UL 60974-1

STANDARD FOR SAFETY

Arc Welding Equipment; Part 1: Welding Power Sources

UL Standard for Safety for Arc Welding Equipment; Part 1: Welding Power Sources, UL 60974-1

First Edition, Dated March 17, 2005

Summary of Topics

Revision pages have been issued to delete the ANSI approval information from the title page.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

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Standard for Arc Welding Equipment; Part 1: Welding Power Sources

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Preface (UL)

This UL Standard is based on IEC Publication 60974-1: Second edition – Arc Welding Equipment; Part 1: Welding Power Sources, as revised by Amendment 1. IEC publication 60974-1 is copyrighted by the IEC.

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Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

NATIONAL DIFFERENCES

GENERAL

National Differences from the text of International Electrotechnical Commission (IEC) Publication 60974-1, Arc Welding Equipment; Part 1: Welding Power Sources copyright 1998 as amended in 2000, are indicated by notations (differences) and are presented in bold text.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are national differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ARC WELDING EQUIPMENT – Part 1: Welding power sources

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60974-1 has been prepared by IEC technical committee 26: Electric welding, and by ISO technical committee 44: Welding and allied processes.

This second edition cancels and replaces the first edition published in 1989 and constitutes a technical revision.

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

FDIS	Report on voting
26/153/FDIS	26/156/RVD

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

This amendment has been prepared by IEC technical committee 26: Electric welding.

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

FDIS	Report on voting
26/181/FDIS	26/197/RVD

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

The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2004. At this date, the publication will be:

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

Annexes C, E, I and J form an integral part of this standard.

Annexes A, B, D, F, G, H and K are for information only.

DV.1 DE *Addition:*

Words in SMALL ROMAN CAPITALS in the text are defined in clause 3.

DV.2 DE *Addition:*

The numbering system in the standard uses a space instead of a comma to indicate thousands and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means 1,000 and 1,01 means 1.01.

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

2DV.1 D2 *Modification of 2 by deleting the following text:*

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

2DV.2 D2 *Modification of 2 by adding the following text:*

IEC 62114
Electrical Insulation Systems (EIS) – Thermal Classification

UL 62
Flexible Cord and Fixture Wire

UL 94
Test for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 486B
Wire Connectors for Use With Aluminum Conductors

UL 489
Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL 498
Attachment Plugs and Receptacles

UL 551
Transformer-Type Arc-Welding Machines

UL 558
Industrial Trucks, Internal Combustion Engine-Powered

UL 969
Marking and Labeling Systems

UL 1059
Terminal Blocks

UL 1248
Engine-Generator Assemblies for Use in Recreational Vehicles

UL 1659
Attachment Plug Blades for Use in Cord Sets and Power-Supply Cords

UL 1682
Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type

UL 2200
Stationary Engine Generator Assemblies

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 manufacturer 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_{2max}): 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_{2min}): 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_{1max}): The maximum value of the RATED SUPPLY CURRENT.

3.33 MAXIMUM EFFECTIVE SUPPLY CURRENT (I_{1eff}): 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:

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

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 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 purpose of this standard, the time period of one complete cycle is 10 min. For example, in the case of a 60% duty cycle (duty factor), 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

a) 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;

b) in locations which are fully or partially limited by conductive elements, and in which there is a high risk or 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.

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.

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.

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 isolation 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.

3.59 PLASMA TIP: Component that provides the constricting orifice through which the plasma arc passes.

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 (±0,5% of full-scale reading, see IEC 60051-2), except for the measurement of insulation resistance and dielectric strength were 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 8.7;

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.

5.1DV D2 *Modification by replacing the third paragraph in 5.1 with the following:*

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

a) GENERAL VISUAL INSPECTION, see 3.7;

b) insulation resistance, see 6.1.3 (preliminary check);

c) thermal requirements, see clause 7;

d) dielectric strength, see 6.1.4;

e) THERMAL PROTECTION, see clause 9;

f) enclosure, see 14.1;

g) impact resistance, see 14.2;

h) handling means, see 14.3;

i) drop withstand, see 14.4;

j) protection provided by the enclosure, see 6.2.1;

k) insulation resistance, see 6.1.3;

l) dielectric strength, see 6.1.4;

m) GENERAL VISUAL INSPECTION, see 3.7.

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 2	POLLUTION DEGREE 3	POLLUTION DEGREE 4	Rated impulse test voltage	AC test voltage	POLLUTION DEGREE 2	POLLUTION DEGREE 3	POLLUTION DEGREE 4
V r.m.s.	peak V	V r.m.s.	CLEARANCE mm			peak V	V r.m.s.	CLEARANCE 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 µs 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								
	POLLUTION DEGREE								
	2			3			4		
	MATERIAL GROUP			MATERIAL GROUP			MATERIAL GROUP		
	I	II	III	I	II	III	I	II	III
V r.m.s.	CREEPAGE DISTANCE mm			CREEPAGE DISTANCE mm			CREEPAGE DISTANCE mm		
10	0,4			1					
12,5	0,42			1,05			1,6		
16	0,45			1,1					
20	0,48			1,2					
25	0,5			1,25			1,7		
32	0,53			1,3			1,8		
40	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
50	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
63	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
80	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
100	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
125	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
160	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5
200	1	1,4	2	2,5	2,8	3,2	4	5	6,3
250	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
320	1,6	2,2	3,2	4	4,5	5	6,3	8	10
400	2	2,8	4	5	5,6	6,3	8	10	12,5
500	2,5	3,6	5	6,3	7,1	8	10	12,5	16
630	3,2	4,5	6,3	8	9	10	12,5	16	20
800	4	5,6	8	10	11	12,5	16	20	25
1 000	5	7,1	10	12,5	14	16	20	25	32
10	0,48			1,2			1,6		
12,5	0,5			1,25			1,7		
16	0,53			1,3			1,8		
20	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
25	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
32	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
40	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
50	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
63	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
80	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5
100	1	1,4	2	2,5	2,8	3,2	4	5	6,3
125	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
160	1,6	2,2	3,2	4	4,5	5	6,3	8	10
200	2	2,8	4	5	5,6	6,3	8	10	12,5
250	2,5	3,6	5	6,3	7,1	8	10	12,5	16
320	3,2	4,5	6,3	8	9	10	12,5	16	20
400	4	5,6	8	10	11	12,5	16	20	25
500	5	7,1	10	12,5	14	16	20	25	32
630	6,3	9	12,5	16	18	20	25	32	40
800	8	11	16	20	22	25	32	40	50
1 000	10	14	20	25	28	32	40	50	63
Values are taken from table 4 of IEC 60664-1.									

Table 2 – Minimum CREEPAGE DISTANCES Continued on Next Page

Table 2 – Minimum CREEPAGE DISTANCES Continued

Voltage[1)]	BASIC OR SUPPLEMENTARY INSULATION								
	POLLUTION DEGREE								
	2			3			4		
	MATERIAL GROUP			MATERIAL GROUP			MATERIAL GROUP		
	I	II	III	I	II	III	I	II	III
V r.m.s.	CREEPAGE DISTANCE mm			CREEPAGE DISTANCE mm			CREEPAGE DISTANCE mm		

[1)]See annex A.

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 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:

a) first test of a welding power source: test voltages given in table 4;

b) repetition of the test of the same welding power source: test voltage 80% of the values given in table 4.

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.

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

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.

Components, for which the relevant standard specifies a voltage level lower than the test voltage level of this standard may be protected by short-circuiting.

Components incorporated wholly 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 isolate a portion of that circuit from being tested.

Components between input and output circuits or between these circuits and exposed conductive parts shall not be disconnected.

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

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.

NOTE – If this requirement is applied to the testing of properly cleaned, used welding power sources (e.g. 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.

Additionally live parts of the input circuits shall be protected to IP2XC.

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 not 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.

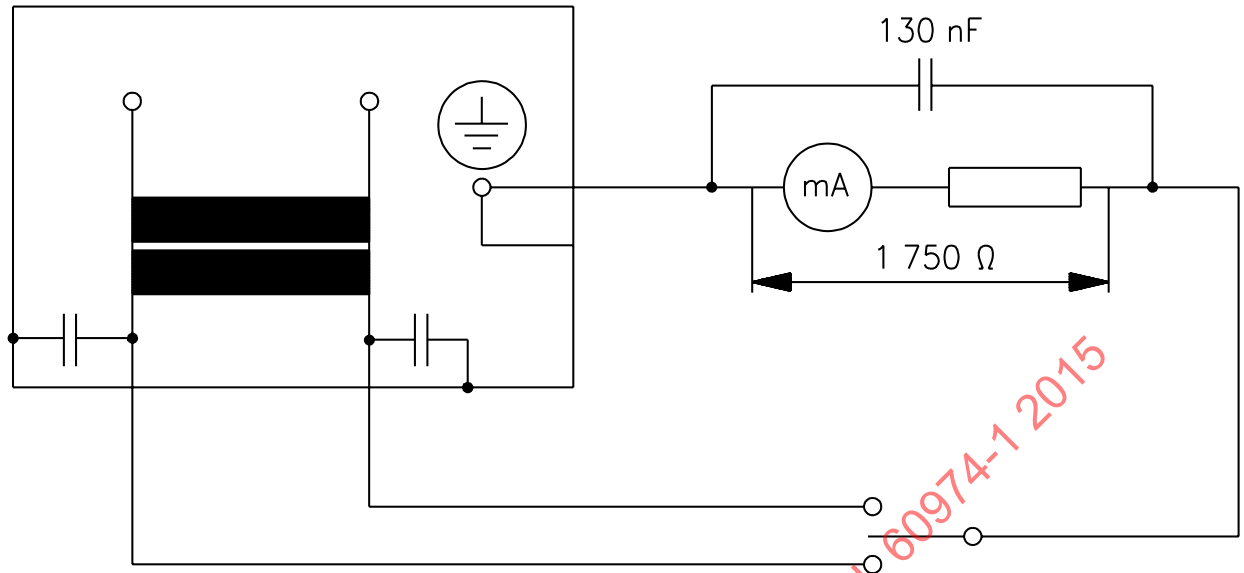
The measuring circuit shall have a total resistance of (1 750 ± 250) Ω and be shunted by a capacitor so that the time constant of the circuit will be (225 ± 15) µs.

In the case of 1 750 Ω, the capacitor will be 130 nF.

6.3.1DV DC *Modification of 6.3.1 by adding the following text:*

Insulation classes above Class 105 shall be evaluated with respect to the requirements in the Standard for Electrical Insulation Systems (EIS) – Thermal Classification, IEC 62114.

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.

6.3.2DV DC *Modification of 6.3.2 by adding the following text:*

Insulation classes above Class 105 shall be evaluated with respect to the requirements in the Standard for Electrical Insulation Systems (EIS) – Thermal Classification, IEC 62114.

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, that for technical reasons cannot be protected against direct contact, shall be considered to be sufficiently protected under a 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 under any circumstances higher than the limits of SELV and

b) when an arc current is present: the d.c. voltage between the PLASMA TIP and the workpiece and/or earth is not under any circumstances higher than 113 V peak or

c) when the voltages of a) or b) above are 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 load or incorrect gas flow.

Conformity shall be checked

for a) and b): by measurement in accordance with 11.1, together with the corresponding PLASMA CUTTING POWER SOURCE and

for c): by simulating a torch fault and by measuring the response time.

6.3.5DV D1 *Modification by replacing 6.3.5 with the following:*

Plasma tips, which can not be protected against direct contact, shall be considered sufficiently protected under normal and single fault conditions when the following circumstances occur:

a) When the voltage between the plasma tip and the workpiece and/or earth is not higher than SELV with no arc current present; and

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

1) In accordance with IEC 60529, the sides of the plasma tip shall not be in contact with the test finger when it is placed on a flat surface with its center line perpendicular to it; or

2) The d.c. voltage between the plasma tip and the workpiece and/or earth shall not be higher than SELV when the plasma tip is placed at the distance recommended by the manufacturer during the cutting and gouging, from a flat surface with the centerline perpendicular to the surface.

When the voltages of (a) or (b)(2) are exceeded, the voltages shall be reduced as specified in Section 13.

NOTE – An example of a fault is an abnormal condition resulting from the electrode being in contact with the plasma tip. A fault can occur due to missing insulators, the plasma tip sticking to the electrode, conductive material between the 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).

7DV D2 *Modification of 7 by adding the following item:*

f) for fuel systems and engine compartment components, in accordance with 19.1.1 of the Standard for Industrial Trucks, Internal Combustion Engine-Powered, UL 558.

7.1 Heating test

The welding power source is operated with constant current at a cycle time of (10 ± 0,2) min

a) with the rated WELDING CURRENT (I_2) at (60 and/or 100) % DUTY CYCLE (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: (+10/-2) % of the appropriate CONVENTIONAL LOAD VOLTAGE;

b) WELDING CURRENT: (+10/-2) % of the appropriate CONVENTIONAL WELDING CURRENT;

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

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 aluminum, 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.

Table 6 – Limits of TEMPERATURE RISE for windings, commutators and slip-rings

Class of insulation	Peak temperature in accordance with IEC 60905	Limits of TEMPERATURE RISE K			
		Windings			
°C	°C	Surface temperature sensor	Resistance	Embedded temperature sensor	Commutators and slip-rings
105(A)	140	55	60	65	60
120(E)	155	70	75	80	70
130(B)	165	75	80	90	80
155(F)	190	95	105	115	90
180(H)	220	115	125	140	100
200	235	130	145	160	Not determined
220(C)	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 6 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 6.

Further, for tests at other than 100% DUTY CYCLE (DUTY FACTOR), the peak temperature occurring during any full cycle shall not exceed the temperatures given in table 6.

Conformity shall be checked by measurement in accordance with 7.2.

7.3.1DV D2 *Modification to Note 3 in Table 6:*

Replace ″IEC 60085″ with ″IEC 62114.″

7.3.2 **External surfaces**

The TEMPERATURE RISE for external surfaces shall not exceed the values given in table 7.

Table 7 – Limits of TEMPERATURE RISE for external surfaces

External surface	Limits of TEMPERATURE RISE K
Bare metal enclosures	25
Painted metal enclosures	35
Non-metallic enclosures	45
Metal handles	10
Non-metallic handles	30

Engine parts such as exhaust parts, silencers, spark arrestors or cylinder heads are allowed to exceed these temperatures provided they are located or guarded to prevent unintentional contact during normal operation.

Conformity shall be checked by measurement in accordance with 7.2.

7.4 Loading test

Welding power sources shall withstand repeated load cycles without damage or functional failure.

Conformity shall be checked by the following tests and by establishing that no damage or functional failure to the welding power source occurs during the tests.

Starting from the cold state, the welding power is loaded at the RATED MAXIMUM WELDING CURRENT until one of the following occurs

a) the THERMAL PROTECTION is actuated;

b) the temperature limits of the windings are reached;

c) a 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, each short circuit 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 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.

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 rotating 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 Abnormal operation

A welding power source shall not suffer hazardous electrical breakdown or cause a risk of fire under the conditions of operation of 8.1 to 8.3. 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 other welding power sources.

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

Conformity shall be checked by the following tests.

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

b) Starting from the cold state, the welding power source is operated in accordance with 8.1 to 8.3.

c) During the test, the welding power source shall not emit flames, molten metal or other materials that ignite the cotton indicator.

d) Following the test and within 5 min, the welding power source shall be capable of withstanding a dielectric test in accordance with 6.1.4 b).

8.1 Stalled fan

A welding power source, which relies on a motor-driven fan 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 is stalled at the output condition of 7.1, which produces the maximum heating.

8.2 Short circuit

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 8.

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 input supply is protected by external fuses or a circuit-breaker with the RATING and type as specified by the manufacturer.

Table 8 – Cross-section of the output short-circuit conductor

RATED MAXIMUM WELDING CURRENT A	Minimum cross-section[1)] mm²
Up to 199	25
200 to 299	35
300 to 499	50
500 and above	70
[1)]For American wire gauge see annex F.	

The welding power source, shall not clear the supply fuse or circuit breaker when short circuited

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

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

The short circuit is then applied for 2 min or until the input protection operates.

The input 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.

8.3 Overload

The welding power source is operated for 4 h in accordance with 7.1 b) at 1,5 times the corresponding DUTY CYCLE (DUTY FACTOR).

If the welding power source is rated for more than 67% DUTY CYCLE, this test is conducted at 100% DUTY CYCLE (DUTY FACTOR).

If the welding power source is provided with output regulating taps, those taps producing the highest supply current are used.

If the DUTY CYCLE (DUTY FACTOR) at the RATED MAXIMUM WELDING CURRENT is 100%, the welding power source need not be tested.

9 THERMAL PROTECTION

A mains operated welding power source shall be fitted with THERMAL PROTECTION if the DUTY CYCLE (DUTY FACTOR) at RATED MAXIMUM WELDING CURRENT is lower than

a) 35% in case of a DROOPING CHARACTERISTIC or

b) 60% in case of a FLAT CHARACTERISTIC.

NOTE – The DROOPING CHARACTERISTIC is generally used for manual metal arc welding with covered electrodes and the tungsten inert-gas welding, while the FLAT CHARACTERISTIC is generally used for the metal inert/active-gas welding.

THERMAL PROTECTION added to other welding power sources at the option of the manufacturer shall also meet the requirements of 9 to 9.6.

Conformity shall be checked by visual inspection.

9.1 Construction

The THERMAL PROTECTION shall be so constructed that it is not possible to change its temperature setting or alter its operation without inflicting obvious physical damage to the device.

Conformity shall be checked by visual inspection.

9.2 Location

The THERMAL PROTECTION shall be permanently located within the welding power source in such a way that the heat transfer is reliable.

Conformity shall be checked by visual inspection.

9.3 Operation

a) The THERMAL PROTECTION shall prevent the welding power source windings from exceeding the peak temperature limits given in table 6.

b) 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 (DUTY FACTOR).

Conformity shall be checked during operation in accordance with 7.1 b), taking into account the maximum ambient air temperature of 40°C, without operation of the THERMAL PROTECTION. After that, the welding power source is overloaded to produce the increased temperature necessary for operation of the THERMAL PROTECTION.

9.4 Resetting

The THERMAL PROTECTION shall not reset automatically or manually until the temperature has dropped below that of the insulation class given in table 6.

Conformity shall be checked by operation and temperature measurement.

9.5 Operating capacity

The THERMAL PROTECTION shall be able to operate at the RATED MAXIMUM WELDING CURRENT consecutively without defect

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

b) 200 times, in case of a DUTY CYCLE (DUTY FACTOR) 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 9.3 and 9.4 shall be met.

9.6 Indication

Welding power sources fitted with THERMAL PROTECTION shall indicate that the thermal overload device 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 showing symbols or words whose meanings are given in the instruction manual.

NOTE – An additional white indicator may be used to show that the input supply to the welding power source is switched on.

Conformity shall be checked by visual inspection.

10 Connection to the input supply

10.1 Supply voltage

Welding power sources shall be capable of operating at the RATED SUPPLY VOLTAGE ±10%. This may give deviations from the RATED VALUES.

In the case of a mechanically driven, electrically powered welding power source, the motor torque shall be sufficient at 90% of the RATED SUPPLY VOLTAGE to supply the RATED MAXIMUM WELDING CURRENT.

In the case of a mechanically driven, engine powered rotating welding power source, the engine shall be capable of tolerating load variations between maximum load and no-load without adversely affecting the welding performance of the generator.

Conformity shall be checked by operation.

10.1DV DC *Modification of 10.1 by adding the following text:*

Fuel and exhaust systems for mechanically driven, engine powered rotating welding power sources shall be evaluated as follows:

a) Fuel systems shall be evaluated with respect to Clause 6 in the Standard for Engine-Generator Assemblies for Use in Recreational Vehicles, UL 1248.

b) Exhaust systems shall be evaluated to Clause 36 in the Standard for Stationary Engine Generator Assemblies, UL 2200.

10.2 Power supply

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 may 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 of welding power sources with several supply connections, the points of connection not provided with covers which are secured by the use of a tool are tested with a voltage tester, using all possible supply connections and switch positions. The requirements are met if no voltage or only a voltage below 12 V is measured between the points of connection not provided with covers and between these points and the enclosure.

In the case d), a selector switch is additionally tested in accordance with 10.7.

10.3 Means of connection

Acceptable means of connection 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.

Conformity shall be checked by visual inspection.

10.4 Input supply terminals

Terminals shall be provided for the connection of input conductors.

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

The terminals shall be chosen in accordance with the MAXIMUM EFFECTIVE SUPPLY CURRENT I_{1eff} 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.

10.4DV DC *Modification of 10.4 by adding the following text:*

Input supply terminals shall be evaluated with respect to the requirements in the Standard for Terminal Blocks, UL 1059 or the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B, as applicable.

10.4.1 Marking of terminals

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.

10.4.2 **Continuity of the protective circuit**

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

Welding power sources of protection class I 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.

The terminal for the external protective conductor shall be marked with the symbol ⏚ (60417-2-IEC-5019).

Optionally the following may be added:

a) the letters: **PE** or

b) the twin colours: **green and yellow**.

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 multiconductor 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 following tests.

NOTE – The method of securing conductive parts to the protective circuits, e.g. paint-piercing washers, paint-piercing screws or non-painted surfaces should be considered during visual inspection.

1) 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 9, using the smallest external protective conductor size in accordance with IEC 60204-1.

Table 9 – 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

During the test there shall be no melting of any metal, deterioration of the bond to the welding power source, or heating likely to cause a fire hazard, nor shall the measured voltage drop from the enclosure part to the terminal exceed 4 V.

2) ROUTINE TEST

The test is carried out in accordance with 20.2 of IEC 60204-1, except that the test time is 1 s.

10.4.2DV D2 *Modification of 10.4.2 by adding the following text:*

A wire connector or terminal intended solely for the connection of an equipment-grounding conductor shall be plainly marked, such as "G," "GR," "GND," "Ground," "Grounding," or the like, or by a wiring diagram provided on the product. The wire connector or terminal shall be located so that it is unlikely to be removed during normal servicing of the product.

10.5 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

a) it is dimensioned for flexible cables having the range of cross-sectional area of conductor as specified in table E.1;

b) the method of anchorage can be easily recognized;

c) the cable can be easily replaced;

d) 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;

e) the cable is not retained by a metal screw which bears directly on it;

f) at least one part of the cable anchorage is securely fixed to the welding power source.

g) any screws that need to be loosened or tightened during cable replacement do not serve to fix any other component;

h) when fitted to a welding power source of protection class II, it shall be made of insulating material or so insulated that, if there is an insulation fault, exposed conductive parts shall not 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 power supply. 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 10 without jerking.

Table 10 – Pull

Nominal cross-sectional area of the conductor mm^2	Pull N
1,5	150
2,5	220
4,0 and more	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 (e.g. 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.

10.6 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.

10.7 Input supply on/off switching device

Where an integral input supply on/off switching device (e.g. switch, contactor or circuit-breaker) is provided, this shall:

a) switch all ungrounded mains conductors, and

b) 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, it is permissible to use separate but duplicate switching devices.

A welding power source is connected for the RATED SUPPLY VOLTAGE that corresponds to the RATED MAXIMUM SUPPLY CURRENT and, in addition for protection class I, a fuse of 10 A to 20 A is placed

– in the case of an earthed input supply, in the protective earth connection;

– in the case of an unearthed input supply, between a supply line and the protective earth circuit.

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

a) Overload

The output of the welding power source is short-circuited in accordance with 8.2. 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.

A switching device need not be tested if its RATING exceeds twice the RATED MAXIMUM SUPPLY CURRENT.

b) Endurance

The output is connected to a CONVENTIONAL LOAD and adjusted to produce the rated WELDING CURRENT at 100% DUTY CYCLE (DUTY FACTOR). 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.

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 protection class I, no clearing of the fuse.

NOTE 1 – A component having demonstrated that it passes these tests can be used in other similar applications if the other requirements are equal or less.

NOTE 2 – Where the welding power source forms part of a larger electrical installation, on requirements for the parts outside the scope of this standard may be found in IEC 60204-1.

10.7DV DC *Modification of 10.7 by adding the following text:*

Circuit breakers shall be evaluated with respect to the requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489.

10.8 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_{1eff} 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, measurement by a true r.m.s. meter with a minimum crest factor of 3 and calculation.

NOTE – The measurement can be affected by the impedance of the input supply (see annex G).

10.8DV DC *Modification of 10.8 by adding the following text:*

Supply cables shall be evaluated with respect to the requirements in the Standard for Flexible Cord and Fixture Wire, UL 62.

10.9 Supply coupling device (attachment plug)

If a supply coupling device is provided as a part of the arc welding equipment, its current RATING shall be not less than a), b) and c) or a), b) and d) as follows:

a) the current RATING of the fuse required to comply with the tests specified in 8.2 regardless of whether or not an input supply switch is incorporated;

b) the MAXIMUM EFFECTIVE SUPPLY CURRENT I_{1eff};

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.

Further, it shall be suitable for hard usage (see IEC 60309-1).

Conformity shall be checked by visual inspection, measurement and calculation.

10.9DV DC *Modification of 10.9 by adding the following text:*

Attachment plugs shall be evaluated with respect to the requirements in the Standard for Attachment Plugs and Receptacles, UL 498, the Standard for Attachment Plug Blades for Use in Cord Sets and Power-Supply Cords, UL 1659, and the Standard for Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type, UL 1682.

11 Output

11.1 RATED NO-LOAD VOLTAGE (U_0)

The RATED NO-LOAD VOLTAGE at all possible settings shall not exceed the values given in 11.1.1 to 11.1.4, summarized in table 11.

Table 11 – Summary of allowable rated NO-LOAD VOLTAGES

Subclause	Working conditions	Rated NO-LOAD VOLTAGE
11.1.1	Environment with increased hazard of electric shock	d.c. 113 V peak a.c. 68 V peak and 48 V r.m.s.
11.1.2	Environment without increased hazard of electric shock	d.c. 113 V peak a.c. 113 V peak and 80 V r.m.s.
11.1.3	Mechanically held torches with increased protection for the operator	d.c. 141 V peak a.c. 141 V peak and 100 V r.m.s.
11.1.4	Plasma cutting	d.c. 500 V peak

Welding power sources, which are electronically controlled, shall be

a) designed to ensure that the output voltages given in table 11 cannot be exceeded should any fault occur in an electronic circuit 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.

If the NO-LOAD VOLTAGE is higher than these values, the welding power source shall be fitted with a HAZARD REDUCING DEVICE in accordance with clause 13.

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.

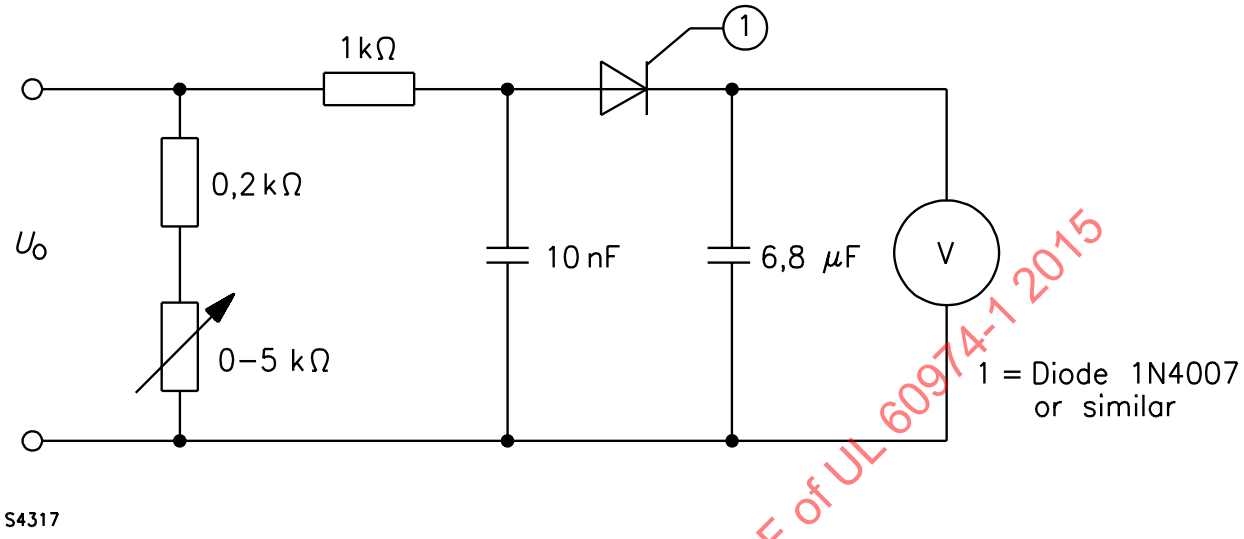
a) RMS values

A true r.m.s. meter is used with a resistance of the external WELDING CIRCUIT of 5 kΩ with a maximum tolerance of ±5%.

b) Peak values

To obtain reproducible measurements of peak values, omitting impulses which are not dangerous, a circuit is used as shown in figure 2.

Figure 2 – 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%.

During the measurement the potentiometer 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.

11.1.1 **RATED NO-LOAD VOLTAGE for use in ENVIRONMENTS WITH INCREASED HAZARD OF ELECTRIC SHOCK**

The RATED NO-LOAD VOLTAGE shall not exceed:

a) d.c. 113 V peak;

b) a.c. 68 V peak and 48 V r.m.s.

A rectifier type d.c. welding power source shall be so constructed that in case of a rectifier failure (e.g., open circuit, short circuit or a phase failure), the allowable values cannot be exceeded.

Such welding power sources may be marked with the symbol [S].

Conformity shall be checked by measurement in accordance with 11.1 and by simulation of a failure.

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

The RATED NO-LOAD VOLTAGE shall not exceed

a) d.c. 113 V peak;

b) a.c. 113 V peak and 80 V r.m.s.

Conformity shall be checked by measurement in accordance with 11.1.

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) d.c. 141 V peak;

b) a.c. 141 V peak and 100 V r.m.s.

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

a) the torch shall not be hand-held;

b) the NO-LOAD VOLTAGE shall be switched off automatically when the welding is stopped; and

c) 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, by operation and by visual inspection.

11.1.4 RATED NO-LOAD VOLTAGE **for special processes e.g. plasma cutting**

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

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

a) These power sources with their corresponding torches shall prevent the output of NO-LOAD VOLTAGE if the torch is disassembled or disconnected from the power source.

b) The NO-LOAD VOLTAGE shall be less than 68 V peak not later than 2 s after the CONTROL CIRCUIT (e.g. start switch) is opened.

c) The voltage between the tip of the torch and the work piece or earth shall not exceed 68 V peak when the arc current is interrupted, that is when both pilot and main arc are extinguished.

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

Such power sources may be marked with the symbol [S].

Conformity shall be checked by measurement in accordance with 11.1, by operation and by visual inspection, except that the series combination of the 200 Ω fixed and 5 kΩ variable resistors may be replaced by a fixed resistance of 5 kΩ.

11.2 TYPE TEST values of the CONVENTIONAL LOAD VOLTAGE

Throughout its range of adjustment, the welding power sources shall be capable of supplying CONVENTIONAL WELDING CURRENTS (I_2) at CONVENTIONAL LOAD VOLTAGES (U_2) in accordance with 11.2.1 to 11.2.4.

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

11.2.1 **Manual metal arc welding with covered electrodes**

DROOPING CHARACTERISTIC:	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 and plasma arc welding**

DROOPING CHARACTERISTIC:	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 selfshielded flux cored arc welding**

FLAT CHARACTERISTIC:	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**

DROOPING CHARACTERISTIC:	I_2 up to 300 A:	$U_2 = (80 + 0{,}4\ I_2)$ V
	I_2 over 300 A:	$U_2 = 200$ V.

11.2.6 **Plasma gouging**

DROOPING CHARACTERISTIC:	I_2 up to 300 A:	$U_2 = (100 + 0{,}4\ I_2)$ V
	I_2 over 300 A:	$U_2 = 200$ V.

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 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 input 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 may be used in other similar applications, if the other requirements are equal or less.

11.4 Output connections

11.4.1 Protection against unintentional contact

Welding output connections, with or without welding cables connected, shall be protected against unintentional contact by persons or by metal objects, e.g. vehicles, crane hooks, etc.

The following are examples of how such protection can be afforded:

a) any live part of a socket-outlet 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 socket outlets

Uncovered socket-outlets shall be located so that their openings are not tilted upwards.

NOTE – Socket outlets fitted with an automatic closing device may 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 openings 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 a.c. 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 the same as each other.

Conformity shall be checked by visual inspection.

11.4.5 **Marking**

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

For d.c. 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, there shall be present no voltage higher than the limits of SELV.

11.5 Power supply to external devices

When a welding power source provides means to supply electrical power to an external wire feed unit or similar auxiliary, 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 voltage RATING up to 120 V r.m.s. 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, e.g. by a current sensing relay or by insulation of the relevant metal parts, e.g. by an enclosure.

Conformity shall be checked by visual inspection and fault simulation.

11.6 Auxiliary power output

In the case of welding power sources designed to supply electrical power, e.g. for lighting or electric tools, these auxiliary circuits and accessories shall comply with the standards and regulations relating to the use of this equipment.

The WELDING CIRCUIT shall be electrically isolated and insulated from such supply circuits in accordance with 6.3.1 and 6.3.2.

Near the output terminal or outlets of such power the available current, voltage, DUTY CYCLE (DUTY FACTOR) if less than 100%, and frequency, number of phases or d.c. as appropriate shall be clearly and indelibly marked.

Conformity shall be checked by visual inspection during the tests in accordance with 6.1.3, 6.1.4, 6.3.1 and 6.3.2 and by rubbing the marking in accordance with clause 15.

12 CONTROL CIRCUITS

CONTROL CIRCUITS not connected electrically to the WELDING CIRCUIT shall comply with the relevant requirements of IEC 60204-1.

Connections between CONTROL CIRCUITS and the WELDING CIRCUIT are permitted in accordance with 6.3.1.

NOTE – If a CONTROL CIRCUIT, having its own power supply, is connected to the output circuit, it should be phased in the case of a.c., or polarity connected in the case of d.c., in such a way that the voltage between any external control lead and/or welding output does not exceed the voltages given in 11.1.

Conformity shall be checked during the test in accordance with 6.1.4.

13 HAZARD REDUCING DEVICE

A HAZARD REDUCING DEVICE shall reduce the electric shock hazard that can originate from NO-LOAD VOLTAGES exceeding the allowable RATED NO-LOAD VOLTAGES. Examples are given in 13.1 and 13.2.

If the unreduced NO-LOAD VOLTAGE falls between the allowable RATED NO-LOAD VOLTAGES, in accordance with 11.1.1 and 11.1.2, the HAZARD REDUCING DEVICE shall operate within 2 s.

If the values in accordance with 11.1.2 are exceeded, the HAZARD REDUCING DEVICE shall operate within 0,3 s.

Conformity shall be checked by measuring the time between interruption of the WELDING CURRENT and completed operation of the HAZARD REDUCING DEVICE.

13.1 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.

NOTE – It is recommended that the rated NO-LOAD VOLTAGE should be as low as practicable.

Conformity shall be checked by connecting a variable load resistor across the welding output connections of the welding power source. Voltage measurements are taken while the resistance is being increased.

13.2 Switching device for a.c. to d.c.

A switching device for a.c. to d.c. shall have automatically switched the rated a.c. NO-LOAD VOLTAGE to a rated d.c. NO-LOAD VOLTAGE not exceeding the values given in 11.1.1 to 11.1.3 at the moment the resistance of the external WELDING CIRCUIT exceeds 200 Ω.

Conformity shall be checked in accordance with 13.1.

13.3 Connection of a HAZARD REDUCING DEVICE

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

Conformity shall be checked by visual inspection.

13.4 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 13.1 with any of the devices that could interfere with the operation of the HAZARD REDUCING DEVICE.

13.5 Indication of satisfactory operation

A reliable device, e.g. 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 d.c.

Conformity shall be checked by visual inspection during the test in accordance with clause 13.

13.6 Fail to a safe condition

If the HAZARD REDUCING DEVICE fails to operate in accordance with clause 13 within 1 s, it should fail to a safe condition (e.g. switching to a reduced voltage condition).

Conformity shall be checked by measuring the time which is necessary to reach a safe condition after activation of such a device.

14 Mechanical requirements

A welding power source shall be so constructed and assembled that it has the strength and rigidity necessary to withstand the normal service to which it is likely to be subjected, without increasing the hazard of electric shock or other hazard whilst maintaining the minimum CLEARANCES required. A welding power source 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 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 14.1 to 14.5, the welding power source shall comply with the provisions of this standard. Some deformation of the structural parts or enclosure is permitted provided this does not increase a hazard.

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 14.1 to 14.5.

14.1 Enclosure

The enclosure of welding power sources, including air louvres, shall withstand an impact energy of 10 Nm applied by an object with a surface whose radius of curvature is (50 ± 2) mm and whose hardness is 60 HRC to 80 HRC.

Alternatively, the enclosure may 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) the test is made at those areas most likely to cause an electrical hazard or malfunction;

4) the minimum number of impacts is five;

5) the impacts are regularly distributed on the parts of the sample most likely to receive blows in normal use;

6) in no case are more than three impacts applied on the same location of the enclosure.

b) By measurement of the thickness of the sheet metal.

14.1DV DC *Modification of 14.1 by adding the following text:*

Nonmetallic enclosures shall be investigated to the requirements in the 20 mm Vertical Burning Test; V-0, V-1, or V-2 in the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

14.2 Impact resistance of handles, push buttons etc.

Controls, meters, handles, push-buttons, etc. shall withstand the mechanical stress of an impact of (0,5 ± 0,05) Nm applied perpendicularly to its surface.

Conformity shall be checked by subjecting any point that is likely to be weak to three blows of a spring hammer in accordance with IEC 60068-2-63 or by equivalent means.

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

14.3 Handling means

Welding power sources shall be capable of being handled safely (see 17.1 b)).

If means are provided (e.g. handle, eyelet or lug) for the purpose of lifting an assembled welding power source, these shall be capable of withstanding the mechanical stress of a static pull with a force calculated from the mass of the assembled welding power source as follows.

a) For welding power sources of less than 150 kg a force calculated from 10 times the mass shall be used.

b) For welding power sources of 150 kg or more 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 welding power source 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 welding power source 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.

14.4 Drop withstand

An assembled welding power source shall be capable of withstanding a drop test. For this test, the welding power source shall be equipped with all the associated attachments (excluding gas cylinder 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) Welding power sources of 25 kg or less shall withstand a drop of 250 (+10/0) mm.

b) Welding power sources of more than 25 kg shall withstand a drop of 100 (+10/0) mm.

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

In the case of an engine-driven welding power source, it is completely filled and serviced ready for use.

14.5 Tilting stability

Welding power sources, when they are in their 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 welding power source 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 welding power source is placed on a plane and tilted from the horizontal level.

14.5DV D2 *Modification of 14.5:*

In the first paragraph, replace ″10°″ with ″15°″.

15 Rating plate

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.

15DV D2 *Modification to 15 by adding the following text:*

Tests to determine the legibility and durability of markings are stated in the Standard for Marking and Labeling Systems, UL 969.

15.1 Description

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

a) identification;

b) welding output;

c) energy output;

d) auxiliary power output, if applicable (see 11.6).

The arrangement and sequence of the data shall comply with the principle shown in figure 3 (for examples, see annex K).

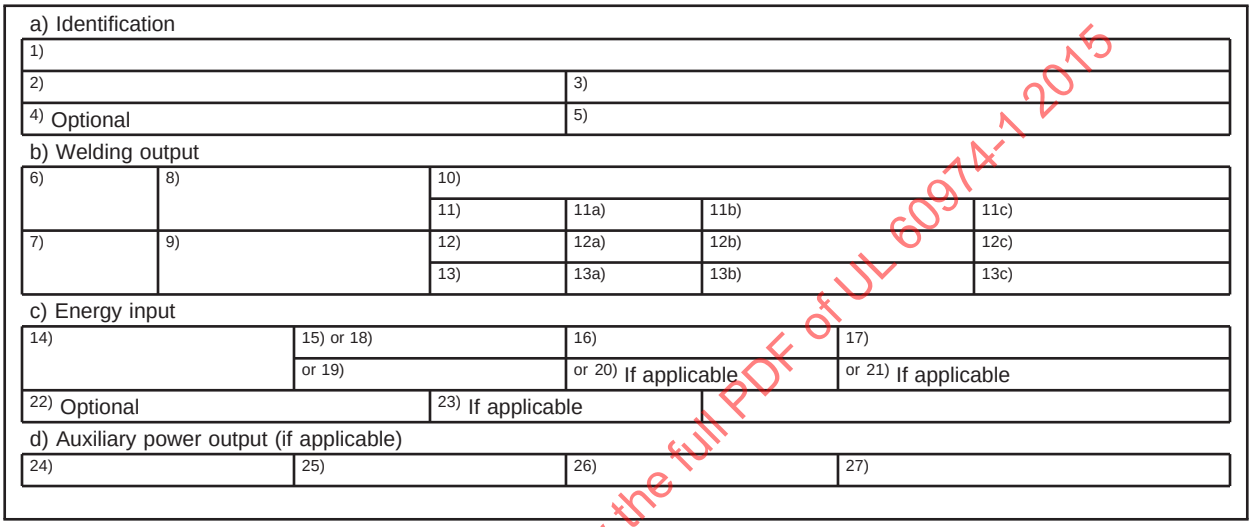
The dimensions of the RATING plate are not specified and may be chosen freely.

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 be used.

NOTE – Additional information may be given. Further useful information, for example class of insulation, POLLUTION DEGREE or power factor, may be given in technical literature supplied by the manufacturer, (see 17.1).

Figure 3 – Principle of the rating plate



15.2 Contents

The following explanations refer to the numbered boxes shown in figure 3.

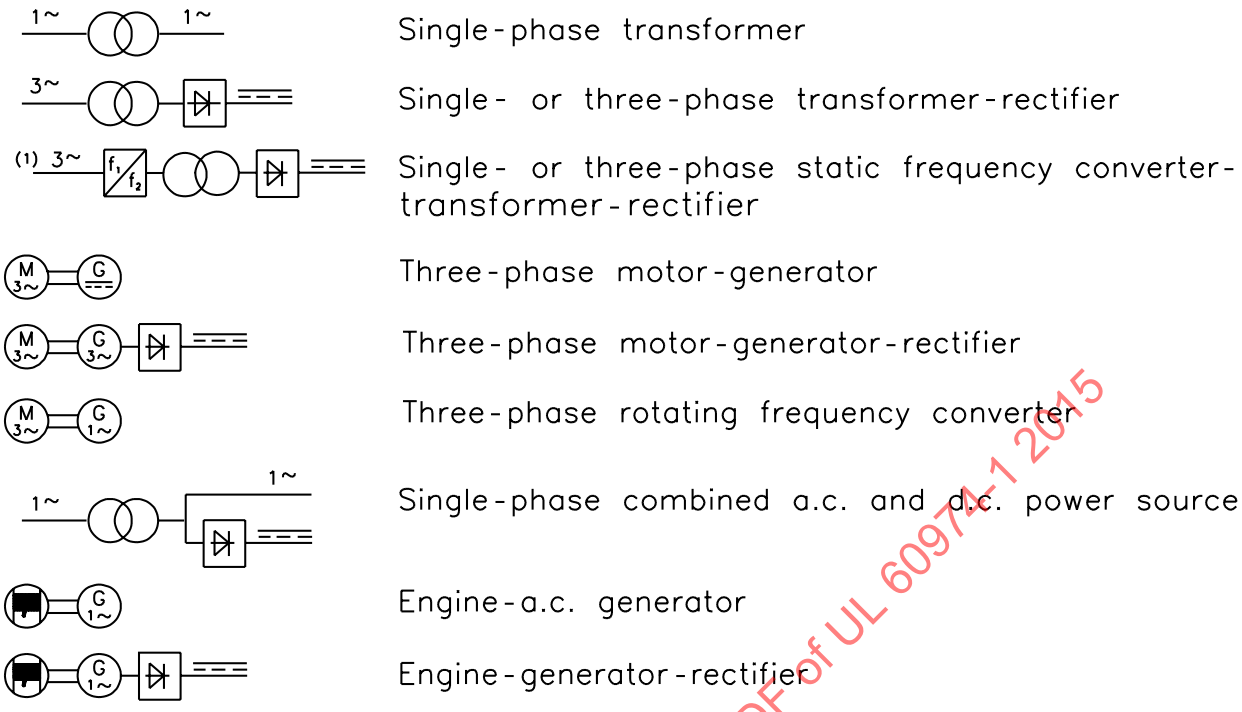
a) Identification

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

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

Box 3 Traceability of design and manufacturing data, e.g. serial number.

Box 4 Welding power source symbol (optional) e.g.:

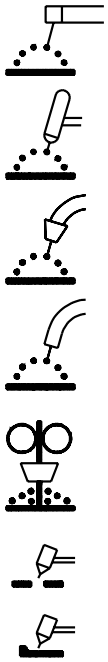


NOTE – For other welding power sources, use symbols or appropriate combinations of symbols in IEC 60417.

Box 5 Reference to this standard confirming that the welding power source complies with its requirements.

b) Welding output

Box 6 Welding process symbol e.g.:



Manual metal arc welding with covered electrodes

Tungsten inert-gas welding

Metal inert and active gas welding including the use of flux cored wire

Selfshielded flux cored arc welding

Submerged arc welding

Symbol for plasma cutting

Symbol for plasma gouging

S5127

NOTE – For other welding processes, use symbols in accordance with ISO 7000.

Box 7 | S | Symbol for welding power sources which are suitable for supplying power to welding operations carried out in an environment with increased hazard of electric shock (if applicable).

S4319

NOTE – In addition, it is recommended that this symbol, of a suitable size, be displayed on the front of the welding power source.

Box 8 WELDING CURRENT symbol e.g.:

⎓ Direct current

∿ Alternating current, and additionally the rated frequency in hertz e.g.: ~50 Hz

Box 9 U_0... V RATED NO-LOAD VOLTAGE

a) Arithmetic mean value in case of direct current

b) RMS value in case of alternating current

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.

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.

c) U_r... V Reduced RATED NO-LOAD VOLTAGE in case of a VOLTAGE REDUCING DEVICE

d) U_s... V Switched RATED NO-LOAD VOLTAGE in case of an A.C. TO D.C. SWITCHING DEVICE

Box 10 ...A/... V to... A/... V Range of output, RATED MINIMUM AND MAXIMUM WELDING CURRENT and their corresponding CONVENTIONAL LOAD VOLTAGE.

Box 11 X DUTY CYCLE (DUTY FACTOR) symbol.

Box 12 I_2 Rated WELDING CURRENT symbol.

Box 13 U_2 CONVENTIONAL LOAD VOLTAGE symbol.

Boxes 11a, 11b, 11c ... % Values of the DUTY CYCLE (DUTY FACTOR).

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

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

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

a) ... % DUTY CYCLE (DUTY FACTOR) at the RATED MAXIMUM WELDING CURRENT;

b) 60% DUTY CYCLE (DUTY FACTOR); and

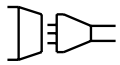
c) 100% DUTY CYCLE (DUTY FACTOR) as far as relevant.

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

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

c) Energy input

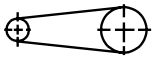
Box 14 Energy input symbol e.g.:



Input supply, number of phases (e.g. 1 or 3), symbol for alternating current and the rated frequency (e.g. 50 Hz or 60 Hz)

Engine

Motor



Belt drive

S5129

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

Box 22 IP.. Degree of protection, e.g. IP21 or IP23.

Box 23 ⧈ Symbol for protection class II, if applicable.

d) Auxiliary power output (if applicable)

Box 24 Frequency, phases or d.c., as appropriate.

Box 25 ... **V** RATED OUTPUT voltage.

Box 26 ... **A** RATED OUTPUT current.

Box 27 ***X***... % DUTY CYCLE (DUTY FACTOR) if less than 100%.

Boxes 25 to 27 form a table with corresponding values.

Conformity shall be checked by visual inspection and by checking of complete data.

15.3 Tolerances

The values obtained from a welding power source shall meet their RATED VALUES within the following tolerances:

a)	U_0	RATED NO-LOAD VOLTAGE in V ± 5% measured in accordance with 11.1, but in no case shall the values summarized in table 11 be exceeded;		
b)	I_{2min}	RATED MINIMUM WELDING CURRENT	in A;	
	U_{2min}	minimum CONVENTIONAL LOAD VOLTAGE	in V;	
	The values of b) shall not be greater than those stated on the RATING plate.			
c)	I_{2max}	RATED MAXIMUM WELDING CURRENT	in A;	
	U_{2max}	maximum CONVENTIONAL LOAD VOLTAGE	in V;	
	The values of c) shall not be less than those stated on the RATING plate.			
d)	n_0	RATED NO-LOAD SPEED of rotation	in min^{-1}	±5%;
e)	P_{1max}	maximum power consumption	in kW	(+10/0)%;
f)	I_{1max}	RATED MAXIMUM SUPPLY CURRENT	in A	±10%.

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

15.4 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 the facility to adjust the output current, output voltage or both, the adjustment may 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

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

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 ±2,5% of the maximum setting.

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

Conformity shall be checked by measurement and visual inspection.

17 Instructions and markings

Each welding power source shall be delivered with instructions and markings.

17.1 Instructions

The instructions 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, e.g. 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 input supply; e.g. suitable supply cables, connection devices or attachment plugs, including the fuse and/or circuit-breaker RATING, see also caution of 6.1;

e) correct operational use relating to the welding power sources; e.g., 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; e.g. a welding power source with a degree of protection of IP21 is not suitable for use in rain;

h) basic guidelines regarding protection against personal hazards for operators and persons in the work area; e.g. electric shock, fumes, gases, arc rays, hot metal, sparks and noise;

i) conditions under which extra precautions are to be observed when welding or cutting; (e.g. environment with increased hazard of electric shock, flammable surroundings, flammable products, closed containers, elevated working position, etc.);

j) how to maintain the welding power source;

k) adequate circuit diagram together with a list of recommended spare parts; in the case of special processes, e.g. plasma cutting, see also 11.1.4;

l) information for a circuit designed to supply electrical power at normal supply voltage; e.g. 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.

Other useful information may also be given, e.g. class of insulation, POLLUTION DEGREE, power factor, etc.

Conformity shall be checked by reading the instructions.

17.1DV D2 *Modification of 17.1 by adding the following text:*

Additional requirements for instructions are stated in the Standard for Transformer-Type Arc-Welding Machines, UL 551.

17.2 Markings

Each welding power source shall be clearly and indelibly marked on or near the front panel indicating that arc welding can be injurious to the operator and persons in the work area and that the instructions shall be consulted before operating.

Conformity shall be checked by visual inspection and by testing in accordance with the test in clause 15.

17.2DV.1 D2 *Modification of 17.2 by adding the following text:*

Additional marking requirements are stated in the Standard for Transformer-Type Arc-Welding Machines, UL 551.

17.2DV.2 D2 *Modification of 17.2 by adding the following text:*

Tests to determine the legibility and durability of markings are stated in the Standard for Marking and Labeling Systems, UL 969.

17.2DV.3 D2 *Modification of 17.2 by adding 17.2DV.3.1 and 17.2DV.3.2:*

17.2DV.3.1 Power sources with ac output receptacles shall be plainly identified such as by being marked ″NEUTRAL FLOATING″ or ″NEUTRAL BONDED TO FRAME.″

17.2DV.3.2 Power sources with dc output receptacles shall be plainly identified such as by being marked ″SYSTEM FLOATING″ or ″SYSTEM BONDED TO FRAME.″

17.3 Addition for PLASMA CUTTING POWER SOURCES

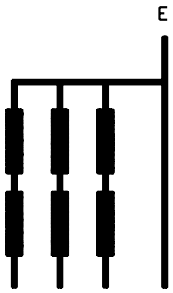
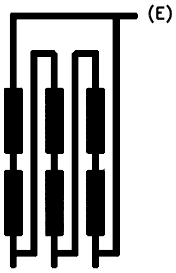
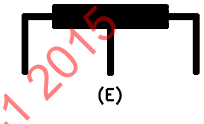
Each PLASMA CUTTING POWER SOURCE shall be clearly and indelibly marked on or near the front panel with the warning symbol combination: ″Danger! Read operator's manual″

The following equivalent wording may be used:

Warning: Refer to the instructions before changing or servicing the torch.

Conformity shall be checked by testing in accordance with the durability test in clause 15.

Annex A
(informative)
Nominal voltages of supply systems (see 6.1.1 and 6.1.2)

Voltage line-to-neutral derived from nominal voltages a.c. or d.c. up to and including	Nominal voltages presently used in the world			
	Three-phase four-wire systems with earthed neutral 	Three-phase three-wire systems earthed or unearthed 	Single-phase two-wire systems a.c. or d.c. 	Single-phase three-wire systems a.c. or d.c. earthed or unearthed 
V	V	V	V	V
50	–	–	12,5; 24; 25; 30; 42; 48	30–60
100	66/115	66	60	–
150	120/208; 127/220	115; 120; 127	110; 120	110–220; 120–240
300	220/380; 230/400; 240/415; 260/440; 277/480	220; 230; 240; 260; 277	220	220–440
600	347/600; 380/660; 400/690; 417/720; 480/830	347; 380; 400; 415; 440; 480; 500; 577; 600	480	480–960
1 000	–	660; 690; 720; 830; 1 000	1 000	–

NOTE 1 Values taken from table B.1 of IEC 60664-1.

NOTE 2 In columns 2 and 5 the lower value is the voltage line-to-neutral, while the higher value is the voltage line-to-line.

NOTE 3 In columns 3 and 4 the values are the voltage line-to-line.

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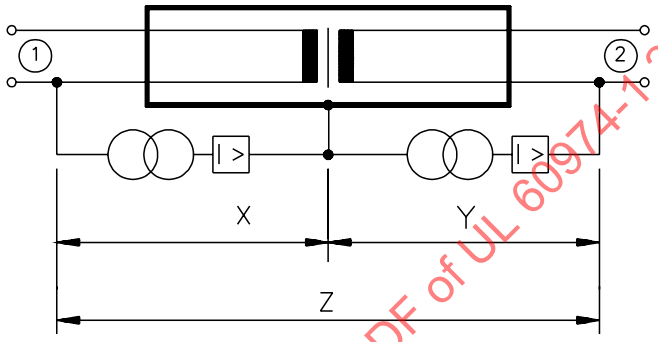
Annex B
(informative)
Example of a combined dielectric test (see 6.1.4)

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

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

Figure B.1 – Combined high-voltage transformers



Key

I > Current sensing tripping device

1 Input

2 Output

X Input circuit to exposed conductive parts

Y Output (welding) circuit to exposed conductive parts

Z Input to output (welding) circuit

S5131

Annex C
(normative)
Unbalanced load in case of a.c. tungsten inert-gas welding power sources (see 7.1)

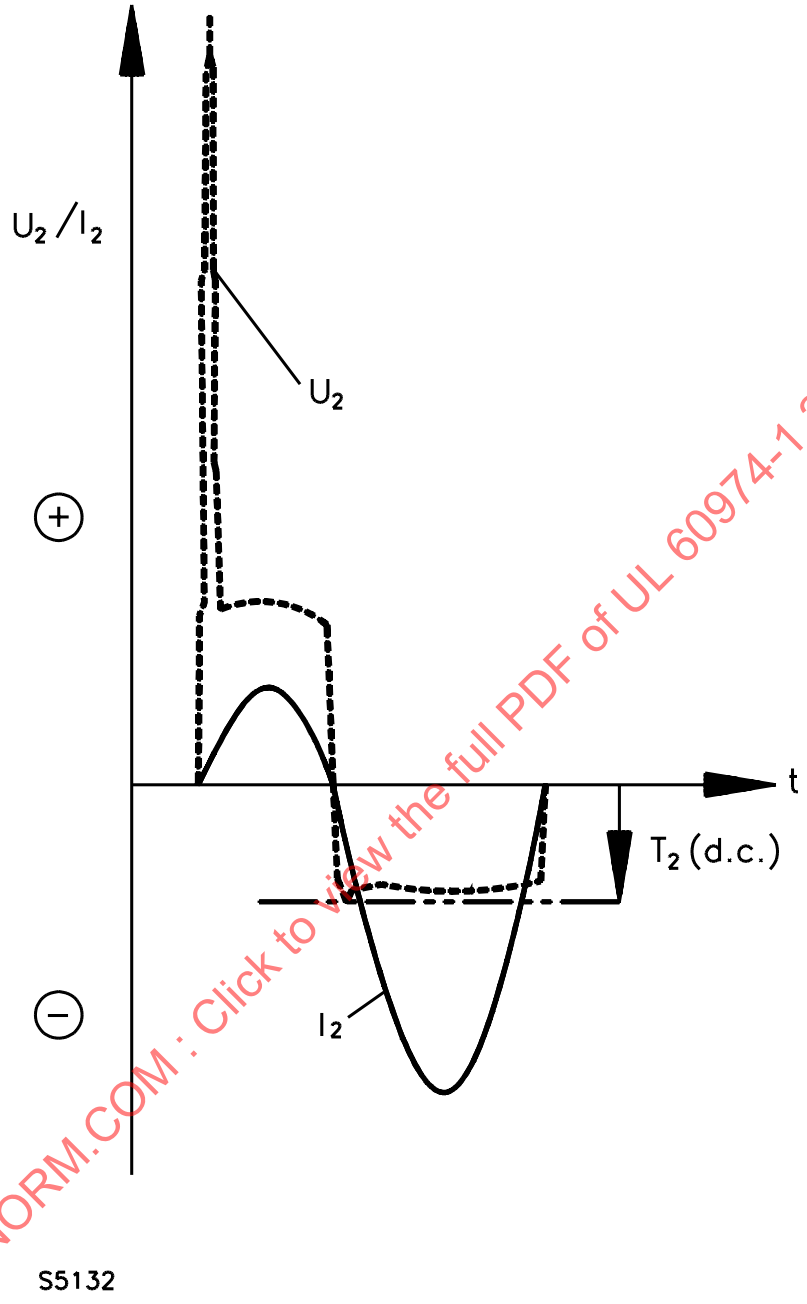
C.1 Introduction

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

This unbalance is called the d.c. component, and can cause saturation of the transformer of a conventional transformer type welding power source. Such saturation will cause an abnormally high input current that could cause severe over-heating.

Figure C.1 shows that the WELDING CURRENT has a d.c. component T_2 that may overheat the winding of the welding power source.

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



Key

U_2 Welding voltage

I_2 WELDING CURRENT

T_2 Arithmetic mean value of the WELDING CURRENT