

Arc welding equipment —

Part 1: Welding power sources

The European Standard EN 60974-1:1998, with the incorporation of amendments A1:2000 and A2:2003, has the status of a British Standard

ICS 25.160.30

National foreword

This British Standard is the English language version of EN 60974-1:1998, including amendments A1:2000 and A2:2003. It is identical with IEC 60974-1:1998, including amendments 1:2000 and 2:2003. It supersedes BS 638-10:1990 which is withdrawn.

Amendment No.1 to BS EN 60974-1:1998 together with BS EN 60974-7:2000 supersedes BS EN 50192:1996.

The UK participation in its preparation was entrusted to Technical Committee WEE/6, Electric arc welding equipment, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement these international or European publications may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 101 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Sidelining in this document indicates the most recent changes by amendment.

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 December 1998

© BSI 30 September 2003

Amendments issued since publication

Amd. No.	Date	Comments
10976	December 2000	
14543	30 September 2003	Indicated by a sideline

ISBN 0 580 30859 6

Descriptors: Arc welding, power sources, safety requirements, test methods

English version

Arc welding equipment — Part 1: Welding power sources

(includes amendments A1:2000 and A2:2003)

(IEC 60974-1:1998 + A1:2000 + A2:2003)

Matériel de soudage électrique —
Partie 1: Sources de courant pour soudage
(inclut les amendements A1:2000 et A2:2003)
(CEI 60974-1:1998 + A1:2000 + A2:2003)

Einrichtungen zum Lichtbogenschweißen —
Teil 1: Schweißstromquellen
(enthält Änderungen A1:2000 und A2:2003)
(IEC 60974-1:1998 + A1 + A1:2000 + A2:2003)

This European Standard was approved by CENELEC on 1998-04-01. Amendment A1 was approved by CENELEC on 2000-04-01 and amendment A2 was approved by CENELEC on 2003-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

The text of document 26/153/FDIS, future edition 2 of IEC 60974-1, prepared by IEC TC 26, Electric welding, and by ISO TC 44, Welding and allied processes, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60974-1 on 1998-04-01.

This European Standard supersedes EN 60974-1:1990.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-07-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2001-01-01

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex C, Annex E, Annex I, Annex J and Annex ZA are normative and Annex A, Annex B, Annex D, Annex F, Annex G, Annex H and Annex K are informative. Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60974-1:1998 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 26/181/FDIS, future amendment 1 to IEC 60974-1:1998, prepared by IEC TC 26, Electric welding, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60974-1:1998 on 2000-04-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2001-01-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2003-04-01

Annexes designated “normative” are part of the body of the standard.

In this standard, Annex ZA is normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the amendment 1:2000 to the International Standard IEC 60974-1:1998 was approved by CENELEC as an amendment to the European Standard without any modification.

Foreword to amendment A2

The text of document 26/251/FDIS, future amendment 2 to IEC 60974-1:1998, prepared by IEC TC 26, Electric welding, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 60974-1:1998 on 2003-06-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2004-03-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2006-06-01

Annexes designated “informative” are given for information only.

In this standard, Annex A and Annex L are informative.

Endorsement notice

The text of amendment 2:2003 to the International Standard IEC 60974-1:1998 was approved by CENELEC as an amendment to the European Standard without any modification.

CONTENTS

Clause	Page
1 Scope	8
2 Normative references	8
3 Definitions	9
4 Environmental conditions	16
5 Test conditions	17
5.1 Type tests	17
5.2 Routine tests	18
6 Protection against electric shock	18
6.1 Insulation	18
6.1.1 Clearances	19
6.1.2 Creepage distances	20
6.1.3 Insulation resistance	22
6.1.4 Dielectric strength	22
6.2 Protection against electric shock in normal service (direct contact)	24
6.2.1 Protection provided by the enclosure	24
6.2.2 Capacitors	24
6.2.3 Automatic discharge of input capacitors	25
6.3 Protection against electric shock in case of a fault condition (indirect contact)	25
6.3.1 Isolation of the input circuit and the welding circuit	25
6.3.2 Insulation between windings of the input circuit and the welding circuit	26
6.3.3 Internal conductors and connections	27
6.3.4 Movable coils and cores	27
6.3.5 Additional requirements for plasma cutting systems	27
7 Thermal requirements	28
7.1 Heating test	28
7.1.1 Tolerances of the test parameters	28
7.1.2 Duration of the heating test	28
7.2 Temperature measurement	29
7.2.1 Surface temperature sensor	29
7.2.2 Resistance	29
7.2.3 Embedded temperature sensor	30
7.2.4 Determination of the ambient air temperature	30
7.2.5 Recording of temperatures	30
7.3 Limits of temperature rise	30
7.3.1 Windings, commutators and slip-rings	30
7.3.2 External surfaces	31
7.4 Loading test	32
7.5 Commutators and slip-rings	32
8 Abnormal operation	32
8.1 Stalled fan	33
8.2 Short-circuit	33
8.3 Overload	34

Clause	Page
9 Thermal protection.....	34
9.1 Construction	34
9.2 Location	34
9.3 Operation	35
9.4 Resetting	35
9.5 Operating capacity.....	35
9.6 Indication.....	35
10 Connection to the input supply	36
10.1 Supply voltage	36
10.2 Power supply	36
10.3 Means of connection.....	37
10.4 Input supply terminals	37
10.4.1 Marking of terminals	37
10.4.2 Continuity of the protective circuit.....	37
10.5 Cable anchorage	39
10.6 Inlet openings	40
10.7 Input supply on/off switching device	40
10.8 Supply cables	41
10.9 Supply coupling device (attachment plug).....	41
11 Output	41
11.1 Rated no-load voltage (U_0)	41
11.1.1 Rated no-load voltage for use in environments with increased hazard of electric shock.....	43
11.1.2 Rated no-load voltage for use in environments without increased hazard of electric shock.....	43
11.1.3 Rated no-load voltage for the use with mechanically held torches with increased protection for the operator.....	43
11.1.4 Rated no-load voltage for special processes e.g. plasma cutting	44
11.2 Type test values of the conventional load voltage	44
11.2.1 Manual metal arc welding with covered electrodes.....	44
11.2.2 Tungsten inert gas and plasma arc welding	44
11.2.3 Metal inert/active gas and selfshielded flux cored arc welding.....	44
11.2.4 Submerged arc welding.....	44
11.2.5 Plasma cutting	45
11.2.6 Plasma gouging	45
11.3 Mechanical switching devices used to adjust output	45
11.4 Output connections.....	45
11.4.1 Protection against unintentional contact	45
11.4.2 Location of socket outlets	45
11.4.3 Outlet openings	46
11.4.4 Three-phase a.c. multi-operator welding transformer.....	46
11.4.5 Marking	46
11.4.6 Connections for plasma cutting torches	46
11.5 Power supply to external devices	47
11.6 Auxiliary power output.....	47

Clause	Page
12 Control circuits	47
13 Hazard reducing device	48
13.1 Voltage reducing device.....	48
13.2 Switching device for a.c. to d.c.....	48
13.3 Connection of a hazard reducing device	48
13.4 Interference with operation of a hazard reducing device	48
13.5 Indication of satisfactory operation.....	48
13.6 Fail to a safe condition.....	49
14 Mechanical requirements	49
14.1 Enclosure	49
14.2 Impact resistance of handles, push buttons etc.	50
14.3 Handling means.....	50
14.4 Drop withstand	50
14.5 Tilting stability	51
15 Rating plate	51
15.1 Description	51
15.2 Contents.....	52
15.3 Tolerances	56
15.4 Direction of rotation	56
16 Adjustment of the output	56
16.1 Type of adjustment	56
16.2 Marking of the adjusting device.....	57
16.3 Indication of current or voltage control	57
17 Instructions and markings	58
17.1 Instructions.....	58
17.2 Markings	59
Annex A (informative) Nominal voltages of supply systems (see 6.6.1)	60
Annex B (informative) Example of a combined dielectric test (see 6.1.4).....	61
Annex C (normative) Unbalanced load in case of a.c. tungsten inert-gas welding power sources (see 7.1)	62
Annex D (informative) Extrapolation of temperature to time of shutdown (see 7.2.5)	64
Annex E (normative) Construction of input supply terminals (see 10.4)	65
Annex F (informative) Cross-reference to non-SI units	68
Annex G (informative) Suitability of input supply for the measurement of the true r.m.s. value of the supply current (see 10.8)	69
Annex H (informative) Plotting of static characteristics (see 11.2).....	70
Annex I (normative) Methods of a 10 Nm impact test (see 14.1)	71
Annex J (normative) Thickness of sheet metal for enclosures (see 14.1)	72
Annex K (informative) Examples of rating plates (see 15.1)	74
Annex L (informative) Graphical symbols for arc welding equipment	77

	Page
Figure 1 – Measurement of leakage current.....	26
Figure 2 – Measurement of peak values	42
Figure 3 – Principle of the rating plate	52
Figure B.1 – Combined high-voltage transformers	61
Figure C.1 – Voltage and current during a.c. tungsten inert-gas welding.....	62
Figure C.2 – Unbalanced voltage during a.c. tungsten inert-gas welding	63
Figure C.3 – AC welding power source with unbalanced load	63
Figure I.1 – Test set-up	71
Figure K.1 – Single-phase transformer	74
Figure K.2 – Three-phase rotating frequency converter.....	74
Figure K.3 – Subdivided rating plate: single-/three-phase transformer rectifier	75
Figure K.4 – Engine-generator-rectifier	76
Figure L.1 – Input voltage power switch	98
Figure L.2 – Arc force control potentiometer	98
Figure L.3 – Remote receptacle and selector switches.....	98
Figure L.4 – Terminals with inductance selector for MIG/MAG welding.....	98
Figure L.5 – Process switch (MMA, TIG, MIG)	99
Figure L.6 – Selector switch on AC/DC equipment	99
Figure L.7 – Panel indicator lights (overheat, fault, arc striking, output voltage	99
Figure L.8 – Setting pulsing parameters using digital display.....	99
Table 1 – Minimum clearances for overvoltage category III	19
Table 2 – Minimum creepage distances.....	21
Table 3 – Insulation resistance	22
Table 4 – Dielectric test voltages	22
Table 5 – Minimum distance through insulation.....	26
Table 6 – Limits of temperature rise for windings, commutators and slip-rings	31
Table 7 – Limits of temperature rise for external surfaces	31
Table 8 – Cross-section of the output short-circuit conductor	33
Table 9 – Current and time requirements for protective circuits.....	38
Table 10 – Pull	39
Table 11 – Summary of allowable rated no-load voltages	42
Table E.1 – Range of conductor dimensions to be accepted by the input supply terminals	65
Table E.2 – Spacing between input supply terminals.....	66
Table F.1 – Cross-reference for mm ² to American wire gauge (AWG) (see 8.2 and E.1).....	68
Table F.2 – Cross-reference for kW to horsepower (hp) (see 15.2, box 21).....	68
Table I.1 – Mass of the free fall weight and height of the free fall	71
Table J.1 – Minimum thickness of sheet metal for steel enclosures.....	72
Table J.2 – Minimum thickness of sheet metal for enclosures of aluminium, brass or copper	73
Table L.1 – Letters used as symbols	78

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 that specified in table 1 of IEC 60038, or driven by mechanical means.

This standard is not applicable to welding power sources for manual metal arc welding with limited duty operation which are designed mainly for use by laymen.

This part of IEC 60974 specifies safety requirements for construction and performance requirements of welding power sources and plasma cutting systems

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

NOTE 2 This standard does not include electromagnetic compatibility (EMC) requirements.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60974. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60974 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60038:1983, *IEC standard voltages*

IEC 60050(151):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*

IEC 60050(851):1991, *International Electrotechnical Vocabulary (IEV) – Chapter 851: Electric welding*

IEC 60051-2:1984, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 2: Special requirements for ammeters and voltmeters*

IEC 60068-2-63:1991, *Environmental testing – Part 2: Test methods – Test Eg: Impact, spring hammer*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60204-1:1992, *Electrical equipment of industrial machines – Part 1: General requirements*

IEC 60309-1:1988, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

IEC 60417:1973, *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets*

IEC 60445:1988, *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60536:1976, *Classification of electrical and electronic equipment with regard to protection against electric shock*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:1992, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating to achieve insulation coordination of printed board assemblies*

IEC 60905:1987, *Loading guide for dry-type power transformers*

IEC 60974-7:1999, *Arc welding equipment – Part 7: Torches*

IEC 60974-12:1992, *Arc welding equipment – Part 12: Coupling devices for welding cables*

IEC 61558 (all parts), *Safety of power transformers, power supply units and similar*

ISO 7000:1989, *Graphical symbols for use on equipments – Index and synopsis. Bilingual edition*

3 Definitions

For the purpose of this part of IEC 60974, the following definitions apply, with those in IEC 60050(151), IEC 60050(851), IEC 60204-1 and IEC 60664-1:

3.1

arc welding power source

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

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

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

3.2

industrial and professional use

use intended only for experts or instructed persons

3.3

expert (competent person, skilled person)

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

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

3.4

instructed person

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

NOTE If necessary, the person has undergone some training.

3.5

type test

a test of one or more devices made to a given design to check if these devices comply with the requirements of the standard concerned [IEV 851-02-09]

3.6

routine test

a 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 [IEV 851-02-10]

3.7

general visual inspection

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

3.8

drooping characteristic

an external static characteristic of a welding power source which, in its normal welding range, is such that, as the current increases, the voltage decreases by more than 7 V/100 A

3.9

flat characteristic

an 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

3.10

static characteristic

the relationship between the load voltage and the welding current of a welding power source in a conventional welding condition

3.11

welding circuit

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

NOTE 1 In arc welding, the arc is a part of the welding circuit.

NOTE 2 In certain arc welding processes, the welding arc may be established between two electrodes. In such a case, the workpiece is not necessarily a part of the welding circuit.

3.12

control circuit

a circuit for the operational control of a welding power source and/or for protection of the power circuits [IEC 60204-1:1992, 3.9 modified]

3.13

welding current

the current delivered by a welding power source during welding

3.14**load voltage**

the voltage between the output terminals when the welding power source is delivering welding current

3.15**no-load voltage**

the voltage, exclusive of any arc striking or arc stabilizing voltage, between the output terminals of a welding power source when the external welding circuit is open

3.16**conventional value**

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

NOTE Conventional values do not necessarily apply during the actual welding process.

3.17**conventional welding condition**

a 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

3.18**conventional load**

a practically non-inductive constant resistive load having a power factor not less than 0,99

3.19**conventional welding current (I_2)**

the current delivered by a welding power source to a conventional load at the corresponding conventional load voltage

NOTE The values of I_2 are given as r.m.s. values for a.c. and arithmetic mean values for d.c.

3.20**conventional load voltage (U_2)**

the load voltage of a welding power source having a specified linear relationship to the conventional welding current

NOTE 1 The values for U_2 are given as r.m.s. values for a.c. and arithmetic mean values for d.c.

NOTE 2 The specified linear relationship varies in accordance with the process (see 11.2).

3.21**rated value**

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

3.22**rating**

the set of rated values and operating conditions

3.23

rated output

the rated values of the output of a welding power source

3.24

rated maximum welding current ($I_{2\max}$)

the 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

3.25

rated minimum welding current ($I_{2\min}$)

the 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

3.26

rated no-load voltage (U_0)

the no-load voltage, measured in accordance with 11.1, at rated supply voltage and frequency or rated no-load speed of rotation

NOTE 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.

3.27

rated reduced no-load voltage (U_r)

the no-load voltage of a welding power source, fitted with a voltage reducing device, measured in accordance with 11.1 immediately after the device acts to effect a reduction in the voltage

3.28

rated switched no-load voltage (U_s)

the d.c. no-load voltage of a welding power source, fitted with an a.c. to d.c. switching device

3.29

rated supply voltage (U_1)

the r.m.s. value of an input voltage for which the welding power source is designed

3.30

rated supply current (I_1)

the r.m.s. value of an input current to the welding power source at a rated conventional welding condition

3.31

rated no-load supply current (I_0)

the input current to the welding power source at rated no-load voltage

3.32

rated maximum supply current ($I_{1\max}$)

the maximum value of the rated supply current

3.33**maximum effective supply current ($I_{1\text{eff}}$)**

the maximum value of the effective input current, calculated from the rated supply current (I_1), the corresponding duty cycle (duty factor) (X) and the supply current at no-load (I_0) by the formula:

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

3.34**rated load speed (n)**

the speed of rotation of a rotating welding power source when operating at rated maximum welding current

3.35**rated no-load speed (n_0)**

the speed of rotation of a rotating welding power source when the external welding circuit is open

NOTE 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.

3.36**rated idle speed (n_i)**

the reduced no-load speed of an engine driven welding power source

3.37**duty cycle; duty factor (X)**

the ratio for a given time interval of the uninterrupted on-load duration to the total time

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

NOTE 2 For the purposes of this standard, the total time period of one complete cycle is 10 min. For example, in the case of a 60 % duty cycle (duty factor), a load is applied continuously for 6 min followed by a no-load period of 4 min.

3.38**clearance**

the shortest distance in air between two conductive parts [IEC 60664-1:1992, 1.3.2]

3.39**creepage distance**

the shortest distance along the surface of the insulating material between two conductive parts [IEV 151-03-37]

3.40**pollution degree**

a numeral characterizing the expected pollution of the micro-environment [IEC 60664-1:1992, 1.3.13]

NOTE For the purpose of evaluating creepage distances and clearances, the following four pollution degrees in the micro-environment are established in 2.5.1 of IEC 60664-1.

- 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 is to be expected.
- d) **pollution degree 4:** The pollution generates persistent conductivity caused by conductive dust or by rain or snow.

3.41

micro-environment

the immediate environment of the insulation which particularly influences the dimensioning of the creepage distances [IEC 60664-1:1992, 1.3.12.2]

3.42

material group

materials are separated into four groups by their comparative tracking index (CTI) values, as follows:

Material group I	600 ≤ CTI
Material group II	400 ≤ CTI < 600
Material group IIIa	175 ≤ CTI < 400
Material group IIIb	100 ≤ CTI < 175

The CTI values above refer to values in accordance with IEC 60112.

NOTE For inorganic insulating materials, e.g. glass or ceramics, which do not track, creepage distances need not be greater than their associated clearance for the purpose of insulation co-ordination.

3.43

temperature rise

the difference between the temperature of a part of a welding power source and that of the ambient air

3.44

thermal equilibrium

the state reached when the observed temperature rise of any part of the welding power source does not exceed 2 K/h

3.45

thermal protection

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

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

3.46

environments with increased hazard of electric shock

environments where the hazard of electric shock by arc welding is increased in relation to normal arc welding conditions

NOTE 1 Such environments are found for example:

- in locations in which freedom of movement is restricted, so that the operator is forced to perform the welding in a cramped (e.g. kneeling, sitting, lying) position with physical contact with conductive parts;
- in locations which are fully or partially limited by conductive elements, and in which there is a high risk of unavoidable or accidental contact by the operator;
- 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.

NOTE 2 Environments with increased hazard of electric shock are not meant to include places where electrically conductive parts in the near vicinity of the operator which can cause the increased hazard have been insulated.

3.47**hazard reducing device**

a device designed to reduce the hazard of electric shock that may originate from the no-load voltage

3.48**voltage reducing device**

a hazard reducing device designed to reduce the no-load voltage automatically when welding is not being performed

3.49**a.c. to d.c. switching device**

a hazard reducing device designed to switch automatically from a.c. to d.c. when welding is not being performed and which restores the a.c. during welding

3.50**protection class I equipment**

equipment with basic insulation between live parts and exposed conductive parts with bonding of exposed conductive parts to a means for connection of an external protective conductor

NOTE 1 Protection class I equipment may have parts with double or reinforced insulation.

NOTE 2 Protection classes I and II should not be confused with the classification of welding processes, used in some countries.

3.51**protection class II equipment**

equipment in which the protection against indirect contact does not rely on basic insulation only, but in which additional dispositions are provided to avoid a fault between live parts and the accessible surface

NOTE Protection classes I and II should not be confused with the classification of welding processes, used in some countries.

3.52**basic insulation**

insulation of live parts, the failure of which causes a risk of electric shock

3.53**supplementary insulation**

independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation

3.54**double insulation**

insulation comprising both basic insulation and supplementary insulation

3.55**reinforced insulation**

single insulation of live parts, which is intended to provide protection against electric shock not less than that provided by double insulation

NOTE It is not implied that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

3.56

plasma cutting system

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

[IEC 60974-7, 3.21]

3.57

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 A plasma cutting power source may also supply services to other equipment and auxiliaries, for example auxiliary power, cooling liquid and gas.

NOTE 2 In the following text, the term "cutting power source" is used.

[IEC 60974-7, 3.22]

3.58

SELV

voltage which does not exceed 50 V a.c. or 120 V ripple free d.c. 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 Maximum voltage lower than 50 V a.c. or 120 V ripple free d.c. may be specified in particular requirements, especially when direct contact with live parts is allowed.

NOTE 2 The voltage limit should not be exceeded at any load between full load and no-load when the source is a **safety isolating transformer**.

NOTE 3 "Ripple-free" is conventionally an r.m.s. ripple voltage not more than 10 % of the d.c. component; the maximum peak value does not exceed 140 V for a nominal 120 V ripple-free d.c. system and 70 V for a nominal 60 V ripple-free d.c. system.

[IEC 61558-1, 3.7.16]

3.59

plasma tip

component that provides the constricting orifice through which the plasma arc passes

[IEC 60974-7, 3.19]

4 Environmental conditions

Welding power sources shall be capable of delivering their rated output when the following environmental conditions prevail:

a) range of the temperature of the ambient air:

during welding: -10 °C to +40 °C;

after transport and storage at: -25 °C to +55 °C;

b) relative humidity of the air:

up to 50 % at 40 °C;

up to 90 % at 20 °C;

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

- d) altitude above sea level up to 1 000 m;
- e) base of the welding power source inclined up to 15°.

NOTE Different environmental conditions may be agreed upon between the manufacturer and the purchaser and the resulting welding power source so marked (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 fungus.

5 Test conditions

The tests shall be carried out on new, dry and completely assembled welding power sources at an ambient air temperature between 10 °C and 40 °C. 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.

Liquid-cooled welding power sources shall be tested with liquid conditions as specified by the manufacturer.

The accuracy of measuring instruments shall be:

- a) electrical measuring instruments: class 0,5 ($\pm 0,5$ % of full-scale reading, see IEC 60051-2), except for the measurement of insulation resistance and dielectric strength where the accuracy of the instruments is not specified, but shall be taken into account for the measurement;
- b) thermometer: ± 2 K;
- c) tachometer: ± 1 % of full-scale reading.

Unless otherwise specified, the tests required in this standard are type tests.

The sequence for some of the type tests is specified in 5.1.

The routine tests are specified in 5.2.

Conformity with other standards referred to shall be checked in accordance with those standards, unless the manufacturer presents proof that components forming part of the welding power source conform to those standards (by test certificates, conformity marks etc.).

5.1 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 i), j) and k):

- a) general visual inspection, see 3.7;
- b) insulation resistance, see 6.1.3 (preliminary check);
- c) thermal requirements, see clause 7;
- d) thermal protection, see clause 9;
- e) enclosure, see 14.1;
- f) impact resistance, see 14.2;
- g) handling means, see 14.3;
- h) drop withstand see 14.4;
- i) protection provided by the enclosure, see 6.2.1;
- j) insulation resistance, see 6.1.3;
- k) dielectric strength, see 6.1.4;
- l) general visual inspection, see 3.7.

The other tests included in this standard and not listed here may be carried out in any convenient sequence.

5.2 Routine tests

All routine tests shall be carried out on each welding power source in the following sequence:

- a) general visual inspection, see 3.7;
- b) continuity of the protective circuit, see 10.4.2;
- c) dielectric strength, see 6.1.4;
- d) rated no-load voltage, see 11.1;
- e) rated minimum and maximum welding current, see 15.3 b) and 15.3 c);
- f) general visual inspection, see 3.7.

6 Protection against electric shock

6.1 Insulation

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.

NOTE Pollution degree 4 may be agreed between the manufacturer and the purchaser.

Components or subassemblies (e.g. printed board assemblies) with clearances or creepage distances corresponding to pollution degree 2 are permitted, if they are completely enclosed, coated or encapsulated in accordance with IEC 60664-1 and IEC 60664-3.

Equipment designed with clearances based on line to neutral voltage values shall be provided with a caution that such equipment shall only be used on a supply system that is either a three-phase, four-wire system with an earthed neutral or a single-phase, three-wire, system with an earthed neutral.

6.1.1 Clearances

For basic insulation or supplementary and reinforced insulation, minimum clearances shall be in accordance with IEC 60664-1, as partially summarized in table 1 for overvoltage category III.

Table 1 – Minimum clearances for overvoltage category III

Voltage ¹⁾	Basic or supplementary insulation					Reinforced insulation					
	Rated impulse test voltage	AC test voltage	Pollution degree			Rated impulse test voltage	AC test voltage	Pollution degree			
			2	3	4			2	3	4	
			Clearance					Clearance			
V r.m.s.	peak V	V r.m.s.	mm			peak V	V r.m.s.	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 taken from tables 1 and 2 of IEC 60664-1.											
NOTE 2 For other pollution degrees and overvoltage categories, see IEC 60664-1.											
¹⁾ See annex A.											

For the purpose of dimensioning clearances 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 input supply terminals see E.2.

Clearances between parts of the welding power source (e.g. electronic circuits or components) which are protected by an overvoltage limiting device (e.g. metal oxide varistor) may 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, e.g. 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 4.2 of IEC 60664-1 or where this is not possible, by submitting the welding power source to an impulse test using the voltages given in table 1.

For the impulse test, a minimum of three impulses of each polarity at the voltage given in table 1 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 a.c. test voltage as given in table 1 may be applied for three cycles or a ripple free d.c. voltage, the value of which is equal to the impulse voltage, may be applied three times for 10 ms, for each polarity.

6.1.2 Creepage distances

For basic insulation or supplementary and reinforced insulation, minimum creepage distances shall be in accordance with IEC 60664-1, as partially summarized in table 2.

For the purpose of dimensioning creepage distances to accessible surfaces of insulation material, 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 input supply terminals see E.2.

Creepage distances between parts of the welding power source (e.g. electronic circuits or components) which are protected by an overvoltage limiting device (e.g. metal oxide varistor) may be rated in accordance with installation category I (see IEC 60664-1).

The values of table 2 shall also be applicable to the welding circuit within the welding power source and to control circuits when separated from the supply circuit by, e.g., 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 4.2 of IEC 60664-1.

Table 2 – Minimum creepage distances

Voltage ¹⁾	Basic or supplementary insulation									Reinforced insulation								
	Pollution degree									Pollution degree								
	2			3			4			2			3			4		
	Material group			Material group			Material group			Material group			Material group			Material group		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
V r.m.s.	Creepage distance mm			Creepage distance mm			Creepage distance mm			Creepage distance mm			Creepage distance mm			Creepage distance mm		
10	0,4			1			1,6			0,48			1,2			1,6		
12,5	0,42			1,05						0,5			1,25			1,7		
16	0,45			1,1						0,53			1,3			1,8		
20	0,48			1,2						0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
25	0,5			1,25			1,7			0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
32	0,53			1,3			1,8			0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
40	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
50	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
63	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
80	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5
100	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8	1	1,4	2	2,5	2,8	3,2	4	5	6,3
125	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
160	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5	1,6	2,2	3,2	4	4,5	5	6,3	8	10
200	1	1,4	2	2,5	2,8	3,2	4	5	6,3	2	2,8	4	5	5,6	6,3	8	10	12,5
250	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8	2,5	3,6	5	6,3	7,1	8	10	12,5	16
320	1,6	2,2	3,2	4	4,5	5	6,3	8	10	3,2	4,5	6,3	8	9	10	12,5	16	20
400	2	2,8	4	5	5,6	6,3	8	10	12,5	4	5,6	8	10	11	12,5	16	20	25
500	2,5	3,6	5	6,3	7,1	8	10	12,5	16	5	7,1	10	12,5	14	16	20	25	32
630	3,2	4,5	6,3	8	9	10	12,5	16	20	6,3	9	12,5	16	18	20	25	32	40
800	4	5,6	8	10	11	12,5	16	20	25	8	11	16	20	22	25	32	40	50
1 000	5	7,1	10	12,5	14	16	20	25	32	10	14	20	25	28	32	40	50	63

This voltage is the working voltage, when equipment is supplied at its rated voltage supply.

This voltage is the working voltage, when equipment is supplied at its rated voltage supply.

6.1.3 Insulation resistance

The insulation resistance shall be not less than the values given in table 3:

Table 3 – Insulation resistance

Input circuit (including control circuits connected to it)	to	welding circuit (including control circuits connected to it)	5 MΩ
Control circuits and exposed conductive parts	to	all circuits	2,5 MΩ

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 without interference suppression or protection capacitors (see 6.3.1) by application of a d.c. voltage of 500 V at room temperature.

Solid-state electronic components and their protective devices may be short-circuited during the measurement.

6.1.4 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 4;
- repetition of the test of the same welding power source: test voltage 80 % of the values given in table 4.

NOTE For the operator's safety, the lowest setting of overload setting (10 mA) is recommended.

Table 4 – Dielectric test voltages

Maximum rated voltage ¹⁾ V r.m.s.	AC dielectric test voltage V r.m.s.			
	All circuits to exposed conductive parts, input circuit to all circuits except the welding circuit		All circuits except input circuit to welding circuit	Input circuit to welding circuit
All circuits	Protection class I	Protection class II		
up to 50	250	500	500	–
200	1 000	2 000	1 000	2 000
450	1 875	3 750	1 875	3 750
700	2 500	5 000	2 500	5 000
1 000	2 750	5 500	–	5 500
NOTE 1 The maximum rated voltage is valid for earthed and unearthed systems.				
NOTE 2 In this standard the dielectric strength test of control circuits is limited to any circuit that enters or exits the enclosure apart from the input circuit and the welding circuit.				
¹⁾ For intermediate values, except between 200 V and 450 V, interpolation of the test voltages is allowed.				

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

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

NOTE For the operator's safety, the lowest setting of overload setting (10 mA) is recommended.

Alternative test: A d.c. test voltage of 1,4 times the r.m.s. test voltage may be used.

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

- a) The components are designed and tested to relevant standards that specify a voltage lower than the test voltage level of this standard. Example: fan motors and pump motors.

The components are completely incorporated within either the input circuit and exposed conductive parts or the output circuit and exposed conductive parts and their disconnection does not stop a portion of that circuit from being tested.

- b) Components completely incorporated within either the input or the output circuits may be short-circuited or disconnected during the dielectric strength test, provided that their disconnection does not stop a portion of that circuit from being tested. Example: electronic circuits.

- c) Interference suppression networks or protection capacitors between the input or welding circuit and any exposed conductive part may be disconnected during the test if they conform to their 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.

The test voltage may be raised to the full value slowly at the discretion of the manufacturer.

The test voltages between the input circuit, the exposed conductive parts and the welding circuit may be applied simultaneously. An example is given in Annex B.

Welding power sources incorporating a rectifier shall be tested after assembly of the complete welding power source, with the power rectifier remaining properly connected to the output circuit of the transformer or alternator. Rectifiers, their protective devices and other solid-state electronic components or capacitors, may be short-circuited during the test.

Mechanically powered welding power sources shall undergo the same test.

NOTE If this requirement is applied to the testing of properly cleaned, used welding power sources (for example after maintenance or repair without provision of new windings), their insulation should withstand 30 % of the values given in Table 4 or not less than 1 500 V a.c. r.m.s. between input and output circuit.

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

The minimum degree of protection for welding power sources shall be IP21S for indoor use as specified in IEC 60529.

Welding power sources specifically designed for outdoor use shall have a minimum degree of protection of IP23.

Welding output connections shall be protected as specified in 11.4.

Conformity shall be checked in accordance with IEC 60529.

The degree of water protection is reached if, immediately after this test, the insulation resistance and the dielectric strength are verified.

6.2.2 Capacitors

A capacitor provided as part of a welding power source and connected either across input supply lines or across a winding of a transformer providing welding current shall:

- a) not cause the welding power source to exhibit hazardous electrical breakdown or present risk of fire in event of a failure;
- b) not contain more than 1 l of flammable liquid;
- c) be designed not to leak during normal service;
- d) be contained within the welding power source enclosure or other enclosure which conforms to the relevant requirements of this standard.

Conformity shall be checked by visual inspection and by the following test.

The welding power source is operated at no-load at its rated input voltage and with an input 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:

- a) any fuse or overcurrent device in the welding power source has operated; or
- b) the input supply fuse or circuit-breaker has cleared; or
- c) the input 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 clause 8.

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

For interference suppression capacitors or capacitors having internal fusing or circuit interrupters, this test is not required.

6.2.3 Automatic discharge of input 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. 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 and the voltages are measured with instruments that do not significantly affect the values being measured.

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

Welding power sources shall be built to protection class I or II in accordance with IEC 60536 with the exception of the welding circuit.

Conformity shall be checked by visual inspection.

6.3.1 Isolation of the input circuit and the welding circuit

The welding circuit shall be electrically isolated from the input circuit and from all other circuits having a voltage higher than the allowable no-load voltage in accordance with 11.1 (e.g. 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. The leakage current between the welding outlets and the protective conductor terminal shall not exceed 10 mA a.c. r.m.s.

Conformity shall be checked by visual inspection and measurement of the leakage current with a circuit as shown in figure 1 at the rated supply voltage and no-load condition.

The measuring circuit shall have a total resistance of $(1\,750 \pm 250) \, \Omega$ and be shunted by a capacitor so that the time constant of the circuit will be $(225 \pm 15) \, \mu\text{s}$.

In the case of $1\,750 \, \Omega$, the capacitor will be 130 nF.

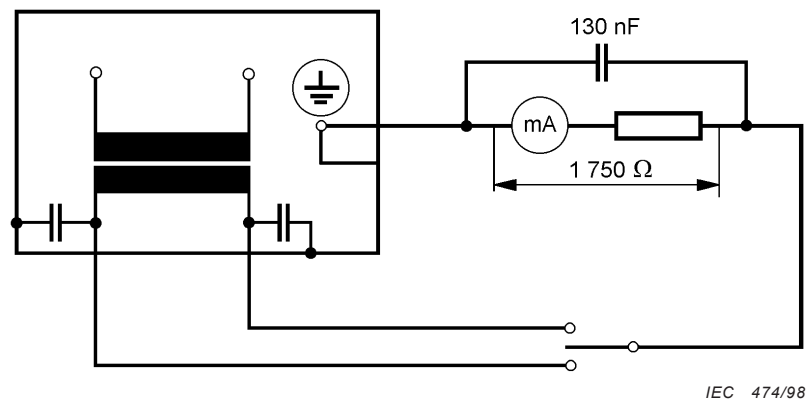


Figure 1 – Measurement of leakage current

6.3.2 Insulation between windings of the input circuit and the welding circuit

Windings of the input circuit and the welding circuit shall be insulated by:

- a) reinforced insulation; or
- b) basic insulation to a metal screen between them which is connected to the protective conductor.

Between the windings of the input and the welding circuit there shall be insulating material which conforms to the values given in table 5. Alternatively, there may be other means that have been shown to give the same safety level (see IEC 61558).

Table 5 – Minimum distance through insulation

Rated supply voltage V r.m.s.	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 5.

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 input 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 welding circuit and the protective conductor, enclosure, frame or core.

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 6.1.1 and 6.3.2).

Conformity shall be checked by visual inspection and by measurement.

6.3.4 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. Frequency of inspection shall be specified in the instruction manual.

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.

6.3.5 Additional requirements for plasma cutting systems

Plasma tips, which for technical reasons cannot be protected against direct contact, shall be considered sufficiently protected from normal and single fault conditions if the following requirements are fulfilled:

- a) when no arc current is present:

if the voltage between the plasma tip and the workpiece and/or earth is no higher than the peak value of 68 V or 48 V r.m.s; and

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

the sides of the plasma tip cannot be touched by the test finger according to IEC 60529 when it is placed on a flat surface with its centre line perpendicular to it; or

the d.c. voltage between the plasma tip and the workpiece and/or earth is not higher than 113 V peak when the plasma tip is placed at the distance recommended by the manufacturer during cutting and gouging, from a flat surface with the centreline perpendicular to the surface; or

- c) when the voltage of a) or b) is exceeded:

the voltages are reduced as specified in Clause 13.

NOTE An example of a 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 duty cycle (duty factor), excessive current or incorrect gas flow.

7 Thermal requirements

The thermal requirements for welding power sources shall be:

- a) for windings, in accordance with 7.3.1;
- b) for external surfaces, in accordance with 7.3.2;
- c) for the welding power source, in accordance with 7.4;
- d) for commutator and slip-rings, in accordance with 7.5;
- e) for the materials of other parts, in accordance with the maximum individual temperature rise during the heating test in accordance with 7.1, taking into account the maximum ambient air temperature of 40 °C by adding the difference between 40 °C and the ambient air temperature (see 7.2.4).

7.1 Heating test

The welding power source is operated 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 (duty factor) as appropriate;
- b) with the rated maximum welding current (I_{2max}) at the corresponding duty cycle (duty factor).

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 a.c. 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.

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

NOTE 2 The tests if relevant may follow each other without having the welding power source returned to the ambient air temperature.

7.1.1 Tolerances of the test parameters

During the last 60 min of the heating test in accordance with 7.1.2, 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.

7.1.2 Duration of the heating 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

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 resistance measurement is 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.

7.2.1 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 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 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.

7.2.2 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.

7.2.3 Embedded temperature sensor

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

When measuring winding and coil temperatures, the thermocouples are applied directly to the conductors and separated from the metallic circuit only by any integrally applied insulation on the conductors themselves.

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

7.2.4 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, the measuring devices are 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.

7.2.5 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 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 a rotating 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 6, regardless of the method of temperature measurement used, except that the resistance measurement or an embedded temperature sensor shall be used for coils and windings wherever possible.