IEC 60974-9

Edition 2.0 2018-04
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Arc welding equipment –
Part 9: Installation and use

IEC 60974-9:2018-04 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 25.160.30

ISBN 978-2-8322-5667-1

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ARC WELDING EQUIPMENT –

Part 9: Installation and use

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60974-9 has been prepared by IEC technical committee 26: Electric welding.

This standard cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

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

a) addition of a new Clause 8;

b) addition of interpolation details in Table 1.

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

FDIS	Report on voting
26/648/FDIS	26/649/RVD

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

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

In this standard, the following print types are used:

– terms defined in Clause 3: in **bold** type.

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

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

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

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ARC WELDING EQUIPMENT –

Part 9: Installation and use

1 Scope

This document is applicable to requirements for installation and instructions for use of equipment for arc welding and allied processes designed in accordance with safety requirements of IEC 60974-1, IEC 60974-6 or equivalent.

This document is applicable for the guidance of instructors, operators, welders, managers, and supervisors in the safe installation and use of equipment for arc welding and allied processes and the safe performance of welding and cutting operations.

National and local regulations take precedence over this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC ~~/TR~~ 60755, *General requirements for residual current operated protective devices*

IEC 60974-1~~:2005~~, *Arc welding equipment – Part 1: Welding power sources*

IEC 60974-4, *Arc welding equipment – Part 4: ~~In-service~~ Periodic inspection and testing*

~~IEC 60974-6, *Arc welding equipment – Part 6: Limited duty manual metal arc welding power sources*~~

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

IEC 60974-11, *Arc welding equipment – Part 11: Electrode holders*

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

IEC 60974-13, *Arc welding equipment – Part 13: Welding clamp*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1
welding circuit
~~circuit that includes all~~ conductive material through which the welding current is intended to flow

Note 1 to entry: In arc welding, the arc is a part of the **welding circuit**.

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

[SOURCE: ~~IEC 60974-1:2005, 3.11~~ IEC 60050-851:2008, 851-14-10]

3.2
extraneous conductive part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the earth potential

Note 1 to entry: Electrical installation includes the **welding circuit**.

[SOURCE: IEC 60050-851:2008, 851-14-57]

3.3
workpiece
metal piece or pieces on which welding or allied processes are performed

[SOURCE: IEC 60050-851:2008, 851-11-19]

3.4
protective clothing
protective accessories
protective clothing and accessories (e.g. gloves, hand shields, head masks and filter lenses) used in order to diminish electric shock risks and the effects of fume and spatter and to protect the skin and eyes against arc radiation

[SOURCE: IEC 60050-851:2008, 851-11-18]

3.5
environments with increased ~~hazard~~ risk of electric shock
environments where the hazard of electric shock by arc welding is increased in relation to normal arc welding conditions

Note 1 to entry: Such environments are found for example

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

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

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

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

[SOURCE: ~~IEC 60974-1:2005, 3.46~~ IEC 60050-851:2008, 851-15-09]

~~**3.6**~~
~~**industrial and professional use**~~
~~use intended only for experts or instructed persons~~

~~[IEC 60974-1:2005, 3.2]~~

3.6
expert
competent person
skilled person
person who can judge the work assigned and recognize possible hazards on the basis of professional training, knowledge, experience and knowledge of the relevant equipment

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

[SOURCE: ~~IEC 60974-1:2005, 3.3~~ IEC 60050-851:2008, 851-11-10]

3.7
wire feeder
equipment that delivers filler wire to the arc or weld zone which includes ~~the wire-feed control and~~ means to apply motion to the filler wire ~~and may also include the filler wire supply~~

Note 1 to entry: The **wire feeder** may also include the wire-feed control, the filler wire supply, devices for gas control, indicators and remote connectors.

[SOURCE: ~~IEC 60974-5:2007, 3.11~~ IEC 60050-851:2008, 851-14-39]

~~**3.8**~~
~~**auxiliary power output**~~
~~circuit of a welding power source designed to provide electrical power to auxiliary equipment~~

4 Installation

4.1 General

Welding equipment used in arc welding installations shall be intended for the purpose ~~and shall be built in accordance with IEC 60974-1, IEC 60974-4, IEC 60974-6, IEC 60974-10, IEC 60974-11 and IEC 60974-12 (see Clause 2),~~ as given on the rating plate.

Electromagnetic compatibility (EMC) requirements shall be taken into consideration during installation, see Clause 5.

The requirements of national and local regulations shall be taken into consideration during installation, including grounding or protective earth connections, fuses, supply disconnecting device, type of supply circuit, etc.

Read the manufacturer's instruction manual before installing the equipment. Full use shall be made of the technical information relevant to the welding equipment.

Specific advice may be obtained from the welding equipment manufacturer, if necessary.

4.2 Supply circuit

4.2.1 Selection of supply cables

Supply cables for welding equipment and their overload protection, if not provided by the manufacturer, shall be selected in accordance with the information given in the manufacturer's instruction manual.

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

Supply cables shall be placed so that they cannot be damaged in use. If that cannot be achieved, a ~~sensitive~~ residual current ~~circuit breaker~~ device (RCD), capable of operating at a leakage current not exceeding 30 mA in accordance with IEC ~~/TR~~ 60755, shall be used to reduce the risk of electric shock.

4.2.2 Supply disconnecting device

The installer shall ensure that a supply disconnecting device is fitted at the point of supply.

NOTE A plug ~~may~~ can be used as supply disconnecting device in accordance with national or local regulation.

4.2.3 Emergency stopping device

When an emergency stopping device is required by a national regulation (e.g. automatic welding equipment), it shall conform to the relevant IEC standard.

For welding in an **environment with increased ~~hazard~~ risk of electric shock**, see 7.10.

4.3 Welding circuit

4.3.1 Isolation from the input supply

The **welding circuit** and circuits electrically connected to the **welding circuit** shall be electrically isolated from the mains supply.

Verification shall be carried out by an **expert**.

4.3.2 Summation of no-load voltages

If more than one welding power source is in use at the same time, their no-load voltages can be cumulative and could create an increased hazard of electric shock. Welding power sources shall be installed so as to minimize this risk. Guidance is given in 7.9.

NOTE In the case of two welding transformers connected to the same lines, the resulting output voltage ~~may~~ can be the sum of both no-load voltages. This can be avoided by using a suitable input or output connection (see 7.9).

~~NOTE~~ Where more than one welding power source is installed, individual welding power sources with their separate controls and connections should be clearly identified to show which items belong to any one **welding circuit**.

4.3.3 Welding cables

Welding cables shall comply with IEC 60245-6. Copper conductor welding cables shall be selected in accordance with the duty cycle and national regulations or, when inexistant, the current rating given in Table 1. Where long cable runs are involved, it ~~may~~ can be necessary to choose the cable size on the basis of voltage drop, see Annex B.

Table 1 – Current ratings for copper welding cables

Nominal cross-sectional area[b]	Current ratings for specified duty cycle at an ambient temperature of 25 °C[a]						
	100 %	85 %	80 %	60 %	35 %	20 %	8 %
mm^2	A	A	A	A	A	A	A
10	100	100	100	101	106	118	158
16	135	136	136	139	150	174	243
25	180	182	183	190	213	254	366
35	225	229	231	243	279	338	497
50	285	293	296	316	371	457	681
70	355	367	373	403	482	602	908
95	430	448	456	498	606	765	1 164
120	500	524	534	587	721	917	1 404
150	580	610	622	689	853	1 090	1 676
185	665	702	717	797	995	1 277	1 971

[a] For higher ambient temperatures, a correction factor shall be applied:
0,96 (30 °C); 0,91 (35 °C); 0,87 (40 °C); 0,82 (45 °C). No interpolation is allowed for duty cycle values.

[b] For intermediate values of nominal cross-section areas, interpolation is allowed.

NOTE Table originates from EN 50565-1:2014.

4.3.4 Connection between the welding power source and the workpiece

When the welding current does not flow entirely in the **welding circuit**, stray currents, which are components of the welding current, occur. These can cause damage ~~and may be eliminated~~ to electrical systems of buildings and to other sensitive systems in buildings and can be minimized by the following means:

a) the electrical connection between the welding power source and the **workpieces** shall be made as direct as practicable by means of an insulated return cable having an adequate current-carrying capacity;

b) **extraneous conductive parts**, such as metal rails, pipes and frames shall not be used as part of the **welding circuit**, unless they constitute the **workpiece** itself;

c) the ~~return~~ welding clamp shall be as near as practicable to the welding arc;

~~NOTE 1 When the return clamp is removed, it should be electrically isolated from parts connected to earth, e.g. metallic enclosures with protective earth connection (class I), metal floors, building services.~~

d) the welding clamp disconnected from the **workpiece** shall be electrically isolated from parts connected to earth, e.g. metallic enclosures with protective earth connection (class I), metal floors, building services;

NOTE 1 The welding clamp can cause an electrical shock when welding current is flowing or when the electrode circuit is in contact with the electrical ground circuit or work piece.

e) the **welding circuit** shall not be earthed unless required by national or local regulations (see 4.3.5);

f) connection of the return cable to the **workpiece** shall be ensured by the use of devices having suitable means for cable connection, a fastening system not liable to come loose accidentally, and good electrical contact. Magnetic devices only present a good electrical contact if the contact surfaces of the magnetic device and the contact area of the **workpiece** are sufficiently large, even, conductive and clean (e.g. free from rust and primer) and if the contact area of the **workpiece** is magnetic;

NOTE 2 If **workpieces** are on a welding bench or a work-handling device, the return cable ~~may~~ can be connected to the bench or the device.

g) connection devices for non-stationary flexible welding cables in the **welding circuit** shall:

1) have an adequate covering of insulating material to prevent inadvertent contact with live parts, when connected, with the exception of the ~~return~~ welding clamp at the **workpiece** itself;

2) be suitable for the sizes of cables used and the welding current;

3) be effectively connected to the welding cables and in good electrical contact with them.

h) Welding, control and mains cables shall be protected from spatter and heat to prohibit unintentional damage to the insulation.

Both the welding cable and the connection device shall be used within their specified current rating. The connection device shall not be fitted with a cable smaller in diameter than specified by the manufacturer of the connection device.

When coupling devices or welding clamps are used, they shall comply with IEC 60974-12 or IEC 60974-13, respectively.

4.3.5 Earthing of the workpiece

The **welding circuit** should not be earthed, since it can increase the risk of stray welding currents (see 4.3.3). Earthing of the **welding circuit** can also increase the area of metal through which a person in contact with the **welding circuit** (e.g. the welding electrode) could receive an electric shock.

NOTE 1 There are **workpieces** that have an inherent connection to earth, e.g. steel structures, ships, pipelines ~~etc~~. When these are welded, the possibility of stray currents is increased.

NOTE 2 In some cases, the **workpiece** ~~may~~ can be in permanent contact with earth, e.g. with protection class I equipment which itself has protective conductors connected to earth. Such a **workpiece** is considered to be inherently connected to earth.

An assessment of the **welding circuit** and the welding area shall be made to ensure that a stray welding current will not flow through any object connected to earth ~~and~~ that is not intended or capable of carrying the welding current (e.g. protective earth connection).

If electrical hand tools are used that ~~may~~ could come into contact with the **workpiece**, then those tools shall be class II equipment (i.e. with double or reinforced insulation without protective earth connection).

If earthing is required by national or local regulations, the earth connection shall be made by a separate dedicated cable or conductor with a rating of at least that of the return cable and connected directly to the **workpiece**.

Precautions shall be taken to insulate the operator from earth as well as from the **workpiece** (see 7.7.2).

~~NOTE~~ Where external radio frequency noise suppression networks are connected to the **welding circuit**, an **expert** ~~should~~ shall assess whether the **welding circuit** can still be regarded as insulated from earth.

NOTE 3 External radio frequency noise suppression networks could consist of a number of different components, for example, LCR filters (inductance/capacitance/resistance).

4.3.6 Location of gas cylinders

Care shall be taken to prevent gas cylinders in the vicinity of the **workpiece** from becoming part of the **welding circuit**.

5 Electromagnetic compatibility (EMC)

5.1 General

The user is responsible for installing and using the arc welding equipment in accordance with the manufacturer's instructions. If electromagnetic disturbances are detected, then it shall be the responsibility of the user of the arc welding equipment to resolve the situation with the technical assistance of the manufacturer.

5.2 Assessment of area

Before installing arc welding equipment, the user shall make an assessment of potential electromagnetic interferences in the surrounding area. The following shall be taken into account:

a) other supply cables, control cables, signalling and telephone cables, above, below and adjacent to the arc welding equipment;

b) radio and television transmitters and receivers;

c) computer and other control equipment;

d) safety-critical equipment, for example, guarding of industrial equipment;

e) the health of the people around, for example, the use of ~~pacemakers and hearing aids~~ wearable medical devices and implants;

f) equipment used for calibration or measurement;

g) the immunity of other equipment in the environment. The user shall ensure that other equipment being used in the environment is compatible. This ~~may~~ can require additional protection measures;

h) the time of day that welding or other activities are to be carried out.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area ~~may~~ can extend beyond the boundaries of the premises.

5.3 Methods of reducing emissions

5.3.1 Public supply system

The arc-welding equipment shall be connected to the public supply system in accordance with the manufacturer's recommendations. If interference occurs, it ~~may~~ can be necessary to take additional precautions, such as filtering of the supply system. Consideration shall be given to shielding the supply cable of permanently installed arc-welding equipment, in a metallic conduit or equivalent. Shielding shall be electrically continuous throughout its length. The shielding shall be connected to the welding power source so that good electrical contact is maintained between the conduit and the welding power source enclosure.

5.3.2 Maintenance of arc-welding equipment

The arc-welding equipment shall be routinely maintained in accordance with IEC 60974-4 and the manufacturer's instructions. All access and service doors and covers shall be closed and properly fastened when the arc-welding equipment is in operation. The arc-welding equipment shall not be modified in any way, except for those changes and adjustments covered in the

manufacturer's instructions. In particular, the spark gaps of arc striking and stabilising devices shall be adjusted and maintained in accordance with the manufacturer's instructions.

5.3.3 Welding cables

The welding cables shall be kept as short as possible and shall be positioned as close as possible to each other, running at or close to the floor level. The welding cables shall never be coiled during welding.

5.3.4 Equipotential bonding

Bonding of all metallic objects in the surrounding area should be considered for the purpose of reducing emissions. However, metallic objects bonded to the **workpiece** will increase the risk that the operator could receive an electric shock by touching these metallic objects and the electrode at the same time. The operator shall be insulated from all such bonded metallic objects.

5.3.5 Earthing of the workpiece

Where the **workpiece** is not bonded to earth for electrical safety, a connection bonding the **workpiece** to earth ~~may~~ can reduce emissions in some, but not all instances. Care should be taken to prevent the earthing of the **workpiece** increasing the risk of injury to users, or damage to other electrical equipment. Where necessary, the connection of the **workpiece** to earth should be made by a direct connection to the **workpiece**, but in some countries where direct connection is not permitted, the bonding should be achieved by suitable capacitance, selected in accordance with national and local regulations.

5.3.6 Screening and shielding

Selective screening and shielding of other cables and equipment in the surrounding area ~~may~~ can alleviate problems of interference. Screening of the entire welding area may be considered for special applications.

6 Electromagnetic fields (EMF)

6.1 General

Electric current flowing through any conductor causes localized electric and magnetic fields (EMF). All welders should use the following procedures in order to minimize the risk associated with exposure to EMFs from the **welding circuit**:

– route the welding cables together – secure them with tape when possible;
– place your ~~torso and head~~ body as far away as possible from the **welding circuit**;
– never coil welding cables around your body;
– do not place your body between welding cables. Keep both welding cables on the same side of your body;
– connect the return cable to the **workpiece** as close as possible to the area being welded;
– do not work next to, sit or lean on the welding power source;
– do not weld whilst carrying the welding power source or **wire feeder**.

EMFs ~~may~~ can also interfere with wearable medical devices and implants~~, e.g. pacemakers~~. Protective measures for persons with wearable medical devices and implants shall be taken. For example, access restrictions for passers-by or individual risk-evaluations for welders. Risk assessment and recommendation for users of wearable medical devices and implants shall be made by a medical expert.

6.2 Assessment of exposure

When arc-welding equipment is configured an assessment of potential effects of electromagnetic fields in the surrounding area shall be done. The following shall be taken into account:

a) the datasheet regarding EMFs and special instructions in the user manual of the arc-welding equipment;

b) busbars and other conductors carrying high voltages and/or currents;

c) other equipment generating high field strengths;

d) the health of the people around, for example the use of pacemakers and hearing aids.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area can extend beyond the boundaries of the premises.

7 Use

7.1 General requirements

User shall ensure that arc-welding equipment and accessories conform to the relevant parts of IEC 60974, see Clause 2, as given on the rating plate. These documents contain necessary information for health and safety to be included in instructions and manuals.

Before welding equipment is put into service, the user shall read and understand the instructions provided by the manufacturer, national or local regulation, trade association and occupational recommendations, national health and safety recommendations.

Consideration shall be given to the environment in which the welding equipment is used as additional precautions ~~may~~ can need to be taken e.g. increased hazard of electric shock; confined spaces; flammable area, asphyxiation (further references to specific hazards, see Annex A).

7.2 Connection between several welding power sources

If welding power sources are to be connected in parallel or in series, this shall be carried out by an **expert** and in accordance with the manufacturer's recommendations. The equipment shall be approved for arc-welding operations only after a check has been carried out to ensure that the permissible no-load voltage cannot be exceeded.

When one welding power source connected in parallel or series is taken out of service, that power source shall be disconnected from the mains supply and from the **welding circuit**, so as to prevent any hazards that might be caused by feedback voltages.

7.3 Inspection and maintenance of the welding installation

7.3.1 Periodical inspection

On installation, and periodically thereafter, an **expert** nominated for the task shall check that the welding equipment has been correctly selected and connected for the work to be carried out in accordance with IEC 60974-4 and the manufacturer's instructions and that all connections are clean and tight and the welding equipment is in good condition.

In addition, all protective earthing shall be checked for effectiveness. Any defects found shall be repaired.

7.3.2 Routine inspection

The operator shall be instructed to check all external connections daily and each time a reconnection is made. Particular attention shall be paid to the installation of supply and welding cables, electrode holders and coupling devices. Any defects found shall be reported, and faulty equipment shall not be used until it has been repaired.

The ~~return~~ welding clamp shall be connected directly to the **workpiece** as close as practicable to the point of welding or to the welding bench on which the **workpiece** is situated or to the work-handling device.

For plasma cutting the no-load voltages are higher than with welding. This shall be considered during inspection and maintenance procedures. Particular attention shall be paid to the watercooling equipment to ensure that any leaks do not affect the insulation.

Before carrying out arc welding on equipment having associated transformers (e.g. arc furnaces), such transformers shall be isolated to avoid the hazard of shock from induced voltages on the input side of the transformer.

7.4 Disconnection of welding power sources and/or welding circuits

If the supply cable or the welding cables are liable to damage when the welding power source is moved to another location, that power source, including its cables, shall be disconnected before it is moved.

When maintenance or repair work is carried out on the welding equipment, the input and output shall be disconnected.

7.5 Guards

Guards and removable parts of the enclosure shall be in position before the welding equipment is ~~made live~~ energised.

7.6 Information for operators

Operators and their assistants shall be trained in the safe use of equipment. Operators and persons working in the vicinity of the welding operation shall be warned of the hazards and informed about protective measures concerning arc processes (see Annex A).

The operator shall prevent gas cylinders in the vicinity of the **workpiece** from becoming part of the **welding circuit**.

7.7 Protective measures

7.7.1 Extraneous conductive parts in the welding area

With respect to **extraneous conductive parts**,

a) persons shall be aware of such parts, see 3.2;

b) care shall be taken to minimize the extent of such parts;

c) torches and electrode holders shall be kept insulated from **extraneous conductive parts** in the welding area.

7.7.2 Protection against electric shock

The operator shall take precautions to be insulated from the electrode, the **workpiece** and conductive parts in contact with earth in the vicinity. This can normally be achieved with dry

gloves, clothing, head gear, footwear, dry boards and insulating mats or similar in good condition. An **expert** shall assess whether the proposed insulation method is suitable.

NOTE An operator who comes into direct contact with both terminals of the welding power source, or conductors connected to them, ~~may~~ can experience an electric shock. Under some circumstances, the electric shock ~~may~~ can be severe enough to cause injury or death.

7.8 Isolation of the welding circuit from the workpiece and earth when not in use

When not in use (e.g. during lunch or changing shift), electrode holders and torch circuits shall, where practicable, be switched off at the welding power source; if this is not possible, they shall be kept isolated and/or be insulated, without contact with the **workpiece** or other conductive parts, especially the welding power source enclosures. Manual metal arc-welding electrodes shall be removed from the electrode holder when the welding operation has been completed. If applicable, the shielding gas supply shall be closed.

The operator shall ensure that the ~~return current~~ welding clamp is either connected to the **workpiece** or stored isolated from earth or any conductive part.

7.9 Voltage between electrode holders or torches

When working with several welding power sources on a single **workpiece** or on conductively connected **workpieces**, a hazardous sum of no-load voltages may arise between two electrode holders or torches. This may reach twice the value of the admissible no-load voltage (see also 4.3.2).

The instructed person who is co-ordinating the welding tasks shall ensure that a measuring device is used to determine whether there is a hazard.

Operators shall:

– be warned of this hazard;

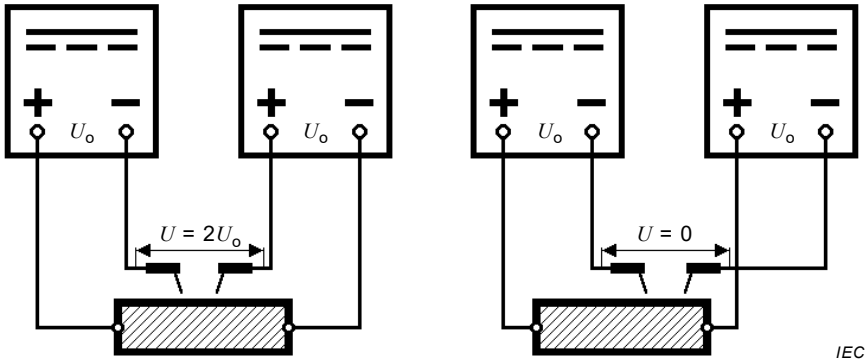
– never touch two electrode holders or torches at the same time;

– work out of reach of each other, where practicable.

The following examples show schematically the influence that the connection to the mains supply and the polarity for welding may have on the sum of welding voltages between electrode holders or torches. It is assumed that the no-load voltages for each welding power source are identical but in practice they ~~may~~ can differ (see items a) to c) below).

a) Direct current

The connections to the mains supply have no influence on the sum of no-load voltages. The voltage U depends on the polarity of the output connections (see Figure 1).



NOTE The polarity for welding depends on the welding process.

Figure 1 – Example of DC voltage between electrode holders or torches

b) Alternating current single-phase welding power sources

The connections to the mains supply and the output connections will influence the sum U of the no-load voltages (see Figure 2).

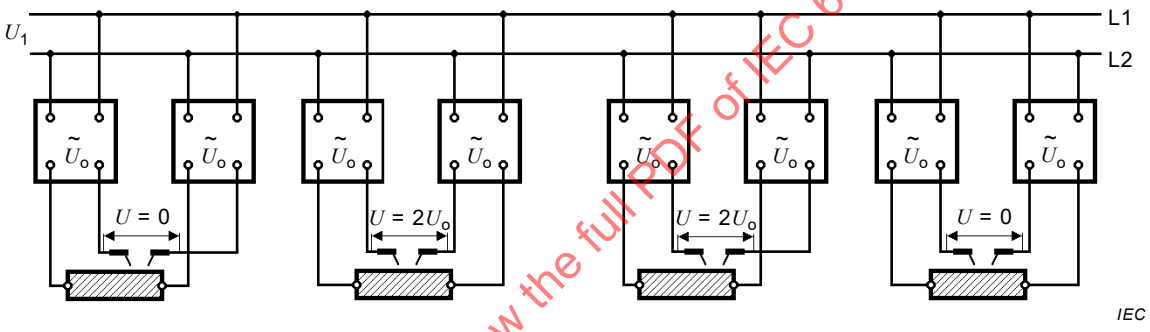
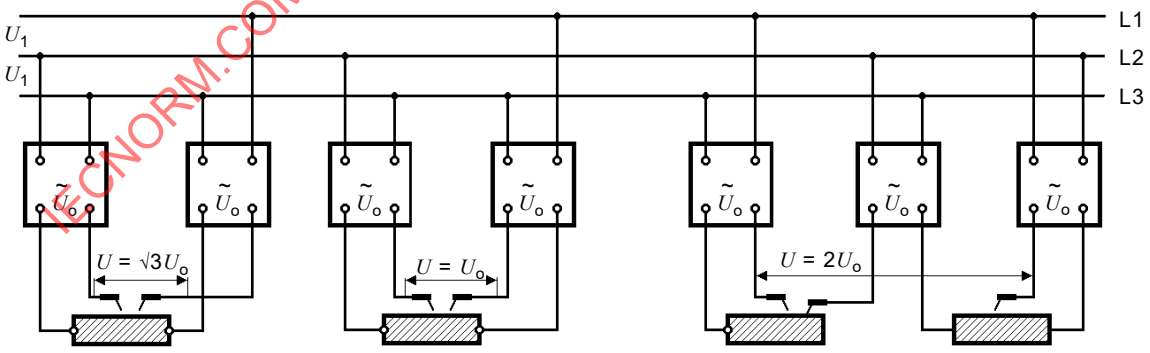


Figure 2 – Example of AC voltage between electrode holders or torches – Single-phase supply from the same pair of lines of a three-phase mains supply

If the connections to a three-phase mains supply are made across different pairs of lines, the sum U of the no-load voltages will always be greater than zero (see Figure 3).



NOTE Unconnected work pieces. The middle electrode is accidentally in contact with the other work piece.

Figure 3 – Example of AC voltage between electrode holders or torches – Single-phase supply from different pairs of lines of a three-phase mains supply

Increased AC voltages can be avoided by reversing

– the welding cable connections, preferably by an **expert**, or

– the mains supply connections to the welding power source (see 4.3.2).

c) Alternating current three-phase multi-operator welding transformer

The connections to the mains supply have no influence on the sum U of the no-load voltages (see Figure 4).

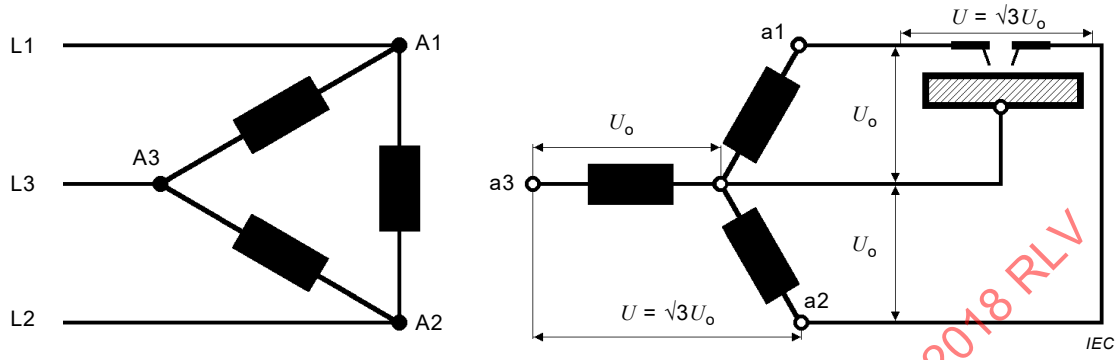


Figure 4 – Example of AC voltage between electrode holders connected between different lines of output

7.10 Welding in an environment with increased ~~hazard~~ risk of electric shock

When welding is carried out in an **environment with increased ~~hazard~~ risk of electric shock**, means for electrically disconnecting the welding power source or the **welding circuit** quickly shall be provided within easy access (e.g. emergency stopping device).

The following precautions shall be taken to reduce the risk of an electric shock from the voltage between the welding electrode and earth:

a) if possible, the welding power source shall not be taken into the **environment with increased ~~hazard~~ risk of electric shock**. If not possible, the welding power source shall be supplied by an insulating transformer;

b) the welding power source shall be out of normal reach of the operator during welding. Additional protection against a shock from current from the mains supply under fault conditions may be provided by the use of a residual current circuit breaker that is capable of operating at a leakage current not exceeding 30 mA and feeds all mains-powered equipment in the vicinity. The residual current circuit breaker shall be sensitive to all types of current;

c) only remote controls supplied with the protective measure "safety extra low voltage" in accordance with IEC 60974-1 shall be used;

d) only welding power sources and welding equipment suitable for use in **environments with increased ~~hazard~~ risk of electric shock** shall be used. Where appropriate, voltage-reducing devices shall be used;

NOTE 1 This ~~should be~~ is verified by an **expert** unless the welding power source is marked with the symbol S (see IEC 60974-1).

e) electrode holders shall conform to IEC 60974-11, i.e. to type A;

f) insulating platforms or mats shall be used.

NOTE 2 Attention ~~should be~~ is drawn to the requirements concerning **protective clothing**, headgear and **protective accessories** in 7.7.2.

7.11 Use of shoulder slings

Welding shall not be carried out whilst carrying the welding power source, or **wire feeder**, for example by a shoulder sling. This is to prevent

a) the risk of loss of balance if any connected cables or hoses are pulled;

b) an increased risk of electric shock as the operator will be in contact with earth if using a class I welding power source whose enclosure is earthed by its protective earth conductor.

7.12 Welding at elevated positions

Welding ~~should not be carried out~~ from elevated positions~~, where practicable~~ should be avoided if possible, for example from a ladder, ~~where~~ since even a minor electric shock ~~may~~ can result in a fall.

Appropriate precautions shall be taken, for example by using a safe working platform.

NOTE A metal ladder or scaffolding can create an **environment with increased** ~~hazard~~ **risk of electric shock** (see 3.5 and 7.10).

7.13 Welding with suspended welding equipment

For practical reasons, welding equipment may be suspended over the welding area. To avoid stray current, the hanging means shall be insulated. Precautions shall be taken to avoid the risk of falling objects (for example the filler wire spool).

8 Battery-powered welding power sources

8.1 Safety recommendations

In addition to Clause 7, the safety recommendations in the instructions of use of the equipment shall be respected. Special attention shall be given in charging of the battery.

Battery-powered welding power sources can operate without connection to the supply network, therefore measures against unintentional operation shall be followed as specified in the instructions for use.

8.2 Transportation

Batteries can be classified as dangerous goods. International and local transportation regulations shall be respected.

NOTE Transporting dangerous goods is regulated internationally by the International Civil Aviation Organization (ICAO), Technical Instructions and corresponding International Air Transport Association (IATA) Dangerous Goods Regulations and the International Maritime Dangerous Goods (IMDG) Code. In the United States, transportation of these batteries is regulated by the Hazardous Materials Regulations (HMR), which is found at Title 49 of the Code of Federal Regulations, Sections 100-185. All of these regulations that govern the transport of rechargeable lithium ion (including lithium ion polymer) cells and batteries (which are classified dangerous goods) are based on the UN Recommendations on the Transport of Dangerous Goods Model Regulations. All energy storage systems (ESS), or components thereof, containing lithium ion chemistry meet the test criteria set forth in the UN "Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria", chapter 38.3 (known as UN 38.3) in order to be shipped in PG II packaging.

Annex A
(informative)

Hazards associated with arc welding

A.1 General

Welding operators and persons working in the vicinity of the welding process should be made aware of the following hazards associated with arc welding. They should be made aware of protective measures as specified in relevant international and national standards and regulations.

A.2 Equipment condition and maintenance

All equipment should be kept in good working condition, inspected and, when defective, promptly repaired or withdrawn from service.

Gas cylinders should be located or secured so that they cannot be knocked over or come in contact with the **welding circuit**.

A.3 Operation

All equipment should be placed so that it does not present a hazard in passageways, on ladders or stairways, and should be operated in accordance with the manufacturer's instructions.

Welding equipment may be heavy (e.g. **wire feeder** fitted with spool and harness). Care shall be taken during manual handling.

A.4 Training

For operators and their supervisors, training is essential in

– the safe use of the equipment;
– the processes;
– the emergency procedures.

A.5 Arc radiation

A.5.1 General

The arc generates

– ultraviolet radiation (can damage skin and eyes);
– visible light (can dazzle eyes and impair vision);
– infrared (heat) radiation (can damage skin and eyes).

Such radiation can be direct or reflected from surfaces such as bright metals and light-coloured objects.

A.5.2 Eye and face protection (see also A.9)

The face and eyes should be protected by suitable welding shields equipped with appropriate ocular protection filters in accordance with ISO 4850.

A.5.3 Body protection (see also A.9)

The body should be protected by suitable clothing in accordance with ISO 11611.

The use of neck protection can be necessary against reflected radiation.

A.5.4 Protection of persons in the vicinity of an arc

In the vicinity of an arc, non-reflective curtains or screens should be used to isolate persons from the arc radiation. A warning, for example a symbol for eye protection, should refer to the hazard of arc optical radiation.

A.6 EMF

A.6.1 General

The welding power source generates currents leading to magnetic fields in the vicinity of the welding cable and the **workpiece**.

Additionally, arc striking and stabilizing devices can introduce high-voltage impulses leading to increased electric field strengths.

Metal objects and the **workpiece** itself affect the resulting fields.

The EMF exposure data that results from the application of IEC 62822-1 can be used to assist in workplace assessment.

A.6.2 Body protection

Due to the physical properties of the magnetic field introduced by the welding current, personal protection devices are not feasible.

Small increases of the distance between the body and the welding cable can result in a relatively large reduction of the exposure to the magnetic field.

Further guidance is given in 6.1.

A.6.3 Protection of persons in the vicinity of the welding operation

Due to the physical properties of the magnetic field, the only feasible protection of people is restricted access to the areas with high magnetic field strengths.

A.7 Welding fume

Arc welding and allied processes produce welding fume which may pollute the atmosphere surrounding the work. Welding fume is a varying mixture of airborne gases and fine particles which, if inhaled or swallowed, constitute a health hazard.

The degree of risk will depend on

a) the composition of the fume;

b) the concentration of the fume;

c) the duration of exposure.

A systematic approach to the assessment of exposure is necessary, taking into account the particular circumstances of the operator and the ancillary worker who can be exposed.

Welding fume may be controlled by a wide range of measures, e.g. process modifications, engineering controls, methods of work, personal protection and administrative action (see Figure A.1).

First, it is necessary to consider whether exposure can be prevented by eliminating the generation of welding fume altogether. Where this cannot be done, measures for reducing the quantity of welding fume generated should be investigated, after which the control of welding fume at the source should be considered. The use of respiratory equipment should not be contemplated until all other possibilities have been eliminated. Normally, respiratory protective equipment should be used only as an interim measure. There will, however, be circumstances where, in addition to ventilation measures, the use of personal protection can be necessary.

A.8 Noise

In the welding environment, damaging levels of noise can exist.

Continued exposure to a high noise level on the unprotected ear is injurious. The noise levels should be reduced to the lowest practicable level.

High levels may be tolerated for very short periods of time by wearing adequate ear protection in accordance with the national or local regulations.

In case of doubt, checks by an **expert** should be made to establish noise levels in any particular environment, and, if these are in excess of the prescribed limit, one of the following alternatives may apply:

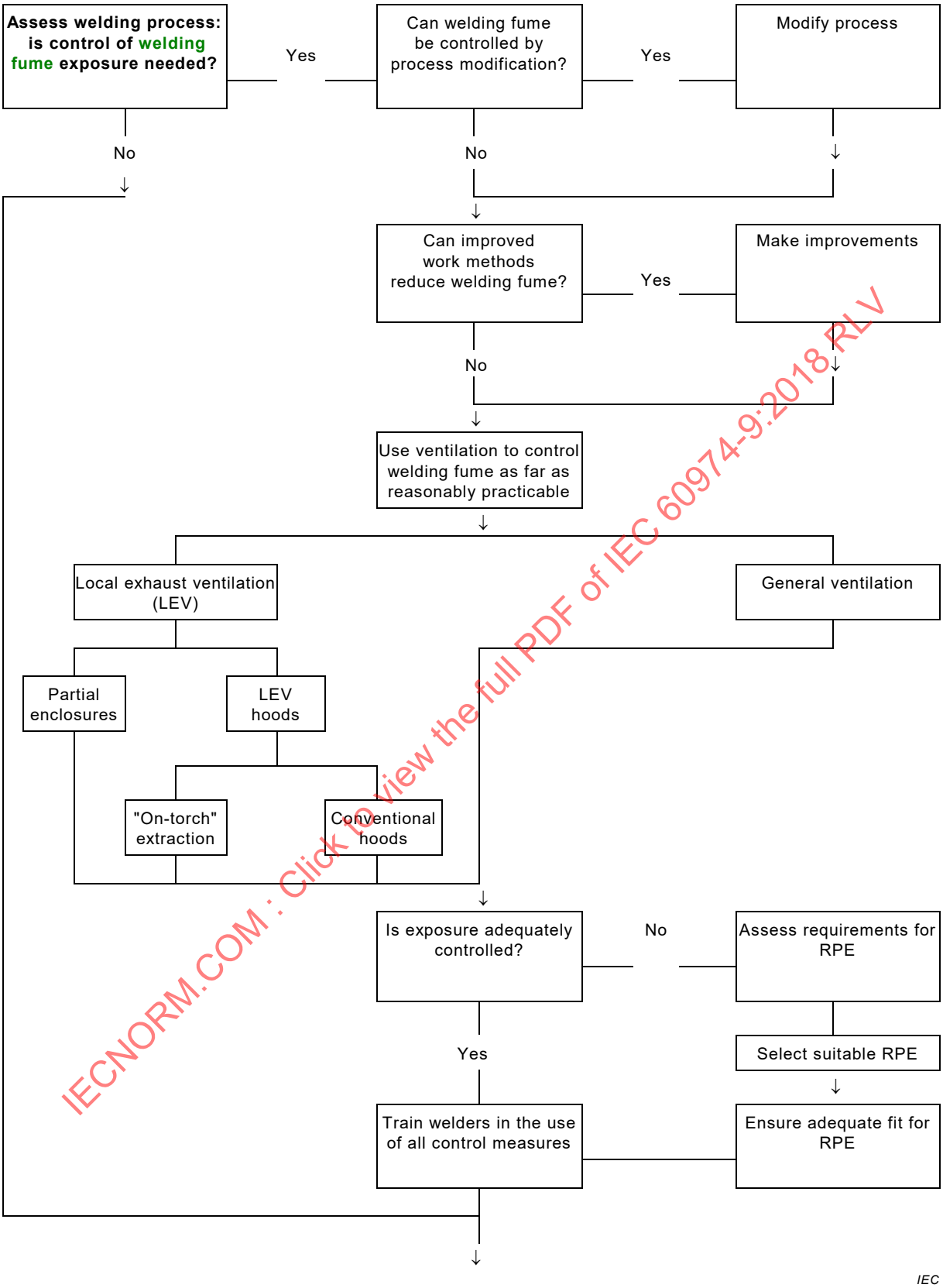
a) insulation of the noise source as far as possible, e.g. by fitting silencers or sound proof enclosures;

b) insulation of the operator from the noise source if more appropriate than a);

c) effective maintenance of sound protection devices;

d) indication as "ear protection areas" where applicable;

e) restriction of entry to these "ear protection areas" to authorized persons wearing suitable ear protection, e.g. ear muffs or plugs.



NOTE RPE = Respiratory protective equipment.

Figure A.1 – Steps for the control of welding fumes

A.9 Fire and explosion

A.9.1 General

Arc welding and allied processes can cause fire and explosions and precautions should be taken to prevent these hazards.

A.9.2 Fire

In order to prevent the risks of fire, flammable material should be removed from the welding area wherever possible. Where this is not possible, the following should be carried out:

a) remaining flammable material should be covered by fire-resistant material, for example in the vicinity of structural material such as wooden beams or floors;

b) the surroundings of the work should be observed for an adequate period after its termination;

c) "hot spots" and their immediate surroundings should be observed until their temperature has dropped to normal;

d) appropriate fire-fighting equipment suitable for the materials used and for use in electrical environments should be available at all times.

A.9.3 Explosion

Do not heat, cut or weld tanks, drums, containers or vacuum equipment until the proper steps have been taken to insure that such procedures will not cause flammable or toxic vapours from substances inside. They can cause an explosion even though they have been "cleaned".

Vent hollow castings or containers before heating, cutting or welding. They may explode.

Before welding, the advice of an **expert** should be obtained.

A.10 General protective clothing

Suitable protective, fire-resistant clothing, free from oil or flammable contaminants, as well as suitable eye protection to prevent injuries from flying particles, e.g. slag, fragments from grinding or wire bristles, should be worn (see also A.5.2 and A.5.3).

A.11 Confined spaces

Welding processes are often carried out in confined spaces where there can be a hazard from toxic or asphyxiating gases, e.g. the shielding gas.

When welding is carried out in a confined space, operators should only be permitted to weld when other persons, who have been instructed and who are able to react in case of an emergency, are in the immediate vicinity.

The first and most important step is the assessment of the situation by an **expert**, to determine what steps are necessary to make the job safe and what precautions should be adopted during the actual operation. Typical steps of operation are shown in Figure A.2.

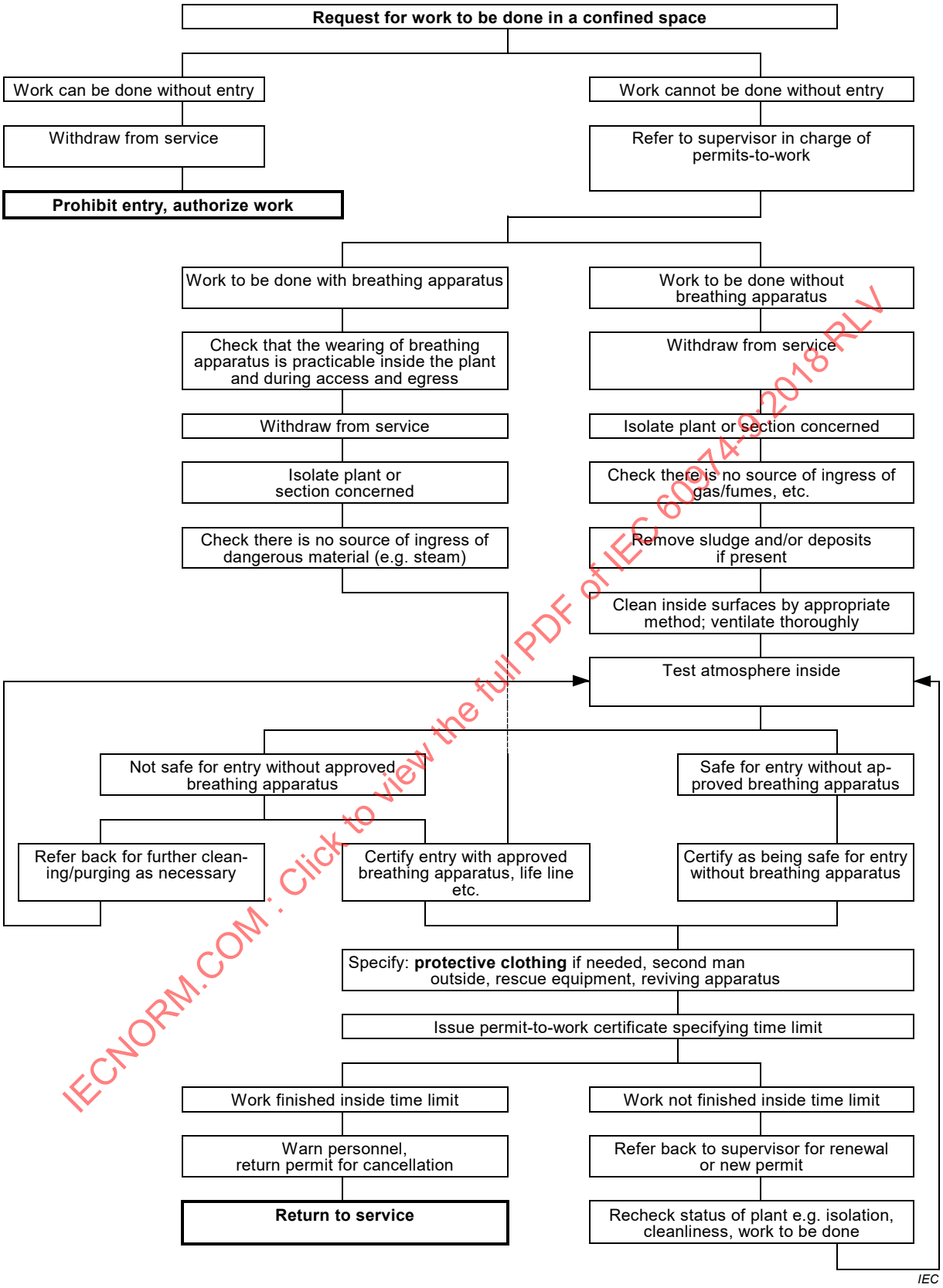


Figure A.2 – Example steps of operation for work in confined spaces

Annex B
(informative)

Voltage drops in the welding circuit

The resistance of the welding cables will introduce voltage drops in the **welding circuit**. If long welding cables are used, this should be taken into account. The Figure B.1 below is shown using MIG/MAG equipment but the principles apply to all welding processes.

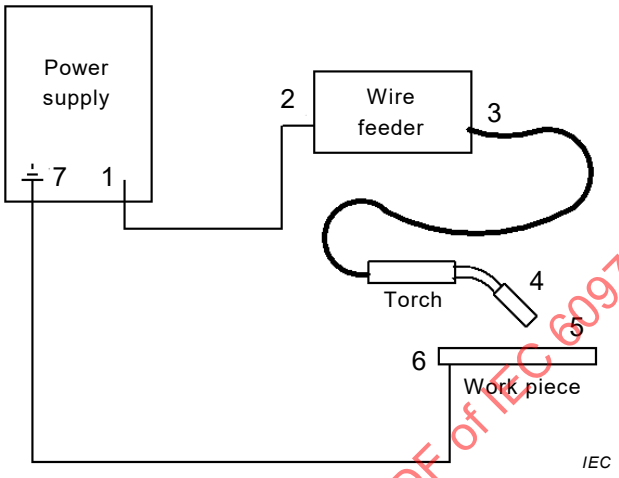


Figure B.1 – Example of MIG/MAG equipment

For example, in the above figure, a voltmeter located on the power supply will normally indicate the potential measured across points 1 to 7. However, this is not ideal for applying the specified weld procedure variables because there are voltage drops in sections 1 to 2, 3 to 4, and 6 to 7 that will vary with welding current, cable diameter, length and temperature.

Problems may arise if these values are used for production welding relying on a power supply voltmeter measuring the potential across points 1 to 7. This is mainly due to the voltage drops in welding cables between points 1 to 2 and 6 to 7.

The voltage drop in a welding cable is proportional to the amount of current flowing through it and can be estimated using Table B.1.

Table B.1 – Voltage drop in copper and aluminium welding cables at normal and elevated temperatures

Nominal cross-sectional area of conductor mm^2	DC [a] Voltage drop / 100 A / 10 m of cable at various temperatures					
	Copper conductors			Aluminium conductors		
	20 °C	60 °C	85 °C	20 °C	60 °C	85 °C
10	1,950	2,260	2,450	-	-	-
16	1,240	1,430	1,560	-	-	-
25	0,795	0,920	0,998	1,248	1,450	1,580
35	0,565	0,654	0,709	0,886	1,030	1,120
50	0,393	0,455	0,493	0,616	0,715	0,778
70	0,277	0,321	0,348	0,440	0,511	0,555
95	0,210	0,243	0,264	0,326	0,379	0,411
120	0,164	0,190	0,206	0,254	0,295	0,321
150	0,132	0,153	0,166	0,208	0,242	0,263
185	0,108	0,125	0,136	-	-	-
240	-	-	-	0,126	0,146	0,159

[a] The corresponding values when using AC ~~may~~ can be much higher, depending on the configuration of the cables.

Bibliography

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

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60974-2, *Arc welding equipment – Part 2: Liquid cooling systems*

IEC 60974-3, *Arc welding equipment – Part 3: Arc striking and stabilizing devices*

IEC 60974-5:~~2007~~ 2013, *Arc welding equipment – Part 5: Wire feeders*

IEC 60974-6:2015, *Arc welding equipment – Part 6: Limited duty equipment*

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

IEC 60974-8, *Arc welding equipment – Part 8: Gas consoles for welding and plasma cutting systems*

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

IEC 61008 (all parts), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)*

IEC 61009 (all parts), *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*

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

IEC 62822-1:2016, *Electric welding equipment – Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz) – Part 1: Product family standard Welding clamp*

ISO 4850, *Personal eye-protectors for welding and related techniques – Filters – Utilisation and transmittance requirements*

ISO 11611, *Protective clothing for use in welding and allied processes*

EN 50525-2-21, *Electric cables – Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U) – Part 2-21: Cables for general applications – Flexible cables with crosslinked elastomeric insulation*

EN 50565-1:2014, *Electric cables – Guide to use for cables with a rated voltage not exceeding 450/750 V (U0/U) – Part 1: General guidance*

CSA C22.1, *Canadian electrical code*

NFPA 70, *National Electrical code*

International Civil Aviation Organization (ICAO) Doc 9284, *Technical Instructions for the Safe Transport of Dangerous Goods by Air (https://www.icao.int/publications/Pages/doc-series.aspx)*

International Air Transport Association (IATA) DGR, *Dangerous Goods Regulations (https://www.iata.org/publications/dgr/pages/index.aspx)*

International Maritime Organisation (IMO) IMDG Code, *International Maritime Dangerous Goods Code (http://www.imo.org/en/Publications/IMDGCode/Pages/Default.aspx)*

Electronic Code of Federal Regulations (e-CFR) HMR, *Hazardous Materials Regulations; Title 49 CFR PARTS 171-180 (https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49tab_02.tpl)*

IEC 60974-9

Edition 2.0 2018-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Arc welding equipment – Part 9: Installation and use

Matériel de soudage à l'arc – Partie 9: Installation et utilisation

IEC 60974-9:2018-04(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ARC WELDING EQUIPMENT –

Part 9: Installation and use

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60974-9 has been prepared by IEC technical committee 26: Electric welding.

This standard cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

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

a) addition of a new Clause 8;

b) addition of interpolation details in Table 1.

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

FDIS	Report on voting
26/648/FDIS	26/649/RVD

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

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

In this standard, the following print types are used:

– terms defined in Clause 3: in **bold** type.

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

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

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

ARC WELDING EQUIPMENT –

Part 9: Installation and use

1 Scope

This document is applicable to requirements for installation and instructions for use of equipment for arc welding and allied processes designed in accordance with safety requirements of IEC 60974-1, IEC 60974-6 or equivalent.

This document is applicable for the guidance of instructors, operators, welders, managers, and supervisors in the safe installation and use of equipment for arc welding and allied processes and the safe performance of welding and cutting operations.

National and local regulations take precedence over this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60755, *General requirements for residual current operated protective devices*

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

IEC 60974-4, *Arc welding equipment – Part 4: Periodic inspection and testing*

IEC 60974-11, *Arc welding equipment – Part 11: Electrode holders*

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

IEC 60974-13, *Arc welding equipment – Part 13: Welding clamp*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1
welding circuit
conductive material through which the welding current is intended to flow

Note 1 to entry: In arc welding, the arc is a part of the **welding circuit**.

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

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

3.2
extraneous conductive part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the earth potential

Note 1 to entry: Electrical installation includes the **welding circuit**.

[SOURCE: IEC 60050-851:2008, 851-14-57]

3.3
workpiece
metal piece or pieces on which welding or allied processes are performed

[SOURCE: IEC 60050-851:2008, 851-11-19]

3.4
protective clothing
protective accessories
protective clothing and accessories (e.g. gloves, hand shields, head masks and filter lenses) used in order to diminish electric shock risks and the effects of fume and spatter and to protect the skin and eyes against arc radiation

[SOURCE: IEC 60050-851:2008, 851-11-18]

3.5
environment with increased risk of electric shock
environment where the hazard of electric shock by arc welding is increased in relation to normal arc welding conditions

Note 1 to entry: Such environments are found for example

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

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

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

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

[SOURCE: IEC 60050-851:2008, 851-15-09]

3.6
expert
competent person
skilled person
person who can judge the work assigned and recognize possible hazards on the basis of professional training, knowledge, experience and knowledge of the relevant equipment

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

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

3.7
wire feeder
equipment that delivers filler wire to the arc or weld zone which includes means to apply motion to the filler wire

Note 1 to entry: The **wire feeder** may also include the wire-feed control, the filler wire supply, devices for gas control, indicators and remote connectors.

[SOURCE: IEC 60050-851:2008, 851-14-39]

4 Installation

4.1 General

Welding equipment used in arc welding installations shall be intended for the purpose as given on the rating plate.

Electromagnetic compatibility (EMC) requirements shall be taken into consideration during installation, see Clause 5.

The requirements of national and local regulations shall be taken into consideration during installation, including grounding or protective earth connections, fuses, supply disconnecting device, type of supply circuit, etc.

Read the manufacturer's instruction manual before installing the equipment. Full use shall be made of the technical information relevant to the welding equipment.

Specific advice may be obtained from the welding equipment manufacturer, if necessary.

4.2 Supply circuit

4.2.1 Selection of supply cables

Supply cables for welding equipment and their overload protection, if not provided by the manufacturer, shall be selected in accordance with the information given in the manufacturer's instruction manual.

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

Supply cables shall be placed so that they cannot be damaged in use. If that cannot be achieved, a residual current device (RCD), capable of operating at a leakage current not exceeding 30 mA in accordance with IEC 60755, shall be used to reduce the risk of electric shock.

4.2.2 Supply disconnecting device

The installer shall ensure that a supply disconnecting device is fitted at the point of supply.

NOTE A plug can be used as supply disconnecting device in accordance with national or local regulation.

4.2.3 Emergency stopping device

When an emergency stopping device is required by a national regulation (e.g. automatic welding equipment), it shall conform to the relevant IEC standard.

For welding in an **environment with increased risk of electric shock**, see 7.10.

4.3 Welding circuit

4.3.1 Isolation from the input supply

The **welding circuit** and circuits electrically connected to the **welding circuit** shall be electrically isolated from the mains supply.

Verification shall be carried out by an **expert**.

4.3.2 Summation of no-load voltages

If more than one welding power source is in use at the same time, their no-load voltages can be cumulative and could create an increased hazard of electric shock. Welding power sources shall be installed so as to minimize this risk. Guidance is given in 7.9.

NOTE In the case of two welding transformers connected to the same lines, the resulting output voltage can be the sum of both no-load voltages. This can be avoided by using a suitable input or output connection (see 7.9).

Where more than one welding power source is installed, individual welding power sources with their separate controls and connections should be clearly identified to show which items belong to any one **welding circuit**.

4.3.3 Welding cables

Welding cables shall comply with IEC 60245-6. Copper conductor welding cables shall be selected in accordance with the duty cycle and national regulations or, when inexistant, the current rating given in Table 1. Where long cable runs are involved, it can be necessary to choose the cable size on the basis of voltage drop, see Annex B.

Table 1 – Current ratings for copper welding cables

Nominal cross-sectional area[b]	Current ratings for specified duty cycle at an ambient temperature of 25 °C[a]						
	100 %	85 %	80 %	60 %	35 %	20 %	8 %
mm^2	A	A	A	A	A	A	A
10	100	100	100	101	106	118	158
16	135	136	136	139	150	174	243
25	180	182	183	190	213	254	366
35	225	229	231	243	279	338	497
50	285	293	296	316	371	457	681
70	355	367	373	403	482	602	908
95	430	448	456	498	606	765	1 164
120	500	524	534	587	721	917	1 404
150	580	610	622	689	853	1 090	1 676
185	665	702	717	797	995	1 277	1 971

[a] For higher ambient temperatures, a correction factor shall be applied:
0,96 (30 °C); 0,91 (35 °C); 0,87 (40 °C); 0,82 (45 °C). No interpolation is allowed for duty cycle values.

[b] For intermediate values of nominal cross-section areas, interpolation is allowed.

NOTE Table originates from EN 50565-1:2014.

4.3.4 Connection between the welding power source and the workpiece

When the welding current does not flow entirely in the **welding circuit**, stray currents, which are components of the welding current, occur. These can cause damage to electrical systems of buildings and to other sensitive systems in buildings and can be minimized by the following means:

a) the electrical connection between the welding power source and the **workpieces** shall be made as direct as practicable by means of an insulated return cable having an adequate current-carrying capacity;

b) **extraneous conductive parts**, such as metal rails, pipes and frames shall not be used as part of the **welding circuit**, unless they constitute the **workpiece** itself;

c) the welding clamp shall be as near as practicable to the welding arc;

d) the welding clamp disconnected from the **workpiece** shall be electrically isolated from parts connected to earth, e.g. metallic enclosures with protective earth connection (class I), metal floors, building services;

NOTE 1 The welding clamp can cause an electrical shock when welding current is flowing or when the electrode circuit is in contact with the electrical ground circuit or work piece.

e) the **welding circuit** shall not be earthed unless required by national or local regulations (see 4.3.5);

f) connection of the return cable to the **workpiece** shall be ensured by the use of devices having suitable means for cable connection, a fastening system not liable to come loose accidentally, and good electrical contact. Magnetic devices only present a good electrical contact if the contact surfaces of the magnetic device and the contact area of the **workpiece** are sufficiently large, even, conductive and clean (e.g. free from rust and primer) and if the contact area of the **workpiece** is magnetic;

NOTE 2 If **workpieces** are on a welding bench or a work-handling device, the return cable can be connected to the bench or the device.

g) connection devices for non-stationary flexible welding cables in the **welding circuit** shall:

1) have an adequate covering of insulating material to prevent inadvertent contact with live parts, when connected, with the exception of the welding clamp at the **workpiece** itself;
2) be suitable for the sizes of cables used and the welding current;
3) be effectively connected to the welding cables and in good electrical contact with them.

h) Welding, control and mains cables shall be protected from spatter and heat to prohibit unintentional damage to the insulation.

Both the welding cable and the connection device shall be used within their specified current rating. The connection device shall not be fitted with a cable smaller in diameter than specified by the manufacturer of the connection device.

When coupling devices or welding clamps are used, they shall comply with IEC 60974-12 or IEC 60974-13, respectively.

4.3.5 Earthing of the workpiece

The **welding circuit** should not be earthed, since it can increase the risk of stray welding currents (see 4.3.3). Earthing of the **welding circuit** can also increase the area of metal through which a person in contact with the **welding circuit** (e.g. the welding electrode) could receive an electric shock.

NOTE 1 There are **workpieces** that have an inherent connection to earth, e.g. steel structures, ships, pipelines. When these are welded, the possibility of stray currents is increased.

NOTE 2 In some cases, the **workpiece** can be in permanent contact with earth, e.g. with protection class I equipment which itself has protective conductors connected to earth. Such a **workpiece** is considered to be inherently connected to earth.

An assessment of the **welding circuit** and the welding area shall be made to ensure that a stray welding current will not flow through any object connected to earth that is not intended or capable of carrying the welding current (e.g. protective earth connection).

If electrical hand tools are used that could come into contact with the **workpiece**, then those tools shall be class II equipment (i.e. with double or reinforced insulation without protective earth connection).

If earthing is required by national or local regulations, the earth connection shall be made by a separate dedicated cable or conductor with a rating of at least that of the return cable and connected directly to the **workpiece**.

Precautions shall be taken to insulate the operator from earth as well as from the **workpiece** (see 7.7.2).

Where external radio frequency noise suppression networks are connected to the **welding circuit**, an **expert** shall assess whether the **welding circuit** can still be regarded as insulated from earth.

NOTE 3 External radio frequency noise suppression networks could consist of a number of different components, for example, LCR filters (inductance/capacitance/resistance).

4.3.6 Location of gas cylinders

Care shall be taken to prevent gas cylinders in the vicinity of the **workpiece** from becoming part of the **welding circuit**.

5 Electromagnetic compatibility (EMC)

5.1 General

The user is responsible for installing and using the arc welding equipment in accordance with the manufacturer's instructions. If electromagnetic disturbances are detected, then it shall be the responsibility of the user of the arc welding equipment to resolve the situation with the technical assistance of the manufacturer.

5.2 Assessment of area

Before installing arc welding equipment, the user shall make an assessment of potential electromagnetic interferences in the surrounding area. The following shall be taken into account:

a) other supply cables, control cables, signalling and telephone cables, above, below and adjacent to the arc welding equipment;

b) radio and television transmitters and receivers;

c) computer and other control equipment;

d) safety-critical equipment, for example, guarding of industrial equipment;

e) the health of the people around, for example, the use of wearable medical devices and implants;

f) equipment used for calibration or measurement;

g) the immunity of other equipment in the environment. The user shall ensure that other equipment being used in the environment is compatible. This can require additional protection measures;

h) the time of day that welding or other activities are to be carried out.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area can extend beyond the boundaries of the premises.

5.3 Methods of reducing emissions

5.3.1 Public supply system

The arc-welding equipment shall be connected to the public supply system in accordance with the manufacturer's recommendations. If interference occurs, it can be necessary to take additional precautions, such as filtering of the supply system. Consideration shall be given to shielding the supply cable of permanently installed arc-welding equipment, in a metallic conduit or equivalent. Shielding shall be electrically continuous throughout its length. The shielding shall be connected to the welding power source so that good electrical contact is maintained between the conduit and the welding power source enclosure.

5.3.2 Maintenance of arc-welding equipment

The arc-welding equipment shall be routinely maintained in accordance with IEC 60974-4 and the manufacturer's instructions. All access and service doors and covers shall be closed and properly fastened when the arc-welding equipment is in operation. The arc-welding equipment shall not be modified in any way, except for those changes and adjustments covered in the manufacturer's instructions. In particular, the spark gaps of arc striking and stabilising devices shall be adjusted and maintained in accordance with the manufacturer's instructions.

5.3.3 Welding cables

The welding cables shall be kept as short as possible and shall be positioned as close as possible to each other, running at or close to the floor level. The welding cables shall never be coiled during welding.

5.3.4 Equipotential bonding

Bonding of all metallic objects in the surrounding area should be considered for the purpose of reducing emissions. However, metallic objects bonded to the **workpiece** will increase the risk that the operator could receive an electric shock by touching these metallic objects and the electrode at the same time. The operator shall be insulated from all such bonded metallic objects.

5.3.5 Earthing of the workpiece

Where the **workpiece** is not bonded to earth for electrical safety, a connection bonding the **workpiece** to earth can reduce emissions in some, but not all instances. Care should be taken to prevent the earthing of the **workpiece** increasing the risk of injury to users, or damage to other electrical equipment. Where necessary, the connection of the **workpiece** to earth should be made by a direct connection to the **workpiece**, but in some countries where direct connection is not permitted, the bonding should be achieved by suitable capacitance, selected in accordance with national and local regulations.

5.3.6 Screening and shielding

Selective screening and shielding of other cables and equipment in the surrounding area can alleviate problems of interference. Screening of the entire welding area may be considered for special applications.

6 Electromagnetic fields (EMF)

6.1 General

Electric current flowing through any conductor causes localized electric and magnetic fields (EMF). All welders should use the following procedures in order to minimize the risk associated with exposure to EMFs from the **welding circuit**:

– route the welding cables together – secure them with tape when possible;
– place your body as far away as possible from the **welding circuit**;
– never coil welding cables around your body;
– do not place your body between welding cables. Keep both welding cables on the same side of your body;
– connect the return cable to the **workpiece** as close as possible to the area being welded;
– do not work next to, sit or lean on the welding power source;
– do not weld whilst carrying the welding power source or **wire feeder**.

EMFs can also interfere with wearable medical devices and implants. Protective measures for persons with wearable medical devices and implants shall be taken. For example, access restrictions for passers-by or individual risk-evaluations for welders. Risk assessment and recommendation for users of wearable medical devices and implants shall be made by a medical expert.

6.2 Assessment of exposure

When arc-welding equipment is configured an assessment of potential effects of electromagnetic fields in the surrounding area shall be done. The following shall be taken into account:

a) the datasheet regarding EMFs and special instructions in the user manual of the arc-welding equipment;

b) busbars and other conductors carrying high voltages and/or currents;

c) other equipment generating high field strengths;

d) the health of the people around, for example the use of pacemakers and hearing aids.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area can extend beyond the boundaries of the premises.

7 Use

7.1 General requirements

User shall ensure that arc-welding equipment and accessories conform to the relevant parts of IEC 60974, see Clause 2, as given on the rating plate. These documents contain necessary information for health and safety to be included in instructions and manuals.

Before welding equipment is put into service, the user shall read and understand the instructions provided by the manufacturer, national or local regulation, trade association and occupational recommendations, national health and safety recommendations.

Consideration shall be given to the environment in which the welding equipment is used as additional precautions can need to be taken e.g. increased hazard of electric shock; confined spaces; flammable area, asphyxiation (further references to specific hazards, see Annex A).

7.2 Connection between several welding power sources

If welding power sources are to be connected in parallel or in series, this shall be carried out by an **expert** and in accordance with the manufacturer's recommendations. The equipment shall be approved for arc-welding operations only after a check has been carried out to ensure that the permissible no-load voltage cannot be exceeded.

When one welding power source connected in parallel or series is taken out of service, that power source shall be disconnected from the mains supply and from the **welding circuit**, so as to prevent any hazards that might be caused by feedback voltages.

7.3 Inspection and maintenance of the welding installation

7.3.1 Periodical inspection

On installation, and periodically thereafter, an **expert** nominated for the task shall check that the welding equipment has been correctly selected and connected for the work to be carried out in accordance with IEC 60974-4 and the manufacturer's instructions and that all connections are clean and tight and the welding equipment is in good condition.

In addition, all protective earthing shall be checked for effectiveness. Any defects found shall be repaired.

7.3.2 Routine inspection

The operator shall be instructed to check all external connections daily and each time a reconnection is made. Particular attention shall be paid to the installation of supply and welding cables, electrode holders and coupling devices. Any defects found shall be reported, and faulty equipment shall not be used until it has been repaired.

The welding clamp shall be connected directly to the **workpiece** as close as practicable to the point of welding or to the welding bench on which the **workpiece** is situated or to the work-handling device.

For plasma cutting the no-load voltages are higher than with welding. This shall be considered during inspection and maintenance procedures. Particular attention shall be paid to the watercooling equipment to ensure that any leaks do not affect the insulation.

Before carrying out arc welding on equipment having associated transformers (e.g. arc furnaces), such transformers shall be isolated to avoid the hazard of shock from induced voltages on the input side of the transformer.

7.4 Disconnection of welding power sources and/or welding circuits

If the supply cable or the welding cables are liable to damage when the welding power source is moved to another location, that power source, including its cables, shall be disconnected before it is moved.

When maintenance or repair work is carried out on the welding equipment, the input and output shall be disconnected.

7.5 Guards

Guards and removable parts of the enclosure shall be in position before the welding equipment is energised.

7.6 Information for operators

Operators and their assistants shall be trained in the safe use of equipment. Operators and persons working in the vicinity of the welding operation shall be warned of the hazards and informed about protective measures concerning arc processes (see Annex A).

The operator shall prevent gas cylinders in the vicinity of the **workpiece** from becoming part of the **welding circuit**.

7.7 Protective measures

7.7.1 Extraneous conductive parts in the welding area

With respect to **extraneous conductive parts**,

a) persons shall be aware of such parts, see 3.2;

b) care shall be taken to minimize the extent of such parts;

c) torches and electrode holders shall be kept insulated from **extraneous conductive parts** in the welding area.

7.7.2 Protection against electric shock

The operator shall take precautions to be insulated from the electrode, the **workpiece** and conductive parts in contact with earth in the vicinity. This can normally be achieved with dry

gloves, clothing, head gear, footwear, dry boards and insulating mats or similar in good condition. An **expert** shall assess whether the proposed insulation method is suitable.

NOTE An operator who comes into direct contact with both terminals of the welding power source, or conductors connected to them, can experience an electric shock. Under some circumstances, the electric shock can be severe enough to cause injury or death.

7.8 Isolation of the welding circuit from the workpiece and earth when not in use

When not in use (e.g. during lunch or changing shift), electrode holders and torch circuits shall, where practicable, be switched off at the welding power source; if this is not possible, they shall be kept isolated and/or be insulated, without contact with the **workpiece** or other conductive parts, especially the welding power source enclosures. Manual metal arc-welding electrodes shall be removed from the electrode holder when the welding operation has been completed. If applicable, the shielding gas supply shall be closed.

The operator shall ensure that the welding clamp is either connected to the **workpiece** or stored isolated from earth or any conductive part.

7.9 Voltage between electrode holders or torches

When working with several welding power sources on a single **workpiece** or on conductively connected **workpieces**, a hazardous sum of no-load voltages may arise between two electrode holders or torches. This may reach twice the value of the admissible no-load voltage (see also 4.3.2).

The instructed person who is co-ordinating the welding tasks shall ensure that a measuring device is used to determine whether there is a hazard.

Operators shall:

– be warned of this hazard;

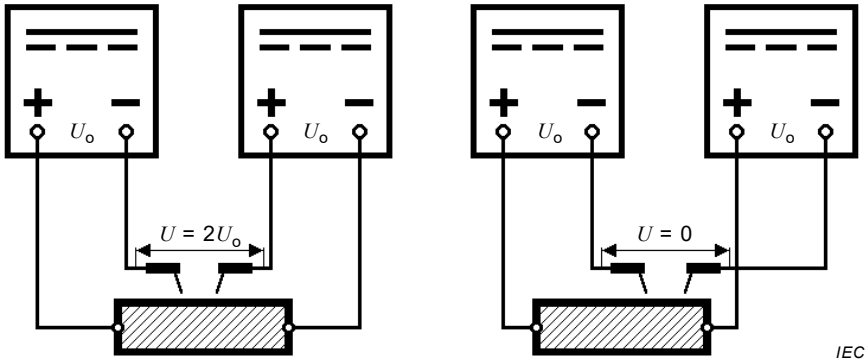
– never touch two electrode holders or torches at the same time;

– work out of reach of each other, where practicable.

The following examples show schematically the influence that the connection to the mains supply and the polarity for welding may have on the sum of welding voltages between electrode holders or torches. It is assumed that the no-load voltages for each welding power source are identical but in practice they can differ (see items a) to c) below).

a) Direct current

The connections to the mains supply have no influence on the sum of no-load voltages. The voltage U depends on the polarity of the output connections (see Figure 1).



NOTE The polarity for welding depends on the welding process.

Figure 1 – Example of DC voltage between electrode holders or torches

b) Alternating current single-phase welding power sources

The connections to the mains supply and the output connections will influence the sum U of the no-load voltages (see Figure 2).

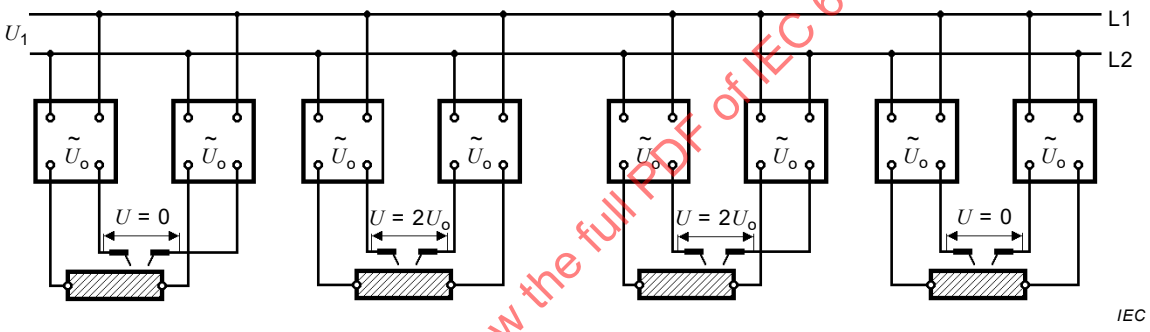
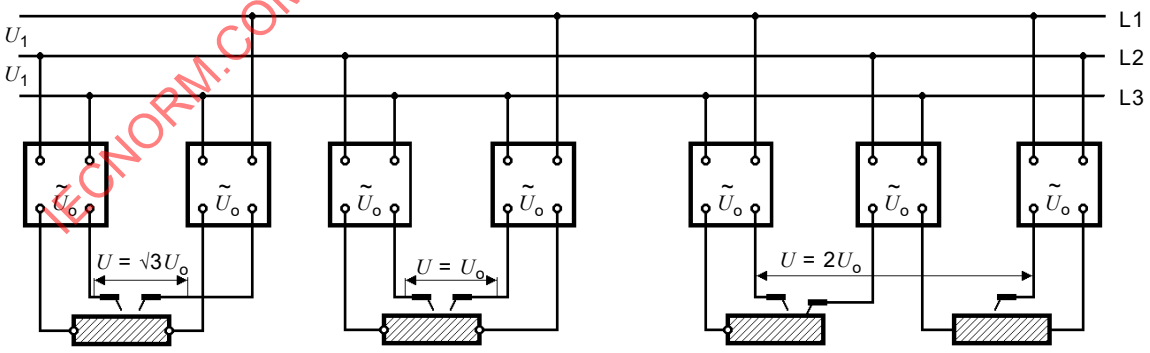


Figure 2 – Example of AC voltage between electrode holders or torches – Single-phase supply from the same pair of lines of a three-phase mains supply

If the connections to a three-phase mains supply are made across different pairs of lines, the sum U of the no-load voltages will always be greater than zero (see Figure 3).



NOTE Unconnected work pieces. The middle electrode is accidentally in contact with the other work piece.

Figure 3 – Example of AC voltage between electrode holders or torches – Single-phase supply from different pairs of lines of a three-phase mains supply

Increased AC voltages can be avoided by reversing

– the welding cable connections, preferably by an **expert**, or

– the mains supply connections to the welding power source (see 4.3.2).

c) Alternating current three-phase multi-operator welding transformer

The connections to the mains supply have no influence on the sum U of the no-load voltages (see Figure 4).

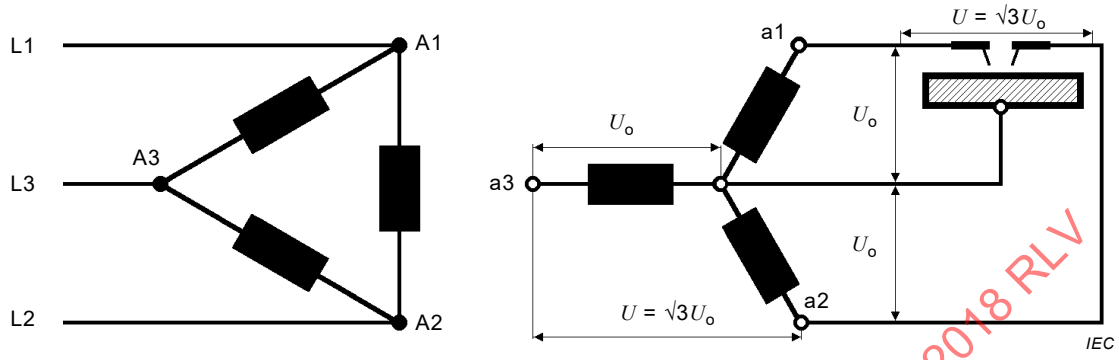


Figure 4 – Example of AC voltage between electrode holders connected between different lines of output

7.10 Welding in an environment with increased risk of electric shock

When welding is carried out in an **environment with increased risk of electric shock**, means for electrically disconnecting the welding power source or the **welding circuit** quickly shall be provided within easy access (e.g. emergency stopping device).

The following precautions shall be taken to reduce the risk of an electric shock from the voltage between the welding electrode and earth:

a) if possible, the welding power source shall not be taken into the **environment with increased risk of electric shock**. If not possible, the welding power source shall be supplied by an insulating transformer;

b) the welding power source shall be out of normal reach of the operator during welding. Additional protection against a shock from current from the mains supply under fault conditions may be provided by the use of a residual current circuit breaker that is capable of operating at a leakage current not exceeding 30 mA and feeds all mains-powered equipment in the vicinity. The residual current circuit breaker shall be sensitive to all types of current;

c) only remote controls supplied with the protective measure "safety extra low voltage" in accordance with IEC 60974-1 shall be used;

d) only welding power sources and welding equipment suitable for use in **environments with increased risk of electric shock** shall be used. Where appropriate, voltage-reducing devices shall be used;

NOTE 1 This is verified by an **expert** unless the welding power source is marked with the symbol S (see IEC 60974-1).

e) electrode holders shall conform to IEC 60974-11, i.e. to type A;

f) insulating platforms or mats shall be used.

NOTE 2 Attention is drawn to the requirements concerning **protective clothing**, headgear and **protective accessories** in 7.7.2.

7.11 Use of shoulder slings

Welding shall not be carried out whilst carrying the welding power source, or **wire feeder**, for example by a shoulder sling. This is to prevent

a) the risk of loss of balance if any connected cables or hoses are pulled;

b) an increased risk of electric shock as the operator will be in contact with earth if using a class I welding power source whose enclosure is earthed by its protective earth conductor.

7.12 Welding at elevated positions

Welding from elevated positions should be avoided if possible, for example from a ladder, since even a minor electric shock can result in a fall.

Appropriate precautions shall be taken, for example by using a safe working platform.

NOTE A metal ladder or scaffolding can create an **environment with increased risk of electric shock** (see 3.5 and 7.10).

7.13 Welding with suspended welding equipment

For practical reasons, welding equipment may be suspended over the welding area. To avoid stray current, the hanging means shall be insulated. Precautions shall be taken to avoid the risk of falling objects (for example the filler wire spool).

8 Battery-powered welding power sources

8.1 Safety recommendations

In addition to Clause 7, the safety recommendations in the instructions of use of the equipment shall be respected. Special attention shall be given in charging of the battery.

Battery-powered welding power sources can operate without connection to the supply network, therefore measures against unintentional operation shall be followed as specified in the instructions for use.

8.2 Transportation

Batteries can be classified as dangerous goods. International and local transportation regulations shall be respected.

NOTE Transporting dangerous goods is regulated internationally by the International Civil Aviation Organization (ICAO), Technical Instructions and corresponding International Air Transport Association (IATA) Dangerous Goods Regulations and the International Maritime Dangerous Goods (IMDG) Code. In the United States, transportation of these batteries is regulated by the Hazardous Materials Regulations (HMR), which is found at Title 49 of the Code of Federal Regulations, Sections 100-185. All of these regulations that govern the transport of rechargeable lithium ion (including lithium ion polymer) cells and batteries (which are classified dangerous goods) are based on the UN Recommendations on the Transport of Dangerous Goods Model Regulations. All energy storage systems (ESS), or components thereof, containing lithium ion chemistry meet the test criteria set forth in the UN "Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria", chapter 38.3 (known as UN 38.3) in order to be shipped in PG II packaging.

Annex A
(informative)

Hazards associated with arc welding

A.1 General

Welding operators and persons working in the vicinity of the welding process should be made aware of the following hazards associated with arc welding. They should be made aware of protective measures as specified in relevant international and national standards and regulations.

A.2 Equipment condition and maintenance

All equipment should be kept in good working condition, inspected and, when defective, promptly repaired or withdrawn from service.

Gas cylinders should be located or secured so that they cannot be knocked over or come in contact with the **welding circuit**.

A.3 Operation

All equipment should be placed so that it does not present a hazard in passageways, on ladders or stairways, and should be operated in accordance with the manufacturer's instructions.

Welding equipment may be heavy (e.g. **wire feeder** fitted with spool and harness). Care shall be taken during manual handling.

A.4 Training

For operators and their supervisors, training is essential in

– the safe use of the equipment;
– the processes;
– the emergency procedures.

A.5 Arc radiation

A.5.1 General

The arc generates

– ultraviolet radiation (can damage skin and eyes);
– visible light (can dazzle eyes and impair vision);
– infrared (heat) radiation (can damage skin and eyes).

Such radiation can be direct or reflected from surfaces such as bright metals and light-coloured objects.

A.5.2 Eye and face protection (see also A.9)

The face and eyes should be protected by suitable welding shields equipped with appropriate ocular protection filters in accordance with ISO 4850.

A.5.3 Body protection (see also A.9)

The body should be protected by suitable clothing in accordance with ISO 11611.

The use of neck protection can be necessary against reflected radiation.

A.5.4 Protection of persons in the vicinity of an arc

In the vicinity of an arc, non-reflective curtains or screens should be used to isolate persons from the arc radiation. A warning, for example a symbol for eye protection, should refer to the hazard of arc optical radiation.

A.6 EMF

A.6.1 General

The welding power source generates currents leading to magnetic fields in the vicinity of the welding cable and the **workpiece**.

Additionally, arc striking and stabilizing devices can introduce high-voltage impulses leading to increased electric field strengths.

Metal objects and the **workpiece** itself affect the resulting fields.

The EMF exposure data that results from the application of IEC 62822-1 can be used to assist in workplace assessment.

A.6.2 Body protection

Due to the physical properties of the magnetic field introduced by the welding current, personal protection devices are not feasible.

Small increases of the distance between the body and the welding cable can result in a relatively large reduction of the exposure to the magnetic field.

Further guidance is given in 6.1.

A.6.3 Protection of persons in the vicinity of the welding operation

Due to the physical properties of the magnetic field, the only feasible protection of people is restricted access to the areas with high magnetic field strengths.

A.7 Welding fume

Arc welding and allied processes produce welding fume which may pollute the atmosphere surrounding the work. Welding fume is a varying mixture of airborne gases and fine particles which, if inhaled or swallowed, constitute a health hazard.

The degree of risk will depend on

a) the composition of the fume;

b) the concentration of the fume;

c) the duration of exposure.

A systematic approach to the assessment of exposure is necessary, taking into account the particular circumstances of the operator and the ancillary worker who can be exposed.

Welding fume may be controlled by a wide range of measures, e.g. process modifications, engineering controls, methods of work, personal protection and administrative action (see Figure A.1).

First, it is necessary to consider whether exposure can be prevented by eliminating the generation of welding fume altogether. Where this cannot be done, measures for reducing the quantity of welding fume generated should be investigated, after which the control of welding fume at the source should be considered. The use of respiratory equipment should not be contemplated until all other possibilities have been eliminated. Normally, respiratory protective equipment should be used only as an interim measure. There will, however, be circumstances where, in addition to ventilation measures, the use of personal protection can be necessary.

A.8 Noise

In the welding environment, damaging levels of noise can exist.

Continued exposure to a high noise level on the unprotected ear is injurious. The noise levels should be reduced to the lowest practicable level.

High levels may be tolerated for very short periods of time by wearing adequate ear protection in accordance with the national or local regulations.

In case of doubt, checks by an **expert** should be made to establish noise levels in any particular environment, and, if these are in excess of the prescribed limit, one of the following alternatives may apply:

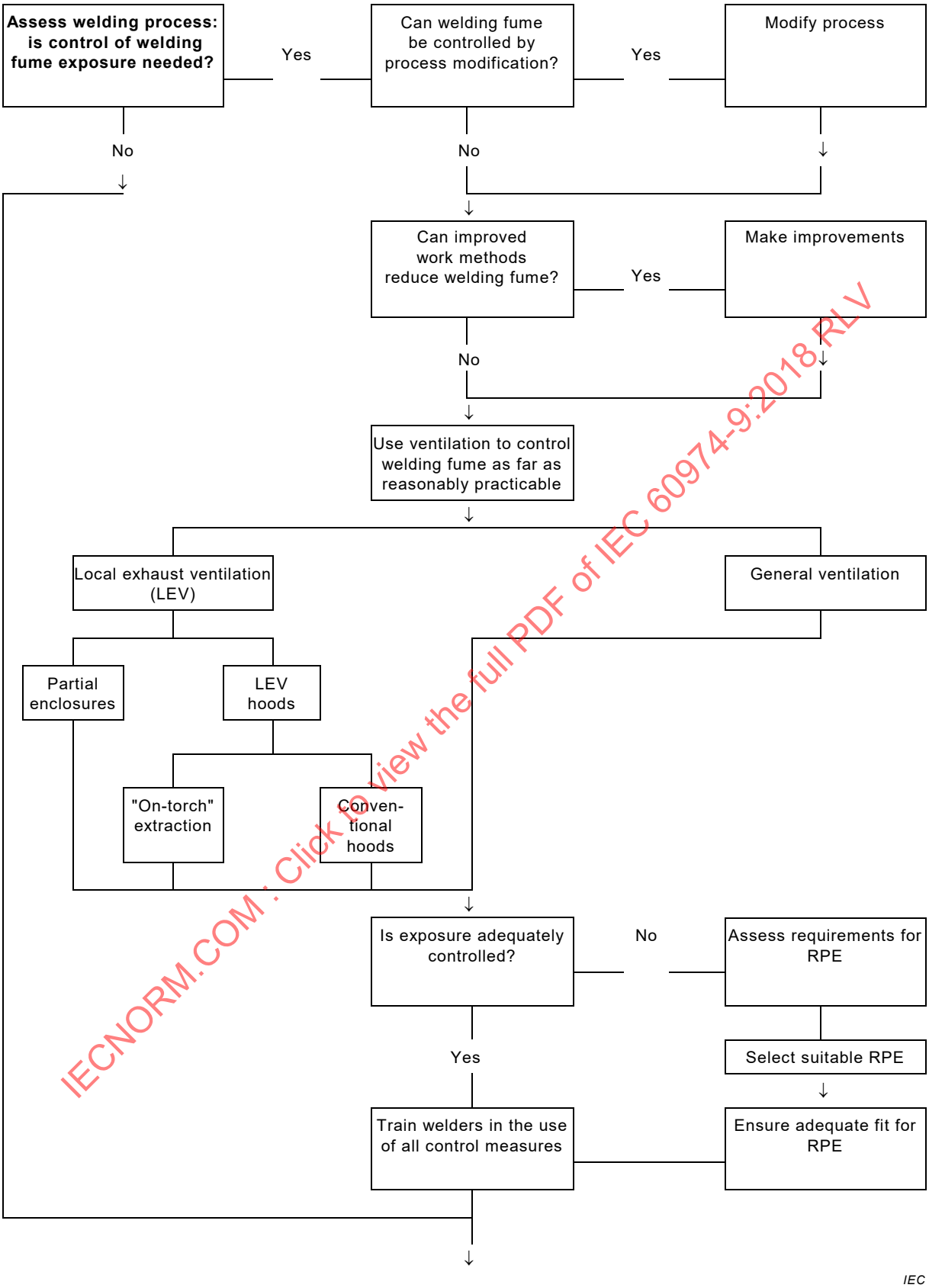
a) insulation of the noise source as far as possible, e.g. by fitting silencers or sound proof enclosures;

b) insulation of the operator from the noise source if more appropriate than a);

c) effective maintenance of sound protection devices;

d) indication as "ear protection areas" where applicable;

e) restriction of entry to these "ear protection areas" to authorized persons wearing suitable ear protection, e.g. ear muffs or plugs.



NOTE RPE = Respiratory protective equipment.

Figure A.1 – Steps for the control of welding fumes

A.9 Fire and explosion

A.9.1 General

Arc welding and allied processes can cause fire and explosions and precautions should be taken to prevent these hazards.

A.9.2 Fire

In order to prevent the risks of fire, flammable material should be removed from the welding area wherever possible. Where this is not possible, the following should be carried out:

a) remaining flammable material should be covered by fire-resistant material, for example in the vicinity of structural material such as wooden beams or floors;

b) the surroundings of the work should be observed for an adequate period after its termination;

c) "hot spots" and their immediate surroundings should be observed until their temperature has dropped to normal;

d) appropriate fire-fighting equipment suitable for the materials used and for use in electrical environments should be available at all times.

A.9.3 Explosion

Do not heat, cut or weld tanks, drums, containers or vacuum equipment until the proper steps have been taken to insure that such procedures will not cause flammable or toxic vapours from substances inside. They can cause an explosion even though they have been "cleaned".

Vent hollow castings or containers before heating, cutting or welding. They may explode.

Before welding, the advice of an **expert** should be obtained.

A.10 General protective clothing

Suitable protective, fire-resistant clothing, free from oil or flammable contaminants, as well as suitable eye protection to prevent injuries from flying particles, e.g. slag, fragments from grinding or wire bristles, should be worn (see also A.5.2 and A.5.3).

A.11 Confined spaces

Welding processes are often carried out in confined spaces where there can be a hazard from toxic or asphyxiating gases, e.g. the shielding gas.

When welding is carried out in a confined space, operators should only be permitted to weld when other persons, who have been instructed and who are able to react in case of an emergency, are in the immediate vicinity.

The first and most important step is the assessment of the situation by an **expert**, to determine what steps are necessary to make the job safe and what precautions should be adopted during the actual operation. Typical steps of operation are shown in Figure A.2.

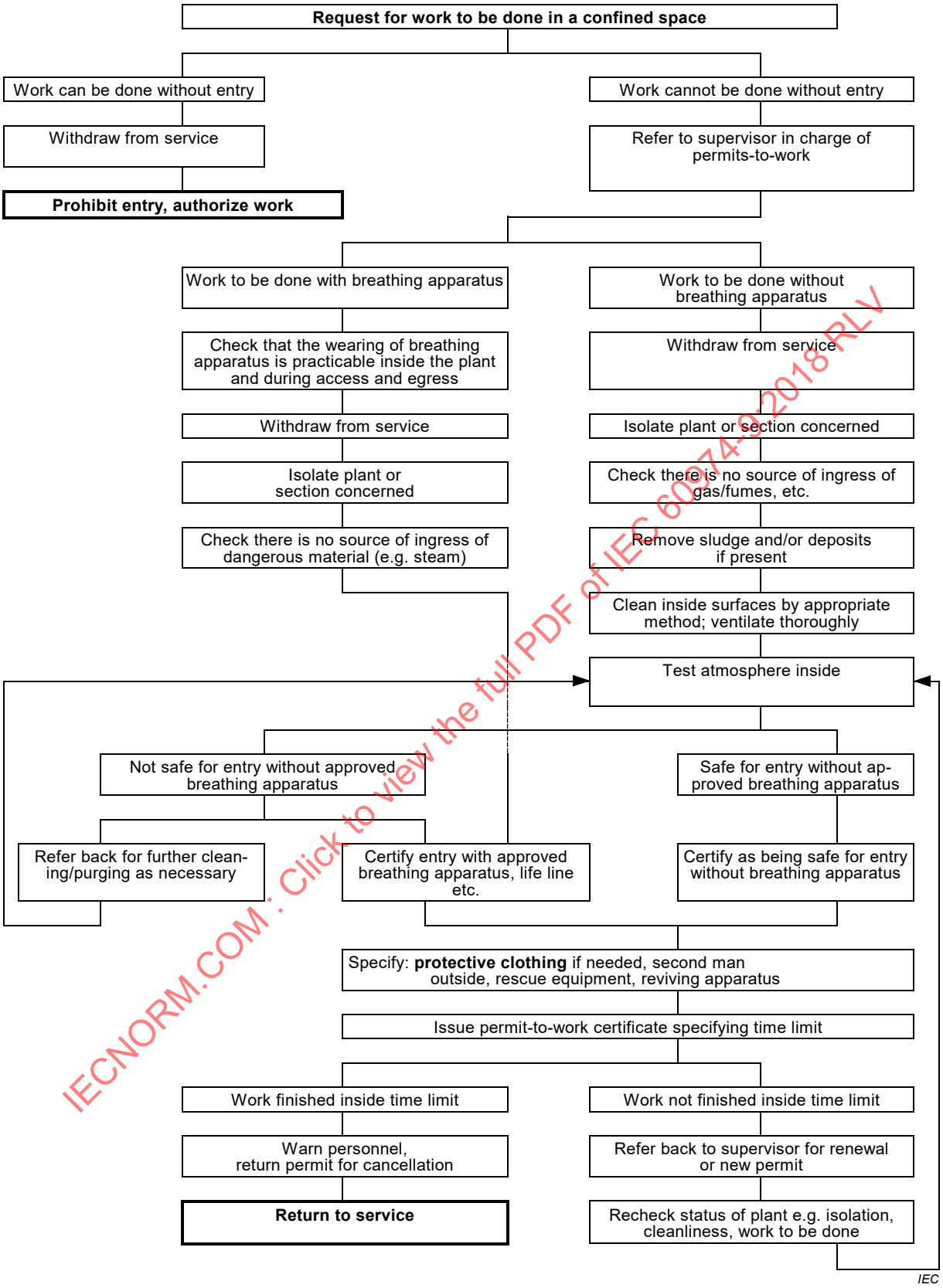


Figure A.2 – Example steps of operation for work in confined spaces

Annex B
(informative)

Voltage drops in the welding circuit

The resistance of the welding cables will introduce voltage drops in the **welding circuit**. If long welding cables are used, this should be taken into account. The Figure B.1 below is shown using MIG/MAG equipment but the principles apply to all welding processes.

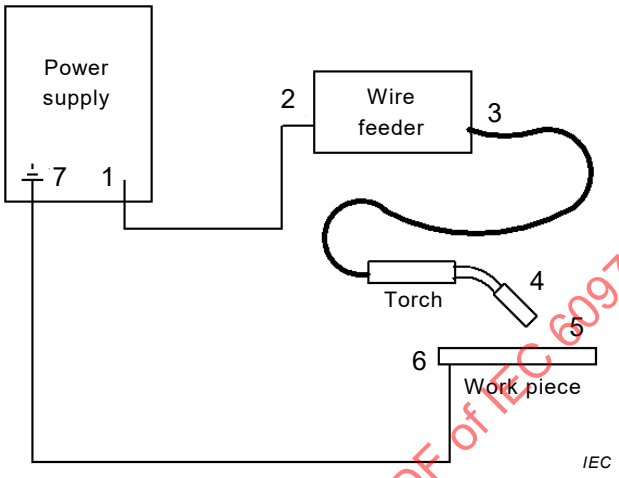


Figure B.1 – Example of MIG/MAG equipment

For example, in the above figure, a voltmeter located on the power supply will normally indicate the potential measured across points 1 to 7. However, this is not ideal for applying the specified weld procedure variables because there are voltage drops in sections 1 to 2, 3 to 4, and 6 to 7 that will vary with welding current, cable diameter, length and temperature.

Problems may arise if these values are used for production welding relying on a power supply voltmeter measuring the potential across points 1 to 7. This is mainly due to the voltage drops in welding cables between points 1 to 2 and 6 to 7.

The voltage drop in a welding cable is proportional to the amount of current flowing through it and can be estimated using Table B.1.

Table B.1 – Voltage drop in copper and aluminium welding cables at normal and elevated temperatures

Nominal cross-sectional area of conductor mm²	DC [a] Voltage drop / 100 A / 10 m of cable at various temperatures					
	Copper conductors			Aluminium conductors		
	20 °C	60 °C	85 °C	20 °C	60 °C	85 °C
10	1,950	2,260	2,450	-	-	-
16	1,240	1,430	1,560	-	-	-
25	0,795	0,920	0,998	1,248	1,450	1,580
35	0,565	0,654	0,709	0,886	1,030	1,120
50	0,393	0,455	0,493	0,616	0,715	0,778
70	0,277	0,321	0,348	0,440	0,511	0,555
95	0,210	0,243	0,264	0,326	0,379	0,411
120	0,164	0,190	0,206	0,254	0,295	0,321
150	0,132	0,153	0,166	0,208	0,242	0,263
185	0,108	0,125	0,136	-	-	-
240	-	-	-	0,126	0,146	0,159

[a] The corresponding values when using AC can be much higher, depending on the configuration of the cables.

Bibliography

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

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60974-2, *Arc welding equipment – Part 2: Liquid cooling systems*

IEC 60974-3, *Arc welding equipment – Part 3: Arc striking and stabilizing devices*

IEC 60974-5:2013, *Arc welding equipment – Part 5: Wire feeders*

IEC 60974-6:2015, *Arc welding equipment – Part 6: Limited duty equipment*

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

IEC 60974-8, *Arc welding equipment – Part 8: Gas consoles for welding and plasma cutting systems*

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

IEC 61008 (all parts), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)*

IEC 61009 (all parts), *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*

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

IEC 62822-1:2016, *Electric welding equipment – Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 GHz) – Part 1: Product family standard Welding clamp*

ISO 4850, *Personal eye-protectors for welding and related techniques – Filters – Utilisation and transmittance requirements*

ISO 11611, *Protective clothing for use in welding and allied processes*

EN 50525-2-21, *Electric cables – Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U) – Part 2-21: Cables for general applications – Flexible cables with crosslinked elastomeric insulation*

EN 50565-1:2014, *Electric cables – Guide to use for cables with a rated voltage not exceeding 450/750 V (U0/U) – Part 1: General guidance*

CSA C22.1, *Canadian electrical code*

NFPA 70, *National Electrical code*

International Civil Aviation Organization (ICAO) Doc 9284, *Technical Instructions for the Safe Transport of Dangerous Goods by Air (https://www.icao.int/publications/Pages/doc-series.aspx)*

International Air Transport Association (IATA) DGR, *Dangerous Goods Regulations (https://www.iata.org/publications/dgr/pages/index.aspx)*

International Maritime Organisation (IMO) IMDG Code, *International Maritime Dangerous Goods Code (http://www.imo.org/en/Publications/IMDGCode/Pages/Default.aspx)*

Electronic Code of Federal Regulations (e-CFR) HMR, *Hazardous Materials Regulations; Title 49 CFR PARTS 171-180 (https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49tab_02.tpl)*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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MATÉRIEL DE SOUDAGE À L'ARC –

Partie 9: Installation et utilisation

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La norme internationale IEC 60974-9 a été établie par le Comité d'études 26 de l'IEC: Soudage électrique.

La présente norme annule et remplace la première édition parue en 2010. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) ajout d'un nouvel Article 8;
b) ajout de détails relatifs à l'interpolation au Tableau 1.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
26/648/FDIS	26/649/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Dans la présente norme, les caractères d'imprimerie suivants sont utilisés:

– les termes définis à l'Article 3: en caractère **gras**.

Une liste de toutes les parties de la série IEC 60974, sous le titre général *Matériel de soudage à l'arc*, peut être consultée sur le site internet de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. À cette date, le document sera

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- remplacé par une édition révisée, ou
- amendé.

MATÉRIEL DE SOUDAGE À L'ARC –

Partie 9: Installation et utilisation

1 Domaine d'application

Le présent document est applicable aux exigences relatives à l'installation et aux instructions d'utilisation du matériel pour le soudage à l'arc et les procédés connexes conçus dans le respect des exigences de sécurité de l'IEC 60974-1, de l'IEC 60974-6 ou équivalent.

Le présent document est applicable aux recommandations destinées aux instructeurs, aux opérateurs, aux soudeurs, aux gestionnaires et aux superviseurs pour obtenir une installation et une utilisation sûres du matériel pour le soudage à l'arc et les techniques connexes et obtenir des performances sûres dans les opérations de soudage et de coupage.

Les règlementations nationales et locales prévalent sur le présent document.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60245-6, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 6: Câbles souples pour électrodes de soudage à l'arc*

IEC 60755, *General requirements for residual current operated protective devices* (disponible en anglais seulement)

IEC 60974-1, *Matériel de soudage à l'arc – Partie 1: Sources de courant de soudage*

IEC 60974-4, *Matériel de soudage à l'arc – Partie 4: Inspection et essais périodiques*

IEC 60974-11, *Matériel de soudage à l'arc – Partie 11: Porte-électrodes*

IEC 60974-12, *Matériel de soudage à l'arc – Partie 12: Dispositifs de connexion pour câbles de soudage*

IEC 60974-13, *Matériel de soudage à l'arc – Partie 13: Pince de retour de courant*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
circuit de soudage
tous les éléments conducteurs à travers lesquels le passage du courant de soudage est prévu

Note 1 à l'article: En soudage à l'arc, l'arc fait partie du **circuit de soudage**.

Note 2 à l'article: Dans certains procédés de soudage à l'arc, l'arc peut être établi entre deux électrodes. Dans un tel cas, la **pièce mise en œuvre** ne fait pas nécessairement partie du **circuit de soudage**.

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

3.2
élément conducteur étranger
partie conductrice ne faisant pas partie de l'installation électrique et susceptible d'introduire un potentiel électrique, généralement celui de la terre

Note 1 à l'article: L'installation électrique comprend le **circuit de soudage**.

[SOURCE: IEC 60050-851:2008, 851-14-57]

3.3
pièce mise en œuvre
pièce métallique ou ensemble de pièces métalliques sur lesquelles le soudage ou les techniques connexes sont réalisés

[SOURCE: IEC 60050-851:2008, 851-11-19]

3.4
vêtements de protection
accessoires de protection
vêtements et accessoires (par exemple, gants, protège-mains ou pare-mains, masques de protection de la tête et verres filtrants) utilisés afin de réduire les risques de choc électrique et les effets des vapeurs et des projections et afin de protéger la peau et les yeux contre le rayonnement de l'arc

[SOURCE: IEC 60050-851:2008, 851-11-18]

3.5
environnement avec risque accru de choc électrique
environnement dans lequel le risque de choc électrique dû au soudage à l'arc est accru par rapport aux conditions normales du soudage à l'arc

Note 1 à l'article: De tels environnements se trouvent par exemple

a) dans des emplacements où la liberté de mouvement restreinte oblige l'opérateur à souder dans une position inconfortable (à genoux, assis, allongé), en contact physique avec des éléments conducteurs;

b) dans des emplacements totalement ou partiellement limités par des éléments conducteurs, présentant un risque élevé de contact involontaire ou accidentel par l'opérateur;

c) dans des emplacements mouillés, humides ou chauds lorsque l'humidité ou la transpiration réduit considérablement la résistance de la peau du corps humain et les propriétés isolantes des **accessoires**.

Note 2 à l'article: Il n'y a pas d'**environnement avec risque accru de choc électrique** dans les emplacements où les parties conductrices au voisinage immédiat de l'opérateur pouvant causer le risque accru ont été isolées.

[SOURCE: IEC 60050-851:2008, 851-15-09]

3.6
expert
personne compétente
personne qualifiée
personne qui peut juger le travail assigné et reconnaître les dangers possibles sur la base de sa formation, ses connaissances, son expérience et sa connaissance du matériel concerné

Note 1 à l'article: Plusieurs années de pratique dans le domaine technique concerné peuvent être prises en considération pour l'estimation de la formation professionnelle.

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

3.7
dévidoir
matériel, qui fournit du fil d'apport à l'arc ou à la zone de soudure, comprenant les moyens pour appliquer le mouvement au fil d'apport

Note 1 à l'article: Le dévidoir peut également inclure la contrôle de dévidage, l'approvisionnement en fil d'apport, les dispositifs de contrôle du gaz, les indicateurs et connecteurs à distance.

[SOURCE: IEC 60050-851:2008, 851-14-39]

4 Installation

4.1 Généralités

Le matériel de soudage utilisé dans les installations de soudage à l'arc doit correspondre aux indications présentes sur la plaque signalétique.

Les exigences de compatibilité électromagnétique (CEM) doivent être prises en compte pendant l'installation, voir l'Article 5.

Les exigences des règlementations nationales et locales doivent être prises en compte pendant l'installation, y compris la mise à la terre ou les connexions à la terre de protection, les fusibles, les dispositifs de déconnexion de l'alimentation, le type de circuit d'alimentation, etc.

Lire le manuel d'instructions du fabricant avant d'installer le matériel. Les informations techniques propres au matériel de soudage doivent être pleinement utilisées.

Si nécessaire, des conseils spécifiques peuvent être obtenus du fabricant du matériel de soudage.

4.2 Circuit d'alimentation

4.2.1 Sélection des câbles d'alimentation

Les câbles d'alimentation du matériel de soudage et leur protection contre les surcharges, s'ils ne sont pas fournis par le fabricant, doivent être sélectionnés conformément aux informations données dans le manuel d'instructions du fabricant.

NOTE Des exemples de réglementations locales sont donnés dans la bibliographie, par exemple l'EN 50525-2-21, le code de l'électricité de la NFPA 70 (SE, SO, ST, STO ou tout autre câble pour service intensif) ou le Code canadien de l'électricité C22.1. L'isolation PVC ne convient pas à cette application.

Les câbles d'alimentation doivent être placés de telle manière qu'ils ne puissent pas être endommagés pendant l'utilisation. S'il n'est pas possible d'y parvenir, un dispositif de coupure différentiel (DDR), capable de fonctionner à un courant de fuite ne dépassant pas 30 mA selon l'IEC 60755, doit être utilisé pour réduire le risque de choc électrique.

4.2.2 Dispositif de déconnexion de l'alimentation

L'installateur doit garantir qu'un dispositif de déconnexion de l'alimentation est installé au point d'alimentation.

NOTE Une prise peut être utilisée comme dispositif de déconnexion de l'alimentation en conformité avec la règlementation nationale ou locale.

4.2.3 Dispositif d'arrêt d'urgence

Lorsqu'un dispositif d'arrêt d'urgence est exigé par une règlementation nationale (par exemple, pour le matériel de soudage automatique), il doit être conforme à la norme IEC applicable.

Pour le soudage dans un **environnement avec risque accru de choc électrique**, voir 7.10.

4.3 Circuit de soudage

4.3.1 Isolation par rapport à l'alimentation

Le **circuit de soudage** et les circuits électriquement connectés au **circuit de soudage** doivent être isolés électriquement du réseau d'alimentation.

La vérification doit être réalisée par un **expert**.

4.3.2 Sommation des tensions à vide

Dans le cas où plus d'une source de courant de soudage est en fonctionnement en même temps, leurs tensions à vide peuvent s'ajouter et causer un danger accru de choc électrique. Les sources de courant de soudage doivent être installées de façon à réduire ce risque le plus possible. Des recommandations sont données en 7.9.

NOTE Dans le cas où deux transformateurs de soudage sont connectés aux mêmes lignes, la tension de sortie qui en résulte peut être la somme des deux tensions à vide. Cela peut être évité en utilisant une connexion d'entrée ou de sortie adéquate (voir 7.9).

Lorsque plusieurs sources de courant de soudage sont installées, il convient d'identifier clairement les sources de courant de soudage individuelles avec leurs commandes et raccordements séparés afin d'indiquer les éléments qui appartiennent à chaque **circuit de soudage**.

4.3.3 Câbles de soudage

Les câbles de soudage doivent être conformes à l'IEC 60245-6. Les câbles de soudage à conducteur en cuivre doivent être sélectionnés selon le facteur de marche et les règlementations nationales ou, à défaut, les caractéristiques assignées de courant données au Tableau 1. Lorsque de grandes longueurs de câbles sont mises en œuvre, il peut être nécessaire de choisir la dimension du câble sur la base de la chute de tension, voir l'Annexe B.

Tableau 1 – Caractéristiques assignées de courant pour les câbles de soudage en cuivre

Section nominale [b]	Caractéristiques assignées de courant pour un facteur de marche spécifié à une température ambiante de 25 °C[a]						
	100 %	85 %	80 %	60 %	35 %	20 %	8 %
mm^2	A	A	A	A	A	A	A
10	100	100	100	101	106	118	158
16	135	136	136	139	150	174	243
25	180	182	183	190	213	254	366
35	225	229	231	243	279	338	497
50	285	293	296	316	371	457	681
70	355	367	373	403	482	602	908
95	430	448	456	498	606	765	1 164
120	500	524	534	587	721	917	1 404
150	580	610	622	689	853	1 090	1 676
185	665	702	717	797	995	1 277	1 971

[a] Pour des températures ambiantes plus élevées, un facteur de correction doit être appliqué: 0,96 (30 °C); 0,91 (35 °C); 0,87 (40 °C); 0,82 (45 °C). Aucune interpolation n'est autorisée pour les valeurs du facteur de marche.

[b] Pour les valeurs intermédiaires des sections nominales, l'interpolation est autorisée.

NOTE Le tableau provient de l'EN 50565-1:2014.

4.3.4 Connexion entre la source de courant de soudage et la pièce mise en œuvre

Quand le courant de soudage ne passe pas entièrement dans le **circuit de soudage**, des courants de fuite, qui sont des éléments du courant de soudage, apparaissent. Ceux-ci peuvent endommager les systèmes électriques des bâtiments ainsi que tout autre système sensible et peuvent être réduits le plus possible par les moyens suivants:

a) le raccordement électrique entre la source de courant de soudage et les **pièces mises en œuvre** doit être aussi direct que possible au moyen d'un câble de retour de courant isolé ayant un courant admissible approprié;

b) les **éléments conducteurs étrangers** tels que les rails métalliques, les tuyaux et les cadres ne doivent pas être utilisés en tant que partie du **circuit de soudage**, à moins qu'ils constituent la **pièce mise en œuvre** elle-même;

c) la pince de retour de courant doit être aussi proche que possible de l'arc de soudage;

d) la pince de retour de courant déconnectée de la **pièce mise en œuvre** doit être isolée électriquement des parties reliées à la terre, par exemple des enveloppes métalliques avec connexion à la terre de protection (classe I), des sols métalliques, des connexions de bâtiments;

NOTE 1 La pince de retour de courant peut provoquer un choc électrique lorsque le courant de soudage circule ou lorsque le circuit à électrode est en contact avec le circuit de terre ou la **pièce mise en œuvre**.

e) le **circuit de soudage** ne doit pas être relié à la terre à moins que cela ne soit exigé par les règlementations nationales ou locales (voir 4.3.5);

f) le raccordement du câble de retour de courant à la **pièce mise en œuvre** doit être assuré par l'utilisation de dispositifs équipés de moyens appropriés pour le raccordement des câbles, un système de fixation ne pouvant être desserré accidentellement et assurant un bon contact électrique. Les dispositifs magnétiques ne présentent un bon contact électrique que lorsque leurs surfaces de contact et la zone de contact de la **pièce mise en œuvre** sont suffisamment grandes, lisses, conductrices et propres (par exemple, sans rouille et apprêts) et que la zone de contact de la **pièce mise en œuvre** est magnétique;

NOTE 2 Si les **pièces mises en œuvre** sont positionnées sur une table de soudage ou un dispositif de manutention de pièces, le câble de retour de courant peut être raccordé à la table ou au dispositif.

g) les dispositifs de raccordement pour les câbles de soudage flexibles et mobiles du **circuit de soudage** doivent:

   1) comporter un enrobage approprié en matériau isolant pour éviter tout contact involontaire avec les parties actives lorsqu'ils sont raccordés, à l'exception de la pince de retour de courant avec la **pièce mise en œuvre** elle-même;

   2) correspondre aux dimensions des câbles utilisés et au courant de soudage;

   3) être efficacement raccordés aux câbles de soudage et assurer un bon contact électrique avec eux.

h) Les câbles de soudage, de commande et d'alimentation doivent être protégés contre les projections et la chaleur afin d'éviter tout dommage involontaire sur l'isolation.

Le câble de soudage et le dispositif de raccordement doivent être utilisés dans les limites de leur courant assigné spécifié. Le dispositif de raccordement ne doit pas être équipé d'un câble ayant un diamètre plus petit que celui spécifié par le fabricant du dispositif de raccordement.

Lorsque des dispositifs de connexion ou des pinces de retour de courant sont utilisés, ils doivent être conformes à l'IEC 60974-12 ou à l'IEC 60974-13, respectivement.

4.3.5 Mise à la terre de la pièce mise en œuvre

Il convient de ne pas relier le **circuit de soudage** à la terre, car cela peut augmenter le risque de courants de soudage de fuite (voir 4.3.3). La mise à la terre du **circuit de soudage** peut également élargir la zone métallique par laquelle une personne en contact avec le **circuit de soudage** (par exemple, l'électrode de soudage) pourrait subir un choc électrique.

NOTE 1 Il existe des **pièces mises en œuvre** présentant un raccordement naturel à la terre, par exemple, les structures en acier, les bateaux, les canalisations. Lorsque celles-ci sont soudées, la possibilité de courants de fuite est accrue.

NOTE 2 Dans certains cas, la **pièce mise en œuvre** peut être en contact permanent avec la terre, par exemple, dans le cas de matériel de protection de classe I, qui lui-même comporte des conducteurs de protection reliés à la terre. Une telle **pièce mise en œuvre** est considérée comme étant naturellement reliée à la terre.

Une évaluation du **circuit de soudage** et de la zone de soudage doit être réalisée pour assurer que le courant de soudage de fuite ne passera pas à travers n'importe quel objet mis à la terre et non destiné ou non capable de transporter le courant de soudage (par exemple, connexion à la terre de protection).

Si des outils à main électriques sont utilisés et sont susceptibles d'entrer en contact avec la **pièce mise en œuvre**, alors ces outils doivent faire partie des matériels de classe II (c'est-à-dire qu'ils comportent une isolation double ou renforcée sans raccordement à la terre de protection).

Si des réglementations nationales ou locales exigent une mise à la terre, le raccordement à la terre doit être réalisé au moyen d'un câble dédié séparé ou d'un conducteur présentant des caractéristiques assignées au moins égales à celles du câble de retour du courant et raccordé directement à la **pièce mise en œuvre**.

Des mesures doivent être prises pour isoler l'opérateur de la terre ainsi que de la **pièce mise en œuvre** (voir 7.7.2).

Lorsque des réseaux externes d'antiparasitage radioélectrique sont raccordés au **circuit de soudage**, un **expert** doit évaluer si le **circuit de soudage** peut toujours être considéré comme étant isolé de la terre.

NOTE 3 Des réseaux externes d'antiparasitage radioélectrique peuvent être constitués de différents composants, par exemple, des filtres LCR (inductance/condensateur/résistance).

4.3.6 Emplacement des bouteilles de gaz

Il faut veiller à éviter que les bouteilles de gaz situées à proximité de la **pièce mise en œuvre** entrent en contact avec le **circuit de soudage**.

5 Compatibilité électromagnétique (CEM)

5.1 Généralités

L'utilisateur est responsable de l'installation et de l'utilisation du matériel de soudage à l'arc en conformité avec les instructions du fabricant. Si des perturbations électromagnétiques sont détectées, l'utilisateur du matériel de soudage à l'arc doit être responsable de la résolution du problème avec l'assistance technique du fabricant.

5.2 Évaluation de l'emplacement

Avant l'installation du matériel de soudage à l'arc, l'utilisateur doit réaliser une évaluation des brouillages électromagnétiques potentiels dans la zone environnante. Les matériels et éléments suivants doivent être pris en compte:

a) autres câbles d'alimentation, de commande, de signalisation et de téléphone, au-dessus, en dessous et adjacents au matériel de soudage à l'arc;

b) émetteurs et récepteurs de radio et de télévision;

c) ordinateur et autre matériel de commande;

d) matériels critiques pour la sécurité, par exemple protection de matériel industriel;

e) santé des personnes aux alentours, par exemple, l'utilisation de dispositifs médicaux portables et d'implants médicaux;

f) matériel utilisé pour l'étalonnage ou le mesurage;

g) immunité d'autres matériels dans l'environnement. L'utilisateur doit s'assurer que les autres matériels utilisés dans l'environnement sont compatibles. Cela peut exiger des mesures supplémentaires de protection;

h) moment de la journée auquel le soudage ou d'autres activités doivent être réalisés.

La dimension de la zone environnante à prendre en compte dépend de la structure de la construction et des autres activités qui y sont réalisées. La zone environnante peut s'étendre au-delà des limites des locaux.

5.3 Méthodes de réduction des émissions

5.3.1 Réseau public d'alimentation

Le matériel de soudage à l'arc doit être raccordé au réseau public d'alimentation selon les recommandations du fabricant. Si des perturbations se produisent, il peut être nécessaire de prendre des précautions supplémentaires telles que le filtrage du réseau d'alimentation. Le câble d'alimentation des matériels de soudage à l'arc installés de façon permanente doit être blindé en utilisant un conduit métallique ou équivalent. Le blindage doit être électriquement continu sur toute sa longueur. Le blindage doit être raccordé à la source de courant de soudage de manière à maintenir un bon contact électrique entre le conduit et l'enveloppe de la source de courant de soudage.

5.3.2 Maintenance du matériel de soudage à l'arc

Le matériel de soudage à l'arc doit faire l'objet d'une maintenance régulière selon l'IEC 60974-4 et les instructions du fabricant. Toutes les portes d'accès et de service ainsi que les couvercles, doivent être fermés et fixés correctement lorsque le matériel de soudage à l'arc est en fonctionnement. Le matériel de soudage à l'arc ne doit être modifié d'aucune façon, sauf pour les changements et ajustements couverts par les instructions du fabricant.