भारतीय मानक

Indian Standard

IS 16593 (Part 14) : 2024
IEC 60974-14 : 2018

आर्क वेल्डिंग उपकरण

भाग 14 अंशांकन, सत्यापन और स्थिरता परीक्षण

Arc Welding Equipment

Part 14 Calibration, Validation and Consistency Testing

ICS 25.160.30

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NATIONAL FOREWORD

This Indian Standard (Part 14) which is identical to IEC 60974-14 : 2018 ‘Arc welding equipment — Part 14: Calibration, validation and consistency testing’ 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.

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

a) Wherever the words ‘International Standard’ appears referring to this standard, they should be read as ‘Indian Standard’; and

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 International Standards for which Indian Standards also exists. The corresponding Indian Standards, which are to be substituted, 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 sources	IS 16593 (Part 1) : 2021/IEC 60974-1 : 2017 Arc welding equipment: Part 1 Welding power source	Identical

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.

CONTENTS

INTRODUCTION

This document is the first international edition for CALIBRATION, VALIDATION and CONSISTENCY TESTING of arc welding equipment. It is based on the European Standard EN 50504:2008 and will replace it. A brief history helps to understand the origin and development of this document.

In Great Britain, BS 7570:1992, *Code of practice for the validation of arc welding equipment*, was published and it became the equivalent European pre-standard ENV 50184:1996 (withdrawn).

The revised second edition of BS 7570 was published in 2000 and was later replaced by the equivalent EN 50504:2008.

For quality management in the field of welding, this document should be used in conjunction with ISO 17662.

The significant changes in respect to EN 50504:2008 are the following:

– terms VERIFICATION and VALIDATION aligned to ISO/IEC Guide 99:2007;
– wire feed equipment moved from the annex to main part of the document;
– new preferred requirement for digital instrument CALIBRATION with fixed tolerance values;
– flow charts for determination of VERIFICATION methods and sample reports added;
– EN 50504:2008 Annex E *Validation of ancillary components in a welding system* and Annex F *Voltage drops in the welding circuit* deleted.

Indian Standard

ARC WELDING EQUIPMENT

PART 14 CALIBRATION, VALIDATION AND CONSISTENCY TESTING

1 Scope

This part of IEC 60974 specifies requirements for the VERIFICATION of arc welding and external monitoring equipment. This document also serves for practical implementation of the VERIFICATION procedure for arc welding equipment.

This document can be applied at the time of installation and any other times or intervals the user deems appropriate to ensure the equipment is capable of operating to the manufacturer's specification or other specifications deemed applicable by the user.

This document is not applicable to

– plasma systems used for cutting and gouging;
– arc striking and stabilizing devices;
– arc welding equipment designed in accordance with IEC 60974-6.

NOTE 1 Other components in welding systems such as for example robots, turning devices, gas consoles, etc. also have influence on the welding result and can be verified, if necessary. Additional information can be found in ISO 17662.

NOTE 2 Periodic inspection and testing for arc welding equipment is covered in IEC 60974-4.

This document is applicable for the user, service shop or manufacturer. It can be used

– stand alone;
– in conjunction with manufacturer's instructions; or
– as the basis for an equivalent VERIFICATION procedure written by the manufacturer for specific equipment.

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*

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
displayed value
<at equipment> measured value by internal instrument and shown at the equipment

Note 1 to entry: In some cases, the same display can be used for both SET VALUES and measured values. In such cases the DISPLAYED VALUE is usually visible during welding.

3.2
set value
value chosen and set by the operator or by an automatic system

[SOURCE: IEC 60050-811:2017, 811-11-34, modified – Reference to motor vehicle and driver removed.]

3.3
reference value
measurement value obtained by the reference instrument and used as a basis for comparison with values of the same kind

3.4
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]

3.5
verification
operations for the purpose of demonstrating that an item of welding equipment or a welding system conforms to the operating parameters for that welding equipment or system

3.6
calibration
set of operations which establishes, by reference to standards, the relationship which exists, under specified conditions, between a DISPLAYED VALUE and a REFERENCE VALUE

[SOURCE: IEC 60050-311:2001, 311-01-09, modified – Notes removed and terms "DISPLAYED VALUE" and "REFERENCE VALUE" used.]

3.7
validation
operations for the purpose of demonstrating that a SET VALUE meets the REFERENCE VALUE (within specified limits)

3.8
consistency test
test to determine the repeatability of the equipment output over a period of time

3.9
standard grade
equipment verified to meet the accuracy for indication and meters required by IEC 60974-1 or IEC 60974-5

3.10
precision grade
equipment verified to a higher level of accuracy for indication and meters than required by IEC 60974-1 or IEC 60974-5

4 Safety precautions

VERIFICATION requirements and procedures for power sources depend on the type of welding power source, i.e. whether these are power sources with "drooping characteristic" or with "flat characteristic".

NOTE Drooping characteristic is related to MMA/TIG welding (typically constant current) and flat characteristic is related to MIG/MAG/FCAW welding (typically constant voltage).

The output of a power source with flat characteristic should not be short-circuited, because a very high current can result. A load resistance shall be used.

Care should be taken that testing instruments are not damaged. See Annex D.

For tungsten inert gas (TIG) equipment, the arc striking and stabilizing device shall be switched off or be deactivated by other means. See Annex D.

If verifying with an arc, follow all local and national safety regulation and safety precautions specified by the manufacturer.

5 Testing personnel

Welding equipment shall be tested by an EXPERT with suitable qualifications, corresponding experience and sufficient training in welding and measurement technology, with knowledge of electrical hazards that may occur and the required protective measures.

6 VERIFICATION accuracies – permitted deviations

For welding equipment that measures and displays current, voltage and/or wire feed speed (DISPLAYED VALUE), the CALIBRATION accuracies given in Table 1 shall be used for the tests. Current and voltage CALIBRATION are performed according to 7.3.2. For wire feed speed, instructions in 8.3 apply.

Table 1 – CALIBRATION accuracies of DISPLAYED VALUES

Measurement	Type of measuring instrument	STANDARD GRADE	PRECISION GRADE	Reference
Current	Analog	± 2,5 %	± 1 %	from upper range value of instrument
	Digital	± 2,5 %	± 1 %	of highest rated value for welding current according to rating plate
Voltage	Analog	± 2,5 %	± 1 %	from upper range value of instrument
	Digital	± 1,5 V or ± 2,5 %	± 0,6 V or ± 1 %	preferred method or of rated no-load voltage (U_0) or according to manufacturer's specifications
Wire feed speed	Analog or Digital	± 2,5 %		of maximum setting below 25 % of maximum setting
		± 10 %		of REFERENCE VALUE between 25 % and 100 % of maximum setting
	Analog or Digital		± 2,5 %	of maximum setting below 40 % of maximum setting
			± 6,25 %	of REFERENCE VALUE between 40 % and 100 % of maximum setting

For welding equipment that uses SET VALUES for current, voltage and/or wire feed speed classified in physical units (e.g. V, A) VALIDATION accuracies given in Table 2 shall be used for the tests. Current and voltage VALIDATION are performed according to 7.3.3. For wire feed speed instructions in 8.3 apply.

NOTE For example a manual metal arc (MMA) typically has only a current SET VALUE.

Table 2 – VALIDATION accuracies of SET VALUES

SET VALUE	Grade	Accuracy	Reference	VALIDATION range
Current	Standard	± 2,5 %	of highest SET VALUE	below 25 % of highest SET VALUE
		± 10 %	of REFERENCE VALUE	25 % to 100 % of highest SET VALUE
	Precision	± 1 %	of highest SET VALUE	below 40 % of highest SET VALUE
		± 2,5 %	of REFERENCE VALUE	40 % to 100 % of highest SET VALUE
Voltage	Standard	± 2,5 %	of highest SET VALUE	below 25 % of highest SET VALUE
		± 10 %	of REFERENCE VALUE	25 % to 100 % of highest SET VALUE
	Precision	± 2 %	of highest SET VALUE	below 40 % of highest SET VALUE
		± 5 %	of REFERENCE VALUE	40 % to 100 % of highest SET VALUE
Wire feed speed	Standard	± 2,5 %	of highest setting	below 25 % of highest setting
		± 10 %	of REFERENCE VALUE	between 25 % and 100 % of highest setting
	Precision	± 2,5 %	of highest setting	below 40 % of highest setting
		± 6,25 %	of REFERENCE VALUE	between 40 % and 100 % of highest setting

See Annex A for diagrams of VERIFICATION accuracies established in Table 1 and Table 2.

7 Arc welding power sources

7.1 Selection related to CALIBRATION, VALIDATION or CONSISTENCY TESTING of process-relevant parameters

7.1.1 VERIFICATION method

Key parameters shall be verified. In general, these include current, voltage and wire feed speed.

The current wave shape shall be considered (see C.1). VERIFICATION is preferred in DC mode. Consult manufacturer for further specifications.

NOTE 1 Key parameters can be listed in a welding procedure specification (WPS).

Depending on the design of the welding equipment to be tested, either CALIBRATION, VALIDATION or CONSISTENCY TESTING shall be carried out (see Figure 1).

The DISPLAYED VALUE and REFERENCE VALUE measurements shall be taken at the same time or in a steady state output condition.

NOTE 2 The selection of voltage or current control mode helps to achieve steady state output conditions. Some welding power sources have control functions that can influence the measurements. Consult relevant manual or manufacturer.

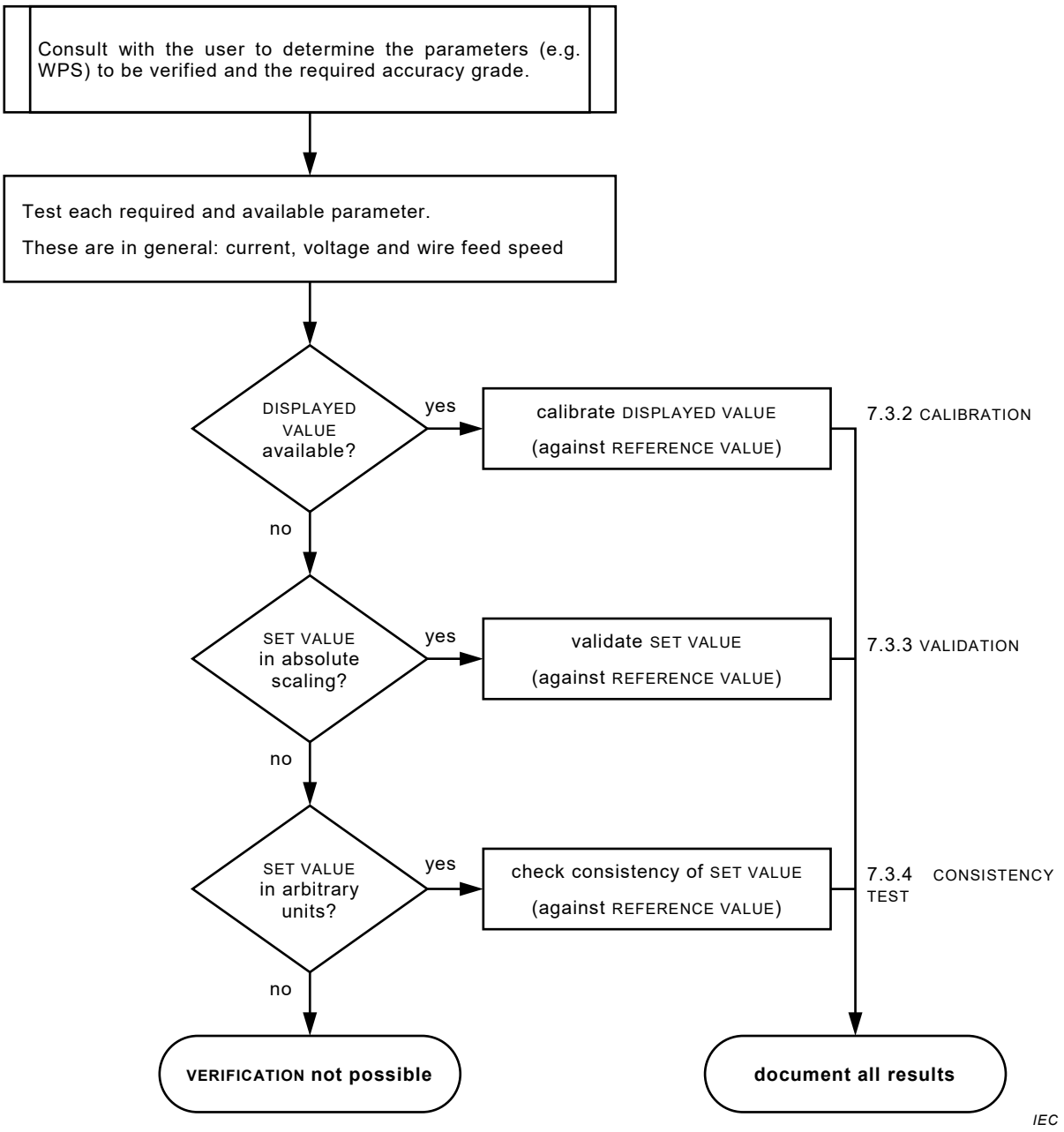


Figure 1 – Determination of VERIFICATION method

NOTE 3 Minimum requirements are shown. For equipment with a DISPLAYED VALUE, it is sufficient to perform CALIBRATION since the measured value is the most important VERIFICATION method. The user can perform additional VERIFICATION such as VALIDATION and CONSISTENCY TESTING.

7.1.2 Special features for AC determination of welding power source output mode for VERIFICATION

For power sources capable of AC and DC output modes, it is sufficient to verify them in DC mode (see Figure 2).

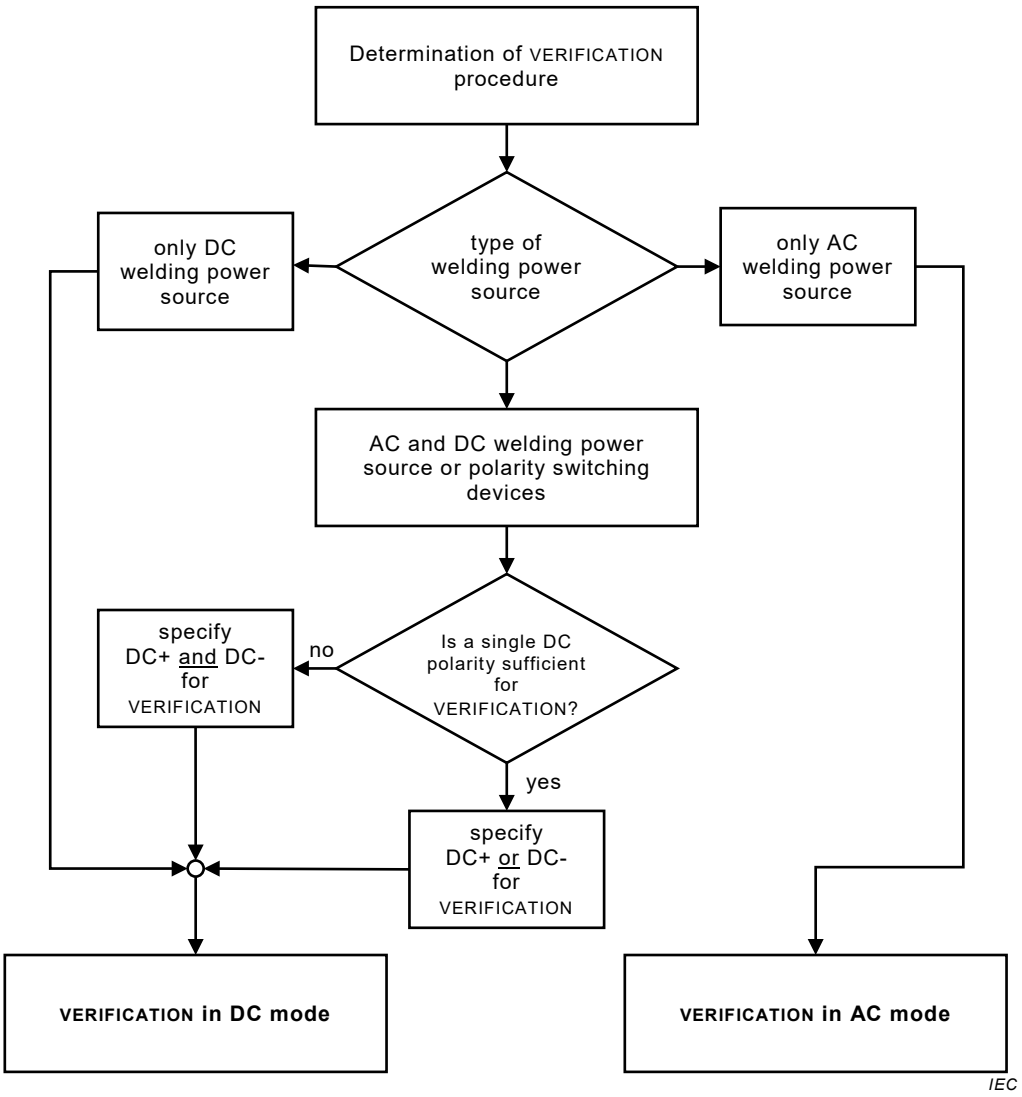


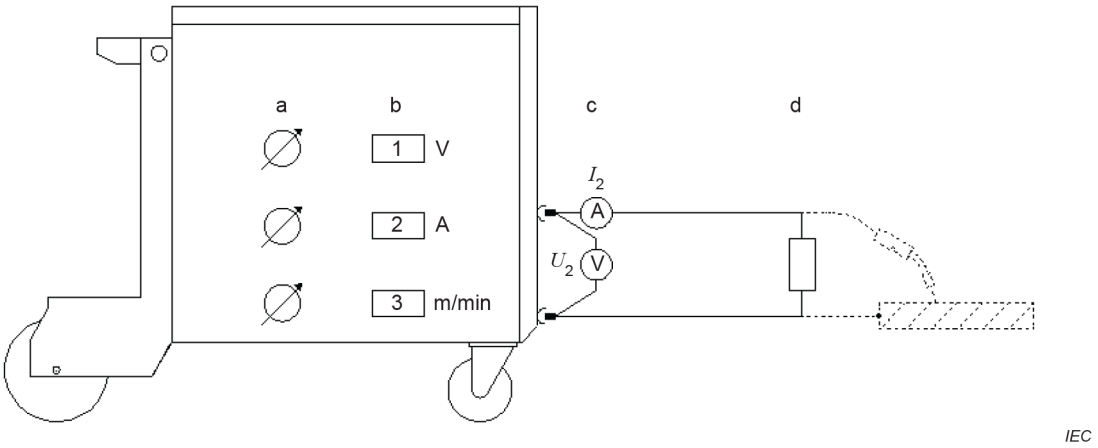
Figure 2 – Determination of VERIFICATION based on power source type

When verifying a pure AC power source, the aim is to identify the reproducibility of the output values of the AC power source under equal conditions (e.g. characteristic, voltage supply, load).

If it is determined for an AC and DC welding power source by the WPS requirements that VERIFICATION in AC mode is still necessary, refer to Annex B and Clause C.1 for additional information.

7.2 Testing equipment and test setup

7.2.1 Test setup



Key

a	SET VALUE	1	voltage
b	DISPLAYED VALUE	2	current
c	REFERENCE VALUE	3	wire feed speed
d	conventional load or arc load		

Figure 3 – Test setup example

Measure the load voltage (U_2) at the welding power source welding circuit connections (see Figure 3) or according to manufacturer's specifications. For welding power sources that are provided with permanently connected welding cables, measure the load voltage at the exit point of the power source enclosure.

Alternate test configuration may be specified by the manufacturer or user.

NOTE IEC 60974-9 provides information on sufficiently dimensioned cables.

7.2.2 Reference instruments

Reference instruments shall meet the following requirements:

a) be calibrated according to standards traceable to a national standard;

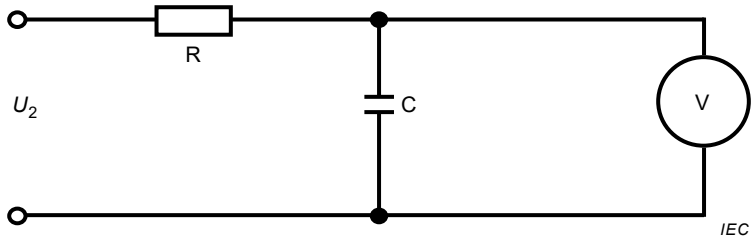
b) have at least 2,5 times the accuracy than that required for the VERIFICATION accuracy;

NOTE 1 For example to calibrate the DISPLAYED VALUE to an accuracy of 2,5 %, the reference instrument minimum required accuracy is 1 %.

NOTE 2 ISO 22514-7 can be used to validate measuring systems and a measurement process in order to state whether a given measurement process can satisfy the requirements for a specific measurement task.

c) U_2 measurements for inverters shall use a low pass filter for signal smoothing having a cut-off frequency not more than 10 kHz or as recommended by the manufacturer. The filter characteristic can be incorporated within the voltmeter or a separate filter may be used. If a separate filter is used, then the attenuation caused by the filter shall be factored into the reference measurement.

NOTE 3 The filter and voltmeter configuration shown in Figure 4 will result in a 0,08 % signal reduction.



Key

V	Reference voltmeter with 10 MΩ input impedance	R	(7,87 ±1 %) kΩ
C	(2 ± 5 %) nF		

Figure 4 – Example 10 kHz filter with reference voltmeter

Reference instruments shall use the same measurement procedure as that for the equipment under test (EUT) (Arithmetical mean, rectified value or RMS value, see Annex B).

7.2.3 Test load

The power source should be loaded with a conventional load in accordance with IEC 60974-1 depending on the process.

An alternative method for CALIBRATION of a TIG power source, is to use a stable welding condition with mechanically held torch.

The required conventional load for a specific working point shall be calculated using the formulae given in 7.2.4.

The load voltage and current should be within 10 % of the conventional load test values.

NOTE Consider the power rating and temperature stability of the load.

7.2.4 Conventional load test values

7.2.4.1 Manual metal arc welding with covered electrodes

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

I_2 over 600 A: $U_2 = 44$ V

7.2.4.2 Tungsten inert gas

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

I_2 over 600 A: $U_2 = 34$ V

7.2.4.3 Metal inert/active gas and flux cored arc welding

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

I_2 above 600 A: $U_2 = 44$ V

7.2.4.4 Submerged arc welding

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

I_2 over 600 A: $U_2 = 44$ V

7.2.4.5 Plasma welding

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

I_2 over 600 A: $U_2 = 49$ V

7.3 CALIBRATION, VALIDATION and CONSISTENCY TESTING procedure

7.3.1 General

It is recommended to test the equipment in accordance with IEC 60974-4 to ensure safe operation before performing a VERIFICATION procedure.

NOTE 1 Observe proper connections and setting of the measurement instrument to prevent damage.

Select measurement points in respect of the setting range of the equipment. The rating plate can be used as reference.

Select one of the following VERIFICATION ranges:

a) the full setting range of the power source or range of DISPLAYED VALUE instrument;

NOTE 2 For digital voltage and current meters the maximum value of the range is given by the rated no-load voltage and maximum rated welding current, respectively, of the power source.

b) a partial range of the setting range of the power source (or DISPLAYED VALUE instrument);

c) selected points over the range of the control or meter.

Options b) or c) require agreement with the manufacturer, customer or user prior to the VERIFICATION being carried out.

The ambient temperature shall be measured and recorded and the nominal rated supply voltage shall be recorded.

For engine driven power sources, check the rated load speed and no-load speed to ensure that the power source meets the rated values.

Perform the measurements at the minimum setting, the maximum setting and three other points nominally equally spaced between minimum and maximum, over the full or partial range. Alternatively, make the measurements at the selected points as given above.

During measurement, the output values of the EUT shall be stable.

Tests shall be carried out at an ambient temperature of (25 ± 10) °C. Other temperatures may be used when accuracy requirements are met by both reference instruments and the welding power source.

7.3.2 CALIBRATION of DISPLAYED VALUE reading

Procedure:

1) Setting of measurement points
2) Read DISPLAYED VALUES and REFERENCE VALUES at the same time or in a steady state output condition and record them. A sample for a CALIBRATION report is given in Clause E.1**.** During each measurement, it is recommended to read the value three times at short intervals and to calculate the resulting arithmetic average.
3) Evaluation:
   a) Differences of indicated DISPLAYED VALUES and REFERENCE VALUES present the absolute error.
   b) Calculation of permissible deviations according to Table 1.

c) The EUT is considered as ”passed“, when the measurements or resulting arithmetic averages do not exceed the limit values.

d) The result shall be documented.

7.3.3 VALIDATION of SET VALUES

Procedure:

1) Setting of SET VALUES and setting of load according to 7.2 such as to ensure that the working point is on the conventional load characteristic.
2) Read REFERENCE VALUES and record them. A sample of a VALIDATION report is given in Clause E.2. During each measurement, it is recommended to read the value three times at short intervals and to calculate the resulting arithmetic average.
3) Evaluation:
   a) differences of SET VALUES and REFERENCE VALUES present the absolute deviations;
   b) calculation of permissible deviations according to Table 2;
   c) the EUT is considered as "passed", when the measurements or resulting arithmetic averages do not exceed the limit values;
   d) the result shall be documented.

7.3.4 CONSISTENCY TEST of SET VALUES

A CONSISTENCY TEST shall be performed on controls which are scaled in arbitrary units.

During the characterization required at the beginning, absolute values are assigned to the control positions as initial values. Results from subsequent tests are compared with the initial values in order to determine the consistency of the output.

Values given in Table 2 shall be used for accuracy of the CONSISTENCY TEST.

Procedure:

1) Verify that the SET VALUE and the load are the same as during the characterization.
2) Read REFERENCE VALUES and record them. A sample of a report is given in Clause E.3. During each measurement, it is recommended to read the value three times at short intervals and to calculate the resulting arithmetic average.
3) Evaluation:
   a) Differences of REFERENCE VALUES between characterization and ongoing testing present the absolute deviations.
   b) Calculation of permissible deviations according to Table 2.
   c) The EUT is considered as "passed", when the measurements or resulting arithmetic averages do not exceed the limit values.
   d) The result shall be documented.

8 Wire feeder

8.1 General

Wire feed equipment includes all systems designed to feed filler wire or consumable continuous electrodes. However, if VERIFICATION of wire feed equipment is possible, the wire feed rate shall conform to the accuracy given in Table 1 and Table 2.

8.2 Requirements for VERIFICATION

The following two basic types of wire feeders are used in welding:

a) wire feeders for consumable electrode processes, e.g. MIG welding, submerged arc welding;
b) wire feeders for additional filler wire, e.g. cold wire TIG welding, hot wire TIG welding.

The type of wire feeder affects the VERIFICATION requirements.

In some cases the speed control may be scaled with arbitrary units and the wire feeder fitted with a wire feed speed meter. In this case the meter shall be calibrated.

Some MIG welding wire feeders may be interlocked with the power source preventing normal wire feed operation without an arc. If the interlock cannot be overridden then the power source shall be energized with an arc to verify the wire feeder.

8.3 Method

Starting with the minimum output setting, energize and stabilize the wire feeder and then take a reading. Repeat this procedure for each of the measurement points up to the maximum.

The following methods may be used:

a) use a measurement system consisting of a pulse generator and a pulse counter that can clip onto or press against the filler wire and measure the wire feed speed directly in conjunction with an indicating instrument;
b) measure the time in seconds for approximately 1 m of wire to be delivered from the welding torch or nozzle with a stopwatch or an electronic timer at the VERIFICATION points selected. Measure the wire length with a steel rule to 1 mm. Calculate the wire feed speed;
c) perform speed measurement at drive and calculate the wire feed speed where manufacturer has provided information on the performance and where it is ensured that the wire does not slip.

Use method a) for measurements in PRECISION GRADE.

Do not use method b) when an arc is used. Consider that the wire or drive can be energized during the measurement operation.

At each VERIFICATION point record the following:

– wire feeder setting; or
– the wire feed speed meter reading;
– REFERENCE VALUE of wire feed speed.

9 Frequency of VERIFICATION

A VERIFICATION interval of 12 months is recommended.

A time period of 3 months is recommended between characterization and first CONSISTENCY TEST.

It may be necessary to conduct CALIBRATION or VALIDATION at more frequent intervals, depending upon the recommendation of the manufacturer, the requirements of the user, or where there is reason to believe that the performance of the equipment may have deteriorated. VERIFICATION shall be carried out after any repair or any process capable of influencing the output values or the DISPLAYED VALUES of the measurement instruments.

10 Marking and VERIFICATION report

10.1 Marking

After finishing a successful VERIFICATION, the equipment shall be marked with a VERIFICATION label indicating the following:

a) "PASSED";
b) information "PRECISION GRADE", if applicable;
c) date of issue and / or expiry date of VERIFICATION label;
d) name of organisation issuing the VERIFICATION label;
e) unique identification of equipment.

10.2 VERIFICATION report

A VERIFICATION report shall be issued after testing indicating whether the equipment has passed the test or not.

The VERIFICATION report shall contain the following information, if applicable:

a) name and address of VERIFICATION organisation;
b) type of equipment tested e.g. power source or wire feeder;
c) manufacturer and model of equipment tested;
d) serial or asset number of equipment tested;
e) ambient temperature;
f) supply voltage;
g) the equipment function under test, e.g. current control, as well as mode of equipment (characteristic) as specified by the welding supervisor if applicable;
h) reference instrument description and CALIBRATION information (CALIBRATION date or due date and serial number);
i) VERIFICATION accuracy, i.e. standard or precision;
j) type of VERIFICATION, i.e. CALIBRATION, VALIDATION or CONSISTENCY TEST;
k) VERIFICATION range;
l) measurement results;
m) additional information or deviations from standard procedures;
n) VERIFICATION result, e.g. passed or failed;
o) date of issue and / or expiry date of VERIFICATION;
p) signature of test personnel;
q) mark of VERIFICATION organisation.

Annex A
(informative)

Diagrams of VERIFICATION accuracies

A.1 CALIBRATION accuracies of DISPLAYED VALUES

Figure A.1 shows VERIFICATION accuracies established in Table 1.

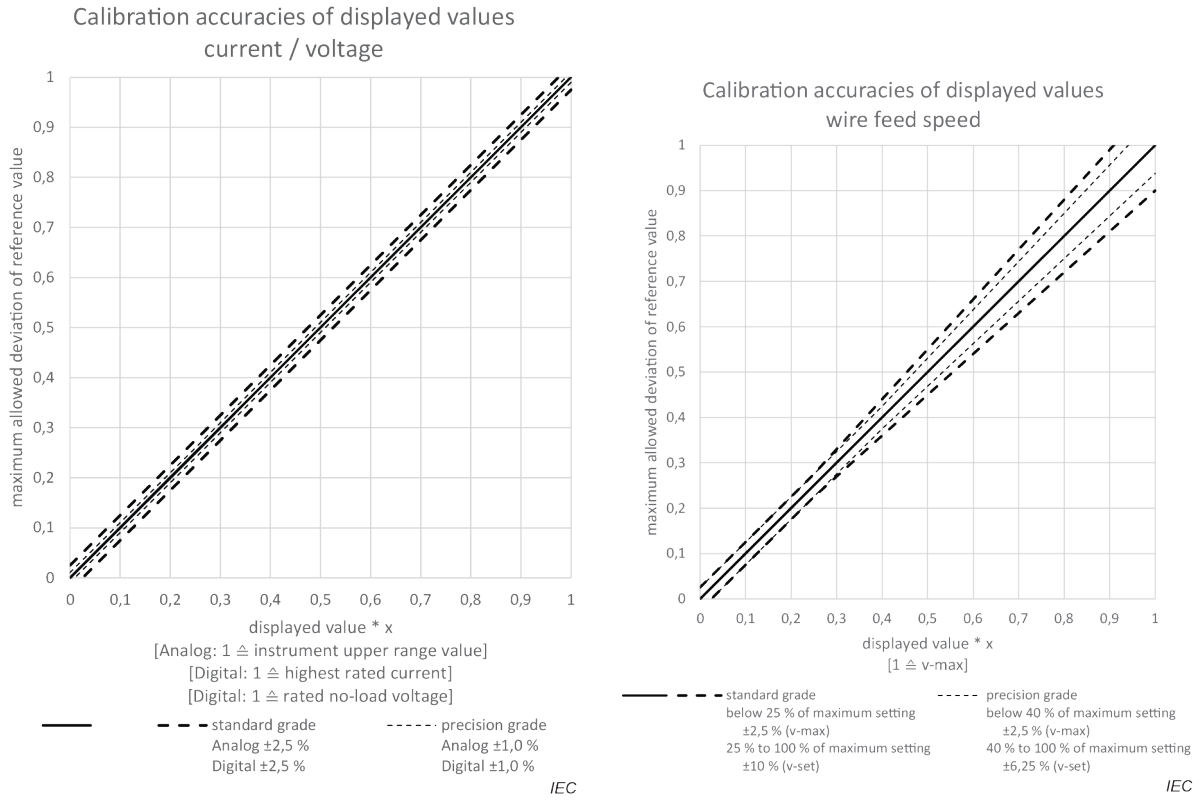


Figure A.1 – Diagrams of CALIBRATION accuracies

A.2 VALIDATION accuracies of SET VALUES

Figure A.2 show VERIFICATION accuracies established in Table 2.

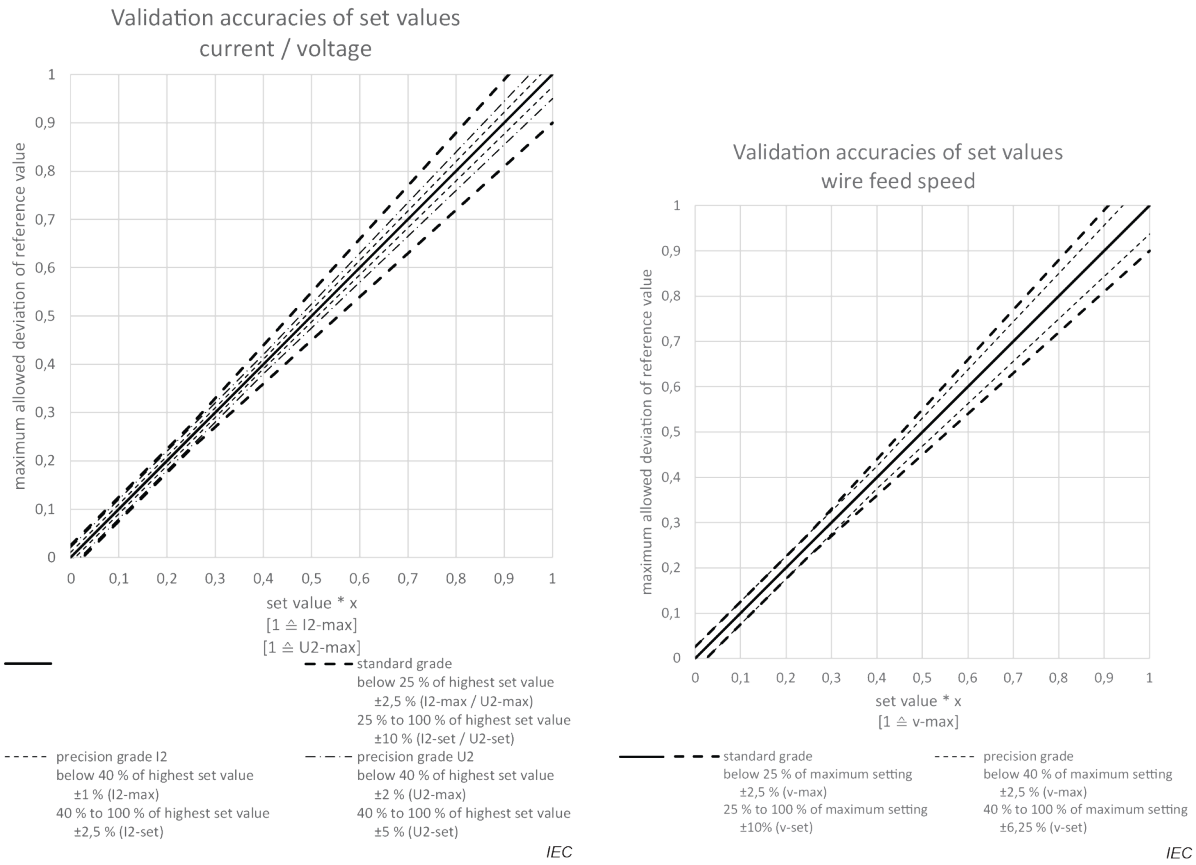


Figure A.2 – Diagrams of VALIDATION accuracies

Annex B
(informative)

Measured value formation

B.1 General

The arithmetic mean is used to calculate the measurement value for signal sequences having no zero-crossing. For signals having a zero-crossing, the arithmetic rectified value is used to calculate the measurement value.

Averaging of measurement values is performed as arithmetic mean for direct current sequences and indicated as arithmetic rectified value for alternating current sequences.

B.2 Averaging of measurement values

B.2.1 Arithmetic mean

Formula for determining the arithmetic mean for the quantity U:

Exact mathematic definition is given by Formula (B.1)

$$\overline{U} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} u(t) dt \tag{B.1}$$

Definition adapted to single values of number n is given by Formula (B.2)

$$\overline{U} = \frac{1}{n} \sum_{i=1}^{n} U_n \tag{B.2}$$

Arithmetic mean = the sum of all single values divided by their quantity.

B.2.2 Arithmetic rectified value

The arithmetic rectified value can be given for alternating current variables.

Formula for the arithmetic rectified value for the quantity U:

Exact mathematic definition is given by Formula (B.3)

$$\overline{U} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} |u(t)| dt \tag{B.3}$$

Definition adapted to single values of number n is given by Formula (B.4)

$$\overline{U} = \frac{1}{n} \sum_{i=1}^{n} |U_n| \tag{B.4}$$

The rectified value is the arithmetic mean of all amounts of single values.

B.2.3 Root mean square (effective value)

For alternating current variables the root mean square (effective value) can also be given.

Formula for the root mean square (effective value) for quantity U:

Exact mathematic definition is given by Formula (B.5)

$$\tilde{U} = \sqrt{\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} [u(t)]^2 dt} \tag{B.5}$$

Definition adapted to single values of number n is given by Formula (B.6)

$$\tilde{U} = \sqrt{\frac{1}{n} \sum_{i=1}^{n} [U_n]^2} \tag{B.6}$$

The root mean square (effective value) is the square root of the arithmetic mean of squared single values.

Annex C
(informative)

Slope, pulse and synergic controls

C.1 VERIFICATION accuracy

DC currents with changing amplitudes (pulse currents) are arithmetically averaged.

For many modern welding power sources, the output is controlled by microprocessors. Output waveform characteristics such as ramps and pulses depend on the (mostly with quartz precision) clock frequency of the processor. An error in clock generation will in general lead to a complete failure of the control or other malfunctions and will be recognized by the user. Therefore, it is not necessary to verify ramp and pulse shapes for such controls.

If a welding power source has an analog control, where times are, for example, generated by resistors or capacitors, values may slowly change in the course of time. Such controls may require being regularly verified.

Slope and pulse controls are considered to be PRECISION GRADE and the VERIFICATION accuracies shall conform to ± 5 % of setting, unless specified by the manufacturer.

C.2 Requirements for VERIFICATION

Slope up and slope down controls on TIG welding power sources are verified in one of the following ways:

– as a variable time (in s) for the current to increase or decrease between two different levels;
– as a rate of change of current (in A/s) between two levels of current.

TIG welding pulse controls are verified in several different ways, for example:

a) peak current pulse height (A);
b) background current height (A);
c) peak current duration (s);
d) background current duration (s);
e) mark space time (s);
f) mark space ratio (number or percentage).

NOTE On or off time is expressed as a fraction or a percentage of the total cycle time.

The VERIFICATION of slope up and slope down controls is straightforward, as the rate of change of current is slow.

The VERIFICATION of TIG welding pulse controls is an important contribution to the quality of pulsed TIG welding. It is a more difficult task than the VERIFICATION of slope controls. It requires equipment with a faster response than is necessary for the VERIFICATION of slope controls. An instrument response of at least ten times that of the maximum pulse frequency of the power source is recommended.

C.3 Method

Energize and stabilize the power source output for 5 s for pulsed current VERIFICATION. A period of load current stabilisation is not applicable to slope up VERIFICATION.

Record the current waveform two times at each setting using appropriate instrumentation.

Verify the slope up and slope down control at the following selected points of the control range at designated points on the current control range:

a) the full range of the slope control; or

b) some part of the slope range; or

c) selected points on the slope range.

Items a), b) and c) and the designated current control points should be agreed by the manufacturer or user or customer and the validator in advance of the CALIBRATION procedure. In the absence of any agreement, the VERIFICATION shall take place at the mid-point of the current control range at the mid-point of the slope up or slope down control range.

Verify the current pulse control at points selected by the following:

1) the welding procedure developer;

2) the validator;

3) the equipment user.

In the absence of any stipulation of VERIFICATION points by 1), 2) or 3), the pulse control shall be validated at the following points on the pulse shape control ranges:

– peak current midrange;

– background current midrange;

– peak current on time minimum and maximum;

– background current on time midrange.

The specification and VERIFICATION of the full range of the pulse shape controls should be the responsibillity of the equipment manufacturer.

At each VERIFICATION point, record the following:

– the pulse control settings;

– the measurement of current flowing in the loading circuit.

The measuring instrument selected will record the current pulse shape electronically or graphically. The record can be measured to determine the magnitude and duration of the current pulses in the power source output circuit. The waveform is often not a true square wave and care should be taken in determining the peak and background periods. It is advisable to consult the equipment manufacturers.

The average value of the two measurements shall be systematically recorded.

C.4 Pulsed MIG and synergic controls

Ammeters and voltmeters that measure mean values of the welding parameters may be validated in accordance with this document. VERIFICATION of other controls and pulsed waveforms should be in accordance with the manufacturer’s procedure.

Annex D
(informative)

Precautions to be taken with TIG welding equipment

The VERIFICATION of TIG welding power sources may involve the operation of the equipment with a welding arc. It may also be necessary to connect electrical measuring instruments directly to the output terminals of the welding power source. Few measuring instruments are protected against the high voltage high frequency arc initiation discharges used in many TIG welding systems. These discharges may be of the order of 5 000 V at a frequency of typically 1 MHz. The discharge will damage or destroy the measuring instrument. The validator shall take precautions, such as the following, against this damage:

a) the simplest method of protection is to connect the measuring instrument after the arc has been initiated. This involves some risk as the arc could fail and automatically restrike;

b) the meter may be connected inside the power source on the low voltage side or safe side of the power source internal protection circuits. The safe connection points may be identified from the power source meter circuits;

c) the measuring instrument may be protected by a filter circuit similar to that provided in the power source;

d) the measuring instrument may be protected by an automatic disconnection circuit;

e) the high voltage initiation circuit may be disconnected and the arc initiated by a tungsten electrode touch start or a carbon rod drawn between the tungsten electrode and the workpiece.

Annex E
(informative)

Samples of VERIFICATION reports

E.1 Sample of CALIBRATION report

Calibration report

for arc welding equipment according to IEC 60974-14

Name of organisation:	
Address:	
Type of equipment:	MIG/MAG power source
Manufacturer:	Freefried Electric Ltd.
Model:	Freefried
Serial number:	123456
Asset number (optional):	1147
highest set values for current (rating plate):	330 A
rated no-load voltage U_0 (rating plate):	45,0 V

max. admis. deviation current display:

Standard grade	± 2,5 % of	330 A	=	8,3 A
Precision grade	± 1,0 % of	330 A	=	3,3 A

max. admis. deviation voltage display:

Standard grade	± 1,5 V	=	1,5 V
Precision grade	± 0,6 V	=	0,6 V

Equipment function:

X	MIG/MAG	$U_2 = (14 + 0{,}05 * I_2)$ V
	TIG	$U_2 = (10 + 0{,}04 * I_2)$ V
	MMA	$U_2 = (20 + 0{,}04 * I_2)$ V

Calibration grade :

	Standard
X	Precision

Ambient temperature :	24 °C
Supply voltage :	400 V

No.:	Specifications					Setting	Corresp.	Display						Test value within tolerance	
						Load resistance acc. standard	to switch position	EUT		Reference		Deviaiton (absolute)			
	X % of highest set value			Setpoint to be set	Set setpoint	[Ω]		Current [ADC]	Voltage [VDC]	Current [ADC]	Voltage [VDC]	Current [ADC]	Voltage [VDC]	Current	Voltage
1.	20 % of	330 A	=	66 A	70 A	0,25		71,43 A	17,76 V	71,37 A	17,80 V	0,07 A	0,04 V	Yes	Yes
2.	40 % of	330 A	=	132 A	130 A	0,16		132,97 A	21,53 V	133,03 A	21,67 V	0,07 A	0,14 V	Yes	Yes
3.	60 % of	330 A	=	198 A	200 A	0,12		198,67 A	24,10 V	199,20 A	24,71 V	0,53 A	0,61 V	Yes	No
4.	80 % of	330 A	=	264 A	260 A	0,10		264,67 A	26,40 V	264,90 A	26,63 V	0,23 A	0,23 V	Yes	Yes
5.	100 % of	330 A	=	330 A	330 A	0,09		330,33 A	29,66 V	330,77 A	29,87 V	0,43 A	0,20 V	Yes	Yes

Test result: **PASS** [ ] **FAIL** [X]

date of expiry of verification (as agreed / recommended):

Remarks

.....
Test personnel name

.....
Date, Test personnel signature

reference instruments calibration information

name	**serial no.**	**calibration date**	**due date**
Device 1	1234	21 Dez. 2017	21 Dez. 2018
Device 2	....	.....	.....

E.2 Sample of VALIDATION report

Validation report

for arc welding equipment according to IEC 60974-14

Name of organisation:	
Address:	
Type of equipment:	MMA power source
Manufacturer:	Freefried Electric Ltd.
Model:	Freefried
Serial number:	123456
Asset number (optional):	1147
highest set values for current (rating plate):	330 A
highest set values for voltage (rating plate):	30,5 V

	MIG/MAG	$U_2 = (14 + 0{,}05 * I_2)$ V
	TIG	$U_2 = (10 + 0{,}04 * I_2)$ V
X	MMA	$U_2 = (20 + 0{,}04 * I_2)$ V

Validation grade:

	Standard
X	Precision

Ambient temperature :	24 °C
Supply voltage :	400 V

No.	Specifications				Setting	Corresp.	Dispaly	Difference	Admisible error					Test value
	X % of highest set value		Setpoint to be set	Set setpoint	Load resistance acc. standard [Ω]	to switch position	Reference Meas.instr. reference value	to set setpoint						within tolerance
									X % of highest set value					
1.	10 % of	330 A =	33 A	**30 A**	0,52		**32,3 A**	**2,3 A**	**1,0 % of**	**330 A**	=	**3,3 A**		**Yes**
2.	20 % of	330 A =	66 A	**70 A**	0,25		**63,0 A**	**7,0 A**	**1,0 % of**	**330 A**	=	**3,3 A**		**No**
3.	30 % of	330 A =	99 A	**100 A**	0,19		**100,1 A**	**0,1 A**	**1,0 % of**	**330 A**	=	**3,3 A**		**Yes**
									X % of reference value					
4.	40 % of	330 A =	132 A	**130 A**	0,16		**131,7 A**	**1,7 A**	**2,5 % of**	**131,7 A**	=	**3,3 A**		**Yes**
5.	60 % of	330 A =	198 A	**200 A**	0,12		**201,0 A**	**1,0 A**	**2,5 % of**	**201,0 A**	=	**5,0 A**		**Yes**
6.	80 % of	330 A =	264 A	**260 A**	0,10		**264,3 A**	**4,3 A**	**2,5 % of**	**264,3 A**	=	**6,6 A**		**Yes**
7.	100 % of	330 A =	330 A	**330 A**	0,09		**331,0 A**	**1,0 A**	**2,5 % of**	**331,0 A**	=	**8,3 A**		**Yes**

Test result: **PASS** ☐ **FAIL** X

date of expiry of verification (as agreed / recommended):

Remarks

....

Test personnel name Date, Test personnel signature

reference instruments calibration information

name	**serial no.**	**calibration date**	**due date**
Device 1	1234	21 Dez. 2017	21 Dez. 2018
Device 2		.....	.....

E.3 Sample of CONSISTENCY TEST report

Consistency test report

for arc welding equipment according to IEC 60974-14

Name of organisation:	
Address:	
Type of equipment:	MIG/MAG power source
Manufacturer:	Freefried Electric Ltd.
Model:	Freefried
Serial number:	123456
Asset number (optional):	1147
highest set values for current (rating plate):	330 A
highest set values for voltage (rating plate):	30,5 V

X	MIG/MAG	$U_2 = (14 + 0{,}05 * I_2)$ V
	TIG	$U_2 = (10 + 0{,}04 * I_2)$ V
	MMA	$U_2 = (20 + 0{,}04 * I_2)$ V

Validation grade :

	Standard
X	Precision

Ambient temperature : 24 °C
Supply voltage : 400 V

No.:	Specifications: X % of highest set value			Setpoint to be set	Set setpoint	Setting: Load resistance acc. standard [Ω]	Corresp. to switch position	Dispaly: Reference Meas. instr. Measurem. 1 reference value	Display: Reference Meas. instr. Measurem. 2 reference value	Difference between Measurem. 1 and Messurem. 2	Admissible error	Test value within tolerance
											X % of highest set value	
1.1	10 % of	330 A	=	33 A	30 A	0,52		32,3 A	31,3 A	1,0 A	1,0 % of 330 A = 3,3 A	Yes
2.1	20 % of	330 A	=	66 A	70 A	0,25		63,0 A	62,0 A	1,0 A	1,0 % of 330 A = 3,3 A	Yes
3.1	30 % of	330 A	=	99 A	100 A	0,19		100,1 A	99,1 A	1,0 A	1,0 % of 330 A = 3,3 A	Yes
											X % of reference value	
4.1	40 % of	330 A	=	132 A	130 A	0,16		131,7 A	130,7 A	1,0 A	2,5 % of 131,7 A = 3,3 A	Yes
5.1	60 % of	330 A	=	198 A	200 A	0,12		201,0 A	200,0 A	1,0 A	2,5 % of 201,0 A = 5,0 A	Yes
6.1	80 % of	330 A	=	264 A	260 A	0,10		264,3 A	263,3 A	1,0 A	2,5 % of 264,3 A = 6,6 A	Yes
7.1	100 % of	330 A	=	330 A	330 A	0,09		331,0 A	330,0 A	1,0 A	2,5 % of 331,0 A = 8,3 A	Yes

Test result **PASS** [X] **FAIL** [ ]
date of expiry of verification (as agreed / recommended):
Remarks

....
Test personnel name Date, Test personnel signature

reference instruments calibration information

name	serial no.	calibration date	due date
Device 1	1234	21 Dez. 2017	21 Dez. 2018
Device 2		.....	.....

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