भारतीय मानक

Indian Standard

IS 16593 (Part 3) : 2023
IEC 60974-3 : 2019

आर्क वेल्डिंग उपकरण

भाग 3 आर्क हड़ताली और स्थिर करने वाले उपकरण

(पहला पुनरीक्षण)

Arc Welding Equipment

Part 3 Arc Striking and Stabilizing Devices

(First Revision)

ICS 25.160.30

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NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with IEC 60974-3 : 2019 'Arc welding equipment — Part 3: Arc striking and stabilizing devices' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electric Welding Equipment Sectional Committee and approval of the Electrotechnical Division Council.

This Indian Standard is published in several parts. The other parts in this series are:

Part 1	Welding power sources
Part 2	Liquid cooling systems
Part 4	Periodic inspection and testing
Part 5	Wire feeders
Part 6	Limited duty equipment
Part 7	Torches
Part 8	Gas consoles for welding and plasma cutting systems
Part 9	Installation and use
Part 10	Electromagnetic compatibility (EMC) requirements
Part 11	Electrode holders
Part 12	Coupling devices for welding cables
Part 13	Welding current return clamp

This standard was first published in 2016 was identical to IEC 60974-3 : 2013. This revision has been undertaken to align it with the latest version of IEC 60974-3 : 2019.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminologies and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60974-1 : 2017 Arc welding equipment — Part 1: Welding power source	IS 16593 (Part 1) : 2021 Arc welding equipment: Part 1 Welding power source	Identical
IEC 60974-7 : 2019 Arc welding equipment — Part 7 : Torches	IS 16593 (Part 7) : 2022 Arc welding equipment: Part 7 Torches	Identical
IEC 61140 Protection against electric shock — Common aspects for installation and equipment	IS 9409 : 1980 Classification of electrical and electronic equipment with regard to protection against electric shock	Technically Equivalent with IEC 536 : 1976

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Indian Standard

ARC WELDING EQUIPMENT

PART 3 ARC STRIKING AND STABILIZING DEVICES

(First Revision)

1 Scope

This part of IEC 60974 specifies safety requirements for industrial and professional ARC STRIKING and ARC STABILIZING DEVICES used in arc welding and allied processes.

This document is applicable to ARC STRIKING and STABILIZING DEVICES which are stand-alone (separate from the welding equipment) or built in (housed in a single enclosure with other arc welding equipment).

NOTE 1 Typical allied processes are, for example, plasma arc cutting and arc spraying.

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

2 Normative references

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

IEC 60974-1:2017, *Arc welding equipment – Part 1: Welding power sources*
IEC 60974-1:2017/AMD1:2019

IEC 60974-7:2013, *Arc welding equipment – Part 7: Torches*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60974-1 and IEC 60974-7 and the following apply.

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

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

3.1
arc striking device
device which superimposes a voltage on the welding circuit to ignite an arc

3.2
arc stabilizing device
device which superimposes a voltage on the welding circuit to maintain an arc

3.3
arc striking voltage
voltage superimposed on the no-load voltage to ignite an arc

3.4
arc stabilizing voltage
voltage superimposed on the arc voltage to maintain the arc

4 Environmental conditions

As specified in IEC 60974-1:2017, Clause 4.

5 Tests

5.1 Test conditions

As specified in 5.1 of IEC 60974-1:2017.

5.2 Measuring instruments

The accuracy of measuring instruments shall be as follows:

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

5.3 Conformity of components

As specified in 5.3 of IEC 60974-1:2017/AMD1:2019.

5.4 Type tests

As a condition of conformity, the type tests given below shall be carried out on stand-alone units in the following sequence with no drying time between f), g) and h):

a) visual inspection, as defined in 3.1.7 of IEC 60974-1:2017;
b) insulation resistance, as specified in 6.1.4 of IEC 60974-1:2017 (preliminary check);
c) enclosure, as specified in 14.2 of IEC 60974-1:2017;
d) handling means, as specified in 14.3 of IEC 60974-1:2017;
e) drop withstand, as specified in 14.4 of IEC 60974-1:2017;
f) protection provided by the enclosure, as specified in 6.2.1 of IEC 60974-1:2017;
g) insulation resistance, as specified in 6.1.4 of IEC 60974-1:2017;
h) dielectric strength, as specified in 6.1.5 of IEC 60974-1:2017;
i) visual inspection, as defined in 3.1.7 of IEC 60974-1:2017.

Rated arc striking and stabilizing peak voltage shall be measured in accordance with 11.1 in any convenient sequence of type tests but before verifying mechanical provisions.

The other type tests included in this document and not listed here shall be carried out in any convenient sequence.

5.5 Routine tests

5.5.1 Stand-alone unit

All routine tests shall be carried out on each stand-alone unit in the following sequence:

a) visual inspection (as defined in 3.1.7 of IEC 60974-1:2017);

b) continuity of the protective circuit (as specified in Clause 10 and, if applicable, 10.5.1 of IEC 60974-1:2017);

c) dielectric strength (as specified in 6.1.5 of IEC 60974-1:2017);

d) high-voltage circuit test: working voltage shall be applied to high-voltage circuits to establish insulation integrity as specified by the manufacturer;

NOTE No-load voltage and connection of the return cable, either to the ground circuit or isolated, affects working voltage.

e) visual inspection (as defined in 3.1.7 of IEC 60974-1:2017).

5.5.2 Built-in unit

The following routine test shall be carried out on each built-in unit in any convenient sequence for the power source (as specified in 5.5 of IEC 60974-1:2017):

High-voltage circuit test: working voltage shall be applied to high-voltage circuits to establish insulation integrity as specified by the manufacturer.

NOTE No-load voltage and connection of the return cable, either to the ground circuit or isolated, affects working voltage.

6 Protection against electric shock

6.1 Insulation

6.1.1 General

Subclause 6.1.1 of IEC 60974-1:2017 applies.

6.1.2 Clearances

The minimum clearances for high-voltage components shall be in accordance with Table 1. The minimum clearance for other components shall be in accordance with 6.1.2 of IEC 60974-1:2017.

Conformity shall be checked by measurement and visual inspection.

6.1.3 Creepage distances

The minimum creepage distances for arc striking and stabilizing circuits shall be in accordance with Table 1. The minimum creepage distances for other components shall be in accordance with 6.1.3 of IEC 60974-1:2017.

Conformity shall be checked by measurement and visual inspection.

Table 1 – Minimum clearances and creepage distances for arc striking and stabilizing circuits

Rated peak voltage[a] kV	Clearance[b] mm	Creepage distance[b] mm
3	3	6,3
6	5,5	10
8	8	12,5
10	11	16
12	14	20
15	18	25
18	25	30
20	30	35
NOTE These values apply to circuits which are designed in accordance with 11.3.		
[a] Rated peak voltage shall be measured in accordance with 11.1. [b] Interpolation is allowed.		

6.1.4 Insulation resistance

Subclause 6.1.4 of IEC 60974-1:2017 applies.

6.1.5 Dielectric strength

The output circuit of ARC STRIKING AND STABILIZING DEVICES and the insulation of coupling components (for example, coupling transformers or coupling capacitors) shall withstand an arc striking test voltage 20 % higher than the rated peak ARC STRIKING VOLTAGE at the maximum pulse repetition rate of the device.

Alternatively, an AC test voltage with the same peak value of approximately sine waveform at 50 Hz or 60 Hz may be used for coupling components only. The maximum permissible setting of the tripping current shall be 100 mA. The high voltage transformer shall deliver the prescribed voltage up to the tripping current. Tripping is regarded as a flashover or a breakdown.

NOTE 1 For the operator's safety, the lowest setting of the tripping current (less than or equal to 10 mA) is typical.

Conformity shall be checked by the following test.

Coupling components intended for use with ARC STRIKING AND STABILIZING VOLTAGES shall be subjected to the arc striking test voltage or the AC test voltage for 60 s.

NOTE 2 Interference suppression capacitors are not coupling devices.

The output circuit shall be subjected to the arc striking test voltage for 60 s applied between the point of connection to the welding electrode and

a) exposed conductive parts;

b) other isolated circuits.

Flashover or breakdown shall not occur. Any discharges unaccompanied by a voltage drop (corona) are disregarded.

NOTE 3 Interference suppression capacitors are subjected to the test of the output circuit.

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

Subclause 6.2 of IEC 60974-1:2017 applies.

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

Stand-alone ARC STRIKING and STABILIZING DEVICES shall be class I or class II equipment in accordance with IEC 61140, with the exception of the welding circuit.

The output circuit of the ARC STRIKING AND STABILIZING DEVICE shall be electrically isolated from the public supply system by double or reinforced insulation in accordance with the maximum rated input voltage. Annex A, Figure A.1 shows examples of coupling systems for ARC STRIKING AND STABILIZING DEVICES.

Internal conductors and connections shall be secured or positioned as specified in 6.3.3 of IEC 60974-1:2017.

For class I stand-alone ARC STRIKING AND STABILIZING DEVICE, weighted touch current in the case of an external protective conductor failure or disconnection shall not exceed the value specified in 6.3.6 of IEC 60974-1:2017 when energized and not providing the ARC STRIKING AND STABILIZING VOLTAGE.

Conformity shall be checked by visual inspection and by measurement.

6.4 Protective provision

Connection of exposed conductive parts to the protective conductor is not required if the rated supply voltage is supplied by the welding circuit or safety extra-low voltage (SELV).

7 Thermal requirements

Current-carrying components, incorporated in the ARC STRIKING AND STABILIZING DEVICE, shall be capable of carrying the rated welding current as specified by the manufacturer without:

a) exceeding the temperature rating of the current-carrying components;
b) causing the surface temperatures specified in Table 7 of IEC 60974-1:2017 to be exceeded.

For liquid-cooled apparatus, the test shall be carried out with the minimum flow and the maximum temperature of the coolant, as recommended by the manufacturer.

Conformity shall be checked by measurement in accordance with 7.2 of IEC 60974-1:2017.

8 Thermal protection

If the ARC STRIKING and STABILIZING DEVICE is designed for use with or built in a specific welding power source, the thermal protection tests shall be carried out with the welding power source.

9 Abnormal operation

In the case of a stand-alone ARC STRIKING and STABILIZING DEVICE, the abnormal operation tests defined in Clause 9 of IEC 60974-1:2017 shall be carried out as applicable.

If the ARC STRIKING and STABILIZING DEVICE is designed for use with a specific welding power source, the abnormal operation tests shall be conducted with the ARC STRIKING and STABILIZING DEVICE connected to that welding power source.

The ARC STABILIZING DEVICE shall be short circuited at the output, with neither a torch nor a return cable connected, until equilibrium is achieved.

ARC STRIKING AND STABILIZING DEVICES protected internally, for example by automatic shut-off, meet this requirement if the protection device operates before an unsafe condition occurs.

10 Connection to the supply network

Clause 10 of IEC 60974-1:2017 applies.

11 Output

11.1 Rated peak voltage

The rated peak voltage (U_p) is obtained by subtraction of the no-load voltage (U_0) from the measured peak voltage (see Figure 1). To determine the peak, the voltage shall be measured across a 220 pF capacitor with neither a torch nor a return cable connected.

When reported on the rating plate of ARC STRIKING AND STABILIZING DEVICES, the rated peak voltage (U_p) shall be equal to or greater than the measured peak voltage, but shall not exceed the maximum values given in Table 2.

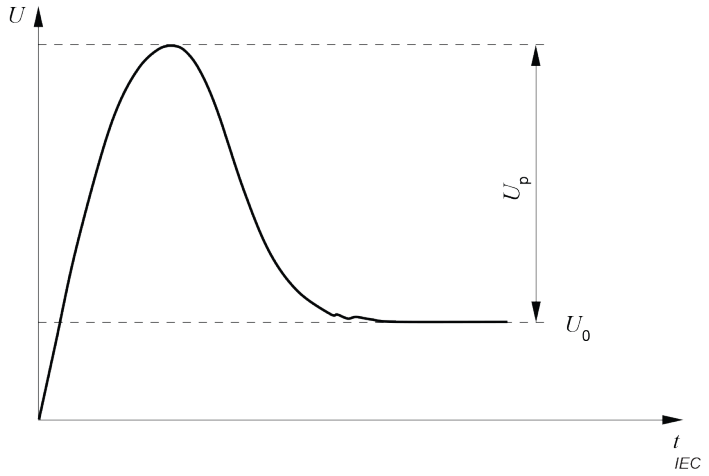


Figure 1 – Rated peak voltage

Table 2 – Maximum peak voltages

Type of torch	Peak voltage
Manually guided	15 kV
Mechanically guided or plasma cutting	20 kV

Conformity shall be checked by measurement with an oscilloscope and a high-voltage probe with sufficient bandwidth.

11.2 Impulse current

11.2.1 Risk of electric shock

Depending on the design of an ARC STRIKING AND STABILIZING DEVICE, a risk of electric shock due to an impulse current can occur under the following situations:

– the human body is in direct contact with the output of the ARC STRIKING AND STABILIZING DEVICE (as specified in 11.2.3);
– the human body is in series with the arc gap as part of the welding circuit (as specified in 11.2.4).

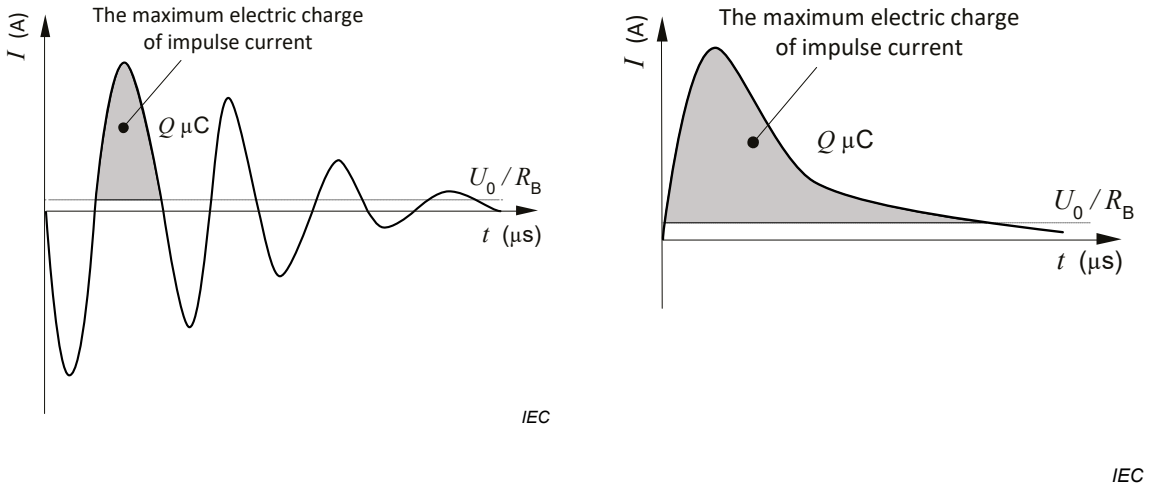
11.2.2 Electric charge

Under the conditions described in 11.2.3 and 11.2.4, the maximum electric charge in one half-cycle of impulse current, regardless of polarity, shall not exceed (see Figure 2):

– 8 µC for equipment intended to be used with manually guided torches;

and

– 15 µC for equipment intended to be used with mechanically guided torches and plasma cutting torches.



a) AC pulse **b) DC pulse**

Figure 2 – Measurement of electric charge of impulse current

Conformity shall be checked by measurement with an oscilloscope and a high-voltage probe with sufficient bandwidth.

11.2.3 Direct contact

To simulate the torch capacitance, the value for C_T shall be:

– 220 pF for equipment intended to be used with torches or return cables up to 10 m length;

or

– 1 000 pF for equipment intended to be used with torches or return cables above 10 m length.

To simulate the body resistance, the value of a non-inductive resistor R_B shall be:

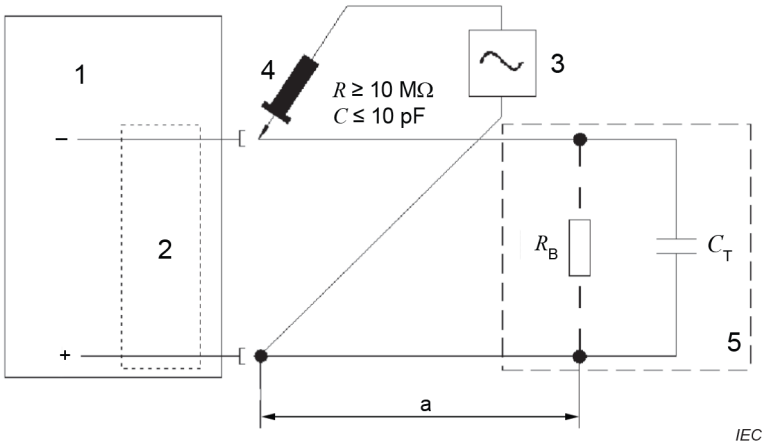
– 1 kΩ for equipment intended to be used in environments without increased hazard of electric shock or with a mechanically guided torch;

or

– 500 Ω for equipment intended to be used in environments with increased hazard of electric shock.

The value of the impulse current is obtained by dividing the value of the measured voltage by the value of the resistor R_B.

Conformity shall be checked by voltage measurement with an oscilloscope and a high-voltage probe with sufficient bandwidth, in a circuit as given in Figure 3, with neither a torch nor a return cable connected. The voltage is obtained by subtraction of the no-load voltage given in Table 13 of IEC 60974-1:2017 (see Figure 5).



Key

1	Welding or cutting power source	4	High-voltage probe
2	Arc striking and stabilizing device	5	Load as compact, as possible
3	Oscilloscope	a	Connection lead, as short as possible

Figure 3 – Measuring circuit for direct contact

11.2.4 Series contact

The arc gap (6) (see Figure 4) shall be adjusted to the maximum distance at which flashover consistently occurs.

To simulate the torch capacitance, the value for C_T shall be:

– 220 pF for equipment intended to be used with torches or return cables up to 10 m in length;

or

– 1 000 pF for equipment intended to be used with torches or return cables above 10 m in length.

To simulate the body resistance, the value of a non-inductive resistor R_B shall be

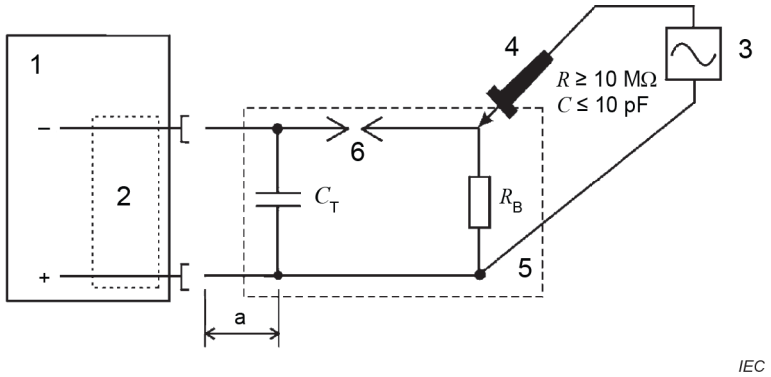
– 1 kΩ for equipment intended to be used in environments without increased hazard of electric shock or with a mechanically guided torch;

or

– 500 Ω for equipment intended to be used in environments with increased hazard of electric shock.

The value of the impulse current is obtained by dividing the value of the measured voltage by the value of the resistor R_B.

Conformity shall be checked by voltage measurement with an oscilloscope and a high-voltage probe with sufficient bandwidth, in a circuit as given in Figure 4, with neither a torch nor a return cable connected. The voltage is obtained by subtraction of the no-load voltage given in Table 13 of IEC 60974-1:2017 (see Figure 5).



Key

1	Welding or cutting power source	5	Load, as compact as possible
2	Arc striking and stabilizing device	6	Arc gap
3	Oscilloscope	a	Connection lead, as short as possible
4	High-voltage probe		

Figure 4 – Measuring circuit for serial contact

11.3 Mean energy

The mean energy generated by ARC STRIKING and STABILIZING DEVICES in a non-inductive resistor, simulating the body resistance shall not exceed during each period of 1 s:

– 4 J for equipment intended to be used with manually guided welding torches;

and

– 20 J for equipment intended to be used with mechanically guided and all plasma cutting torches.

Conformity shall be checked by testing in accordance with 11.2.

ARC STRIKING AND STABILIZING DEVICES with a mean energy below 4 J are considered as energy limited for all parts of IEC 60974.

The ARC STRIKING AND STABILIZING VOLTAGE is obtained by subtraction of the no-load voltage given in Table 13 of IEC 60974-1:2017 (see Figure 5).

NOTE The value of the mean energy is obtained by dividing the squared value of the measured voltage by the value of the resistor R_B and integrating the result over 1 s.

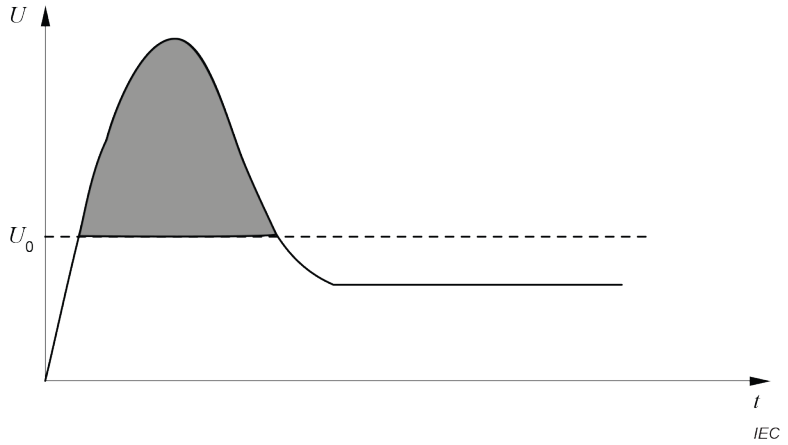
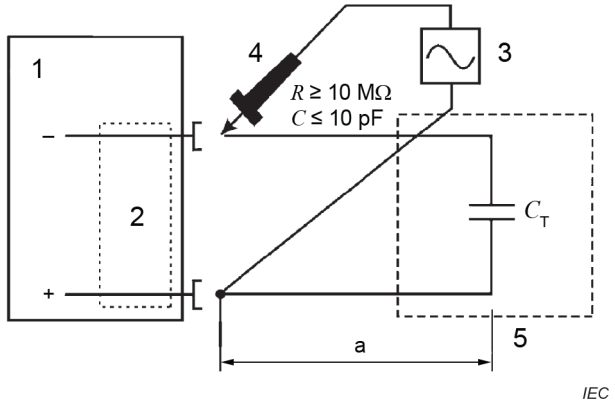


Figure 5 – Measurement of mean energy

11.4 Output circuit capacitance discharging

One second after the ARC STRIKING AND STABILIZING DEVICE output is cut off or disabled, the output voltage shall not exceed 113 V DC.

Conformity shall be checked by measurement of the voltage in a circuit as indicated in Figure 6 by an oscilloscope and a high-voltage probe.



Key

1	Welding or cutting power source	4	High-voltage probe
2	Arc striking and stabilizing device	5	Load, as compact as possible
3	Oscilloscope	a	Connection lead, as short as possible

Figure 6 – Measuring circuit for capacitance discharging

To simulate the torch capacitance, the value for C_T shall be:

– 220 pF for equipment intended to be used with torches or return cables up to 10 m in length;

or

– 1 000 pF for equipment intended to be used with torches or return cables above 10 m in length.

11.5 Additional requirements

ARC STRIKING AND STABILIZING DEVICES shall be designed to ensure that the output limits as specified in 11.1 through 11.4 are not exceeded in the event of failure of any component.

The following conditions are considered and, if necessary, applied one at a time, consequential faults being taken into consideration:

a) open-circuit at the terminal of any component;

b) short-circuit of capacitors, unless they comply with IEC 60384-14;

c) short-circuit of any two terminals of an electronic component, other than a monolithic integrated circuit. This fault is not applied between the two circuits of an optocoupler;

d) failure of triacs in the diode mode;

e) failure of a monolithic integrated circuit or other circuits that cannot be assessed by the fault conditions a) to d). In this case, the possible hazardous situations of the ARC STRIKING and STABILIZING DEVICE are assessed to ensure that safety does not rely on the correct functioning of such a component. All possible output signals are considered under fault conditions within the integrated circuit. If it can be shown that a particular output signal is unlikely to occur, then the relevant fault is not considered.

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

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

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

– thermal equilibrium is achieved; or

– the test samples return to within 5 K of the ambient temperature; or

– a test period of 3 h has elapsed.

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

Conformity shall be checked by a fault simulation or by analysing the circuit diagram.

12 Control circuits

Clause 12 of IEC 60974-1:2017 applies.

13 Hazard reducing device

Not applicable.

14 Mechanical provisions

Only applicable for stand-alone units as specified in Clause 14 of IEC 60974-1:2017.

15 Rating plate

15.1 General requirements

Subclause 15.1 of IEC 60974 1:2017 applies.

15.2 Description

The rating plate shall be divided into three sections:

a) identification of the stand-alone ARC STRIKING AND STABILIZING DEVICE;

b) output of the ARC STRIKING AND STABILIZING DEVICE;

c) energy supply of the stand-alone ARC STRIKING AND STABILIZING DEVICE.

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

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

In the case of built-in ARC STRIKING AND STABILIZING DEVICE, box 5 of Figure 7 shall be added to the rating plate of the welding power source, as specified in Clause 15 of IEC 60974-1:2017.

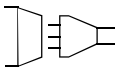
a) Identification

1)	2)
3)	4)

b) Output

5)			
6) X	6a)	6b)	6c)
7) I_2	7a)	7b)	7c)

c) Energy supply

8) 	9)	10)
	11) Optional	12) If applicable

IEC

Figure 7 – Rating plate

15.3 Contents

a) Identification

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

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

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

Box 4 Reference to IEC 60974-3 confirming that the ARC STRIKING AND STABILIZING DEVICE complies with its requirements.

b) Output of arc striking and stabilizing device

Box 5 U_P Rated peak voltage.

Box 6 X … % Duty cycle, if applicable.

Box 7 I_2 Rated welding current, if applicable.

c) Energy supply

Box 8		[IEC 60417-5939:2002-10] Energy supply symbol, number of phases (for example, 1 or 3), symbol for alternating current ~ and the rated frequency (for example, 50 Hz or 60 Hz).
Box 9	U_1 ... V	Rated supply voltage.
Box 10	I_{1max} ... A	Rated maximum supply current.
Box 11	IP	Degree of protection, for example, IP 21 or IP 23.
Box 12		[IEC 60417-5172:2003-02] Symbol for class II equipment, if applicable.

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

16 Adjustment of the output

Clause 16 of IEC 60974-1:2017 applies.

17 Instructions and markings

17.1 Instructions

Subclause 17.1 of IEC 60974-1:2017 applies, with the addition of the following requirement.

The manufacturer shall state in the instructions:

– the rated peak voltage;

– if the ARC STRIKING AND STABILIZING DEVICE is designed for manual or mechanically guided operation.

If the use of longer torch or return cables increases the risk of electric shock (limits are specified in Clause 11) due to an impulse current, the manufacturer shall specify the maximum length (in m) and torch type. The following warning shall be given:

Warning: Increasing the length of torch or return cables more than manufacturer maximum specified length will increase the risk of electric shock.

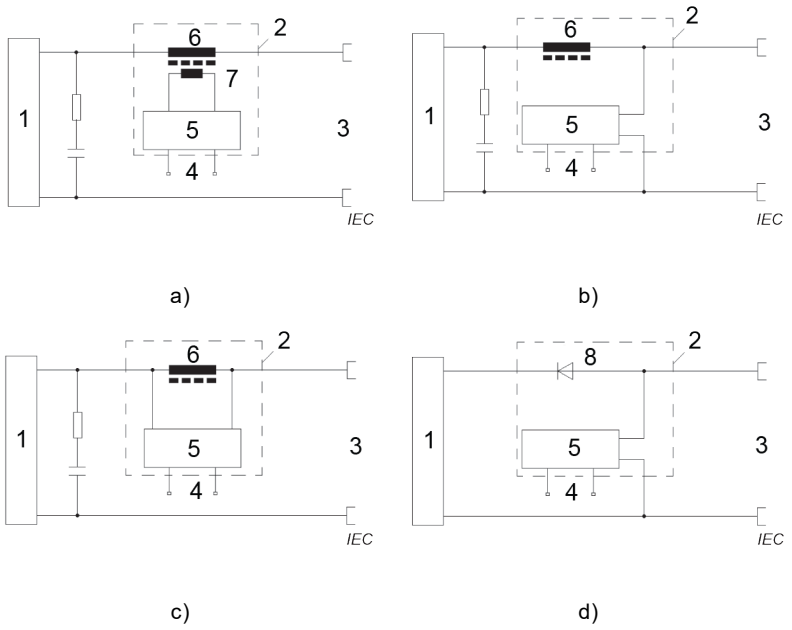
17.2 Markings

Only applicable for stand-alone units; subclause 17.2 of IEC 60974-1:2017 applies.

Annex A
(informative)

Examples of coupling systems for arc striking and stabilizing devices

Figure A.1 gives examples of coupling systems for ARC STRIKING and STABILIZING DEVICES.



Key

1	Welding or cutting power source	5	Voltage generator
2	Arc striking and stabilizing device	6	Choke
3	Output	7	Input coupling winding
4	Voltage supply	8	Blocking diode

Figure A.1 – Examples of coupling systems for arc striking and stabilizing devices

Annex B
(informative)

Example of a rating plate

Figure B.1 gives an example of a stand-alone unit.

a) Identification

1) Manufacturer	2) Type
3) Serial number	4) IEC 60974-3

b) Output

5) U_p = 8,5 kV							
6)	X	6a)	35 %	6b)	60 %	6c)	100 %
7)	I_2	7a)	300 A	7b)	220 A	7c)	180 A

c) Energy input

8)  1 ~ 50 Hz	9) U_1 = 230 V	10) I_1 = 0,5 A	
	10) IP23	11)	

IEC

Figure B.1 – Stand-alone unit

Bibliography

IEC 60974 (all parts), *Arc welding equipment*

IEC TS 60479-2, *Effects of current on human beings and livestock – Part 2: Special aspects*

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

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