generator-rectifier

a) Identification					
1) Manufacturer Address		Trademark			
2) Type		3) Serial number			
4) 		5) IEC 60974-1 IEC 60974-10 Class A			
b) Welding output					
6) 	8) 	10) 20 A / 20,8 V to 250 A / 32 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7) 	9) $U_0 = 105 \text{ V}$	12) I_2	12a) 250 A	12b) 200 A	12c) 160 A
		13) U_2	13a) 30 V	13b) 28 V	13c) 27 V
c) Energy supply					
14)  1(3) ~ 50 Hz	15) U_1 230 V 400 V		16) $I_{1\max}$ 57 A 34 A		17) $I_{1\text{eff}}$ 34 A 20 A
	22) IP23S		23) 		

IEC

Figure K.5 – Single-/three-phase inverter type

a) Identification			
1) Manufacturer Address		Trademark	
2) Type		3) Serial number	
4) Li-ion		5) IEC 60974-1 IEC 60974-10 Class A	
b) Welding output			
6) 	8) 	10) 10 A / 20,4 V to 120 A / 24,8 V	
7) 	9) $U_0 = 58 \text{ V}$	12) $I_{2\text{max}} = 120 \text{ A}$	
		13) $U_2 = 24,8 \text{ V}$	
c) Energy supply			
14) 	15) $U_b = 57,6 \text{ V}$	16) $E = 5 \text{ Ah}$	17) $I_b = 10 \text{ A}$
19) For use only with _____ charger			
22) IP23			

IEC

Figure K.6 – Battery-powered WELDING POWER SOURCE with INTEGRAL BATTERY

WELDING POWER SOURCE related plate

a) Identification			
1) Manufacturer Address		Trademark	
2) Type		3) Serial number	
4)		5) IEC 60974-1 IEC 60974-10 Class A	
b) Welding output			
6) 	8) 	10) 10 A / 20,4 V to 120 A / 24,8 V	
7) 	9) $U_0 = 58 \text{ V}$	12) $I_{2\max} = 120 \text{ A}$	
		13) $U_2 = 24,8 \text{ V}$	
c) Energy supply			
14) 	15) $U_b = 57,6 \text{ V}$		
	19) For use only with ____ battery		
22) IP23			

BATTERY related plate

d) Separable and detachable battery packs	
1) type (identification) as given by the manufacturer	
Li-ion	year and date code
$U_b = 57,6 \text{ V}$	$E = 5 \text{ Ah}$

IEC

**Figure K.7 – Battery-powered WELDING POWER SOURCE
with detachable / separable BATTERY**

Annex L (informative)

Graphical symbols for arc welding equipment

L.1 General

Annex L describes symbols, which are not all internationally standardized, but of practical use in welding applications. IEC technical committee 26 and subcommittee 3C have decided to consider those symbols for a future possible inclusion in IEC 60417. When this process will be terminated, Annex L will be modified accordingly.

Annex L contains graphic symbols for arc welding and allied processes equipment to identify controls, indicators, connection points, functions, and to select processes.

The symbols are for use on the panel, the RATING PLATE and any documentation for arc welding and allied processes equipment.

Annex L does not cover graphic symbols used to alert personnel of immediate or potential personal hazards in the use of the equipment.

NOTE 1 For safety symbols, see ISO 3864-1.

NOTE 2 For installation instructions, see IEC 60974-9.

L.2 Use of symbols

L.2.1 General

Symbols should be placed on equipment to instruct on use and operation. Examples of control panel are given in L.5.

L.2.2 Selection of symbols

Symbols specified in Clause L.3 can be used either as a single item or in combination to fit the intended application. Examples of combinations are given in L.4.

L.2.3 Size of symbols

For the application of these symbols, it ~~may~~ can be necessary either to reduce or to enlarge the original to a suitable size. In the case of symbols composed of several graphic elements, or when reducing to minimum height, check that clear identification is still possible and legibility is adequate. Available light, user distance, and possible operating conditions as factors during size selection should also be considered.

The recommended minimum symbol size is 6 mm.

L.2.4 Use of colour

In general, the graphic form of a symbol reproduced in black on white or white on black should be sufficient for its identification.

For the purposes of these symbols, adequate contrast between symbol and background is most important. As long as the symbol is clearly delineated and fully legible, actual colour selection is not mandatory. Be aware that certain colours, such as red, orange, and yellow are designated as safety-alerting colours.

L.3 Symbols

L.3.1 General

Clause L.3 presents the symbols along with their reference number, function keyword or phrase, application and source.

L.3.2 Letter symbols

Table L.1 gives a list of letters, which may be used in a symbol.

Table L.1 – Letters used as symbols

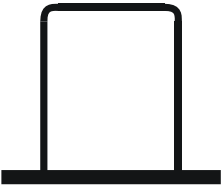
Function, keyword or phrase	Letter	Unit
Amperage	I	A
CONVENTIONAL WELDING CURRENT	I_2	A
Conventional welding voltage	U_2	V
Diameter	$\varnothing$	mm
DUTY CYCLE; DUTY FACTOR	X	%
Efficiency	η	%
Frequency	F	Hz
Idle state power (idle state energy consumption rate)	P_i	W (W-h/h)
Power	P	W
Rated no-load current	I_0	A
Rated BATTERY capacity	Q	Ah
Rated no-LOAD VOLTAGE	U_0	V
Rated peak voltage	U_p	V
RATED SUPPLY CURRENT	I_1	A
RATED SUPPLY VOLTAGE	U_1	V
RATED REDUCED NO-LOAD VOLTAGE	U_r	V
Speed of rotation	n	min ⁻¹
Supply ACTIVE POWER (supply energy consumption rate)	P_1	W (W-h/h)
RATED SWITCHED NO-LOAD VOLTAGE	U_s	V
Temperature (change)	T	°C (K)
Time	t	s, min, h
Voltage	U	V
Welding output ACTIVE POWER (welding output energy rate)	P_2	W (W-h/h)

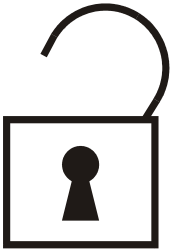
L.3.3 Graphical symbols

L.3.3.1 Symbols to describe the switch or control

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
1.	IEC 60417-5004:2002-10		Variability	To identify an increase/decrease of a quantity continuously. NOTE Symbol can be curved.

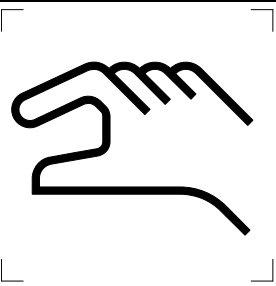
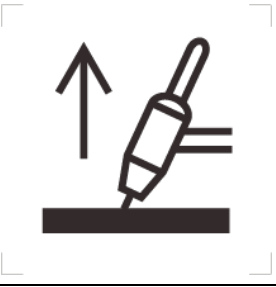
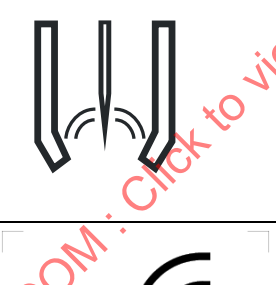
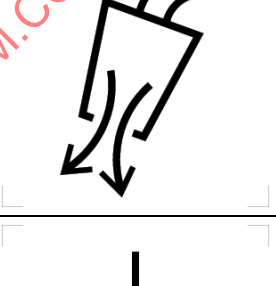
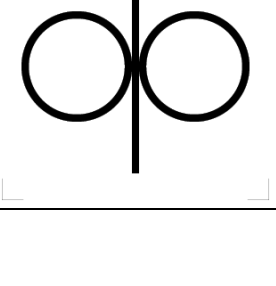
L.3.3.2 Symbols to indicate switch or control position

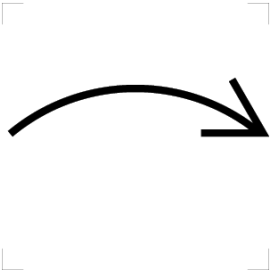
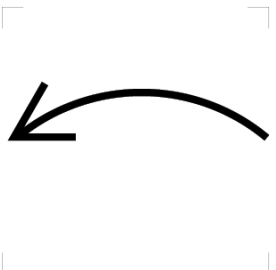
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
2.	IEC 60417-5007:2002-10		ON (power)	To indicate connection to the mains, at least for mains switches or their positions, and all those cases where safety is involved.
3.	IEC 60417-5008:2002-10		OFF (power)	To indicate disconnection from the mains, at least for mains switches or their positions, and all those cases where safety is involved.
4.	IEC 60417-5268:2002-10		"IN" position of a bi-stable push control	To ~~identify~~ associate the "IN" position of a ~~bi-stable~~ push control ~~where the push control is used to energize or deenergize a function~~ with the corresponding function. NOTE 1 This symbol is used together with a function symbol.
5.	IEC 60417-5269:2002-10		"OUT" position of a bi-stable push control	To ~~identify~~ associate the "OUT" position of a ~~bi-stable~~ push control ~~where the push control is used to energize or de-energize a function~~ with the corresponding function. NOTE 2 This symbol is used together with a function symbol.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
6.	IEC 60417-5569:2005-08		~~Locked~~ Locking, general	To identify ~~a locked function or control~~ on a control that a function is locked or to show the locked status. NOTE 3 This symbol is used together with a function symbol.
7.	IEC 60417-5570:2002-10		~~Unlocked~~ Unlocking	To identify ~~an unlocked function or control~~ on a control that a function is not locked or to show the unlocked status. NOTE 4 This symbol is used together with a function symbol.

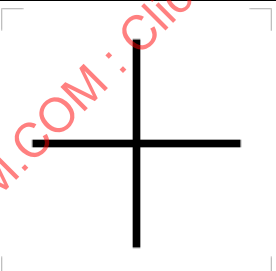
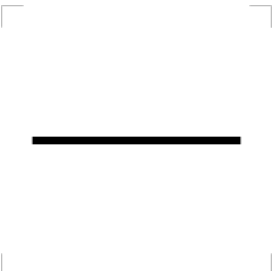
L.3.3.3 Symbols to indicate switch or control function

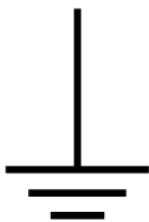
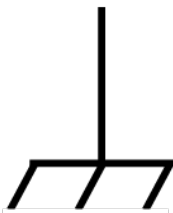
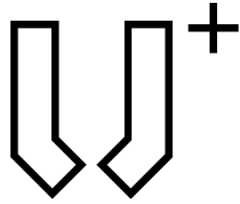
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
8.	IEC 60417-6302:2015-01		~~Continuous welding~~ Welding time, continuous mode	To identify a continuous welding.
9.	IEC 60417-6303:2015-01		~~Intermittent (stitch) welding~~ Welding time, intermittent mode (stitch)	To identify an intermittent (stitch) welding.
10.	ISO 7000-0468:2004-01		Arc spot welding	To identify arc spot welding.

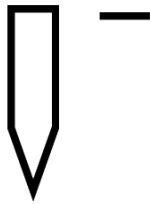
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
11.	ISO 7000-0096:2004-01		Manual control	To identify a manually operated control. To identify the switch position ~~for manual control~~ that places the equipment under manual (as opposed to automatic) control. To identify the control that activates manual control. To indicate that the equipment is in manual control mode.
12.	IEC 60417-6318:2015-03		Arc striking, without contact	To identify the control for a tungsten inert gas (TIG) arc striking function which initiates an arc without contact.
13.	IEC 60417-6319:2015-03		Arc striking, with contact	To identify the control for a tungsten inert gas (TIG) arc striking function which initiates an arc with contact.
14.			Pilot arc starting	To identify pilot arc starting of a plasma torch.
15.	ISO 7000-0474:2004-01		Purging of air (by gas)	To identify purging of air (by gas).
16.	ISO 7000-0823:2004-01		Wire feed drive	To identify a wire feeder or wire feed control.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
17.	IEC 60417-6377:2017-10		Wire burnback control	To identify the control for burnback at the end of the weld.
18.	ISO 7000-0004:2004-01		Direction of continuous rotation (clockwise)	To identify ~~a direction of continuous rotation~~ that a control, or an object by means of a control, can be moved in a clockwise rotary motion.
19.	ISO 7000-0004:2004-01		Direction of continuous rotation (anticlockwise)	To identify ~~a direction of continuous rotation~~ that a control, or an object by means of a control, can be moved in an anticlockwise rotary motion.

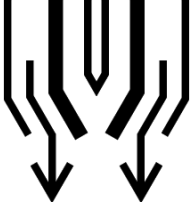
L.3.3.4 Symbols to indicate electrical connection

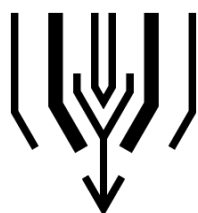
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
20.	IEC 60417-5005:2002-10		Plus; ~~plus pole~~ positive polarity	To identify the positive ~~polarity~~ terminal(s) of equipment which is used with, or generates direct current.
21.	IEC 60417-5006:2002-10		Minus; ~~minus pole~~ negative polarity	To identify the negative ~~polarity~~ terminal(s) of equipment which is used with, or generates direct current.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
22.	IEC 60417-5017:2006-08		Earth; ground	To identify the earth (ground) ~~connection~~ terminal in cases where neither the symbol 5018 nor 5019 is explicitly required. NOTE 1 Not for a protective earth connection.
23.	IEC 60417-5019:2006-08		Protective earth; ~~protective~~ ground	To identify ~~the equipment connection point for the protective earth (ground)~~ any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth (ground) electrode.
24.	IEC 60417-5020:2002-10		Frame or chassis	To identify the frame or chassis ~~connection~~ terminal. NOTE 2 Not for a protective earth connection.
25.	IEC 60417-5939:2002-10		Power supply type of electric device	On device or equipment for example on arc welding equipment. To identify the type of power supply, socket-outlet with 3-poles.
26.	ISO 7000-0453:2004-01		Workpiece connection	To identify a workpiece connection.
27.	ISO 7000-0483:2004-01		~~Connection to the nozzle of a plasma torch (positive terminal)~~ Plasma torch connection to nozzle, positive supply	To identify a plasma torch connection – nozzle connection to positive ~~terminal~~ supply.

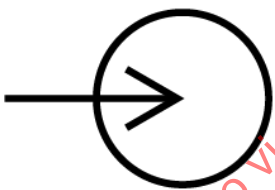
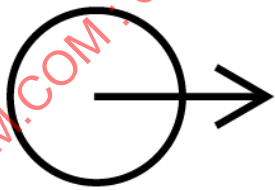
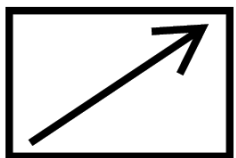
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
28.	ISO 7000-0482:2004-01		Connection to the electrode of a plasma torch (negative terminal) Plasma torch connection to the electrode, negative supply	To identify a plasma torch connection – electrode connection to negative terminal supply.

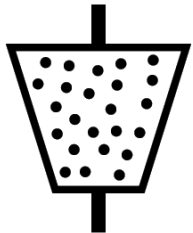
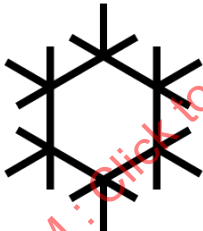
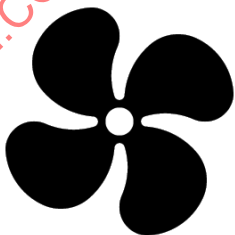
L.3.3.5 Symbols to indicate fluid connection or control

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
29.	IEC 60417-6315:2015-02		Air flow, general	To indicate the function of air flow.
30.	ISO 7000-0536:2004-01		Liquid Water, fluid	To indicate liquid water or water-base fluid, e.g coolant.
31.			Gas supply	To identify a gas supply connection or control.
32.	ISO 7000-0481:2004-01		Plasma shielding gas	To identify plasma shielding gas connection or control.

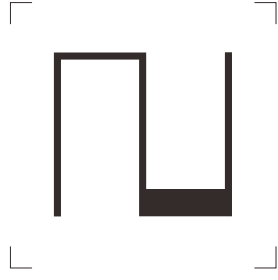
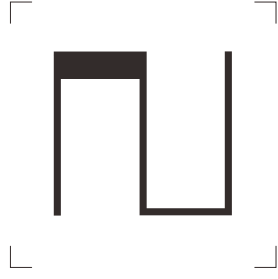
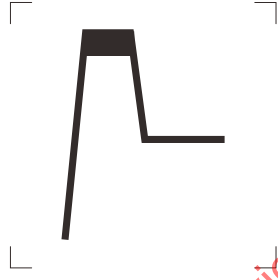
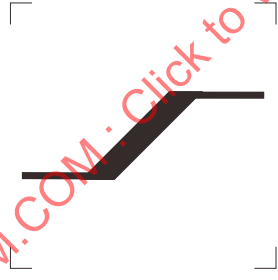
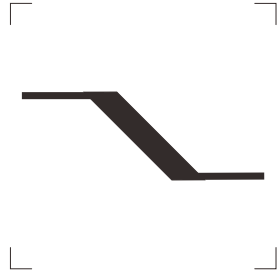
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
33.	ISO 7000-0480:2004-01		Plasma gas	To identify plasma gas connection or control.
34.	IEC 60417-6316:2015-02		Air pressure	To identify air pressure function or control.

L.3.3.6 Symbols to indicate auxiliary device, connection or function

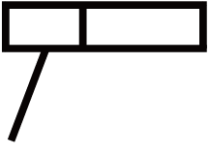
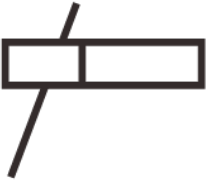
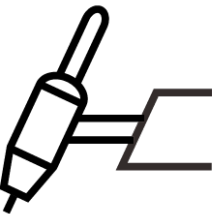
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
35.	IEC 60417-5034:2014-06		Input	To identify input connection or control.
36.	IEC 60417-5035:2014-06		Output	To identify output connection or control.
37.	ISO 7000-0093:2004-01		REMOTE CONTROL	To identify ~~a REMOTE CONTROL, connection or function~~ the REMOTE CONTROL function, for example the connection point for a REMOTE CONTROL lead.

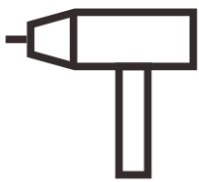
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
38.	IEC 60417-6378:2017-10		Foot control	To identify a foot control device, connection or function.
39.	IEC 60417-6379:2017-10		Panel; local	To identify a panel or local function or control.
40.	ISO 7000-0466:2004-01		Hopper (powder, flux)	To identify ~~a flux (powder)~~ hopper a hopper (powder, flux).
41.	ISO 7000-0027:2004-01		Cooling	To identify a cooling device, connection or control.
42.	ISO 7000-0089:2004-01, modified		Ventilating fan ~~or~~ , air circulating fan	~~To identify a ventilating or air circulating fan~~ To identify the control which activates the fan and circulates air. To indicate the operational status of the fan function.
43.	IEC 60417-6317:2015-02		Air filter	To identify the air flow filter.

L.3.3.7 Symbols to indicate control of the welding amperage/voltage

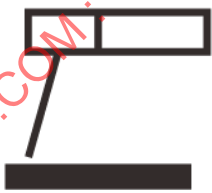
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
44.	IEC 60417-6005:2006-12		Pulse background	To ~~indicate~~ identify the control of pulse background. NOTE 1 Control is identified by one letter chosen in Table L.1.
45.	IEC 60417-6006:2006-12		Pulse peak	To ~~indicate~~ identify the control of pulse peak. NOTE 2 Control is identified by one letter chosen in Table L.1.
46.	IEC 60417-6007:2006-12		Hot start	To ~~indicate~~ identify the control or function increasing the energy at the beginning of the weld. NOTE 3 Control is identified by one letter chosen in Table L.1.
47.	IEC 60417-6008:2006-12		Slope, increasing	To ~~indicate~~ identify the control or function regulating the increase of a value. NOTE 4 Control is identified by one letter chosen in Table L.1.
48.	IEC 60417-6009:2006-12		Slope, decreasing	To ~~indicate~~ identify the control or function regulating the decrease of a value. NOTE 5 Control is identified by one letter chosen in Table L.1.

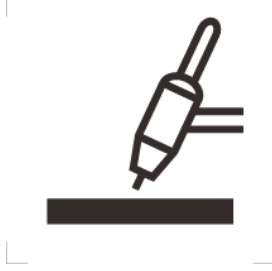
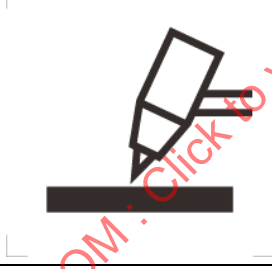
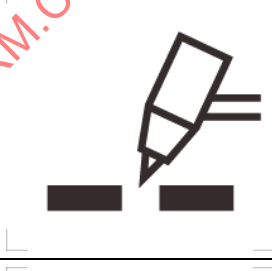
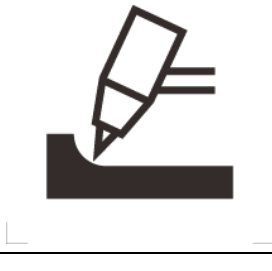
L.3.3.8 Symbols to indicate type of torch

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
49.	IEC 60417-6380:2017-07		~~Manual metal arc welding~~ Electrode holder, manual	To identify the electrode holder for a manual metal arc welding.
50.	IEC 60417-6313:2015-01		Electrode holder, air carbon arc gouging ~~electrode holder~~	To identify ~~an~~ the holder for air carbon arc gouging electrode ~~holder~~ .
51.	IEC 60417-6381:2017-07		Arc welding torch, MIG/MAG ~~Torch~~	To identify ~~a MIG/MAG~~ the torch for metal inert gas (MIG) and metal active gas (MAG) welding.
52.	IEC 60417-6382:2017-07		~~Self shielded flux cored arc welding torch~~ Arc welding torch, self-shielded flux cored	To identify the torch for self-shielded flux cored arc welding ~~torch~~ without gas shielding.
53.	IEC 60417-6383:2017-07		Arc welding torch, TIG ~~Torch~~	To identify the torch for tungsten inert gas (TIG) welding.
54.	IEC 60417-6384:2017-07		Arc welding torch, plasma	To identify the plasma torch for welding, cutting and/or gouging.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
55.	IEC 60417-6385:2017-07		Motorised gun	To identify the gun incorporating a wire drive system.
56.	IEC 60417-6386:2017-07		Motorised gun with filler wire supply	To identify the gun incorporating a wire drive system and including a filler wire supply.
57.	IEC 60417-6387:2017-07		Arc welding torch, submerged	To identify the torch for the submerged arc welding.

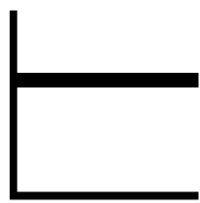
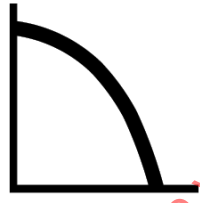
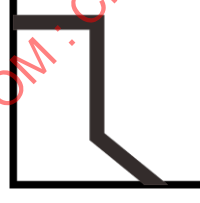
L.3.3.9 Symbols to indicate processes

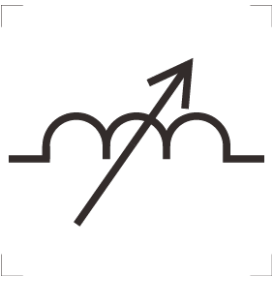
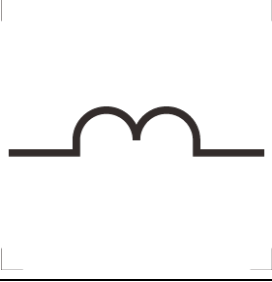
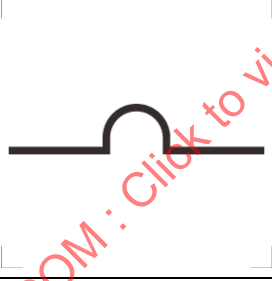
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
58.	IEC 60417-6306:2015-01		Welding power output, MMA	To identify on a RATING PLATE that the type of welding output is for a manual metal arc (MMA) welding process with covered electrodes.
59.	IEC 60417-6314:2015-01		Air carbon arc gouging	To identify the process for air carbon arc gouging.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
60.	IEC 60417-6308:2015-01		Welding power output, MIG/MAG-welding	To identify-MIG/MAG-welding on a RATING PLATE that the type of welding output is for metal inert gas (MIG) and metal active gas (MAG) welding process including the use of flux cored wire.
61.	IEC 60417-6309:2015-01		Flux-cored Welding power output, self-shielded flux cored arc welding	To identify-flux-cored on a RATING PLATE that the type of welding output is for self-shielded flux cored arc welding process (without gas shielding).
62.	IEC 60417-6307:2015-01		Welding power output, TIG welding	To identify on a RATING PLATE that the type of welding output is for tungsten inert-gas (TIG) welding process.
63.	IEC 60417-6312:2015-01		Welding power output, plasma welding	To identify on a RATING PLATE that the type of welding output is for plasma arc welding process.
64.	IEC 60417-6310:2015-01		Welding power output, plasma cutting	To identify on a RATING PLATE that the type of welding output is for plasma arc cutting process.
65.	IEC 60417-6311:2015-01		Welding power output, plasma gouging	To identify on a RATING PLATE that the type of welding output is for plasma gouging process.

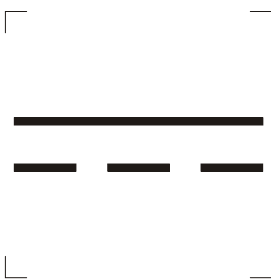
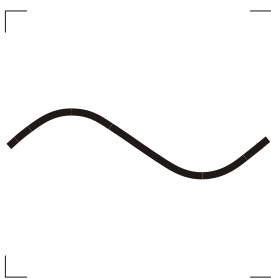
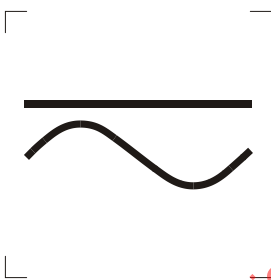
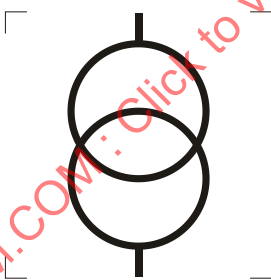
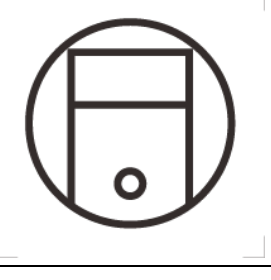
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
66.	IEC 60417-6305:2015-01		Welding power output, submerged arc welding	To identify on a RATING PLATE that the type of welding output is for submerged arc welding process.

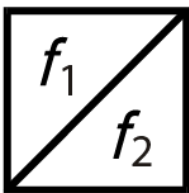
L.3.3.10 Symbols to indicate control of welding characteristics

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
67.	ISO 7000-0455:2004-01		FLAT CHARACTERISTIC	To identify a substantially ~~constant~~ level LOAD VOLTAGE characteristic.
68.	ISO 7000-0454:2004-01		DROOPING CHARACTERISTIC	To identify a substantially drooping ~~current~~ voltage characteristic
69.	IEC 60417-6388:2017-07		Arc force, increase	To indicate the control or function for increasing current when low arc voltage is detected.
70.	IEC 60417-6389:2017-07		Pulsed	To identify the reference to control welding characteristic by pulse value.

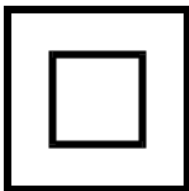
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
71.	IEC 60417-6390:2017-07		Inductance, variable	To identify a variable inductance function or control.
72.	IEC 60417-6391:2017-07		Inductance, high	To identify inductance or used with other inductance symbols, high inductance connection, function or control.
73.	IEC 60417-6392:2017-07		Inductance, medium	To identify medium inductance connection, function or control.
74.	IEC 60417-6393:2017-07		Inductance, low	To identify low inductance connection, function or control.

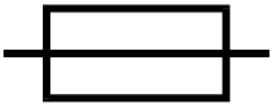
L.3.3.11 Symbols to describe the type of power source

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
75.	IEC 60417-5031:2002-10		Direct current (DC)	To identify that power source delivers direct current.
76.	IEC 60417-5032:2002-10		Alternating current (AC)	To identify that power source delivers alternating current. NOTE Symbol can be mixed with a number to indicate the number of phases.
77.	IEC 60417-5033:2002-10		Both direct and alternating current	To identify that the power source delivers both direct and alternating current.
78.	IEC 60417-5156:2003-08		Transformer	To identify a transformer.
79.	ISO 7000-1153:2004-01		Electric generator, rotating, general	To identify a generator.
80.	IEC 60417-6304:2015-01		WELDING POWER SOURCE, engine	To identify an engine driven WELDING POWER SOURCE.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
81.	ISO 7000-0147:2004-01		Electric motor	To identify an electric motor.
82.	IEC 60417-5970:2003-08		~~Inverter~~ Frequency converter	To identify a frequency ~~conversion stage function~~ converter.
83.	IEC 60417-5194:2002-10		DC/AC-converter	To identify a DC/AC-converter and its associated terminals and controls.

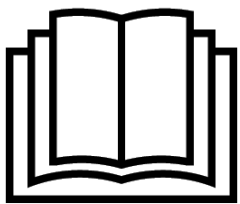
L.3.3.12 Symbols to indicate protective component and class of protection

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
84.	IEC 60417-6395:2017-12		~~Suitable for welding in an environment with increased risk of electric shock~~ WELDING POWER SOURCE, type S	To identify the WELDING POWER SOURCE equipment which is suitable for supplying power to welding operations carried out in an ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK.
85.	IEC 60417-5172:2003-02		CLASS II EQUIPMENT	To identify equipment meeting the safety requirements specified for CLASS II equipment according to IEC 61140.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
86.	IEC 60417-5016:2002-10		Fuse	To ~~indicate~~ identify fuse boxes or their location.

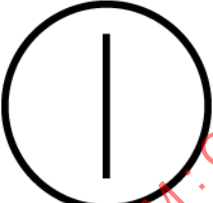
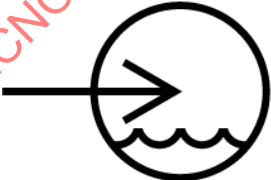
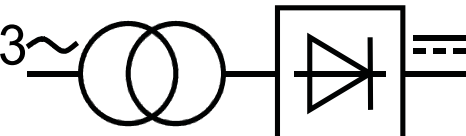
L.3.3.13 Symbols to inform users

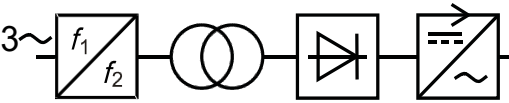
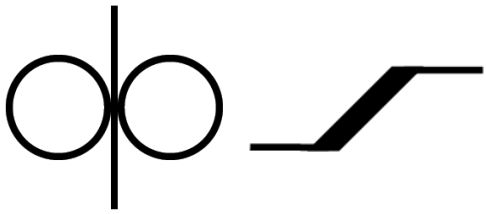
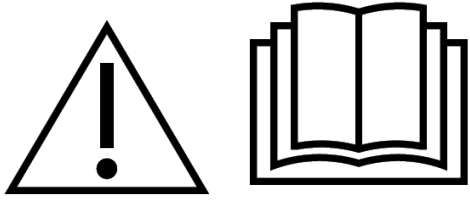
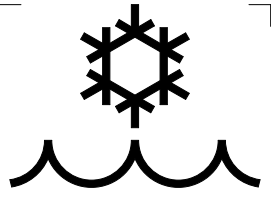
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
87.	IEC 60417-5036:2002-10		Dangerous voltage	To ~~identify~~ indicate hazards arising from dangerous voltages.
88.	ISO 7000-0228:2004-01		Disturbance	To ~~identify~~ indicate a disturbance of the correct operation.
89.	ISO 7000-0434A:2004-01		Caution	~~To make operator aware of general hazard.~~ To indicate that caution is necessary when operating the device or control close to where the symbol is placed, or to indicate that the current situation needs operator awareness or operator action in order to avoid undesirable consequences.
90.	IEC 60417-5041:2002-10		Caution, hot surface	To indicate that the marked item can be hot and should not be touched without taking care.

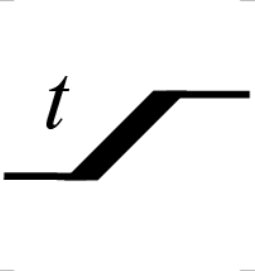
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
91.	ISO 7000-0790:2004-01		Read ~~instruction~~ operator's manual	To ~~identify~~ indicate that the ~~instruction~~ operator's manual or card should be read before continuing the operation.
92.	ISO 7000-0034:2004-01		Temperature indication	To ~~identify~~ indicate temperature ~~indication~~ or function associated with temperature (for example excess temperature warning light).

L.4 Examples of combinations of symbols

This clause gives examples of combination of symbols which can be used on arc welding and allied processes equipment.

SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
 IEC 60417-5010:2002-10	"ON"/"OFF" (push-push)	To indicate connection to or disconnection from the mains, at least for mains switches or their position, and all those cases where safety is involved. Each position, "ON" or "OFF", is a stable position.
 IEC 60417-6024:2009-11	Inlet for liquid, input for liquid	To identify inlet connections for the cooling liquid.
	Three-phase transformer-rectifier	To indicate WELDING POWER SOURCE symbol on the RATING PLATE.

SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
	Inverter power source AC/DC	To indicate WELDING POWER SOURCE symbol on the RATING PLATE.
	Slow wire feed start	To identify the slow advance of wire towards the workpiece at the start of the weld.
	Caution ! Read the ~~instruction~~ operator's manual	To indicate a hazard and identify that the ~~instruction~~ operator's manual should be read.
 ISO 7000-0544:2004-01	Water cooling	To identify a water cooling system (for example, operating controls switching the water cooling on or off).
 IEC 60417-6394:2017-10	Variability ~~and~~ with OFF position, rotary adjustment	To identify the control for continuous increase and decrease of a quantity and an off position ~~of a control~~ .
 ISO 7000-0469:2004-01, modified	MIG/MAG spot welding	To identify MIG/MAG spot welding

SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
	Upslope time	To indicate a control of upslope time

L.5 Examples of control panels

This clause (see Figure L.1 to Figure L.8) gives examples of control panels for arc welding and allied processes equipment.

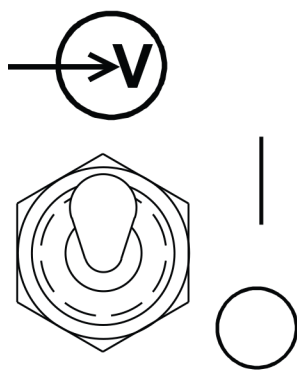


Figure L.1 – Input voltage power switch

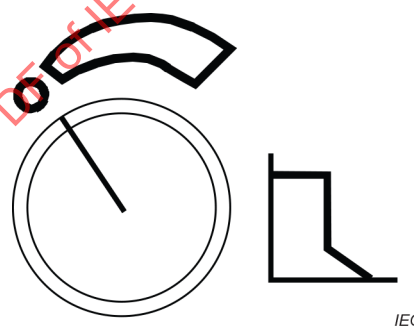


Figure L.2 – Arc force control potentiometer

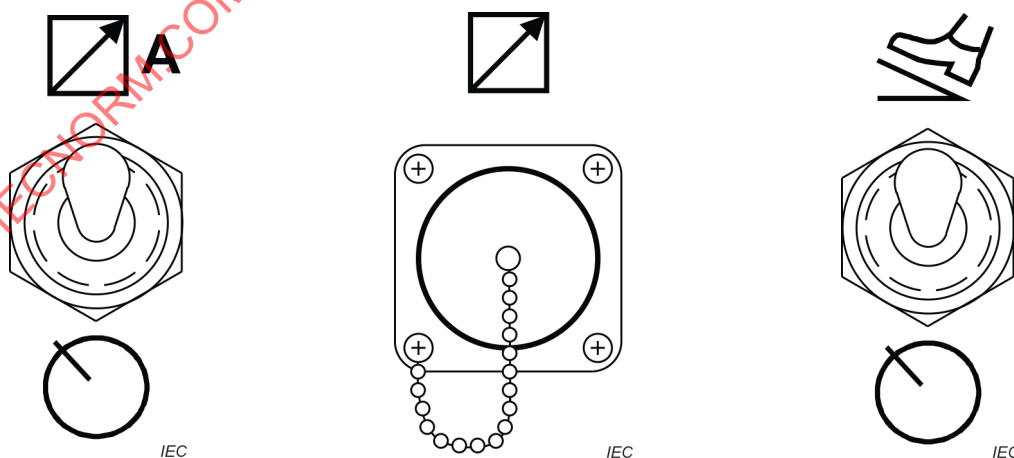


Figure L.3 – Remote receptacle and selector switches

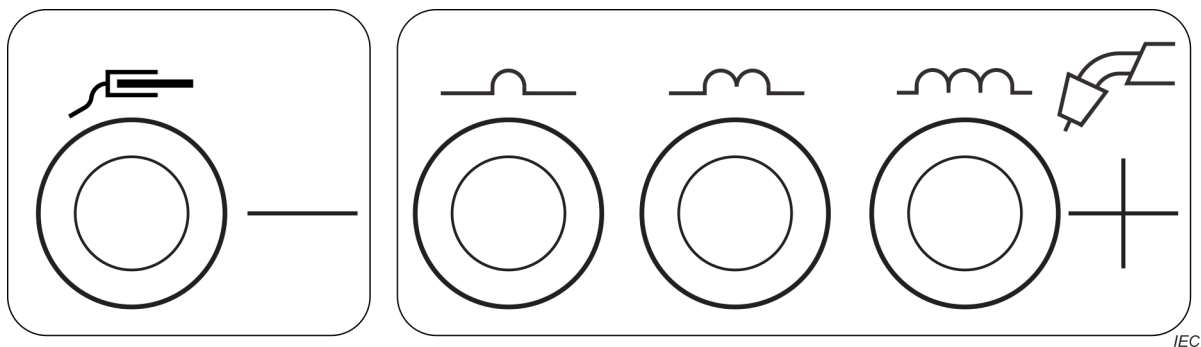


Figure L.4 – Terminals with inductance selector for MIG/MAG welding

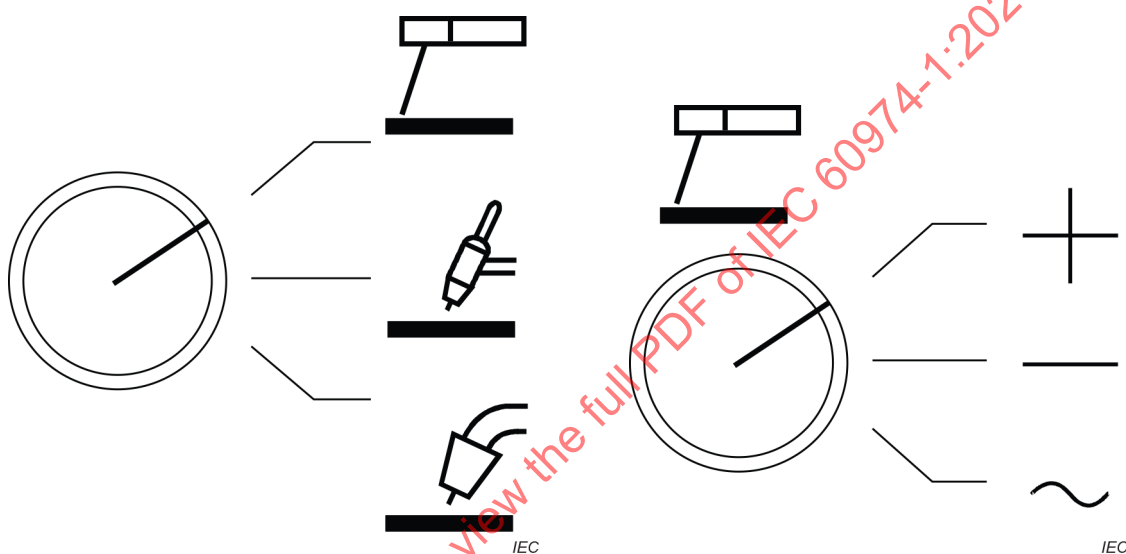


Figure L.5 – Process switch (MMA, TIG, MIG)

Figure L.6 – Selector switch on AC/DC equipment

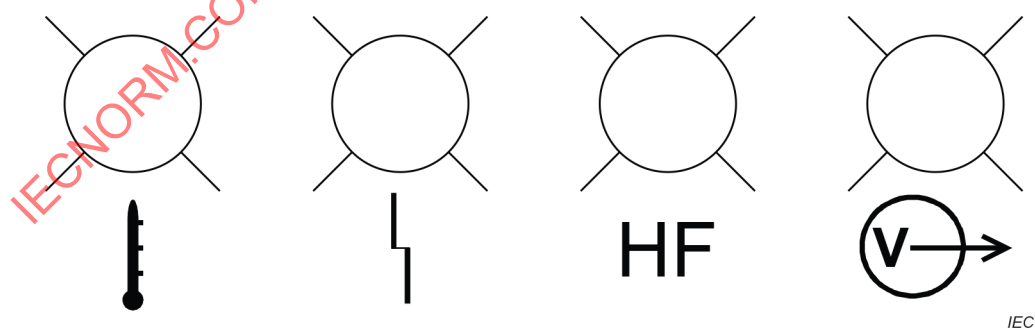


Figure L.7 – Panel indicator lights (overheat, fault, arc striking, output voltage)

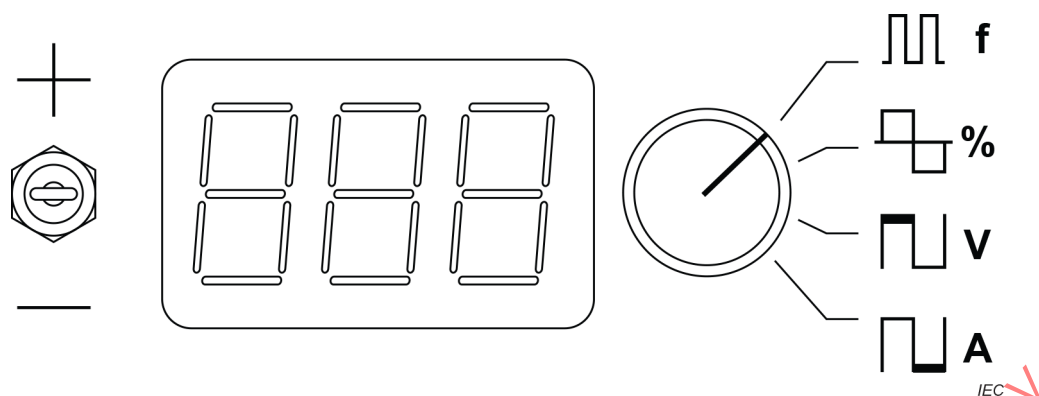


Figure L.8 – Setting pulsing parameters using digital display

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Annex M (informative)

Efficiency and IDLE STATE power measurement

M.1 Measuring efficiency

To ensure repeatability and data accuracy in measuring efficiency, the following procedure shall be used:

- a) Use power meters to measure supply power and welding output power.
- b) Ensure conformance to 5.1 for test conditions.
- c) Ensure accuracy of power measurement is equal to or better than $\pm 0,25\%$.
- d) Ensure conformance of the supply network to Annex G.
- e) Measure the supply voltage of the supply network connected welding power source at the point of coupling of the welding power source to the supply network.
- f) Measure the **load voltage** at the welding power source **welding circuit** connections. For welding power sources that are provided with permanently connected welding cables, measure the **load voltage** at the exit point of the power source enclosure.
- g) Measure efficiency:
 - 1) if not stated in national regulation, using the process which results in the highest power consumption;
 - 2) at **conventional welding conditions** (given in 3.4.17) and **conventional load voltages** as specified in 11.2;
 - 3) halfway into the load cycle for **duty cycles** less than 100 %;
 - 4) excluding the power draw from external devices or auxiliary power supplies in the measurement (see 11.5 and 11.6).
- h) Record efficiency as a percentage rounded to two significant figures.

$$\text{Efficiency: } \eta = \frac{P_2}{P_1}$$

where

P_2 is the welding output power;

P_1 is the supply power consumption.

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

NOTE 2 Efficiency can depend on factors such as output load, supply network voltage (for equipment with multiple input voltages), operating modes, and environmental conditions.

M.2 Measuring idle state power

To ensure repeatability and data accuracy in measuring **idle state** power consumption, the following procedure shall be used:

- 1) Ensure the power source is at **thermal equilibrium**.
- 2) Measure **idle state** power after
 - a) any cool-down period of the power source (e.g. after the fan and cooling pump has stopped); and
 - b) the power source has switched into a low energy **idle state** (if equipped).

Do not include the power draw from external devices or auxiliary power supplies in the measurement (see 11.5 and 11.6).

The idle state power consumption shall be stated as an average value.

~~NOTE — Idle state power measurements are influenced by variations in instantaneous power.~~

M.1 General conditions for measurement

M.1.1 General

Unless otherwise specified, measurements shall be made under test conditions and with equipment specified in IEC 62301.

NOTE This Annex was written in response to EU 2019/1784. This Annex makes extensive reference to IEC 62301 *Household electrical appliances – Measurement of standby power*, which was also prepared under an EC mandate as EN 50564 to support the ecodesign Directive.

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

M.1.2 Test room

The tests shall be carried out in a room that has an air speed close to the product under test of $\leq 0,5$ m/s. The ambient temperature shall be maintained at (23 ± 5) °C throughout the test.

Where the product has an ambient light sensor that affects the power consumption, the test shall be carried out with controlled ambient light conditions. Where the illuminance levels are externally defined (in the instructions for use), these values shall be used. Otherwise reference illuminance levels of >300 lx and <10 lx shall be used.

Information on the method used to achieve the above illuminance levels, where relevant, shall be recorded in the test report (see M.4). Where values of illuminance are given, they shall be measured as close to the product's light sensor as practical.

NOTE 1 The measured power for some products could be affected by the ambient conditions (e.g. illuminance, temperature).

During tests the ARC WELDING POWER SOURCE shall not be intentionally cooled by external means.

NOTE 2 Placing the ARC WELDING POWER SOURCE on a metal surface during tests is an example of cooling by external means.

M.1.3 Power supply

M.1.3.1 Supply voltage and frequency

Where the test voltage and frequency are not defined by an external standard or regulation, the test voltage and test frequency shall be the nominal voltage ± 5 % and the nominal frequency ± 1 % of the country for which the measurement is being determined (see Table M.1).

Table M.1 – Typical nominal electricity supply details for some regions

Country/Region	Nominal voltage and frequency	
	single phase system	two phase or three-phase systems
Europe	230 V, 50 Hz	400 V, 50 Hz
North America	120 V, 60 Hz	208 V, 60 Hz; 240 V, 60 Hz; 480 V, 60 Hz; 600 V, 60 Hz
Japan ^a	100 V, 50/60 Hz	200 V, 50/60 Hz; 220 V, 50/60 Hz; 400 V, 50/60 Hz
China	220 V, 50 Hz	380 V, 50 Hz
Australia and New Zealand	230 V, 50 Hz	400 V, 50 Hz
^a "50 Hz" is applicable for Eastern part and "60 Hz" for the Western part, respectively.		

M.1.3.2 Supply voltage waveform

For IDLE STATE power consumption measurements equal to or less than 5 W, the total HARMONIC CONTENT of the supply voltage when supplying the product under test shall not exceed 2 % (up to and including the 13th harmonic); HARMONIC CONTENT is defined as the root-mean-square (RMS) summation of the individual components using the fundamental as 100 %.

For IDLE STATE power consumption measurements greater than 5 W and for WELDING POWER SOURCE EFFICIENCY measurement, the total HARMONIC CONTENT of the supply voltage can exceed 2 %.

The value of the total HARMONIC CONTENT of the supply voltage shall be recorded during the test and reported (see M.4).

In addition to the above, the ratio of peak value to RMS value of the supply voltage (i.e. crest factor) when supplying the product under test shall be between 1,34 and 1,49.

NOTE Power supplies meeting IEC 61000-3-2 are likely to meet the above requirements.

M.1.4 Power measuring instruments

The requirements of IEC 62301:2011, 4.4 apply to the measurement of supply power and output power.

M.2 Measurements

M.2.1 General

Efficiency of the ARC WELDING POWER SOURCE is determined at load condition that results in the highest output power as specified by the manufacturer in the instruction manual or as stated on the RATING PLATE. In addition, power consumption is measured at IDLE STATE condition if an IDLE STATE condition is present and described in the user manual.

ARC WELDING POWER SOURCES are measured excluding the power drawn from external devices or auxiliary power supplies (see 11.5 and 11.6), and if part of the WELDING POWER SOURCE:

- liquid cooling system;
- wire feeder;
- arc striking and stabilizing devices;
- gas console;
- torch;
- air compressor.

In the instruction manual, the manufacturer shall indicate the procedure to switch off or to disable the excluded devices.

If any external device is necessary for full operation of the WELDING POWER SOURCE, it shall be connected to the WELDING POWER SOURCE.

Tests are made measuring the supply power and output power simultaneously.

M.2.2 Preparation of the ARC WELDING POWER SOURCE

The measurement procedure shall be performed on the same sample of ARC WELDING POWER SOURCE.

The following steps shall be followed and documented in the test report as applicable:

- output measurements shall be made at the WELDING POWER SOURCE WELDING CIRCUIT connections. For WELDING POWER SOURCES provided with permanently connected welding cables, measure the LOAD VOLTAGE at the exit point of the power source enclosure;
- for efficiency measurement, select the process which results in the highest output power;
- for AC capable ARC WELDING POWER SOURCE:
 - measure in DC operation and evaluate against AC limit, or
 - if DC operation is not available select the lowest frequency setting, but not lower than 50 Hz and set the waveform to rectangular or as specified by the manufacturer;
- for DC ARC WELDING POWER SOURCE with rapid current shut down utilizing an additional switch to interrupt the WELDING CURRENT, the AC limit applies;
- use CONVENTIONAL WELDING CONDITIONS (given in 3.1.17) and CONVENTIONAL LOAD VOLTAGES as specified in 11.2;
- measure the supply voltage of the supply-network-connected WELDING POWER SOURCE at the point of coupling of the WELDING POWER SOURCE to the supply network. If the power source is delivered without supply cable attach a cable according to the manufacturer's specifications with a length of $2^{+0,1}_0$ m from the exit point of the enclosure as specified in 10.9.

M.2.3 CONVENTIONAL LOAD conditions

The ARC WELDING POWER SOURCE shall be tested at the load conditions specified in Table M.2.

Table M.2 – Load conditions for the ARC WELDING POWER SOURCE

Conditions as specified	
Load condition	Description
1	IDLE STATE
2	Rated DUTY CYCLE (40 °C rating) at highest output power

Apply tolerances of ± 2 % for LOAD VOLTAGE and WELDING CURRENT. If LOAD VOLTAGE and WELDING CURRENT tolerance cannot be met due to load restrictions, two measurements shall be taken, as close as possible to the CONVENTIONAL LOAD condition, one above and one below. The results shall be linearly interpolated to the CONVENTIONAL LOAD condition and used for the efficiency calculation in M.2.8.

M.2.4 Test load

The load conditions specified in Table M.2 shall be achieved by using a resistive load. The resistive load can be a variable resistor, an electronic test load, or a combination thereof, as specified in 3.1.18 CONVENTIONAL LOAD.

M.2.5 Test set-up

Output power measurements of an ARC WELDING POWER SOURCE having an AC output shall be made with a power meter.

Output power measurements of an ARC WELDING POWER SOURCE having a DC output with a peak-to-peak ripple voltage that is less than 5 % of the RMS voltage at full load can be made either with a suitable power meter or with a separate voltmeter and ammeter. Using separate voltmeter and ammeter the voltage shall be filtered by applying a low pass filter for signal smoothing having a cut-off frequency between 2 kHz and 10 kHz or as recommended by the manufacturer. The filter characteristic can be incorporated within the voltmeter or a separate filter can be used. If a separate filter is used, then the attenuation caused by the filter shall be factored into the measurement.

Output power measurements of an ARC WELDING POWER SOURCE having a DC output with a peak-to-peak voltage ripple greater than or equal to 5 % of the RMS voltage at full load shall be made with a DC coupled power meter.

The load is adjusted to achieve CONVENTIONAL LOAD condition as specified in 11.2.

M.2.6 Measurement uncertainty

The measurement uncertainty related to determination of supply power due to the measuring instrument (U_e) is given in IEC 62301:2011, 4.4.1 and IEC 62301:2011, Annex D.

Measurement of output power shall be made such that the calculated or measured power due to the measuring instrument has an uncertainty of ≤ 2 % at the 95 % confidence level.

M.2.7 Measurement procedure

M.2.7.1 IDLE STATE power consumption

Verify equipment is in an operation mode compliant with IDLE STATE as specified in the instruction manual (see Note). ARC WELDING POWER SOURCES for mechanized systems may require external configuration to achieve IDLE STATE. Wait for any cool-down period of the power source (e.g. after the fan and cooling pump has stopped); and if equipped, wait until the power source has switched into a low energy IDLE STATE. The supply ACTIVE POWER is monitored for a period of 5 min to assess stability. If the supply ACTIVE POWER does not change by more than 5 % during these 5 min the measurement is considered to be stable and the measurements are recorded at the end of the 5 min period. If the supply ACTIVE POWER is not stable over a 5 min period, the stability shall be determined in accordance with IEC 62301:2011, 5.3.2.

NOTE If the IDLE STATE supply power limit is exceeded the welding output is possibly not in IDLE STATE. Select a welding mode where the WELDING CIRCUIT is not energized e.g. no voltage present (see 3.1.66).

M.2.7.2 WELDING POWER SOURCE EFFICIENCY

The output of the WELDING POWER SOURCE shall be maintained at 100 % DUTY CYCLE (40 °C rating) for at least 20 min, this is the warm-up period. After this warm-up period, the supply power is monitored for a period of 5 min to assess stability as specified in M.2.7.1. If the supply power level is stable, configure the WELDING POWER SOURCE to achieve the highest output power. Perform the measurements immediately after achieving the highest output power but not later than 60 s after the end of the 5 min stability assessment period. For machines rated only at 100 % DUTY CYCLE, this measurement can be taken at the end of the 5 min stability assessment period. See Figure M.1 for the measurement procedure.

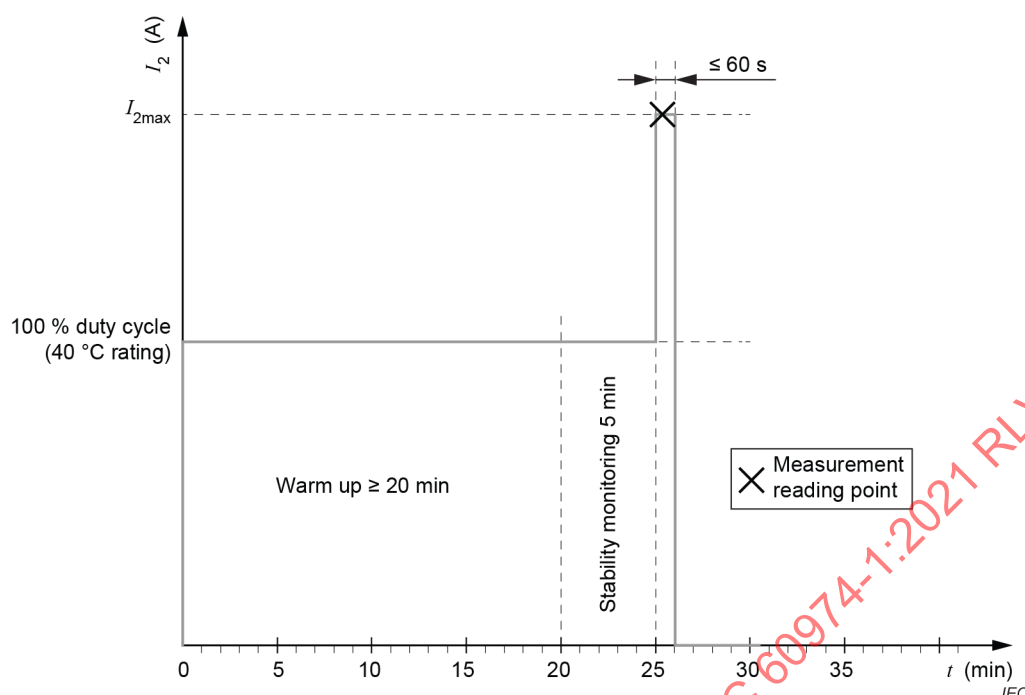


Figure M.1 – Measurement procedure

M.2.8 Efficiency calculation

The efficiency shall be calculated by dividing the measured output ACTIVE POWER at a given load condition by the supply ACTIVE POWER measured at that load condition.

M.3 Test report

M.3.1 Product details

All of the following information shall be recorded in the test report:

- details of the organisation taking responsibility for the product (e.g. the manufacturer);
- brand, model number, version or serial number;
- product description, as appropriate;
- RATED SUPPLY VOLTAGES and RATED SUPPLY FREQUENCY. CONVENTIONAL LOAD conditions as given in the specification or on the RATING PLATE.

M.3.2 Test parameters

All of the following information shall be reported:

- ambient temperature;
- supply voltage and frequency;
- TOTAL HARMONIC DISTORTION of the voltage waveform of the electricity supply system (%UTHD);
- information to describe the test set-up at load condition (e.g.: IDLE STATE condition, CONVENTIONAL LOAD condition of 11.2, DC setting, AC waveform type and setting, supply cable cross section and length; information on the illuminance levels if applicable, other significant parameters).

If any of the above values change during the test the minimum and maximum values shall be recorded.

NOTE For 3 phase supply system, report the average of all 3 line to line voltage measurements.

M.3.3 Test and laboratory details

All of the following information shall be recorded in the test report:

- test report number/reference;
- date of test;
- laboratory name and address;
- test officer(s);
- test equipment used;
- calibration due date.

M.3.4 Test data

All of the following information shall be recorded in the test report:

- measured and calculated data as described in Table M.3;
- efficiency as a percentage rounded to two significant figures;
- average power in watts rounded to three significant figures;
- measured output current and voltage;
- identification of the measurement method used (see IEC 62301:2011, 5.3.2 or IEC 62301:2011, 5.3.4);
- calculated uncertainty of the result due to the measuring instrument (U_e) (see IEC 62301:2011, Annex D) and whether the result complies with IEC 62301:2011, 4.4.1.

Table M.3 – Required reported data (measured and calculated)

Reported quantity	Description
Output current (A) (DC average or AC RMS)	Measured at load condition 2
Output voltage (V) (DC average or AC RMS)	
Output ACTIVE POWER (W)	
RMS supply voltage (V)	Measured at load conditions 1 and 2
Supply ACTIVE POWER (W)	
TOTAL HARMONIC DISTORTION of the supply voltage (%UTHD)	
IDLE STATE power consumption by the arc WELDING POWER SOURCE (W)	Measured at load condition 1
Efficiency	Calculated at load condition 2 (see M.2.8)

M.4 Test report template

ARC WELDING POWER SOURCE under test						
Brand name, as marked on ARC WELDING POWER SOURCE						
Organisation taking responsibility for the ARC WELDING POWER SOURCE (e.g. Manufacturer or importer)		Name		Address		
Model identification						
Version or serial number						
Product description		Number of supply phases				
Rated supply	Voltage (V)		Current (A)		Frequency (Hz)	
RATED OUTPUT	Voltage (V)		Current (A)		AC or DC?	
Test laboratory details						
Name of laboratory						
Address						
Test report number		Test date				
Prepared by		Approved by				
Test conditions						
Ambient temperature (°C)						
Information describing the test set-up used at load condition						
Test equipment	Manufacturer of test instrument	Model designation	Serial number	Calibration due date		
Voltage source						
Instrument used for measuring supply power						
Instrument(s) used for measuring output power						
Test configuration						
Nominal test supply voltage (V)						
Supply frequency (Hz)						
		Setting used when performing tests				
Supply cable length and cross section						
Measurement method for IDLE STATE power consumption from IEC 62301:2011, 5.3.2 or IEC 62301:2011, 5.3.4 used						

Results		
	Load condition	
	IDLE STATE	DUTY CYCLE
Output current (A),(DC average or AC RMS)		
Output voltage (V),(DC average or AC RMS)		
Output ACTIVE POWER (W)		
Supply voltage (V RMS)		
Supply ACTIVE POWER (W)		
TOTAL HARMONIC DISTORTION of supply voltage waveform (%UTHD)		
Efficiency		
Calculated measurement uncertainty		

NOTE For 3 phase supply, report the average of all 3 line to line voltage measurements.

Conclusion			
IDLE STATE condition power consumption (W)			
IDLE STATE limit applied (W)		Regulatory reference	
IDLE STATE verdict (PASS/FAIL)			
Efficiency (%)			
Efficiency limit applied (%)		Regulatory reference	
Efficiency verdict (PASS/FAIL)			

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Annex N

(normative)

TOUCH CURRENT measurement ~~in fault condition~~

For measuring the ~~touch current~~ in fault condition, the measuring network in accordance with Figure N.1 and the appropriate configurations in Figures N.2 and N.3 shall be used with an appropriate measuring device.

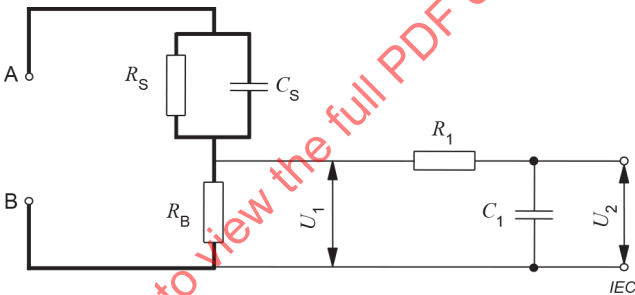
~~Caution! An expert shall perform this test. The protective conductor is disabled for this test.~~

For measuring the TOUCH CURRENT in normal condition, the measuring network in accordance of Figure N.1 shall be used. For measuring the TOUCH CURRENT in fault condition, the measuring network in accordance with Figure N.2 and the appropriate configurations in Figure N.3 and Figure N.4 shall be used with an appropriate measuring device.

NOTE 1 Guidance on construction and application of TOUCH CURRENT instruments can be found in IEC 60990:2016 Annex G. Measuring network performance and calibration can be found in IEC 60990:2016, Annex K.

NOTE 2 Definitions for let-go, immobilization, perception and startle reaction thresholds are given IEC 60479-1:2018.

Caution! An EXPERT shall perform this test. The protective conductor is disabled for this test.

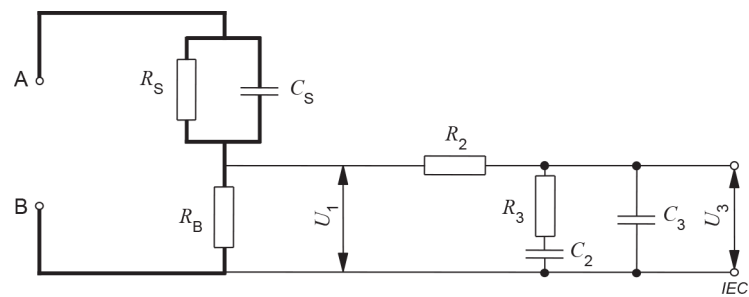


Key

A, B	Test terminals	C_S	0,22 μ F
R_S	1 500 Ω	R_1	10 000 Ω
R_B	500 Ω	C_1	0,022 μ F
U_1	RMS voltage	U_2	peak voltage

Weighted TOUCH CURRENT (perception or ~~startle-reaction~~) = $\frac{U_2}{500}$ (peak value)

Figure N.1 – Measuring network ~~for weighted touch current~~, TOUCH CURRENT weighted for perception or startle-reaction



Key

A, B	Test terminals	R_2	10 000 Ω
R_S	1 500 Ω	R_3	20 000 Ω
R_B	500 Ω	C_2	0,006 2 μF
C_S	0,22 μF	C_3	0,009 1 μF
U_1	RMS voltage	U_3	peak voltage

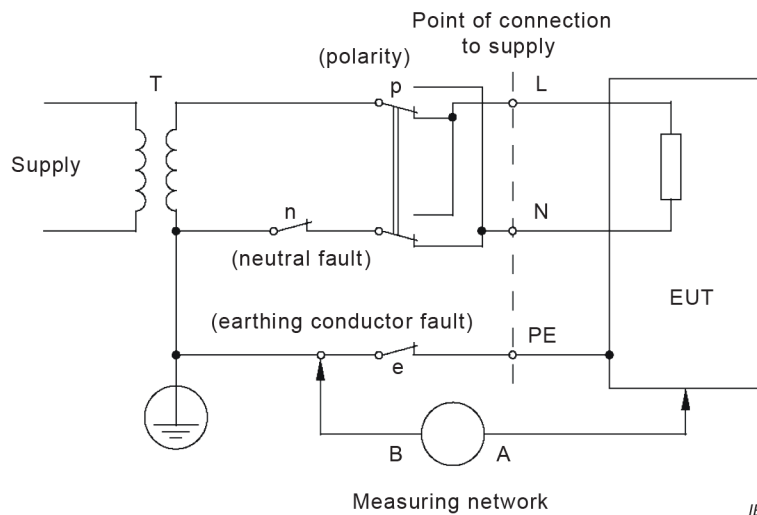
Weighted TOUCH CURRENT (letgo-immobilization) $= \frac{U_3}{500}$ (peak value)

Figure N.2 – Measuring network, TOUCH CURRENT weighted for letgo-immobilization

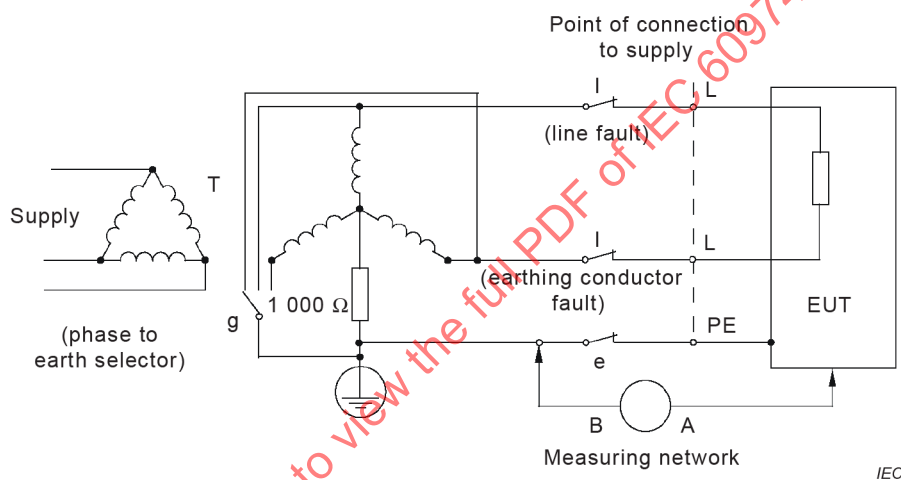
For three-phase equipment, TOUCH CURRENT in fault condition is measured with the switches (I) and (n) in the closed position and switch (e) in the open position. The measurement is then repeated with each of the switches (I) and (n) opened one by one, with the other switches closed, except switch (e). The measurements are similar for single-phase equipment, except that they shall be repeated for each position of the polarity switch (p).

The manufacturer shall identify the configuration (TN, TT, star IT, etc.) to which its equipment is intended to be connected in its final application. The equipment under test shall be tested to those identified configurations or the worst-case configuration.

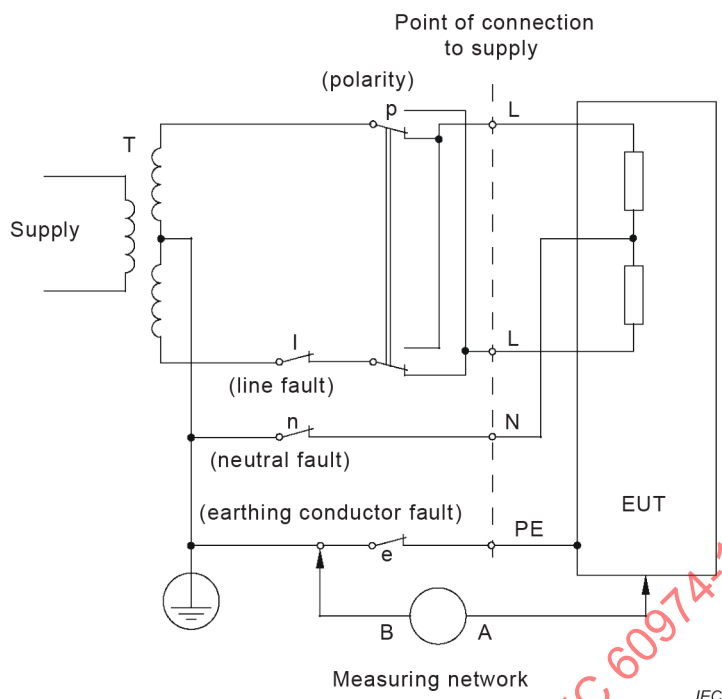
The use of isolating transformer (T) is optional. When not used, safety precautions shall be taken to protect the test operator from any hazardous voltage on the enclosure and other accessible conductive parts of the equipment.



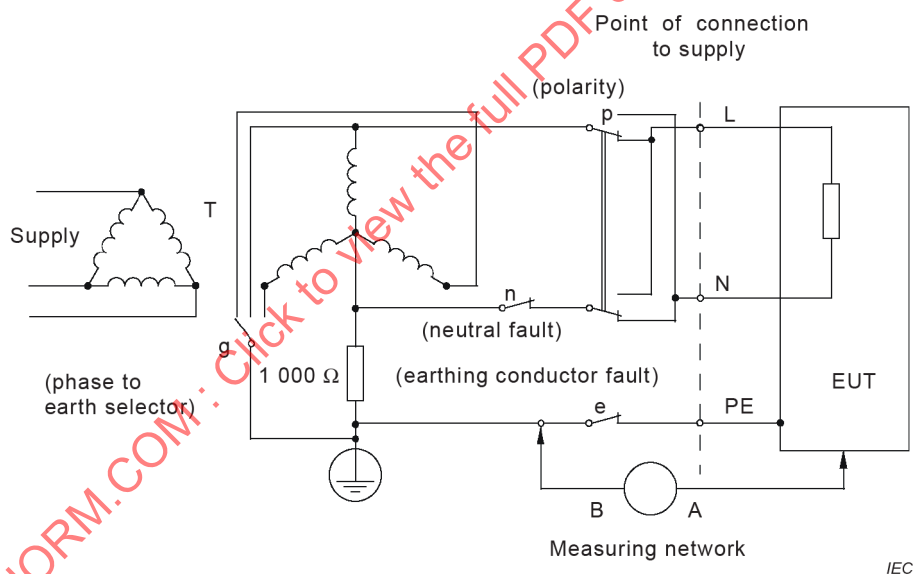
a) Single-phase equipment on star TN or TT system



b) Single-phase equipment connected line-to-line on star TN or TT system

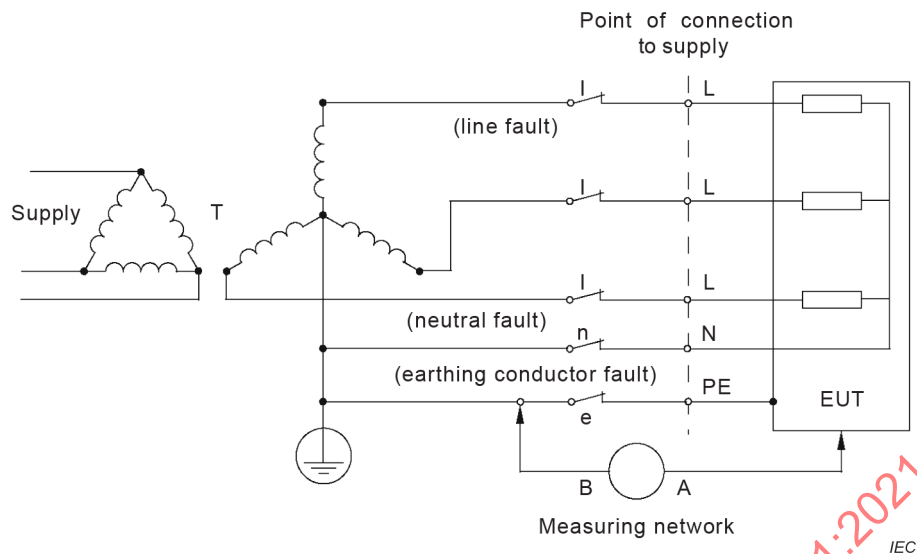


c) Single-phase equipment on centre-earthed TN or TT system

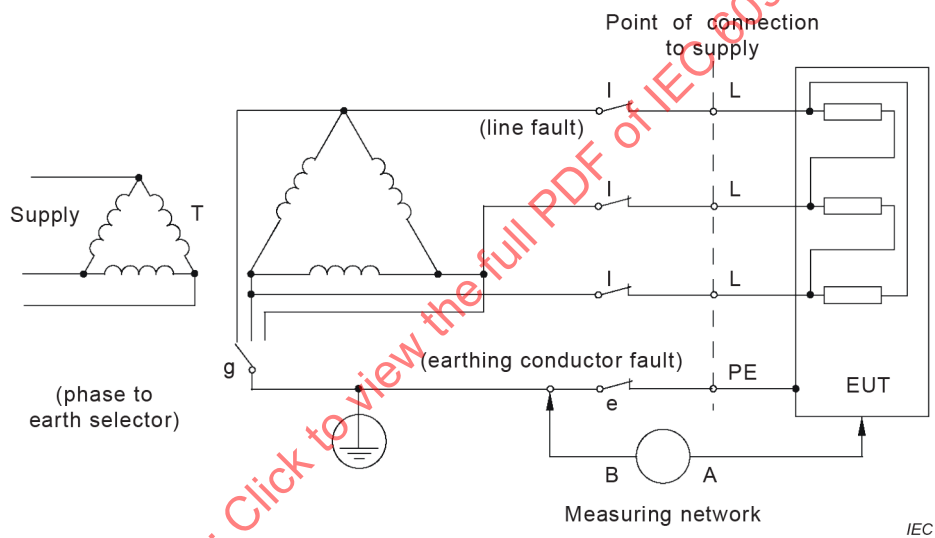


d) Single-phase equipment connected line-to-neutral on star IT system

Figure N.3 – Diagram for TOUCH CURRENT measurement on fault condition at operating temperature for single-phase connection of appliances other than those of CLASS II



a) Three-phase equipment on star TN or TT system



b) Three-phase equipment on unearthed three-phase three-line system

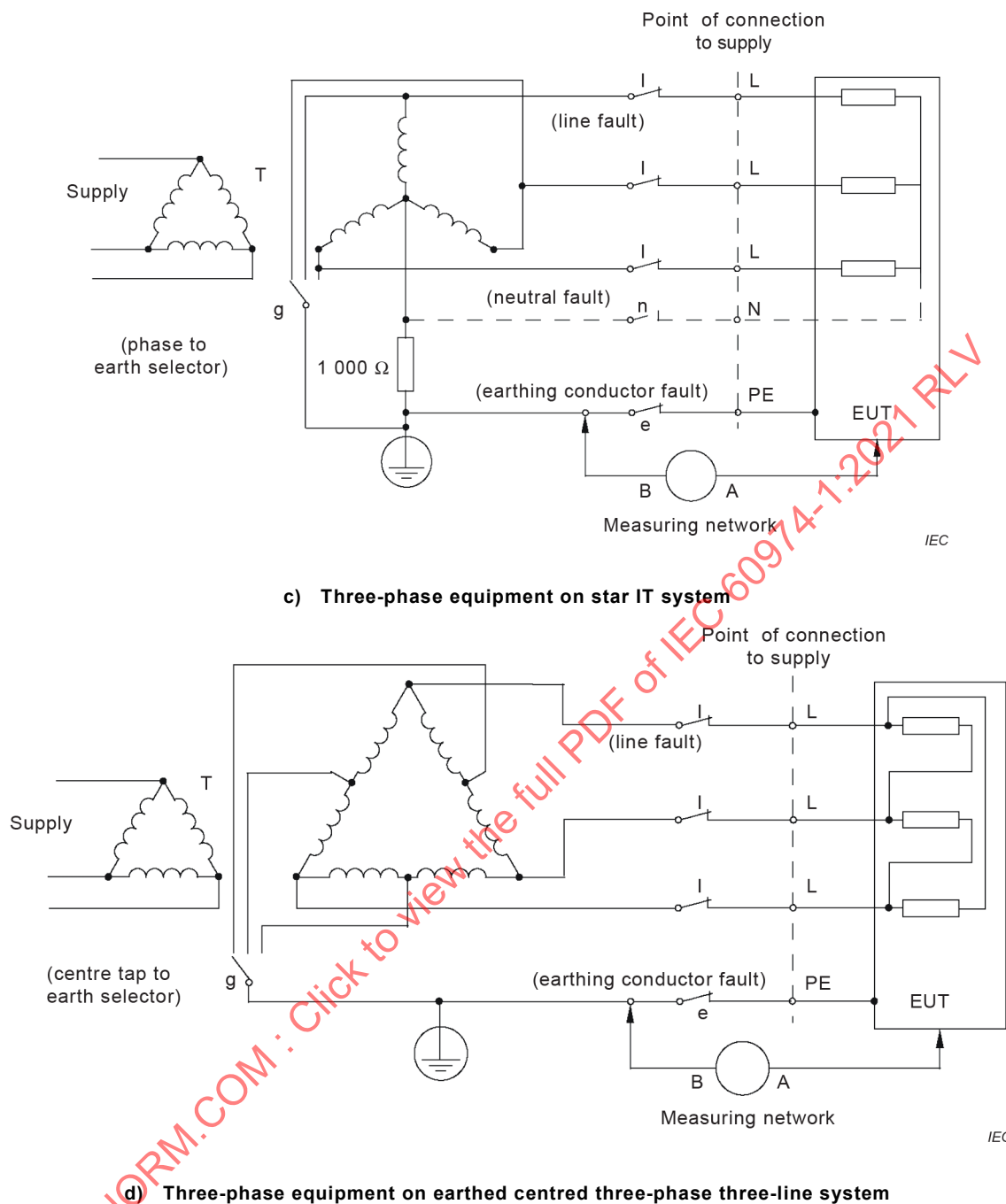


Figure N.4 – Diagram for TOUCH CURRENT measurement on fault condition for three-phase four-wire system connection of appliances other than those of CLASS II

Annex O (normative)

Battery-powered WELDING POWER SOURCES

O.1 General

Annex O applies to rechargeable battery-powered WELDING POWER SOURCES for arc welding and allied processes and the BATTERY packs for such equipment.

Battery-powered WELDING POWER SOURCES are WELDING POWER SOURCES powered either by:

- INTEGRAL BATTERIES,
- DETACHABLE BATTERY PACKS,
- SEPARABLE BATTERY PACKS.

All clauses of this document apply unless otherwise specified in Annex O. If a clause is included in Annex O, the numbered clauses of Annex O replace or add to the numbered clauses of the main body. Unless otherwise specified, the content of clauses and subclauses in Annex O replaces the content of the corresponding clauses and subclauses in the main body. Additional subclauses are numbered O.x.201, O.x.202, etc.

Battery-powered WELDING POWER SOURCES and BATTERY packs covered by Annex O can be operated:

- completely disconnected and isolated from the supply network;
- connected to the supply network with the WELDING CIRCUIT isolated from supply network.

Requirements for protection against risk of electric shock depend on specific electrical topology.

If the battery-powered WELDING POWER SOURCE can also be used during charging, the insulation requirements ~~have to~~ shall be considered when designing the charging unit.

Since BATTERY packs for WELDING POWER SOURCES are submitted to different use patterns (such as rough use, high charging and discharging currents), their safety can be evaluated only by Annex O and not by using other standards for BATTERY packs, such as the IEC 62133 series, unless otherwise indicated in Annex O. All relevant requirements of IEC 62133-1:2017 and IEC 62133-2:2017 are addressed in Annex O.

When evaluating the risk of fire associated with DETACHABLE BATTERY PACKS, consideration has been given to the fact that these BATTERY packs are unattended energy sources and have been evaluated as such in this document. Requirements in other standards regarding the risk of fire due to the charging of these DETACHABLE BATTERY PACKS are therefore considered to be fulfilled.

Annex O also addresses requirements covering the use of lithium-ion CELLS employed in BATTERY SYSTEMS in WELDING POWER SOURCES. The following shall be considered within the context of these requirements.

- These requirements address the safety of BATTERIES during storage and use including discharge and charge, and not any possible hazards associated with toxicity nor potential hazards associated with transportation or disposal.

NOTE 1 IEC 62281 covers the safety aspects of lithium-ion BATTERIES during transport.

- BATTERY SYSTEMS covered by these requirements are not intended to be serviced by the end user.

- These requirements are intended to provide comprehensive evaluation of a BATTERY only if used in products covered by this document.
- These requirements address the safety of BATTERY SYSTEMS during storage and use including discharge and charge. These requirements are only considered to be supplementary requirements in regards to BATTERY CHARGER fire and electric shock.
- These requirements refer to and require parameters supplied in reference to the CELLS that establish conditions for safe use of those CELLS. Those parameters form the basis of acceptance criteria for a number of tests contained herein. This document does not independently evaluate the safety of CELLS. These parameters, taken as a set, constitute the “SPECIFIED OPERATING REGION” for a CELL. There ~~may~~ can be several sets of SPECIFIED OPERATING REGION(S).

Annex O does not apply to the safety of BATTERY CHARGERS themselves. However, it covers the safe functioning of BATTERY SYSTEMS. The equipment including charging unit, BATTERY pack and WELDING POWER SOURCE shall meet the separation requirements of the standard applied to the BATTERY CHARGER.

NOTE 2 IEC 60335-2-29 covers a variety of CHARGERS.

Annex O does not provide comprehensive safety information for manufacturing, maintenance and repair personnel.

O.4 Environmental conditions

Addition to Clause 4 of this document:

BATTERY conditions shall not exceed the BATTERY'S SPECIFIED OPERATING REGION. Depending on the technology used, different environmental conditions can be necessary and the resulting WELDING POWER SOURCE and/or BATTERY pack shall be marked accordingly (see 15.1).

NOTE See IEC 62133-2:2017, Figure A.1 for details.

O.5 Tests

O.5.1 Test conditions

Successive testing performed on a BATTERY can result in cumulative stress which can cause permanent damage to the BATTERY and should be avoided. Additional samples ~~may~~ can be used as necessary, except for the TYPE TESTS where only one sample shall be used.

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

The heating test defined in O.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).

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

Unless otherwise specified, tests shall be performed starting with a FULLY CHARGED BATTERY.

Some of the tests ~~may~~ can result in fire or EXPLOSION. It is therefore recommended that personnel should be protected from the flying fragments, explosive force, sudden release of heat, chemical burns, intense light and noise that ~~may~~ can result from such EXPLOSIONS. The test area should be well ventilated to protect personnel from possible harmful fumes or gases.

Addition to 5.1 of this document:

O.5.1.201 When measuring voltage, the peak value of any superimposed ripple exceeding 10 % of the average value shall be included. Transient voltages are ignored, such as a temporary increase of voltage, for example after the BATTERY pack is removed from the CHARGER.

O.5.1.202 Measurements of CELL voltages during the tests of lithium-ion systems shall be made using a single pole resistive-capacitive low pass filter with a cut-off frequency of 5 kHz $\pm$ 500 Hz. If charging voltage limits have been exceeded, the peak value of the voltage measured after this network shall be used. The measurement shall have a measurement tolerance within ± 1 % for the combined filter circuit and voltmeter.

O.5.1.203 Unless otherwise specified, all BATTERIES shall be fully conditioned as follows: BATTERIES shall be FULLY DISCHARGED and after a rest of two hours charged in accordance with the manufacturer's instructions.

O.5.1.204 The location of thermocouples for CELL temperature measurements shall be on the outer surface, half way along the longest dimension, of the CELL that results in the highest temperature.

O.5.1.205 Currents measured during BATTERY charging shall be average currents with an averaging period of 1 s to 5 s. Current limits set by the BATTERY manufacturer's specification shall not be exceeded.

O.5.1.206 If not otherwise specified, a FULLY CHARGED BATTERY shall be used.

O.5.1.207 When a BATTERY comprised of a single CELL is employed, instructions in this document referring to special preparations of a CELL in a series configuration do not apply.

O.5.1.208 For BATTERY designs where there is a series arrangement of parallel clusters of CELLS, the cluster shall be treated as a single CELL for those tests that require altering the amount of charge on a single CELL prior to conducting the test.

O.5.1.209 Unless the manufacturer specifies a different voltage, the end-of-discharge voltages for common CELL chemistries are:

- 0,9 V per CELL for nickel cadmium or nickel metal-hydride BATTERIES;
- 1,75 V per CELL for lead-acid BATTERIES;
- 2,5 V per CELL for lithium-ion BATTERIES.

O.5.3 Conformity of components

Addition to 5.3 of this document:

CELLS employed in WELDING POWER SOURCES or CELLS employed in BATTERY packs shall comply with IEC 62133-1:2017 or IEC 62133-2:2017, except for lead-acid BATTERIES.

NOTE The above requirement for testing according to IEC 62133-1:2017 or IEC 62133-2:2017 does not include the BATTERY pack itself.

O.6 Protection against electric shock

O.6.1 Insulation

O.6.1.1 General

Addition to 6.1.1 of this document:

Protection against electric shock from BATTERY VOLTAGE CLASS B circuits shall be composed of:

- BASIC PROTECTION measures against direct contact with live parts;
- measures for protection under SINGLE-FAULT CONDITIONS.

The protection measures shall meet the requirements as described in a) and b) or a) and c).

a) BASIC PROTECTION measures

Persons shall be protected against direct contact with the live parts of the BATTERY VOLTAGE CLASS B electric circuits. The protection measures against direct contact shall be provided by one of the following:

- BASIC INSULATION of the live parts;
- enclosures, preventing access to the live parts.

The enclosures ~~may~~ can be electrically conductive or non-conductive.

b) Protection under SINGLE-FAULT CONDITIONS

• Equipotential bonding

Exposed conductive parts of BATTERY VOLTAGE CLASS B electric equipment, including exposed conductive enclosures, shall be bonded together for potential equalization in accordance with the requirements in O.10.5.201.

• Insulation resistance

The BATTERY VOLTAGE CLASS B electric circuits intended to be not conductively connected to the supply network shall have sufficient insulation resistance in accordance with the requirements in O.6.1.4.

Requirements on insulation resistance for BATTERY VOLTAGE CLASS B electric circuits intended to be conductively connected to the supply network shall comply with 6.1.4.

c) Alternative approach for protection against electric shock

As an alternative to b), the equipment manufacturer shall conduct an appropriate risk assessment and establish a set of measures which give sufficient protection against electric shock under SINGLE-FAULT CONDITIONS.

O.6.1.4 Insulation resistance

Addition to 6.1.4 of this document:

The minimum insulation resistance from BATTERY VOLTAGE CLASS B circuits to accessible surfaces shall be at least 100 Ω/V . The reference shall be the maximum WORKING VOLTAGE.

NOTE Hazard of electric shock occurs when electric currents depending on value and duration pass through the human body. Harmful effects can be avoided if the current is within zone DC-2 for DC or zone AC-2 for AC as shown in IEC TS 60479-1:2005/2018, Figure 20 and Figure 22, respectively. The relation of harmful body currents and other wave forms and frequencies is described in IEC TS 60479-2:2019. The insulation resistance requirements of 100 Ω/V for DC ~~allow~~ equals body currents of 10 mA.

To meet the above requirement for the entire circuit, it is necessary to have a higher insulation resistance for each component, depending on the number of the components and the structure of the circuit to which they belong.

Conformity shall be checked by the following procedure

a) Preconditioning and conditioning

Prior to the measurement, the device under test (DUT) shall be subjected to a preconditioning period of at least 8 h at $(5 \pm 2) ^\circ\text{C}$, followed by a conditioning period of 8 h at a temperature of $(23 \pm 5) ^\circ\text{C}$, a humidity of $90^{+10}_{-5} \%$, and an atmospheric pressure of between 86 kPa and 106 kPa.

Alternative preconditioning and conditioning parameters ~~may~~ can be selected provided transition across the dew point occurs shortly after the beginning of the conditioning period.

The insulation resistance shall be measured during the conditioning period at a rate from which the lowest value can be determined.

b) Insulation resistance measurements

The insulation resistance of entire conductively connected BATTERY VOLTAGE CLASS B electric circuits ~~may~~ can be measured using the test procedure for the measurement of the rechargeable energy storage system (RESS) given in ISO 6469-1:2009, 6.1.3.

If the system has several voltage ranges (e.g. because of boost converter) in a conductively connected circuit and some of the components cannot withstand the maximum WORKING VOLTAGE of the entire circuit, the insulation resistances of components can be measured separately by applying their own maximum WORKING VOLTAGES after those components are disconnected.

The measurements shall be performed using suitable instruments that can apply DC voltage (e.g. megohmmeter, provided they deliver the required test voltage).

O.6.1.5 Dielectric strength

Addition to 6.1.5 of this document:

a) BATTERY VOLTAGE CLASS B circuits not conductively connected to the supply network

For BATTERY VOLTAGE CLASS B circuits the test voltage, AC or DC, shall be greater than the highest voltage that can actually occur to the component. The test voltage shall be derived from the relevant over-voltages of the electric circuit to which the component is connected. Transient over-voltages that can be expected, including influences from other connections to the supply network, if any, shall be considered. The test voltage and its duration shall be specified, considering the applicable parts and sections of IEC 60664 by the manufacturer.

This test is intended to demonstrate the adequacy of the protection measures to isolate live parts of BATTERY VOLTAGE CLASS B electric circuits.

b) BATTERY VOLTAGE CLASS B circuits conductively connected to the supply network

These shall comply with 6.1.5.

Addition to 6.1 of this document:

O.6.1.201 CREEPAGE DISTANCES (6.1.3) and CLEARANCES (6.1.2) do not apply to the construction of BATTERY CELLS or the interconnections between CELLS in a BATTERY pack.

O.6.1.202 When evaluating a BATTERY pack for protection against electric shock, CREEPAGE DISTANCES, CLEARANCES and distances through insulation, the BATTERY pack shall be connected to the CHARGER.

O.6.2 Protection against electric shock in normal service

Addition to 6.2 of this document:

O.6.2.201 Battery-powered WELDING POWER SOURCES and BATTERY packs shall be so constructed and enclosed that there is adequate protection against electric shock.

Conformity shall be checked by *VISUAL INSPECTION*, and by the tests of O.6.2.202 to O.6.2.205, as applicable.

O.6.2.202 For detachable and SEPARABLE BATTERY PACKS, it shall not be possible to have two conductive, simultaneously accessible parts where the voltage between them exceeds 60 V DC.

O.6.2.203 A BATTERY SYSTEM shall be short-circuit protected by an over-current interruption device. The over-current interruption device shall be suitable for this application.

O.6.2.204 BATTERIES exceeding a voltage of 113 V DC shall be insulated in accordance with 6.2.4 (isolation of the WELDING CIRCUIT).

O.6.2.205 BATTERY VOLTAGE CLASS B circuits up to a voltage of 113 V DC ~~may~~ can be conductively connected to the WELDING CIRCUIT provided the NO-LOAD VOLTAGE does not exceed 60 V DC in a SINGLE-FAULT CONDITION.

NOTE A switch-disconnector element in accordance with IEC 60947-3 having an appropriate rating is considered to meet the single-fault requirement.

O.7 Thermal requirements

O.7.1 Heating test

O.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 constant current starting with a FULLY CHARGED BATTERY:

- a) with the RATED MAXIMUM WELDING CURRENT (I_{2max}) with CONSECUTIVE OPERATING CYCLES;
- b) with the rated WELDING CURRENT (I_2) which allows continuous operation;

until the WELDING POWER SOURCE no longer operates due to the BATTERY being discharged.

For WELDING POWER SOURCES with DETACHABLE BATTERY PACKS or SEPARABLE BATTERY PACKS the test is performed three times on one WELDING POWER SOURCE in immediate succession with FULLY CHARGED BATTERY packs.

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.

Additionally for WELDING POWER SOURCES where continuous charging during welding is possible a heating test as specified in 7.1 shall be conducted where the charge of the BATTERY is the same at the end of the test as it was at the beginning.

The ambient temperature condition of O.5.1 shall be fulfilled before starting the test and the BATTERIES shall be conditioned as specified in O.5.1.203.

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

NOTE 2 Operation time of welding equipment changes with BATTERY temperature, which could lead to higher component temperatures at different ambient temperatures (e.g. 20 °C).

O.7.1.3 Duration of test

The heating test for the continuous operation shall be carried out at the highest WELDING CURRENT and CONVENTIONAL LOAD VOLTAGE that fully discharges the BATTERY without interruption (e.g. THERMAL PROTECTION or automatic means).

O.7.2 Temperature measurement

O.7.2.1 Measurement conditions

The temperature shall be determined 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.

O.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) the BATTERY is FULLY DISCHARGED.

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

Immediately, while equipment is still hot, the equipment shall be checked in accordance with 6.1.5 and O.6.1.5 if applicable.

Addition to Clause 7 of this document:

O.7.201 Normal charging of lithium-ion systems

Charging a lithium-ion BATTERY under normal conditions shall not exceed the SPECIFIED OPERATING REGION FOR CHARGING of the CELL.

Conformity shall be checked by the following tests.

The BATTERY is charged in accordance with the CHARGING SYSTEM instructions starting with a FULLY DISCHARGED BATTERY. Testing is carried out at an ambient temperature of $(40 \pm 5) ^\circ\text{C}$ and

- *if the WELDING POWER SOURCE is recommended to be operated at a minimum temperature lower than $4 ^\circ\text{C}$, the test is also conducted at that minimum temperature $_{-5}^0 ^\circ\text{C}$;*

- if the WELDING POWER SOURCE is recommended to be operated at a maximum temperature greater than 40 °C, the test is also conducted at that maximum temperature $^{+5}_{0}$ °C.

For individual CELLS, the voltage, the temperature measured in accordance with O.5.1.205 and the charging current are monitored to ensure that the hotspot of the BATTERY PACK is within limits. In the case of parallel configurations, analysis ~~may~~ can be used to avoid measuring the individual branch currents. The result shall not exceed their SPECIFIED OPERATING REGION FOR CHARGING (e.g. limits of voltage and current dependent on the temperature).

NOTE 1 The following is an example result of such analysis: the charging current for each branch of a parallel connection ~~would~~ is not ~~need to be~~ monitored, if the maximum deliverable current of the CHARGER did not exceed the MAXIMUM CHARGING CURRENT of a single CELL.

For BATTERIES employing series configurations, the test is repeated with a deliberately imbalanced BATTERY. The imbalance is introduced into a FULLY DISCHARGED BATTERY by charging one CELL to approximately 50 % of full charge.

If it can be demonstrated through testing and/or design evaluation that an imbalance less than 50 % would actually occur in normal use, then this lower imbalance ~~may~~ can be used.

NOTE 2 Examples are those designs that employ circuitry intended for maintaining balance between CELLS in the BATTERY pack. Systems with a small number of CELLS in series ~~may~~ can be shown to exhibit limited imbalance in practice, if the product ceases to operate with a BATTERY prepared with a smaller initial imbalance.

NOTE 3 An example for a testing is repeated charging and discharging of a BATTERY in accordance with the manufacturer's instructions until its capacity has decreased to 80 % of the rated capacity, using the imbalance at the end of the test.

O.8 THERMAL PROTECTION

O.8.1 General requirements

A battery-powered WELDING POWER SOURCE shall be fitted with THERMAL PROTECTION. This THERMAL PROTECTION shall meet the requirements of 8.2, 8.3, O.8.4 and 8.5 to 8.7.

Conformity shall be checked by VISUAL INSPECTION.

O.8.4 Operating capacity

The THERMAL PROTECTION shall be able to operate 200 times, when the WELDING POWER SOURCE delivers its RATED MAXIMUM WELDING CURRENT.

The conformity shall be checked with a suitable overload of a circuit having the same electrical characteristics, especially current and reactance, as the circuit in which the THERMAL PROTECTION is used.

O.9 Abnormal operation

O.9.1 General requirements

All WELDING POWER SOURCES and their BATTERY packs shall not break down and increase the risk of electric shock or fire under the conditions of operations O.9.2 to O.9.207.

Conformity shall be checked by the following tests.

O.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 with a FULLY CHARGED BATTERY while the fan motor(s) is(are) mechanically stalled and the WELDING POWER SOURCE is operated at the output condition of O.7.1.

O.9.3 Short circuit test

The battery-powered 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 battery-powered WELDING POWER SOURCE at the maximum output setting with a FULLY CHARGED BATTERY shall not clear fuses or circuit-breakers 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 a protection device operates.

O.9.4 Overload test

This subclause is not applicable.

Addition to Clause 9 of this document:

O.9.201 WELDING POWER SOURCE – abnormal conditions

The battery-powered WELDING POWER SOURCE, BATTERY pack and the cables of b) and c), as appropriate, are placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm. The test is conducted until failure or until the test sample returns to within 5 K of the ambient temperature or, if neither of these occurs, until at least 3 h has elapsed. A new sample ~~may~~ can be used for each fault listed below. No EXPLOSION shall occur during or after the test. There shall be adequate protection against electric shock as defined in O.6.2. No CHARRING or burning of the cotton shall result. VENTING of the CELLS is permitted.

The resistance for the short in items a), b) and c) shall not exceed 10 mΩ. CHARRING or igniting of the cotton from the shorting means is not considered a failure.

Fuses, thermal cut-outs, thermal links, temperature limiters, electronic devices or any component(s) or conductors(s) that interrupt the discharge current may operate during the above tests. If these devices are relied upon to pass the test, the test ~~is to~~ shall be repeated two more times, using two additional sample devices, and shall open the circuit in the same manner, unless the test is otherwise satisfactorily completed. Alternatively, the test ~~may~~ can be repeated with the open-circuited device bridged.

- a) Combinations of exposed terminals of a DETACHABLE BATTERY PACK are shorted so as to produce the worst result. BATTERY pack terminals that can be contacted using either test probe B of IEC 61032:1997 or test probe 13 of IEC 61032:1997 are considered exposed. The means of shorting shall be selected or positioned such that CHARRING or ignition of the cotton is not influenced.
- b) Any cable provided between the SEPARABLE BATTERY PACK and the battery-powered WELDING POWER SOURCE shall be shorted at the point likely to produce the most adverse effects.
- c) Any cable provided between the BATTERY pack or the battery-powered WELDING POWER SOURCE and the CHARGER shall be shorted at the point likely to produce the most adverse effects.

O.9.202 WELDING CIRCUIT components – abnormal conditions

The following fault conditions are considered for the power circuit path of the WELDING POWER SOURCE and, if necessary, applied one at a time, consequential faults being taken into consideration:

- a) open-circuit at the terminal of any component;
- b) short-circuit of capacitors, unless they comply with IEC 60384-14;
- c) short-circuit of any two terminals of an ELECTRONIC COMPONENT, other than a monolithic integrated circuit. This fault is not applied between the two circuits of an optocoupler;
- d) failure of triacs in the diode mode;
- e) failure of a monolithic integrated circuit or other circuits that cannot be assessed by the fault conditions a) to d). In this case the possible hazardous situations of the WELDING POWER SOURCE are assessed to ensure that safety does not rely on the correct functioning of such a component. All possible output signals are considered under fault conditions within the integrated circuit. If it can be shown that a particular output signal is unlikely to occur, then the relevant fault is not considered.

Components such as thyristors and triacs are not subjected to fault condition e).

Positive temperature coefficient resistors (PTCs) are not short-circuited if they are used within their manufacturer's declared specification.

For simulation of the conditions, the WELDING POWER SOURCE is operated at no-load condition adjusted to maximum output setting.

The test is conducted until failure or until one of the following occurs:

- THERMAL EQUILIBRIUM is achieved; or
- the test samples return to within 5 K of the ambient temperature; or
- a test period of 3 h has elapsed.

NOTE Examination of the WELDING POWER SOURCE and its circuit diagram will reveal the fault conditions which ~~have to be~~ are simulated through circuit analysis, so that testing can be limited to those cases which ~~may~~ can be expected to give the most unfavourable result.

O.9.203 Lithium-ion CHARGING SYSTEMS – abnormal conditions

This subclause applies only to lithium-ion BATTERIES.

The CHARGING SYSTEM and BATTERY of a lithium-ion system shall be so designed that the risk of fire and EXPLOSION as a result of abnormal operation during charging is obviated as far as is practical.

Conformity shall be checked by the following test.

A sample containing the BATTERY and the associated assemblies of the CHARGING SYSTEM are placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm. The BATTERY SYSTEM is operated as specified in O.17.1 t) 1) with all of the categories of abnormal conditions listed below in a) to d).

- a) Components in the CHARGING SYSTEM are faulted as in O.9.202 a) to e), one at a time, if the outcome of such a fault is uncertain based upon analysis. For each fault condition introduced, the state of the BATTERY before charging is as follows:
 - a series configured BATTERY shall have a deliberate imbalance. The imbalance is introduced into a FULLY DISCHARGED BATTERY by charging one CELL to approximately 50 % of full charge; or

- if the test of O.7.201 is conducted with an imbalance of less than 50 %, a series configured BATTERY shall have a deliberate imbalance as established in O.7.201; or
 - a single CELL or parallel only configuration BATTERY shall be FULLY DISCHARGED.
- b) If the test of O.7.201 is conducted with an imbalance of less than 50 % due to the function of circuit(s), and if a single fault of any component within that circuit(s) is shown to result in the loss of that function, then a series configured BATTERY shall be charged with a deliberate imbalance. The imbalance is introduced into a FULLY DISCHARGED BATTERY by charging one CELL to approximately 50 % of full charge.
- c) For a BATTERY with a series configuration, all CELLS are at approximately 50 % charge, except for one which is shorted. The BATTERY is then charged.
- d) With a FULLY CHARGED BATTERY connected to the CHARGER, a short is introduced to the CHARGING SYSTEM across a component or between adjacent PCB tracks at a location expected to produce the most unfavourable results to evaluate the effect of back-feed from the BATTERY. For a CHARGER with a cable that connects to the BATTERY, the short shall be introduced at the point likely to produce the most adverse effects. The resistance of the short shall not exceed 10 mΩ.

During the tests, each CELL voltage is continuously monitored to determine if it has exceeded the limit condition. VENTING of the CELLS is permitted.

The test is conducted until the sample under test experiences a failure, returns to within 5 K of the ambient temperature or, if neither of these, until at least 7 h or twice the normal charge period has elapsed, whichever is longer.

Tests are considered passed if all of the following are true:

- *There has been no EXPLOSION during the test.*
- No CHARRING or burning of the cotton has resulted. CHARRING or igniting of the cotton from the shorting means is not considered a failure.
- *The CELLS shall not have exceeded the UPPER LIMIT CHARGING VOLTAGE by more than 150 mV or, if they have, then the CHARGING SYSTEM shall be permanently disabled from recharging the BATTERY. To determine if recharging is disabled, the BATTERY shall be discharged by using the WELDING POWER SOURCE tested (in the case of an integral system) or by using a new sample of the WELDING POWER SOURCE (in the case of a detachable BATTERY SYSTEM) to approximately 50 % charge, followed by an attempt to recharge the BATTERY normally. There shall be no charging current after 10 min or after 25 % of the nominal capacity has been delivered, whichever occurs first.*
- *There shall be no evidence of damage to the CELL vent to impair compliance with O.14.204.*

O.9.204 Lithium-ion BATTERY short circuit

This subclause applies only to lithium-ion BATTERIES.

There shall be no risk of fire or EXPLOSION when the main discharge connections of a series configured INTEGRAL BATTERY, DETACHABLE BATTERY PACK or SEPARABLE BATTERY PACK are shorted under conditions of extreme imbalance.

Conformity shall be checked by the following test.

The test is conducted with all the CELLS of the BATTERY FULLY CHARGED and one CELL FULLY DISCHARGED.

A DETACHABLE BATTERY PACK or SEPARABLE BATTERY PACK is placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm.

A WELDING POWER SOURCE containing an integral BATTERY is placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm.

The main discharge connections of the BATTERY are shorted with a resistance not to exceed 10 mΩ. The test is conducted until the test sample experiences a failure or until the test sample returns to within 5 K of the ambient temperature. There shall be no EXPLOSION during or after the test. As a result of the test, there shall be no CHARRING or burning of the cotton. VENTING of CELLS is acceptable.

CHARRING or igniting of the cotton from the shorting means is not considered a failure.

Fuses, **thermal cut-outs, thermal links, temperature limiters**, electronic devices or any component(s) or conductor(s) that interrupt the discharge current ~~may~~ can operate during the above tests. If these devices are relied upon to pass the test, the test ~~is to~~ shall be repeated two more times, using two additional samples, and shall open the circuit in the same manner, unless the test is otherwise satisfactorily completed. Alternatively, the test ~~may~~ can be repeated with the open-circuited device bridged.

O.9.205 BATTERIES other than lithium-ion – overcharging

BATTERIES comprised of CELLS other than the lithium-ion type shall withstand abusive overcharging without risk of fire or EXPLOSION.

Conformity shall be checked by the following test.

The BATTERY is placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm and charged at a rate of 10 times the C₅ RATE for the BATTERY for 85 min. There shall be no EXPLOSION and no CHARRING or burning of the cotton. VENTING of the CELLS is acceptable.

O.9.206 BATTERY pack disconnection

Plugs, connectors and switches in the electrical current path of BATTERY packs shall be suitable for this application and shall be able to disconnect the BATTERY pack from battery-powered WELDING POWER SOURCES without risk of fire and without risk of electrical shock.

This clause does not apply to a WELDING POWER SOURCE with an INTEGRAL BATTERY.

Conformity shall be checked by VISUAL INSPECTION according to O.6.1.202 after the following tests.

The FULLY CHARGED BATTERY pack operating the battery-powered WELDING POWER SOURCE the output of which is connected to a CONVENTIONAL LOAD and adjusted to produce the RATED MAXIMUM WELDING CURRENT is disconnected 10 times.

O.9.207 GENERAL PURPOSE BATTERIES

For GENERAL PURPOSE BATTERIES replaceable by the user additional risk analysis should be performed by the manufacturer.

O.10 Connection to the supply network

Clause 10 is applicable only for BATTERY VOLTAGE CLASS B circuits conductively connected to the supply network, except as follows:

O.10.5 PROTECTIVE CIRCUIT

Addition to 10.5 of this document:

O.10.5.201 Continuity test for equipotential bonding of BATTERY VOLTAGE CLASS B circuits

All components forming the equipotential bonding current path (conductors, connections) shall withstand the maximum current in a single-fault situation.

The resistance of the equipotential bonding path between any two exposed conductive parts of the BATTERY VOLTAGE CLASS B electric circuit that can be touched simultaneously by a person shall not exceed 0,1 Ω .

The equipotential bonding resistances shall be tested by injecting a current of at least 10 A at 50 Hz or 60 Hz derived from a SELV source, which shall be passed through the potential current path between any two exposed conductive parts for at least 5 s. This path shall be isolated from other unintended potential paths for measurement. These conducting parts shall include BATTERY VOLTAGE CLASS B component housings, connections to battery-powered WELDING POWER SOURCE and the enclosures.

The voltage drop between any two reachable exposed conductive parts in a distance up to 2,5 m shall be measured and the resistance calculated from the current and this voltage drop.

NOTE 2,5 m is the usual distance which a person can reach.

O.10.8 SUPPLY CIRCUIT on/off switching device

Addition to 10.8 of this document:

Where a built-in BATTERY circuit on/off switching device (for example switch, contactor or circuit-breaker) is provided, this shall:

- a) plainly indicate whether the circuit is open or closed, and
- b) be rated as follows:
 - voltage: not less than the rated BATTERY voltage,
 - current: not less than the BATTERY current at CONVENTIONAL WELDING CONDITION with RATED MAXIMUM WELDING CURRENT,or
- c) be suitable for this application.

Conformity shall be checked by VISUAL INSPECTION for b) in accordance with other relevant standards, and for c) by the following tests.

Overload: The output of the FULLY CHARGED battery-powered WELDING POWER SOURCE is short-circuited in accordance with O.9.3. The switching device is operated for 100 cycles at the rate of 6 to 10 cycles per minute with a minimum on-time of 1 s.

Endurance: The output is connected to a CONVENTIONAL LOAD and adjusted to produce the RATED MAXIMUM WELDING CURRENT. The switching device is operated for 1 000 cycles at a rate of 6 to 10 cycles per minute with a minimum on-time of 1 s.

Addition to Clause 10 of this document:

O.10.201 For battery-powered WELDING POWER SOURCES with SEPARABLE BATTERY PACKS, the external flexible cable shall have anchorages such that the conductors are relieved from strain, including twisting, where they are connected within the WELDING POWER SOURCE, and protected from abrasion.

Conformity shall be checked by test in accordance with 10.6.

O.14 Mechanical provisions

O.14.1 General requirements

Addition to 14.1 of this document:

Following the test, the battery-powered WELDING POWER SOURCE and BATTERY pack shall not catch fire or explode.

In addition, the following applies for lithium-ion BATTERIES after the test of O.14.2.2 and O.14.4:

- the open circuit voltage of the BATTERY shall not be less than 90 % of the voltage measured immediately prior to the test;
- the BATTERY shall demonstrate normal discharging and recharging after the test;
- there shall be no damage to the CELL vent that impairs compliance with O.14.204.

O.14.2 Enclosure

O.14.2.2 Enclosure strength

Addition to 14.2.2 of this document:

DETACHABLE BATTERY PACKS shall be fitted during enclosure strength test.

For DETACHABLE BATTERY PACKS or SEPARABLE BATTERY PACKS with a mass greater than or equal to 3 kg the test is repeated on the BATTERY packs separately.

O.14.4 Drop withstand

Equipment with any DETACHABLE BATTERY PACK attached shall be capable of withstanding a drop test. For this test, the equipment shall be equipped with all the associated attachments, cooling liquid and filler wire (excluding gas cylinders, separate trailers, carts and wheel undercarriages, unless these items are standard equipment and permanently affixed) that are recommended to be installed.

The heights for the drop test shall be as follows:

- a) equipment with a mass of up to 25 kg shall withstand a drop of 250 mm;
- b) equipment with a mass of greater than 25 kg shall withstand a drop of 100 mm.

NOTE 1 Mass of equipment includes mass of associated attachments, cooling liquid and filler wire.

Conformity shall be checked by dropping the equipment three times on a hard and rigid surface. This test is so arranged that a different bottom edge of the equipment is struck each time it drops.

NOTE 2 In practice, one corner will touch the impact surface first.

In addition, for DETACHABLE BATTERY PACKS or SEPARABLE BATTERY PACKS with a mass less than 3 kg, the test is repeated on the BATTERY packs separately three times from a height of 1 m. The sample shall be positioned to vary the point of impact.

Addition to Clause 14 of this document:

O.14.201 It shall not be possible to install a DETACHABLE BATTERY PACK or a SEPARABLE BATTERY PACK in reverse polarity.

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

O.14.202 Lithium-ion BATTERY enclosure pressure test

This subclause applies only to lithium-ion BATTERIES.

An enclosure for lithium-ion BATTERIES shall be designed such that it will safely release gasses that ~~may~~ can be generated as a result of VENTING.

Conformity shall be checked by measurement in the case of a) or by the test of b):

- a) the total area of the openings in the enclosure allowing gasses to pass without obstruction shall be equal to or greater than 20 mm²; or
- b) the enclosure shall be tested as follows.

A total of $(21 \pm 2,1)$ ml of air shall be delivered at an initial pressure of $(2\,070 \pm 207)$ kPa through a $(2,87 \pm 0,05)$ mm diameter orifice to the enclosure of a WELDING POWER SOURCE with INTEGRAL BATTERY or the enclosure of a DETACHABLE BATTERY PACK or SEPARABLE BATTERY PACK. The pressure within the enclosure shall drop below 70 kPa in 30 s. There shall be no rupturing that would cause the enclosure to fail to meet the requirements of this document. An additional volume, not to exceed 3 ml, is allowed to be added to the enclosure volume as may be required for test fittings.

O.14.203 The manufacturer shall instruct the user that only GENERAL PURPOSE BATTERIES specified by the manufacturer shall be used as the primary energy source for battery-powered WELDING POWER SOURCES.

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

O.14.204 Vents of BATTERY CELLS shall not be obstructed in such a way as to defeat their operation if VENTING is relied upon for safety.

Conformity shall be checked by **VISUAL INSPECTION** or, if in doubt, by inspecting the CELLS after conclusion of the abnormal tests of O.9.201 a), b) and c) to ensure that CELLS have not vented by any means other than through the CELL vent.

O.14.205 User accessible interfaces between elements of a BATTERY SYSTEM shall not employ connectors of the following types:

- standard mains inlet connectors, except for mains supply connections;
- barrel connectors with outside diameters of 6,5 mm or less;
- phone plugs with a diameter of 3,5 mm or less.

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

O.15 RATING PLATE

O.15.3 Contents

a) Identification

Box 4 WELDING POWER SOURCE symbol if applicable (optional) and type of INTEGRAL BATTERY for example:

NiCd	nickel cadmium BATTERIES
NiMH	nickel metal-hydride BATTERIES
Li-ion	lithium-ion BATTERIES

b) Welding output

Box 12 $I_{2\max} = \dots A$ Symbol and value of RATED MAXIMUM WELDING CURRENT.

Box 13 $U_2 = \dots V$ Symbol and value of the CONVENTIONAL LOAD VOLTAGE.

Boxes 11a, 11b, 11c Not applicable.

12a, 12b, 12c Not applicable.

13a, 13b, 13c Not applicable.

Alternatively for WELDING POWER SOURCES where continuous charging during welding is possible in accordance with O.7.1.1, the DUTY CYCLE as specified in 15.3 b) ~~may~~ can be used.

c) Energy supply

Box 14 Energy supply symbol, for example:

--- Direct current

Box	WELDING POWER SOURCES with INTEGRAL BATTERY		Box	WELDING POWER SOURCES with detachable or separable BATTERY	
15	$U_b \dots V$	Rated BATTERY voltage	15	$U_b \dots V$	Rated BATTERY voltage
16	~~$E \dots Wh$~~ $Q \dots Ah$	Rated BATTERY capacity based on the rated capacity of the CELLS determined			
17	$I_b \dots A$	Rated charging current			
19	CHARGER	CHARGER specified by the manufacturer	19	BATTERY	BATTERY specified by the manufacturer
Boxes 15 to 17 form a table with corresponding values.					

Addition to 15.3 of this document:

d) Separable and DETACHABLE BATTERY PACKS shall also be marked with additional information as follows:

- type (identification) as given by the manufacturer;
- the year of manufacture and a date code identifying at least the month of manufacture;
- rated BATTERY voltage;
- the capacity assigned by the manufacturer in ~~Wh~~ Ah , based on the rated capacity of the CELLS determined;
- for alkaline or other non-acid electrolyte BATTERIES, the type of BATTERY such as Li-Ion, NiCd and NiMH.

NOTE In Canada and the United States of America, the following additional requirements apply.

A battery-powered WELDING POWER SOURCE provided with a DETACHABLE BATTERY PACK or a SEPARABLE BATTERY PACK shall be marked: "For use only with battery", or the equivalent, where the underlined space is completed with the manufacturer's name or trademark, a catalogue number, a series identification, or the equivalent, of the BATTERY pack. Alternatively, the statement "See instruction manual for additional BATTERY packs" or the equivalent ~~may~~ can be employed in addition to at least one BATTERY pack referenced by catalogue number.

A DETACHABLE BATTERY PACK, a SEPARABLE BATTERY PACK, or a battery-powered WELDING POWER SOURCE provided with an INTEGRAL BATTERY shall be marked "For use only with charger", or the equivalent, where the underlined space is completed with the manufacturer's name or trademark, a catalogue number, a series identification, or the equivalent, of the CHARGER. Alternatively, the statement "See instruction manual for additional chargers," or the equivalent ~~may~~ can be employed in addition to at least one CHARGER referenced by catalogue number.

O.17 Instructions and markings

O.17.1 Instructions

Addition to 17.1 of this document:

t) For battery-powered WELDING POWER SOURCES:

- 1) Instructions regarding BATTERY charging, information regarding ambient temperature range for WELDING POWER SOURCE and BATTERY use and storage, and the recommended ambient temperature range for the CHARGING SYSTEM during charging;
- 2) For a battery-powered WELDING POWER SOURCE intended for use with a DETACHABLE BATTERY PACK or a SEPARABLE BATTERY PACK: instructions indicating the appropriate BATTERY packs for use, such as by a catalogue number, series identification or the equivalent;
- 3) Instructions indicating the appropriate CHARGER for use, such as by a catalogue number, series identification or the equivalent;
- 4) Information regarding durability and lifetime of BATTERY, typical welding range for a FULLY CHARGED BATTERY and typical charging times;
- 5) Warnings concerning battery-powered WELDING POWER SOURCES:
 - **Recharge only with the CHARGER specified by the manufacturer.** A CHARGER that is suitable for one type of BATTERY PACK ~~may~~ can create a risk of fire when used with another BATTERY PACK.
 - **Use WELDING POWER SOURCES only with specifically designated BATTERY PACKS.** Use of any other BATTERY PACKS ~~may~~ can create a risk of injury and fire.
 - **When BATTERY PACK is not in use, keep it away from other metal objects, like paper clips, coins, keys, nails, screws or other small metal objects that can make a connection from one terminal to another.** Shorting the BATTERY terminals together ~~may~~ can cause burns or a fire.
 - **Under abusive conditions, liquid ~~may~~ can be ejected from the BATTERY; avoid contact. If contact accidentally occurs, flush with water.** If liquid contacts eyes, additionally seek medical help. Liquid ejected from the BATTERY ~~may~~ can cause irritation or burns.
 - **Do not use a BATTERY PACK or WELDING POWER SOURCE that is damaged or modified.** Damaged or modified batteries ~~may~~ can exhibit unpredictable behaviour resulting in fire, EXPLOSION or risk of injury.
 - **Do not expose a BATTERY PACK or WELDING POWER SOURCE to fire or excessive temperature.** Exposure to fire or temperature above 130 °C ~~may~~ can cause EXPLOSION.

NOTE 1 The temperature "130 °C" can be replaced by the temperature "265 °F".

Follow all charging instructions and do not charge the BATTERY PACK or WELDING POWER SOURCE outside the temperature range specified in the instructions. Charging improperly or at temperatures outside the specified range ~~may~~ can damage the BATTERY and increase the risk of fire.

NOTE 2 In Europe (~~EN 62841-1~~ EN 60974-1), the following additional requirement applies:

For battery-powered WELDING POWER SOURCES with INTEGRAL BATTERY: instruction, how the INTEGRAL BATTERY can be removed safely from the WELDING POWER SOURCE after the WELDING POWER SOURCE's end of life, and information about the type of BATTERY such as Li-Ion, NiCd and NiMH.

O.17.2 Markings

Addition to 17.2 of this document:

Marking of BATTERY VOLTAGE CLASS B electric components:

The symbol W012:2011-05 in accordance with ISO 7010:2019 shown in Figure O.1 shall appear on (preferably) or near BATTERY VOLTAGE CLASS B electric power sources.



Figure O.1 – Marking of BATTERY VOLTAGE CLASS B electric components

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Annex P **(normative)**

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 standard 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 need not be repeated, even if the tests were performed using a non-IEC standard.~~

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

~~Conformity is checked by inspection and, if necessary, by test.~~

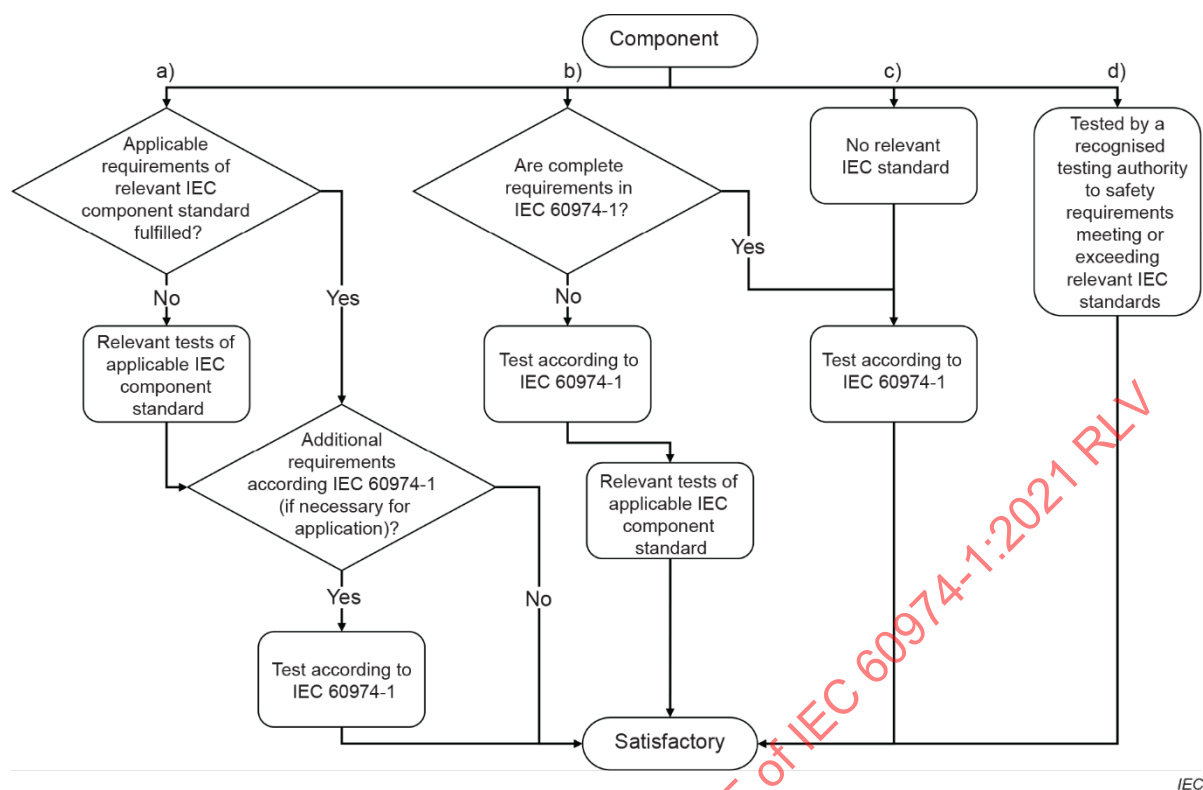


Figure P.1 – Flow chart for conformity methods of Annex P

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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Arc welding equipment –
Part 1: Welding power sources**

**Matériel de soudage à l'arc –
Partie 1: Sources de courant de soudage**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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: 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.

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

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

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

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 62133-1:2017, *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 62133-2:2017, *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 7010:2019, *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.

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

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]

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.

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).

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

$I_{2\max}$

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

$I_{2\min}$

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

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

$I_{1\max}$

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

$I_{1\text{eff}}$

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:

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

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.

**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 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 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 60664-1:2020.

- 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: Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

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

**3.1.41
micro-environment**

<of an electrical system> ambient conditions which immediately influences the dimensioning of the CLEARANCE and CREEPAGE DISTANCES

[SOURCE: IEC 60664-1:2020, 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

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

- MATERIAL GROUP I: $600 \leq \text{CTI}$;
- MATERIAL GROUP II: $400 \leq \text{CTI} < 600$;
- MATERIAL GROUP IIIa: $175 \leq \text{CTI} < 400$;
- MATERIAL GROUP IIIb: $100 \leq \text{CTI} < 175$.

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]

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.

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.

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, 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 60050-811:2017, 811-13-33, modified – Deletion of the Note 1 to entry.]

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 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**C₅ 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]

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 can be charged utilizing a mains supply cable or 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.5.1.209.

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

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”.

3.3.3

active power

P

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

$$P = \frac{1}{T} \int_0^T p dt$$

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

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]

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: $-10\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$;
- b) relative humidity of the air:
up to 50 % at $40\text{ }^{\circ}\text{C}$;
up to 90 % at $20\text{ }^{\circ}\text{C}$;
- 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 $-20\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ 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 $40\text{ }^{\circ}\text{C}$, 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 of $(25 \pm 10)\text{ }^{\circ}\text{C}$.

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 $\pm 5\text{ }%$.

5.2 Measuring instruments

The accuracy of measuring instruments shall be:

- a) electrical measuring instruments: CLASS I ($\pm 1\text{ }%$ 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: $\pm 2\text{ K}$;
- c) tachometer: $\pm 1\text{ }%$ of full-scale reading.

All electrical measurements shall be made with a maximum measurement uncertainty of $5\text{ }%$.

5.3 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.

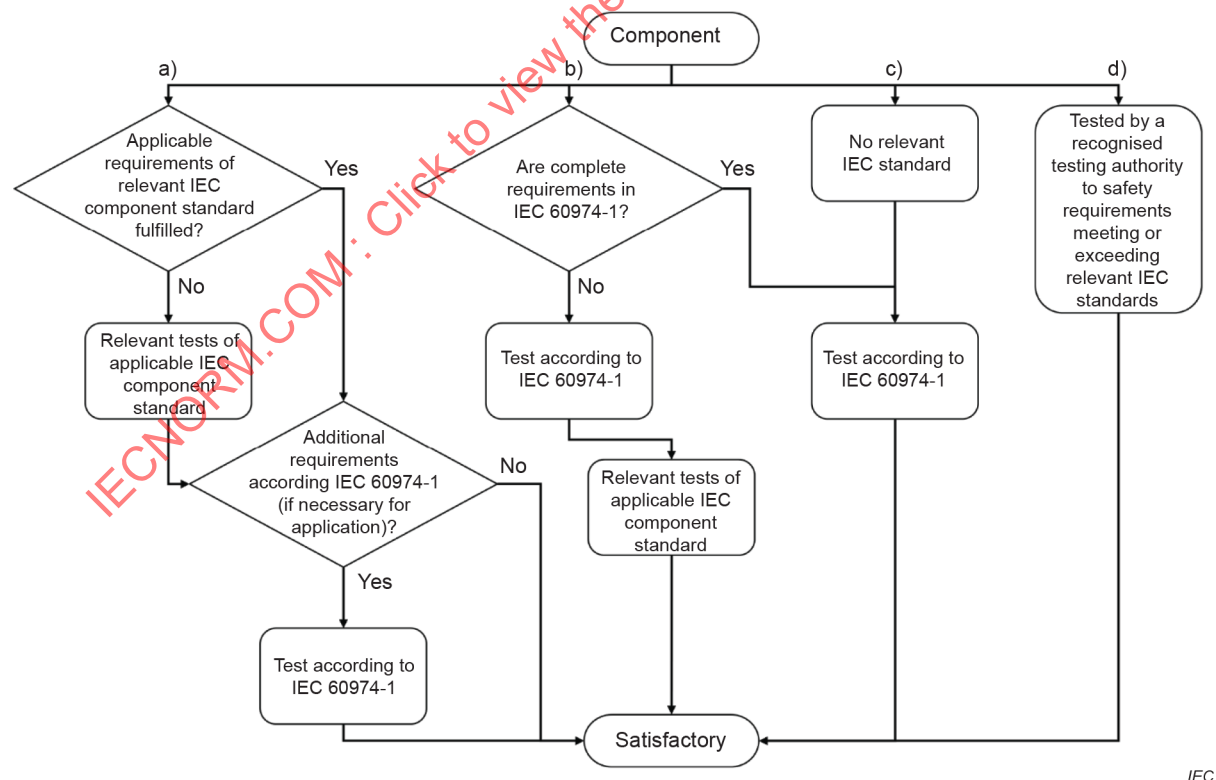


Figure 1 – Flow chart for conformity methods of 5.3

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 can be completed in any convenient sequence.

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 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.

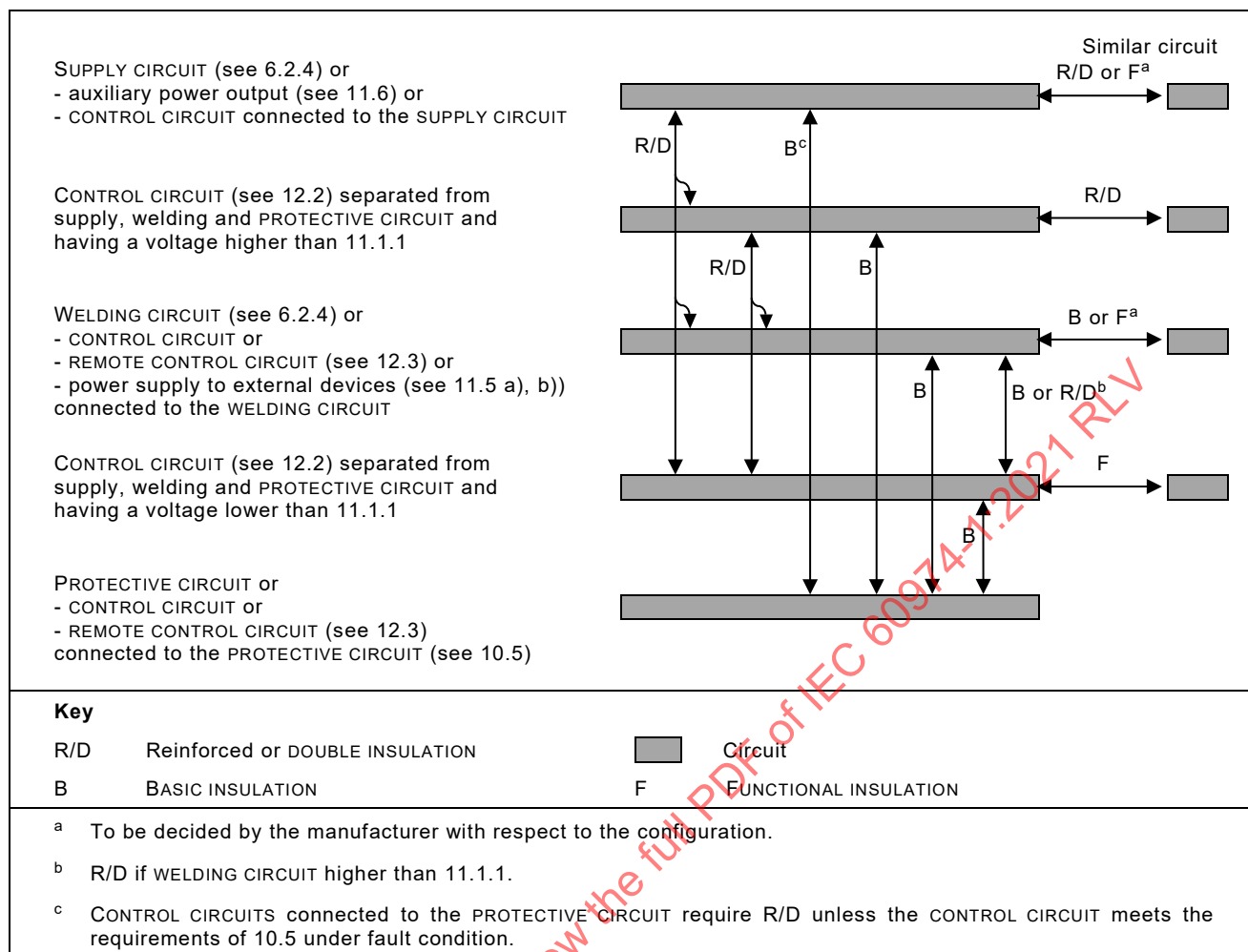
Components or subassemblies with CLEARANCES or CREEPAGE DISTANCES corresponding to POLLUTION DEGREE 2 are permitted if the MICRO-ENVIRONMENT of the component or subassembly is improved (by means such as filtering, coating, potting, moulding) so that only non-conductive pollution or occasional temporary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



IEC

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.

Table 2 – Minimum CLEARANCES for overvoltage category III

Voltage line-to-neutral derived from nominal voltages AC or DC up to and including ^a V RMS	Basic or SUPPLEMENTARY INSULATION					REINFORCED INSULATION				
	Rated impulse test voltage peak V	AC test voltage V RMS.	POLLUTION DEGREE			Rated impulse test voltage peak V	AC test voltage V RMS	POLLUTION DEGREE		
			2	3	4			2	3	4
			CLEARANCE					CLEARANCE		
			mm					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 60664-1:2020.										
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) can be rated in accordance with overvoltage category I (see IEC 60664-1).

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 60664-1:2020 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 μ s and an output impedance of less than 500 Ω .

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

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 are the sum of the values for the BASIC INSULATION and SUPPLEMENTARY INSULATION which make up the DOUBLE INSULATION.

CREEPAGE DISTANCES for REINFORCED INSULATION shall be twice 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.

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 60664-1:2020.

Table 3 – Minimum CREEPAGE DISTANCES

Working voltage	CREEPAGE DISTANCES in mm								
	Basic or SUPPLEMENTARY INSULATION								
	Printed wiring material		POLLUTION DEGREE						
	POLLUTION DEGREE								
V RMS	1	2	1	2			3		
	a	b	a	MATERIAL GROUP			MATERIAL GROUP		
	mm	mm	mm	I	II	III	I	II	III
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).

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 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:

- first test of a WELDING POWER SOURCE: test voltages given in Table 5;
- repetition of the test of the same WELDING POWER SOURCE: test voltage 80 % of the values given in Table 5.

Table 5 – Dielectric test voltages

Maximum rated voltage ^a V RMS	AC dielectric test voltage V RMS			
	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 can be used.

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

- 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.
- 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.
- 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 can be applied simultaneously. An example is given in Annex B.

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 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.

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.

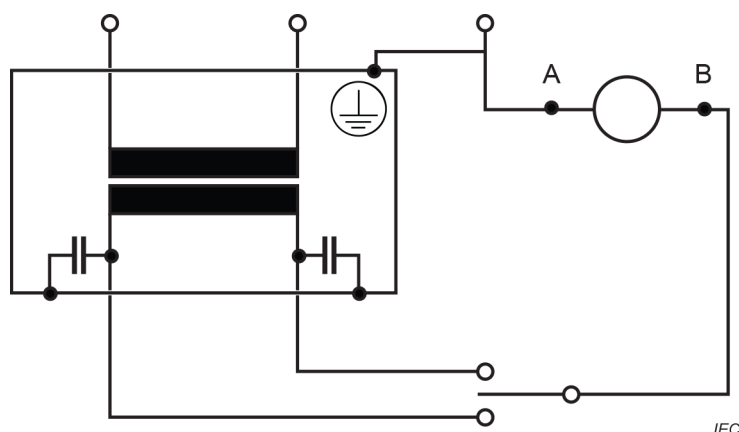
Conformity shall be checked by tests given in 6.1.

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.

The measuring network specified in 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.

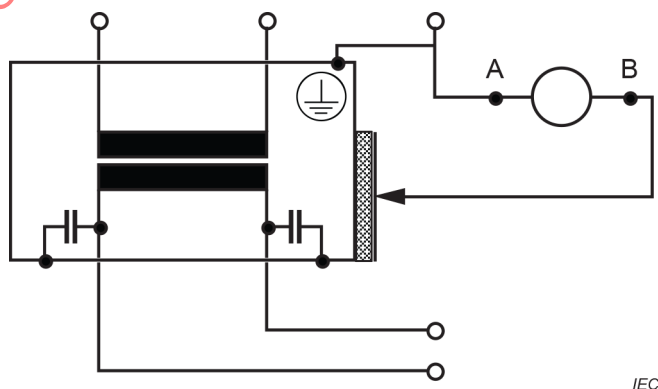


Figure 4 – Measurement of TOUCH CURRENT in normal condition

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).

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.

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 $(10 \pm 0,2)$ 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.

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: $\begin{matrix} +10 \\ -2 \end{matrix}$ % of the appropriate CONVENTIONAL LOAD VOLTAGE;
- b) WELDING CURRENT: $\begin{matrix} +10 \\ -2 \end{matrix}$ % 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: $\begin{matrix} +10 \\ -2 \end{matrix}$ 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.

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 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.

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 and slip-rings
°C	°C	Surface temperature sensor	Resistance	Embedded temperature sensor	
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.

Table 8 – Temperature limits for external surfaces

External surface	Maximum TEMPERATURE RISE	Burn threshold for contact period ^a
	K	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 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 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.

- 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.

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.

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 layer of dry absorbent surgical type cotton is placed under the WELDING POWER SOURCE, extending beyond each side for a distance of 150 mm.
- Starting from the cold state, the WELDING POWER SOURCE is operated in accordance with 9.2 to 9.4.
- During the test, the WELDING POWER SOURCE shall not emit flames, molten metal or other materials that ignite the cotton indicator.
- 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			Minimum cross-section ^a
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:

- for 15 s in the case of a DROOPING CHARACTERISTIC;
- 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.

The supply voltage shall not decrease by more than 10 % during this test.

Mechanically driven WELDING POWER SOURCES are short circuited for 2 min at maximum output setting and set for operation at RATED LOAD SPEED.

9.4 Overload test

The WELDING POWER SOURCE is operated for 4 h in accordance with 7.1.1 b) at 1,5 times the corresponding DUTY CYCLE.

If the WELDING POWER SOURCE is rated for more than 67 % DUTY CYCLE, this test is conducted at 100 % DUTY CYCLE.

If the WELDING POWER SOURCE is provided with output regulating taps, those taps producing the highest supply current shall be used.

If the DUTY CYCLE at the RATED MAXIMUM WELDING CURRENT is 100 %, the WELDING POWER SOURCE shall not be tested.

9.5 Capacitors short circuit

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 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:

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 capacitor class X and class Y, or capacitors having internal fusing or a circuit-breaker, this test is not required.

10 Connection to the supply network

10.1 Supply voltage

WELDING POWER SOURCES shall be capable of operating at the RATED SUPPLY VOLTAGE ± 10 %. This can give deviations from the RATED VALUES.

Conformity shall be checked by the following test:

The WELDING POWER SOURCE is connected to a CONVENTIONAL LOAD and adjusted to minimum and maximum output. Each setting is tested at RATED SUPPLY VOLTAGE ± 10 %. Verify presence of stable current flow in the WELDING CIRCUIT under these four conditions.

10.2 Multi-supply voltage

WELDING POWER SOURCES which are designed to operate from different supply voltages shall be fitted with one of the following:

- a) an internal voltage selection panel where the adjustment for the supply voltage is made by links. A marking shall indicate the arrangement of links for each supply voltage;
- b) an internal terminal box or panel in which the terminals are clearly marked with the supply voltages;
- c) a switch for tap selection which shall be fitted with an interlocking system which prevents the switch being moved to an incorrect position. The interlocking system shall be adjusted only by the use of a tool;
- d) two supply cables, each fitted with a different plug, and a selector switch which ensures that the pins of the plug not in use cannot become live;
- e) a system to automatically configure the WELDING POWER SOURCE in accordance with the supply voltage.

NOTE WELDING POWER SOURCES can be fitted with an external indication of the supply voltage selected.

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

In the case d), a selector switch is additionally tested in accordance with 10.8.

10.3 Means of connection to the SUPPLY CIRCUIT

Acceptable means of connection to the SUPPLY CIRCUIT are one of the following:

- a) terminals intended for the permanent connection of flexible supply cables;
- b) terminals intended for the connection of supply cables to a permanent installation;
- c) appliance inlets fitted to the WELDING POWER SOURCE.

NOTE This requirement can also be met by using terminals on a device such as a switch, contactor, etc.

The means of connection to the SUPPLY CIRCUIT shall be chosen in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT I_{ref} and the maximum supply voltage and meet the requirements of the relevant standards or be designed in accordance with Annex E.

Conformity shall be checked by VISUAL INSPECTION.

10.4 Marking of terminals

The terminal for the external protective conductor shall be marked with the symbol  (IEC 60417-5019:2006-08).

Optionally the following may be added:

- a) the letters: **PE**
or
- b) the twin colours: **green and yellow**.

Additionally, three-phase equipment terminals shall be clearly marked in accordance with IEC 60445 or other relevant component standards. The identifying marking notation shall be located on or adjacent to the corresponding terminal.

Conformity shall be checked by VISUAL INSPECTION.

10.5 PROTECTIVE CIRCUIT

10.5.1 Continuity requirement

The internal PROTECTIVE CIRCUIT shall be capable of withstanding currents likely to be encountered in the case of a fault.

CLASS I WELDING POWER SOURCES shall have a suitable terminal, adjacent to the phase-conductor terminals, dimensioned in accordance with Annex E and Table E.1, for the connection of the external protective conductor. This terminal shall not be used for any other purpose (such as for clamping two parts of the casing together).

On and inside the WELDING POWER SOURCE, if there is a neutral-conductor terminal, this shall not be in electrical contact with the terminal for the connection of the protective conductor.

Both inside and outside the WELDING POWER SOURCE, insulated protective conductors shall have the twin colours green and yellow. If the WELDING POWER SOURCE is supplied with a flexible multi-conductor supply cable, this shall have the protective conductor with the twin colours green and yellow.

In some countries, the single colour green is also used to identify the protective conductor and the protective conductor terminal.

If the WELDING POWER SOURCE is fitted with a protective conductor, it shall be connected in such a way that if the cable is pulled away from the terminals, the phase conductors break before the protective conductor.

Conformity shall be checked by VISUAL INSPECTION and the tests given in 10.5.2 and 10.5.3.

The method of securing conductive parts to the PROTECTIVE CIRCUITS, for example paint-piercing washers, paint-piercing screws or non-painted surfaces shall be considered during VISUAL INSPECTION.

10.5.2 TYPE TEST

A current of 200 % of the MAXIMUM EFFECTIVE SUPPLY CURRENT as given on the RATING PLATE is applied from an enclosure part, that is likely to become live, through the external protective conductor terminal for a period of time given in Table 10, using the smallest external protective conductor size given in Table 11.

NOTE The waveform of the test current is not defined as long as the effective value is used for comparison.

Table 10 – Current and time requirements for PROTECTIVE CIRCUITS

Current A	Time min
Up to 30	2
31 to 60	4
61 to 100	6
101 to 200	8
Above 200	10

Table 11 – Minimum cross-sectional area of the external protective copper conductor

Cross-sectional area of phase conductors supplying the equipment S mm^2	Minimum cross-sectional area of the external protective copper conductor S_p mm^2
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

During the test there shall be no melting of any metal, deterioration of the bond to the WELDING POWER SOURCE, nor heating likely to cause a fire, nor shall the measured voltage drop from the enclosure part to the terminal exceed 4 V RMS.

10.5.3 ROUTINE TEST

The test is to verify the continuity of the PROTECTIVE CIRCUIT by injecting a current of at least 10 A at 50 Hz or 60 Hz derived from a SELV source. The tests are to be made between the PE terminal and relevant points that are part of the PROTECTIVE CIRCUIT. The test time is 1 s.

The measured voltage between the PE terminal and the points of test shall not exceed the values given in Table 12:

Table 12 – Verification of continuity of the PROTECTIVE CIRCUIT

Minimum effective protective conductor cross-sectional area of the branch under test mm^2	Maximum measured voltage drop (values are given for a test current of 10 A) V
1,0	3,3
1,5	2,6
2,5	1,9
4,0	1,4
> 6,0	1,0

10.6 Cable anchorage

WELDING POWER SOURCES fitted with terminals for the connection of flexible supply cables shall be provided with a cable anchorage that relieves the electrical connection from strain.

The cable anchorage shall be so constructed that

- it is dimensioned for flexible cables having the range of cross-sectional area of conductor as specified in Table E.1;
- the method of anchorage can be easily recognized;
- the cable can be easily replaced;
- the cable cannot come into contact with conductive clamping screws of the cable anchorage if these screws are accessible or in electrical contact with exposed conductive parts;
- the cable is not retained by a metal screw which bears directly on it;
- at least one part of the cable anchorage is securely fixed to the WELDING POWER SOURCE;
- any screws that shall be loosened or tightened during cable replacement do not serve to fix any other component;

- h) when fitted to a CLASS II WELDING POWER SOURCE, it shall be made of insulating material or so insulated that, if there is a cable insulation fault, no exposed conductive parts shall become live.

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

A flexible supply cable, which has the minimum cross-sectional area of the conductor specified, is connected at the point of connection to the equipment. The cable anchorage is fitted to the cable and tightened.

It shall then not be possible to push the cable so far into the WELDING POWER SOURCE that either the cable itself or internal parts of the WELDING POWER SOURCE are likely to be damaged.

The cable anchorage is then loosened and retightened 10 times.

The cable is then subjected for 1 min to a pull as specified in Table 13 without jerking.

Table 13 – Pull

Nominal cross-sectional area of the conductor mm ²	Pull N
1,5	150
2,5	220
4,0	330
6 and above	440

At the end of the test, the cable shall not have been displaced by more than 2 mm and the ends of the conductors shall not have been noticeably displaced in the terminals. To measure the displacement, prior to the test, a mark is provided at a distance of 20 mm from the cable anchorage on the cable with the cable in the stressed condition.

After the test, the displacement of this mark in relation to the cable anchorage is measured, with the cable in the stressed condition.

During the test, no visible damage (for example nicks, cuts or tears in the sheath) shall be caused to the cable.

The test is then repeated with the maximum cross-sectional area of the conductor specified.

10.7 Inlet openings

Where the supply cable passes through metallic parts, it shall be provided with a bushing of insulating material, or the openings shall be smoothly rounded with a radius of at least 1,5 mm.

Conformity shall be checked by VISUAL INSPECTION.

10.8 SUPPLY CIRCUIT on/off switching device

Where a built-in SUPPLY CIRCUIT on/off switching device (for example switch, contactor or circuit-breaker) is provided, this shall:

- switch all ungrounded mains conductors, and
- plainly indicate whether the circuit is open or closed, and either

c) be rated as follows:

- voltage: not less than the values given on the RATING PLATE,
 - current: not less than the highest effective supply current as given on the RATING PLATE,
- or

d) be suitable for this application.

Conformity shall be checked by VISUAL INSPECTION; for c) in accordance with other relevant standards, and for d) by the following tests.

For the tests, the SUPPLY CIRCUIT on/off switching devices can be mounted external to the power source.

A WELDING POWER SOURCE is connected for the RATED SUPPLY VOLTAGE that corresponds to the RATED MAXIMUM SUPPLY CURRENT and, in addition for CLASS I EQUIPMENT, a fuse of 10 A to 20 A is placed

- in the case of an earthed SUPPLY CIRCUIT, in the protective earth connection;
- in the case of an unearthed SUPPLY CIRCUIT, between a phase conductor and the PROTECTIVE CIRCUIT.

During the tests, the supply voltage shall be maintained at not less than at the RATED VALUE.

Overload: The output of the WELDING POWER SOURCE is short-circuited in accordance with 9.3. The switching device is operated for 100 cycles at the rate of 6 cycles/min to 10 cycles/min with a minimum on-time of 1 s.

A switching device shall not be tested if its RATED VALUE exceeds twice the RATED MAXIMUM SUPPLY CURRENT of the WELDING POWER SOURCE.

Endurance: The output is connected to a CONVENTIONAL LOAD and adjusted to produce the rated WELDING CURRENT at 100 % DUTY CYCLE. The switching device is operated for 1 000 cycles at a rate of 6 cycles/min to 10 cycles/min with a minimum on-time of 1 s.

A WELDING POWER SOURCE with more than one RATED SUPPLY VOLTAGE is also tested at the rated maximum supply voltage.

There shall be no electrical or mechanical failure and, in addition for CLASS I EQUIPMENT, no clearing of the fuse.

NOTE A component having demonstrated that it passes these tests can be used in other similar applications if the other requirements are equal or less.

10.9 Supply cables

When supply cables are attached to the WELDING POWER SOURCE, they shall:

- a) be suitable for the application and meet national and local regulations;
 - b) be dimensioned in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT $I_{1\text{eff}}$;
- and
- c) have a length of at least 2 m as measured from the exit point of the enclosure.

Conformity shall be checked by VISUAL INSPECTION.

NOTE Examples of local regulations are given in the Bibliography, e.g. EN 50525-2-21, Electrical code NFPA 70 (SE, SO, ST, STO or other extra hard usage cable) or CSA C22.1. PVC insulation has been proven not suitable for the application.

10.10 Supply coupling device (attachment plug)

If a supply coupling device is provided as a part of the arc welding equipment, its RATED VALUES shall be not less than:

- a) the rated current of the fuse required to comply with the tests specified in 9.3 regardless of whether or not a SUPPLY CIRCUIT switch is incorporated;
- b) the MAXIMUM EFFECTIVE SUPPLY CURRENT $I_{1\text{eff}}$.

For supply networks up to 125 V, the rated current shall, additionally, not be less than either c) or d):

- c) 70 % of the RATED MAXIMUM SUPPLY CURRENT for equipment incorporating a supply switch;
- d) 70 % of the supply current measured with the output short-circuited at maximum setting for equipment not incorporating a supply switch.

Furthermore, the coupling device shall be suitable for industrial purposes.

NOTE Example of coupling devices suitable for industrial purposes can be found in IEC 60309-1.

Conformity shall be checked by VISUAL INSPECTION, measurement and calculation.

11 Output

11.1 RATED NO-LOAD VOLTAGE

11.1.1 RATED NO-LOAD VOLTAGE for use in environments with increased risk of electric shock

If the WELDING POWER SOURCE is not fitted with a HAZARD REDUCING DEVICE in accordance with Clause 13, the RATED NO-LOAD VOLTAGE shall not exceed:

- a) DC 113 V peak;
- b) AC 68 V peak and 48 V RMS.

Such WELDING POWER SOURCES may be marked with symbol 84 of Annex L S.

Conformity shall be checked by measurement and by analysis of the circuit and/or by failure simulation in accordance with 11.1.5.

11.1.2 RATED NO-LOAD VOLTAGE for use in environments without increased risk of electric shock

If the WELDING POWER SOURCE is not fitted with a HAZARD REDUCING DEVICE in accordance with Clause 13, the RATED NO-LOAD VOLTAGE shall not exceed

- a) DC 113 V peak;
- b) AC 113 V peak and 80 V RMS.

Conformity shall be checked by measurement in accordance with 11.1.5.

11.1.3 RATED NO-LOAD VOLTAGE for the use with mechanically held torches with increased protection for the operator

The RATED NO-LOAD VOLTAGE shall not exceed

- a) DC 141 V peak;
- b) AC 141 V peak and 100 V RMS.

These values may only be used if the following requirements are fulfilled:

- 1) the torch shall not be hand-held;
- 2) the NO-LOAD VOLTAGE shall be switched off automatically when the welding is stopped;
and
- 3) the protection against direct contact with live parts shall be given by:
 - a minimum degree of protection of IP2X,
 - or
 - a HAZARD REDUCING DEVICE (see Clause 13).

Conformity shall be checked by measurement in accordance with 11.1.5, by operation and by VISUAL INSPECTION.

11.1.4 RATED NO-LOAD VOLTAGE for special processes for example plasma cutting

The RATED NO-LOAD VOLTAGE shall not exceed 500 V peak DC.

Conformity shall be checked by measurement in accordance with 11.1.5, by operation and by VISUAL INSPECTION, except that the series combination of the 200 Ω fixed and 5 k Ω variable resistors can be replaced by a fixed resistance of 5 k Ω .

A RATED NO-LOAD VOLTAGE exceeding 113 V peak DC can only be used if the following requirements are fulfilled.

- a) These PLASMA CUTTING POWER SOURCES with their corresponding torches shall prevent the output of NO-LOAD VOLTAGE if the torch is disassembled or disconnected from the PLASMA CUTTING POWER SOURCE.
- b) The NO-LOAD VOLTAGE shall be less than 68 V peak not later than 2 s after the CONTROL CIRCUIT (for example start switch) is opened.
- c) The voltage between the tip of the torch and the workpiece or earth shall be less than 68 V peak not later than 2 s after both pilot and main arcs are extinguished.

The conditions for complying with these requirements shall be given in the instructions.

Such PLASMA CUTTING POWER SOURCES may be marked with the symbol 84 of Annex L.

Conformity shall be checked by measurement by meter or oscilloscope in parallel with 5 k Ω minimum resistance.

11.1.5 Additional requirements

The RATED NO-LOAD VOLTAGE at all possible output settings shall not exceed the values given in 11.1.1 to 11.1.4, summarized in Table 14.

During measurement, the actual supply voltage shall not vary from the RATED SUPPLY VOLTAGE by greater than $\pm 6\%$. If the NO-LOAD VOLTAGE varies with supply voltage, then for a variation of supply voltage greater than $\pm 1\%$, the NO-LOAD VOLTAGE shall be linearly corrected in accordance with the actual supply voltage.

Table 14 – Summary of allowable RATED NO-LOAD VOLTAGES

Subclause	Working conditions	RATED NO-LOAD VOLTAGE
11.1.1	ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK	DC 113 V peak AC 68 V peak and 48 V RMS
11.1.2	Environment without increased risk of electric shock	DC 113 V peak AC 113 V peak and 80 V RMS
11.1.3	Mechanically held torches with increased protection for the operator	DC 141 V peak AC 141 V peak and 100 V RMS
11.1.4	Plasma cutting	DC 500 V peak

WELDING POWER SOURCES shall be

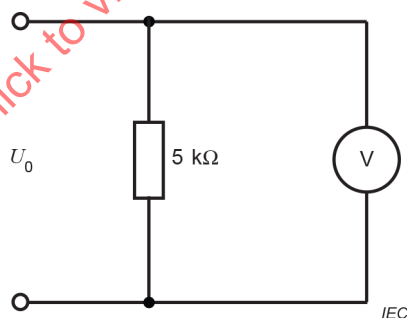
- a) designed to ensure that the output voltages given in Table 14 are not exceeded in the event of failure of any component (for example, open circuit or short circuit failure)
- or
- b) fitted with a protection system, which switches off the voltage at the output terminals within 0,3 s and shall not be reset automatically.

These values are not applicable to voltages for arc striking or arc stabilizing that could be superimposed.

Conformity shall be checked by measurement and by analysis of the circuit and/or by failure simulation.

11.1.6 Measuring circuits

For measuring RMS values, a true RMS meter shall be used together with a resistor of $(5 \pm 0,25) \text{ k}\Omega$, connected across the WELDING CIRCUIT terminals as shown in Figure 5.



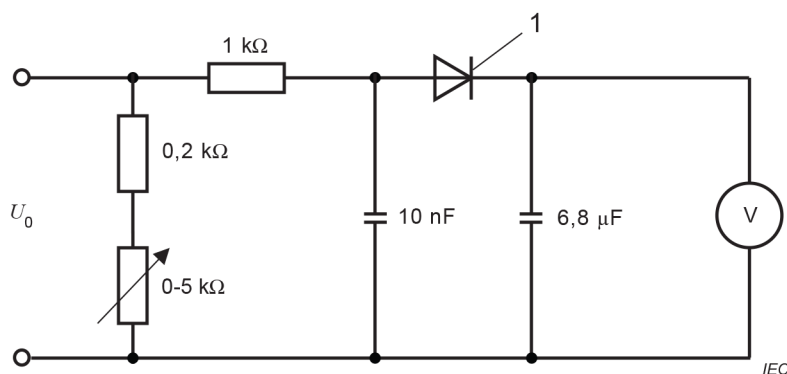
Key

U_0 NO-LOAD VOLTAGE

V True RMS voltmeter

Figure 5 – Measurement of RMS values

To obtain reproducible measurements of peak values, omitting impulses which are not dangerous, a circuit as shown in Figure 6 shall be used.

**Key** U_0 NO-LOAD VOLTAGE

V Voltmeter

1 Diode 1N4007 or similar

Figure 6 – Measurement of peak values

The voltmeter shall indicate mean values. The measurement range chosen shall be as near as possible to the actual value of the NO-LOAD VOLTAGE. The voltmeter shall have an internal resistance of at least 1 MΩ.

The tolerance of the component values in the measurement circuit shall not exceed $\pm 5\%$.

For the TYPE TEST, the rheostat is varied from 0 Ω to 5 kΩ in order to obtain the highest peak value of the voltage measured with these loads of 200 Ω to 5,2 kΩ. This measurement is repeated with the two connections to the measuring apparatus reversed.

The rheostat resistance and connection that produces the highest value of the voltage can be determined during the TYPE TEST. This resistance and lead polarity can be used for the ROUTINE TEST.

11.2 TYPE TEST values of the CONVENTIONAL LOAD VOLTAGE**11.2.1 Manual metal arc welding with covered electrodes**

$$I_2 \text{ up to } 600 \text{ A: } U_2 = (20 + 0,04 I_2) \text{ V}$$

$$I_2 \text{ over } 600 \text{ A: } U_2 = 44 \text{ V}$$

11.2.2 Tungsten inert gas

$$I_2 \text{ up to } 600 \text{ A: } U_2 = (10 + 0,04 I_2) \text{ V}$$

$$I_2 \text{ over } 600 \text{ A: } U_2 = 34 \text{ V}$$

11.2.3 Metal inert/active gas and flux cored arc welding

$$I_2 \text{ up to } 600 \text{ A: } U_2 = (14 + 0,05 I_2) \text{ V}$$

$$I_2 \text{ over } 600 \text{ A: } U_2 = 44 \text{ V}$$

11.2.4 Submerged arc welding

$$I_2 \text{ up to } 600 \text{ A: } U_2 = (20 + 0,04 I_2) \text{ V}$$

$$I_2 \text{ over } 600 \text{ A: } U_2 = 44 \text{ V}$$

11.2.5 Plasma cutting

I_2 up to 170 A: $U_2 = (80 + 0,4 I_2) \text{ V}$

I_2 between 170 A and 500 A: $U_2 = (131 + 0,1 I_2) \text{ V}$

I_2 above 500 A: $U_2 = 181 \text{ V}$

For plasma cutting, the manufacturer can specify additional LOAD VOLTAGES as determined under typical cutting conditions.

NOTE The manufacturer-specified LOAD VOLTAGE is used due to the nature of the plasma process. Factors that can influence the voltage at which satisfactory performance occurs include the interaction of the plasma torch design, recommended plasma gas, and standoff distance.

11.2.6 Plasma welding

I_2 up to 600 A: $U_2 = (25 + 0,04 I_2) \text{ V}$

I_2 over 600 A: $U_2 = 49 \text{ V}$

11.2.7 Plasma gouging

I_2 up to 300 A: $U_2 = (100 + 0,4 I_2) \text{ V}$

I_2 over 300 A: $U_2 = 220 \text{ V}$

For plasma gouging, the manufacturer can specify additional LOAD VOLTAGES as determined under typical gouging conditions.

NOTE The manufacturer-specified LOAD VOLTAGE is used due to the nature of the plasma process. Factors that can influence the voltage at which satisfactory performance occurs include the interaction of the plasma torch design, recommended plasma gas, and standoff distance.

11.2.8 Additional requirements

Throughout its range of adjustment, the electrically powered WELDING POWER SOURCES shall be capable of delivering CONVENTIONAL WELDING CURRENTS (I_2) at CONVENTIONAL LOAD VOLTAGES (U_2) in accordance with 11.2.1 to 11.2.7.

Conformity shall be checked by sufficient measurements (see Annex H).

11.3 Mechanical switching devices used to adjust output

A switch, contactor, circuit-breaker or other control device used to adjust or control the level of output from the WELDING POWER SOURCE shall have an endurance suitable for the application.

Conformity shall be checked by the following test.

The device is installed in a test WELDING POWER SOURCE and subjected to 6 000 cycles of operation over the complete range of mechanical movement with the output at the no-load condition. If the device is in the SUPPLY CIRCUIT, the WELDING POWER SOURCE is operated at the highest RATED SUPPLY VOLTAGE. Check that no electrical or mechanical failure of the device or damage to the WELDING POWER SOURCE occurs.

NOTE A component having demonstrated that it passes these tests can be used in other similar applications, if the other requirements are equal or less.

11.4 WELDING CIRCUIT connections

11.4.1 Protection against unintentional contact

WELDING CIRCUIT connections, with or without welding cables connected, shall be protected against unintentional contact by persons or by metal objects, for example vehicles, crane hooks, etc.

Examples of how such protection can be afforded.

- a) Any live part of a coupling device is recessed behind the plane of the access opening. Devices complying with IEC 60974-12 meet the requirement.
- b) A hinged cover or a protective guard is provided.

Conformity shall be checked by VISUAL INSPECTION.

11.4.2 Location of coupling devices

Uncovered coupling devices shall be located so that their openings are not tilted upwards.

NOTE Coupling devices fitted with an automatic closing device can have their openings tilted upwards.

Conformity shall be checked by VISUAL INSPECTION.

11.4.3 Outlet openings

Where welding cables pass through metallic parts, the edges of the opening shall be smoothly rounded with a radius of at least 1,5 mm.

Conformity shall be checked by VISUAL INSPECTION.

11.4.4 Three-phase multi-operator welding transformer

All welding output connections intended to be connected to the workpiece shall have a common interconnection within the WELDING POWER SOURCE.

Welding output connections of the same phase shall all be marked in the same way as each other.

Conformity shall be checked by VISUAL INSPECTION.

11.4.5 Marking

Connections designed specifically for attachment to the workpiece or to the electrode shall be so identified.

For DC WELDING POWER SOURCES, the polarity shall be clearly marked, either on the welding output connections or on the polarity selector. This requirement is not relevant for PLASMA CUTTING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION.

11.4.6 Connections for plasma cutting torches

The torch shall be connected to and disconnected from the PLASMA CUTTING POWER SOURCE:

- a) within the PLASMA CUTTING POWER SOURCE, by use of a tool, by screws or coupling devices;
- or

b) on the PLASMA CUTTING POWER SOURCE, by a coupling device which is:

- 1) designed to avoid connection of incompatible torches
or
- 2) operated by use of a tool.

When the coupling device is disconnected, no voltage higher than the limits of SELV accessible to the operator shall be present.

Conformity shall be checked by VISUAL INSPECTION and measurement.

11.5 Power supply to external devices connected to the WELDING CIRCUIT

When a WELDING POWER SOURCE supplies electrical power to an external device including a connection to the WELDING CIRCUIT, such power shall be supplied by one of the following:

- a) the WELDING CIRCUIT;
- b) a safety isolating transformer in accordance with IEC 61558-2-6 or equivalent means incorporated in the WELDING POWER SOURCE;
- c) an isolating transformer in accordance with IEC 61558-2-4 with a rated secondary voltage up to 120 V RMS if all exposed conductive parts of the external device, as recommended by the manufacturer, are connected to the protective earth conductor that is protected against the WELDING CURRENT, for example by a current sensing relay or by insulation of the relevant metal parts, for example by an enclosure.

External devices include wire feed units, arc striking and stabilizing devices, torches, seam trackers or other devices containing a connection to the WELDING CIRCUIT.

Conformity shall be checked by VISUAL INSPECTION and fault simulation.

11.6 Auxiliary power supply

In the case of WELDING POWER SOURCES designed to supply electrical power to external devices which are not a part of the WELDING CIRCUIT (for example for lighting, external cooling system or electric tools), these auxiliary circuits and accessories shall comply with the standards and regulations relating to the use of these external devices.

The WELDING CIRCUIT shall be isolated from such SUPPLY CIRCUITS in accordance with 6.2.4 and 6.3.2.

Near the socket-outlet of the auxiliary power supply, the available current, voltage, DUTY CYCLE if less than 100 %, AC or DC and the status of the neutral (for example earthed or unearthed) as appropriate, shall be clearly and indelibly marked.

Conformity shall be checked by VISUAL INSPECTION during the tests in accordance with 6.1.4, 6.1.5, 6.2.4 and 6.3.2 and by rubbing the marking in accordance with 15.1.

11.7 Welding cables

If a WELDING POWER SOURCE is supplied with welding cables, they shall meet the requirements of IEC 60245-6 or meet national and local regulations.

If a PLASMA CUTTING POWER SOURCE is supplied with welding cables, they shall meet the current and NO-LOAD VOLTAGE ratings suitable for the application and meet national and local regulations.

NOTE 1 Example or local regulations are given in the Bibliography, e.g. EN 50525-2-81:2011. Additional information about the current carrying capability of welding cables can be found in EN 50565-1:2014.

NOTE 2 PVC insulation has been proved not suitable for the application and is not recognised in welding cable product standards of IEC or CENELEC.

NOTE 3 The rated voltage of welding cables complying with IEC 60245-6 is typically not suitable for plasma cutting applications.

12 CONTROL CIRCUITS

12.1 General requirement

All inputs and outputs of CONTROL CIRCUITS shall be tested at the maximum load as specified by the manufacturer. REMOTE CONTROL CIRCUITS can be tested without connection to the power source, provided that the power source can be simulated.

Conformity shall be checked by measurement or analysis, as appropriate.

12.2 Isolation of CONTROL CIRCUITS

A CONTROL CIRCUIT that leaves the enclosure that has a voltage lower than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1, and that is separated from the WELDING CIRCUIT and SUPPLY CIRCUIT shall be:

- a) insulated from the SUPPLY CIRCUIT by double or REINFORCED INSULATION,
- b) insulated from all other circuits having a voltage higher than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1 (e.g. auxiliary power SUPPLY CIRCUITS, plasma cutting circuit) by double or REINFORCED INSULATION, and
- c) insulated from the WELDING CIRCUIT having a voltage lower than the allowable NO-LOAD VOLTAGE in accordance with 11.1.1 by BASIC INSULATION.

NOTE Example of insulation configuration for CLASS I EQUIPMENT is given in 6.1.1.

Conformity shall be checked by measurement or analysis, as appropriate.

12.3 WORKING VOLTAGES of remote CONTROL CIRCUITS

The WORKING VOLTAGES in REMOTE CONTROL CIRCUITS that are designed to be handheld shall not exceed 50 V AC or 120 V ripple free DC between conductors, or between any conductor and PROTECTIVE CIRCUIT, under normal operating conditions and after a single fault.

NOTE WORKING VOLTAGE requirements for local or wide area computer networks are contained in IEC 60950-1.

Conformity shall be checked by measurement or analysis, as appropriate.

13 HAZARD REDUCING DEVICE

13.1 General requirements

A HAZARD REDUCING DEVICE shall reduce the severity of the electric shock that can originate from NO-LOAD VOLTAGES exceeding the allowable RATED NO-LOAD VOLTAGE for a given environment. Types of HAZARD REDUCING DEVICES are given in 13.2.

Requirements are given in Table 15.

Table 15 – HAZARD REDUCING DEVICE requirements

Unreduced NO-LOAD VOLTAGE in accordance with subclause	Reduced NO-LOAD VOLTAGE in accordance with subclause	Operating time s
Between 11.1.3 and 11.1.2	11.1.1	0,3
Between 11.1.2 and 11.1.1	11.1.1	2
For DC WELDING POWER SOURCE above 113 V, an operating time of 0,3 s is required.		

13.2 Types of HAZARD REDUCING DEVICES

13.2.1 Voltage reducing device

A voltage reducing device shall have automatically reduced the RATED NO-LOAD VOLTAGE to a level not exceeding the values of 11.1.1 at the moment the resistance of the external WELDING CIRCUIT exceeds 200 Ω . The operating time is specified in Table 15.

Such WELDING POWER SOURCES may be marked with the symbol 84 of Annex L.

Conformity shall be checked by connecting a variable load resistor across the welding output connections of the WELDING POWER SOURCE. Voltage measurements and operating time are taken while the resistance is being increased.

13.2.2 Switching device for AC to DC

A switching device for AC to DC shall have automatically switched the rated AC NO-LOAD VOLTAGE to a rated DC NO-LOAD VOLTAGE not exceeding the values given in 11.1.1 at the moment the resistance of the external WELDING CIRCUIT exceeds 200 Ω . The operating time is specified in Table 15.

Such WELDING POWER SOURCES can be marked with the symbol 84 of Annex L.

Conformity shall be checked in accordance with 13.2.1.

13.3 Requirements for HAZARD REDUCING DEVICES

13.3.1 Disabling the HAZARD REDUCING DEVICE

The design shall be such that the operator cannot disable or by-pass the HAZARD REDUCING DEVICE without the use of a tool.

Conformity shall be checked by VISUAL INSPECTION.

13.3.2 Interference with operation of a HAZARD REDUCING DEVICE

REMOTE CONTROLS, as specified by the manufacturer, and arc striking or arc stabilizing devices of the WELDING POWER SOURCE shall not interfere with the proper functioning of the HAZARD REDUCING DEVICE, i.e. NO-LOAD VOLTAGE limits shall not be exceeded.

Conformity shall be checked by repeating the tests of 13.2.1 with any of the devices that could interfere with the operation of the HAZARD REDUCING DEVICE.

13.3.3 Indication of satisfactory operation

A reliable device, for example a signal lamp, shall be provided which indicates that the HAZARD REDUCING DEVICE is operating satisfactorily. Where a signal lamp is used, it shall light when the voltage has been reduced or changed to DC.

Conformity shall be checked by VISUAL INSPECTION during the test in accordance with 13.1.

13.3.4 Fail to a safe condition

If the HAZARD REDUCING DEVICE fails to operate in accordance with 13.1, the voltage at the output terminals shall be reduced to a level not exceeding 11.1.1 in accordance with Table 15 and shall not be reset automatically.

Conformity shall be checked by simulating a fault of the HAZARD REDUCING DEVICE and measuring the time to reach a safe condition after failure of the HAZARD REDUCING DEVICE.

14 Mechanical provisions

14.1 General requirements

Equipment shall be constructed and assembled so that it has the strength and rigidity necessary to withstand the normal service to which it is likely to be subjected, without increasing the risk of electric shock or other hazards whilst maintaining the minimum CLEARANCES required. Equipment shall be provided with a case or cabinet that encloses all live and hazardous moving parts (such as pulleys, belts, fans, gears etc.) except that the following shall not be fully enclosed:

- a) supply, control and welding cables;
- b) output terminals for the connection of welding cables.

After the tests in accordance with 14.2 to 14.5, the equipment shall comply with the provisions of this document. Some deformation of the structural parts or enclosure is permitted provided this does not reduce the level of safety protection.

Accessible parts shall have no sharp edges, rough surfaces or protruding parts likely to cause injury.

Conformity shall be checked by VISUAL INSPECTION after meeting the requirements of 14.2 to 14.5.

14.2 Enclosure

14.2.1 Enclosure materials

Non-metallic materials intended to protect from contact with live parts, except welding and SELV circuits, shall have a flammability classification of V-1 or better in accordance with IEC 60695-11-10.

Conformity is checked by inspection of non-metallic materials specification.

14.2.2 Enclosure strength

The enclosure, including air louvers, shall withstand an impact energy of 10 Nm in accordance with Annex I.

Handles, push buttons, adjustment dials etc. shall not be tested with the pendulum hammer.

Alternatively, the enclosure can be constructed of sheet metal with a minimum thickness in accordance with Annex J.

Conformity shall be checked in accordance with a) or b) below.

- a) By an impact test using a pendulum impact hammer in accordance with I.1 or using a free fall weight in accordance with I.2 or equivalent means as follows:
 - 1) one sample is tested;
 - 2) the WELDING POWER SOURCE is not energized during the test;
 - 3) select one impact point on each side, where risk of electrical shock or malfunction is highest;
 - 4) apply three impacts to selected impact points.
- b) By measurement of the thickness of the sheet metal.

14.3 Handling means

14.3.1 Mechanised handling

If means for mechanical handling are provided (for example eyelet or lug) for the purpose of lifting an assembled equipment, these shall be capable of withstanding the mechanical stress of a static pull with a force calculated from the mass of the assembled equipment as follows.

- a) For equipment with a mass of up to 150 kg, a force calculated from 10 times the mass shall be used.
- b) For equipment with a mass of greater than 150 kg, a force calculated from four times the mass or at least 15 kN shall be used.

If only a single lifting means is provided, it shall be designed so that a torque applied during lifting cannot cause it to be loosened.

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

The equipment is fitted with all the associated attachments, (excluding gas cylinders, separate trailers, carts and wheel undercarriages) that are likely to be installed and, in the case of engine-driven WELDING POWER SOURCES, completely serviced and ready for operation. The equipment is anchored rigidly at its base and a chain or cable is attached to its lifting means, as recommended by the manufacturer, and an upward force is then exerted continuously for 10 s.

If two or more lifting means are provided, the chains or cables are arranged so that the force is equally shared between them and is applied at an angle not greater than 15° to the vertical.

14.3.2 Manual handling

If means for manual handling are provided for lifting or carrying (for example handles, straps), these shall be capable of withstanding the mechanical stress of a static pull with a force calculated from the mass of the assembled equipment as follows.

A force calculated from four times the mass or at least 600 N shall be used.

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

The equipment is fitted with all the associated attachments, (excluding gas cylinders, separate trailers, carts and wheel undercarriages) that are likely to be installed. The equipment is anchored rigidly at its base and a chain or cable is attached to its handles or strap, as recommended by the manufacturer, and an upward force is then exerted continuously for 10 s.

14.4 Drop withstand

Equipment shall be capable of withstanding a drop test. For this test, the equipment shall be equipped with all the associated attachments, cooling liquid and filler wire (excluding gas cylinders, separate trailers, carts and wheel undercarriages, unless these items are standard equipment and permanently affixed) that are recommended to be installed.

The heights for the drop test shall be as follows:

- a) equipment with a mass of up to 25 kg shall withstand a drop of 250^{+10}_0 mm;
- b) equipment with a mass of greater than 25 kg shall withstand a drop of 100^{+10}_0 mm.

NOTE 1 Mass of equipment includes mass of associated attachments, cooling liquid and filler wire.

Conformity shall be checked by dropping the equipment three times on a hard and rigid surface. This test is so arranged that a different bottom edge of the equipment is struck each time it drops.

NOTE 2 In practice, one corner will touch the impact surface first.

Engine-driven WELDING POWER SOURCES shall be filled up and be ready for immediate use.

14.5 Tilting stability

Equipment in its most unstable position shall not topple over when tilted up to 10°. Auxiliary items as specified by the manufacturer in accordance with the type of the equipment such as gas cylinders, wire feed unit or cooling device could affect the stability, and these shall be taken into account.

If the manufacturer specifies other auxiliary items, so that the requirement of this subclause cannot be met, then instructions shall be provided for anchorage or other means as necessary.

Conformity shall be checked by the following test.

The equipment is placed on a plane and tilted from the horizontal level.

15 RATING PLATE

15.1 General requirements

A clearly and indelibly marked RATING PLATE shall be fixed securely to or printed on each WELDING POWER SOURCE.

NOTE The purpose of the RATING PLATE is to indicate to the user the electrical characteristics, which enables the comparison and correct selection of WELDING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

After this test, the marking shall be easily legible. It shall not be easy to remove the RATING PLATE and it shall show no curling.

15.2 Description

The RATING PLATE shall be divided into sections containing information and data for the

- a) identification;
- b) welding output;
- c) energy supply.

The arrangement and sequence of the data shall comply with the principle shown in Figure 7 (for examples, see Annex K).

The dimensions of the RATING PLATE are not specified and can be chosen freely.

It is permissible to separate the above sections from each other and affix them at locations more accessible or convenient for the user.

For WELDING POWER SOURCES to be used for several welding processes or for rotating WELDING POWER SOURCES, either one combined or several separate RATING PLATE(S) can be used.

NOTE Additional information can be given. Further useful information, for example CLASS OF INSULATION, POLLUTION DEGREE or POWER FACTOR, can be given in technical literature supplied by the manufacturer (see 17.1).

a) Identification					
1)					
2)			3)		
4) Optional			5)		
b) Welding output					
6)		8)		10)	
		11)		11a)	
				11b)	
				11c)	
7)		9)		12)	
				12a)	
				12b)	
				12c)	
		13)		13a)	
				13b)	
				13c)	
c) Energy supply					
14)		15) or 18)		16)	
		or 19)		or 20) If applicable	
				or 21) If applicable	
22) Optional		23) If applicable			

IEC

Figure 7 – Principle of the RATING PLATE

15.3 Contents

The following explanations refer to the numbered boxes shown in Figure 7.

a) Identification

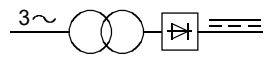
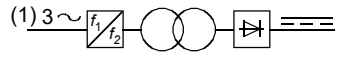
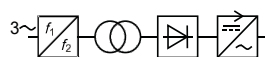
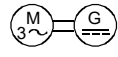
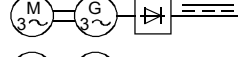
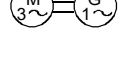
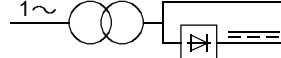
Box 1 Name and address of the manufacturer or distributor or importer and, optionally, a trademark and the country of origin, if required.

Box 2 Type (identification) as given by the manufacturer.

Box 3 Traceability of design and manufacturing data, for example serial number.

NOTE 1 National or local regulation (e.g. Commission Regulation (EU) 2019/1784) may require to provide the year of manufacture on the RATING PLATE. Alternative methods like decoding the traceability number or retrieving the year of manufacture by typing the traceability number into a web-tool provided by the manufacturer, is considered to fulfil the requirement.

Box 4 WELDING POWER SOURCE symbol (optional) for example:

	Single-phase transformer
	Three-phase transformer-rectifier
	Single- or three-phase static frequency converter-transformer-rectifier
	Inverter power source with AC and DC output
	Three-phase motor-generator
	Three-phase motor-generator-rectifier
	Three-phase rotating frequency converter
	Single-phase combined AC and DC power source
	Engine-AC generator
	Engine-generator-rectifier

Box 5 Reference to the standards confirming that the WELDING POWER SOURCE complies with their requirements.

b) Welding output

Box 6 Welding process symbol for example:

	Manual metal arc welding with covered electrodes
	Tungsten inert-gas welding
	Metal inert and active gas welding including the use of flux cored wire
	Self shielded flux cored arc welding
	Submerged arc welding
	Plasma cutting
	Plasma gouging
	Plasma welding

Box 7  Mark for WELDING POWER SOURCES which are suitable for supplying power to welding operations carried out in an ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK (if applicable).

NOTE 2 In addition, this symbol, of a suitable size, can be displayed on the front of the WELDING POWER SOURCE.

Box 8 WELDING CURRENT symbol for example:



Direct current



Alternating current, and additionally the rated frequency in hertz for example: ~50 Hz



Direct and alternating current at the same output, and additionally the rated frequency in hertz

Box 9 $U_0 \dots V$ RATED NO-LOAD VOLTAGE (see 11.1)

- 1) peak value in case of direct current;
- 2) RMS value in case of alternating current.

NOTE 3 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.

If several NO-LOAD VOLTAGES are adjustable, their range shall be given by the rated minimum and maximum NO-LOAD VOLTAGE.

Additionally, the following shall be given.

- 3) $U_r \dots V$ reduced RATED NO-LOAD VOLTAGE in case of a voltage reducing device;
- 4) $U_s \dots V$ switched RATED NO-LOAD VOLTAGE in case of an AC to DC switching device.

Box 10 $\dots A / \dots V$ to $\dots A / \dots V$ Range of output, minimum WELDING CURRENT and its corresponding CONVENTIONAL LOAD VOLTAGE or less, maximum WELDING CURRENT and its corresponding CONVENTIONAL LOAD VOLTAGE or greater.

Box 11 X DUTY CYCLE symbol.

Box 12 I_2 Rated WELDING CURRENT symbol.

Box 13 U_2 CONVENTIONAL LOAD VOLTAGE symbol.

Boxes 11a, 11b, 11c $\dots \%$ Values of the DUTY CYCLE at an ambient temperature of 40 °C.

12a, 12b, 12c $\dots A$ Values of the rated WELDING CURRENT.

13a, 13b, 13c $\dots V$ Values of the CONVENTIONAL LOAD VOLTAGE.

These boxes form a table with corresponding values of the three settings:

- 1) $\dots \%$ DUTY CYCLE at the RATED MAXIMUM WELDING CURRENT;
- 2) 60 % DUTY CYCLE;
- and
- 3) 100 % DUTY CYCLE as far as relevant.

Column a) shall not be used if the DUTY CYCLE for the RATED MAXIMUM WELDING CURRENT is 60 % or 100 %.

Column b) shall not be used if the DUTY CYCLE at the RATED MAXIMUM WELDING CURRENT is 100 %.

c) Energy supply

Box 14 Energy supply symbol, for example:



SUPPLY CIRCUIT, number of phases (for example 1 or 3), symbol for alternating current and the rated frequency (for example 50 Hz or 60 Hz)



Engine



Motor



Belt drive

Box	Electrically powered WELDING POWER SOURCES		Box	Mechanically powered WELDING POWER SOURCES	
15	$U_1 \dots V$	RATED SUPPLY VOLTAGE	18	$n \dots \text{min}^{-1}$	RATED LOAD SPEED
16	$I_{1\text{max}} \dots A$	RATED MAXIMUM SUPPLY CURRENT	19	$n_0 \dots \text{min}^{-1}$	RATED NO-LOAD SPEED
17	$I_{1\text{eff}} \dots A$	MAXIMUM EFFECTIVE SUPPLY CURRENT	20	$n_i \dots \text{min}^{-1}$	RATED IDLE SPEED, if applicable
Boxes 15 to 17 form a table with corresponding values.			21	$P_{1\text{max}} \dots \text{kW}$	Maximum power consumption, if applicable

Box 22 IP.. Degree of protection, for example IP21 or IP23.



Box 23 Symbol for CLASS II EQUIPMENT, if applicable.

Conformity shall be checked by VISUAL INSPECTION and by checking of complete data.

15.4 Tolerances

Manufacturers shall meet RATING PLATE values within the following tolerances by controlling component and manufacturing tolerances:

- a) U_0 RATED NO-LOAD VOLTAGE in $V \pm 5 \%$ measured in accordance with 11.1, but in no case shall the values summarized in Table 14 be exceeded;
- b) $I_{2\text{min}}$ RATED MINIMUM WELDING CURRENT in A;
 $U_{2\text{min}}$ minimum CONVENTIONAL LOAD VOLTAGE in V;
 The values of b) shall be no greater than 102 % of those stated on the RATING PLATE.
- c) $I_{2\text{max}}$ RATED MAXIMUM WELDING CURRENT in A;
 $U_{2\text{max}}$ maximum CONVENTIONAL LOAD VOLTAGE in V;
 The values of c) shall be no less than 98 % of those stated on the RATING PLATE.
- d) n_0 RATED NO-LOAD SPEED of rotation in $\text{min}^{-1} \pm 5 \%$;
- e) $P_{1\text{max}}$ maximum power consumption in $\text{kW} \begin{smallmatrix} +10 \\ 0 \end{smallmatrix} \%$;
- f) $I_{1\text{max}}$ RATED MAXIMUM SUPPLY CURRENT in $A \pm 10 \%$.

- g) The efficiency measured on any equipment connected to the supply network shall not be less than the reported value. The IDLE STATE power consumption shall not be greater than the reported value.

Conformity shall be checked by measuring under CONVENTIONAL WELDING CONDITIONS.

15.5 Direction of rotation

If necessary, the direction of rotation shall be indicated on rotating WELDING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION.

16 Adjustment of the output

16.1 Type of adjustment

If the WELDING POWER SOURCE has a means to adjust the output current, output voltage or both, the adjustment can be continuous, step-by-step, or both.

In the case of a continuous adjustment with several ranges, there shall be no gap between the ranges.

Conformity shall be checked by measuring.

16.2 Marking of the adjusting device

The output of the WELDING POWER SOURCE corresponding to different control settings shall be clearly and indelibly marked either on or by the controls, or displayed digitally.

With the exception of WELDING POWER SOURCES that are set or adjusted with or by means of a digital read-out, the following shall apply.

- a) The setting indications on the scales or control tables shall take into account the relationship between the CONVENTIONAL LOAD VOLTAGE and the CONVENTIONAL WELDING CURRENT.
- b) Each position in the case of a step-by-step adjustment or each major graduation in the case of a continuous adjustment shall be clearly marked with
 - 1) a numerical indication of the controllable parameters;
or, where this is not possible,
 - 2) an alphanumeric marking.

In case 2), a table on the apparatus or in the instructions shall indicate, for each control position, the nominal value of the (control) parameter.
- c) In the case of multiple range adjustment, maximum and minimum values for each range shall be given.
- d) WELDING POWER SOURCES designed for use with more than one process, for which the CONVENTIONAL LOAD VOLTAGE differs, shall be marked with a separate control scale for each process. If this is not possible, alphanumeric marks as given in b) shall be used.
- e) Where the WELDING POWER SOURCE is designed so that it can be supplied at several RATED SUPPLY VOLTAGES and where, for the same control position, the numerical values of the welding parameters are not the same, separate scales or a separate series of alphanumeric markings shall be fitted.

Conformity shall be checked by VISUAL INSPECTION.

16.3 Indication of current or voltage control

16.3.1 General

Where there is a voltage or current control, the output setting shall be indicated in volts, amperes or an arbitrary reference scale.

16.3.2 Set value

The accuracy of voltage or current indication shall be

- a) between 100 % and 25 % of the maximum setting ± 10 % of the true value;
- b) below 25 % of the maximum setting $\pm 2,5$ % of the maximum setting.

Conformity shall be checked by measurement and VISUAL INSPECTION.

16.3.3 Displayed value

If the manufacturer provides an analog ammeter or voltmeter on the equipment, this shall be of class 2,5 and be properly damped.

The accuracy of provided digital ammeters shall be equal or better than $\pm 2,5$ % of highest RATED VALUE for WELDING CURRENT according to RATING PLATE.

The accuracy of provided digital voltmeters shall be equal or better than $\pm 1,5$ V.

Conformity shall be checked by measurement and VISUAL INSPECTION.

NOTE Where a display is provided, Commission Regulation (EU) 2019/1784 requires to provide indication of the use of welding wire or filler material in g/min or equivalent standardised units of measurement, Providing the wire-feed speed in m/min, or optionally in inch/min, is considered to fulfil the requirement.

17 Instructions and markings

17.1 Instructions

Each WELDING POWER SOURCE shall be delivered with instructions which shall include the following (as applicable):

- a) general description;
- b) mass of the WELDING POWER SOURCE and its various parts and correct methods of handling them, for example by fork-lift or crane, and precautions to be taken with gas cylinders, wire feeders, etc.;
- c) the meaning of indications, markings and graphical symbols;
- d) information for selection and connection to the supply network (for example suitable supply cables, connection devices or attachment plugs, including the type and RATED VALUES for RCD, fuse or circuit-breaker, see also caution of 6.1.1) by qualified personnel in accordance with relevant national and local regulations;

NOTE Some national and local regulations require use of RCDs. Types of RCDs and their use are given in Annex B of IEC 60755:2017. Only Type B" RCDs provide protection where SUPPLY CIRCUIT DC fault currents are likely to occur.

- e) correct operational use relating to the WELDING POWER SOURCES (for example cooling requirements, location, control device, indicators, fuel type);
- f) welding capability, STATIC CHARACTERISTIC (drooping and/or flat), DUTY CYCLE (DUTY FACTOR) limitations and explanation of THERMAL PROTECTION if relevant;
- g) limitations of use relating to the degree of protection provided, for example WELDING POWER SOURCES are not suitable for use in rain or snow;

- h) basic guidelines regarding protection against personal hazards for operators and persons in the work area (for example electric shock, fumes, gases, arc rays, hot metal, sparks, noise, back injury during manual handling);
- i) conditions under which extra precautions are to be observed when welding or cutting (for example ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK, flammable surroundings, flammable products, closed containers, elevated working positions, etc.);
- j) how to maintain the WELDING POWER SOURCE, such as recommended cycles for partial and complete test and other operation (for example cleaning);
- k) a list of parts typically replaced due to wear;
- l) information on supply of electrical power to external devices, for example for lighting or electric tools;
- m) precautions against toppling over, if the WELDING POWER SOURCE shall be placed on tilted plane;
- n) warning against the use of a WELDING POWER SOURCE for pipe thawing;
- o) type (identification) of plasma cutting torches that are specified for use with the PLASMA CUTTING POWER SOURCE;
- p) pressure, flow rate and type of plasma gas and if relevant, of cooling gas or cooling liquid;
- q) steps or range of the output current and the corresponding plasma gas as a set of values;
- r) EMC classification in accordance with IEC 60974-10;
- s) for an engine-driven WELDING POWER SOURCE, warning against the carbon monoxide component of engine exhaust (example of National Labelling Regulation is given in *US Code of Federal Regulations, Title 16, Parts 1407*).

Other useful information can also be given, for example CLASS OF INSULATION, POLLUTION DEGREE, efficiency (see Annex M), etc.

Conformity shall be checked by reading the instructions.

17.2 Markings

Each WELDING POWER SOURCE shall be clearly and indelibly marked on or near the front panel or near the ON/OFF switching device with the following combination of symbols to signify "Caution! Read instruction manual":



This marking shall also be used near the torch connector of PLASMA CUTTING POWER SOURCES indicating that the operator should read the instruction manual before selecting and connecting a torch. A single marking readily visible within operator line of sight to the front panel, ON/OFF switching device and torch connector is permitted.

The following equivalent wording can be used:

Warning: Read instruction manuals before operating and servicing this equipment.

For other additional markings, see Annex L.

NOTE Precautionary labels appearing on power sources can consist of text only, text and symbols, or symbols only. Symbols-only precautionary labels are specified in ISO 17846.

Conformity shall be checked by VISUAL INSPECTION and by testing in accordance with the durability test in 15.1.

Annex A

(normative)

Nominal voltages of supply networks

Table A.1 – Nominal voltages for supply networks with protective overvoltage control

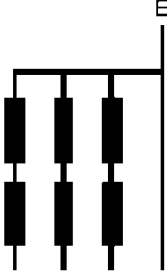
Voltage line-to-neutral derived from nominal voltages AC or DC up to and including ^c	Nominal voltages presently used in the world			
	Three-phase four-wire systems with earthed neutral  V	Three-phase three-wire systems earthed or unearthed (E)  V	Single-phase two-wire systems AC or DC  V	Single-phase three-wire systems AC or DC  V
50			12,5 24 25 30 42 48	30 to 60
100	66/115	66	60	
150	120/208 ^a , 127/220	115, 120, 127	100 ^b 110, 120	100 to 200 ^b , 110 to 220, 120 to 240
300	220/380, 230/400, 240/415, 260/440, 277/480	200 ^b , 220, 230, 240, 260, 277	220	220 to 440
600	347/600, 380/660, 400/690, 417/720, 480/830	347, 380, 400, 415, 440, 480 500, 577, 600	480	480 to 960
1 000		660, 690, 720, 830, 1 000	1 000	
NOTE 1 Values taken from Table B.2 of IEC 60664-1:2020.				
NOTE 2 "E" means "earthed".				
^a Practice in the United States of America and in Canada.				
^b Practice in Japan.				
^c Voltage line-to-neutral to be used in Table 2.				

Table A.2 – Single-phase three-wire or two-wire AC or DC systems

Nominal voltage of the mains supply	Voltage rationalized for Table 3	
	For insulation line-to-line ^a	For insulation line-to-earth ^a
	All systems	Three-wire systems mid-point earthed
V	V	V
12,5	12,5	
24 25	25	
30	32	
42 48 50 ^b	50	
60	63	
30 to 60	63	32
100 ^b	100	
110 120	125	
150 ^b	160	
200	200	
100 to 200	200	100
220	250	
110 to 220 120 to 240	250	125
300 ^b	320	
220 to 440	500	250
600 ^b	630	
480 to 960	1 000	500
1 000 ^b	1 000	

NOTE Values taken from Table F.3 of IEC 60664-1:2020.

^a Line-to-earth insulation level for unearthed or impedance-earthed systems equals that for line-to-line because the operating voltage to earth of any line can, in practice, approach full line-to-line voltage. This is because the actual voltage to earth is determined by the insulation resistance and capacitive reactance of each line to earth; thus, low (but acceptable) insulation resistance of one line can in effect earth it and raise the other two to full line-to-line voltage to earth.

^b These values correspond to the values given in Table A.1.

Table A.3 – Three-phase four-wire or three-wire AC systems

Nominal voltage of the mains supply	Voltages rationalized for Table 3		
	For insulation line-to-line	For insulation line-to-earth	
	All systems	Three-phase four-wire systems neutral-earthed ^b	Three-phase three-wire systems unearthed ^a or corner-earthed
V	V	V	V
60	63	32	63
110 120 127	125	80	125
150 ^c	160	–	160
200	200		200
208	200	125	200
220 230 240	250	160	250
300 ^c	320	–	320
380 400 415	400	250	400
440	500	250	500
480 500	500	320	500
575	630	400	630
600 ^c	630	–	630
660 690	630	400	630
720 830	800	500	800
960	1 000	630	1 000
1 000 ^c	1 000	–	1 000

NOTE Values taken from Table F.4 of IEC 60664-1:2020.

^a Line-to-earth insulation level for unearthed or impedance-earthed systems equals that for line-to-line because the operating voltage to earth of any line can, in practice, approach full line-to-line voltage. This is because the actual voltage to earth is determined by the insulation resistance and capacitive reactance of each line to earth; thus, low (but acceptable) insulation resistance of one line can in effect earth it and raise the other two to full line-to-line voltage to earth.

^b For equipment for use on both three-phase four-wire and three-phase three-wire supplies, earthed and unearthed, use the values for three-wire systems only.

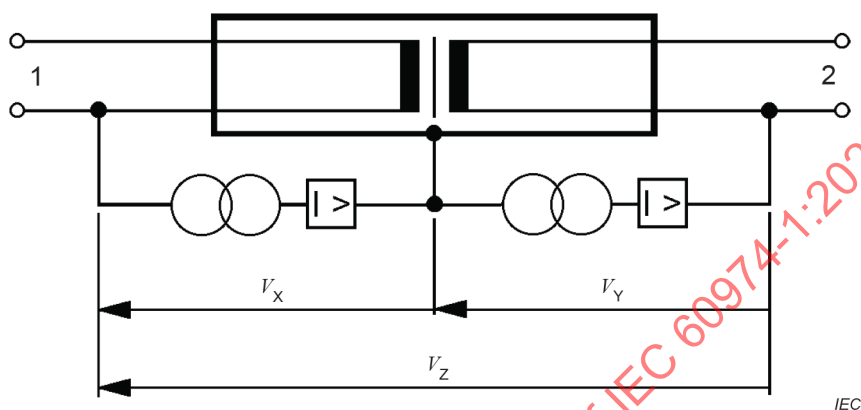
^c These values correspond to the values given in Table A.1.

Annex B (informative)

Example of a combined dielectric test

Two high voltage transformers may be connected in series, correctly phased.

The common connection is to exposed conductive parts (see Figure B.1).



Key



Current sensing tripping device



SUPPLY CIRCUIT



WELDING CIRCUIT

V_X SUPPLY CIRCUIT to exposed conductive parts

V_Y WELDING CIRCUIT to exposed conductive parts

V_Z SUPPLY CIRCUIT to WELDING CIRCUIT

Figure B.1 – Combined high-voltage transformers

Annex C (normative)

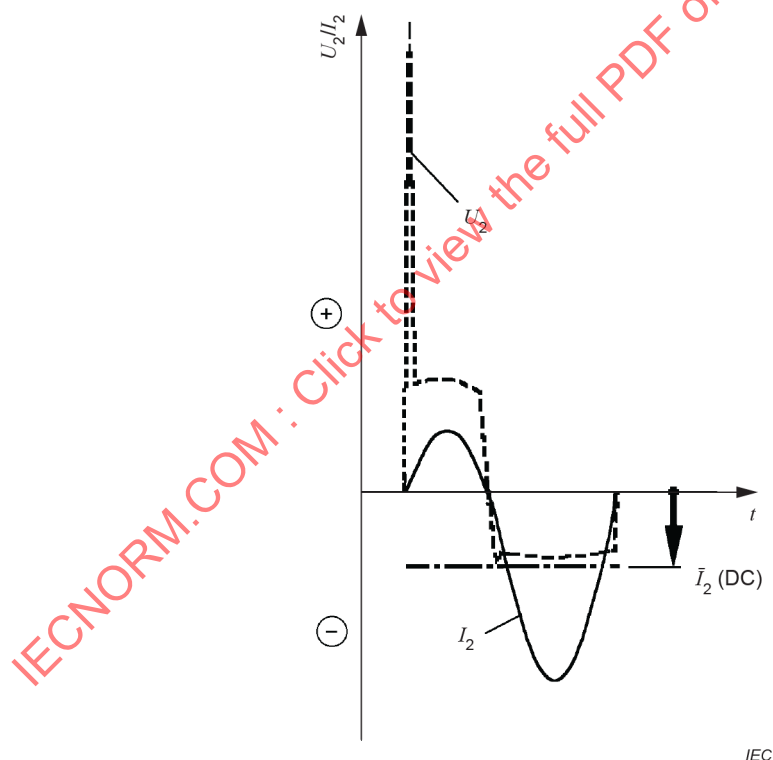
Unbalanced load in case of AC tungsten inert-gas WELDING POWER SOURCES

C.1 General

The difference in emissivity between the electrode and the workpiece in AC tungsten inert-gas welding causes an unbalanced welding voltage and a corresponding unbalance in the WELDING CURRENT.

This unbalance is called the DC component, and can cause saturation of the transformer of a transformer type WELDING POWER SOURCE. Such saturation will cause an abnormally high supply current that could cause severe over-heating.

Figure C.1 shows that the WELDING CURRENT has a DC component $\bar{I}_2$ that may overheat the winding of the WELDING POWER SOURCE.



Key

U_2 Welding voltage

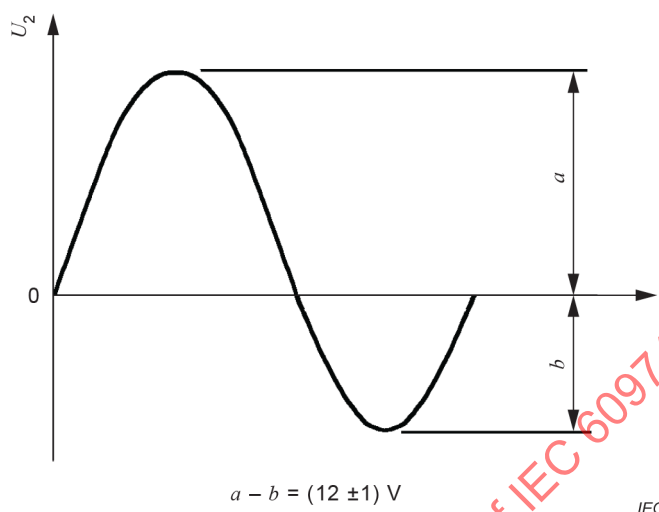
I_2 WELDING CURRENT

$\bar{I}_2$ Arithmetic mean value of the WELDING CURRENT

Figure C.1 – Voltage and current during AC tungsten inert-gas welding

C.2 Unbalanced load

To simulate the required WELDING CURRENTS for the heating test, a CONVENTIONAL LOAD shall be used with a partial rectifying characteristic, so that if the polarity of the electrode is negative, the half-cycle voltage shall be (12 ± 1) V less than the half-cycle voltage if the polarity of the electrode is positive (see Figure C.2).



Key

- a peak voltage value when the electrode is positive
- b peak voltage value when the electrode is negative

Figure C.2 – Unbalanced voltage during AC tungsten inert-gas welding

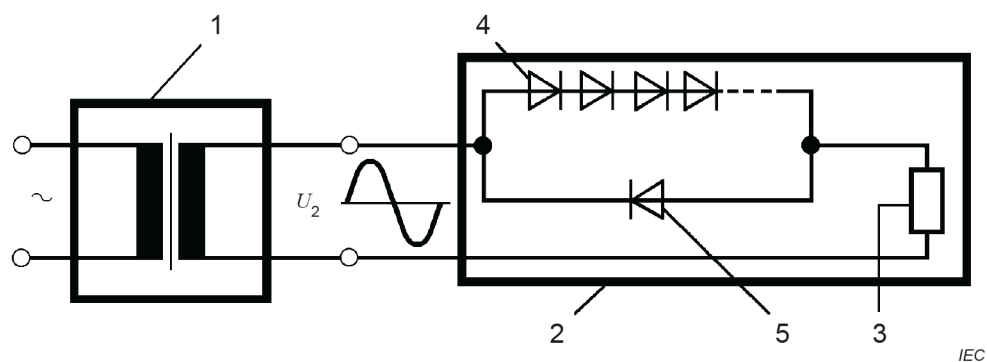
This difference of the half-cycle welding voltages is determined by passing a DC test current through the unbalanced load in both directions and measuring the DC LOAD VOLTAGE.

WELDING POWER SOURCES that incorporate a balance control are tested with a CONVENTIONAL LOAD, but with the balance control set to the condition producing the maximum unbalance, but not higher than 12 V.

C.3 Example for an unbalanced load

The rectifying characteristic of the load is achieved by a circuit of diodes in accordance with Figure C.3.

The required voltage difference between the half-cycle voltages is adjusted by the numbers of diodes in the string.

**Key**

- 1 Transformer
2 Unbalanced load

- 3 CONVENTIONAL LOAD
4 Series of diodes

- 5 Single diode

Figure C.3 – AC WELDING POWER SOURCE with unbalanced load

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Annex D

(informative)

Extrapolation of temperature to time of shutdown

When the temperature at the instant of shutdown cannot be recorded, it is necessary to use an extrapolation to obtain this temperature. The procedure for such extrapolation is as follows:

- a) the time is marked at the instant of shutdown;
- b) successive temperature readings are taken, and the elapsed time from shutdown noted for each;
- c) a minimum of four readings is taken for each temperature to be extrapolated;
- d) using logarithmic/linear graph paper, the readings are plotted so that the temperature is against the logarithmic scale, and the time from shutdown against the linear scale. A straight line extending back to $t = 0$ will give the extrapolated temperature at shutdown.

Alternative: A mathematical regression analysis can be used as an alternative to the graphical method. If a linear regression is chosen, then the logarithms of the temperatures are used with the linear values of the reading times from the instant of shutdown. The regression analysis is solved for the time $t = 0$ and the antilogarithm taken to find the true temperature.

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Annex E (normative)

Construction of SUPPLY CIRCUIT terminals

E.1 Size of terminals

The terminals shall be dimensioned in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT $I_{1\text{eff}}$ and it shall be possible to connect flexible conductors with cross-sectional areas as given in Table E.1. These values are based on wire rated at 60 °C.

**Table E.1 – Range of conductor dimensions to be accepted
by the SUPPLY CIRCUIT terminals**

MAXIMUM EFFECTIVE SUPPLY CURRENT A	Range of cross-sectional area of the conductor mm ²
10	1,5 to 2,5
16	1,5 to 4
25	2,5 to 6
35	4 to 10
50	6 to 16
63	10 to 25
80	16 to 35
100	25 to 50
125	35 to 70
160	50 to 95
200	70 to 120
250	95 to 150
315	120 to 240
400	150 to 300

Alternative cross-section ranges are permitted if the manufacturer indicates in the instructions the type and size of wire to be used.

Conformity shall be checked by calculation and measurement.

E.2 Connections at the terminals

Connections at the terminals shall be made by means of screws, nuts or other equivalent means and shall comply with the requirement given in 5.3.

NOTE Electrical quick-connect terminals are considered equivalent when fitted with two independent fixings, one clamping the insulation and the other clamping the conductor.

The terminal screws or nuts shall not be used to secure other parts or to connect other conductors.

Conformity shall be checked by VISUAL INSPECTION.

E.3 Construction of the terminals

Conductors or their lugs shall be clamped between metallic parts and shall not be able to escape when the clamping means are tightened.

Live parts that can turn and reduce the CLEARANCE shall not rely on friction between mounting surfaces to prevent turning. A suitable lock washer, properly applied, shall be acceptable. Leads or busbars that are secured by other means shall not have a lock washer.

Iron or steel, plain or plated, shall not be used for current carrying parts.

Conformity shall be checked by VISUAL INSPECTION and by the temporary connection of conductors with the minimum and maximum cross-sectional area specified.

E.4 Fixing of the terminals

The terminals shall be securely fixed so that they cannot work loose when the clamping means are tightened or loosened. Furthermore, if friction alone is relied on to prevent turning or shifting of the terminals on the supporting surface, the CLEARANCES shall not be reduced below the values of Table 2 by shifting or turning. A pressure terminal connector shall not be prevented from turning provided no CLEARANCES less than those required result when the terminals are turned 30° towards each other, or towards other uninsulated parts of opposite polarity, or towards grounded metal parts.

Conformity shall be checked by VISUAL INSPECTION and by tightening and loosening 10 times the clamping means holding a conductor of the maximum cross-sectional area specified.

The test shall be repeated using a conductor of the minimum cross-sectional area specified.

Annex F (informative)

Cross-reference to non-SI units

Cross references to non-SI units for short-circuit test (see 9.3) are given in Table F.1.

Table F.1 – Cross-reference for mm² to American wire gauge (AWG)

mm ²	AWG
1,5	15
2,5	13
4	11
6	9
10	7
16	5
25	3
35	1
50	1/0
70	2/0
95	3/0
120	250 MCM
150	350 MCM
240	600 MCM
300	700 MCM

Annex G (informative)

Suitability of supply network for the measurement of the true RMS value of the supply current

The peak and RMS values of the supply current (I_1) can be substantially affected by the supply network impedance (R_s). To obtain valid measurements, the supply network impedance is 4 % or less than the input impedance of the WELDING POWER SOURCE:

$$R_s \leq 0,04 \frac{U_1}{I_1} (\Omega) \quad (G.1)$$

where

R_s is the impedance of the supply network in Ω ;

U_1 is the RATED SUPPLY VOLTAGE in V;

I_1 is the RATED SUPPLY CURRENT in A.

To determine the impedance of the supply network, it is loaded by a CONVENTIONAL LOAD that is able to reduce the supply voltage at least 1 % below the unloaded value.

NOTE 1 If the rated voltage of this CONVENTIONAL LOAD is lower than the supply voltage, a transformer can be used.

NOTE 2 Automatic supply network voltage regulators are turned off.

NOTE 3 If a transformer is used $I_{1 \text{ unloaded}}$ is the no-load current of that transformer, otherwise $I_{1 \text{ unloaded}} = 0 \text{ A}$.

The impedance of the supply network is calculated by the following formula:

$$R_s = \frac{U_{1 \text{ unloaded}} - U_{1 \text{ loaded}}}{I_{1 \text{ loaded}} - I_{1 \text{ unloaded}}} (\Omega) \quad (G.2)$$

where

R_s is the impedance of the supply network in Ω ;

$U_{1 \text{ loaded}}$ is the supply voltage in V when loaded by a CONVENTIONAL LOAD;

$U_{1 \text{ unloaded}}$ is the supply voltage in V when unloaded;

$I_{1 \text{ loaded}}$ is the supply current in A when loaded by a CONVENTIONAL LOAD;

$I_{1 \text{ unloaded}}$ is the supply current in A when unloaded.

Example:

Supply network:

$$U_{1 \text{ unloaded}} = 230 \text{ V}$$

$$I_{1 \text{ unloaded}} = 1 \text{ A}$$

$$U_{1 \text{ loaded}} = 227 \text{ V}$$

$$I_{1 \text{ loaded}} = 31 \text{ A}$$

$$R_s = \frac{230 - 227}{31 - 1} = 0,10 \Omega$$

WELDING POWER SOURCE: $U_1 = 230 \text{ V}$ $I_{1 \text{ max}} = 30 \text{ A}$

With these values, the condition in accordance with Formula (G.1) is fulfilled:

$$R_s = 0,10 \Omega \leq 0,04 \frac{230}{30} = 0,31 \Omega$$

Annex H (informative)

Plotting of STATIC CHARACTERISTICS

H.1 General

By varying the resistance of a CONVENTIONAL LOAD connected to the output terminals of the WELDING POWER SOURCE, a set of values of WELDING CURRENT (I_2) and corresponding LOAD VOLTAGE (U_2) can be obtained for a given output setting of the WELDING POWER SOURCE. The STATIC CHARACTERISTIC is obtained by plotting these values on a graph with the WELDING CURRENT on the horizontal and the LOAD VOLTAGE on the vertical axis.

The slope of the STATIC CHARACTERISTIC is given by its tangent at the operating point.

H.2 Method

The number of values measured should be sufficient to enable a smooth curve to be plotted. In all cases, the NO-LOAD VOLTAGE and the RATED VALUES corresponding to each DUTY CYCLE (DUTY FACTOR) stated on the RATING PLATE should be recorded. For DROOPING CHARACTERISTIC WELDING POWER SOURCES, the short-circuit current should also be recorded.

If the WELDING POWER SOURCE has a step-by-step setting, values should be measured at each position of the control. If a WELDING POWER SOURCE is designed for several supply voltages, the measurement should be repeated at each supply voltage.

For each point, the following should also be recorded: supply voltage (U_1), supply current (I_1), power delivered to the WELDING POWER SOURCE (P_1).

For WELDING POWER SOURCES with no feedback circuitry (for example simple transformers), the values of U_2 and I_2 should be multiplied by a correction factor of (U_1/U_1') if the measured supply voltage (U_1') differs from the RATED SUPPLY VOLTAGE (U_1). The power (P_1) should be multiplied by $(U_1/U_1')^2$.

H.3 Analysis of the results

The series of curves obtained for the STATIC CHARACTERISTICS of a WELDING POWER SOURCE can be used to confirm conformity to the relevant requirements of this document. If the negative slope at the operating point is greater than or equal to 7 V per 100 A, the STATIC CHARACTERISTIC is considered to be drooping.

Annex I (normative)

Test methods for a 10 Nm impact

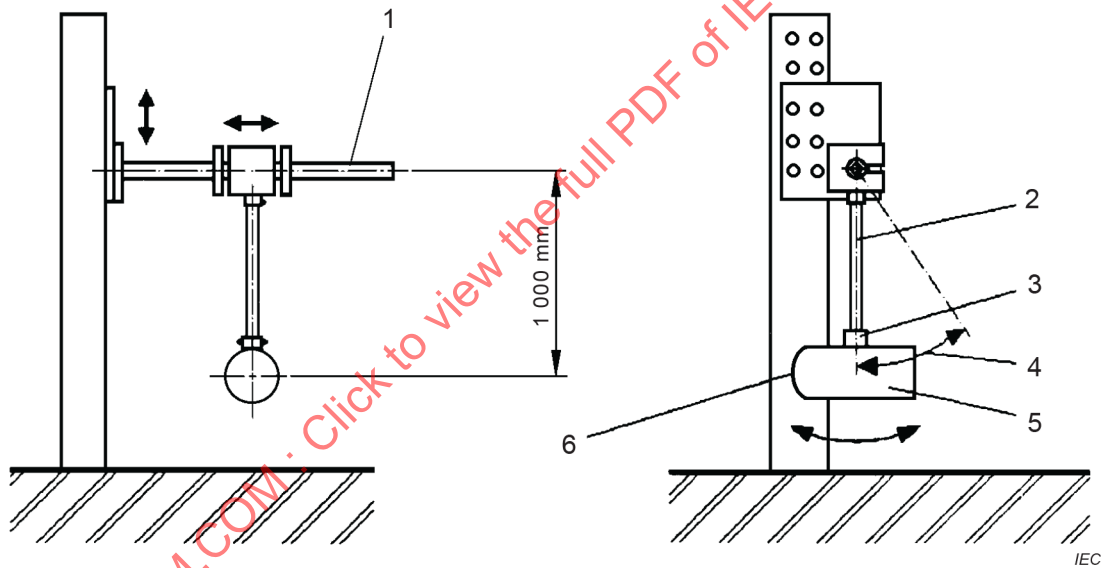
I.1 Pendulum impact hammer

The WELDING POWER SOURCE is placed against a rigid vertical surface and the impact is directed against the opposite side.

The angle of rotation θ (see Figure I.1) is adjusted (see Table I.1) to account for hammer and swing arm tolerances with the objective of delivering the required impact energy of 10 Nm.

Table I.1 – Angle of rotation θ to obtain 10 Nm impact

Hammer mass (kg)	1	1,5	2	2,5	3
Angle of rotation θ (°)	90	71	60	53	48



Key

- 1 Support shaft (should not deflect more than 1,5 mm)
- 2 Swing arm, steel tubing (its mass is negligible)
- 3 Hammer collar (mass up to 100 g)
- 4 Angle of rotation θ
- 5 Steel hammer
- 6 Radius (50 ± 2) mm

Figure I.1 – Test set-up

I.2 Free fall spherical steel weight

The WELDING POWER SOURCE is laid on a rigid horizontal surface. The mass of the free fall weight and the height of the free fall are given in Table I.2.

Table I.2 – Mass of the free fall weight and height of the free fall

Mass (kg)	0,50	0,75	1,00	1,25	1,50	1,75	2,00
Height (m)	2,04	1,36	1,02	0,82	0,68	0,58	0,51

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Annex J (normative)

Thickness of sheet metal for enclosures

The minimum thickness of sheet metal for enclosures shall be

- a) for steel, in accordance with Table J.1;
- b) for aluminium, brass or copper, in accordance with Table J.2.

The thickness values are based on a uniform deflection of the indicated sheet metal sizes, if loaded at the centre of their surface.

The thickness of an enclosure can be less than that given in Table J.1 and Table J.2, if the enclosure shows the same deflection as an enclosure of the same size having the required thickness.

Table J.1 – Minimum thickness of sheet metal for steel enclosures

Minimum thickness of uncoated steel ^a	Without supporting frame ^b		With supporting frame ^c	
	Maximum width	Maximum length	Maximum width	Maximum length
mm	mm	mm	mm	mm
0,50	105 125	Not limited 150	160 175	Not limited 210
0,65	155 180	Not limited 225	245 255	Not limited 320
0,80	205 230	Not limited 300	305 330	Not limited 410
1,00	320 360	Not limited 460	500 535	Not limited 635
1,35	460 510	Not limited 635	690 740	Not limited 915
1,50	560 635	Not limited 790	840 890	Not limited 1 095
1,70	635 740	Not limited 915	995 1 045	Not limited 1 295
2,00	840 890	Not limited 1 200	1 295 1 375	Not limited 1 680
2,35	1 070 1 200	Not limited 1 500	1 630 1 730	Not limited 2 135
2,70	1 325 1 525	Not limited 1 880	2 035 2 135	Not limited 2 620
3,00	1 600 1 860	Not limited 2 290	2 470 2 620	Not limited 3 230
^a 1) For stainless steel, only 80 % of the given values are necessary. 2) For zinc-coated steel, the thickness shall be adjusted to take into account the coating thickness (usually 0,05 mm to 0,1 mm). ^b Constructions considered to be without a supporting frame are for example: 1) a single sheet with single formed flanges; 2) a single sheet that is corrugated or ribbed; 3) an enclosure surface loosely attached to a frame, for example with spring clips or latch; 4) an enclosure surface having an unsupported edge. ^c These two columns apply when the enclosure is strengthened by one of the following means: 1) a supporting frame that is a structural channel, angle, or folded rigid section that is at least equal to the metal thickness of the enclosure, and is rigidly attached to the enclosure; 2) a supporting frame other than metal that has an equivalent torsional rigidity to a sheet steel angle in accordance with 1) above, and is fire resistant; 3) all of the edges of the enclosure are turned through a 90° angle to produce a formed flange with a minimum width of 10 mm.				

Table J.2 – Minimum thickness of sheet metal for enclosures of aluminium, brass or copper

Minimum thickness of metal mm	Without supporting frame ^a		With supporting frame ^b	
	Maximum width mm	Maximum length mm	Maximum width mm	Maximum length mm
0,55	80 90	Not limited 110	180 220	Not limited 245
0,70	105 130	Not limited 155	260 270	Not limited 345
0,90	155 165	Not limited 205	360 385	Not limited 460
1,10	205 245	Not limited 295	485 535	Not limited 640
1,45	305 360	Not limited 410	715 765	Not limited 940
1,90	460 510	Not limited 635	1 070 1 145	Not limited 1 400
2,40	635 740	Not limited 915	1 525 1 630	Not limited 1 985
3,10	940 1 070	Not limited 1 350	2 210 2 365	Not limited 2 900
3,85	1 325 1 525	Not limited 1 880	3 125 3 305	Not limited 4 065

^a Constructions considered to be without a supporting frame are for example:

- 1) a single sheet with single formed flanges;
- 2) a single sheet that is corrugated or ribbed;
- 3) an enclosure surface loosely attached to a frame, for example with spring clips or latch;
- 4) an enclosure surface having an unsupported edge.

^b These two columns apply when the enclosure is strengthened by one of the following means:

- 1) a supporting frame that is a structural channel, angle, or folded rigid section that is at least equal to the metal thickness of the enclosure, and is rigidly attached to the enclosure;
- 2) a supporting frame other than metal that has an equivalent torsional rigidity to a sheet steel angle in accordance with a) above, and is fire resistant;
- 3) all of the edges of the enclosure are turned through a 90° angle to produce a formed flange with a minimum width of 10 mm.

Annex K (informative)

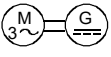
Examples of RATING PLATES

Examples of RATING PLATES are given in Figure K.1 to Figure K.7.

a) Identification					
1) Manufacturer		Trademark			
Address					
2) Type		3) Serial number			
4) 		5) IEC 60974-1 IEC 60974-10 Class A			
b) Welding output					
6) 	8) ~50 Hz	10) 15 A / 20,6 V to 160 A / 27 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7) 	9) $U_0 = 48 \text{ V}$	12) I_2	12a) 160 A	12b) 130 A	12c) 100 A
		13) U_2	13a) 26 V	13b) 25 V	13c) 24 V
c) Energy supply					
14)  1 ~ 50 Hz	15) $U_1 = 230 \text{ V}$		16) $I_{1\text{max}} = 37 \text{ A}$		17) $I_{1\text{eff}} = 22 \text{ A}$
	22) IP23		23) 		

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Figure K.1 – Single-phase transformer

a) Identification					
1) Manufacturer Address		Trademark			
2) Type		3) Serial number			
4) 		5) IEC 60974-1 IEC 60974-10 Class A			
b) Welding output					
6) 	8) ~450 Hz	10) 60 A / 22,4 V to 500 A / 40 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7)	9) $U_0 = 78 \text{ V}$	12) I_2	12a) 500 A	12b) 400 A	12c) 320 A
		13) U_2	13a) 40 V	13b) 36 V	13c) 33 V
c) Energy supply					
14) 	18) $n = 2\,800 \text{ min}^{-1}$				
	3 ~ 50 Hz	15) $U_1 = 400 \text{ V}$	16) $I_{1\max} = 68 \text{ A}$	17) $I_{1\text{eff}} = 40 \text{ A}$	
22) IP23		23)			

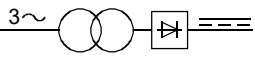
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Figure K.2 – Three-phase rotating frequency converter

Distributor-related plate

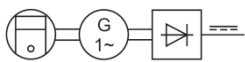
a) Identification	
1) Manufacturer Address	Trademark
2) Type	3) Serial number

Manufacturer-related plate

a) Identification		5) IEC 60974-1 IEC 60974-10 Class A			
4) 					
b) Welding output					
6) 	8) 	10) 20 A / 20,8 V to 250 A / 30 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7) 	9) $U_0 = 105 \text{ V}$	12) I_2	12a) 250 A	12b) 200 A	12c) 160 A
		13) U_2	13a) 30 V	13b) 28 V	13c) 27 V
c) Energy supply					
14)  1(3) ~ 50 Hz	15) $U_1 = 230 \text{ V}$ $U_1 = 400 \text{ V}$	16) $I_{1\max} = 57 \text{ A}$ $I_{1\max} = 34 \text{ A}$	17) $I_{1\text{eff}} = 34 \text{ A}$ $I_{1\text{eff}} = 20 \text{ A}$		
	22) IP23	23) 			

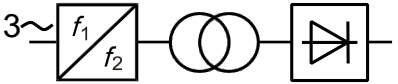
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Figure K.3 – Subdivided RATING PLATE: single-/three-phase transformer rectifier

a) Identification					
1) Manufacturer Address		Trademark			
2) Type		3) Serial number			
4) 		5) IEC 60974-1			
b) Welding output					
6) 	8) 	10) 40 A / 21,6 V to 400 A / 36 V			
7) 	9) $U_0 = 110 \text{ V}$	11) X	11a) 35 %	11b) 60 %	11c) 100 %
		12) I_2	12a) 400 A	12b) 320 A	12c) 255 A
		13) U_2	13a) 36 V	13b) 33 V	13c) 30 V
c) Energy supply					
14) 	18) $n = 3\,150 \text{ min}^{-1}$				
19) $n_0 = 3\,300 \text{ min}^{-1}$		20) $n_i = 980 \text{ min}^{-1}$		21) $P_{1\text{max}} = 34 \text{ kW}$	
22) IP23		23)			

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Figure K.4 – Engine-generator-rectifier

a) Identification					
1) Manufacturer Address		Trademark			
2) Type		3) Serial number			
4) 		5) IEC 60974-1 IEC 60974-10 Class A			
b) Welding output					
6) 	8) 	10) 20 A / 20,8 V to 250 A / 32 V			
		11) X	11a) 35 %	11b) 60 %	11c) 100 %
7) 	9) $U_0 = 105 \text{ V}$	12) I_2	12a) 250 A	12b) 200 A	12c) 160 A
		13) U_2	13a) 30 V	13b) 28 V	13c) 27 V
c) Energy supply					
14)  1(3) ~ 50 Hz	15) U_1 230 V 400 V	16) $I_{1\max}$ 57 A 34 A		17) $I_{1\text{eff}}$ 34 A 20 A	
22) IP23S	23) 				

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Figure K.5 – Single-/three-phase inverter type

a) Identification			
1) Manufacturer Address		Trademark	
2) Type		3) Serial number	
4) Li-ion		5) IEC 60974-1 IEC 60974-10 Class A	
b) Welding output			
6) 	8) 	10) 10 A / 20,4 V to 120 A / 24,8 V	
7) 	9) $U_0 = 58 \text{ V}$	12) $I_{2\text{max}} = 120 \text{ A}$	
		13) $U_2 = 24,8 \text{ V}$	
c) Energy supply			
14) 	15) $U_b = 57,6 \text{ V}$	16) $E = 5 \text{ Ah}$	17) $I_b = 10 \text{ A}$
19) For use only with _____ charger			
22) IP23			

IEC

Figure K.6 – Battery-powered WELDING POWER SOURCE with INTEGRAL BATTERY

WELDING POWER SOURCE related plate

a) Identification			
1) Manufacturer Address		Trademark	
2) Type		3) Serial number	
4)		5) IEC 60974-1 IEC 60974-10 Class A	
b) Welding output			
6) 	8) 	10) 10 A / 20,4 V to 120 A / 24,8 V	
7) 	9) $U_0 = 58 \text{ V}$	12) $I_{2\max} = 120 \text{ A}$	
		13) $U_2 = 24,8 \text{ V}$	
c) Energy supply			
14) 	15) $U_b = 57,6 \text{ V}$		
	19) For use only with _____ battery		
22) IP23			

BATTERY related plate

d) Separable and detachable battery packs	
1) type (identification) as given by the manufacturer	
Li-ion	year and date code
$U_b = 57,6 \text{ V}$	$E = 5 \text{ Ah}$

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**Figure K.7 – Battery-powered WELDING POWER SOURCE
with detachable / separable BATTERY**

Annex L (informative)

Graphical symbols for arc welding equipment

L.1 General

Annex L describes symbols, which are not all internationally standardized, but of practical use in welding applications. IEC technical committee 26 and subcommittee 3C have decided to consider those symbols for a future possible inclusion in IEC 60417. When this process will be terminated, Annex L will be modified accordingly.

Annex L contains graphic symbols for arc welding and allied processes equipment to identify controls, indicators, connection points, functions, and to select processes.

The symbols are for use on the panel, the RATING PLATE and any documentation for arc welding and allied processes equipment.

Annex L does not cover graphic symbols used to alert personnel of immediate or potential personal hazards in the use of the equipment.

NOTE 1 For safety symbols, see ISO 3864-1.

NOTE 2 For installation instructions, see IEC 60974-9.

L.2 Use of symbols

L.2.1 General

Symbols should be placed on equipment to instruct on use and operation. Examples of control panel are given in L.5.

L.2.2 Selection of symbols

Symbols specified in Clause L.3 can be used either as a single item or in combination to fit the intended application. Examples of combinations are given in L.4.

L.2.3 Size of symbols

For the application of these symbols, it can be necessary either to reduce or to enlarge the original to a suitable size. In the case of symbols composed of several graphic elements, or when reducing to minimum height, check that clear identification is still possible and legibility is adequate. Available light, user distance, and possible operating conditions as factors during size selection should also be considered.

The recommended minimum symbol size is 6 mm.

L.2.4 Use of colour

In general, the graphic form of a symbol reproduced in black on white or white on black should be sufficient for its identification.

For the purposes of these symbols, adequate contrast between symbol and background is most important. As long as the symbol is clearly delineated and fully legible, actual colour selection is not mandatory. Be aware that certain colours, such as red, orange, and yellow are designated as safety-alerting colours.

L.3 Symbols

L.3.1 General

Clause L.3 presents the symbols along with their reference number, function keyword or phrase, application and source.

L.3.2 Letter symbols

Table L.1 gives a list of letters, which may be used in a symbol.

Table L.1 – Letters used as symbols

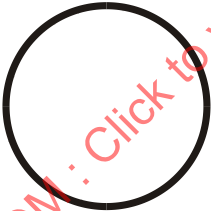
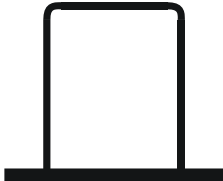
Function, keyword or phrase	Letter	Unit
Amperage	I	A
CONVENTIONAL WELDING CURRENT	I_2	A
Conventional welding voltage	U_2	V
Diameter	$\varnothing$	mm
DUTY CYCLE; DUTY FACTOR	X	%
Efficiency	η	%
Frequency	F	Hz
Power	P	W
Rated BATTERY capacity	Q	Ah
Rated no-LOAD VOLTAGE	U_0	V
Rated peak voltage	U_p	V
RATED SUPPLY CURRENT	I_1	A
RATED SUPPLY VOLTAGE	U_1	V
RATED REDUCED NO-LOAD VOLTAGE	U_r	V
Speed of rotation	n	min ⁻¹
Supply ACTIVE POWER	P_1	W
RATED SWITCHED NO-LOAD VOLTAGE	U_s	V
Temperature (change)	T	°C (K)
Time	t	s, min, h
Voltage	U	V
Welding output ACTIVE POWER	P_2	W

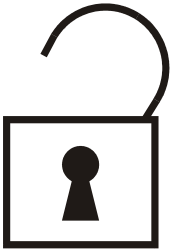
L.3.3 Graphical symbols

L.3.3.1 Symbols to describe the switch or control

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
1.	IEC 60417-5004:2002-10		Variability	To identify an increase/decrease of a quantity continuously. NOTE Symbol can be curved.

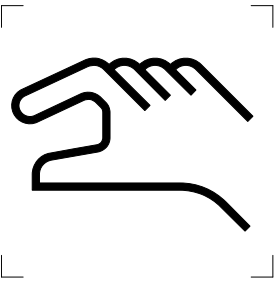
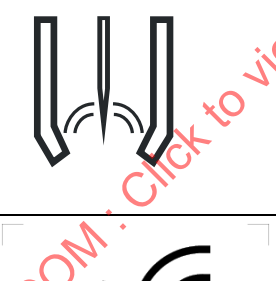
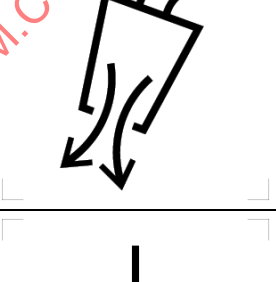
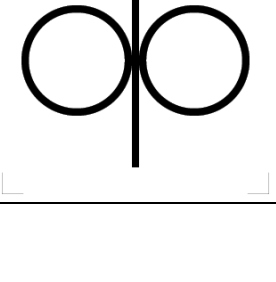
L.3.3.2 Symbols to indicate switch or control position

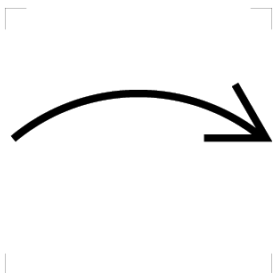
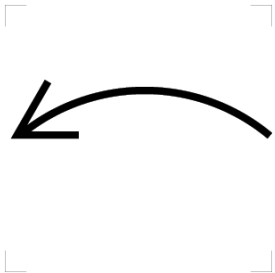
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
2.	IEC 60417-5007:2002-10		ON (power)	To indicate connection to the mains, at least for mains switches or their positions, and all those cases where safety is involved.
3.	IEC 60417-5008:2002-10		OFF (power)	To indicate disconnection from the mains, at least for mains switches or their positions, and all those cases where safety is involved.
4.	IEC 60417-5268:2002-10		"IN" position of a bi-stable push control	To associate the "IN" position of a bi-stable push control with the corresponding function. NOTE 1 This symbol is used together with a function symbol.
5.	IEC 60417-5269:2002-10		"OUT" position of a bi-stable push control	To associate the "OUT" position of a bi-stable push control with the corresponding function. NOTE 2 This symbol is used together with a function symbol.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
6.	IEC 60417-5569:2005-08		Locking, general	To identify on a control that a function is locked or to show the locked status. NOTE 3 This symbol is used together with a function symbol.
7.	IEC 60417-5570:2002-10		Unlocking	To identify on a control that a function is not locked or to show the unlocked status. NOTE 4 This symbol is used together with a function symbol.

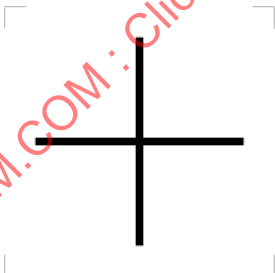
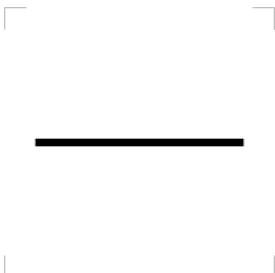
L.3.3.3 Symbols to indicate switch or control function

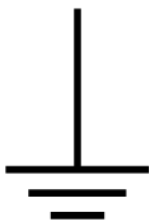
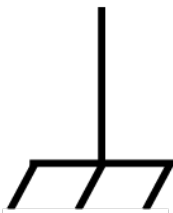
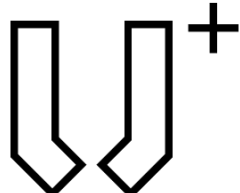
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
8.	IEC 60417-6302:2015-01		Welding time, continuous mode	To identify a continuous welding.
9.	IEC 60417-6303:2015-01		Welding time, intermittent mode (stitch)	To identify an intermittent (stitch) welding.
10.	ISO 7000-0468:2004-01		Arc spot welding	To identify arc spot welding.

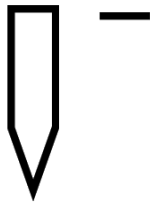
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
11.	ISO 7000-0096:2004-01		Manual control	To identify a manually operated control. To identify the switch position that places the equipment under manual (as opposed to automatic) control. To identify the control that activates manual control. To indicate that the equipment is in manual control mode.
12.	IEC 60417-6318:2015-03		Arc striking, without contact	To identify the control for a tungsten inert gas (TIG) arc striking function which initiates an arc without contact.
13.	IEC 60417-6319:2015-03		Arc striking, with contact	To identify the control for a tungsten inert gas (TIG) arc striking function which initiates an arc with contact.
14.			Pilot arc starting	To identify pilot arc starting of a plasma torch.
15.	ISO 7000-0474:2004-01		Purging of air (by gas)	To identify purging of air (by gas).
16.	ISO 7000-0823:2004-01		Wire feed drive	To identify a wire feeder or wire feed control.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
17.	IEC 60417-6377:2017-10		Wire burnback control	To identify the control for burnback at the end of the weld.
18.	ISO 7000-0004:2004-01		Direction of continuous rotation (clockwise)	To identify that a control, or an object by means of a control, can be moved in a clockwise rotary motion.
19.	ISO 7000-0004:2004-01		Direction of continuous rotation (anticlockwise)	To identify that a control, or an object by means of a control, can be moved in an anticlockwise rotary motion.

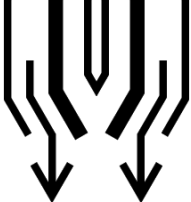
L.3.3.4 Symbols to indicate electrical connection

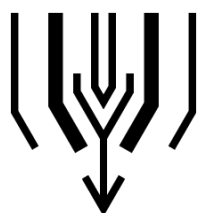
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
20.	IEC 60417-5005:2002-10		Plus; positive polarity	To identify the positive terminal(s) of equipment which is used with, or generates direct current.
21.	IEC 60417-5006:2002-10		Minus; negative polarity	To identify the negative terminal(s) of equipment which is used with, or generates direct current.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
22.	IEC 60417-5017:2006-08		Earth; ground	To identify the earth (ground) terminal in cases where neither the symbol 5018 nor 5019 is explicitly required. NOTE 1 Not for a protective earth connection.
23.	IEC 60417-5019:2006-08		Protective earth; protective ground	To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth (ground) electrode.
24.	IEC 60417-5020:2002-10		Frame or chassis	To identify the frame or chassis terminal. NOTE 2 Not for a protective earth connection.
25.	IEC 60417-5939:2002-10		Power supply type of electric device	On device or equipment for example on arc welding equipment. To identify the type of power supply, socket-outlet with 3-poles.
26.	ISO 7000-0453:2004-01		Workpiece connection	To identify a workpiece connection.
27.	ISO 7000-0483:2004-01		Plasma torch connection to nozzle, positive supply	To identify a plasma torch connection – nozzle connection to positive supply.

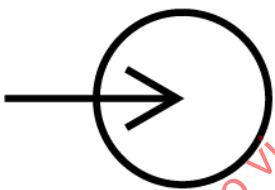
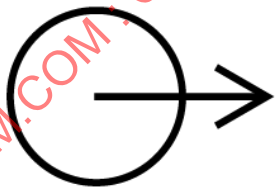
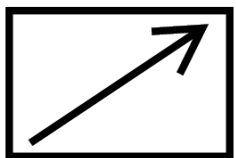
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
28.	ISO 7000-0482:2004-01		Plasma torch connection to the electrode, negative supply	To identify a plasma torch connection – electrode connection to negative supply.

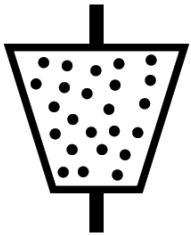
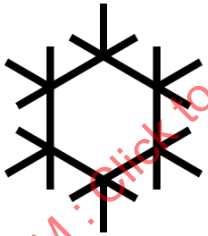
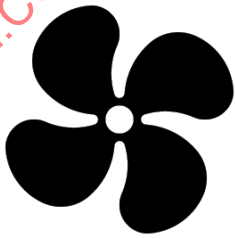
L.3.3.5 Symbols to indicate fluid connection or control

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
29.	IEC 60417-6315:2015-02		Air flow, general	To indicate the function of air flow.
30.	ISO 7000-0536:2004-01		Water; fluid	To indicate water or water-base fluid, e.g coolant.
31.			Gas supply	To identify a gas supply connection or control.
32.	ISO 7000-0481:2004-01		Plasma shielding gas	To identify plasma shielding gas connection or control.

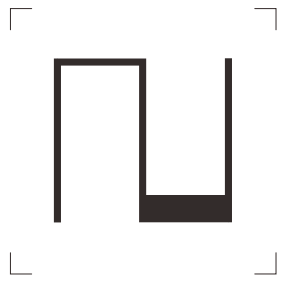
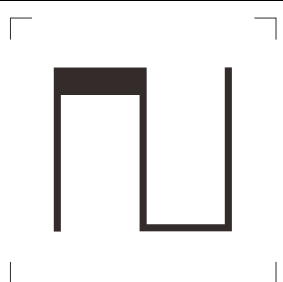
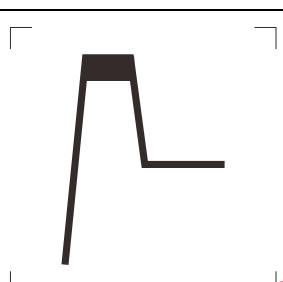
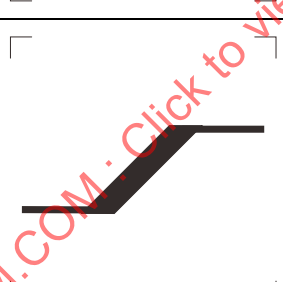
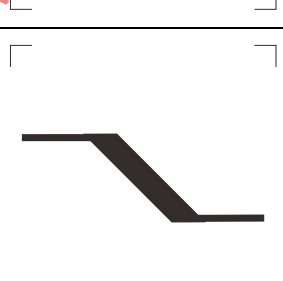
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
33.	ISO 7000-0480:2004-01		Plasma gas	To identify plasma gas connection or control.
34.	IEC 60417-6316:2015-02		Air pressure	To identify air pressure function or control.

L.3.3.6 Symbols to indicate auxiliary device, connection or function

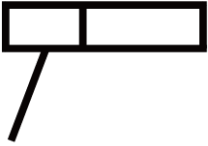
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
35.	IEC 60417-5034:2014-06		Input	To identify input connection or control.
36.	IEC 60417-5035:2014-06		Output	To identify output connection or control.
37.	ISO 7000-0093:2004-01		REMOTE CONTROL	To identify the REMOTE CONTROL function, for example the connection point for a REMOTE CONTROL lead.

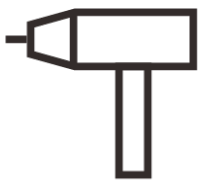
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
38.	IEC 60417-6378:2017-10		Foot control	To identify a foot control device, connection or function.
39.	IEC 60417-6379:2017-10		Panel; local	To identify a panel or local function or control.
40.	ISO 7000-0466:2004-01		Hopper (powder, flux)	To identify a hopper (powder, flux).
41.	ISO 7000-0027:2004-01		Cooling	To identify a cooling device, connection or control.
42.	ISO 7000-0089:2004-01, modified		Ventilating fan, air circulating fan	To identify the control which activates the fan and circulates air. To indicate the operational status of the fan function.
43.	IEC 60417-6317:2015-02		Air filter	To identify the air flow filter.

L.3.3.7 Symbols to indicate control of the welding amperage/voltage

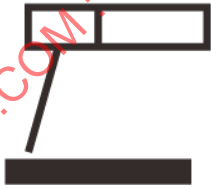
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
44.	IEC 60417-6005:2006-12		Pulse background	To identify the control of pulse background. NOTE 1 Control is identified by one letter chosen in Table L.1.
45.	IEC 60417-6006:2006-12		Pulse peak	To identify the control of pulse peak. NOTE 2 Control is identified by one letter chosen in Table L.1.
46.	IEC 60417-6007:2006-12		Hot start	To identify the control or function increasing the energy at the beginning of the weld. NOTE 3 Control is identified by one letter chosen in Table L.1.
47.	IEC 60417-6008:2006-12		Slope, increasing	To identify the control or function regulating the increase of a value. NOTE 4 Control is identified by one letter chosen in Table L.1.
48.	IEC 60417-6009:2006-12		Slope, decreasing	To identify the control or function regulating the decrease of a value. NOTE 5 Control is identified by one letter chosen in Table L.1.

L.3.3.8 Symbols to indicate type of torch

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
49.	IEC 60417-6380:2017-07		Electrode holder, manual	To identify the electrode holder for a manual metal arc welding.
50.	IEC 60417-6313:2015-01		Electrode holder, air carbon arc gouging	To identify the holder for air carbon arc gouging electrode.
51.	IEC 60417-6381:2017-07		Arc welding torch, MIG/MAG	To identify the torch for metal inert gas (MIG) and metal active gas (MAG) welding.
52.	IEC 60417-6382:2017-07		Arc welding torch, self-shielded flux cored	To identify the torch for self-shielded flux cored arc welding without gas shielding.
53.	IEC 60417-6383:2017-07		Arc welding torch, TIG	To identify the torch for tungsten inert gas (TIG) welding.
54.	IEC 60417-6384:2017-07		Arc welding torch, plasma	To identify the plasma torch for welding, cutting and/or gouging.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
55.	IEC 60417-6385:2017-07		Motorised gun	To identify the gun incorporating a wire drive system.
56.	IEC 60417-6386:2017-07		Motorised gun with filler wire supply	To identify the gun incorporating a wire drive system and including a filler wire supply.
57.	IEC 60417-6387:2017-07		Arc welding torch, submerged	To identify the torch for the submerged arc welding.

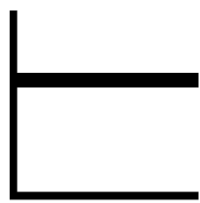
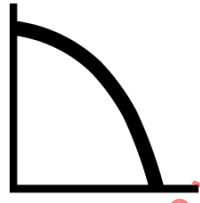
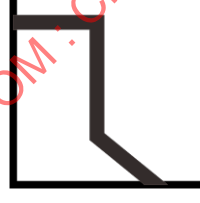
L.3.3.9 Symbols to indicate processes

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
58.	IEC 60417-6306:2015-01		Welding power output, MMA	To identify on a RATING PLATE that the type of welding output is for a manual metal arc (MMA) welding process with covered electrodes.
59.	IEC 60417-6314:2015-01		Air carbon arc gouging	To identify the process for air carbon arc gouging.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
60.	IEC 60417-6308:2015-01		Welding power output, MIG/MAG	To identify on a RATING PLATE that the type of welding output is for metal inert gas (MIG) and metal active gas (MAG) welding process including the use of flux cored wire.
61.	IEC 60417-6309:2015-01		Welding power output, self-shielded flux cored arc welding	To identify on a RATING PLATE that the type of welding output is for self-shielded flux cored arc welding process (without gas shielding).
62.	IEC 60417-6307:2015-01		Welding power output, TIG	To identify on a RATING PLATE that the type of welding output is for tungsten inert-gas (TIG) welding process.
63.	IEC 60417-6312:2015-01		Welding power output, plasma welding	To identify on a RATING PLATE that the type of welding output is for plasma arc welding process.
64.	IEC 60417-6310:2015-01		Welding power output, plasma cutting	To identify on a RATING PLATE that the type of welding output is for plasma arc cutting process.
65.	IEC 60417-6311:2015-01		Welding power output, plasma gouging	To identify on a RATING PLATE that the type of welding output is for plasma gouging process.

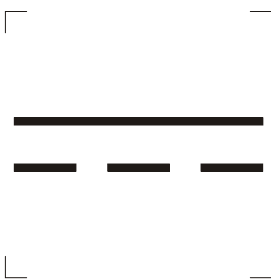
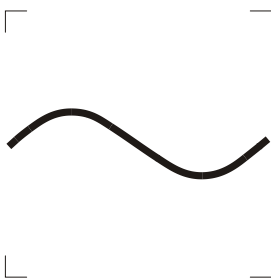
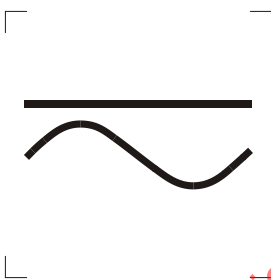
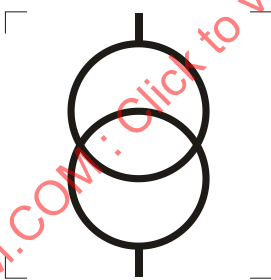
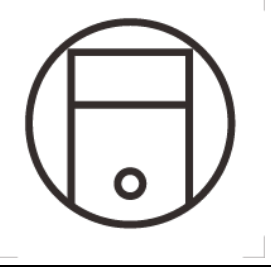
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
66.	IEC 60417-6305:2015-01		Welding power output, submerged arc welding	To identify on a RATING PLATE that the type of welding output is for submerged arc welding process.

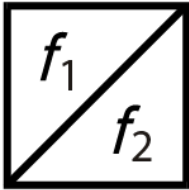
L.3.3.10 Symbols to indicate control of welding characteristics

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
67.	ISO 7000-0455:2004-01		FLAT CHARACTERISTIC	To identify a substantially level LOAD VOLTAGE characteristic.
68.	ISO 7000-0454:2004-01		DROOPING CHARACTERISTIC	To identify a substantially drooping voltage characteristic
69.	IEC 60417-6388:2017-07		Arc force, increase	To indicate the control or function for increasing current when low arc voltage is detected.
70.	IEC 60417-6389:2017-07		Pulsed	To identify the reference to control welding characteristic by pulse value.

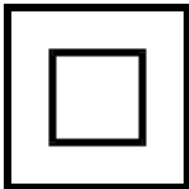
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
71.	IEC 60417-6390:2017-07		Inductance, variable	To identify a variable inductance function or control.
72.	IEC 60417-6391:2017-07		Inductance, high	To identify high inductance connection, function or control.
73.	IEC 60417-6392:2017-07		Inductance, medium	To identify medium inductance connection, function or control.
74.	IEC 60417-6393:2017-07		Inductance, low	To identify low inductance connection, function or control.

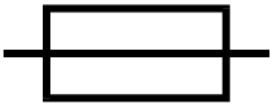
L.3.3.11 Symbols to describe the type of power source

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
75.	IEC 60417-5031:2002-10		Direct current (DC)	To identify that power source delivers direct current.
76.	IEC 60417-5032:2002-10		Alternating current (AC)	To identify that power source delivers alternating current. NOTE Symbol can be mixed with a number to indicate the number of phases.
77.	IEC 60417-5033:2002-10		Both direct and alternating current	To identify that the power source delivers both direct and alternating current.
78.	IEC 60417-5156:2003-08		Transformer	To identify a transformer.
79.	ISO 7000-1153:2004-01		Electric generator, rotating, general	To identify a generator.
80.	IEC 60417-6304:2015-01		WELDING POWER SOURCE, engine	To identify an engine driven WELDING POWER SOURCE.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
81.	ISO 7000-0147:2004-01		Electric motor	To identify an electric motor.
82.	IEC 60417-5970:2003-08		Frequency converter	To identify a frequency converter.
83.	IEC 60417-5194:2002-10		DC/AC-converter	To identify a DC/AC-converter and its associated terminals and controls.

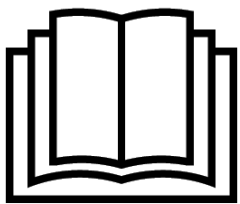
L.3.3.12 Symbols to indicate protective component and class of protection

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
84.	IEC 60417-6395:2017-12		WELDING POWER SOURCE, type S	To identify the WELDING POWER SOURCE equipment which is suitable for supplying power to welding operations carried out in an ENVIRONMENT WITH INCREASED RISK OF ELECTRIC SHOCK.
85.	IEC 60417-5172:2003-02		CLASS II EQUIPMENT	To identify equipment meeting the safety requirements specified for CLASS II equipment according to IEC 61140.

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
86.	IEC 60417-5016:2002-10		Fuse	To identify fuse boxes or their location.

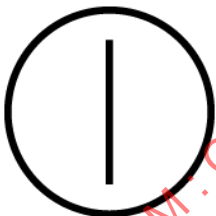
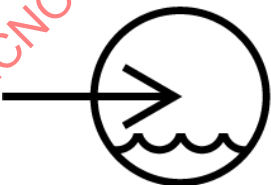
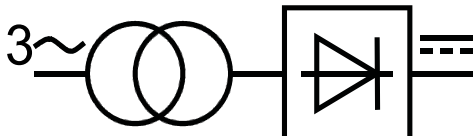
L.3.3.13 Symbols to inform users

N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
87.	IEC 60417-5036:2002-10		Dangerous voltage	To indicate hazards arising from dangerous voltages.
88.	ISO 7000-0228:2004-01		Disturbance	To indicate a disturbance of the correct operation.
89.	ISO 7000-0434A:2004-01		Caution	To indicate that caution is necessary when operating the device or control close to where the symbol is placed, or to indicate that the current situation needs operator awareness or operator action in order to avoid undesirable consequences.
90.	IEC 60417-5041:2002-10		Caution, hot surface	To indicate that the marked item can be hot and should not be touched without taking care.

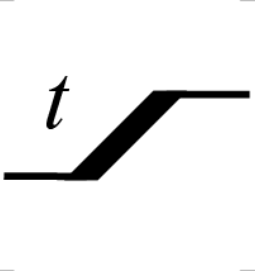
N°	SOURCE	SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
91.	ISO 7000-0790:2004-01		Read operator's manual	To indicate that the operator's manual or card should be read before continuing the operation.
92.	ISO 7000-0034:2004-01		Temperature indication	To indicate temperature or function associated with temperature (for example excess temperature warning light).

L.4 Examples of combinations of symbols

This clause gives examples of combination of symbols which can be used on arc welding and allied processes equipment.

SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
 IEC 60417-5010:2002-10	"ON"/"OFF" (push-push)	To indicate connection to or disconnection from the mains, at least for mains switches or their position, and all those cases where safety is involved. Each position, "ON" or "OFF", is a stable position.
 IEC 60417-6024:2009-11	Inlet for liquid, input for liquid	To identify inlet connections for the cooling liquid.
	Three-phase transformer-rectifier	To indicate WELDING POWER SOURCE symbol on the RATING PLATE.

SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
	Inverter power source AC/DC	To indicate WELDING POWER SOURCE symbol on the RATING PLATE.
	Slow wire feed start	To identify the slow advance of wire towards the workpiece at the start of the weld.
	Caution ! Read the operator's manual	To indicate a hazard and identify that the operator's manual should be read.
ISO 7000-0544:2004-01	Water cooling	To identify a water cooling system (for example, operating controls switching the water cooling on or off).
IEC 60417-6394:2017-10	Variability with OFF position, rotary adjustment	To identify the control for continuous increase and decrease of a quantity and an off position.
ISO 7000-0469:2004-01, modified	MIG/MAG spot welding	To identify MIG/MAG spot welding

SYMBOL	FUNCTION, KEYWORD OR PHRASE	APPLICATION
	Upslope time	To indicate a control of upslope time

L.5 Examples of control panels

This clause (see Figure L.1 to Figure L.8) gives examples of control panels for arc welding and allied processes equipment.

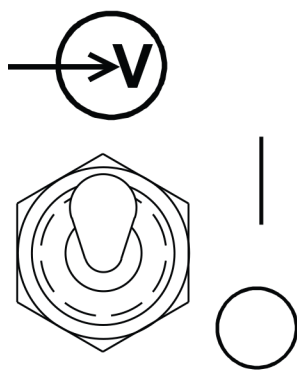


Figure L.1 – Input voltage power switch

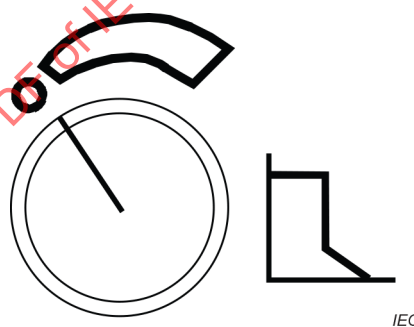


Figure L.2 – Arc force control potentiometer

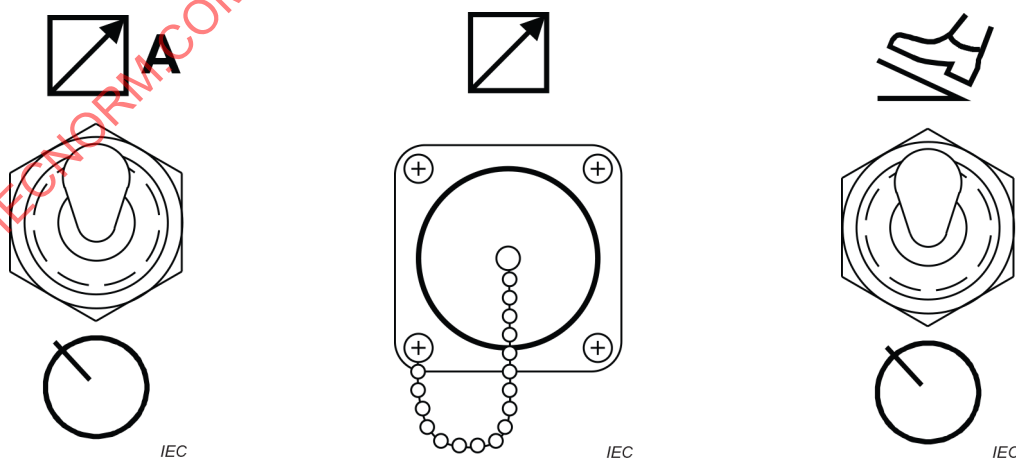


Figure L.3 – Remote receptacle and selector switches

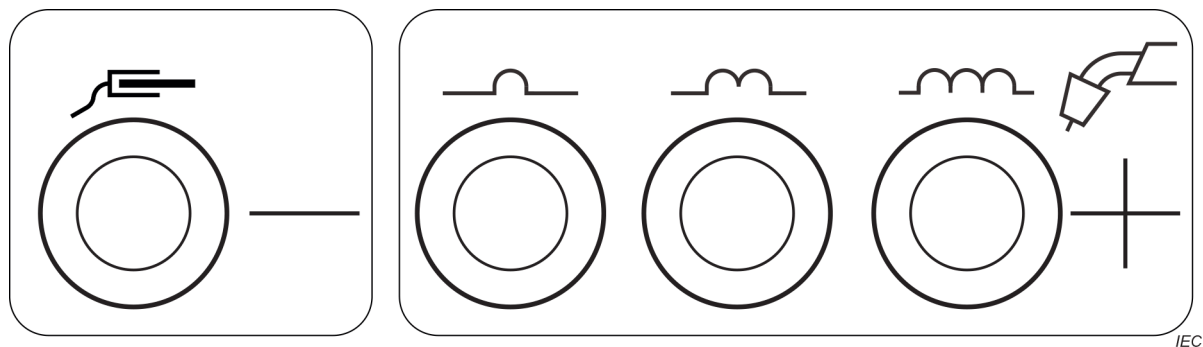


Figure L.4 – Terminals with inductance selector for MIG/MAG welding

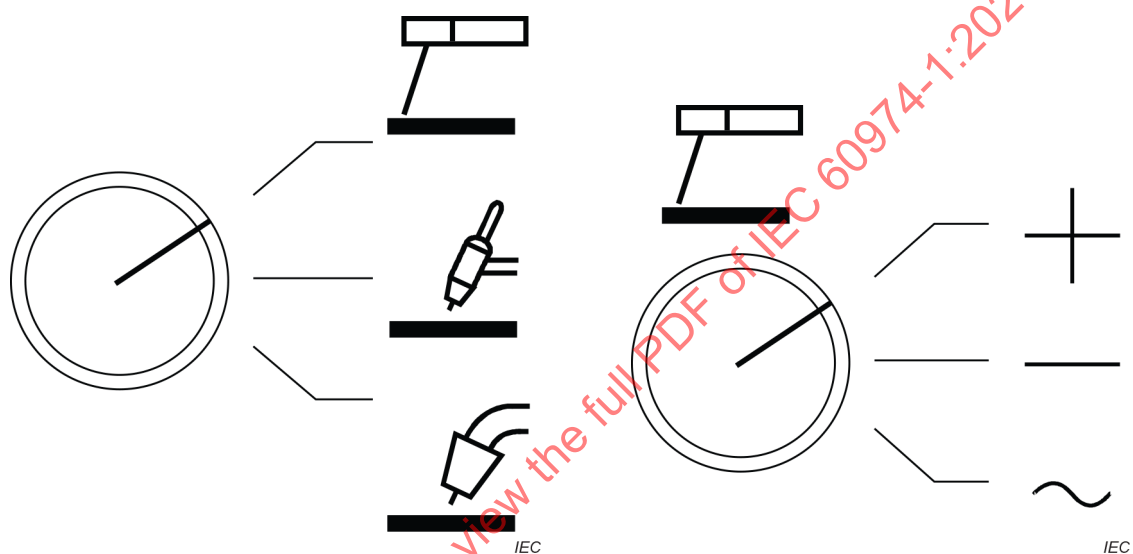


Figure L.5 – Process switch
(MMA, TIG, MIG)

Figure L.6 – Selector switch
on AC/DC equipment

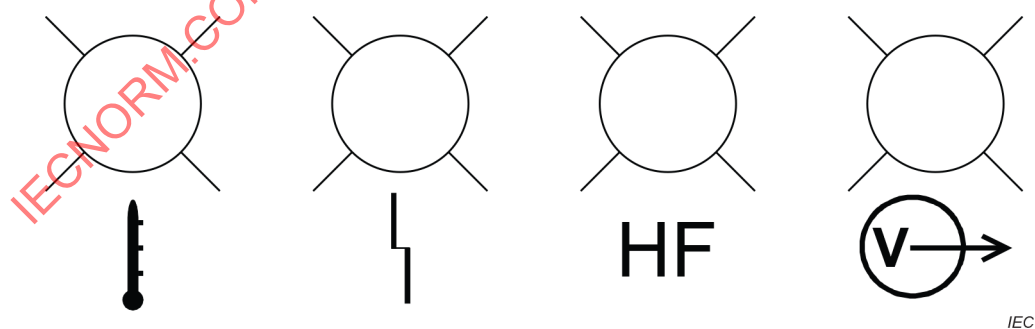


Figure L.7 – Panel indicator lights (overheat, fault, arc striking, output voltage)

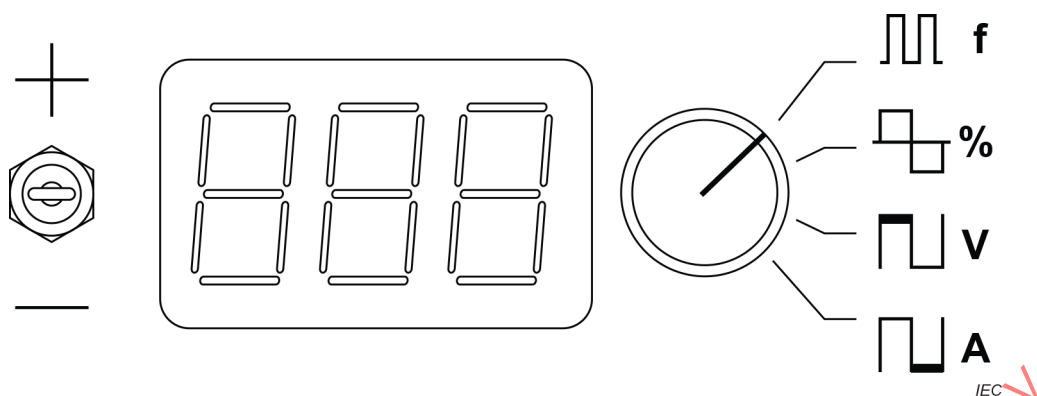


Figure L.8 – Setting pulsing parameters using digital display

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Annex M (informative)

Efficiency and IDLE STATE power measurement

M.1 General conditions for measurement

M.1.1 General

Unless otherwise specified, measurements shall be made under test conditions and with equipment specified in IEC 62301.

NOTE This Annex was written in response to EU 2019/1784. This Annex makes extensive reference to IEC 62301 *Household electrical appliances – Measurement of standby power*, which was also prepared under an EC mandate as EN 50564 to support the ecodesign Directive.

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

M.1.2 Test room

The tests shall be carried out in a room that has an air speed close to the product under test of $\leq 0,5$ m/s. The ambient temperature shall be maintained at (23 ± 5) °C throughout the test.

Where the product has an ambient light sensor that affects the power consumption, the test shall be carried out with controlled ambient light conditions. Where the illuminance levels are externally defined (in the instructions for use), these values shall be used. Otherwise reference illuminance levels of >300 lx and <10 lx shall be used.

Information on the method used to achieve the above illuminance levels, where relevant, shall be recorded in the test report (see M.4). Where values of illuminance are given, they shall be measured as close to the product's light sensor as practical.

NOTE 1 The measured power for some products could be affected by the ambient conditions (e.g. illuminance, temperature).

During tests the ARC WELDING POWER SOURCE shall not be intentionally cooled by external means.

NOTE 2 Placing the ARC WELDING POWER SOURCE on a metal surface during tests is an example of cooling by external means.

M.1.3 Power supply

M.1.3.1 Supply voltage and frequency

Where the test voltage and frequency are not defined by an external standard or regulation, the test voltage and test frequency shall be the nominal voltage ± 5 % and the nominal frequency ± 1 % of the country for which the measurement is being determined (see Table M.1).

Table M.1 – Typical nominal electricity supply details for some regions

Country/Region	Nominal voltage and frequency	
	single phase system	two phase or three-phase systems
Europe	230 V, 50 Hz	400 V, 50 Hz
North America	120 V, 60 Hz	208 V, 60 Hz; 240 V, 60 Hz; 480 V, 60 Hz; 600 V, 60 Hz
Japan ^a	100 V, 50/60 Hz	200 V, 50/60 Hz; 220 V, 50/60 Hz; 400 V, 50/60 Hz
China	220 V, 50 Hz	380 V, 50 Hz
Australia and New Zealand	230 V, 50 Hz	400 V, 50 Hz
^a "50 Hz" is applicable for Eastern part and "60 Hz" for the Western part, respectively.		

M.1.3.2 Supply voltage waveform

For IDLE STATE power consumption measurements equal to or less than 5 W, the total HARMONIC CONTENT of the supply voltage when supplying the product under test shall not exceed 2 % (up to and including the 13th harmonic); HARMONIC CONTENT is defined as the root-mean-square (RMS) summation of the individual components using the fundamental as 100 %.

For IDLE STATE power consumption measurements greater than 5 W and for WELDING POWER SOURCE EFFICIENCY measurement, the total HARMONIC CONTENT of the supply voltage can exceed 2 %.

The value of the total HARMONIC CONTENT of the supply voltage shall be recorded during the test and reported (see M.4).

In addition to the above, the ratio of peak value to RMS value of the supply voltage (i.e. crest factor) when supplying the product under test shall be between 1,34 and 1,49.

NOTE Power supplies meeting IEC 61000-3-2 are likely to meet the above requirements.

M.1.4 Power measuring instruments

The requirements of IEC 62301:2011, 4.4 apply to the measurement of supply power and output power.

M.2 Measurements

M.2.1 General

Efficiency of the ARC WELDING POWER SOURCE is determined at load condition that results in the highest output power as specified by the manufacturer in the instruction manual or as stated on the RATING PLATE. In addition, power consumption is measured at IDLE STATE condition if an IDLE STATE condition is present and described in the user manual.

ARC WELDING POWER SOURCES are measured excluding the power drawn from external devices or auxiliary power supplies (see 11.5 and 11.6), and if part of the WELDING POWER SOURCE:

- liquid cooling system;
- wire feeder;
- arc striking and stabilizing devices;
- gas console;
- torch;

- air compressor.

In the instruction manual, the manufacturer shall indicate the procedure to switch off or to disable the excluded devices.

If any external device is necessary for full operation of the WELDING POWER SOURCE, it shall be connected to the WELDING POWER SOURCE.

Tests are made measuring the supply power and output power simultaneously.

M.2.2 Preparation of the ARC WELDING POWER SOURCE

The measurement procedure shall be performed on the same sample of ARC WELDING POWER SOURCE.

The following steps shall be followed and documented in the test report as applicable:

- output measurements shall be made at the WELDING POWER SOURCE WELDING CIRCUIT connections. For WELDING POWER SOURCES provided with permanently connected welding cables, measure the LOAD VOLTAGE at the exit point of the power source enclosure;
- for efficiency measurement, select the process which results in the highest output power;
- for AC capable ARC WELDING POWER SOURCE:
 - measure in DC operation and evaluate against AC limit, or
 - if DC operation is not available select the lowest frequency setting, but not lower than 50 Hz and set the waveform to rectangular or as specified by the manufacturer;
- for DC ARC WELDING POWER SOURCE with rapid current shut down utilizing an additional switch to interrupt the WELDING CURRENT, the AC limit applies;
- use CONVENTIONAL WELDING CONDITIONS (given in 3.1.17) and CONVENTIONAL LOAD VOLTAGES as specified in 11.2;
- measure the supply voltage of the supply-network-connected WELDING POWER SOURCE at the point of coupling of the WELDING POWER SOURCE to the supply network. If the power source is delivered without supply cable attach a cable according to the manufacturer's specifications with a length of $2^{+0,1}_0$ m from the exit point of the enclosure as specified in 10.9.

M.2.3 CONVENTIONAL LOAD conditions

The ARC WELDING POWER SOURCE shall be tested at the load conditions specified in Table M.2.

Table M.2 – Load conditions for the ARC WELDING POWER SOURCE

Conditions as specified	
Load condition	Description
1	IDLE STATE
2	Rated DUTY CYCLE (40 °C rating) at highest output power

Apply tolerances of ± 2 % for LOAD VOLTAGE and WELDING CURRENT. If LOAD VOLTAGE and WELDING CURRENT tolerance cannot be met due to load restrictions, two measurements shall be taken, as close as possible to the CONVENTIONAL LOAD condition, one above and one below. The results shall be linearly interpolated to the CONVENTIONAL LOAD condition and used for the efficiency calculation in M.2.8.

M.2.4 Test load

The load conditions specified in Table M.2 shall be achieved by using a resistive load. The resistive load can be a variable resistor, an electronic test load, or a combination thereof, as specified in 3.1.18 CONVENTIONAL LOAD.

M.2.5 Test set-up

Output power measurements of an ARC WELDING POWER SOURCE having an AC output shall be made with a power meter.

Output power measurements of an ARC WELDING POWER SOURCE having a DC output with a peak-to-peak ripple voltage that is less than 5 % of the RMS voltage at full load can be made either with a suitable power meter or with a separate voltmeter and ammeter. Using separate voltmeter and ammeter the voltage shall be filtered by applying a low pass filter for signal smoothing having a cut-off frequency between 2 kHz and 10 kHz or as recommended by the manufacturer. The filter characteristic can be incorporated within the voltmeter or a separate filter can be used. If a separate filter is used, then the attenuation caused by the filter shall be factored into the measurement.

Output power measurements of an ARC WELDING POWER SOURCE having a DC output with a peak-to-peak voltage ripple greater than or equal to 5 % of the RMS voltage at full load shall be made with a DC coupled power meter.

The load is adjusted to achieve CONVENTIONAL LOAD condition as specified in 11.2.

M.2.6 Measurement uncertainty

The measurement uncertainty related to determination of supply power due to the measuring instrument (U_e) is given in IEC 62301:2011, 4.4.1 and IEC 62301:2011, Annex D.

Measurement of output power shall be made such that the calculated or measured power due to the measuring instrument has an uncertainty of ≤ 2 % at the 95 % confidence level.

M.2.7 Measurement procedure

M.2.7.1 IDLE STATE power consumption

Verify equipment is in an operation mode compliant with IDLE STATE as specified in the instruction manual (see Note). ARC WELDING POWER SOURCES for mechanized systems may require external configuration to achieve IDLE STATE. Wait for any cool-down period of the power source (e.g. after the fan and cooling pump has stopped); and if equipped, wait until the power source has switched into a low energy IDLE STATE. The supply ACTIVE POWER is monitored for a period of 5 min to assess stability. If the supply ACTIVE POWER does not change by more than 5 % during these 5 min the measurement is considered to be stable and the measurements are recorded at the end of the 5 min period. If the supply ACTIVE POWER is not stable over a 5 min period, the stability shall be determined in accordance with IEC 62301:2011, 5.3.2.

NOTE If the IDLE STATE supply power limit is exceeded the welding output is possibly not in IDLE STATE. Select a welding mode where the WELDING CIRCUIT is not energized e.g. no voltage present (see 3.1.66).

M.2.7.2 WELDING POWER SOURCE EFFICIENCY

The output of the WELDING POWER SOURCE shall be maintained at 100 % DUTY CYCLE (40 °C rating) for at least 20 min, this is the warm-up period. After this warm-up period, the supply power is monitored for a period of 5 min to assess stability as specified in M.2.7.1. If the supply power level is stable, configure the WELDING POWER SOURCE to achieve the highest output power. Perform the measurements immediately after achieving the highest output power but not later than 60 s after the end of the 5 min stability assessment period. For machines rated only at 100 % DUTY CYCLE, this measurement can be taken at the end of the 5 min stability assessment period. See Figure M.1 for the measurement procedure.

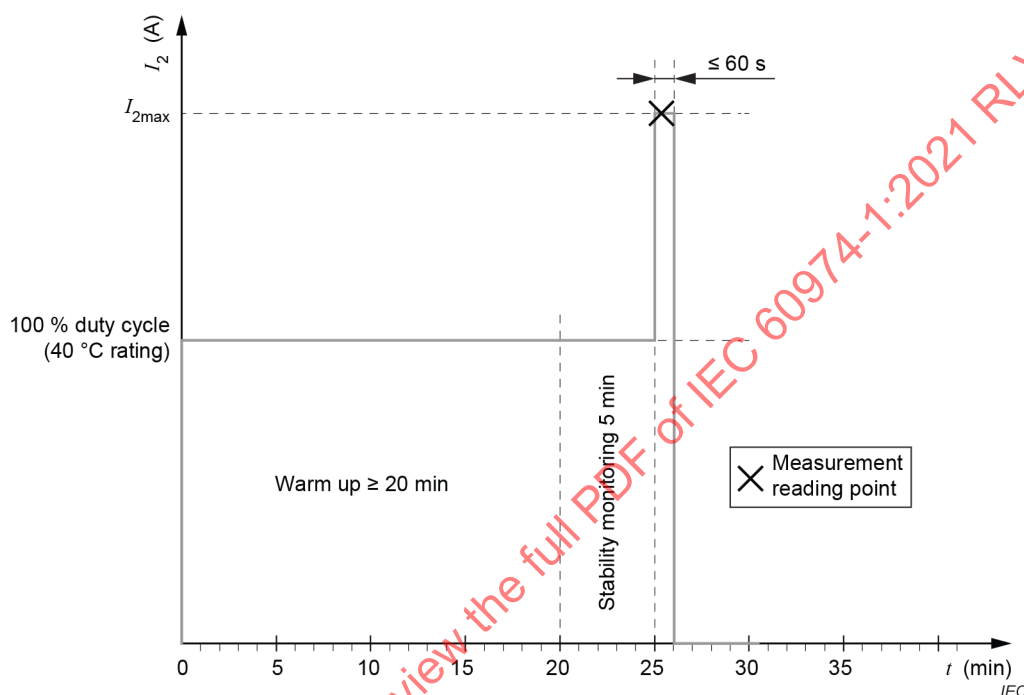


Figure M.1 – Measurement procedure

M.2.8 Efficiency calculation

The efficiency shall be calculated by dividing the measured output ACTIVE POWER at a given load condition by the supply ACTIVE POWER measured at that load condition.

M.3 Test report

M.3.1 Product details

All of the following information shall be recorded in the test report:

- details of the organisation taking responsibility for the product (e.g. the manufacturer);
- brand, model number, version or serial number;
- product description, as appropriate;
- RATED SUPPLY VOLTAGES and RATED SUPPLY FREQUENCY. CONVENTIONAL LOAD conditions as given in the specification or on the RATING PLATE.

M.3.2 Test parameters

All of the following information shall be reported:

- ambient temperature;
- supply voltage and frequency;
- TOTAL HARMONIC DISTORTION of the voltage waveform of the electricity supply system (%UTHD);
- information to describe the test set-up at load condition (e.g.: IDLE STATE condition, CONVENTIONAL LOAD condition of 11.2, DC setting, AC waveform type and setting, supply cable cross section and length; information on the illuminance levels if applicable, other significant parameters).

If any of the above values change during the test the minimum and maximum values shall be recorded.

NOTE For 3 phase supply system, report the average of all 3 line to line voltage measurements.

M.3.3 Test and laboratory details

All of the following information shall be recorded in the test report:

- test report number/reference;
- date of test;
- laboratory name and address;
- test officer(s);
- test equipment used;
- calibration due date.

M.3.4 Test data

All of the following information shall be recorded in the test report:

- measured and calculated data as described in Table M.3;
- efficiency as a percentage rounded to two significant figures;
- average power in watts rounded to three significant figures;
- measured output current and voltage;
- identification of the measurement method used (see IEC 62301:2011, 5.3.2 or IEC 62301:2011, 5.3.4);
- calculated uncertainty of the result due to the measuring instrument (U_e) (see IEC 62301:2011, Annex D) and whether the result complies with IEC 62301:2011, 4.4.1.

Table M.3 – Required reported data (measured and calculated)

Reported quantity	Description
Output current (A) (DC average or AC RMS)	Measured at load condition 2
Output voltage (V) (DC average or AC RMS)	
Output ACTIVE POWER (W)	
RMS supply voltage (V)	Measured at load conditions 1 and 2
Supply ACTIVE POWER (W)	
TOTAL HARMONIC DISTORTION of the supply voltage (%UTHD)	
IDLE STATE power consumption by the arc WELDING POWER SOURCE (W)	Measured at load condition 1
Efficiency	Calculated at load condition 2 (see M.2.8)

M.4 Test report template

ARC WELDING POWER SOURCE under test						
Brand name, as marked on ARC WELDING POWER SOURCE						
Organisation taking responsibility for the ARC WELDING POWER SOURCE (e.g. Manufacturer or importer)		Name		Address		
Model identification						
Version or serial number						
Product description		Number of supply phases				
Rated supply	Voltage (V)		Current (A)		Frequency (Hz)	
RATED OUTPUT	Voltage (V)		Current (A)		AC or DC?	
Test laboratory details						
Name of laboratory						
Address						
Test report number		Test date				
Prepared by		Approved by				
Test conditions						
Ambient temperature (°C)						
Information describing the test set-up used at load condition						
Test equipment	Manufacturer of test instrument	Model designation	Serial number	Calibration due date		
Voltage source						
Instrument used for measuring supply power						
Instrument(s) used for measuring output power						
Test configuration						
Nominal test supply voltage (V)						
Supply frequency (Hz)						
		Setting used when performing tests				
Supply cable length and cross section						
Measurement method for IDLE STATE power consumption from IEC 62301:2011, 5.3.2 or IEC 62301:2011, 5.3.4 used						

Results		
	Load condition	
	IDLE STATE	DUTY CYCLE
Output current (A),(DC average or AC RMS)		
Output voltage (V),(DC average or AC RMS)		
Output ACTIVE POWER (W)		
Supply voltage (V RMS)		
Supply ACTIVE POWER (W)		
TOTAL HARMONIC DISTORTION of supply voltage waveform (%UTHD)		
Efficiency		
Calculated measurement uncertainty		

NOTE For 3 phase supply, report the average of all 3 line to line voltage measurements.

Conclusion			
IDLE STATE condition power consumption (W)			
IDLE STATE limit applied (W)		Regulatory reference	
IDLE STATE verdict (PASS/FAIL)			
Efficiency (%)			
Efficiency limit applied (%)		Regulatory reference	
Efficiency verdict (PASS/FAIL)			

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Annex N
(normative)

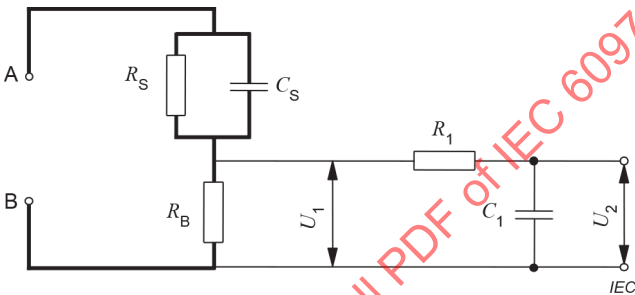
TOUCH CURRENT measurement

For measuring the TOUCH CURRENT in normal condition, the measuring network in accordance of Figure N.1 shall be used. For measuring the TOUCH CURRENT in fault condition, the measuring network in accordance with Figure N.2 and the appropriate configurations in Figure N.3 and Figure N.4 shall be used with an appropriate measuring device.

NOTE 1 Guidance on construction and application of TOUCH CURRENT instruments can be found in IEC 60990:2016 Annex G. Measuring network performance and calibration can be found in IEC 60990:2016, Annex K.

NOTE 2 Definitions for let-go, immobilization, perception and startle reaction thresholds are given IEC 60479-1:2018.

Caution! An EXPERT shall perform this test. The protective conductor is disabled for this test.

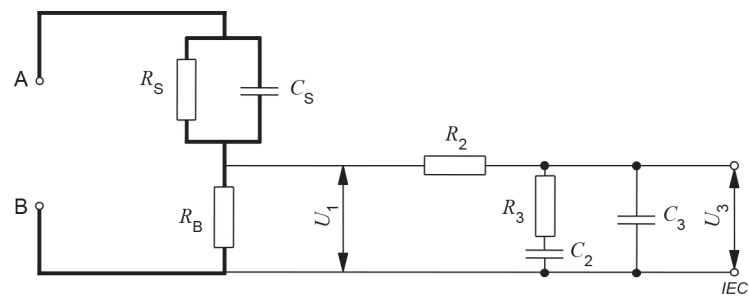


Key

A, B	Test terminals	C_S	0,22 μ F
R_S	1 500 Ω	R_1	10 000 Ω
R_B	500 Ω	C_1	0,022 μ F
U_1	RMS voltage	U_2	peak voltage

Weighted TOUCH CURRENT (perception or startle-reaction) = $\frac{U_2}{500}$ (peak value)

Figure N.1 – Measuring network, TOUCH CURRENT weighted for perception or startle-reaction



Key

A, B	Test terminals	R_2	10 000 Ω
R_S	1 500 Ω	R_3	20 000 Ω
R_B	500 Ω	C_2	0,006 2 μF
C_S	0,22 μF	C_3	0,009 1 μF
U_1	RMS voltage	U_3	peak voltage

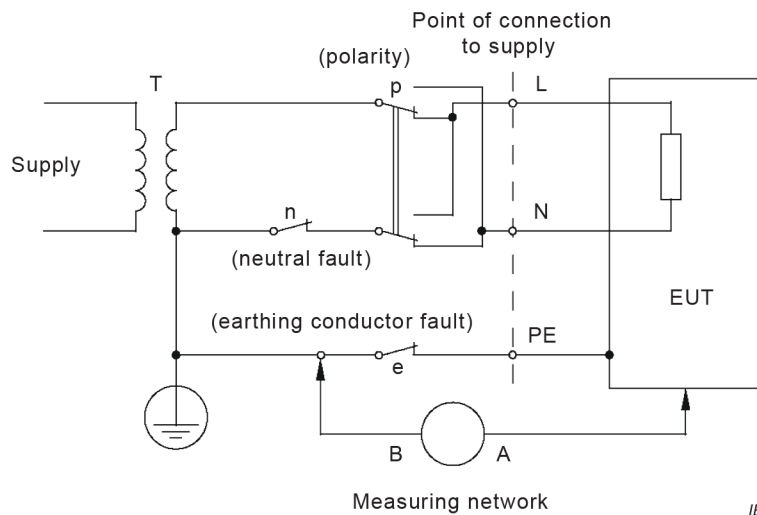
Weighted TOUCH CURRENT (letgo-immobilization) $= \frac{U_3}{500}$ (peak value)

Figure N.2 – Measuring network, TOUCH CURRENT weighted for letgo-immobilization

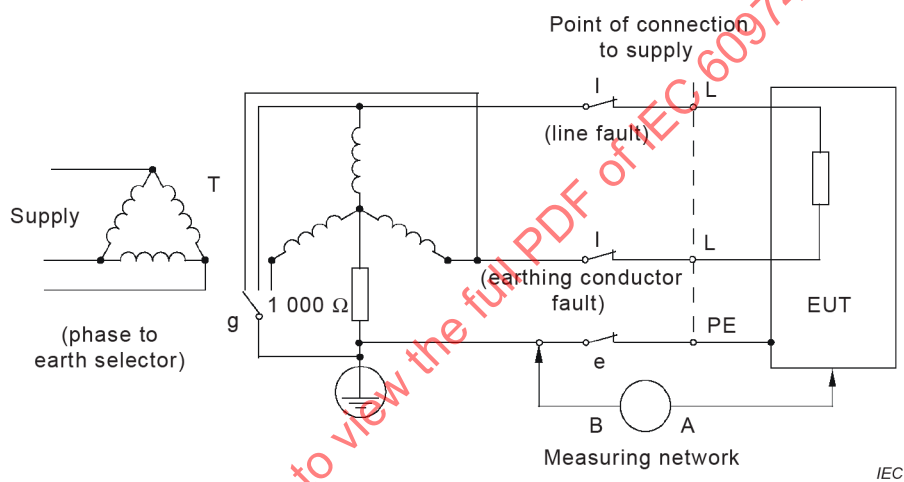
For three-phase equipment, TOUCH CURRENT in fault condition is measured with the switches (I) and (n) in the closed position and switch (e) in the open position. The measurement is then repeated with each of the switches (I) and (n) opened one by one, with the other switches closed, except switch (e). The measurements are similar for single-phase equipment, except that they shall be repeated for each position of the polarity switch (p).

The manufacturer shall identify the configuration (TN, TT, star IT, etc.) to which its equipment is intended to be connected in its final application. The equipment under test shall be tested to those identified configurations or the worst-case configuration.

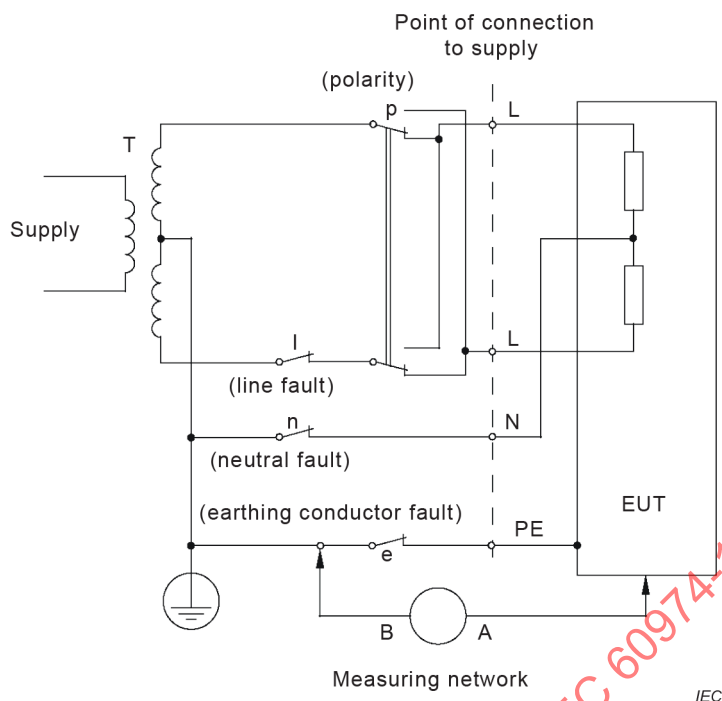
The use of isolating transformer (T) is optional. When not used, safety precautions shall be taken to protect the test operator from any hazardous voltage on the enclosure and other accessible conductive parts of the equipment.



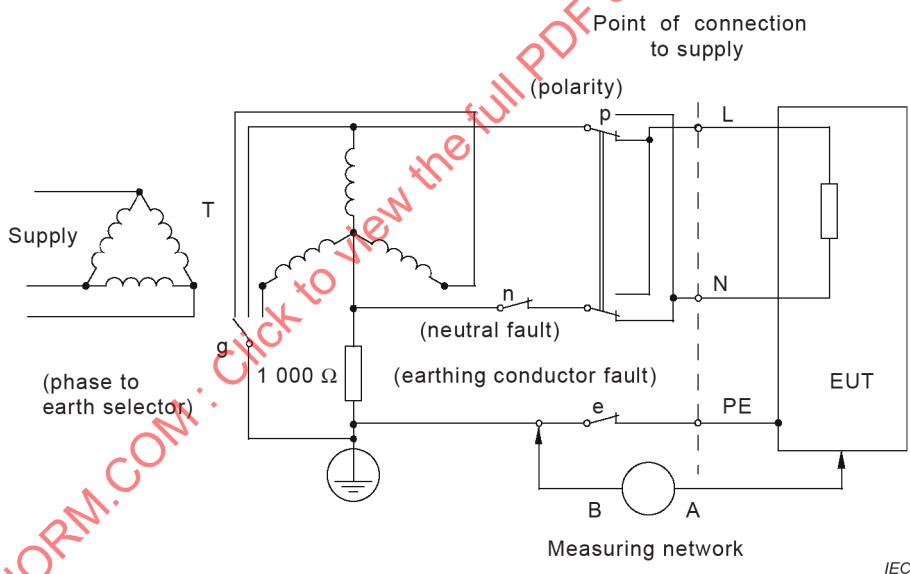
a) Single-phase equipment on star TN or TT system



b) Single-phase equipment connected line-to-line on star TN or TT system

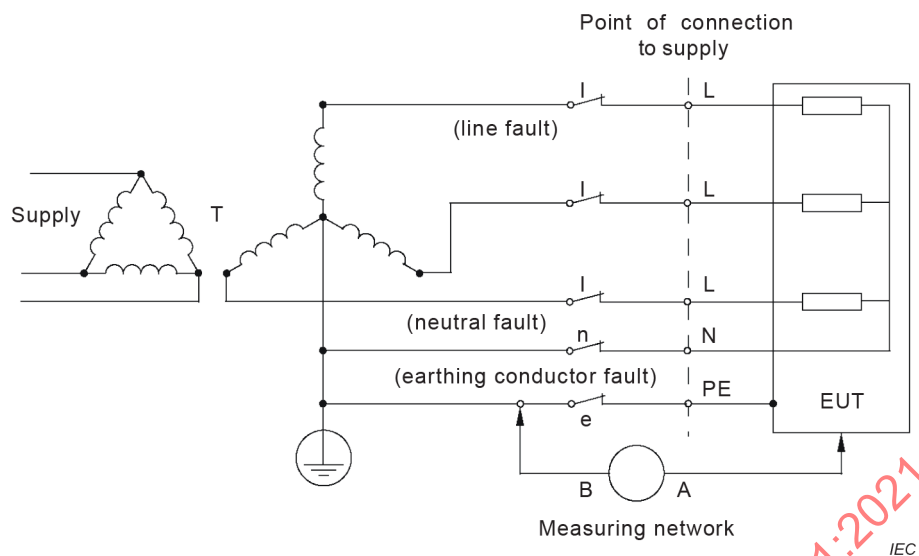


c) Single-phase equipment on centre-earthed TN or TT system

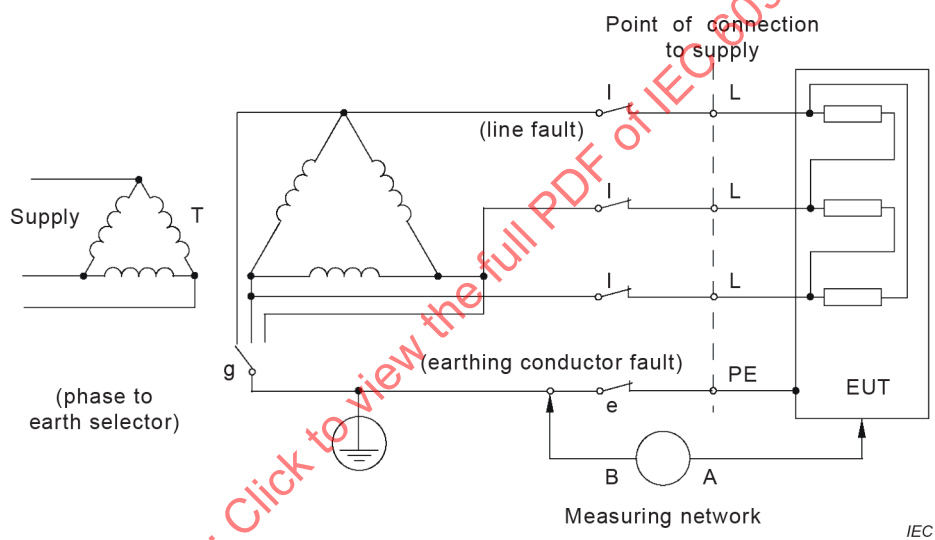


d) Single-phase equipment connected line-to-neutral on star IT system

Figure N.3 – Diagram for TOUCH CURRENT measurement on fault condition at operating temperature for single-phase connection of appliances other than those of CLASS II



a) Three-phase equipment on star TN or TT system



b) Three-phase equipment on unearthed three-phase three-line system

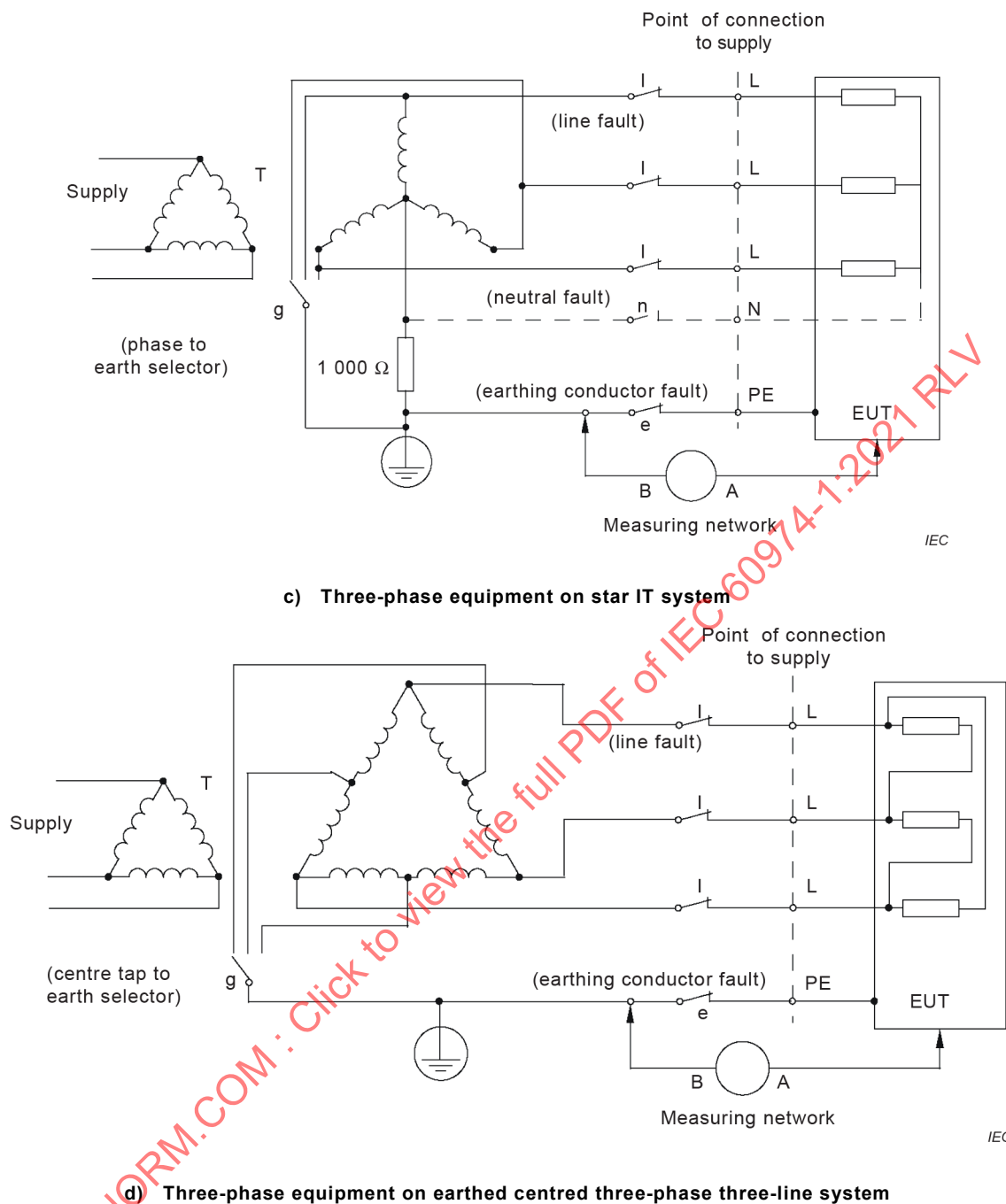


Figure N.4 – Diagram for TOUCH CURRENT measurement on fault condition for three-phase four-wire system connection of appliances other than those of CLASS II

Annex O (normative)

Battery-powered WELDING POWER SOURCES

O.1 General

Annex O applies to rechargeable battery-powered WELDING POWER SOURCES for arc welding and allied processes and the BATTERY packs for such equipment.

Battery-powered WELDING POWER SOURCES are WELDING POWER SOURCES powered either by:

- INTEGRAL BATTERIES,
- DETACHABLE BATTERY PACKS,
- SEPARABLE BATTERY PACKS.

All clauses of this document apply unless otherwise specified in Annex O. If a clause is included in Annex O, the numbered clauses of Annex O replace or add to the numbered clauses of the main body. Unless otherwise specified, the content of clauses and subclauses in Annex O replaces the content of the corresponding clauses and subclauses in the main body. Additional subclauses are numbered O.x.201, O.x.202, etc.

Battery-powered WELDING POWER SOURCES and BATTERY packs covered by Annex O can be operated:

- completely disconnected and isolated from the supply network;
- connected to the supply network with the WELDING CIRCUIT isolated from supply network.

Requirements for protection against risk of electric shock depend on specific electrical topology.

If the battery-powered WELDING POWER SOURCE can also be used during charging, the insulation requirements shall be considered when designing the charging unit.

Since BATTERY packs for WELDING POWER SOURCES are submitted to different use patterns (such as rough use, high charging and discharging currents), their safety can be evaluated only by Annex O and not by using other standards for BATTERY packs, such as the IEC 62133 series, unless otherwise indicated in Annex O. All relevant requirements of IEC 62133-1:2017 and IEC 62133-2:2017 are addressed in Annex O.

When evaluating the risk of fire associated with DETACHABLE BATTERY PACKS, consideration has been given to the fact that these BATTERY packs are unattended energy sources and have been evaluated as such in this document. Requirements in other standards regarding the risk of fire due to the charging of these DETACHABLE BATTERY PACKS are therefore considered to be fulfilled.

Annex O also addresses requirements covering the use of lithium-ion CELLS employed in BATTERY SYSTEMS in WELDING POWER SOURCES. The following shall be considered within the context of these requirements.

- These requirements address the safety of BATTERIES during storage and use including discharge and charge, and not any possible hazards associated with toxicity nor potential hazards associated with transportation or disposal.

NOTE 1 IEC 62281 covers the safety aspects of lithium-ion BATTERIES during transport.

- BATTERY SYSTEMS covered by these requirements are not intended to be serviced by the end user.

- These requirements are intended to provide comprehensive evaluation of a BATTERY only if used in products covered by this document.
- These requirements address the safety of BATTERY SYSTEMS during storage and use including discharge and charge. These requirements are only considered to be supplementary requirements in regards to BATTERY CHARGER fire and electric shock.
- These requirements refer to and require parameters supplied in reference to the CELLS that establish conditions for safe use of those CELLS. Those parameters form the basis of acceptance criteria for a number of tests contained herein. This document does not independently evaluate the safety of CELLS. These parameters, taken as a set, constitute the “SPECIFIED OPERATING REGION” for a CELL. There can be several sets of SPECIFIED OPERATING REGION(S).

Annex O does not apply to the safety of BATTERY CHARGERS themselves. However, it covers the safe functioning of BATTERY SYSTEMS. The equipment including charging unit, BATTERY pack and WELDING POWER SOURCE shall meet the separation requirements of the standard applied to the BATTERY CHARGER.

NOTE 2 IEC 60335-2-29 covers a variety of CHARGERS.

Annex O does not provide comprehensive safety information for manufacturing, maintenance and repair personnel.

O.4 Environmental conditions

Addition to Clause 4 of this document:

BATTERY conditions shall not exceed the BATTERY'S SPECIFIED OPERATING REGION. Depending on the technology used, different environmental conditions can be necessary and the resulting WELDING POWER SOURCE and/or BATTERY pack shall be marked accordingly (see 15.1).

NOTE See IEC 62133-2:2017, Figure A.1 for details.

O.5 Tests

O.5.1 Test conditions

Successive testing performed on a BATTERY can result in cumulative stress which can cause permanent damage to the BATTERY and should be avoided. Additional samples can be used as necessary, except for the TYPE TESTS where only one sample shall be used.

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

The heating test defined in O.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).

Other tests shall be carried out at an ambient air temperature of (25 ± 10) °C.

Unless otherwise specified, tests shall be performed starting with a FULLY CHARGED BATTERY.

Some of the tests can result in fire or EXPLOSION. It is therefore recommended that personnel should be protected from the flying fragments, explosive force, sudden release of heat, chemical burns, intense light and noise that can result from such EXPLOSIONS. The test area should be well ventilated to protect personnel from possible harmful fumes or gases.

Addition to 5.1 of this document:

O.5.1.201 When measuring voltage, the peak value of any superimposed ripple exceeding 10 % of the average value shall be included. Transient voltages are ignored, such as a temporary increase of voltage, for example after the BATTERY pack is removed from the CHARGER.

O.5.1.202 Measurements of CELL voltages during the tests of lithium-ion systems shall be made using a single pole resistive-capacitive low pass filter with a cut-off frequency of 5 kHz $\pm$ 500 Hz. If charging voltage limits have been exceeded, the peak value of the voltage measured after this network shall be used. The measurement shall have a measurement tolerance within ± 1 % for the combined filter circuit and voltmeter.

O.5.1.203 Unless otherwise specified, all BATTERIES shall be fully conditioned as follows: BATTERIES shall be FULLY DISCHARGED and after a rest of two hours charged in accordance with the manufacturer's instructions.

O.5.1.204 The location of thermocouples for CELL temperature measurements shall be on the outer surface, half way along the longest dimension, of the CELL that results in the highest temperature.

O.5.1.205 Currents measured during BATTERY charging shall be average currents with an averaging period of 1 s to 5 s. Current limits set by the BATTERY manufacturer's specification shall not be exceeded.

O.5.1.206 If not otherwise specified, a FULLY CHARGED BATTERY shall be used.

O.5.1.207 When a BATTERY comprised of a single CELL is employed, instructions in this document referring to special preparations of a CELL in a series configuration do not apply.

O.5.1.208 For BATTERY designs where there is a series arrangement of parallel clusters of CELLS, the cluster shall be treated as a single CELL for those tests that require altering the amount of charge on a single CELL prior to conducting the test.

O.5.1.209 Unless the manufacturer specifies a different voltage, the end-of-discharge voltages for common CELL chemistries are:

- 0,9 V per CELL for nickel cadmium or nickel metal-hydride BATTERIES;
- 1,75 V per CELL for lead-acid BATTERIES;
- 2,5 V per CELL for lithium-ion BATTERIES.

O.5.3 Conformity of components

Addition to 5.3 of this document:

CELLS employed in WELDING POWER SOURCES or CELLS employed in BATTERY packs shall comply with IEC 62133-1:2017 or IEC 62133-2:2017, except for lead-acid BATTERIES.

NOTE The above requirement for testing according to IEC 62133-1:2017 or IEC 62133-2:2017 does not include the BATTERY pack itself.

O.6 Protection against electric shock

O.6.1 Insulation

O.6.1.1 General

Addition to 6.1.1 of this document:

Protection against electric shock from BATTERY VOLTAGE CLASS B circuits shall be composed of:

- BASIC PROTECTION measures against direct contact with live parts;
- measures for protection under SINGLE-FAULT CONDITIONS.

The protection measures shall meet the requirements as described in a) and b) or a) and c).

a) BASIC PROTECTION measures

Persons shall be protected against direct contact with the live parts of the BATTERY VOLTAGE CLASS B electric circuits. The protection measures against direct contact shall be provided by one of the following:

- BASIC INSULATION of the live parts;
- enclosures, preventing access to the live parts.

The enclosures can be electrically conductive or non-conductive.

b) Protection under SINGLE-FAULT CONDITIONS

• Equipotential bonding

Exposed conductive parts of BATTERY VOLTAGE CLASS B electric equipment, including exposed conductive enclosures, shall be bonded together for potential equalization in accordance with the requirements in O.10.5.201.

• Insulation resistance

The BATTERY VOLTAGE CLASS B electric circuits intended to be not conductively connected to the supply network shall have sufficient insulation resistance in accordance with the requirements in O.6.1.4.

Requirements on insulation resistance for BATTERY VOLTAGE CLASS B electric circuits intended to be conductively connected to the supply network shall comply with 6.1.4.

c) Alternative approach for protection against electric shock

As an alternative to b), the equipment manufacturer shall conduct an appropriate risk assessment and establish a set of measures which give sufficient protection against electric shock under SINGLE-FAULT CONDITIONS.

O.6.1.4 Insulation resistance

Addition to 6.1.4 of this document:

The minimum insulation resistance from BATTERY VOLTAGE CLASS B circuits to accessible surfaces shall be at least 100 Ω/V . The reference shall be the maximum WORKING VOLTAGE.

NOTE Hazard of electric shock occurs when electric currents depending on value and duration pass through the human body. Harmful effects can be avoided if the current is within zone DC-2 for DC or zone AC-2 for AC as shown in IEC 60479-1:2018, Figure 20 and Figure 22, respectively. The relation of harmful body currents and other wave forms and frequencies is described in IEC 60479-2:2019. The insulation resistance requirements of 100 Ω/V for DC equals body currents of 10 mA.

To meet the above requirement for the entire circuit, it is necessary to have a higher insulation resistance for each component, depending on the number of the components and the structure of the circuit to which they belong.

Conformity shall be checked by the following procedure

a) Preconditioning and conditioning

Prior to the measurement, the device under test (DUT) shall be subjected to a preconditioning period of at least 8 h at $(5 \pm 2) ^\circ\text{C}$, followed by a conditioning period of 8 h at a temperature of $(23 \pm 5) ^\circ\text{C}$, a humidity of $90^{+10}_{-5} \%$, and an atmospheric pressure of between 86 kPa and 106 kPa.

Alternative preconditioning and conditioning parameters can be selected provided transition across the dew point occurs shortly after the beginning of the conditioning period.

The insulation resistance shall be measured during the conditioning period at a rate from which the lowest value can be determined.

b) Insulation resistance measurements

The insulation resistance of entire conductively connected BATTERY VOLTAGE CLASS B electric circuits can be measured using the test procedure for the measurement of the rechargeable energy storage system (RESS) given in ISO 6469-1:2009, 6.1.3.

If the system has several voltage ranges (e.g. because of boost converter) in a conductively connected circuit and some of the components cannot withstand the maximum WORKING VOLTAGE of the entire circuit, the insulation resistances of components can be measured separately by applying their own maximum WORKING VOLTAGES after those components are disconnected.

The measurements shall be performed using suitable instruments that can apply DC voltage (e.g. megohmmeter, provided they deliver the required test voltage).

O.6.1.5 Dielectric strength

Addition to 6.1.5 of this document:

a) BATTERY VOLTAGE CLASS B circuits not conductively connected to the supply network

For BATTERY VOLTAGE CLASS B circuits the test voltage, AC or DC, shall be greater than the highest voltage that can actually occur to the component. The test voltage shall be derived from the relevant over-voltages of the electric circuit to which the component is connected. Transient over-voltages that can be expected, including influences from other connections to the supply network, if any, shall be considered. The test voltage and its duration shall be specified, considering the applicable parts and sections of IEC 60664 by the manufacturer.

This test is intended to demonstrate the adequacy of the protection measures to isolate live parts of BATTERY VOLTAGE CLASS B electric circuits.

b) BATTERY VOLTAGE CLASS B circuits conductively connected to the supply network

These shall comply with 6.1.5.

Addition to 6.1 of this document:

O.6.1.201 CREEPAGE DISTANCES (6.1.3) and CLEARANCES (6.1.2) do not apply to the construction of BATTERY CELLS or the interconnections between CELLS in a BATTERY pack.

O.6.1.202 When evaluating a BATTERY pack for protection against electric shock, CREEPAGE DISTANCES, CLEARANCES and distances through insulation, the BATTERY pack shall be connected to the CHARGER.

O.6.2 Protection against electric shock in normal service

Addition to 6.2 of this document:

O.6.2.201 Battery-powered WELDING POWER SOURCES and BATTERY packs shall be so constructed and enclosed that there is adequate protection against electric shock.

Conformity shall be checked by VISUAL INSPECTION, and by the tests of O.6.2.202 to O.6.2.205, as applicable.

O.6.2.202 For detachable and SEPARABLE BATTERY PACKS, it shall not be possible to have two conductive, simultaneously accessible parts where the voltage between them exceeds 60 V DC.

O.6.2.203 A BATTERY SYSTEM shall be short-circuit protected by an over-current interruption device. The over-current interruption device shall be suitable for this application.

O.6.2.204 BATTERIES exceeding a voltage of 113 V DC shall be insulated in accordance with 6.2.4 (isolation of the WELDING CIRCUIT).

O.6.2.205 BATTERY VOLTAGE CLASS B circuits up to a voltage of 113 V DC can be conductively connected to the WELDING CIRCUIT provided the NO-LOAD VOLTAGE does not exceed 60 V DC in a SINGLE-FAULT CONDITION.

NOTE A switch-disconnector element in accordance with IEC 60947-3 having an appropriate rating is considered to meet the single-fault requirement.

O.7 Thermal requirements

O.7.1 Heating test

O.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 constant current starting with a FULLY CHARGED BATTERY:

- a) with the RATED MAXIMUM WELDING CURRENT (I_{2max}) with CONSECUTIVE OPERATING CYCLES;
- b) with the rated WELDING CURRENT (I_2) which allows continuous operation;

until the WELDING POWER SOURCE no longer operates due to the BATTERY being discharged.

For WELDING POWER SOURCES with DETACHABLE BATTERY PACKS or SEPARABLE BATTERY PACKS the test is performed three times on one WELDING POWER SOURCE in immediate succession with FULLY CHARGED BATTERY packs.

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.

Additionally for WELDING POWER SOURCES where continuous charging during welding is possible a heating test as specified in 7.1 shall be conducted where the charge of the BATTERY is the same at the end of the test as it was at the beginning.

The ambient temperature condition of O.5.1 shall be fulfilled before starting the test and the BATTERIES shall be conditioned as specified in O.5.1.203.

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

NOTE 2 Operation time of welding equipment changes with BATTERY temperature, which could lead to higher component temperatures at different ambient temperatures (e.g. 20 °C).

O.7.1.3 Duration of test

The heating test for the continuous operation shall be carried out at the highest WELDING CURRENT and CONVENTIONAL LOAD VOLTAGE that fully discharges the BATTERY without interruption (e.g. THERMAL PROTECTION or automatic means).

O.7.2 Temperature measurement

O.7.2.1 Measurement conditions

The temperature shall be determined 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.

O.7.4 Loading test

WELDING POWER SOURCES shall withstand repeated load cycles without damage or functional failure. This test 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) the BATTERY is FULLY DISCHARGED.

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

Immediately, while equipment is still hot, the equipment shall be checked in accordance with 6.1.5 and O.6.1.5 if applicable.

Addition to Clause 7 of this document:

O.7.201 Normal charging of lithium-ion systems

Charging a lithium-ion BATTERY under normal conditions shall not exceed the SPECIFIED OPERATING REGION FOR CHARGING of the CELL.

Conformity shall be checked by the following tests.

The BATTERY is charged in accordance with the CHARGING SYSTEM instructions starting with a FULLY DISCHARGED BATTERY. Testing is carried out at an ambient temperature of $(40 \pm 5) ^\circ\text{C}$ and

- *if the WELDING POWER SOURCE is recommended to be operated at a minimum temperature lower than $4 ^\circ\text{C}$, the test is also conducted at that minimum temperature $_{-5}^0 ^\circ\text{C}$;*
- *if the WELDING POWER SOURCE is recommended to be operated at a maximum temperature greater than $40 ^\circ\text{C}$, the test is also conducted at that maximum temperature $_{0}^{+5} ^\circ\text{C}$.*

For individual CELLS, the voltage, the temperature measured in accordance with O.5.1.205 and the charging current are monitored to ensure that the hotspot of the BATTERY PACK is within limits. In the case of parallel configurations, analysis can be used to avoid measuring the individual branch currents. The result shall not exceed their SPECIFIED OPERATING REGION FOR CHARGING (e.g. limits of voltage and current dependent on the temperature).

NOTE 1 The following is an example result of such analysis: the charging current for each branch of a parallel connection is not monitored, if the maximum deliverable current of the CHARGER did not exceed the MAXIMUM CHARGING CURRENT of a single CELL.

For BATTERIES employing series configurations, the test is repeated with a deliberately imbalanced BATTERY. The imbalance is introduced into a FULLY DISCHARGED BATTERY by charging one CELL to approximately 50 % of full charge.

If it can be demonstrated through testing and/or design evaluation that an imbalance less than 50 % would actually occur in normal use, then this lower imbalance can be used.

NOTE 2 Examples are those designs that employ circuitry intended for maintaining balance between CELLS in the BATTERY pack. Systems with a small number of CELLS in series can be shown to exhibit limited imbalance in practice, if the product ceases to operate with a BATTERY prepared with a smaller initial imbalance.

NOTE 3 An example for a testing is repeated charging and discharging of a BATTERY in accordance with the manufacturer's instructions until its capacity has decreased to 80 % of the rated capacity, using the imbalance at the end of the test.

O.8 THERMAL PROTECTION

O.8.1 General requirements

A battery-powered WELDING POWER SOURCE shall be fitted with THERMAL PROTECTION. This THERMAL PROTECTION shall meet the requirements of 8.2, 8.3, O.8.4 and 8.5 to 8.7.

Conformity shall be checked by VISUAL INSPECTION.

O.8.4 Operating capacity

The THERMAL PROTECTION shall be able to operate 200 times, when the WELDING POWER SOURCE delivers its RATED MAXIMUM WELDING CURRENT.

The conformity shall be checked with a suitable overload of a circuit having the same electrical characteristics, especially current and reactance, as the circuit in which the THERMAL PROTECTION is used.

O.9 Abnormal operation

O.9.1 General requirements

All WELDING POWER SOURCES and their BATTERY packs shall not break down and increase the risk of electric shock or fire under the conditions of operations O.9.2 to O.9.207.

Conformity shall be checked by the following tests.

O.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 with a FULLY CHARGED BATTERY while the fan motor(s) is(are) mechanically stalled and the WELDING POWER SOURCE is operated at the output condition of O.7.1.

O.9.3 Short circuit test

The battery-powered 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 battery-powered WELDING POWER SOURCE at the maximum output setting with a FULLY CHARGED BATTERY shall not clear fuses or circuit-breakers 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 a protection device operates.

O.9.4 Overload test

This subclause is not applicable.

Addition to Clause 9 of this document:

O.9.201 WELDING POWER SOURCE – abnormal conditions

The battery-powered WELDING POWER SOURCE, BATTERY pack and the cables of b) and c), as appropriate, are placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm. The test is conducted until failure or until the test sample returns to within 5 K of the ambient temperature or, if neither of these occurs, until at least 3 h has elapsed. A new sample can be used for each fault listed below. No EXPLOSION shall occur during or after the test. There shall be adequate protection against electric shock as defined in O.6.2. No CHARRING or burning of the cotton shall result. VENTING of the CELLS is permitted.

The resistance for the short in items a), b) and c) shall not exceed 10 mΩ. CHARRING or igniting of the cotton from the shorting means is not considered a failure.

Fuses, thermal cut-outs, thermal links, temperature limiters, electronic devices or any component(s) or conductors(s) that interrupt the discharge current may operate during the above tests. If these devices are relied upon to pass the test, the test shall be repeated two more times, using two additional sample devices, and shall open the circuit in the same manner, unless the test is otherwise satisfactorily completed. Alternatively, the test can be repeated with the open-circuited device bridged.

- a) Combinations of exposed terminals of a DETACHABLE BATTERY PACK are shorted so as to produce the worst result. BATTERY pack terminals that can be contacted using either test probe B of IEC 61032:1997 or test probe 13 of IEC 61032:1997 are considered exposed. The means of shorting shall be selected or positioned such that CHARRING or ignition of the cotton is not influenced.
- b) Any cable provided between the SEPARABLE BATTERY PACK and the battery-powered WELDING POWER SOURCE shall be shorted at the point likely to produce the most adverse effects.
- c) Any cable provided between the BATTERY pack or the battery-powered WELDING POWER SOURCE and the CHARGER shall be shorted at the point likely to produce the most adverse effects.

O.9.202 WELDING CIRCUIT components – abnormal conditions

The following fault conditions are considered for the power circuit path of the WELDING POWER SOURCE and, if necessary, applied one at a time, consequential faults being taken into consideration:

- a) open-circuit at the terminal of any component;

- b) short-circuit of capacitors, unless they comply with IEC 60384-14;
- c) short-circuit of any two terminals of an ELECTRONIC COMPONENT, other than a monolithic integrated circuit. This fault is not applied between the two circuits of an optocoupler;
- d) failure of triacs in the diode mode;
- e) failure of a monolithic integrated circuit or other circuits that cannot be assessed by the fault conditions a) to d). In this case the possible hazardous situations of the WELDING POWER SOURCE are assessed to ensure that safety does not rely on the correct functioning of such a component. All possible output signals are considered under fault conditions within the integrated circuit. If it can be shown that a particular output signal is unlikely to occur, then the relevant fault is not considered.

Components such as thyristors and triacs are not subjected to fault condition e).

Positive temperature coefficient resistors (PTCs) are not short-circuited if they are used within their manufacturer's declared specification.

For simulation of the conditions, the WELDING POWER SOURCE is operated at no-load condition adjusted to maximum output setting.

The test is conducted until failure or until one of the following occurs:

- THERMAL EQUILIBRIUM is achieved; or
- the test samples return to within 5 K of the ambient temperature; or
- a test period of 3 h has elapsed.

NOTE Examination of the WELDING POWER SOURCE and its circuit diagram will reveal the fault conditions which are simulated through circuit analysis, so that testing can be limited to those cases which can be expected to give the most unfavourable result.

O.9.203 Lithium-ion CHARGING SYSTEMS – abnormal conditions

This subclause applies only to lithium-ion BATTERIES.

The CHARGING SYSTEM and BATTERY of a lithium-ion system shall be so designed that the risk of fire and EXPLOSION as a result of abnormal operation during charging is obviated as far as is practical.

Conformity shall be checked by the following test.

A sample containing the BATTERY and the associated assemblies of the CHARGING SYSTEM are placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm. The BATTERY SYSTEM is operated as specified in O.17.1 t) 1) with all of the categories of abnormal conditions listed below in a) to d).

- a) Components in the CHARGING SYSTEM are faulted as in O.9.202 a) to e), one at a time, if the outcome of such a fault is uncertain based upon analysis. For each fault condition introduced, the state of the BATTERY before charging is as follows:
 - a series configured BATTERY shall have a deliberate imbalance. The imbalance is introduced into a FULLY DISCHARGED BATTERY by charging one CELL to approximately 50 % of full charge; or
 - if the test of O.7.201 is conducted with an imbalance of less than 50 %, a series configured BATTERY shall have a deliberate imbalance as established in O.7.201; or
 - a single CELL or parallel only configuration BATTERY shall be FULLY DISCHARGED.

- b) If the test of O.7.201 is conducted with an imbalance of less than 50 % due to the function of circuit(s), and if a single fault of any component within that circuit(s) is shown to result in the loss of that function, then a series configured BATTERY shall be charged with a deliberate imbalance. The imbalance is introduced into a FULLY DISCHARGED BATTERY by charging one CELL to approximately 50 % of full charge.
- c) For a BATTERY with a series configuration, all CELLS are at approximately 50 % charge, except for one which is shorted. The BATTERY is then charged.
- d) With a FULLY CHARGED BATTERY connected to the CHARGER, a short is introduced to the CHARGING SYSTEM across a component or between adjacent PCB tracks at a location expected to produce the most unfavourable results to evaluate the effect of back-feed from the BATTERY. For a CHARGER with a cable that connects to the BATTERY, the short shall be introduced at the point likely to produce the most adverse effects. The resistance of the short shall not exceed 10 mΩ.

During the tests, each CELL voltage is continuously monitored to determine if it has exceeded the limit condition. VENTING of the CELLS is permitted.

The test is conducted until the sample under test experiences a failure, returns to within 5 K of the ambient temperature or, if neither of these, until at least 7 h or twice the normal charge period has elapsed, whichever is longer.

Tests are considered passed if all of the following are true:

- *There has been no EXPLOSION during the test.*
- No CHARRING or burning of the cotton has resulted. CHARRING or igniting of the cotton from the shorting means is not considered a failure.
- *The CELLS shall not have exceeded the UPPER LIMIT CHARGING VOLTAGE by more than 150 mV or, if they have, then the CHARGING SYSTEM shall be permanently disabled from recharging the BATTERY. To determine if recharging is disabled, the BATTERY shall be discharged by using the WELDING POWER SOURCE tested (in the case of an integral system) or by using a new sample of the WELDING POWER SOURCE (in the case of a detachable BATTERY SYSTEM) to approximately 50 % charge, followed by an attempt to recharge the BATTERY normally. There shall be no charging current after 10 min or after 25 % of the nominal capacity has been delivered, whichever occurs first.*
- *There shall be no evidence of damage to the CELL vent to impair compliance with O.14.204.*

O.9.204 Lithium-ion BATTERY short circuit

This subclause applies only to lithium-ion BATTERIES.

There shall be no risk of fire or EXPLOSION when the main discharge connections of a series configured INTEGRAL BATTERY, DETACHABLE BATTERY PACK or SEPARABLE BATTERY PACK are shorted under conditions of extreme imbalance.

Conformity shall be checked by the following test.

The test is conducted with all the CELLS of the BATTERY FULLY CHARGED and one CELL FULLY DISCHARGED.

A DETACHABLE BATTERY PACK or SEPARABLE BATTERY PACK is placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm.

A WELDING POWER SOURCE containing an integral BATTERY is placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm.

The main discharge connections of the BATTERY are shorted with a resistance not to exceed 10 mΩ. The test is conducted until the test sample experiences a failure or until the test sample returns to within 5 K of the ambient temperature. There shall be no EXPLOSION during or after the test. As a result of the test, there shall be no CHARRING or burning of the cotton. VENTING of CELLS is acceptable.

CHARRING or igniting of the cotton from the shorting means is not considered a failure.

Fuses, **thermal cut-outs, thermal links, temperature limiters**, electronic devices or any component(s) or conductor(s) that interrupt the discharge current can operate during the above tests. If these devices are relied upon to pass the test, the test shall be repeated two more times, using two additional samples, and shall open the circuit in the same manner, unless the test is otherwise satisfactorily completed. Alternatively, the test can be repeated with the open-circuited device bridged.

O.9.205 BATTERIES other than lithium-ion – overcharging

BATTERIES comprised of CELLS other than the lithium-ion type shall withstand abusive overcharging without risk of fire or EXPLOSION.

Conformity shall be checked by the following test.

The BATTERY is placed on a layer of dry absorbent surgical type cotton, extending beyond each side for a distance of 150 mm and charged at a rate of 10 times the C₅ RATE for the BATTERY for 85 min. There shall be no EXPLOSION and no CHARRING or burning of the cotton. VENTING of the CELLS is acceptable.

O.9.206 BATTERY pack disconnection

Plugs, connectors and switches in the electrical current path of BATTERY packs shall be suitable for this application and shall be able to disconnect the BATTERY pack from battery-powered WELDING POWER SOURCES without risk of fire and without risk of electrical shock.

This clause does not apply to a WELDING POWER SOURCE with an INTEGRAL BATTERY.

Conformity shall be checked by VISUAL INSPECTION according to O.6.1.202 after the following tests.

The FULLY CHARGED BATTERY pack operating the battery-powered WELDING POWER SOURCE the output of which is connected to a CONVENTIONAL LOAD and adjusted to produce the RATED MAXIMUM WELDING CURRENT is disconnected 10 times.

O.9.207 GENERAL PURPOSE BATTERIES

For GENERAL PURPOSE BATTERIES replaceable by the user additional risk analysis should be performed by the manufacturer.

O.10 Connection to the supply network

Clause 10 is applicable only for BATTERY VOLTAGE CLASS B circuits conductively connected to the supply network, except as follows:

O.10.5 PROTECTIVE CIRCUIT

Addition to 10.5 of this document:

O.10.5.201 Continuity test for equipotential bonding of BATTERY VOLTAGE CLASS B circuits

All components forming the equipotential bonding current path (conductors, connections) shall withstand the maximum current in a single-fault situation.

The resistance of the equipotential bonding path between any two exposed conductive parts of the BATTERY VOLTAGE CLASS B electric circuit that can be touched simultaneously by a person shall not exceed 0,1 Ω .

The equipotential bonding resistances shall be tested by injecting a current of at least 10 A at 50 Hz or 60 Hz derived from a SELV source, which shall be passed through the potential current path between any two exposed conductive parts for at least 5 s. This path shall be isolated from other unintended potential paths for measurement. These conducting parts shall include BATTERY VOLTAGE CLASS B component housings, connections to battery-powered WELDING POWER SOURCE and the enclosures.

The voltage drop between any two reachable exposed conductive parts in a distance up to 2,5 m shall be measured and the resistance calculated from the current and this voltage drop.

NOTE 2,5 m is the usual distance which a person can reach.

O.10.8 SUPPLY CIRCUIT on/off switching device

Addition to 10.8 of this document:

Where a built-in BATTERY circuit on/off switching device (for example switch, contactor or circuit-breaker) is provided, this shall:

- a) plainly indicate whether the circuit is open or closed, and
- b) be rated as follows:
 - voltage: not less than the rated BATTERY voltage,
 - current: not less than the BATTERY current at CONVENTIONAL WELDING CONDITION with RATED MAXIMUM WELDING CURRENT,or
- c) be suitable for this application.

Conformity shall be checked by VISUAL INSPECTION for b) in accordance with other relevant standards, and for c) by the following tests.

Overload: The output of the FULLY CHARGED battery-powered WELDING POWER SOURCE is short-circuited in accordance with O.9.3. The switching device is operated for 100 cycles at the rate of 6 to 10 cycles per minute with a minimum on-time of 1 s.

Endurance: The output is connected to a CONVENTIONAL LOAD and adjusted to produce the RATED MAXIMUM WELDING CURRENT. The switching device is operated for 1 000 cycles at a rate of 6 to 10 cycles per minute with a minimum on-time of 1 s.

Addition to Clause 10 of this document:

O.10.201 For battery-powered WELDING POWER SOURCES with SEPARABLE BATTERY PACKS, the external flexible cable shall have anchorages such that the conductors are relieved from strain, including twisting, where they are connected within the WELDING POWER SOURCE, and protected from abrasion.

Conformity shall be checked by test in accordance with 10.6.

O.14 Mechanical provisions

O.14.1 General requirements

Addition to 14.1 of this document:

Following the test, the battery-powered WELDING POWER SOURCE and BATTERY pack shall not catch fire or explode.

In addition, the following applies for lithium-ion BATTERIES after the test of O.14.2.2 and O.14.4:

- the open circuit voltage of the BATTERY shall not be less than 90 % of the voltage measured immediately prior to the test;
- the BATTERY shall demonstrate normal discharging and recharging after the test;
- there shall be no damage to the CELL vent that impairs compliance with O.14.204.

O.14.2 Enclosure

O.14.2.2 Enclosure strength

Addition to 14.2.2 of this document:

DETACHABLE BATTERY PACKS shall be fitted during enclosure strength test.

For DETACHABLE BATTERY PACKS or SEPARABLE BATTERY PACKS with a mass greater than or equal to 3 kg the test is repeated on the BATTERY packs separately.

O.14.4 Drop withstand

Equipment with any DETACHABLE BATTERY PACK attached shall be capable of withstanding a drop test. For this test, the equipment shall be equipped with all the associated attachments, cooling liquid and filler wire (excluding gas cylinders, separate trailers, carts and wheel undercarriages, unless these items are standard equipment and permanently affixed) that are recommended to be installed.

The heights for the drop test shall be as follows:

- a) equipment with a mass of up to 25 kg shall withstand a drop of 250 mm;
- b) equipment with a mass of greater than 25 kg shall withstand a drop of 100 mm.

NOTE 1 Mass of equipment includes mass of associated attachments, cooling liquid and filler wire.

Conformity shall be checked by dropping the equipment three times on a hard and rigid surface. This test is so arranged that a different bottom edge of the equipment is struck each time it drops.

NOTE 2 In practice, one corner will touch the impact surface first.

In addition, for DETACHABLE BATTERY PACKS or SEPARABLE BATTERY PACKS with a mass less than 3 kg, the test is repeated on the BATTERY packs separately three times from a height of 1 m. The sample shall be positioned to vary the point of impact.

Addition to Clause 14 of this document:

O.14.201 It shall not be possible to install a DETACHABLE BATTERY PACK or a SEPARABLE BATTERY PACK in reverse polarity.

Conformity shall be checked by VISUAL INSPECTION.

O.14.202 Lithium-ion BATTERY enclosure pressure test

This subclause applies only to lithium-ion BATTERIES.

An enclosure for lithium-ion BATTERIES shall be designed such that it will safely release gasses that can be generated as a result of VENTING.

Conformity shall be checked by measurement in the case of a) or by the test of b):

- a) *the total area of the openings in the enclosure allowing gasses to pass without obstruction shall be equal to or greater than 20 mm²; or*
- b) *the enclosure shall be tested as follows.*

A total of $(21 \pm 2,1)$ ml of air shall be delivered at an initial pressure of $(2\,070 \pm 207)$ kPa through a $(2,87 \pm 0,05)$ mm diameter orifice to the enclosure of a WELDING POWER SOURCE with INTEGRAL BATTERY or the enclosure of a DETACHABLE BATTERY PACK or SEPARABLE BATTERY PACK. The pressure within the enclosure shall drop below 70 kPa in 30 s. There shall be no rupturing that would cause the enclosure to fail to meet the requirements of this document. An additional volume, not to exceed 3 ml, is allowed to be added to the enclosure volume as may be required for test fittings.

O.14.203 The manufacturer shall instruct the user that only GENERAL PURPOSE BATTERIES specified by the manufacturer shall be used as the primary energy source for battery-powered WELDING POWER SOURCES.

Conformity shall be checked by VISUAL INSPECTION.

O.14.204 Vents of BATTERY CELLS shall not be obstructed in such a way as to defeat their operation if VENTING is relied upon for safety.

Conformity shall be checked by VISUAL INSPECTION or, if in doubt, by inspecting the CELLS after conclusion of the abnormal tests of O.9.201 a), b) and c) to ensure that CELLS have not vented by any means other than through the CELL vent.

O.14.205 User accessible interfaces between elements of a BATTERY SYSTEM shall not employ connectors of the following types:

- standard mains inlet connectors, except for mains supply connections;
- barrel connectors with outside diameters of 6,5 mm or less;
- phone plugs with a diameter of 3,5 mm or less.

Conformity shall be checked by VISUAL INSPECTION.

O.15 RATING PLATE

O.15.3 Contents

a) Identification

Box 4 WELDING POWER SOURCE symbol if applicable (optional) and type of INTEGRAL BATTERY for example:

NiCd	nickel cadmium BATTERIES
NiMH	nickel metal-hydride BATTERIES
Li-ion	lithium-ion BATTERIES

b) Welding output

Box 12 $I_{2\max} = \dots A$ Symbol and value of RATED MAXIMUM WELDING CURRENT.

Box 13 $U_2 = \dots V$ Symbol and value of the CONVENTIONAL LOAD VOLTAGE.

Boxes 11a, 11b, 11c Not applicable.

12a, 12b, 12c Not applicable.

13a, 13b, 13c Not applicable.

Alternatively for WELDING POWER SOURCES where continuous charging during welding is possible in accordance with O.7.1.1, the DUTY CYCLE as specified in 15.3 b) can be used.

c) Energy supply

Box 14 Energy supply symbol, for example:

== Direct current

Box	WELDING POWER SOURCES with INTEGRAL BATTERY		Box	WELDING POWER SOURCES with detachable or separable BATTERY	
15	$U_b \dots V$	Rated BATTERY voltage	15	$U_b \dots V$	Rated BATTERY voltage
16	$Q \dots Ah$	Rated BATTERY capacity based on the rated capacity of the CELLS determined	19	BATTERY	BATTERY specified by the manufacturer
17	$I_b \dots A$	Rated charging current			
19	CHARGER	CHARGER specified by the manufacturer			
Boxes 15 to 17 form a table with corresponding values.					

Addition to 15.3 of this document:

d) Separable and DETACHABLE BATTERY PACKS shall also be marked with additional information as follows:

- type (identification) as given by the manufacturer;
- the year of manufacture and a date code identifying at least the month of manufacture;
- rated BATTERY voltage;
- the capacity assigned by the manufacturer in Ah, based on the rated capacity of the CELLS determined;
- for alkaline or other non-acid electrolyte BATTERIES, the type of BATTERY such as Li-Ion, NiCd and NiMH.

NOTE In Canada and the United States of America, the following additional requirements apply.

A battery-powered WELDING POWER SOURCE provided with a DETACHABLE BATTERY PACK or a SEPARABLE BATTERY PACK shall be marked: "For use only with ____ battery", or the equivalent, where the underlined space is completed with the manufacturer's name or trademark, a catalogue number, a series identification, or the equivalent, of the BATTERY pack. Alternatively, the statement "See instruction manual for additional BATTERY packs" or the equivalent can be employed in addition to at least one BATTERY pack referenced by catalogue number.

A DETACHABLE BATTERY PACK, a SEPARABLE BATTERY PACK, or a battery-powered WELDING POWER SOURCE provided with an INTEGRAL BATTERY shall be marked "For use only with ____ charger", or the equivalent, where the underlined space is completed with the manufacturer's name or trademark, a catalogue number, a series identification, or the equivalent, of the CHARGER. Alternatively, the statement "See instruction manual for additional chargers," or the equivalent can be employed in addition to at least one CHARGER referenced by catalogue number.

O.17 Instructions and markings

O.17.1 Instructions

Addition to 17.1 of this document:

t) For battery-powered WELDING POWER SOURCES:

- 1) Instructions regarding BATTERY charging, information regarding ambient temperature range for WELDING POWER SOURCE and BATTERY use and storage, and the recommended ambient temperature range for the CHARGING SYSTEM during charging;
 - 2) For a battery-powered WELDING POWER SOURCE intended for use with a DETACHABLE BATTERY PACK or a SEPARABLE BATTERY PACK: instructions indicating the appropriate BATTERY packs for use, such as by a catalogue number, series identification or the equivalent;
 - 3) Instructions indicating the appropriate CHARGER for use, such as by a catalogue number, series identification or the equivalent;
 - 4) Information regarding durability and lifetime of BATTERY, typical welding range for a FULLY CHARGED BATTERY and typical charging times;
 - 5) Warnings concerning battery-powered WELDING POWER SOURCES:
 - **Recharge only with the CHARGER specified by the manufacturer.** A CHARGER that is suitable for one type of BATTERY PACK can create a risk of fire when used with another BATTERY PACK.
 - **Use WELDING POWER SOURCES only with specifically designated BATTERY PACKS.** Use of any other BATTERY PACKS can create a risk of injury and fire.
 - **When BATTERY PACK is not in use, keep it away from other metal objects, like paper clips, coins, keys, nails, screws or other small metal objects that can make a connection from one terminal to another.** Shorting the BATTERY terminals together can cause burns or a fire.
 - **Under abusive conditions, liquid can be ejected from the BATTERY; avoid contact. If contact accidentally occurs, flush with water.** If liquid contacts eyes, additionally seek medical help. Liquid ejected from the BATTERY can cause irritation or burns.
 - **Do not use a BATTERY PACK or WELDING POWER SOURCE that is damaged or modified.** Damaged or modified batteries can exhibit unpredictable behaviour resulting in fire, EXPLOSION or risk of injury.
 - **Do not expose a BATTERY PACK or WELDING POWER SOURCE to fire or excessive temperature.** Exposure to fire or temperature above 130 °C can cause EXPLOSION.
- NOTE 1 The temperature "130 °C" can be replaced by the temperature "265 °F".
- **Follow all charging instructions and do not charge the BATTERY PACK or WELDING POWER SOURCE outside the temperature range specified in the instructions.** Charging improperly or at temperatures outside the specified range can damage the BATTERY and increase the risk of fire.

NOTE 2 In Europe (EN 60974-1), the following additional requirement applies:

For battery-powered WELDING POWER SOURCES with INTEGRAL BATTERY: instruction, how the INTEGRAL BATTERY can be removed safely from the WELDING POWER SOURCE after the WELDING POWER SOURCE's end of life, and information about the type of BATTERY such as Li-Ion, NiCd and NiMH.

O.17.2 Markings

Addition to 17.2 of this document:

Marking of BATTERY VOLTAGE CLASS B electric components:

The symbol W012:2011-05 in accordance with ISO 7010:2019 shown in Figure O.1 shall appear on (preferably) or near BATTERY VOLTAGE CLASS B electric power sources.

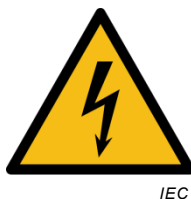


Figure O.1 – Marking of BATTERY VOLTAGE CLASS B electric components

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

MATÉRIEL DE SOUDAGE À L'ARC –

Partie 1: Sources de courant de soudage

AVANT-PROPOS

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L'IEC 60974-1 a été établie par le comité d'études 26 de l'IEC: Soudage électrique. Il s'agit d'une Norme internationale.

Cette sixième édition annule et remplace la cinquième édition parue en 2017 et l'Amendement 1:2019. Elle constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente.

- a) Ajout du Tableau 1 avec la liste des termes par référence croisée dans l'ordre alphabétique de la langue source.
- b) Le document de référence des distances d'ISOLEMENT DANS L'AIR et des LIGNES DE FUITE devient IEC 60664-1:2020.

- c) Modification du 6.1.2 et du 6.1.3 afin de respecter le dimensionnement de l'ISOLATION PRINCIPALE spécifié dans l'IEC 60664-1 pour le réseau d'alimentation avec des tensions rationalisées.
- d) Déplacement de l'essai de condensateur anormal du 6.2.2 au nouveau 9.5.
- e) Modification du 6.2.5 du 6.3.6 afin d'utiliser le réseau de mesure du COURANT DE CONTACT pondéré pour une opération de non-lâcher/immobilisation et ajout d'une exigence de tolérance pour la tension d'alimentation.
- f) Nouvelle structure du 16.3 et nouvelle exigence d'exactitude pour la valeur de tension affichée.
- g) Modification de l'Annexe A qui devient une annexe normative et ajout du Tableau A.2 et du Tableau A.3.
- h) Mise à jour rédactionnelle de l'Annexe L pour l'utilisation des symboles normalisés.
- i) Nouvelle rédaction du mesurage du rendement et de la puissance en ETAT AU RALENTI (Annexe M sur la base de l'IEC 62301:2011).
- j) Ajout d'un réseau de mesure pondéré pour une opération de non-lâcher/immobilisation (Annexe N).

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
26/724/FDIS	26/727/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue utilisée pour l'élaboration de la présente Norme internationale est l'anglais.

Le présent document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, supplément IEC; disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Dans le présent document, les caractères d'imprimerie suivants sont utilisés:

- *critères de conformité*: caractères *italiques*;
- termes utilisés dans le présent document qui ont été définis à l'Article 3: PETITES MAJUSCULES EN CARACTERES ROMAINS.

Une liste de toutes les parties de la série IEC 60974, sous le titre général *Matériel de soudage à l'arc*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu du présent document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives à la publication recherchée. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

IMPORTANT – Le logo 'colour inside' qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer le présent document en utilisant une imprimante couleur.

MATÉRIEL DE SOUDAGE À L'ARC –

Partie 1: Sources de courant de soudage

1 Domaine d'application

La présente partie de l'IEC 60974 s'applique aux sources de courant de soudage à l'arc et aux procédés connexes conçus pour un USAGE INDUSTRIEL ET PROFESSIONNEL qui sont alimentés sous une tension ne dépassant pas 1 000 V, alimentés par BATTERIE ou entraînés par des moyens mécaniques.

Le présent document spécifie les exigences de sécurité et de fonctionnement des SOURCES DE COURANT DE SOUDAGE et des SYSTEMES DE COUPAGE PAR PLASMA.

Le présent document ne s'applique pas aux sources de courant de soudage et de coupage à l'arc à service limité qui sont utilisées essentiellement par des non professionnels et qui sont conçues conformément à l'IEC 60974-6.

Le présent document inclut les exigences relatives aux SOURCES DE COURANT DE SOUDAGE alimentées par BATTERIE et aux blocs de batteries qui sont donnés à l'Annexe O.

Le présent document ne s'applique pas aux essais des sources de courant pendant la maintenance périodique ou après réparation.

NOTE 1 Le coupage à l'arc électrique et la projection à l'arc électrique sont des exemples de procédés connexes types.

NOTE 2 Des systèmes en courant alternatif de tension nominale comprise entre 100 V et 1 000 V sont présentés dans le Tableau 1 de l'IEC 60038:2009.

NOTE 3 Le présent document ne contient pas les exigences de compatibilité électromagnétique (CEM).

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-151, *Vocabulaire électrotechnique international (IEV) – Partie 151: Dispositifs électriques et magnétiques* (disponible à l'adresse: <http://www.electropedia.org>)

IEC 60050-851, *Vocabulaire électrotechnique international (IEV) – Partie 851: Soudage électrique* (disponible à l'adresse: <http://www.electropedia.org>)

IEC 60245-6, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 6: Câbles souples pour électrodes de soudage à l'arc*

IEC 60417, *Symboles graphiques utilisables sur le matériel* (disponible à l'adresse: <http://www.graphical-symbols.info/equipment>)

IEC 60445, *Principes fondamentaux et de sécurité pour les interfaces homme-machine, le marquage et l'identification – Identification des bornes de matériels, des extrémités de conducteurs et des conducteurs*

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60664-1:2020, *Coordination de l'isolement des matériels dans les réseaux d'énergie électrique à basse tension – Partie 1: Principes, exigences et essais*

IEC 60664-3, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution*

IEC 60695-11-10, *Essais relatifs aux risques du feu – Partie 11-10: Flammes d'essai – Méthodes d'essai horizontal et vertical à la flamme de 50 W*

IEC 60974-7, *Matériel de soudage à l'arc – Partie 7: Torches*

IEC 60974-10, *Matériel de soudage à l'arc – Partie 10: Exigences de compatibilité électromagnétique (CEM)*

IEC 61140, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*

IEC 61558-2-4, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-4: Règles particulières et essais pour les transformateurs de séparation des circuits et les blocs d'alimentation incorporant des transformateurs de séparation des circuits*

IEC 61558-2-6, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-6: Règles particulières et essais pour les transformateurs de sécurité et les blocs d'alimentation incorporant des transformateurs de sécurité*

IEC 62133-1:2017, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs portables étanches, et pour les batteries qui en sont constituées, destinés à l'utilisation dans des applications portables – Partie 1: Systèmes au nickel*

IEC 62133-2:2017, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs portables étanches, et pour les batteries qui en sont constituées, destinés à l'utilisation dans des applications portables – Partie 2: Systèmes au lithium*

IEC 62301:2011, *Appareils électrodomestiques – Mesure de la consommation en veille*

ISO 7010:2019, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Signaux de sécurité enregistrés*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60050-151, l'IEC 60050-851 et l'IEC 60664-1 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

Le Tableau 1 fournit une liste des termes par référence croisée classée par ordre alphabétique.

Tableau 1 – Liste alphabétique des termes

Terme	Numéro du terme	Terme	Numéro du terme	Terme	Numéro du terme
batterie	3.2.1	cycle de fonctionnement consécutif	3.2.22	micro-environnement	3.1.41
batterie incorporée	3.2.2	degré de pollution	3.1.40	personne avertie	3.1.4
batteries à usage général éléments à usage général	3.2.12	dispositif réducteur de risques	3.1.47	plaque signalétique	3.1.22
bloc de batteries amovibles	3.2.3	distance d'isolement	3.1.38	protection principale	3.2.18
bloc de batteries démontables	3.2.4	double isolation	3.1.52	protection thermique	3.1.45
caractéristique plate	3.1.9	échappement de gaz	3.2.16	puissance active	3.3.3
caractéristique statique	3.1.10	échauffement	3.1.43	puissance apparente	3.3.4
caractéristique tombante	3.1.8	efficacité de la source de courant de soudage	3.3.2	puissance assignée	3.1.23
carbonisation	3.2.21	élément	3.2.7	rapport harmonique total taux de distorsion harmonique total	3.3.6
charge conventionnelle	3.1.18	élément complètement chargé batterie complètement chargée	3.2.10	régime C ₅	3.2.6
chargeur	3.2.8	élément complètement déchargé batterie complètement déchargée	3.2.11	région de fonctionnement spécifiée	3.2.14
circuit d'alimentation	3.1.57	environnement avec risque accru de choc électrique	3.1.46	région de fonctionnement spécifiée pour le chargement	3.2.14.1
circuit de commande	3.1.12	équilibre thermique	3.1.44	source de courant de soudage source de courant de soudage à l'arc	3.1.1
circuit de protection	3.1.63	essai de type	3.1.5	source de courant électrique de coupage par plasma	3.1.55
circuit de soudage	3.1.11	essai individuel de série	3.1.6	système de batterie	3.2.5
classe de tension de batterie A	3.2.19	état au ralenti	3.1.66	système de charge	3.2.9
classe de tension de batterie B	3.2.20	examen visuel	3.1.7	système de coupage par plasma	3.1.54
classe d'isolation	3.1.64	expert personne compétente personne qualifiée	3.1.3	tension à vide	3.1.15
commande à distance	3.1.60	explosion	3.2.23	tension à vide assignée	3.1.26

Terme	Numéro du terme	Terme	Numéro du terme	Terme	Numéro du terme
composant électronique	3.2.17	facteur de marche	3.1.37	tension à vide assignée commutée	3.1.28
condition conventionnelle de soudage	3.1.17	facteur de puissance	3.3.5	tension à vide assignée réduite	3.1.27
condition de premier défaut	3.1.61	fréquence assignée d'alimentation	3.3.1	tension assignée d'alimentation	3.1.29
courant assigné d'alimentation	3.1.30	groupe de matériau	3.1.42	tension conventionnelle en charge	3.1.20
courant d'alimentation assigné à vide	3.1.31	installation fixe	3.1.62	tension en charge	3.1.14
courant d'alimentation assigné maximal	3.1.32	isolation fonctionnelle	3.1.65	tension locale	3.1.58
courant d'alimentation effectif maximal	3.1.33	isolation principale	3.1.50	très basse tension de sécurité	3.1.56
courant de charge maximal	3.2.13	isolation renforcée	3.1.53	usage industriel et professionnel	3.1.2
courant de contact	3.1.59	isolation supplémentaire	3.1.51	valeur assignée	3.1.21
courant de soudage	3.1.13	ligne de fuite	3.1.39	valeur conventionnelle	3.1.16
courant de soudage assigné maximal	3.1.24	limite supérieure de la tension de charge	3.2.15	vitesse assignée en charge	3.1.34
courant de soudage assigné minimal	3.1.25	matériel de classe I	3.1.48	vitesse de rotation assignée à vide	3.1.35
courant de soudage conventionnel	3.1.19	matériel de classe II	3.1.49	vitesse de rotation assignée au ralenti	3.1.36

3.1 Termes et définitions généraux

3.1.1

source de courant de soudage

source de courant de soudage à l'arc

matériel destiné à fournir un courant électrique et une tension et ayant les caractéristiques exigées, appropriées au soudage à l'arc et à des procédés connexes

Note 1 à l'article: Une SOURCE DE COURANT DE SOUDAGE peut également alimenter d'autres équipements et accessoires, par exemple des tensions auxiliaires, liquide de refroidissement, électrode fusible pour soudage à l'arc et gaz pour la protection de l'arc et de la zone de soudage.

Note 2 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-13-01, qui sera mis à jour.

3.1.2

usage industriel et professionnel

usage prévu uniquement pour des EXPERTS ou des PERSONNES AVERTIES

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

3.1.3**expert****personne compétente****personne qualifiée**

personne qui peut juger le travail assigné et reconnaître les dangers possibles sur la base de sa formation, ses connaissances, son expérience et sa connaissance du matériel concerné

Note 1 à l'article: Plusieurs années de pratique dans le domaine technique concerné peuvent être prises en considération pour l'estimation de la formation professionnelle.

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

3.1.4**personne avertie**

personne informée des tâches assignées et des dangers possibles dus à des négligences

Note 1 à l'article: Si nécessaire, la personne a subi une formation.

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

3.1.5**essai de type**

essai effectué sur un ou plusieurs dispositifs réalisés selon une conception donnée, afin de vérifier si ces dispositifs satisfont aux exigences de la norme concernée

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

3.1.6**essai individuel de série**

essai effectué sur chaque dispositif en cours ou en fin de fabrication pour vérifier qu'il satisfait aux exigences de la norme concernée ou à des critères spécifiés

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

3.1.7**examen visuel**

examen à l'œil nu destiné à vérifier qu'il n'y a pas de désaccord apparent par rapport aux dispositions de la norme concernée

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

3.1.8**caractéristique tombante**

CARACTÉRISTIQUE externe STATIQUE d'une SOURCE DE COURANT DE SOUDAGE qui, dans la zone normale de soudage, est telle que la pente négative est supérieure ou égale à 7 V/100 A

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-34, qui sera mis à jour.

3.1.9**caractéristique plate**

CARACTÉRISTIQUE externe STATIQUE d'une SOURCE DE COURANT DE SOUDAGE qui, dans la zone normale de soudage, est telle que lorsque le courant croît, la tension décroît de moins de 7 V/100 A ou croît de moins de 10 V/100 A

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

3.1.10

caractéristique statique

relation entre la tension et le courant aux bornes de sortie d'une SOURCE DE COURANT DE SOUDAGE quand elle est connectée à une CHARGE CONVENTIONNELLE

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-32, qui sera mis à jour.

3.1.11

circuit de soudage

tous les éléments conducteurs à travers lesquels le passage du COURANT DE SOUDAGE est prévu

Note 1 à l'article: En soudage à l'arc, l'arc fait partie du CIRCUIT DE SOUDAGE.

Note 2 à l'article: Dans certains procédés de soudage à l'arc, l'arc peut être établi entre deux électrodes. Dans un tel cas, la pièce mise en œuvre ne fait pas nécessairement partie du CIRCUIT DE SOUDAGE.

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

3.1.12

circuit de commande

circuit interne ou externe servant à commander le fonctionnement du matériel et/ou la protection des circuits de puissance

EXEMPLE 1 CIRCUITS DE COMMANDE destinés à réaliser l'interface entre la SOURCE DE COURANT DE SOUDAGE et un matériel externe conçu par le fabricant.

EXEMPLE 2 CIRCUITS DE COMMANDE destinés à réaliser l'interface entre la SOURCE DE COURANT DE SOUDAGE et d'autres types de matériels accessoires.

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-14-11, qui sera mis à jour.

3.1.13

courant de soudage

courant fourni par une SOURCE DE COURANT DE SOUDAGE pendant le soudage

3.1.14

tension en charge

tension entre les bornes de sortie lorsque la SOURCE DE COURANT DE SOUDAGE débite un COURANT DE SOUDAGE

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

3.1.15

tension à vide

tension entre les bornes de sortie accessibles d'une SOURCE DE COURANT DE SOUDAGE, lorsque le CIRCUIT DE SOUDAGE est ouvert, mais sous tension, à l'exclusion de toute tension d'amorçage ou de stabilisation

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-24, qui sera mis à jour.

3.1.16

valeur conventionnelle

valeur normalisée utilisée pour la mesure d'un paramètre en vue de comparaison, étalonnage, essai, etc.

Note 1 à l'article: Les VALEURS CONVENTIONNELLES ne s'appliquent pas nécessairement au cours d'une opération de soudage.

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

3.1.17**condition conventionnelle de soudage**

condition de la SOURCE DE COURANT DE SOUDAGE sous tension et à l'état thermiquement stabilisé définie par un COURANT DE SOUDAGE CONVENTIONNEL établi sous la TENSION CONVENTIONNELLE EN CHARGE correspondante dans une CHARGE CONVENTIONNELLE pour la TENSION D'ALIMENTATION, la fréquence ou la vitesse de rotation assignées

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

3.1.18**charge conventionnelle**

charge résistive constante pratiquement non inductive ayant un FACTEUR DE PUISSANCE non inférieur à 0,99

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

3.1.19**courant de soudage conventionnel**

I_2

courant débité par une SOURCE DE COURANT DE SOUDAGE dans une CHARGE CONVENTIONNELLE sous la TENSION CONVENTIONNELLE EN CHARGE correspondante

Note 1 à l'article: Les valeurs de I_2 sont données en valeurs efficaces pour le courant alternatif et en valeurs moyennes arithmétiques pour le courant continu.

3.1.20**tension conventionnelle en charge**

U_2

TENSION EN CHARGE d'une SOURCE DE COURANT DE SOUDAGE, liée au COURANT CONVENTIONNEL DE SOUDAGE par une relation linéaire spécifiée

Note 1 à l'article: Les valeurs de U_2 sont données en valeurs efficaces pour le courant alternatif et en valeurs moyennes arithmétiques pour le courant continu.

Note 2 à l'article: La relation linéaire spécifiée varie suivant le procédé de soudage (voir 11.2).

Note 3 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-30, qui sera mis à jour.

3.1.21**valeur assignée**

valeur, assignée généralement par le fabricant, pour une condition de fonctionnement spécifiée d'un composant, d'un dispositif ou d'un matériel

3.1.22**plaque signalétique**

plaque, fixée de façon permanente sur un dispositif électrique, où sont inscrites de façon indélébile les caractéristiques assignées et d'autres informations, selon les exigences de la norme applicable

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

3.1.23**puissance assignée**

VALEURS ASSIGNEES de la puissance de l'équipement

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-17, qui sera mis à jour.

3.1.24

courant de soudage assigné maximal

$I_{2\max}$

valeur maximale du COURANT CONVENTIONNEL DE SOUDAGE pouvant être fournie par la SOURCE DE COURANT DE SOUDAGE à son réglage maximal dans la CONDITION CONVENTIONNELLE DE SOUDAGE

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

3.1.25

courant de soudage assigné minimal

$I_{2\min}$

valeur minimale du COURANT CONVENTIONNEL DE SOUDAGE qui peut être fournie par la SOURCE DE COURANT DE SOUDAGE à son réglage minimal dans les CONDITIONS CONVENTIONNELLES DE SOUDAGE

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

3.1.26

tension à vide assignée

U_0

TENSION A VIDE dans les CONDITIONS ASSIGNEES DE TENSION D'ALIMENTATION et de fréquence ou de VITESSE DE ROTATION ASSIGNEE A VIDE

Note 1 à l'article: Si une SOURCE DE COURANT DE SOUDAGE est équipée d'un DISPOSITIF REDUCTEUR DE RISQUES, il s'agit de la tension mesurée avant que le DISPOSITIF REDUCTEUR DE RISQUES n'ait rempli sa fonction.

3.1.27

tension à vide assignée réduite

U_r

TENSION A VIDE d'une SOURCE DE COURANT DE SOUDAGE équipée d'un dispositif réducteur de tension immédiatement après l'action du dispositif pour diminuer la tension

3.1.28

tension à vide assignée commutée

U_s

TENSION CONTINUE A VIDE d'une SOURCE DE COURANT DE SOUDAGE équipée d'un dispositif de commutation courant alternatif à courant continu

3.1.29

tension assignée d'alimentation

U_1

valeur efficace d'une tension d'alimentation pour laquelle le matériel est conçu

3.1.30

courant assigné d'alimentation

I_1

valeur efficace d'un courant d'alimentation absorbé par la SOURCE DE COURANT DE SOUDAGE dans une CONDITION CONVENTIONNELLE DE SOUDAGE assignée

3.1.31

courant d'alimentation assigné à vide

I_0

valeur efficace d'un courant d'alimentation absorbé par la SOURCE DE COURANT DE SOUDAGE à TENSION A VIDE ASSIGNEE

3.1.32**courant d'alimentation assigné maximal** $I_{1\max}$

valeur maximale du COURANT D'ALIMENTATION ASSIGNE

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-13, qui sera mis à jour.

3.1.33**courant d'alimentation effectif maximal** $I_{1\text{eff}}$

valeur maximale du courant effectif d'alimentation, calculée à partir du COURANT D'ALIMENTATION ASSIGNE (I_1), du FACTEUR DE MARCHE (X) correspondant et du courant d'alimentation à vide (I_0), par la formule:

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

Note 1 à l'article: Le COURANT D'ALIMENTATION EFFECTIF MAXIMAL n'est pas toujours calculé au FACTEUR DE MARCHE correspondant au COURANT D'ALIMENTATION ASSIGNE MAXIMAL.

[SOURCE: IEC 60050-851:2008, 851-12-39, modifié – Ajout d'une Note 1 à l'article.]

3.1.34**vitesse assignée en charge** n

vitesse de rotation d'une source de COURANT DE SOUDAGE pilotée par un moteur lorsqu'elle fonctionne au COURANT DE SOUDAGE ASSIGNE MAXIMAL

Note 1 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-12, qui sera mis à jour.

3.1.35**vitesse de rotation assignée à vide** n_0

vitesse de rotation d'une SOURCE DE COURANT DE SOUDAGE pilotée par un moteur lorsque le CIRCUIT DE SOUDAGE extérieur est ouvert

Note 1 à l'article: Si un moteur thermique est équipé d'un dispositif réducteur de vitesse en l'absence de soudage, n_0 sera mesurée avant fonctionnement de ce dispositif.

Note 2 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-12-16, qui sera mis à jour.

3.1.36**vitesse de rotation assignée au ralenti** n_i

vitesse à vide réduite d'une SOURCE DE COURANT DE SOUDAGE pilotée par un moteur

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

3.1.37**facteur de marche** X

REEMPLACÉ: cycle de marche

rapport, sur un intervalle de temps donné, de la durée en charge non interrompue à la durée totale

Note 1 à l'article: Ce rapport, compris entre 0 et 1, est exprimé en pourcentage.

Note 2 à l'article: Pour les besoins du présent document, la durée complète d'un cycle est de 10 min. Par exemple, dans le cas d'un FACTEUR DE MARCHE de 60 %, une période de charge continue de 6 min est suivie d'une période de marche à vide de 4 min.

3.1.38

distance d'isolement

plus petite distance dans l'air entre deux parties conductrices

[SOURCE: IEC 60050-581:2008, 581-27-76]

3.1.39

ligne de fuite

distance la plus courte, le long de la surface d'un isolant solide, entre deux parties conductrices

[SOURCE: IEC 60050-151:2001, 151-15-50]

3.1.40

degré de pollution

chiffre caractérisant la pollution attendue du MICRO-ENVIRONNEMENT

Note 1 à l'article: Afin d'évaluer les LIGNES DE FUITE et les DISTANCES D'ISOLEMENT DANS L'AIR, les quatre DEGRES DE POLLUTION suivants sont définis au 4.5.2 de l'IEC 60664-1:2020 pour le MICRO-ENVIRONNEMENT.

- a) DEGRE DE POLLUTION 1: Il n'existe pas de pollution ou il se produit seulement une pollution sèche, non conductrice. La pollution n'a pas d'influence.
- b) DEGRE DE POLLUTION 2: Il ne se produit qu'une pollution non conductrice. Cependant, dans certains cas, une conductivité temporaire provoquée par la condensation doit être envisagée.
- c) DEGRE DE POLLUTION 3: Présence d'une pollution conductrice ou d'une pollution sèche, non conductrice, qui devient conductrice par suite de la condensation qui peut se produire.
- d) DEGRE DE POLLUTION 4: Il se produit une conductivité continue, en raison de poussières conductrices, de la pluie ou autres conditions mouillées.

[SOURCE: IEC 60050-581:2008, 581-21-07, modifié – Modification de la Note à l'article.]

3.1.41

micro-environnement

<d'un système électrique> conditions ambiantes qui influencent immédiatement le dimensionnement de la DISTANCE D'ISOLEMENT et des LIGNES DE FUITE

[SOURCE: IEC 60664-1:2020, 3.1.23]

3.1.42

groupe de matériau

matériaux classés en quatre groupes selon les valeurs de leur indice de résistance au cheminement (IRC) conformément à l'IEC 60664-1

Note 1 à l'article: Les quatre groupes suivants sont définis dans le 5.3.2.4 de l'IEC 60664-1:2020:

- GROUPE DE MATERIAU I: $600 \leq CTI$;
- GROUPE DE MATERIAU II: $400 \leq CTI < 600$;
- GROUPE DE MATERIAU IIIa: $175 \leq CTI < 400$;
- GROUPE DE MATERIAU IIIb: $100 \leq CTI < 175$.

3.1.43

échauffement

différence entre la température d'une partie du matériel et celle de l'air ambiant

3.1.44

équilibre thermique

état atteint lorsque l'ECHAUFFEMENT constaté d'une partie quelconque du matériel ne dépasse pas 2 K/h

3.1.45**protection thermique**

système destiné à assurer la protection d'une partie, et donc l'ensemble de l'équipement contre les températures excessives résultant de certaines conditions de surcharge thermique

Note 1 à l'article: Elle peut être réarmée (soit manuellement, soit automatiquement) lorsque la température redescend à la valeur de réenclenchement.

Note 2 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-15-03, qui sera mis à jour.

3.1.46**environnement avec risque accru de choc électrique**

environnement dans lequel la probabilité de choc électrique due au soudage à l'arc est accrue par rapport aux conditions normales du soudage à l'arc

Note 1 à l'article: De tels environnements se trouvent, par exemple:

- a) dans des emplacements auxquels la liberté de mouvement restreinte oblige l'opérateur à souder dans une position inconfortable (à genoux, assis, allongé, par exemple), en contact physique avec des parties conductrices;
- b) dans des emplacements totalement ou partiellement limités par des éléments conducteurs, présentant une probabilité élevée de contact involontaire ou accidentel par l'opérateur;
- c) dans des emplacements mouillés, humides ou chauds lorsque l'humidité ou la transpiration réduit considérablement la résistance de la peau du corps humain et les propriétés isolantes des accessoires.

3.1.47**dispositif réducteur de risques**

dispositif conçu pour réduire le danger de choc électrique pouvant résulter de la TENSION A VIDE

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

3.1.48**matériel de classe I**

matériel dont l'ISOLATION PRINCIPALE est la disposition de PROTECTION PRINCIPALE et dont l'équipotentialité de protection assure la protection contre les défauts

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

3.1.49**matériel de classe II**

matériel dont l'ISOLATION PRINCIPALE est la mesure de PROTECTION PRINCIPALE, et l'ISOLATION SUPPLEMENTAIRE est la mesure de protection en cas de défaut, ou dont les protections principales et protections en cas de défaut sont assurées par une ISOLATION RENFORCEE

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

3.1.50**isolation principale**

isolation des parties actives dangereuses qui assure la PROTECTION PRINCIPALE

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

3.1.51**isolation supplémentaire**

isolation indépendante prévue, en plus de l'ISOLATION PRINCIPALE, en tant que protection en cas de défaut

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

3.1.52

double isolation

isolation comprenant à la fois une ISOLATION PRINCIPALE et une ISOLATION SUPPLEMENTAIRE

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

3.1.53

isolation renforcée

isolation des parties actives dangereuses assurant un degré de protection contre les chocs électriques équivalant à celui d'une DOUBLE ISOLATION

Note 1 à l'article: L'ISOLATION RENFORCEE peut comporter plusieurs couches qui ne peuvent pas être essayées séparément en tant qu'ISOLATION PRINCIPALE ou ISOLATION SUPPLEMENTAIRE.

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

3.1.54

système de coupage par plasma

combinaison de source de courant électrique, torche et dispositifs de sécurité associés pour le coupage et le gougeage par plasma

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

3.1.55

source de courant électrique de coupage par plasma

équipement destiné à fournir un courant électrique et une tension, ayant des caractéristiques appropriées pour le coupage et le gougeage par plasma et pouvant fournir du gaz et du liquide de refroidissement

Note 1 à l'article: Une SOURCE DE COURANT ELECTRIQUE DE COUPAGE PLASMA peut également fournir des services à d'autres équipements et accessoires, par exemple tensions auxiliaires, liquide de refroidissement et gaz.

Note 2 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-13-04, qui sera mis à jour.

3.1.56

très basse tension de sécurité TBTS

tension ne dépassant pas 50 V en courant alternatif ou 120 V en courant continu lissé entre conducteurs ou entre un conducteur quelconque et la terre dans un circuit dont la séparation du réseau d'alimentation est assurée par des moyens tels qu'un transformateur de sécurité

Note 1 à l'article: Une tension maximale inférieure à 50 V en courant alternatif ou 120 V en courant continu lissé est spécifiée dans des règles particulières, plus spécialement lorsque le contact direct avec des parties actives est admis.

Note 2 à l'article: Lorsque la source est un transformateur de sécurité, la limite de tension n'est pas dépassée à toute charge comprise entre la pleine charge et à vide.

Note 3 à l'article: "Lissé" se dit par convention d'une tension en courant continu lorsque le rapport de la valeur efficace de l'ondulation à la composante continue ne dépasse pas 10 %. La valeur crête maximale ne dépasse pas 140 V pour un système en courant continu lissé de tension nominale 120 V, et 70 V pour un système en courant continu lissé de tension nominale 60 V.

Note 4 à l'article: Cet article révisé l'IEC 60050-851:2008, 851-15-08, qui sera mis à jour.

3.1.57

circuit d'alimentation

circuit d'entrée

matériau conducteur dans le matériel, à travers lequel le passage du courant d'alimentation est prévu

3.1.58**tension locale**

valeur efficace la plus élevée de la tension en courant alternatif ou continu qui peut apparaître à travers n'importe quelle isolation lorsqu'un matériel est alimenté sous la tension assignée

Note 1 à l'article: Les surtensions transitoires sont négligées.

Note 2 à l'article: Il est tenu compte à la fois des conditions à vide et des conditions normales de fonctionnement.

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

3.1.59**courant de contact**

courant électrique passant dans le corps humain ou dans le corps d'un animal lorsque ce corps est en contact avec une ou plusieurs parties accessibles d'une installation ou de matériels

Note 1 à l'article: Le COURANT DE CONTACT est mesuré à l'aide d'un réseau de mesure simulant l'impédance du corps humain.

[SOURCE: IEC 60050-195:1998, 195-05-21, modifié – Ajout d'une note à l'article.]

3.1.60**commande à distance**

dispositif ou circuit extérieur au matériel, utilisé pour la surveillance ou la commande du fonctionnement

3.1.61**condition de premier défaut**

condition dans laquelle un seul moyen de protection contre les dangers est défectueux

Note 1 à l'article: Lorsqu'une CONDITION DE PREMIER DEFAUT résulte inévitablement dans une autre CONDITION DE PREMIER DEFAUT, les deux défaillances sont considérées comme une CONDITION DE PREMIER DEFAUT.

3.1.62**installation fixe**

combinaison particulière de plusieurs types d'appareils et, le cas échéant, d'autres dispositifs, qui sont assemblés, installés et destinés à être utilisés de façon permanente sur un emplacement prédéfini

3.1.63**circuit de protection**

circuit destiné à être relié à la terre de protection pour la protection contre les chocs électriques

3.1.64**classe d'isolation**

repère dans une nomenclature appliquée à un matériau d'isolation utilisé dans les machines ou appareils électriques et spécifiant la nature des matériaux et la limite de température recommandée

[SOURCE: IEC 60050-811:2017, 811-13-33, modifié – Suppression de la Note 1 à l'article.]

3.1.65**isolation fonctionnelle**

isolation entre parties conductrices, nécessaire pour le bon fonctionnement du matériel

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

3.1.66

état au ralenti

état de fonctionnement dans lequel l'alimentation est activée, mais le CIRCUIT DE SOUDAGE n'est pas mis sous tension

Note 1 à l'article: Pour certains types de matériels, il n'y a pas d'ETAT AU RALENTI, mais un état de soudage précédant l'amorçage de l'arc.

Note 2 à l'article: Pour une source de courant dans un système mécanisé, la configuration réalisant l'ETAT AU RALENTI est définie par le fabricant.

Note 3 à l'article: Un ETAT AU RALENTI peut inclure un état énergétique faible dans lequel un procédé de soudage ne peut pas être initié sans une réactivation automatique ou manuelle.

3.2 Termes et définitions relatifs aux SYSTEMES DE BATTERIE

3.2.1

batterie

assemblage d'un ou de plusieurs ELEMENTS destinés à fournir du courant électrique à la SOURCE DE COURANT DE SOUDAGE

3.2.2

batterie incorporée

BATTERIE qui est placée à l'intérieur de la SOURCE DE COURANT DE SOUDAGE alimentée par batterie et qui n'est pas retirée de cette SOURCE pour le chargement

Note 1 à l'article: Une BATTERIE qui est retirée de la SOURCE DE COURANT DE SOUDAGE alimentée par batterie uniquement pour sa mise au rebut ou son recyclage est considérée comme une BATTERIE INCORPOREE.

3.2.3

bloc de batteries amovibles

BATTERIE qui est à l'intérieur d'une enveloppe séparée de la SOURCE DE COURANT DE SOUDAGE alimentée par batterie et qui est destinée à être retirée de cette SOURCE pour le chargement

3.2.4

bloc de batteries démontables

BATTERIE qui est à l'intérieur d'une enveloppe séparée de la SOURCE DE COURANT DE SOUDAGE alimentée par batterie et qui est raccordée à cette SOURCE par un câble

3.2.5

système de batterie

combinaison d'une BATTERIE, du SYSTEME DE CHARGE, de la SOURCE DE COURANT DE SOUDAGE et des interfaces entre eux tels qu'ils existent pendant le fonctionnement de la SOURCE DE COURANT DE SOUDAGE ou pendant le chargement

3.2.6

régime C₅

courant, en ampères, auquel un ELEMENT ou une BATTERIE peut être déchargé(e) pendant 5 h au point de coupure de la tension spécifié par le fabricant d'ELEMENTS

3.2.7

élément

unité fonctionnelle de base, consistant en un assemblage d'électrodes, d'électrolyte, de conteneur, de bornes et généralement de séparateurs, qui est une source d'énergie électrique obtenue par transformation directe d'énergie chimique

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

3.2.8

chargeur

tout ou partie du SYSTEME DE CHARGE contenu dans une enveloppe séparée

Note 1 à l'article: Au minimum, le CHARGEUR comprend certains des circuits de conversion du courant. Tous les SYSTEMES DE CHARGE ne possèdent pas un CHARGEUR séparé comme dans le cas où une SOURCE DE COURANT DE SOUDAGE peut être chargée en utilisant un câble d'alimentation secteur ou peut incorporer une fiche de prise de courant pour sa fixation à une prise secteur.

3.2.9

système de charge

combinaison de circuits destinés à charger, équilibrer et/ou maintenir l'état de charge de la BATTERIE

3.2.10

élément complètement chargé

batterie complètement chargée

ELEMENT ou BATTERIE chargé(e) à l'état maximal de charge permis par le SYSTEME DE CHARGE de BATTERIE destiné(e) à être utilisé(e) avec la SOURCE DE COURANT DE SOUDAGE

3.2.11

élément complètement déchargé

batterie complètement déchargée

BATTERIE ou ELEMENT qui a été déchargé(e) jusqu'à ce qu'une des conditions suivantes se produise: la décharge prend fin du fait de l'intervention d'un circuit de protection ou la BATTERIE (ou ELEMENT) atteint une tension totale avec une tension moyenne par ELEMENT égale à la tension de fin de décharge pour la chimie des ELEMENTS utilisés sauf si une autre tension de fin de décharge est spécifiée par le fabricant de BATTERIES/d'ELEMENTS

Note 1 à l'article: Les tensions de fin de décharge pour les chimies courantes de l'ELEMENT sont fournies en O.5.1.209.

3.2.12

batteries à usage général

éléments à usage général

BATTERIES et ELEMENTS disponibles chez plusieurs fabricants, au niveau d'une variété de points de vente des produits de différents fabricants

Note 1 à l'article: Les BATTERIES de 12 V pour automobiles et les ELEMENTS alcalins AA, C et D sont des exemples d'USAGE GENERAL.

3.2.13

courant de charge maximal

courant le plus élevé qu'un ELEMENT est autorisé à recevoir pendant le chargement pour une plage spécifique de températures, tel que spécifié par le fabricant d'ELEMENTS et évalué conformément à l'IEC 62133-1:2017 ou à l'IEC 62133-2:2017

3.2.14

région de fonctionnement spécifiée

plage de fonctionnement admissible pour les ELEMENTS, exprimée par les limites des paramètres des ELEMENTS

3.2.14.1

région de fonctionnement spécifiée pour le chargement

conditions relatives à la tension et au courant pendant le chargement dans lesquelles l'ELEMENT est autorisé à fonctionner, telles que spécifiées par le fabricant d'ELEMENTS et évaluées conformément à l'IEC 62133-1:2017 ou à l'IEC 62133-2:2017

3.2.15

limite supérieure de la tension de charge

tension la plus élevée qu'un ELEMENT est autorisé à atteindre pendant le chargement normal pour une plage spécifique de températures, telle que spécifiée par le fabricant d'ELEMENTS et évaluée conformément à l'IEC 62133-1:2017 ou à l'IEC 62133-2:2017

3.2.16

échappement de gaz

condition dans laquelle un ELEMENT libère une pression interne excessive prévue par conception, de manière à prévenir l'EXPLOSION

3.2.17

composant électronique

pièce dans laquelle la conduction est obtenue principalement par des électrons qui se déplacent à travers un vide, un gaz ou un semiconducteur, à l'exclusion des indicateurs en néon

Note 1 à l'article: Des exemples de COMPOSANTS ELECTRONIQUES incluent les diodes, transistors, triacs et les circuits intégrés monolithiques. Les résistances, condensateurs et inductances ne sont pas considérés comme des COMPOSANTS ELECTRONIQUES.

3.2.18

protection principale

protection contre les chocs électriques en l'absence de défaut

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

3.2.19

classe de tension de batterie A

classification d'un composant électrique ou d'un circuit électrique ayant une TENSION LOCALE pour BATTERIE maximale de 60 V en courant continu

3.2.20

classe de tension de batterie B

classification d'un composant électrique ou d'un circuit électrique ayant une TENSION LOCALE pour BATTERIE maximale comprise entre 60 V en courant continu et 1 500 V en courant continu

3.2.21

carbonisation

noircissement du coton causé par une combustion

Note 1 à l'article: La décoloration du coton causée par la fumée est acceptable.

3.2.22

cycle de fonctionnement consécutif

mise en cycle immédiate après réenclenchement du dispositif de commande thermique

3.2.23

explosion

<d'une atmosphère explosive> augmentation soudaine de la pression et de la température due à une oxydation ou une autre réaction exothermique

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

3.3 Termes et définitions relatifs au mesurage de l'efficacité et de la puissance en ETAT AU RALENTI

3.3.1

fréquence assignée d'alimentation

valeur efficace de la fréquence d'alimentation de la SOURCE DE COURANT DE SOUDAGE, telle que spécifiée par le fabricant

3.3.2

efficacité de la source de courant de soudage

rapport, exprimé en pourcentage, entre PUISSANCE ACTIVE de sortie et PUISSANCE ACTIVE d'alimentation de la source de courant de soudage aux conditions de charge assignées

Note 1 à l'article: Dans le Règlement de la Commission (UE) 2019/1784, le terme correspondant est "efficacité de la source d'alimentation électrique".

3.3.3

puissance active

P

en régime périodique, moyenne, sur une période T , de la puissance instantanée p

$$P = \frac{1}{T} \int_0^T p dt$$

Note 1 à l'article: En régime sinusoïdal, la PUISSANCE ACTIVE est la partie réelle de la puissance complexe S , soit $P = \text{Re } S$.

Note 2 à l'article: L'unité SI cohérente de PUISSANCE ACTIVE est le watt, W.

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

3.3.4

puissance apparente

S

produit des valeurs efficaces de la tension électrique U aux bornes d'un bipôle, élémentaire ou non, et du courant électrique I dans le bipôle

Note 1 à l'article: En régime sinusoïdal, la PUISSANCE APPARENTE est le module de la puissance complexe S , soit $S = |S|$.

Note 2 à l'article: L'unité SI cohérente de PUISSANCE APPARENTE est le voltampère, VA.

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

3.3.5

facteur de puissance

λ

en régime périodique, rapport de la valeur absolue de la PUISSANCE ACTIVE P à la PUISSANCE APPARENTE S

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

Note 1 à l'article: En régime sinusoïdal, le FACTEUR DE PUISSANCE est la valeur absolue du facteur de puissance active.

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

3.3.6

rapport harmonique total

taux de distorsion harmonique total

THD (abréviation)

rapport de la valeur efficace du RESIDU HARMONIQUE à la valeur efficace de la composante fondamentale ou de la composante fondamentale de référence d'une grandeur alternative

Note 1 à l'article: Le RAPPORT HARMONIQUE TOTAL THD dépend du choix de la composante fondamentale. En cas d'ambiguïté dans le contexte, il convient d'indiquer de quelle composante il s'agit.

Note 2 à l'article: Le RAPPORT HARMONIQUE TOTAL THD peut faire l'objet d'une approximation à un certain rang. Les conditions de l'approximation doivent alors être indiquées.

Note 3 to entry: L'abréviation "THD" est dérivée du terme anglais développé correspondant "*total harmonic distortion*".

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

4 Conditions ambiantes

Les SOURCES DE COURANT DE SOUDAGE doivent être capables de fournir leurs PUISSANCES ASSIGNEES pour les FACTEURS DE MARCHE assignés dans les conditions ambiantes suivantes:

- a) plage de températures de l'air ambiant:
pendant le soudage: $-10\text{ }^{\circ}\text{C}$ à $+40\text{ }^{\circ}\text{C}$;
- b) humidité relative de l'air:
inférieure ou égale à 50 % à $40\text{ }^{\circ}\text{C}$;
inférieure ou égale à 90 % à $20\text{ }^{\circ}\text{C}$;
- c) air ambiant exempt de quantités anormales de poussières, d'acides, de gaz corrosifs ou substances corrosives, etc. autres que celles créées au cours de l'opération de soudage;
- d) altitude au-dessus du niveau de la mer inférieure ou égale à 1 000 m;
- e) base de la SOURCE DE COURANT DE SOUDAGE inclinée jusqu'à 10° .

Les SOURCES DE COURANT DE SOUDAGE doivent résister au stockage et au transport à une température de l'air ambiant comprise entre $-20\text{ }^{\circ}\text{C}$ et $+55\text{ }^{\circ}\text{C}$ sans subir aucune dégradation de leur fonctionnement ni de leurs performances.

NOTE 1 Des conditions ambiantes différentes peuvent faire l'objet d'un accord entre le fabricant et l'acheteur et la SOURCE DE COURANT DE SOUDAGE résultante est marquée en conséquence (voir 15.1). Parmi ces conditions, il est possible de citer: humidité élevée, fumées corrosives inhabituelles, vapeur d'eau, excès de vapeur d'huile, vibration ou choc anormal, excès de poussières, conditions climatiques sévères, conditions inhabituelles au bord de la mer ou à bord d'un navire, infestation de vermine et conditions favorisant le développement de moisissures.

NOTE 2 Les exigences spécifiées dans le présent document concernant la DISTANCE D'ISOLEMENT et les LIGNES DE FUITE permet une utilisation à une altitude au-dessus du niveau de la mer inférieure ou égale à 2 000 m.

5 Essais

5.1 Conditions d'essai

Les essais doivent être effectués sur des SOURCES DE COURANT DE SOUDAGE Neuves, sèches et entièrement assemblées.

L'essai d'échauffement défini au 7.1 et l'essai de PROTECTION THERMIQUE défini au 8.5 doivent être effectués à une température ambiante de $40\text{ }^{\circ}\text{C}$, voir les tolérances au 7.1.2 e), à l'exception des groupes électrogènes de soudage et des matériels d'INSTALLATIONS FIXES, qui doivent être soumis à des essais conformément aux spécifications du fabricant.

D'autres essais doivent être effectués à une température de l'air ambiant de $(25 \pm 10)\text{ }^{\circ}\text{C}$.

Les SOURCES DE COURANT DE SOUDAGE refroidies par liquide doivent être soumises à l'essai en présence de liquide comme cela est spécifié par le fabricant.

Sauf spécification contraire, le matériel doit être alimenté sous une tension assignée d'alimentation TENSION ASSIGNEE D'ALIMENTATION avec une tolérance de ± 5 %.

5.2 Instruments de mesure

L'exactitude des instruments de mesure doit être la suivante:

- a) instruments de mesure électriques: CLASSE I (± 1 % de la lecture à pleine échelle), à l'exception du mesurage de la résistance d'isolement et de la rigidité diélectrique, pour lequel l'exactitude des instruments de mesure n'est pas spécifiée, mais doit être prise en compte pour le mesurage;
- b) thermomètre: ± 2 K;
- c) tachymètre: ± 1 % de la lecture à pleine échelle.

Tous les mesurages électriques doivent être réalisés avec une incertitude de mesure maximale de 5 %.

5.3 Conformité des composants

Les composants et sous-ensembles qui, en cas de défaillance, peuvent provoquer un danger, tels que des sorties d'alimentation et des matériels de traitement de l'information intégrés, doivent être utilisés selon leurs caractéristiques assignées spécifiées, à moins qu'une exception spécifique ne soit formulée. Ils doivent être conformes à l'un des éléments suivants:

- a) les exigences de sécurité applicables d'une norme IEC appropriée. La conformité à d'autres exigences de la norme de composant n'est pas exigée. Si nécessaire pour l'application, les composants doivent être soumis aux essais du présent document, sauf lorsque ces essais sont identiques ou équivalents aux essais exigés pour vérifier la conformité à la norme de composant appropriée;

Par exemple, si les composants satisfont aux exigences de sécurité de l'IEC 60950-1, mais sont assignés pour un environnement moins sévère que l'environnement applicable de l'Article 4 et du 6.1.1, ils doivent également satisfaire aux exigences supplémentaires correspondantes du présent document.

- b) les exigences du présent document et, si nécessaire pour l'application, toutes les exigences de sécurité applicables supplémentaires de la norme de composant IEC appropriée;
- c) en l'absence de norme IEC appropriée, les exigences du présent document;
- d) les exigences de sécurité applicables d'une norme non établie par l'IEC qui sont au moins aussi sévères que les exigences de la norme IEC appropriée, à condition que la conformité du composant à une norme non établie par l'IEC ait été certifiée par un organisme d'essai reconnu.

NOTE Il n'est pas nécessaire de répéter les essais réalisés par un organisme d'essai reconnu, qui confirment la conformité aux exigences de sécurité applicables, même si les essais ont été réalisés à l'aide d'une norme non établie par l'IEC.

La Figure 1 est un diagramme présentant les méthodes de vérification de la conformité.

La vérification est effectuée par EXAMEN VISUEL et, si nécessaire, par un essai.

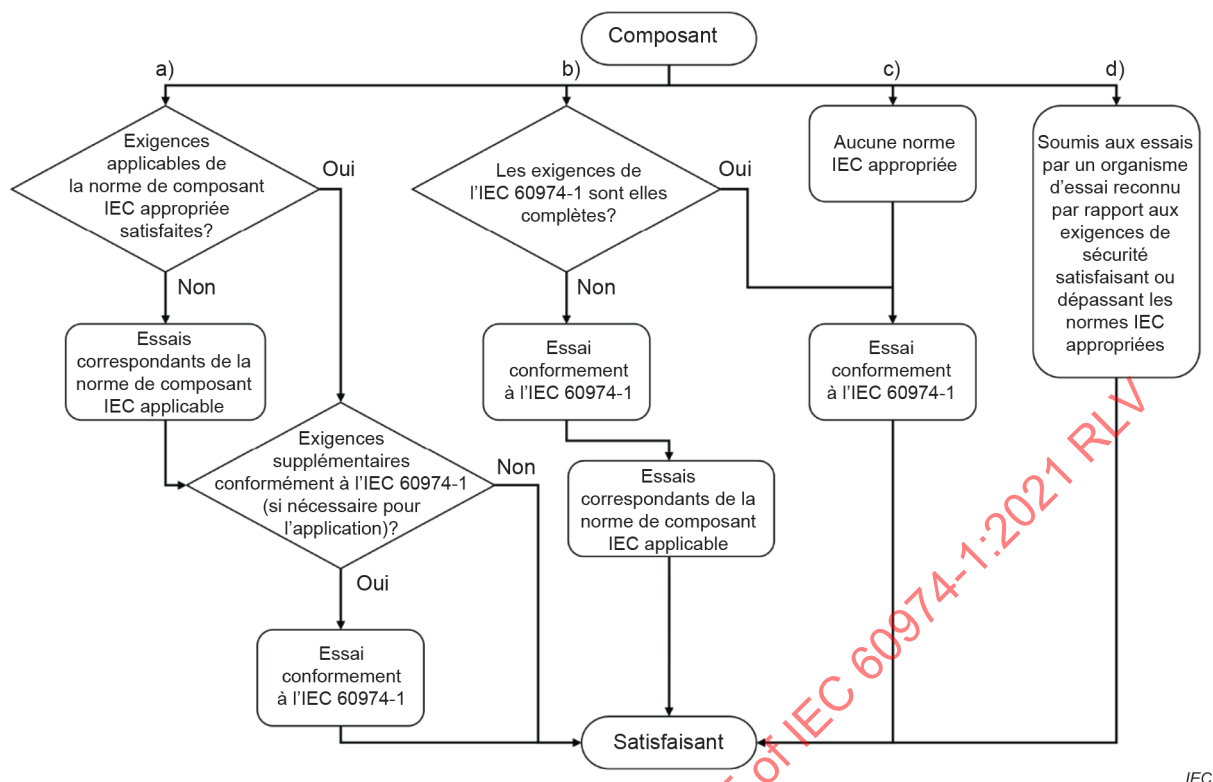


Figure 1 – Diagramme présentant les méthodes de conformité du 5.3

5.4 ESSAIS DE TYPE

Sauf spécification contraire, les essais du présent document sont des ESSAIS DE TYPE.

La SOURCE DE COURANT DE SOUDAGE à l'essai doit comprendre tous les matériels accessoires qui peuvent affecter les résultats des essais.

Tous les ESSAIS DE TYPE doivent être effectués sur la même SOURCE DE COURANT DE SOUDAGE, sauf s'il est spécifié qu'un essai peut être effectué sur une autre SOURCE DE COURANT DE SOUDAGE.

Pour vérifier la conformité, les ESSAIS DE TYPE indiqués ci-après doivent être effectués dans l'ordre suivant sans temps de séchage entre f), g) et h):

- EXAMEN VISUEL général, voir 3.1.7;
- résistance d'isolement, voir 6.1.4 (contrôle préliminaire);
- enveloppe, voir 14.2;
- moyens de manutention, voir 14.3;
- essai de résistance à la chute, voir 14.4;
- protection procurée par l'enveloppe, voir 6.2.1;
- résistance d'isolement, voir 6.1.4;
- rigidité diélectrique, voir 6.1.5;
- EXAMEN VISUEL général, voir 3.1.7.

Les autres essais prévus par le présent document qui ne sont pas mentionnés ici doivent être effectués, mais peuvent être effectués dans l'ordre le plus pratique.

5.5 ESSAIS INDIVIDUELS DE SÉRIE

Tous les ESSAIS INDIVIDUELS DE SÉRIE doivent être effectués sur chaque SOURCE DE COURANT DE SOUDAGE. L'ordre suivant est recommandé:

- a) EXAMEN VISUEL conforme aux spécifications du fabricant;
- b) continuité du CIRCUIT DE PROTECTION, voir 10.5.3;
- c) rigidité diélectrique, voir 6.1.5;
- d) TENSION À VIDE:
 - 1) TENSION A VIDE ASSIGNEE, voir 11.1 par mesurage uniquement; ou
 - 2) le cas échéant, TENSION A VIDE ASSIGNEE REDUITE, voir 13.2.1; ou
 - 3) le cas échéant, TENSION A VIDE ASSIGNEE COMMUTE, voir 13.2.2;
- e) essai pour garantir les valeurs de sortie minimales et maximales assignées selon 15.4 b) et 15.4 c). Le fabricant peut choisir des essais sur CHARGE CONVENTIONNELLE, en court-circuit ou dans d'autres conditions d'essai.

NOTE 1 En court-circuit et dans d'autres conditions d'essai, les valeurs de sortie peuvent différer des valeurs obtenues sur CHARGE CONVENTIONNELLE.

NOTE 2 Lorsque la conception le justifie, les valeurs mesurées peuvent être compensées en raison des variations du réseau d'alimentation.

6 Protection contre les chocs électriques

6.1 Isolation

6.1.1 Généralités

La majorité des SOURCES DE COURANT DE SOUDAGE appartiennent à la catégorie de surtension III, conformément à l'IEC 60664-1; les SOURCES DE COURANT DE SOUDAGE à moteur thermique appartiennent à la catégorie de surtension II. Toutes les SOURCES DE COURANT DE SOUDAGE doivent être conçues pour une utilisation dans les conditions ambiantes présentant au moins un DEGRE DE POLLUTION 3.

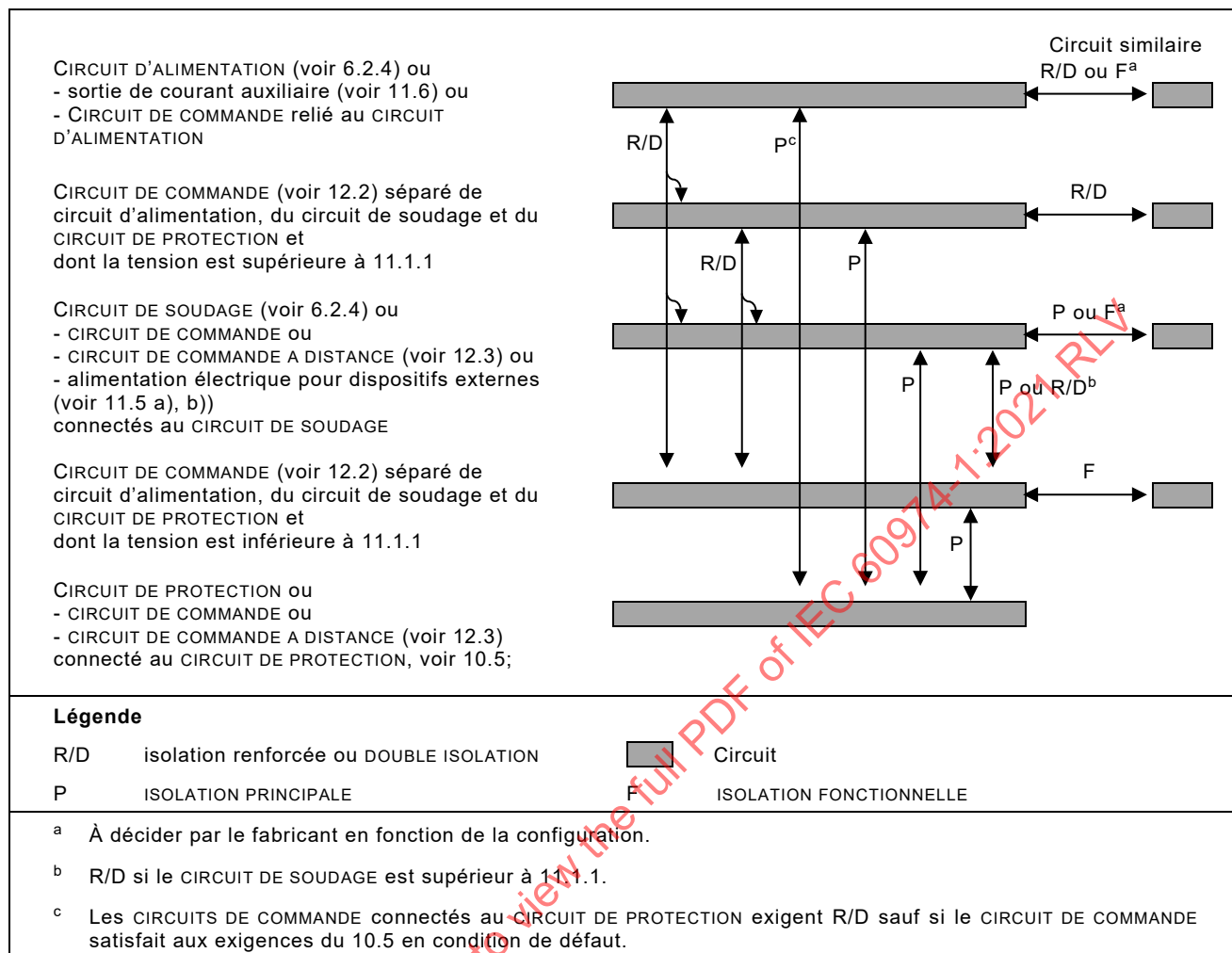
Les composants ou sous-ensembles présentant des DISTANCES D'ISOLEMENT DANS L'AIR ou des LIGNES DE FUITE correspondant au DEGRE DE POLLUTION 2 sont permis, si le MICRO-ENVIRONNEMENT du composant ou du sous-ensemble est amélioré (par des moyens tels que le filtrage, le revêtement, l'empotage ou le moulage) de sorte que seule la pollution non conductrice ou la conductivité occasionnelle temporaire due à la condensation se produise.

Les composants ou sous-ensembles présentant des DISTANCES D'ISOLEMENT DANS L'AIR ou des LIGNES DE FUITE correspondant au DEGRE DE POLLUTION 1 sont permis s'ils sont totalement revêtus, empotés ou moulés conformément à l'IEC 60664-3.

Voir le Tableau 3 pour les LIGNES DE FUITE des cartes imprimées.

Le MATERIEL DE CLASSE I destiné à être connecté à un système triphasé à trois fils relié à la terre doit être conçu avec une isolation fondée sur les valeurs de la tension entre phases. Le MATERIEL DE CLASSE I conçu avec une isolation fondée sur les valeurs de la tension phase-neutre doit comporter un avertissement indiquant qu'un tel matériel ne doit être utilisé que sur un réseau d'alimentation qui est soit triphasé à quatre fils avec un neutre relié à la terre soit monophasé à trois fils avec un neutre relié à la terre.

L'application de l'isolation dans de nombreuses configurations est représentée à la Figure 2, mais d'autres configurations et solutions sont possibles. Si une configuration particulière n'est pas représentée à la Figure 2, l'isolation exigée doit être déterminée en examinant l'effet d'un premier défaut.



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Figure 2 – Exemple de configuration d'isolation pour le MATERIEL DE CLASSE I

6.1.2 DISTANCES D'ISOLEMENT DANS L'AIR

Pour les circuits directement raccordés au réseau d'alimentation, la tension phase-neutre doit être dérivée du Tableau A.1. Pour l'ISOLATION PRINCIPALE ou SUPPLEMENTAIRE et pour l'ISOLATION RENFORCEE, les DISTANCES D'ISOLEMENT DANS L'AIR minimales doivent être conformes au Tableau 2 pour la catégorie de surtension III. Pour d'autres catégories de surtension, les DISTANCES D'ISOLEMENT DANS L'AIR minimales doivent être conformes à l'IEC 60664-1.

Les valeurs du Tableau 2 doivent également s'appliquer au CIRCUIT DE SOUDAGE à l'intérieur de la SOURCE DE COURANT DE SOUDAGE et aux CIRCUITS DE COMMANDE lorsqu'ils sont séparés du CIRCUIT D'ALIMENTATION, par exemple par un transformateur.

**Tableau 2 – DISTANCES D'ISOLEMENT DANS L'AIR minimales
pour la catégorie de surtension III**

Tension phase-neutr e dérivée des tensions nominales en courant alternatif ou en courant continu jusques et y compris ^a V efficace	ISOLATION PRINCIPALE ou supplémentaire					ISOLATION RENFORCÉE				
	Tension assignée d'essai en impulsion	Tension d'essai en courant alternatif	DEGRÉ DE POLLUTION			Tension assignée d'essai en impulsion	Tension d'essai en courant alternatif	DEGRÉ DE POLLUTION		
			2	3	4			2	3	4
			DISTANCE D'ISOLEMENT					DISTANCE D'ISOLEMENT		
V crête	V efficace	mm			V crête	V efficace	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 Valeurs fondées sur les Tableaux F.1 et F.2 de l'IEC 60664-1:2020.										
NOTE 2 Pour les autres DEGRES DE POLLUTION et catégories de surtension, voir l'IEC 60664-1.										
NOTE 3 Si un autotransformateur est raccordé au CIRCUIT D'ALIMENTATION et fourni en tant qu'élément d'une SOURCE DE COURANT DE SOUDAGE, la tension d'alimentation détermine les DISTANCES D'ISOLEMENT DANS L'AIR.										
^a Voir le Tableau A.1.										

Afin de déterminer les DISTANCES D'ISOLEMENT DANS L'AIR par rapport aux surfaces accessibles non conductrices, de telles surfaces doivent être considérées comme étant recouvertes d'une feuille métallique à tout endroit auquel elles peuvent être touchées par le doigt d'essai normalisé conforme à l'IEC 60529.

Les DISTANCES D'ISOLEMENT DANS L'AIR ne doivent pas être interpolées.

Pour les bornes du CIRCUIT D'ALIMENTATION, voir l'Article E.2.

Les DISTANCES D'ISOLEMENT DANS L'AIR entre des éléments de la SOURCE DE COURANT DE SOUDAGE (par exemple circuits ou composants électroniques) qui sont protégés par un dispositif limiteur des surtensions (par exemple varistance métal-oxyde) peuvent être définies conformément à la catégorie de surtension I (voir l'IEC 60664-1).

Si le CIRCUIT DE COMMANDE est directement raccordé au CIRCUIT D'ALIMENTATION, les valeurs correspondant à la tension d'alimentation doivent s'appliquer.

La vérification doit être effectuée par mesurage, conformément au 6.8 de l'IEC 60664-1:2020 ou, si cela n'est pas possible, en soumettant la SOURCE DE COURANT DE SOUDAGE à un essai par impulsion avec les tensions indiquées dans le Tableau 2.

Pour l'essai par impulsion, au moins trois impulsions, espacées d'au moins 1 s pour chaque polarité sont appliquées avec la tension indiquée dans le Tableau 2, en utilisant un générateur d'impulsions ayant une forme d'onde de sortie de 1,2/50 µs et une impédance de sortie inférieure à 500 Ω.

En variante, une tension d'essai en courant alternatif comme indiquée dans le Tableau 2 peut être appliquée pendant trois cycles ou une tension en courant continu sans ondulation dont la valeur est égale à la tension d'impulsion peut être appliquée trois fois pendant 10 ms, dans chaque polarité.

6.1.3 LIGNES DE FUITE

La base utilisée pour la détermination d'une LIGNE DE fuite est la valeur efficace de long terme de la tension qui la traverse. Cette tension est la valeur la plus élevée de la TENSION locale en régime établi (telle que spécifiée au 4.2.5 de l'IEC 60664-1:2020), la tension assignée d'isolement ou la tension assignée. Le Tableau A.2 et le Tableau A.3 peuvent être utilisés pour la détermination de la tension assignée d'isolement.

Pour l'ISOLATION PRINCIPALE et l'ISOLATION SUPPLEMENTAIRE, les LIGNES DE FUITE doivent être choisies dans le Tableau 3.

Les LIGNES DE FUITE de la DOUBLE ISOLATION constituent la somme des valeurs pour l'ISOLATION PRINCIPALE et l'ISOLATION SUPPLEMENTAIRE qui forment la DOUBLE ISOLATION.

Les LIGNES DE FUITE pour l'ISOLATION RENFORCEE doivent correspondre à deux fois la LIGNE DE FUITE pour l'ISOLATION PRINCIPALE.

Lorsque le Tableau 3 est utilisé, il est admis d'interpoler les valeurs des tensions intermédiaires. En cas d'interpolation des valeurs, une interpolation linéaire doit être appliquée et les valeurs doivent être arrondies au même nombre de chiffres que les valeurs prélevées dans le tableau.

Afin de déterminer les LIGNES DE FUITE par rapport aux surfaces accessibles non conductrices, de telles surfaces doivent être considérées comme étant recouvertes d'une feuille métallique à tout endroit auquel elles peuvent être touchées par le doigt d'essai normalisé conforme à l'IEC 60529.

Pour les bornes du CIRCUIT D'ALIMENTATION, voir l'Article E.2.

Les valeurs du Tableau 3 doivent s'appliquer également au CIRCUIT DE SOUDAGE à l'intérieur de la SOURCE DE COURANT DE SOUDAGE et aux CIRCUITS DE COMMANDE lorsqu'ils sont séparés du CIRCUIT D'ALIMENTATION, par exemple par un transformateur.

Une LIGNE DE FUITE ne peut pas être inférieure à la DISTANCE D'ISOLEMENT associée, et la LIGNE DE FUITE la plus courte possible est donc égale à la DISTANCE D'ISOLEMENT exigée.

Si le CIRCUIT DE COMMANDE est directement raccordé au CIRCUIT D'ALIMENTATION, les valeurs correspondant à la tension d'alimentation doivent s'appliquer.

La vérification doit être effectuée par mesurage linéaire, conformément au 6.8 de l'IEC 60664-1:2020.

Tableau 3 – LIGNES DE FUITE minimales

Tension locale	LIGNES DE FUITE en mm								
	ISOLATION PRINCIPALE ou supplémentaire								
	Matériau des cartes imprimées		DEGRÉ DE POLLUTION						
	DEGRÉ DE POLLUTION								
V efficace	1	2	1	2			3		
				GROUPE DE MATÉRIAU			GROUPE DE MATÉRIAU		
	a mm	b mm	a mm	I mm	II mm	III mm	I mm	II mm	III 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 GROUPES DE MATERIAUX I, II, IIIa et IIIb.

^b GROUPES DE MATERIAUX I, II et IIIa.

NOTE Conformément à l'IEC 60664-1, les dimensions de la LIGNE DE FUITE ne peuvent pas être spécifiées en présence d'une pollution conductrice en permanence (DEGRE DE POLLUTION 4).

6.1.4 Résistance d'isolement

La résistance d'isolement ne doit pas être inférieure aux valeurs indiquées dans le Tableau 4.

Tableau 4 – Résistance d'isolement

Mesurage ^a			Résistance	Isolation
CIRCUIT D'ALIMENTATION	par rapport au	CIRCUIT DE SOUDAGE	5,0 MΩ	Double ou renforcée
CIRCUIT DE SOUDAGE	par rapport au	CIRCUIT DE PROTECTION	2,5 MΩ	Principale
CIRCUIT D'ALIMENTATION	par rapport au	CIRCUIT DE PROTECTION	2,5 MΩ	Principale
CIRCUIT D'ALIMENTATION du MATERIEL DE CLASSE II	par rapport aux	surfaces accessibles ^b	5,0 MΩ	Double ou renforcée
^a Les CIRCUITS DE COMMANDE sont soumis à l'essai avec le circuit auquel ils sont reliés de façon galvanique. Les CIRCUITS DE COMMANDE accessibles séparés de tous les autres circuits sont soumis à l'essai selon les spécifications du fabricant.				
^b Pour le mesurage par rapport aux surfaces accessibles non conductrices, ces surfaces doivent être considérées comme étant recouvertes d'une feuille métallique.				

Tout circuit de commande ou circuit auxiliaire relié à la borne du conducteur de protection doit, pour cet essai, être considéré comme une partie conductrice accessible.

La vérification doit être réalisée par mesurage stabilisé de la résistance d'isolement par application d'une tension continue égale à 500 V, à la température ambiante.

Pendant le mesurage, les torches doivent être déconnectées, les COMPOSANTS ELECTRONIQUES à semiconducteurs et leurs dispositifs de protection peuvent être court-circuités et les unités de refroidissement par liquide doivent être soumises aux essais sans liquide.

6.1.5 Rigidité diélectrique

L'isolation doit supporter les tensions d'essai suivantes sans contournement ni claquage:

- premier essai d'une SOURCE DE COURANT DE SOUDAGE: tensions d'essai indiquées dans le Tableau 5;
- répétition de l'essai sur la même SOURCE DE COURANT DE SOUDAGE: tension d'essai égale à 80 % des valeurs indiquées dans le Tableau 5.

Tableau 5 – Tensions d'essai diélectrique

Tension assignée maximale ^a V efficace	Tension alternative d'essai diélectrique V efficace			
	Entre tous les circuits et les parties conductrices accessibles, entre le CIRCUIT D'ALIMENTATION et tous les autres circuits sauf le CIRCUIT DE SOUDAGE		Entre tous les circuits, sauf entre le CIRCUIT D'ALIMENTATION et le CIRCUIT DE SOUDAGE	Entre le CIRCUIT D'ALIMENTATION et le CIRCUIT DE SOUDAGE
	MATÉRIEL DE CLASSE I	MATÉRIEL DE CLASSE II		
Jusqu'à 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 La tension assignée maximale est valable pour les systèmes mis à la terre ou non.				
NOTE 2 L'essai de rigidité diélectrique des CIRCUITS DE COMMANDE est limité dans le présent document à tous les circuits qui entrent ou sortent de l'enveloppe, autres que le CIRCUIT D'ALIMENTATION et le CIRCUIT DE SOUDAGE.				
^a Pour les valeurs intermédiaires, l'interpolation est permise sur tous les réseaux d'alimentation (CIRCUIT D'ALIMENTATION) fonctionnant en dehors de la plage comprise entre 220 V et 450 V et sur tous les systèmes triphasés à trois fils reliés à la terre sans exemption de tension (voir l'Annexe A).				
^b Pour les valeurs intermédiaires, l'interpolation est permise sur les CIRCUITS DE SOUDAGE et de COMMANDE.				

La tension d'essai en courant alternatif doit être de forme sensiblement sinusoïdale avec une valeur de crête ne dépassant pas 1,45 fois la valeur efficace, et d'une fréquence d'environ 50 Hz ou 60 Hz.

Le réglage maximal admissible du courant de déclenchement doit être 100 mA. Le transformateur haute tension doit délivrer la tension spécifiée jusqu'au courant de déclenchement. Un déclenchement est considéré comme un contournement ou un claquage.

NOTE Pour la sécurité de l'opérateur, le réglage le plus faible possible du courant de déclenchement (inférieur ou égal à 10 mA) est généralement utilisé.

Essai en variante: Une tension d'essai en courant continu égale à 1,4 fois la tension d'essai efficace peut être utilisée.

Les composants ou sous-ensembles ne doivent pas être déconnectés ou court-circuités sauf si les conditions de a), b) ou c) ci-dessous sont satisfaites:

- Les composants ou sous-ensembles sont conçus et soumis à l'essai conformément aux normes appropriées qui spécifient une tension plus faible que le niveau de tension d'essai du présent document. Ces composants ou sous-ensembles ne sont pas connectés entre le circuit d'alimentation et le CIRCUIT DE SOUDAGE et leur déconnexion ou mise en court-circuit n'empêche pas de soumettre à l'essai une partie du circuit. Exemples: moteurs de ventilateurs et moteurs de pompes.
- Les composants ou sous-ensembles sont complètement incorporés soit dans le circuit d'alimentation soit dans le CIRCUIT DE SOUDAGE et leur déconnexion n'empêche pas de soumettre à l'essai une partie du circuit. Exemple: circuits électroniques.
- Les circuits destinés à éliminer les parasites ou les condensateurs destinés à la protection entre le circuit d'alimentation ou le CIRCUIT DE SOUDAGE et toutes les parties conductrices accessibles qui sont conformes aux normes appropriées.

Les CIRCUITS DE COMMANDE connectés à une borne conductrice de protection ne doivent pas être déconnectés pendant l'essai et ils sont alors soumis à l'essai comme des parties conductrices accessibles.

À la discrétion du fabricant, la tension d'essai peut être portée lentement à sa pleine valeur.

Les tensions d'essai entre le CIRCUIT D'ALIMENTATION, les parties conductrices accessibles et le CIRCUIT DE SOUDAGE peuvent être appliquées simultanément. Un exemple est donné à l'Annexe B.

Les GROUPES ELECTROGENES DE SOUDAGE doivent être soumis au même essai.

La vérification doit être effectuée par application de la tension d'essai pendant

- a) 60 s (ESSAI DE TYPE);
- b) 5 s (ESSAI INDIVIDUEL DE SERIE);
- ou
- c) 1 s (ESSAI INDIVIDUEL DE SERIE avec tension d'essai augmentée de 20 %).

6.2 Protection contre les chocs électriques en service normal (contact direct)

6.2.1 Degré de protection procuré par l'enveloppe

Les SOURCES DE COURANT DE SOUDAGE conçues spécifiquement pour un usage à l'intérieur doivent avoir un degré de protection minimal de IP21S en utilisant les conditions et procédures d'essai de l'IEC 60529.

Les SOURCES DE COURANT DE SOUDAGE conçues spécifiquement pour un usage à l'extérieur doivent avoir un degré de protection minimal de IP23S en utilisant les conditions et procédures d'essai de l'IEC 60529.

Les SOURCES DE COURANT DE SOUDAGE avec un degré de protection IP23S peuvent être stockées, mais ne sont pas prévues pour être utilisées en extérieur sans protection pendant des précipitations.

Un drainage approprié doit être assuré par l'enveloppe. Si de l'eau est retenue, elle ne doit pas empêcher le fonctionnement correct du matériel ou compromettre la sécurité. La quantité d'eau qui peut pénétrer dans l'enveloppe n'est pas limitée.

Les dispositifs de connexion au CIRCUIT DE SOUDAGE doivent être protégés comme cela est spécifié au 11.4.1.

Les COMMANDES A DISTANCE destinées aux SOURCES DE COURANT DE SOUDAGE doivent avoir un degré de protection minimal de IP2X en utilisant les conditions et procédures d'essai de l'IEC 60529.

La vérification doit être effectuée par l'essai suivant:

une SOURCE DE COURANT DE SOUDAGE doit être soumise à l'essai à l'eau approprié sans être alimentée. Immédiatement après l'essai, la SOURCE DE COURANT DE SOUDAGE doit être placée dans un environnement sûr et soumise à l'essai de résistance d'isolement indiqué en 5.4 g) et à l'essai de rigidité diélectrique indiqué en 5.4 h).

6.2.2 Condensateurs

Un condensateur fourni comme partie d'une SOURCE DE COURANT DE SOUDAGE et connecté aux bornes du CIRCUIT D'ALIMENTATION ou de l'enroulement d'un transformateur fournissant le COURANT DE SOUDAGE doit

- a) ne pas contenir plus de 1 l de liquide inflammable;
- b) être conçu pour ne pas fuir en service normal;
- c) être contenu à l'intérieur de l'enveloppe de la SOURCE DE COURANT DE SOUDAGE ou dans une enveloppe qui satisfait aux exigences applicables du présent document.

La vérification doit être effectuée par EXAMEN VISUEL.

Pour l'essai de court-circuit des condensateurs, voir 9.5.

6.2.3 Décharge automatique des condensateurs sur le CIRCUIT D'ALIMENTATION

Chaque condensateur doit être équipé d'un moyen de décharge automatique qui doit réduire la tension aux bornes du condensateur à une valeur inférieure ou égale à 60 V dans le temps nécessaire pour donner accès à toute partie conductrice connectée au condensateur ou une étiquette d'avertissement appropriée doit être utilisée. Pour toute fiche de prise de courant mise sous tension par l'intermédiaire d'un condensateur, le temps d'accès est considéré comme étant de 1 s.

Les condensateurs de capacité assignée inférieure ou égale à 0,1 μF ne sont pas considérés comme entraînant un risque de choc électrique.

La vérification doit être effectuée par EXAMEN VISUEL et par l'essai suivant.

La SOURCE DE COURANT DE SOUDAGE est mise en fonctionnement sous la TENSION ASSIGNEE D'ALIMENTATION la plus élevée. La SOURCE DE COURANT DE SOUDAGE est alors déconnectée du réseau d'alimentation et les tensions sont mesurées au moyen d'instruments n'ayant pas d'influence notable sur les valeurs mesurées.

6.2.4 Isolation du CIRCUIT DE SOUDAGE

Le CIRCUIT DE SOUDAGE doit être électriquement séparé du CIRCUIT D'ALIMENTATION et de tous les autres circuits ayant une tension supérieure à la TENSION A VIDE admissible conformément au 11.1.1 (CIRCUITS D'ALIMENTATION auxiliaires, par exemple) par une DOUBLE ISOLATION ou une isolation renforcée ou par des moyens équivalents satisfaisant aux exigences du 6.1. Si un autre circuit est connecté au CIRCUIT DE SOUDAGE, la puissance de l'autre circuit doit être fournie par l'intermédiaire d'un transformateur de séparation ou par un dispositif équivalent.

Le CIRCUIT DE SOUDAGE ne doit pas être connecté, à l'intérieur de la source de courant de soudage, aux moyens de connexion du conducteur de protection externe, à l'enveloppe, au châssis ou au noyau magnétique de la SOURCE DE COURANT DE SOUDAGE sauf, si nécessaire, par l'intermédiaire d'un condensateur d'antiparasitage ou de protection.

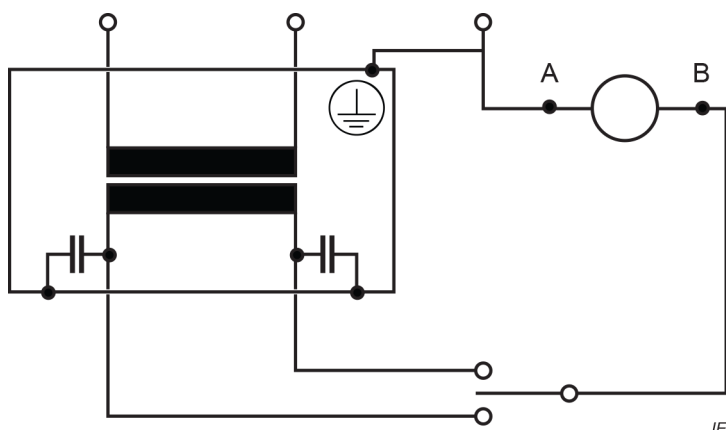
La vérification doit être effectuée par les essais indiqués au 6.1.

6.2.5 COURANT DE CONTACT d'un CIRCUIT DE SOUDAGE

Le COURANT DE CONTACT entre les connexions du CIRCUIT DE SOUDAGE et la borne du conducteur de protection ne doit pas dépasser une valeur de crête de 14,1 mA.

La vérification doit être effectuée par EXAMEN VISUEL et par mesure du COURANT DE CONTACT sur un circuit tel que celui indiqué à la Figure 3 à la ou aux TENSIONS D'ALIMENTATION ASSIGNEES et en condition à vide.

Le réseau de mesure spécifié à la Figure N.2 doit être raccordé comme cela est représenté à la Figure 3.



Légende

A, B Connexions du réseau de mesure

NOTE Pour le MATERIEL DE CLASSE II, utiliser la borne PE du réseau d'alimentation relié à la terre.

Figure 3 – Mesurage du COURANT DE CONTACT d'un CIRCUIT DE SOUDAGE

6.2.6 COURANT DE CONTACT en condition normale

Le COURANT DE CONTACT pour les surfaces conductrices accessibles, non raccordées au CIRCUIT DE PROTECTION, ne doit pas dépasser la valeur de crête de 0,7 mA dans des conditions normales.

La vérification doit être effectuée par mesurage du COURANT DE CONTACT avec un circuit comme cela est représenté à la Figure 4 et le réseau de mesure de la Figure N.1, sans simulation de défaut et dans les conditions suivantes:

- la SOURCE DE COURANT DE SOUDAGE est:
 - isolée du plan de masse;
 - alimentée par la TENSION ASSIGNEE D'ALIMENTATION la plus élevée plus une tolérance de fonctionnement appropriée telle que spécifiée par le fabricant, à savoir au moins +10 % pour toute alimentation, sauf +6 % pour les systèmes d'alimentation avec une tension supérieure ou égale à 600 V;
- le CIRCUIT DE SOUDAGE est placé en condition à vide;
- les condensateurs d'antiparasitage ne sont pas déconnectés.

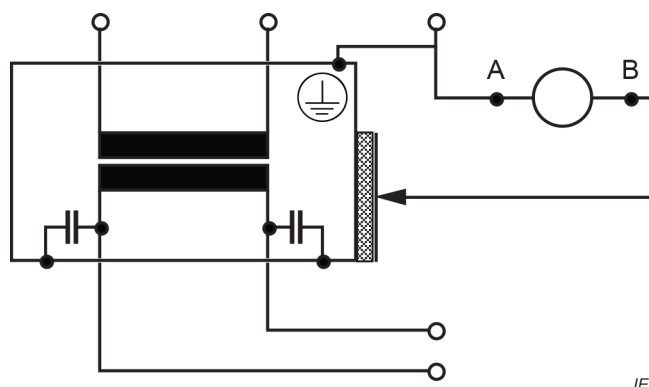


Figure 4 – Mesurage du COURANT DE CONTACT en condition normale

6.3 Protection contre les chocs électriques en cas de défaut (contacts indirects)

6.3.1 Mesures de protection

Les SOURCES DE COURANT DE SOUDAGE doivent être un MATERIEL DE CLASSE I ou de CLASSE II, conformément à l'IEC 61140, à l'exception du CIRCUIT DE SOUDAGE.

6.3.2 Isolation entre les enroulements du CIRCUIT D'ALIMENTATION et le CIRCUIT DE SOUDAGE

Les enroulements du CIRCUIT D'ALIMENTATION et du CIRCUIT DE SOUDAGE doivent être isolés au moyen

- a) d'une DOUBLE ISOLATION ou d'une isolation renforcée
ou
- b) d'une ISOLATION PRINCIPALE par rapport à un écran métallique situé entre eux et raccordé au conducteur de protection.

Entre les enroulements du CIRCUIT D'ALIMENTATION et du CIRCUIT DE SOUDAGE, il doit y avoir une isolation conforme aux valeurs données dans le Tableau 6. En variante, d'autres moyens spécifiés dans l'IEC 61558-1 peuvent être utilisés, à condition que toutes les exigences de l'IEC 61558-1 soient satisfaites.

Tableau 6 – Distance minimale à travers l'isolation

TENSION ASSIGNEE D'ALIMENTATION V efficace	Distance minimale à travers l'isolation mm	
	Une seule couche	Total de trois couches séparées ou plus
jusqu'à 440	1,3	0,35
441 à 690	1,5	0,4
691 à 1 000	2,0	0,5

Lorsqu'il y a un écran métallique entre les enroulements, l'épaisseur de l'isolation entre chaque enroulement et l'écran doit être au moins égale à la moitié des valeurs données dans le Tableau 6.

La vérification doit être effectuée par EXAMEN VISUEL et par mesure.

6.3.3 Conducteurs et connexions internes

Les conducteurs et connexions internes doivent être fixés ou placés de façon à éviter un desserrage accidentel qui peut entraîner des contacts électriques entre

- a) le CIRCUIT D'ALIMENTATION ou tout autre circuit et le CIRCUIT DE SOUDAGE de sorte que la tension de sortie peut devenir plus élevée que la TENSION A VIDE admissible;
- b) le conducteur de protection, l'enveloppe, le châssis ou le circuit magnétique et le CIRCUIT DE SOUDAGE.

Lorsque les conducteurs isolés traversent des parties métalliques, des manchons en matériau isolant doivent être prévus ou bien les arêtes des ouvertures doivent être usinées avec un rayon d'au moins 1,5 mm.

Les conducteurs nus doivent être fixés de sorte que les DISTANCES D'ISOLEMENT DANS L'AIR et LIGNES DE FUITE entre eux et par rapport aux parties conductrices soient maintenues (voir 6.1.2 et 6.3.2).

Les conducteurs de différents circuits peuvent être positionnés côte à côte, peuvent occuper le même conduit (par exemple la même canalisation, le même système de câblage), ou peuvent être dans les mêmes câbles multiconducteurs à condition que la disposition ne compromette pas le bon fonctionnement des circuits respectifs. Quand de tels circuits fonctionnent à des tensions différentes, les conducteurs doivent être séparés par des barrières appropriées ou doivent être isolés en fonction de la plus forte tension à laquelle chacun des conducteurs du même conduit peut être soumis.

La vérification doit être effectuée par EXAMEN VISUEL et par mesurage.

6.3.4 Exigences supplémentaires pour les SYSTEMES DE COUPAGE PAR PLASMA

La torche de coupage par plasma, les pièces (par exemple, les pièces généralement remplacées en raison de l'usure) ainsi que la SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA, recommandées par le fabricant, doivent former un système sûr.

Les tuyères qui, pour des raisons techniques, ne peuvent pas être protégées contre les contacts directs doivent être considérées comme étant suffisamment protégées en utilisation normale ou en CONDITION DE PREMIER DEFAUT, lorsqu'elles répondent aux exigences suivantes:

a) en l'absence du courant d'alimentation de l'arc:

la tension entre la tuyère et la pièce mise en œuvre et/ou la terre ne dépasse pas les valeurs données en 11.1.1,

ou

la SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA est équipée d'un SYSTEME REDUCTEUR DE RISQUES conformément à l'Article 13,

et

b) pour les systèmes manuels, en présence du courant d'alimentation de l'arc:

les côtés de la tuyère ne peuvent pas être touchés par le doigt d'essai normalisé conforme à l'IEC 60529 quand elle est placée sur une surface plane avec sa ligne d'axe qui lui est perpendiculaire,

ou

la TENSION EN CHARGE en courant continu entre la tuyère et la pièce mise en œuvre et/ou la terre ne dépasse pas les valeurs données en 11.1.1.

NOTE Un premier défaut est une condition anormale résultant d'une électrode en contact avec la tuyère due à l'absence de canons isolants, au collage de la tuyère avec l'électrode, à un élément conducteur entre la tuyère et l'électrode, à des pièces inadaptées, à des pièces desserrées, à l'abrasion de l'électrode, à des pièces mal positionnées, à une charge excessive ou à un débit de gaz incorrect.

La vérification doit être effectuée conformément à 11.1 et par simulation d'un défaut de torche et par essai conformément à l'Article 13. La torche doit être soumise à l'essai conformément à l'IEC 60974-7.

6.3.5 Noyaux et bobines mobiles

Si des noyaux ou bobines mobiles sont utilisés pour le réglage du COURANT DE SOUDAGE, la construction doit être telle que les DISTANCES D'ISOLEMENT DANS L'AIR et les LIGNES DE FUITE exigées soient maintenues, en tenant compte des contraintes électriques et mécaniques.

La vérification doit être effectuée en faisant fonctionner 500 fois le mécanisme, sur la totalité de sa course, de la position minimale à la position maximale, à la cadence spécifiée par le fabricant et par EXAMEN VISUEL.

6.3.6 COURANT DE CONTACT en cas de défaut

Pour le MATERIEL DE CLASSE I, le COURANT DE CONTACT pondéré en cas de défaillance ou de déconnexion d'un conducteur de protection externe ne doit pas dépasser une valeur de crête de 14,1 mA à l'exception des matériels destinés à être raccordés de façon permanente avec un conducteur de protection renforcé conformément à l'IEC 61140.

Les matériels destinés à être raccordés de façon permanente avec un conducteur de protection renforcé peuvent avoir un courant de fuite pouvant atteindre 5 % du COURANT ASSIGNE D'ALIMENTATION par phase.

La vérification doit être effectuée en utilisant les configurations présentées à l'Annexe N avec le réseau de mesure de la Figure N.2 dans les conditions suivantes:

- 1) la SOURCE DE COURANT DE SOUDAGE est:
 - isolée du plan de masse;
 - entièrement assemblée et prête à être utilisée dans la configuration maximale;
 - alimentée par la TENSION ASSIGNEE D'ALIMENTATION la plus élevée plus une tolérance de fonctionnement appropriée telle que spécifiée par le fabricant, à savoir au moins +10 % pour toute alimentation, sauf +6 % pour les systèmes d'alimentation avec une tension supérieure ou égale à 600 V;
 - non raccordée à la terre de protection sauf à travers les équipements de mesure.
- 2) le CIRCUIT DE SOUDAGE est placé en condition à vide;
- 3) les condensateurs d'antiparasitage ne doivent pas être déconnectés.

NOTE 1 Lorsque le COURANT DE CONTACT est proche de la valeur limite, les effets des condensateurs d'antiparasitage sont pris en considération et une attention particulière est accordée à la précision de mesure et à l'étalonnage.

NOTE 2 Traditionnellement, le COURANT DE CONTACT était maximal à la tension d'alimentation la plus élevée. Les SOURCES DE COURANT DE SOUDAGE électroniques ne délivrent pas toujours le COURANT DE CONTACT maximal dans cette condition d'alimentation. Le COURANT DE CONTACT peut être rendu maximal à la tension la plus basse, c'est-à-dire au tirage maximal du courant, ou dans d'autres conditions. Une protection contre les chocs électriques est prévue dans les conditions de fonctionnement les plus défavorables.

7 Exigences thermiques

7.1 Essai d'échauffement

7.1.1 Conditions d'essai

Lors de la mise en place des dispositifs de mesure, les seuls accès permis doivent être les ouvertures équipées de couvercles, portes de visite ou panneaux aisément amovibles prévus par le fabricant. La ventilation dans la zone d'essai et les dispositifs de mesure utilisés ne doivent pas interférer avec la ventilation normale de la SOURCE DE COURANT DE SOUDAGE ni provoquer des échanges anormaux de chaleur dans un sens ou dans l'autre.

La SOURCE DE COURANT DE SOUDAGE est mise en fonctionnement à la TENSION ASSIGNEE D'ALIMENTATION avec un courant constant, à un cycle de $(10 \pm 0,2)$ min:

- a) avec le COURANT DE SOUDAGE assigné (I_2) égal à 60 % et/ou à 100 % du FACTEUR DE MARCHE selon le cas;
- b) avec le COURANT DE SOUDAGE ASSIGNE MAXIMAL ($I_{2\max}$) et le FACTEUR DE MARCHE correspondant.

S'il est connu que ni a) ni b) ne donnent l'échauffement maximal, un essai doit alors être effectué au réglage de la plage assignée qui donne l'échauffement maximal.

Dans le cas d'une SOURCE DE COURANT DE SOUDAGE prévue pour soudage à l'arc en atmosphère inerte avec électrode de tungstène en courant alternatif, un déséquilibre de charge peut provoquer un échauffement maximal. Dans ce cas, un essai doit être effectué comme cela est indiqué à l'Annexe C.

La condition de température ambiante du 5.1 doit être remplie.

NOTE 1 Il est possible que l'échauffement maximal soit obtenu au cours de la marche à vide.

NOTE 2 S'il y a lieu, les essais sont effectués les uns après les autres sans que la SOURCE DE COURANT DE SOUDAGE ne revienne à la température de l'air ambiant.

7.1.2 Tolérances des paramètres d'essai

Pendant les 60 dernières minutes de l'essai d'échauffement, conformément à 7.1.3, les tolérances suivantes doivent être satisfaites:

a) TENSION EN CHARGE:	$\begin{matrix} +10 \\ -2 \end{matrix}$ % de la TENSION CONVENTIONNELLE EN CHARGE appropriée;
b) COURANT DE SOUDAGE:	$\begin{matrix} +10 \\ -2 \end{matrix}$ % du COURANT DE SOUDAGE CONVENTIONNEL approprié;
c) tension d'alimentation	± 5 % de la TENSION ASSIGNEE D'ALIMENTATION appropriée;
d) vitesse du moteur:	± 5 % de la vitesse assignée appropriée;
e) température	$\begin{matrix} +10 \\ -2 \end{matrix}$ K de la température ambiante.

7.1.3 Durée de l'essai

L'essai d'échauffement doit se poursuivre jusqu'à ce que la vitesse d'ECHAUFFEMENT ne dépasse pas 2 K/h sur tout composant pendant une période au moins égale à 60 min.

7.2 Mesurage des températures

7.2.1 Conditions de mesure

La température doit être déterminée au milieu de la période de charge du dernier cycle comme suit:

- a) pour les enroulements, par le mesurage de la résistance ou par des capteurs de température en surface ou incorporés;

NOTE 1 La méthode par capteurs de température en surface n'est pas privilégiée.

NOTE 2 Dans le cas d'enroulements de faible résistance ayant des contacts de commutation en série, le mesurage des résistances peut donner des résultats erronés.

- b) pour les autres parties, par des capteurs de température en surface.

7.2.2 Capteur de température de surface

La température est mesurée au moyen d'un capteur de température appliqué sur les surfaces accessibles des enroulements ou d'autres parties, conformément aux conditions stipulées ci-après.

NOTE 1 Les thermocouples, les thermomètres à résistance, etc., sont des exemples de capteurs de température types.

Les thermomètres à bulbe ne doivent pas être utilisés pour le mesurage des températures des enroulements et des surfaces.

Les capteurs de température sont placés aux points accessibles auxquels il est vraisemblable que la température sera maximale. Il est judicieux de localiser les points chauds prévisibles par un examen préliminaire.

NOTE 2 La dimension et l'étendue des points chauds dans les enroulements dépendent de la conception de la SOURCE DE COURANT DE SOUDAGE.

Une transmission efficace de la chaleur doit être assurée entre le point de mesure et le capteur de température, et le capteur de température doit être protégé contre l'effet des courants d'air et des rayonnements.

7.2.3 Résistance

L'ECHAUFFEMENT des enroulements est déterminé par l'accroissement de leur résistance et est obtenu, pour le cuivre, par la formule suivante:

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

où

t_1 est la température de l'enroulement au moment du mesurage de R_1 (°C);

t_2 est la température calculée de l'enroulement à la fin de l'essai (°C);

t_a est la température de l'air ambiant à la fin de l'essai (°C);

R_1 est la résistance initiale de l'enroulement (Ω);

R_2 est la résistance de l'enroulement à la fin de l'essai (Ω).

Pour l'aluminium, le nombre 235 dans la formule ci-dessus est remplacé par le nombre 225.

La température t_1 doit être à ± 3 K de la température de l'air ambiant.

7.2.4 Capteur de température incorporé

La température est mesurée au moyen de thermocouples ou d'autres instruments de mesure de température adaptés de dimension comparable incorporés dans les parties les plus chaudes.

Les thermocouples doivent être placés directement sur les enroulements et les bobines. Il n'est pas exigé que toute isolation appliquée intégralement sur les conducteurs eux-mêmes soit enlevée.

Un thermocouple placé au point le plus chaud d'un enroulement monocouche est considéré comme incorporé.

7.2.5 Détermination de la température de l'air ambiant

La température de l'air ambiant est déterminée par au moins trois dispositifs de mesure. Ceux-ci sont espacés uniformément autour de la SOURCE DE COURANT DE SOUDAGE, à peu près à sa mi-hauteur et à une distance de 1 m à 2 m de sa surface. Ils sont protégés contre les courants d'air et les échauffements anormaux. La valeur moyenne des relevés de température effectués est adoptée comme température de l'air ambiant.

Dans le cas de SOURCES DE COURANT DE SOUDAGE à ventilation forcée, un seul dispositif de mesure est placé à l'entrée de l'air dans le système de refroidissement. La moyenne des relevés effectués à intervalles réguliers pendant le dernier quart de la durée de l'essai est adoptée comme température de l'air ambiant.

7.2.6 Enregistrement des températures

Dans la mesure du possible, les températures sont enregistrées pendant que le matériel est en fonctionnement et après coupure. Sur les éléments pour lesquels l'enregistrement des températures n'est pas possible pendant que le matériel est en fonctionnement, les températures se mesurent après coupure, comme cela est décrit ci-après.

Chaque fois qu'il s'est écoulé, entre le moment de la coupure et le moment de mesure de la température finale, un temps suffisant pour que la température ait baissé, les corrections nécessaires sont apportées, de façon à obtenir une température aussi proche que possible de celle du moment de la coupure. Cela peut être fait en relevant une courbe conformément à l'Annexe D. Au moins quatre relevés de températures sont effectués dans un délai de 5 min après la coupure. Dans le cas où les mesurages successifs font apparaître une élévation de température après coupure, la valeur la plus élevée est retenue.

Pour maintenir la température pendant la période d'arrêt, des précautions doivent être prises pour raccourcir la période d'arrêt d'un GROUPE ELECTROGENE DE SOUDAGE.

7.3 Limites d'ÉCHAUFFEMENT

7.3.1 Enroulements, collecteurs et bagues collectrices

L'ÉCHAUFFEMENT des enroulements, collecteurs et bagues collectrices ne doit pas dépasser les valeurs données dans le Tableau 7, quelle que soit la méthode de mesure des températures utilisée.

Tableau 7 – Limites de température pour les enroulements, collecteurs et bagues collectrices

CLASSE D'ISOLATION	Température maximale	ÉCHAUFFEMENT maximal K			
		Enroulements			Collecteurs
°C	°C	Capteur de température de surface	Résistance	Capteur de température incorporé	et bagues collectrices
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	Non déterminée
220 (R)	250	150	160	180	

NOTE 1 Capteur de température de surface signifie que la température est mesurée au moyen de capteurs non incorporés au point le plus chaud accessible à la surface extérieure des enroulements.

NOTE 2 La température à la surface est généralement la plus faible. La méthode de résistance donne la valeur moyenne de toutes les températures apparaissant dans un enroulement. La température la plus élevée apparaissant dans les enroulements (point chaud) peut être mesurée au moyen de capteurs de température incorporés.

NOTE 3 D'autres classes d'isolation ayant des températures limites plus élevées que celles indiquées dans le Tableau 7 existent (voir l'IEC 60085).

Aucune partie ne doit pouvoir atteindre une température susceptible de provoquer un dommage sur une autre partie, même si cette partie peut être conforme aux exigences du Tableau 7.

De plus, pour les essais avec un FACTEUR DE MARCHE autre que 100 %, la température atteinte pendant tout cycle complet ne doit pas dépasser les températures maximales données dans le Tableau 7.

La vérification doit être effectuée par mesurage, conformément à 7.2.

7.3.2 Surfaces externes

L'ÉCHAUFFEMENT des surfaces externes ne doit pas dépasser les valeurs données dans le Tableau 8. Les limites d'ÉCHAUFFEMENT sont données pour:

- une période de contact non intentionnel de 1 s pour les enveloppes;
- une période de contact de 4 s pour les boutons; et
- une période de contact de 60 s pour les poignées.

Tableau 8 – Limites de température des surfaces externes

Surface externe	ÉCHAUFFEMENT maximal K	Seuil de combustion pour la période de contact ^a s
Enveloppes métalliques non revêtues	25	1
Enveloppes métalliques peintes	35	1
Enveloppes en plastique	45	1
Boutons métalliques non revêtus	18	4
Boutons métalliques peints	22	4
Boutons en plastique	35	4
Poignées métalliques	10	60
Poignées en plastique	20	60
^a Valeurs informatives conformes à l'ISO 13732-1.		

Pour les GROUPES ELECTROGENES DE SOUDAGE, les limites du Tableau 8 peuvent être dépassées pour les surfaces qui sont:

- a) reconnaissables par leur aspect ou leur fonction; ou
- b) marquées avec le symbole IEC 60417-5041:2002-10; ou
- c) situées ou protégées afin de prévenir un contact non intentionnel pendant un fonctionnement normal.

NOTE Les surfaces reconnaissables par leur aspect ou leur fonction incluent des éléments tels que les échappements, silencieux, pare-étincelles ou têtes de cylindre.

La vérification doit être effectuée par mesurage conformément à 7.2 et par EXAMEN VISUEL.

7.3.3 Autres composants

La température maximale des autres composants ne doit pas dépasser leur température maximale assignée conformément à la norme appropriée.

7.4 Essai en charge

Les SOURCES DE COURANT DE SOUDAGE doivent supporter des cycles de charge répétés sans dommage ou défaillance de fonctionnement. Cet essai peut être effectué sur toute SOURCE DE COURANT DE SOUDAGE qui fonctionne correctement.

La vérification doit être effectuée par les essais suivants et en déterminant qu'aucun dommage ni défaillance de fonctionnement de la SOURCE DE COURANT de soudage ne surviennent pendant les essais.

La SOURCE DE COURANT DE SOUDAGE est chargée, en partant de l'état froid, au COURANT DE SOUDAGE ASSIGNE MAXIMAL jusqu'à ce qu'un des phénomènes suivants se produise:

- a) la PROTECTION THERMIQUE fonctionne;
- b) la limite maximale de température des enroulements est atteinte;
- c) une période de 10 min est écoulée.

Immédiatement après le réenclenchement de la PROTECTION THERMIQUE dans le cas a), ou après les cas b) ou c), l'un des essais suivants est effectué.

- 1) Dans le cas d'une SOURCE DE COURANT DE SOUDAGE à CARACTERISTIQUE TOMBANTE, les commandes sont réglées pour fournir le COURANT DE SOUDAGE ASSIGNE MAXIMAL. Elle est alors soumise 60 fois à un cycle comprenant un court-circuit de résistance externe comprise entre 8 mΩ et 10 mΩ et d'une durée de 2 s, suivi d'une marche à vide de 3 s.
- 2) Dans le cas d'une SOURCE DE COURANT DE SOUDAGE à CARACTERISTIQUE PLATE, la source est chargée une fois pendant 15 s par un courant égal à 1,5 fois le COURANT DE SOUDAGE ASSIGNE MAXIMAL à la TENSION EN CHARGE maximale disponible. Pour les SOURCES DE COURANT DE SOUDAGE équipées d'un dispositif de protection qui limite le COURANT DE SOUDAGE à une valeur inférieure à 1,5 fois le COURANT DE SOUDAGE ASSIGNE MAXIMAL, l'essai est effectué au COURANT MAXIMAL DE SOUDAGE pouvant être obtenu à la TENSION EN CHARGE correspondante.

Immédiatement après la réalisation de l'essai 1) ou 2), tandis que le matériel est encore chaud, celui-ci doit être vérifié conformément à 6.1.5.

7.5 Collecteurs et bagues collectrices

Les collecteurs, bagues collectrices et leurs balais ne doivent pas laisser apparaître de traces d'étincelles nuisibles ou de dommages, sur toute la plage de réglages du GROUPE ELECTROGENE DE SOUDAGE.

La vérification doit être effectuée par EXAMEN VISUEL au cours

- a) de l'essai d'échauffement, conformément à 7.1;
- et
- b) de l'essai de charge, conformément au point 1) ou 2) du 7.4.

8 PROTECTION THERMIQUE

8.1 Exigences générales

Une SOURCE DE COURANT DE SOUDAGE alimentée par le réseau électrique doit être équipée d'une PROTECTION THERMIQUE si le FACTEUR DE MARCHÉ au COURANT DE SOUDAGE ASSIGNE MAXIMAL est inférieur à

- a) 35 % dans le cas d'une CARACTERISTIQUE TOMBANTE;
- ou
- b) 60 % dans le cas d'une CARACTERISTIQUE PLATE.

NOTE Une CARACTERISTIQUE TOMBANTE est généralement utilisée pour le soudage manuel à l'arc et pour le soudage à l'arc en atmosphère inerte avec électrode de tungstène, alors que la CARACTERISTIQUE PLATE est généralement utilisée pour le soudage à l'arc sous atmosphère de gaz inerte ou actif.

Si la SOURCE DE COURANT DE SOUDAGE est équipée d'une PROTECTION THERMIQUE, celle-ci doit satisfaire aux exigences du 8.2 au 8.7.

La vérification doit être effectuée par EXAMEN VISUEL.

8.2 Construction

La PROTECTION THERMIQUE doit être conçue de façon à empêcher toute modification du réglage de la température ou du fonctionnement.

La vérification doit être effectuée par EXAMEN VISUEL.

8.3 Emplacement

La PROTECTION THERMIQUE doit être située de façon permanente à l'intérieur de la SOURCE DE COURANT DE SOUDAGE pour assurer que le transfert de chaleur soit fiable.

La vérification doit être effectuée par EXAMEN VISUEL.

8.4 Capacité de fonctionnement

La PROTECTION THERMIQUE doit pouvoir fonctionner lorsque la SOURCE DE COURANT DE SOUDAGE débite son COURANT DE SOUDAGE ASSIGNE MAXIMAL:

- a) 100 fois dans le cas d'un FACTEUR DE MARCHE supérieur ou égal à 35 %;
- ou
- b) 200 fois dans le cas d'un FACTEUR DE MARCHE inférieur à 35 %.

La vérification doit être effectuée avec une surcharge appropriée en provoquant le nombre exigé d'interruptions successives sur un circuit ayant les mêmes caractéristiques électriques, en particulier courant et réactance, que le circuit dans lequel la PROTECTION THERMIQUE est utilisée.

Après cet essai, les exigences du 8.5 et du 8.6 doivent être satisfaites.

8.5 Fonctionnement

La PROTECTION THERMIQUE doit fonctionner pour empêcher la température des enroulements de la SOURCE DE COURANT DE SOUDAGE de dépasser les limites de températures maximales indiquées dans le Tableau 7.

La PROTECTION THERMIQUE ne doit pas fonctionner lorsque la SOURCE DE COURANT DE SOUDAGE est chargée avec le COURANT DE SOUDAGE ASSIGNE MAXIMAL au FACTEUR DE MARCHE assigné correspondant indiqué sur la PLAQUE SIGNALÉTIQUE.

La vérification doit être effectuée pendant le fonctionnement conformément à 7.1, au COURANT DE SOUDAGE ASSIGNE MAXIMAL, , à la température ambiante du 5.1 et sans fonctionnement de la PROTECTION THERMIQUE. Après cela, la SOURCE DE COURANT DE SOUDAGE est surchargée conformément à 9.4. De plus, si la condition de température du 5.1 ne provoque pas l'échauffement maximal des enroulements, l'essai doit être effectué à une température ambiante qui donne l'échauffement maximal des enroulements.

8.6 Réenclenchement

La PROTECTION THERMIQUE ne doit pas se réenclencher, automatiquement ou manuellement, tant que la température n'est pas redescendue en dessous de celle de la CLASSE D'ISOLATION indiquée dans le Tableau 7.

La vérification doit être effectuée par des essais de fonctionnement et mesurage de la température.

8.7 Indication

Les SOURCES DE COURANT DE SOUDAGE équipées d'une PROTECTION THERMIQUE doivent indiquer que cette dernière a réduit ou déconnecté la sortie de la SOURCE DE COURANT DE SOUDAGE. Lorsque la PROTECTION THERMIQUE est à réenclenchement automatique, l'indicateur doit être soit une lampe de signalisation jaune (ou un indicateur jaune placé dans une fenêtre) soit un affichage alphanumérique sur la SOURCE DE COURANT DE SOUDAGE, le dévidoir ou les équipements auxiliaires, indiquant des symboles ou des termes dont la signification est donnée dans le manuel d'instructions.

La vérification doit être effectuée par EXAMEN VISUEL.

9 Fonctionnement anormal

9.1 Exigences générales

Une SOURCE DE COURANT DE SOUDAGE ne doit pas subir de claquage et accroît le risque de choc électrique ou d'incendie, dans les conditions de fonctionnement du 9.2 au 9.5. Ces essais sont réalisés sans considération de la température atteinte sur chacune des parties, ni du fonctionnement correct continu de la SOURCE DE COURANT DE SOUDAGE. Le seul critère est que la SOURCE DE COURANT DE SOUDAGE ne devienne pas dangereuse. Ces essais peuvent être effectués sur toute SOURCE DE COURANT DE SOUDAGE fonctionnant correctement.

Les SOURCES DE COURANT DE SOUDAGE protégées à l'intérieur par exemple par un disjoncteur ou une PROTECTION THERMIQUE satisfont à cette exigence si le dispositif de protection fonctionne avant qu'une condition dangereuse ne survienne.

La vérification doit être effectuée par les essais suivants:

- une couche de coton chirurgical absorbant sec est placée sous la SOURCE DE COURANT DE SOUDAGE et étendue à 150 mm au-delà de chaque côté;
- la SOURCE DE COURANT DE SOUDAGE est mise en fonctionnement, en partant de l'état froid, selon 9.2 à 9.4;
- pendant l'essai, la SOURCE DE COURANT DE SOUDAGE ne doit pas émettre de flammes, de métal fondu ou d'autres matériaux qui enflamment l'indicateur en coton;
- après l'essai et dans les 5 min qui suivent, la SOURCE DE COURANT DE SOUDAGE doit être capable de supporter un essai de rigidité diélectrique conformément à 6.1.5 b).

9.2 Essai de ventilateur bloqué

Une SOURCE DE COURANT DE SOUDAGE qui dépend d'un ou plusieurs ventilateurs à moteur pour la conformité aux essais de l'Article 7 est mise en fonctionnement sous la TENSION ASSIGNEE D'ALIMENTATION ou la VITESSE ASSIGNEE EN CHARGE pendant une durée de 4 h au cours de laquelle le ou les ventilateurs sont bloqués ou mis hors service, et la SOURCE DE COURANT DE SOUDAGE mise en fonctionnement dans les conditions de sortie du 7.1.

NOTE Le but de cet essai est de faire fonctionner la SOURCE DE COURANT DE SOUDAGE avec le ventilateur fixe pour vérifier à la fois la sécurité du ventilateur et de la SOURCE DE COURANT DE SOUDAGE.

9.3 Essai de courant de court-circuit

La SOURCE DE COURANT DE SOUDAGE est court-circuitée par la torche et les câbles de soudage généralement fournis par le fabricant ou, s'ils ne sont pas fournis, par un conducteur de 1,2 m de longueur et de la section donnée dans le Tableau 9.

NOTE Les sections pour les systèmes non SI sont données dans le Tableau F.1.

La SOURCE DE COURANT DE SOUDAGE au réglage de sortie maximal est reliée à la TENSION ASSIGNEE D'ALIMENTATION qui produit le COURANT ASSIGNE D'ALIMENTATION le plus élevé, au COURANT DE SOUDAGE ASSIGNE MAXIMAL. Le CIRCUIT D'ALIMENTATION est protégé par des fusibles extérieurs ou par un disjoncteur de type et de caractères assignés spécifiés par le fabricant.

Tableau 9 – Section du conducteur de court-circuit de sortie

COURANT DE SOUDAGE ASSIGNE MAXIMAL			Section minimale ^a
A			mm ²
Jusqu'	à	199	25
200	à	299	35
300	à	499	50
500	et au-dessus		70
^a Voir l'Annexe F.			

La SOURCE DE COURANT DE SOUDAGE ne doit pas engendrer la fusion du fusible d'alimentation ou le déclenchement du disjoncteur lorsqu'elle est court-circuitée:

- a) pendant 15 s dans le cas d'une CARACTERISTIQUE TOMBANTE;
- b) trois fois pendant 1 s, dans une période de 1 min, dans le cas d'une CARACTERISTIQUE PLATE.

Le court-circuit est alors appliqué pendant 2 min ou jusqu'au fonctionnement du fusible d'alimentation ou du disjoncteur.

La tension d'alimentation ne doit pas décroître de plus 10 % pendant cet essai.

Les SOURCES DE COURANT DE SOUDAGE à moteur thermique sont court-circuitées pendant 2 min au réglage de sortie maximal et sont réglées pour fonctionner à la VITESSE ASSIGNEE EN CHARGE.

9.4 Essai de surcharge

La SOURCE DE COURANT DE SOUDAGE est mise en fonctionnement pendant 4 h conformément à 7.1.1 b) pour 1,5 fois le FACTEUR DE MARCHE correspondant.

Si la SOURCE DE COURANT DE SOUDAGE a un FACTEUR DE MARCHE assigné supérieur à 67 %, cet essai est effectué avec un FACTEUR DE MARCHE de 100 %.

Si la SOURCE DE COURANT DE SOUDAGE est équipée de plots pour régler la sortie, les plots produisant le plus fort courant d'alimentation doivent être utilisés.

Si le FACTEUR DE MARCHE au COURANT DE SOUDAGE ASSIGNE MAXIMAL est de 100 %, la SOURCE DE COURANT DE SOUDAGE ne doit pas être soumise à l'essai.

9.5 Court-circuit des condensateurs

Chaque condensateur fourni comme partie intégrante d'une SOURCE DE COURANT DE SOUDAGE et raccordé soit par un CIRCUIT D'ALIMENTATION, soit par un enroulement d'un transformateur fournissant le COURANT DE SOUDAGE, ne doit provoquer aucun claquage électrique dangereux de la SOURCE DE COURANT DE SOUDAGE, ou présenter aucun risque d'incendie dans le cas d'une défaillance.

La vérification doit être effectuée par l'essai suivant:

La SOURCE DE COURANT DE SOUDAGE est mise en fonctionnement à sa TENSION ASSIGNEE D'ALIMENTATION, à vide avec un fusible ou disjoncteur d'alimentation de calibre au maximum égal à 200 % du COURANT D'ALIMENTATION ASSIGNE MAXIMAL, avec tous les condensateurs ou un des condensateurs court-circuités jusqu'à:

- 1) fusion d'un fusible ou déclenchement du dispositif contre les surintensités dans la SOURCE DE COURANT DE SOUDAGE;
- 2) fusion du fusible du CIRCUIT D'ALIMENTATION ou déclenchement du disjoncteur; ou
- 3) obtention, sur les composants du CIRCUIT D'ALIMENTATION de la SOURCE DE COURANT DE SOUDAGE, de températures constantes inférieures ou égales à celles permises en 7.3.

Si un échauffement anormal ou un ramollissement apparaît, la SOURCE DE COURANT DE SOUDAGE doit satisfaire aux exigences des points a), c) et d) du 9.1.

Il ne doit pas y avoir de fuite de liquide au cours des ESSAIS DE TYPE exigés par le présent document.

Pour les condensateurs d'antiparasitage de classe X et de classe Y, ou les condensateurs ayant un fusible intégré ou un disjoncteur, cet essai n'est pas exigé.

10 Raccordement au réseau d'alimentation

10.1 Tension d'alimentation

Les SOURCES DE COURANT DE SOUDAGE doivent pouvoir fonctionner avec la TENSION ASSIGNEE D'ALIMENTATION $\pm 10\%$. Cela peut donner des écarts par rapport aux VALEURS ASSIGNEES.

La vérification doit être effectuée par l'essai suivant:

la SOURCE DE COURANT DE SOUDAGE est raccordée à une CHARGE CONVENTIONNELLE et réglée à la sortie maximale et minimale. Chaque réglage est soumis à l'essai avec la TENSION ASSIGNEE D'ALIMENTATION $\pm 10\%$. Vérifier la présence d'une intensité stable de courant dans le CIRCUIT DE SOUDAGE dans ces quatre conditions.

10.2 Tension d'alimentation multiple

Les SOURCES DE COURANT DE SOUDAGE conçues pour fonctionner sous plusieurs tensions d'alimentation doivent comporter une des dispositions suivantes:

- a) un bornier interne sur lequel le réglage de la tension d'alimentation est effectué au moyen de barrettes. Un marquage doit indiquer la disposition des barrettes pour chaque tension d'alimentation;
- b) une boîte ou plaque à bornes interne dans laquelle les tensions d'alimentation sont clairement marquées sur les bornes;
- c) un interrupteur de sélection de prises qui doit être équipé d'un verrouillage évitant de le placer dans une position incorrecte. Le système de verrouillage ne doit pouvoir être réglé qu'à l'aide d'un outil;

- d) deux câbles d'alimentation, chacun équipé d'une fiche différente et d'un interrupteur de sélection assurant que les broches de la fiche non utilisée ne puissent être sous tension;
- e) un système pour adapter automatiquement les SOURCES DE COURANT DE SOUDAGE à la tension d'alimentation.

NOTE Les SOURCES DE COURANT DE SOUDAGE peuvent être équipées d'une indication externe de la tension d'alimentation choisie.

La vérification doit être effectuée par EXAMEN VISUEL et par les essais suivants.

Dans le cas d), un interrupteur de sélection est également soumis à l'essai conformément à 10.8.

10.3 Moyens de raccordement au CIRCUIT D'ALIMENTATION

Les moyens acceptables de raccordement au circuit d'alimentation sont:

- a) les bornes prévues pour le raccordement permanent de câbles d'alimentation souples;
- b) les bornes prévues pour le raccordement de câbles d'alimentation à une installation fixe;
- c) les connecteurs fixés à la SOURCE DE COURANT DE SOUDAGE.

NOTE Cette exigence peut également être satisfaite en utilisant des bornes sur un dispositif tel qu'un interrupteur, un contacteur, etc.

Les moyens de raccordement au CIRCUIT D'ALIMENTATION doivent être choisis conformément au COURANT D'ALIMENTATION EFFECTIF MAXIMAL $I_{1\text{eff}}$ et à la tension d'alimentation maximale, et ils doivent satisfaire aux exigences des normes correspondantes ou être conçus conformément à l'Annexe E.

La vérification doit être effectuée par EXAMEN VISUEL.

10.4 Marquage des bornes

La borne pour le conducteur de protection externe doit être marquée du symbole  (IEC 60417-5019:2006-08).

L'une ou l'autre des options suivantes peut être ajoutée:

- a) les lettres: **PE**;
ou
- b) la double coloration: **vert et jaune**.

De plus, les bornes des matériels triphasés doivent être clairement marquées conformément à l'IEC 60445 ou à d'autres normes de composants correspondantes. Le marquage d'identification doit être placé sur ou à côté de la borne correspondante.

La vérification doit être effectuée par EXAMEN VISUEL.

10.5 CIRCUIT DE PROTECTION

10.5.1 Exigence de continuité

Le CIRCUIT DE PROTECTION interne doit être capable de supporter les courants susceptibles d'exister en cas de défaut.

Les SOURCES DE COURANT DE SOUDAGE de CLASSE I doivent avoir, à proximité des bornes des conducteurs de phase, une borne appropriée dimensionnée conformément à l'Annexe E et au Tableau E.1 pour le raccordement du conducteur de protection externe. Cette borne ne doit être utilisée à aucune autre fin (par exemple pour fixer ensemble deux éléments de l'enveloppe).

Lorsque, à l'extérieur ou à l'intérieur de la SOURCE DE COURANT DE SOUDAGE, il y a une borne de raccordement du conducteur de neutre, celle-ci ne doit pas être en contact électrique avec la borne pour le raccordement du conducteur de protection.

À l'intérieur comme à l'extérieur de la SOURCE DE COURANT DE SOUDAGE, les conducteurs de protection isolés doivent avoir la double coloration vert/jaune. Si la SOURCE DE COURANT DE SOUDAGE est alimentée par un câble d'alimentation souple à plusieurs conducteurs, le conducteur de protection doit avoir la double coloration vert/jaune.

Dans certains pays, la couleur unique verte est également utilisée pour identifier le conducteur de protection et la borne du conducteur de protection.

Si la SOURCE DE COURANT DE SOUDAGE est équipée d'un conducteur de protection, il doit être connecté de façon telle que si le câble est arraché des bornes, les conducteurs de phase se cassent avant le conducteur de protection.

La vérification doit être effectuée par EXAMEN VISUEL et par les essais donnés en 10.5.2 et 10.5.3.

La méthode de fixation des parties conductrices sur les CIRCUITS DE PROTECTION, par exemple des rondelles ou vis pénétrant la peinture ou des surfaces non peintes, doit être prise en considération au cours de l'EXAMEN VISUEL.

10.5.2 ESSAI DE TYPE

Un courant égal à 200 % du COURANT D'ALIMENTATION EFFECTIF MAXIMAL, comme cela est indiqué sur la PLAQUE SIGNALÉTIQUE, est appliqué d'une partie de l'enveloppe susceptible d'être portée sous tension à travers la borne du conducteur de protection externe pendant une durée indiquée dans le Tableau 10, en utilisant la plus petite section de conducteurs externes, indiquée dans le Tableau 11.

NOTE La forme d'onde du courant d'essai n'est pas définie tant que la valeur effective est utilisée pour la comparaison.

Tableau 10 – Exigences de courant et de temps pour les CIRCUITS DE PROTECTION

Courant A	Temps min
Jusqu'à 30	2
31 à 60	4
61 à 100	6
101 à 200	8
Au-dessus de 200	10

Tableau 11 – Section minimale du conducteur de protection externe en cuivre

Section des conducteurs de phase alimentant le matériel S mm^2	Section minimale du conducteur de protection externe en cuivre S_p mm^2
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

Pendant l'essai, il ne doit y avoir aucune fusion de métal, aucune détérioration de la liaison de la SOURCE DE COURANT DE SOUDAGE ni d'échauffement susceptible de provoquer un incendie, et la chute de tension mesurée à travers la partie de l'enveloppe et la borne ne doit pas dépasser 4 V en valeur efficace.

10.5.3 ESSAI INDIVIDUEL DE SÉRIE

L'essai doit vérifier la continuité du CIRCUIT DE PROTECTION en injectant un courant d'au moins 10 A à 50 Hz ou 60 Hz provenant d'une source TBTS. Les essais doivent être effectués entre la borne PE et les points significatifs qui font partie du CIRCUIT DE PROTECTION. La durée de l'essai est de 1 s.

La tension mesurée entre la borne PE et les points d'essai ne doit pas dépasser les valeurs données dans le Tableau 12:

Tableau 12 – Vérification de la continuité du CIRCUIT DE PROTECTION

Section minimale effective du conducteur de protection de la boucle en essai mm^2	Chute de tension maximale mesurée (valeurs données pour un courant d'essai de 10 A) V
1,0	3,3
1,5	2,6
2,5	1,9
4,0	1,4
> 6,0	1,0

10.6 Serre-câble

Les SOURCES DE COURANT DE SOUDAGE équipées de bornes pour le raccordement des câbles d'alimentation souples doivent être équipées d'un serre-câble qui protège le raccordement électrique contre les efforts de traction.

Le serre-câble doit être construit de sorte

- qu'il soit dimensionné pour des câbles souples ayant la plage de sections de conducteurs comme cela est spécifié dans le Tableau E.1;
- que le mode d'attache puisse être facilement reconnaissable;
- que le câble puisse être aisément remplacé;
- que le câble ne puisse entrer en contact avec les vis de serrage conductrices du serre-câble si celles-ci sont accessibles ou en contact électrique avec des parties conductrices accessibles;
- que le câble ne soit pas retenu par une vis métallique portant directement sur lui;

- f) qu'au moins une partie du serre-câble soit fixée de façon sûre à la SOURCE DE COURANT DE SOUDAGE;
- g) qu'aucune des vis qui doivent être desserrées ou resserrées pendant le remplacement du câble ne soit utilisée pour la fixation d'autres parties;
- h) que lorsqu'il est fixé sur une SOURCE DE COURANT DE SOUDAGE de CLASSE II, il soit constitué d'un matériau isolant ou isolé, comme cela est exigé. Ainsi, en cas de défaut d'isolation du câble, les parties conductrices accessibles ne doivent pas devenir actives.

La vérification doit être effectuée par EXAMEN VISUEL et par l'essai suivant.

Un câble d'alimentation souple, qui a la section minimale spécifiée du conducteur, est connecté au point de raccordement du matériel. Le serre-câble est fixé au câble et serré.

Il ne doit alors pas être possible de pousser le câble à l'intérieur de la SOURCE DE COURANT DE SOUDAGE au point que le câble lui-même ou des éléments internes de la SOURCE DE COURANT DE SOUDAGE puissent être endommagés.

Le serre-câble est alors desserré et resserré 10 fois.

Le câble est ensuite soumis pendant 1 min à une traction appliquée sans secousse, comme cela est spécifié dans le Tableau 13.

Tableau 13 – Traction

Section nominale du conducteur mm ²	Traction N
1,5	150
2,5	220
4,0	330
6 et au-dessus	440

À la fin de l'essai, le câble ne doit pas s'être déplacé de plus de 2 mm et les extrémités des conducteurs ne doivent pas s'être déplacées de façon perceptible dans les bornes. Afin de mesurer le déplacement, une marque est faite, avant l'essai, sur le câble tendu, à 20 mm du point d'ancrage.

Après l'essai, le déplacement de cette marque par rapport au serre-câble est mesuré, le câble étant soumis à l'effort.

Pendant l'essai, le câble ne doit pas être endommagé de façon visible (entailles, coupures ou déchirures du revêtement, par exemple).

L'essai est alors répété avec la section maximale de conducteur spécifiée.

10.7 Entrées de câbles

Lorsque le câble d'alimentation traverse des parties métalliques, il doit être prévu un manchon isolant ou les ouvertures doivent être arrondies avec un rayon d'au moins 1,5 mm.

La vérification doit être effectuée par EXAMEN VISUEL.

10.8 Dispositif de commutation marche/arrêt sur le CIRCUIT D'ALIMENTATION

Lorsqu'un dispositif de commutation marche/arrêt intégré sur le CIRCUIT D'ALIMENTATION (par exemple, un interrupteur, un contacteur ou un disjoncteur) est fourni, il doit:

- a) déconnecter tous les conducteurs du réseau non mis à la terre; et
- b) indiquer clairement si le circuit est ouvert ou fermé; et
soit
- c) avoir les caractéristiques assignées suivantes:
 - tension: non inférieure aux valeurs données sur la PLAQUE SIGNALETIQUE;
 - courant: non inférieur au courant d'alimentation effectif maximal mentionné sur la PLAQUE SIGNALETIQUE.ou
- d) convenir pour cette application;

La vérification doit être effectuée par EXAMEN VISUEL; pour c) conformément aux autres normes concernées et pour d) par les essais suivants.

Pour les essais, les dispositifs de commutation marche/arrêt du CIRCUIT D'ALIMENTATION peuvent être installés à l'extérieur de la source de courant.

Une SOURCE DE COURANT DE SOUDAGE est connectée à la TENSION ASSIGNEE D'ALIMENTATION qui correspond au COURANT D'ALIMENTATION ASSIGNE MAXIMAL; en plus, pour un MATERIEL DE CLASSE I, un fusible de 10 A à 20 A est placé

- dans le cas d'un CIRCUIT D'ALIMENTATION mis à la terre, dans la connexion de la terre de protection;
- dans le cas d'un CIRCUIT D'ALIMENTATION non mis à la terre, entre un conducteur de phase et le CIRCUIT DE PROTECTION.

Pendant les essais, la tension d'alimentation doit être maintenue à une valeur au moins égale à la VALEUR ASSIGNEE.

Surcharge: La sortie de la SOURCE DE COURANT DE SOUDAGE est court-circuitée conformément à 9.3. Le dispositif de commutation est mis en fonctionnement pendant 100 cycles à la cadence de 6 cycles/min à 10 cycles/min avec une durée de marche minimale de 1 s.

Un dispositif de commutation ne doit pas être soumis à l'essai si ses CARACTERISTIQUES ASSIGNEES dépassent deux fois le COURANT D'ALIMENTATION ASSIGNE MAXIMAL de la SOURCE DE COURANT DE SOUDAGE.

Endurance: La sortie est reliée à une CHARGE CONVENTIONNELLE et réglée pour produire le COURANT DE SOUDAGE assigné à un FACTEUR DE MARCHE de 100 %. Le dispositif de commutation est mis en fonctionnement pendant 1 000 cycles à une cadence de 6 cycles/min à 10 cycles/min avec une durée de marche minimale de 1 s.

Une SOURCE DE COURANT DE SOUDAGE ayant plus d'une TENSION ASSIGNEE D'ALIMENTATION est aussi soumise à l'essai sous la tension d'alimentation maximale assignée.

Il ne doit y avoir aucune défaillance électrique ou mécanique, et en outre, pour un MATERIEL DE CLASSE I, aucune fusion du fusible.

NOTE Un composant ayant prouvé sa conformité à ces essais peut être utilisé dans d'autres applications similaires si les autres exigences sont du même niveau ou inférieures.

10.9 Câbles d'alimentation

Lorsque les câbles d'alimentation font partie de la SOURCE DE COURANT DE SOUDAGE, ils doivent:

- a) être appropriés pour cette application et satisfaire aux réglementations nationales et locales;
- b) être dimensionnés pour le COURANT D'ALIMENTATION EFFECTIF MAXIMAL $I_{1\text{eff}}$;
et
- c) avoir une longueur au moins égale à 2 m, mesurée depuis le point de sortie de l'enveloppe.

La vérification doit être effectuée par EXAMEN VISUEL.

NOTE Des exemples de réglementations locales sont donnés dans la Bibliographie, par exemple, EN 50525-2-21, Code électrique NFPA 70 (SE, SO, ST, STO ou autres câbles à très haute résistance) ou CSA C22.1. Il a été démontré que l'isolation PVC n'est pas adaptée à cette application.

10.10 Dispositif de connexion à l'alimentation (fiche de prise de courant montée)

Si un dispositif de connexion à l'alimentation est fourni comme partie du matériel de soudage à l'arc, ses VALEURS ASSIGNEES ne doivent pas être inférieures:

- a) au courant assigné du fusible exigé pour la conformité aux essais spécifiés en 9.3 qu'il y ait ou non un interrupteur du CIRCUIT D'ALIMENTATION incorporé;
- b) au COURANT D'ALIMENTATION EFFECTIF MAXIMAL $I_{1\text{eff}}$;

Pour les réseaux d'alimentation jusqu'à 125 V, le courant assigné doit, de plus, ne pas être inférieur soit à c) soit à d):

- c) 70 % du COURANT D'ALIMENTATION ASSIGNE MAXIMAL pour les matériels incorporant un interrupteur d'alimentation;
- d) 70 % du courant d'alimentation mesuré avec la sortie court-circuitée au réglage maximal pour les matériels n'incorporant pas un interrupteur d'alimentation.

De plus, le dispositif de connexion doit être approprié aux besoins industriels.

NOTE L'IEC 60309-1 fournit des exemples de dispositifs de connexion adaptés aux besoins industriels.

La vérification doit être effectuée par EXAMEN VISUEL, par mesurage et par calcul.

11 Sortie

11.1 TENSION À VIDE ASSIGNÉE

11.1.1 TENSION À VIDE ASSIGNEE dans le cas d'environnements avec risque accru de choc électrique

Si la SOURCE DE COURANT DE SOUDAGE n'est pas équipée d'un DISPOSITIF REDUCTEUR DE RISQUES conformément à l'Article 13, la TENSION À VIDE ASSIGNEE ne doit pas dépasser:

- a) une valeur de crête de 113 V en courant continu;
- b) une valeur de crête de 68 V et 48 V en valeur efficace en courant alternatif.

De telles SOURCES DE COURANT DE SOUDAGE peuvent être marquées avec le symbole 84 de l'Annexe L S.

La vérification doit être effectuée par mesurage et par analyse du circuit et/ou simulation de défaut conformément à 11.1.5.

11.1.2 TENSION A VIDE ASSIGNEE dans le cas d'environnements sans risque accru de choc électrique

Si la SOURCE DE COURANT DE SOUDAGE n'est pas équipée d'un DISPOSITIF REDUCTEUR DE RISQUES conformément à l'Article 13, la TENSION A VIDE ASSIGNEE ne doit pas dépasser:

- a) une valeur de crête de 113 V en courant continu;
- b) une valeur de crête de 113 V et 80 V en valeur efficace en courant alternatif.

La vérification doit être effectuée par mesurage, conformément à 11.1.5.

11.1.3 TENSION A VIDE ASSIGNEE dans le cas de torches tenues mécaniquement avec une protection accrue de l'opérateur

La TENSION A VIDE ASSIGNEE ne doit pas dépasser

- a) une valeur de crête de 141 V en courant continu;
- b) une valeur de crête de 141 V et 100 V en valeur efficace en courant alternatif.

Ces valeurs ne peuvent être utilisées que lorsque les exigences suivantes sont satisfaites:

- 1) la torche ne doit pas être tenue à la main;
- 2) la TENSION A VIDE doit être coupée automatiquement lorsque le soudage est arrêté;
et
- 3) la protection contre les contacts directs avec des parties actives doit être assurée au moyen:
 - d'un degré de protection minimal de IP2X;
 - ou
 - d'un DISPOSITIF REDUCTEUR DE RISQUES (voir l'Article 13).

La vérification doit être effectuée par mesurage conformément à 11.1.5, par une mise en fonctionnement et par EXAMEN VISUEL.

11.1.4 TENSION A VIDE ASSIGNEE pour les procédés spéciaux, par exemple le coupage par plasma

La TENSION A VIDE ASSIGNEE ne doit pas dépasser une valeur de crête de 500 V en courant continu.

La vérification doit être effectuée par mesurage conformément à 11.1.5, par une mise en fonctionnement et par EXAMEN VISUEL, avec l'exception suivante: la combinaison en série des résistances fixes de 200 Ω et variables de 5 k Ω peut être remplacée par une résistance fixe de 5 k Ω .

Une TENSION A VIDE ASSIGNEE dépassant une valeur de crête de 113 V en courant continu ne peut être appliquée que lorsque les exigences suivantes sont satisfaites.

- a) Ces SOURCES DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA avec leurs torches correspondantes doivent empêcher la sortie de la TENSION A VIDE lorsque la torche est démontée ou déconnectée de la SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA.
- b) La TENSION A VIDE doit être inférieure à 68 V crête au plus tard 2 s après ouverture du CIRCUIT DE COMMANDE (par exemple interrupteur de démarrage).
- c) La tension entre la tuyère de la torche et la pièce mise en œuvre ou la terre doit être inférieure à 68 V crête au plus tard 2 s après l'extinction de l'arc pilote et de l'arc principal.

Les conditions de conformité à ces exigences doivent être données dans les instructions d'emploi.

De telles SOURCES DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA peuvent être marquées du symbole 84 de l'Annexe L.

La vérification doit être effectuée par mesurage avec un appareil de mesure ou un oscilloscope en parallèle avec une résistance d'au moins 5 kΩ.

11.1.5 Exigences supplémentaires

La TENSION A VIDE ASSIGNEE pour tous les réglages de sortie possibles ne doit pas dépasser les valeurs données de 11.1.1 à 11.1.4, résumées dans le Tableau 14.

Au cours du mesurage, la variation de la tension d'alimentation réelle par rapport à la TENSION ASSIGNEE D'ALIMENTATION ne doit pas dépasser ± 6 %. Si la TENSION A VIDE varie avec la tension d'alimentation, alors, pour une variation de tension d'alimentation supérieure à ± 1 %, la TENSION A VIDE doit être corrigée de façon linéaire en fonction de la tension d'alimentation réelle.

Tableau 14 – Résumé des TENSIONS A VIDE ASSIGNEES admissibles

Paragraphe	Conditions de travail	TENSION A VIDE ASSIGNEE
11.1.1	ENVIRONNEMENT AVEC RISQUE ACCRU DE CHOC ELECTRIQUE	courant continu 113 V crête courant alternatif 68 V crête et 48 V en valeur efficace
11.1.2	Environnement sans risque accru de choc électrique	courant continu 113 V crête courant alternatif 113 V crête et 80 V en valeur efficace
11.1.3	Torches tenues mécaniquement avec protection accrue de l'opérateur	courant continu 141 V crête courant alternatif 141 V crête et 100 V en valeur efficace
11.1.4	Coupage par plasma	courant continu 500 V crête

Les SOURCES DE COURANT DE SOUDAGE doivent être

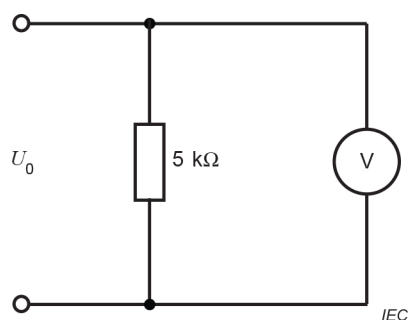
- a) conçues pour garantir que les tensions de sortie données dans le Tableau 14 ne sont pas dépassées en cas de défaillance d'un composant quelconque (circuit ouvert ou court-circuit, par exemple);
- ou
- b) équipées d'un système de protection qui, en 0,3 s, interrompt automatiquement la tension aux bornes de sortie et ne doit pas être réenclenché automatiquement.

Ces valeurs ne sont pas applicables aux tensions d'amorçage et de stabilisation de l'arc pouvant être superposées.

La vérification doit être effectuée par mesurage et par analyse du circuit et/ou simulation de défaut.

11.1.6 Circuits de mesure

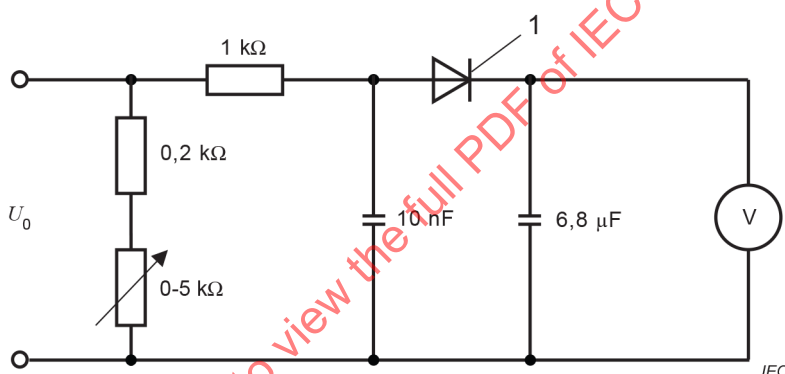
Pour mesurer les valeurs efficaces, un appareil mesurant une valeur efficace vraie doit être utilisé, avec une résistance de $(5 \pm 0,25)$ kΩ, connecté aux bornes du CIRCUIT DE SOUDAGE comme cela est représenté à la Figure 5.

**Légende** U_0 TENSION A VIDE

V Voltmètre à valeurs efficaces vraies

Figure 5 – Mesurage des valeurs efficaces

Afin d'obtenir des résultats de mesure reproductibles des valeurs de crête, en ne tenant pas compte des impulsions qui ne sont pas dangereuses, un circuit conforme à la Figure 6 doit être utilisé.

**Légende** U_0 TENSION A VIDE

V Voltmètre

1 Diode 1N4007 ou similaire

Figure 6 – Mesurage des valeurs de crête

Le voltmètre doit indiquer des valeurs moyennes. L'étendue de mesure doit être choisie de façon à être aussi proche que possible de la TENSION A VIDE. Le voltmètre doit avoir une résistance interne d'au moins 1 MΩ.

La tolérance sur les valeurs des composants du circuit de mesure ne doit pas dépasser ±5 %.

Pour l'ESSAI DE TYPE, le rhéostat est réglé de 0 Ω à 5 kΩ afin d'obtenir la plus grande valeur de la tension de crête mesurée avec ces charges de 200 Ω à 5,2 kΩ. Ce mesurage est répété avec les deux connexions à l'appareil de mesure inversées.

La résistance du rhéostat et la connexion qui produit la plus grande valeur de la tension peuvent être déterminées pendant l'ESSAI DE TYPE. Cette résistance et la polarité principale peuvent être utilisées pour l'ESSAI INDIVIDUEL DE SERIE.

11.2 Valeurs d'ESSAIS DE TYPE de la TENSION CONVENTIONNELLE EN CHARGE

11.2.1 Soudage manuel électrique à l'arc avec électrodes enrobées

I_2 jusqu'à 600 A: $U_2 = (20 + 0,04 I_2) \text{ V}$

I_2 au-dessus de 600 A: $U_2 = 44 \text{ V}$

11.2.2 Soudage à l'arc en atmosphère inerte avec électrode de tungstène

I_2 jusqu'à 600 A: $U_2 = (10 + 0,04 I_2) \text{ V}$

I_2 au-dessus de 600 A: $U_2 = 34 \text{ V}$

11.2.3 Soudage à l'arc sous atmosphère de gaz inerte / actif au fil fourré

I_2 jusqu'à 600 A: $U_2 = (14 + 0,05 I_2) \text{ V}$

I_2 au-dessus de 600 A: $U_2 = 44 \text{ V}$

11.2.4 Soudage à l'arc sous flux en poudre

I_2 jusqu'à 600 A: $U_2 = (20 + 0,04 I_2) \text{ V}$

I_2 au-dessus de 600 A: $U_2 = 44 \text{ V}$

11.2.5 Coupage par plasma

I_2 jusqu'à 170 A: $U_2 = (80 + 0,4 I_2) \text{ V}$

I_2 entre 170 A et 500 A: $U_2 = (131 + 0,1 I_2) \text{ V}$

I_2 au-dessus de 500 A: $U_2 = 181 \text{ V}$

Pour le coupage par plasma, le fabricant peut spécifier des TENSIONS EN CHARGE supplémentaires déterminées selon les conditions types de coupage.

NOTE La TENSION EN CHARGE spécifiée par le fabricant est utilisée en raison de la nature du procédé plasma. Les facteurs qui peuvent influencer la tension à laquelle les performances satisfaisantes sont obtenues incluent l'interaction de la conception de la torche plasma, le gaz plasma recommandé et la distance de sécurité.

11.2.6 Soudage plasma

I_2 jusqu'à 600 A: $U_2 = (25 + 0,04 I_2) \text{ V}$

I_2 au-dessus de 600 A: $U_2 = 49 \text{ V}$

11.2.7 Gougeage par plasma

I_2 jusqu'à 300 A: $U_2 = (100 + 0,4 I_2) \text{ V}$

I_2 au-dessus de 300 A: $U_2 = 220 \text{ V}$

Pour le gougeage par plasma, le fabricant peut spécifier des TENSIONS EN CHARGE supplémentaires déterminées selon les conditions types de coupage.

NOTE La TENSION EN CHARGE spécifiée par le fabricant est utilisée en raison de la nature du procédé plasma. Les facteurs qui peuvent influencer la tension à laquelle les performances satisfaisantes sont obtenues incluent l'interaction de la conception de la torche plasma, le gaz plasma recommandé et la distance de sécurité.

11.2.8 Exigences supplémentaires

Sur toute sa plage de réglages, les SOURCES DE COURANT DE SOUDAGE alimentées électriquement doivent pouvoir fournir les COURANTS CONVENTIONNELS DE SOUDAGE (I_2) sous les TENSIONS CONVENTIONNELLES EN CHARGE (U_2), conformément aux spécifications du 11.2.1 au 11.2.7.

La vérification doit être effectuée par un nombre suffisant de mesurages (voir l'Annexe H).

11.3 Dispositifs de commutation mécaniques utilisés pour ajuster la sortie

Un interrupteur, contacteur, disjoncteur ou autre dispositif de commande utilisé pour ajuster ou commander le niveau de sortie de la SOURCE DE COURANT DE SOUDAGE doit avoir une endurance adaptée à son application.

La vérification doit être effectuée par les essais suivants.

Le dispositif est installé dans une SOURCE DE COURANT DE SOUDAGE d'essai et soumis à 6 000 cycles de fonctionnement de la plage complète du mouvement mécanique avec la sortie en condition à vide. Si le dispositif est dans le CIRCUIT D'ALIMENTATION, la SOURCE DE COURANT DE SOUDAGE est mise en fonctionnement sous la TENSION ASSIGNEE D'ALIMENTATION la plus élevée. Vérifier qu'aucune défaillance électrique ou mécanique du dispositif ne survient et que la SOURCE DE COURANT DE SOUDAGE ne subit aucun dommage.

NOTE Un composant ayant prouvé sa conformité à ces essais peut être utilisé dans d'autres applications similaires si les autres exigences sont du même niveau ou inférieures.

11.4 Raccordement au CIRCUIT DE SOUDAGE

11.4.1 Protection contre les contacts involontaires

Les dispositifs de connexion au CIRCUIT DE SOUDAGE, avec ou sans câbles connectés, doivent être protégés contre les contacts involontaires par des personnes ou des objets métalliques tels que véhicules, crochets de levage, etc.

Les exemples suivants montrent comment une telle protection peut être procurée.

- a) Toutes les parties actives du dispositif de connexion sont en retrait du plan des ouvertures d'accès. Les dispositifs conformes à l'IEC 60974-12 satisfont à ces exigences.
- b) Il existe un couvercle à charnière ou un système de protection.

La vérification doit être effectuée par EXAMEN VISUEL.

11.4.2 Emplacement des dispositifs de connexion

Les dispositifs de connexion non protégés doivent être disposés de sorte que leurs ouvertures ne soient pas orientées vers le haut.

NOTE Les dispositifs de connexion équipés d'un dispositif de fermeture automatique peuvent avoir leurs ouvertures orientées vers le haut.

La vérification doit être effectuée par EXAMEN VISUEL.

11.4.3 Ouvertures de sortie

Lorsque les câbles de soudage traversent des parties métalliques, les bords des ouvertures doivent être arrondis avec un rayon d'au moins 1,5 mm.

La vérification doit être effectuée par EXAMEN VISUEL.

11.4.4 Transformateur de soudage multiopérateur triphasé

Tous les dispositifs de connexion de sortie de soudage prévus pour le raccordement à la pièce mise en œuvre doivent avoir une interconnexion commune à l'intérieur de la SOURCE DE COURANT DE SOUDAGE.

Les dispositifs de connexion de sortie de soudage d'une même phase doivent tous être marqués de la même façon.

La vérification doit être effectuée par EXAMEN VISUEL.

11.4.5 Marquage

Les dispositifs de connexion conçus spécifiquement pour le raccordement à la pièce mise en œuvre ou à l'électrode doivent être identifiés en conséquence.

Pour les SOURCES DE COURANT DE SOUDAGE à courant continu, la polarité doit être clairement marquée, soit sur les dispositifs de connexion de sortie eux-mêmes, soit sur le sélecteur de polarité. Cette exigence ne s'applique pas aux SOURCES DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA.

La vérification doit être effectuée par EXAMEN VISUEL.

11.4.6 Connexions pour les torches de coupage par plasma

La torche doit être connectée et déconnectée de la SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA:

- a) à l'intérieur de la SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA, au moyen d'un outil, par des écrous ou des dispositifs de connexion;
- ou
- b) sur la SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA, par un dispositif de connexion qui est:
 - 1) conçu pour éviter la connexion de torches incompatibles;
 - ou
 - 2) qui fonctionne avec l'aide d'un outil.

Quand le dispositif de connexion est déconnecté, il ne doit pas y avoir de tension supérieure aux limites de la TBTS accessible à l'opérateur.

La vérification doit être effectuée par EXAMEN VISUEL et par mesurage.

11.5 Alimentation de dispositifs extérieurs raccordés au CIRCUIT DE SOUDAGE

Lorsqu'une SOURCE DE COURANT DE SOUDAGE fournit une alimentation électrique à un dispositif extérieur incluant une connexion au CIRCUIT DE SOUDAGE, cette énergie doit être fournie par l'un des dispositifs suivants:

- a) le CIRCUIT DE SOUDAGE;
- b) un transformateur de sécurité conforme à l'IEC 61558-2-6, ou des moyens équivalents, incorporés dans la SOURCE DE COURANT DE SOUDAGE;
- c) un transformateur de sécurité conforme à l'IEC 61558-2-4, avec une tension secondaire assignée jusqu'à 120 V en valeur efficace, si toutes les parties conductrices accessibles du dispositif extérieur sont connectées, selon les recommandations du fabricant, au conducteur de protection à la terre qui est protégé contre le COURANT DE SOUDAGE, par exemple, par un relais sensible au courant ou par isolation des parties métalliques concernées, par exemple par une enveloppe.

Les dispositifs extérieurs comprennent des dévidoirs, des systèmes d'amorçage et de stabilisation d'arc, des torches, des dispositifs de suivi de joint ou d'autres dispositifs contenant une connexion avec le CIRCUIT DE SOUDAGE.

La vérification doit être effectuée par EXAMEN VISUEL et par simulation de défaut.

11.6 Sortie d'alimentation auxiliaire

Si des SOURCES DE COURANT DE SOUDAGE sont conçues pour fournir de l'énergie électrique à des dispositifs extérieurs ne faisant pas partie du CIRCUIT DE SOUDAGE (par exemple pour l'éclairage, un système de refroidissement extérieur ou des outils électriques), ces circuits auxiliaires et accessoires doivent être conformes aux normes et réglementations qui régissent leur utilisation.

Le CIRCUIT DE SOUDAGE doit être électriquement séparé de tels CIRCUITS D'ALIMENTATION conformément à 6.2.4 et 6.3.2.

Près des socles de prises de courant fournissant l'alimentation auxiliaire, le courant disponible, la tension, le FACTEUR DE MARCHE disponible lorsqu'il est inférieur à 100 %, le courant alternatif ou continu et le régime de neutre (par exemple mis à la terre ou non) suivant ce qui est approprié, doivent être marqués de façon claire et indélébile.

La vérification doit être effectuée par EXAMEN VISUEL au cours des essais conformément à 6.1.4, 6.1.5, 6.2.4 et 6.3.2 et en frottant le marquage conformément à 15.1.

11.7 Câbles de soudage

Si une SOURCE DE COURANT DE SOUDAGE est fournie avec des câbles de soudage, ils doivent être conformes aux exigences de l'IEC 60245-6 ou satisfaire aux réglementations nationales et locales.

Si une SOURCE DE COURANT ELECTRIQUE DE COUPAGE PAR PLASMA est fournie avec des câbles de soudage, il est de la responsabilité de l'utilisateur qu'ils soient conformes aux caractéristiques assignées de courant et de TENSION A VIDE correspondant à l'application et qu'ils satisfassent réglementations nationales et locales.

NOTE 1 Des exemples de réglementations locales sont donnés dans la Bibliographie, par exemple, l'EN 50525-2-81:2011. Des informations complémentaires sur le courant admissible des câbles sont données dans l'EN 50565-1:2014.

NOTE 2 Il a été démontré que l'isolation PVC n'est pas adaptée à cette application et n'est pas reconnue par les normes de produits IEC ou CENELEC relatives aux câbles de soudage.

NOTE 3 La tension assignée des câbles de soudage satisfaisant aux exigences de l'IEC 60245-6 n'est généralement pas adaptée aux applications de coupage par plasma.

12 CIRCUITS DE COMMANDE

12.1 Exigence générale

Toutes les entrées et sorties des CIRCUITS DE COMMANDE doivent être soumises à des essais en charge maximale, comme cela est spécifié par le fabricant. Les CIRCUITS DE COMMANDE A DISTANCE peuvent être soumis à l'essai sans connexion à la source de courant, à condition que la source de courant puisse être simulée.

La vérification doit être effectuée par mesurage ou analyse, selon le cas.

12.2 Isolation des CIRCUITS DE COMMANDE

Un CIRCUIT DE COMMANDE qui quitte l'enveloppe qui possède une tension inférieure à la TENSION A VIDE admissible conformément à 11.1.1, et qui est séparé des CIRCUITS DE SOUDAGE et d'ALIMENTATION, doit être:

- a) isolé du CIRCUIT D'ALIMENTATION par une double isolation ou une ISOLATION RENFORCEE;

- b) isolé de tous les autres circuits possédant une tension supérieure à la TENSION A VIDE admissible conformément à 11.1.1 (CIRCUITS D'ALIMENTATION auxiliaires, circuit de coupage par plasma, par exemple), par une double isolation ou une ISOLATION RENFORCEE; et
- c) isolé du CIRCUIT DE SOUDAGE possédant une tension inférieure à la TENSION A VIDE admissible conformément à 11.1.1, par une ISOLATION PRINCIPALE.

NOTE La configuration de l'isolation pour les MATERIELS DE CLASSE I est présentée au 6.1.1.

La vérification doit être effectuée par mesurage ou analyse, selon le cas.

12.3 TENSIONS LOCALES des CIRCUITS DE COMMANDE à distance

Les TENSIONS LOCALES dans les CIRCUITS DE COMMANDE A DISTANCE conçus pour fonctionner à la main ne doivent pas dépasser 50 V en courant alternatif ou 120 V en courant continu lissé entre les conducteurs, ou entre tout conducteur et le CIRCUIT DE PROTECTION, dans des conditions normales de fonctionnement et après un premier défaut.

NOTE Les exigences de TENSION LOCALE pour les réseaux informatiques étendus ou locaux sont indiquées dans l'IEC 60950-1.

La vérification doit être effectuée par mesurage ou analyse, selon le cas.

13 DISPOSITIF REDUCTEUR DE RISQUES

13.1 Exigences générales

Un DISPOSITIF REDUCTEUR DE RISQUES doit réduire la sévérité du choc électrique qui peut être causé par des TENSIONS A VIDE dépassant les VALEURS DE TENSION ASSIGNEE A VIDE admissibles pour un environnement donné. Des exemples de DISPOSITIFS REDUCTEURS DE RISQUES sont donnés en 13.2.

Les exigences sont indiquées dans le Tableau 15.

Tableau 15 – Exigences pour le DISPOSITIF REDUCTEUR DE RISQUES

TENSION A VIDE non réduite selon le paragraphe	TENSION A VIDE réduite selon le paragraphe	Temps de réaction s
Entre 11.1.3 et 11.1.2	11.1.1	0,3
Entre 11.1.2 et 11.1.1	11.1.1	2
Pour une SOURCE DE COURANT DE SOUDAGE en tension continue supérieure à 113 V, un temps de réaction de 0,3 s est exigé.		

13.2 Types de DISPOSITIFS REDUCTEURS DE RISQUES

13.2.1 Dispositif réducteur de tension

Un dispositif réducteur de tension doit avoir automatiquement réduit la TENSION A VIDE ASSIGNEE à un niveau ne dépassant pas les valeurs du 11.1.1 au moment auquel la résistance du CIRCUIT DE SOUDAGE extérieur dépasse 200 Ω . Le temps de réaction est spécifié dans le Tableau 15.

De telles SOURCES DE COURANT DE SOUDAGE peuvent être marquées du symbole 84 de l'Annexe L.

La vérification doit être effectuée en connectant une résistance de charge variable entre les dispositifs de connexion de sortie de la SOURCE DE COURANT DE SOUDAGE. Les mesurages de la tension et du temps de réaction sont effectués pendant que la résistance est augmentée.

13.2.2 Dispositif de commutation de courant alternatif à courant continu

Un dispositif de commutation de courant alternatif à courant continu doit avoir commuté automatiquement la TENSION A VIDE assignée alternative à une TENSION A VIDE continue assignée ne dépassant pas les valeurs indiquées en 11.1.1 au moment auquel la résistance du CIRCUIT DE SOUDAGE extérieur dépasse 200 Ω . Le temps de réaction est spécifié dans le Tableau 15.

De telles SOURCES DE COURANT DE SOUDAGE peuvent être marquées du symbole 84 de l'Annexe L.

La vérification doit être effectuée conformément à 13.2.1.

13.3 Exigences pour les DISPOSITIFS REDUCTEURS DE RISQUES

13.3.1 Mise hors service d'un DISPOSITIF REDUCTEUR DE RISQUES

La conception doit être telle que l'opérateur ne puisse mettre hors service ou court-circuiter le DISPOSITIF REDUCTEUR DE RISQUES sans l'usage d'un outil.

La vérification doit être effectuée par EXAMEN VISUEL.

13.3.2 Interférences avec le fonctionnement d'un DISPOSITIF REDUCTEUR DE RISQUES

Les COMMANDES A DISTANCE spécifiées par le fabricant et les dispositifs d'amorçage ou de stabilisation d'arc de la SOURCE DE COURANT DE SOUDAGE ne doivent pas interférer avec le fonctionnement correct du DISPOSITIF REDUCTEUR DE RISQUES, c'est-à-dire que les limites de TENSION A VIDE ne doivent pas être dépassées.

La vérification doit être effectuée en répétant les essais du 13.2.1 avec tout dispositif susceptible d'interférer avec le fonctionnement du DISPOSITIF REDUCTEUR DE RISQUE.

13.3.3 Indicateur de fonctionnement satisfaisant

Un dispositif fiable, par exemple une lampe de signalisation, doit être prévu pour indiquer que le DISPOSITIF REDUCTEUR DE RISQUES fonctionne de façon satisfaisante. Lorsqu'une lampe de signalisation est utilisée, celle-ci doit s'allumer lorsque la tension est réduite ou modifiée en tension continue.

La vérification doit être effectuée par EXAMEN VISUEL au cours de l'essai, conformément à 13.1.

13.3.4 Non-danger en cas de défaillance

Si le DISPOSITIF REDUCTEUR DE RISQUES ne fonctionne pas conformément à 13.1, la tension aux bornes de sortie doit être réduite à un niveau ne dépassant pas 11.1.1 conformément au Tableau 15 et ne doit pas être réinitialisée automatiquement.

La vérification doit être effectuée en simulant un défaut du DISPOSITIF REDUCTEUR DE RISQUES en mesurant le temps nécessaire pour parvenir à un état de non-danger après défaillance du DISPOSITIF REDUCTEUR DE RISQUES.

14 Dispositions mécaniques

14.1 Exigences générales

Le matériel doit être fabriqué et assemblé de sorte qu'il ait la résistance et la rigidité nécessaires pour supporter le service normal auquel il est destiné sans augmentation des risques de choc électrique ou autres dangers, et que soient maintenues les DISTANCES D'ISOLEMENT DANS L'AIR minimales exigées. Le matériel doit avoir un boîtier ou une armoire abritant toutes les parties actives et les parties mobiles dangereuses (telles que poulies, courroies, ventilateurs, engrenages, etc.) à l'exception des parties suivantes qui ne doivent pas être totalement enfermées:

- a) les câbles d'alimentation, de commande et de soudage;
- b) les bornes de sortie pour le raccordement des câbles de soudage.

Après les essais effectués conformément aux paragraphes 14.2 à 14.5, le matériel doit satisfaire aux dispositions du présent document. Quelques déformations d'éléments de la structure ou de l'enveloppe sont permises à condition que cela ne réduise pas le niveau de protection de sécurité.

Les parties accessibles ne doivent pas avoir de bords tranchants, de surfaces rugueuses ou de parties en saillie susceptibles de provoquer des blessures.

La vérification doit être effectuée par EXAMEN VISUEL après avoir satisfait aux exigences du 14.2 au 14.5.

14.2 Enveloppe

14.2.1 Matériaux de l'enveloppe

Les matériaux non métalliques destinés à protéger contre le contact avec les parties actives, à l'exception des circuits de soudage et des circuits TBTS, doivent avoir une classification d'inflammabilité V-1 ou meilleure conformément à l'IEC 60695-11-10.

La vérification est effectuée par examen des spécifications des matériaux non métalliques.

14.2.2 Résistance de l'enveloppe

L'enveloppe, y compris les ouïes d'aération, doit supporter un choc de 10 Nm conforme à l'Annexe I.

Les poignées de manutention, les boutons-poussoirs, les écrans de réglage, etc. ne doivent pas être soumis à l'essai avec le marteau pendulaire.

En variante, l'enveloppe peut être constituée d'une tôle d'épaisseur minimale conforme à l'Annexe J.

La vérification doit être effectuée conformément à a) ou b) ci-dessous.

- a) Par un essai de choc en utilisant un marteau pendulaire de choc conformément à l'Article I.1 ou un corps de chute libre conformément à l'Article I.2 ou des moyens équivalents, comme suit:
 - 1) un échantillon est soumis à l'essai;
 - 2) la SOURCE DE COURANT DE SOUDAGE n'est pas sous tension pendant l'essai;
 - 3) choisir de chaque côté un point d'impact où le risque de choc électrique ou de dysfonctionnement est le plus élevé;
 - 4) appliquer trois chocs aux points d'impact choisis.

b) Par mesurage de l'épaisseur de la tôle.

14.3 Moyens de manutention

14.3.1 Moyens de manutention mécanisés

Si des dispositifs pour une manutention mécanisée (par exemple des œillets ou anneaux) sont prévus pour le levage d'un matériel assemblé, ceux-ci doivent être capables de supporter les contraintes mécaniques d'une traction statique appliquée avec une force calculée en fonction de la masse du matériel assemblé, comme suit.

- a) Pour le matériel dont la masse est inférieure ou égale à 150 kg, une force calculée à partir de 10 fois la masse doit être utilisée.
- b) Pour le matériel dont la masse est supérieure à 150 kg, une force calculée à partir de quatre fois la masse ou d'au moins 15 kN doit être utilisée.

Si un seul dispositif de levage est prévu, il doit être conçu de telle façon qu'un couple appliqué pendant le levage ne puisse pas le desserrer.

La vérification doit être effectuée par EXAMEN VISUEL et par l'essai suivant.

Le matériel est équipé de tous les accessoires (à l'exception des bouteilles de gaz, traîneaux séparés, chariots et châssis à roues) qui sont susceptibles d'être installés et, dans le cas de GROUPES ELECTROGENES DE SOUDAGE, totalement équipé et prêt à être mis en marche. Le matériel est ensuite ancré rigidement sur sa base et une chaîne ou un câble est attaché à ses moyens de levage, comme cela est recommandé par le fabricant; une traction est ensuite exercée vers le haut et de façon continue pendant 10 s.

Si deux ou plus de deux dispositifs de levage sont prévus, les chaînes et câbles sont disposés de façon que la force soit répartie équitablement et soit appliquée avec un angle maximal de 15° par rapport à la verticale.

14.3.2 Moyens de manutention manuels

Si des dispositifs pour une manutention manuelle de levage ou portage (par exemple des poignées ou des sangles) sont prévus, ceux-ci doivent être capables de supporter les contraintes mécaniques d'une traction statique appliquée avec une force calculée en fonction de la masse du matériel assemblé, comme suit.

Une force calculée à partir de quatre fois la masse ou de 600 N au moins doit être utilisée.

La vérification doit être effectuée par EXAMEN VISUEL et par l'essai suivant.

Le matériel est équipé de tous les accessoires (à l'exception des bouteilles de gaz, traîneaux séparés, chariots et châssis à roues) qui sont susceptibles d'être installés. Le matériel est ensuite ancré rigidement sur sa base et une chaîne ou un câble est attaché à ses poignées ou sangles, comme cela est recommandé par le fabricant; une traction est ensuite exercée vers le haut et de façon continue pendant 10 s.

14.4 Essai de chute

Le matériel doit être capable de supporter l'essai de chute. Pour cet essai, le matériel doit inclure tous les accessoires, le liquide de refroidissement et le fil d'apport (à l'exception des bouteilles de gaz, traîneaux séparés, chariots et châssis à roues, sauf s'ils font partie du matériel normal et sont fixés de façon permanente) qu'il est recommandé d'installer.

Pour l'essai de chute, les hauteurs doivent être les suivantes:

a) le matériel d'une masse inférieure ou égale à 25 kg doit supporter une chute de 250^{+10}_0 mm;

b) le matériel d'une masse supérieure à 25 kg doit supporter une chute de 100^{+10}_0 mm.

NOTE 1 La masse du matériel comprend la masse des accessoires, du liquide de refroidissement et du fil d'apport.

La vérification doit être effectuée en faisant tomber le matériel trois fois sur une surface dure et rigide. Cet essai est effectué de sorte qu'un bord inférieur différent du matériel reçoive le choc à chaque fois qu'il tombe.

NOTE 2 En pratique, un des coins touche la surface d'impact en premier.

Les GROUPES ELECTROGENES DE SOUDAGE doivent être chargés et prêts pour un usage immédiat.

14.5 Essai de stabilité

Le matériel dans sa position la plus instable ne doit pas basculer pour une inclinaison allant jusqu'à 10°. Des équipements auxiliaires, comme cela est spécifié par le fabricant suivant le type de matériel, tels que bouteilles de gaz, dévidoir ou système de refroidissement peuvent affecter la stabilité et doivent être pris en compte.

Si le fabricant spécifie d'autres éléments auxiliaires de telle sorte que les exigences du présent paragraphe ne peuvent pas être satisfaites, les instructions doivent alors prévoir l'ancrage ou d'autres moyens, si nécessaire.

La vérification doit être effectuée par l'essai suivant.

Le matériel est placé sur un plan et est écarté du plan horizontal.

15 PLAQUE SIGNALÉTIQUE

15.1 Exigences générales

Une PLAQUE SIGNALÉTIQUE claire et indélébile doit être fixée de façon sûre ou imprimée sur chaque SOURCE DE COURANT DE SOUDAGE.

NOTE L'objet de la PLAQUE SIGNALÉTIQUE est d'indiquer à l'utilisateur les caractéristiques électriques, ce qui permet des comparaisons et un choix correct des SOURCES DE COURANT DE SOUDAGE.

La vérification doit être effectuée par EXAMEN VISUEL et en frottant le marquage pendant 15 s à la main avec un tissu imbibé d'eau puis à nouveau pendant 15 s avec un tissu imbibé d'essence.

Après cet essai, le marquage doit être facilement lisible. Il ne doit pas être facile d'enlever la PLAQUE SIGNALÉTIQUE et celle-ci ne doit pas se recroqueviller.

15.2 Description

La PLAQUE SIGNALÉTIQUE doit être divisée en sections contenant des informations et caractéristiques pour

- a) l'identification;
- b) la sortie de soudage;
- c) l'alimentation en énergie.