British Standard

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Akin Koksal

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Code of practice for validation of arc welding equipment

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Committees responsible for this British Standard

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Association of Welding Distributors
British Cable Makers' Confederation
British Cables Association
Cranfield University
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Welding Manufacturers' Association

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Contents

Foreword

This British Standard is published under the authority of committee WEE/6, Arc welding equipment. It supersedes BS 7570:1992, which is withdrawn.

Welding is considered to be a special process because the final result may not always be capable of being verified by testing, hence it requires continuous control and/or adherence to documented procedures.

The standard series BS EN 729, *Quality requirements for welding — Fusion welding of metallic materials*, has been published to identify the controls and procedures required. BS EN 729 requires the use of calibrated welding equipment, then the quality/consistency of the weld depends upon accurate and repeatable setting of parameters such as current, voltage, speed, gas flow, etc.

This new edition of BS 7570 has been written based on the experience gained in using BS 7570:1992 over the last few years.

This edition has been simplified and concentrates on validating equipment built to the constructional standard BS EN 60974-1. The accuracy of this equipment is designated as standard grade. A higher level of accuracy (precision grade) was introduced in BS 7570:1992, but this has not gained wide acceptance so is now included in annex A for information.

Annexes A to F are all informative.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover, and a back cover.

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Introduction

The quality and consistency of a weld depends on the welder, the materials and the welding equipment. Variability in the output of the welding equipment will affect the quality of the weld. In some arc welding processes, e.g. MMA, the welder controls the process through his experience, and measurement of run out length is used to monitor the heat input. However, in other arc welding processes, the quality of the weld depends upon accurate and repeatable setting of parameters such as current, voltage, speed, gas flow, pulse characteristics etc.

The relevant construction standard for arc welding equipment is BS EN 60974-1. This standard sets the reference level for the accuracy and consistency of the welding output. BS EN 60974-1 derives its specification for performance accuracy from the requirements of manual welding. In manual welding the welder plays a key role in adapting and adjusting the output of the equipment to meet the requirements of the weld. This adaptability allows equipment to be constructed with a relaxed specification for calibration of output.

Mechanized welding methods lack the skilled adaptability of the manual welder and require precise control of all aspects of the welding process. The control of the output of the welding equipment is of particular importance. Manufacturers have responded to this need by producing equipment with an accuracy of output control and calibration which far exceed the requirements of BS EN 60974-1.

In addition to the demands of mechanized welding, manual welding methods have become more refined and welding procedures often call for the precise control of power source outputs to limit the freedom of the manual welder in order to produce particular results.

The improvement in equipment construction, the adoption of mechanized welding, the introduction of quality assurance programmes and the increased understanding of the factors which control weld quality have led to the demand for more rigorous calibration and validation of welding equipment performance.

The term calibration has been used in the foregoing text to introduce the general subject of checking that the welding equipment output meets the manufacturer's specification and is fit for the purpose of making welds. This is a commonly accepted term for this checking operation but it does not meet the strict definition of the word calibration.

Clause **3** of this document gives the definition of calibration. The operation of calibration can be applied only to determining and adjusting the errors of a measuring instrument. An item of welding equipment is not a measuring instrument though the meters fitted to the welding equipment are and can be calibrated. The difficulty of terminology and the checking task is further compounded as many pieces of welding equipment do not have calibrated outputs but are scaled in arbitrary units. Again this is a function of the manual welding usage in which the skill of the manual welder is used to adjust and set the welding variables. It is necessary to use an alternative term to describe the operation of verifying that the welding equipment is fit for the intended purpose. The term selected is validation.

Validation is the operation which verifies that the welding equipment conforms to the operating specification for that equipment. If the equipment fails to conform to the specification then the correction of the errors within the equipment is outside the scope of this standard. That operation is the province of the manufacturers or equipment specialists.

It is implicit in the introduction of a more rigorous standard for accuracy of control of output for welding equipment that the scope of application of that standard should be defined. This standard defines two levels of accuracy. One is derived directly from BS EN 60974-1 and is called standard grade. A higher level of accuracy for more exacting welding applications is defined, called precision grade, and this is given in annex A for information. The use of precision grade is dependent upon the welding application.

The welding equipment covered by this standard will be fitted with controls intended to regulate the output of the welding equipment. The controls may be scaled in absolute units (amperes, volts, metres per minute) or in arbitrary units (numbers, letters, geometrical marks). Controls scaled in absolute units may be validated and the consistency of those controls scaled in arbitrary units may be assessed.

The welding equipment may be fitted with meters that measure the output of the equipment and these meters should normally be validated against the appropriate standard, unless a different method is used to control the welding process.

The use of meters and measuring instrument packages with welding equipment that is required to produce welds of integrity and reliability is strongly recommended.

This code of practice recommends the use of resistive loads to validate the power source and associated meters. Alternatively, independent instrumentation may be used to monitor the welding process, rather than validating the power source itself. The method of control and type of instrumentation should be detailed on the welding procedure sheet.

1 Scope

This British Standard gives recommendations for validation methods for welding equipment constructed and used to the accuracy specified in BS EN 60974-1 or other equivalent standards. The accuracy of this equipment is designated as standard grade.

The welding equipment covered by this standard includes:

1) welding power sources;

2) wire feeders;

3) welding instrumentation.

Guidance is also given on the calibration and validation of ancillary equipment which may affect the quality of the weld, e.g. flow gauges, thermocouples, robots and manipulators.

2 Normative references

The following normative documents contain provisions which, through reference to this text, constitute provisions of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 89-2:1990, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 2: Specification for special requirements for ammeters and voltmeters.*

BS 90:1975, *Specification for direct-acting electrical recording instruments and their accessories.*

BS 499-1:1991, *Welding terms and symbols — Glossary for welding, brazing and thermal cutting.*

BS 638-4:1996, *Arc welding power sources, equipment and accessories — Part 4: Specification for welding cables.*

BS 638-7:1984, *Arc welding power sources, equipment and accessories — Part 7: Specification for safety requirements for installation and use.*

BS 638-10:1990, *Arc welding power sources, equipment and accessories — Part 10: Specification for safety requirements for arc welding equipment: welding power sources* (withdrawn, see clause **4**).

BS EN 729:1995 (all parts), *Quality requirements for welding — Fusion welding of metallic materials.*

BS EN 60051-1:1999, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 1: Definitions and general requirements common to all parts.*

BS EN 60974-1:1998, *Arc welding equipment — Part 1: Welding power sources.*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS 499-1 and the following apply.

3.1

calibration

operations for the purpose of determining the magnitude of the errors of a measuring instrument and if necessary to determine other metrological properties

3.2

validation

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

3.3

accuracy

closeness of an observed quantity to the defined or true value

3.4

consistency test

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

NOTE The results obtained from the present validation are compared to the results of the previous validation. The repeatability/consistency is the difference between these readings.

3.5

class

designation according to the accuracy of a measuring instrument conforming to BS EN 60051-1:1999, BS 89-2:1990 or BS 90:1975

NOTE For example, class 2.5 refers to ± 2.5 % full scale deflection.

3.6

portable welding monitor (brief case monitor)

assembly of measuring instruments packaged in a portable case used to measure, record and/or analyse the welding equipment output

3.7

expert (competent, skilled person)

person who can judge the work assigned to him and recognize possible dangers on the basis of his professional training, knowledge and experience and his knowledge of the relevant requirements

3.8

standard grade

grade of validating equipment built to the constructional standard BS EN 60974-1 or BS EN 638-10:1990

NOTE BS 638-10:1990 was withdrawn in 1998 and superseded by BS EN 60941-1:1998.

3.9

precision grade

grade of validating equipment built to the constructional standard BS EN 60974-1 or BS 638-10:1990 but with a higher level of accuracy for more exacting welding applications

NOTE See annex A for power sources and annex B for wire feeders.

4 Validation accuracies

When tested in accordance with clause **9**, the validation accuracies for standard grade power source controls and instrumentation should conform to Table 1.

NOTE 1 Equipment manufactured since 1998 should conform to BS EN 60974-1:1998.

NOTE 2 Equipment manufactured between 1990 and 1998 should conform to BS 638-10:1990 (or equivalent).

NOTE 3 Equipment manufactured prior to 1990 will be made to other national standards, which may specify different levels of accuracy. For example, earlier parts of BS 638 state "The accuracy of this indication shall be within ±10 % of the true value, unless the maximum output current exceeds ten times the minimum output current. In this case the accuracy at minimum current shall be $\pm I_{max} / I_{min}$ % and the accuracy at maximum current shall be ±10 %, with the accuracy varying linearly between these two values". The manufacturer should be consulted for equipment made to other standards.

Table 1 — Validation accuracies for standard grade power sources

Quantity	Accuracy	
Current and voltage BS 638-10:1990	±10 %	of the true value
Current and voltage (BS EN 60974-1:1998)	±10 %	of the true value, between 100 % and 25 % of the maximum setting
	±2.5 %	of the maximum setting, below 25 % of the maximum setting
Analogue meters	Class 2.5	See clause **3.5**
Digital meters		
Current	±2.5 %	of maximum rated welding current
Voltage	±2.5%	of no-load voltage OR according to the manufacturer's specification

Validation may be carried out over a limited range, as agreed by the manufacturer and user or specified in the welding procedure.

5 Consistency

It is recognized that the consistency of the equipment is important and in clause **9** tests for consistency are recommended.

A consistency test should be carried out on controls which cannot be calibrated or validated because they are not graduated in absolute units or the original validation is not applicable due to the way the equipment is being used, e.g. under abnormal load conditions.

Absolute values are assigned to control positions during an initial characterization. The results obtained from subsequent tests are compared to these initial values to determine the consistency of the output.

The same percentage values for accuracy, as specified in Table 1, should be used in the consistency test as for standard or precision grade as appropriate.

6 Frequency of validation and calibration

The welding equipment should be validated or recalibrated at yearly intervals. Following an initial consistency test it is recommended that the equipment be initially revalidated after three months.

It may be necessary to validate or recalibrate 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. Validation should always be carried out after any repair or operation liable to affect the validation.

NOTE Recommendations for precision grade equipment are given in annex A.

7 Validators of welding equipment

The welding equipment should be validated in accordance with clause **9** by an expert, using equipment which has calibration traceable to national standards.

Validation does not require third party certification although an equipment repairer or validation agent often carries it out. Manufacturers of equipment may provide a validation service or the users may carry out the work themselves.

8 Validation

8.1 General

Unless specified otherwise, e.g. by the welding procedure, all power source controls should be validated. If meters are fitted these should be validated in preference to other methods of setting the relevant parameter.

The requirements and method of power source and meter validation will depend on the type of power source, i.e. whether it is a flat (constant voltage) or drooping (constant current) characteristic power source.

Welding power sources can be classified as follows:

a) a.c. power sources with constant current (drooping characteristic);

b) d.c. power sources with constant current (drooping characteristic);

c) d.c. power sources with constant voltage (flat characteristic).

CAUTION. The output of a constant voltage power source should not be short-circuited as a very high current will flow; use a load resistor.

Welding power sources may or may not have meters fitted. The general practice has been to fit moving coil indicating instruments on direct current power sources and moving iron indicating instruments on alternating current power sources.

Moving coil instruments measure the average or mean value of the instantaneous parameter t with respect to time. Moving iron instruments measure the true r.m.s. value. There has been a trend over the years to fit moving coil meters to a.c. power sources. These give an indicated rather than a true r.m.s. reading, see **9.3**. Increasingly, digital meters are now being fitted to power sources. These may give true or indicated r.m.s. readings. For some equipment a single digital meter may be used to measure a.c. and d.c. voltage and current. Expert knowledge may be required to validate such equipment and the manufacturer should be consulted.

The standard methods of measurement are as follows.

i) Direct current welding supplies should be measured with averaging techniques.

ii) Alternating current supplies should be measured with root mean square methods using true r.m.s. meters or using indicated r.m.s. meters (i.e. assuming pure sinusoidal form).

NOTE For power sources with non-sinusoidal waveforms e.g. square waves, averaging techniques may be used and the manufacturer should be consulted (see **9.3**).

8.2 MMA

MMA power sources are a.c. or d.c., with a constant current characteristic. The current control if marked in absolute units should be validated at conventional load voltages. An arbitrarily marked scale should be checked for consistency.

The MMA process is often controlled by measurement of run-out length where measurement of welding current is not necessary. However, if accurate measurement of the welding current is required it is preferable to use an ammeter (fitted to the power source or separate) which can be calibrated, or to use independent monitoring equipment.

MMA power sources do not have voltage controls.

8.3 TIG

TIG power sources are a.c. or d.c., with a constant current characteristic. The current control should be marked in absolute units and can be validated at conventional load voltages. Generally, TIG power sources are fitted with ammeters and possibly voltmeters, which can be calibrated. TIG power sources do not have voltage controls.

TIG welding power sources are used in complex TIG welding systems and it may be required to validate the system with load conditions, which closely duplicate the arc load conditions. The resistance of the load is calculated for a specific welding condition using the welding current and the arc voltage at that current. The welding conditions could be taken from the welding procedure. Alternatively, a stable arc may be used with a mechanically held torch.

CAUTION. Care should be taken to ensure damage does not occur to instrumentation. See annex D for recommended precautions.

A validation method for pulsed TIG power sources is recommended in annex C.

8.4 MIG/MAG and FCW

MIG/MAG and FCW power sources are usually d.c. with a flat characteristic.

The voltage control may be scaled in absolute or arbitrary units. The voltage control sets the no-load voltage, and the voltage will fall slightly as current is drawn (typically 3 V to 5 V per 100 A). Some power sources have a slope control which may be used to adjust the static characteristic and the setting of this control should be noted on the validation certificate.

The voltage control if marked in absolute units should be validated at no-load voltages. An arbitrarily marked scale should be checked for reproducibility/consistency.

MIG power sources do not have current controls. The output current of a MIG welding power source is controlled by the wire feed speed setting which is set on the wire feeder control panel. The current varies automatically to regulate the burn off rate of the consumable electrode. See annex B on wire feed rate consistency and validate the wire feeder if necessary.

If accurate measurement of the welding current and voltage is required it is preferable to use an ammeter and voltmeter (fitted to the power source or separate) which can be calibrated or to use independent monitoring equipment.

CAUTION. Do not short-circuit the output of a constant voltage power source as a very high current will flow; use a load resistor.

For synergically controlled and pulsed MIG power sources, a validation method is recommended in annex C.

8.5 Auxiliary components

For validation of auxiliary components see annex E.

9 Validation techniques

9.1 General

It is recognized that manufacturers have developed many specialized methods of validating their welding equipment that may require detailed knowledge of the construction or access to the interior of the equipment. The validation methods described in this standard are intended to enable the user to check that the equipment is fit for the intended purpose without the manufacturer's specialist knowledge. The methods of measurement described may require specialist knowledge or apparatus.

9.2 Safety precautions

The validator should observe all normal welding safety precautions. Welding equipment should be installed and used in accordance with BS 638-7. If a TIG power source is being validated using a welding arc as a power source load, protective clothing and eye protection should be worn.

The validator should pay particular attention to safety earthing recommendations. Special attention should be given to the connection of measuring instruments and the welding current circuit to prevent high current passing through the instruments.

9.3 Instrumentation

The general rule for the selection of measuring instruments for use in validation tasks is that they should conform to the following.

a) They should be in good condition.

b) They should be calibrated by a recognized calibrator with standards traceable to a national standard.

c) They should be at least twice and preferably five times more accurate than the accuracy required for the validation grade.

The type of measurement and meter will be specified for the grade of accuracy and the type of electrical output of the power source.

It is proposed that only three measuring terms be used for describing the basic electrical measuring techniques:

1) instantaneous value;

2) mean value;

3) r.m.s. value.

NOTE The r.m.s. value may be "true" or "indicated". Some meters measure r.m.s. directly ("true" r.m.s.) but many measure the mean and indicate 1.11 times the mean to give an equivalent to the r.m.s. value for a true sine wave.

The straightforward measurement of welding parameters is complicated by the following factors.

a) The current waveform is usually complex, i.e. the direct current has some fluctuating component and the alternating current is not sinusoidal.

b) The measurement of current from the output of power sources with a large ripple content, especially some types of inverter direct current power sources, will produce different results depending upon the type of meter being used.

c) The shape of the waveform will affect the accuracy of the measurement if the waveshape contains higher frequency components, e.g. TIG square wave pulses, and the measuring equipment has an inductive component, e.g. some types of shunts. This may be limited by using non-inductive shunts.

d) The shape of the current and voltage waveform for a.c. power sources is assumed to be sinusoidal. Errors will result if the waveform departs significantly from the sinusoidal, especially when using digital meters and portable welding monitors. For example, this is the case with arc voltage that is nearer a square wave than a sine wave.

e) There are a wider range of meters and sensing devices in use now, which enable more complex measurements and instant operations and computations on the measurement.

f) The purpose of the measurement may be comparative in order to transfer a welding procedure or absolute in order to make heat input calculations. This may influence the measuring method.

g) The resistance of the welding circuit will have an effect on the application of the welding procedure parameters (see annex F).

In all cases where the validator is in doubt about the shape of the waveform and the effect on the validation then specialist advice should be sought from the manufacturer of the equipment or a similar specialist.

9.4 Power source loads

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

a) MMA

Drooping characteristic: $U_2 = (20 + 0{,}04\,I_2)$ V up to $I_2 = 600$ A, after which U_2 remains constant at 44 V.

b) TIG

Drooping characteristic: $U_2 = (10 + 0{,}04\,I_2)$ V up to $I_2 = 600$ A, after which U_2 remains constant at 34 V.

c) MIG/MAG and FCW

Flat characteristic: $U_2 = (14 + 0{,}05\,I_2)$ V up to $I_2 = 600$ A, after which U_2 remains constant at 44 V.

d) Submerged arc welding

$U_2 = (20 + 0{,}04\ I_2)$ V up to $I_2 = 600$ A, after which U_2 remains constant at 44 V.

For TIG welding an arc load is permitted provided that the torch is mechanically guided.

No-load voltages for MIG power sources should be measured without a load connected and it should be noted that these values might not agree with the rated no-load voltage which appears on the rating plate. The rating plate no-load voltage is stated for safety reasons on power sources conforming to BS 638-10:1990 and is the peak voltage measured with a specified loading circuit. However, for power sources conforming to BS EN 60974-1:1998, the no-load voltage should be stated as the mean or r.m.s. value.

9.5 Method

9.5.1 ***General***

9.5.1.1 Measure the ambient temperature to ensure that it is within the limits specified for the power source and test the instrumentation rating. Record the ambient temperature on the validation certificate.

9.5.1.2 Measure the input voltage to ensure that it is within the value specified for the power source. Record the result of this measurement on the validation certificate. Check that the correct tappings have been connected within the power source if relevant.

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

9.5.1.4 Connect the resistive load across the output terminals of the power source as far as practical. Connect the instrumentation used for validation of voltage across the resistive load, and the current transducer in the circuit.

9.5.1.5 Connect the wire feed unit for validation to the source of power supply normally used during welding.

9.5.1.6 Assemble and adjust the wire feeder according to the manufacturer's instructions.

9.5.1.7 Do not drive the wire feeder at speeds or loaded with filler wire diameters in excess of that shown on the rating plate or recommended by the manufacturer.

9.5.1.8 Use terminals, cables and wires of high quality to connect the welding equipment during validation and make all joints sound. Make all crimped and soldered joints free from any signs of overheating.

9.5.1.9 The current rating of validation welding cables should exceed by a factor of two the maximum current flowing in the welding circuits except where the welding system is being validated with specific welding cable or circuit assembly characteristics.

9.5.1.10 Select the validation/calibration range of the control or meter fitted to the power source from one of the following:

a) the full range of the control or meter (see note);

b) a partial range of the control or meter;

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

NOTE 1 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.

Agree options b) or c) with the manufacturer, customer or user, prior to the validation/calibration being carried out.

Make 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.

NOTE 2 If a partial range is selected, the minimum measurement point should be approached from below initially. The second measurement point at maximum should be approached from above. The two measurements at each point should then be averaged and compared to the control setting or meter reading to determine the errors.

9.5.2 ***Power source and welding instrumentation***

9.5.2.1 Switch on the equipment 5 min before any calibration measurements.

9.5.2.2 Start with the minimum output setting (see **9.5.1**), energize and stabilize the power source output for 10 s and then take a reading. Repeat this procedure for each of the measurement points up to the maximum.

9.5.2.3 After a further 10 s, take a second reading at the maximum setting (see **9.5.1**), and repeat this procedure for each of the measurement points down to the minimum.

9.5.2.4 The power source should not be loaded in excess of that shown on the rating plate.

9.5.2.5 If validation at a particular current and or voltage is required, but the nature of the load does not permit that current or voltage at the corresponding load voltage or current to be achieved, then take points above and below the desired values and calculate the required value.

9.5.2.6 At each validation point selected record the following:

a) the current and/or voltage control setting; or

b) the power source meter readings;

c) the two values of the true measurement of current and/or voltage from the test instrumentation;

d) the mean value of the two measurements.

Record the results of measurements systematically and supply them on or with the validation certificate.

9.5.2.7 If the power source has a slope control, note the setting. If it is necessary to validate the power source at different settings of the slope control agree this prior to the validation.

9.5.2.8 If a check of consistency of an arbitrary scale is being carried out, compare the results obtained to those obtained during the previous validation (see clause **5**).

10 Validation labels and certificates

10.1 Validation labels

10.1.1 On completion of a validation mark the equipment with a validation label indicating that the equipment has passed or failed.

10.1.2 If the equipment meets the accuracy recommended in Table 1, then mark the equipment with a label with the following information:

a) the statement "PASSED";

b) the date the label is valid;

c) the date of expiry of the validation;

d) the name of the authority issuing the label;

e) the make, model and serial number of the equipment.

10.1.3 If the equipment does not meet the accuracy recommended in Table 1 then attach a label bearing the following information:

a) the statement "FAILED";

b) the date the label was issued;

c) the name of the authority issuing the label;

d) the make, model and serial number of the equipment.

10.2 Validation certificate

Issue a validation certificate, indicating that the equipment has passed or failed.

The validation certificate should contain the following information:

a) the name and address of the validating authority;

b) the type of equipment under test;

c) the model and make of equipment under test;

d) the serial number of the equipment under test;

e) the ambient temperature;

f) the supply voltage;

g) the equipment function under test, e.g. current control;

h) the method of validation, e.g. load resistor type, meter type;

i) the grade of validation, i.e. standard or precision;

j) the type of validation, i.e. accuracy or consistency;

k) the range of the function under validation;

l) the results of the measurements on the function under validation, comparing the equipment readings with validation meter readings (these may be supplied on an attached sheet);

m) the result of the validation, i.e,. passed or failed;

n) the date of validation;

o) the signature or mark of the validating authority.

Annex A (informative)

Proposed accuracies for precision grade power sources

The validation accuracies for precision grade power source controls and instrumentation should conform to Table A1.

Table A.1 — Validation accuracies for precision grade power sources

Quantity	Accuracy	
Current	± 2.5 %	of the true value, between 100 % and 40 % of the maximum setting
	± 1 %	of the maximum setting, below 40 % of the maximum setting.
Voltage	± 5 %	of the true value, between 100 % and 40 % of the maximum setting
	± 2 %	of the maximum setting, below 40 % ofthe maximum setting.
Analogue meters	Class 1	(see **3.5**)
Digital meters		
Current	± 1 %	of maximum rated welding current
Voltage	± 1 %	of no-load voltage OR according to the manufacturer's specification

NOTE It is recommended that precision grade equipment is validated more frequently than standard grade equipment and a 6 month interval, or less, is recommended.

Annex B (informative)

Wire feed equipment

B.1 Validation accuracies

Wire feed equipment includes all systems designed to feed filler wire or consumable continuous electrodes. It is recognized that in MIG/MAG and allied self-adjusting arc systems in which the wire feed rate is linked to a function of the welding power, an absolute calibration of wire feed rate is not necessary.

However, if validation of wire feed equipment is required, the wire feed rate should conform to the accuracy given in Table B.1.

Table B.1 — Validation accuracies for wire feed equipment

Grade	Accuracy
Standard	±10 %
Precision	± 2.5 %

B.2 Requirements for validation

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 validation requirements.

On wire feeders for the consumable electrode processes, the speed control may or may not be calibrated in units of wire feed speed. For example, in MIG welding the wire feed speed may be adjusted to give a specific welding current with the speed control scale in arbitrary units. It is not necessary to validate the speed control on such a wire feeder.

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 should be validated.

On a few wire feeders the speed control may be calibrated in absolute units in which case the control should be validated.

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 has to be energized with an arc to validate the wire feeder.

The speed controls on wire feeders for filler wire are often scaled in wire feed speed units. These units can be validated. If the unit is scaled in arbitrary units the validation procedure can be used to compile a validation chart for the wire feeder. Wire feeders with wire speed meters should be validated.

B.3 Method

Starting with the minimum output setting, energize and stabilize the wire feeder for 5 s and then take a reading. Repeat this procedure for each of the measurement points up to the maximum.

After a further 5 s, take a second reading at the maximum setting and repeat this procedure for each of the measurement points down to the minimum.

The following methods may be used.

a) 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 validation points selected. Measure the wire length with a steel rule to 1 mm. Calculate the wire feed speed.

b) Use a rotary transducer or tachogenerator that can clip onto or press against the filler wire and measure the wire feed speed directly in conjunction with an indicating instrument.

At each validation point record the following:

a) wire feeder speed control setting; or

b) the wire feed speed meter reading;

c) the two measurements of wire feed speed;

d) the mean value of the two measurements.

The results of measurements should be systematically recorded either using a notebook with numbered pages or numbered record sheets or directly on to the validation certificate.

If a check of repeatability/consistency of an arbitrary scale is being carried out, the results obtained should be compared to those obtained during the previous validation.

Annex C (informative)

Slope, pulse and synergic controls

C.1 Validation accuracy

Slope and pulse controls are considered to be precision grade and the validation accuracies should conform to ±5 % of setting, unless specified by the manufacturer.

C.2 Requirements for validation

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

a) as a variable time (in seconds) for the current to increase or decay between two different levels;

b) as a rate of change of current (in amps per second) between two levels of current.

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

a) peak current pulse height, amps;

b) background current height, amps;

c) peak current duration, seconds;

d) background current duration seconds;

e) peak current pulse height, amps;

f) background current height, amps;

g) mark space time, seconds;

h) 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 validation of slope up and slope down controls is straightforward, as the rate of change of current is slow.

The validation of TIG welding pulse controls is an important contribution to the quality of pulsed TIG welding. It is a more difficult task than the validation of slope controls. It requires equipment with a faster response than is necessary for the validation 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 validation. A period of load current stabilization is not applicable to slope up validation.

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

Validate 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, user or customer and the validator in advance of the calibration procedure. In the absence of any agreement the validation should take place at the mid-point of the current control range at the mid-point of the slope up or slope down control range.

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

a) the welding procedure developer;

b) the validator;

c) the equipment user.

In the absence of any stipulation of validation points by a), b) or c), the pulse control should 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 mid-range.

The specification and validation of the full range of the pulse shape controls should be the province of the equipment manufacturer.

At each validation point, record the following:

a) the pulse control settings;

b) 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 should be systematically recorded either using a notebook with numbered pages or numbered record sheets or directly on to the validation certificate.

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 standard. Validation 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 validation 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 should 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)
The validation of ancillary components in a welding system

A welding system may consist of a single power source or a complex assembly of components. This standard recommends the means to ensure that the key components of the most widely used welding systems conform to the required accuracy of control of output. Other components in the welding system will affect the quality of the welded product and need care and maintenance to ensure correct operation.

Welding manipulators, welding rotators, orbital welding rotation drives and robotic manipulation devices control the welding speed and therefore influence the heat input to the weld and metallurgical and mechanical properties of the weld. The speed control on these machines should be checked at intervals compatible with other maintenance and validation tasks on the welding equipment to ensure that it conforms to the manufacturer's specification.

Three factors need to be checked:

a) the absolute accuracy of the speed control calibration;

b) the repeatability of the speed control calibration;

c) the consistency of the speed control during operation.

A number of devices are available to assist the user of welding equipment to check the speed control. The simplest of these is the stopwatch and measuring rule; these instruments will enable most rotary and linear devices to be checked. Electrical transducers are available from the manufacturers of the portable welding monitors. A rubber-tyred wheel runs on the moving component and this wheel drives a tachogenerator which gives an output proportional to the speed. More complex electromechanical transducers are available to fit on to welding equipment to measure welding speed and displacement. Equipment manufacturers should be consulted about these devices.

Arc voltage control devices are feedback control systems. A control to set the desired arc voltage is normally part of the system. This may be a scaled control or an unscaled control with a digital or analogue meter showing the set arc voltage.

The simplest way to check the arc voltage control is to do so with an arc running. The welding set-up should be arranged so that the arc runs with the minimum of variation. Compare the set voltage with the actual arc voltage over the desired operating range. To measure the arc voltage, use a meter with a calibrated accuracy of 0.5 or better conforming to BS EN 60051-1:1998 and BS 89-2:1990.

CAUTION: Do not start TIG arcs with high voltage high frequency initiators with the meter connected across the output terminals. (See annex D.)

Validation of an arc voltage control device without an arc is more difficult and specialist knowledge should be sought.

The most widely used gas flow control device is the bobbin flow meter. The easiest way to check the operation of these meters is by direct comparison with a similar meter of known accuracy. Such gauges can be obtained from the manufacturers with a traceable calibration. This will rarely be better than 2 %.

The gauge to be checked should be connected in series with the standard gauge using short lengths of pipework of the largest practical diameter. The system should be connected to a supply of the appropriate gas and the flow readings compared at the desired gauge readings.

Electronic flow gauges are available and the validation of these devices should be entrusted to specialists. A calibrated electronic flow device can be used to validate production flow gauges.

Annex F (informative)

Voltage drops in the welding circuit

The resistance of the welding circuit will introduce voltage drops between measurement points. If long welding cables are used this should be taken into account. Figure F.1 shows a circuit using GMAW equipment but the principles apply to all welding processes.

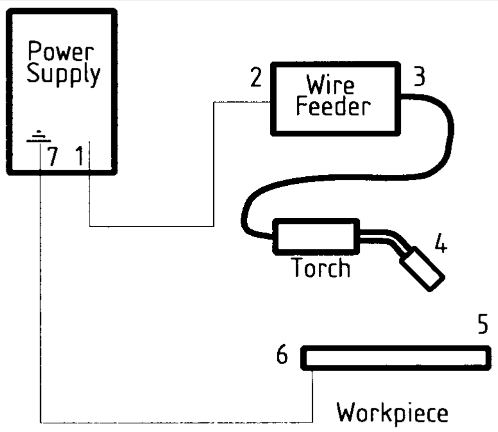

Figure F.1 — Example of a welding circuit

It is important to note that the meters and control circuits used in arc welding equipment are connected at particular points in the welding circuit; these points may be different to those used to attach measuring equipment during procedure qualification. The meter reading will therefore tend to be higher than the actual arc voltage due to voltage drops in other sections of the circuit.

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

During procedure qualification it is desirable to measure the true arc voltage between points 4-5 but this is usually impractical so connections are often made across 3-5. In practice this is rarely a problem because the welding torch is usually the same in production and can be considered a constant. However the difference may be significant when making a change from an air-cooled torch to a water-cooled version or vice-versa. The voltage drop between points 5-6 is also normally insignificant provided that there is a good earth return connection.

Assuming that the arc voltage has been measured across points 3-5 during qualification, problems will arise if these values are used for production welding relying on a power supply voltage meter measuring the potential across 1-7. This is mainly due to the voltage drops between 1-2 and 6-7.

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

NOTE Table F.1 is for guidance only; the information is extracted from Tables A.9 and A.10 of BS 638-4:1996.

Some welding equipment is designed in such a manner that these effects are minimized or avoided, such as in the following examples.

— Constant current equipment may eliminate the effect if the control variables are wire feed speed and welding current; the arc voltage will vary to suit the welding conditions.

— Constant voltage equipment may measure the potential between points 3-7 avoiding any effect due to changing the length of interconnection cables (1-2), but there can still be significant voltage drops in the earth return cable (6-7).

— Constant voltage equipment may be fitted with a 0 V sensing lead that attaches to the workpiece; the arc voltage is then measured between points 3-5.

When equipment is used that does not specifically address this problem, the following precautions will reduce the effects of voltage drops in the welding circuit.

Use the shortest possible interconnection and return current cable lengths.

— Use heavier, lower-resistance welding cables.

— Consider the use of external voltage meters.

— Ensure that connectors are suitably rated; any overheating is indicative of significant voltage drops at the connection.

— Provide a comparison table for the operator to assist in compensating for the voltage drop effect.

Table F.1 — Voltage drop in copper and aluminium welding cables at normal and elevated temperatures

Nominal cross-sectional area of conductor mm^2	d.c.[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 a.c. may be much higher, depending on the configuration of the cables.

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