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Validation of arc welding equipment

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Gültigkeitserklärung von Lichtbogenschweißausrüstung

Validation de l'équipement de soudage à l'arc

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Validation of arc welding equipment
(BS 7570:1992)

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Gültigkeitserklärung von Lichtbogenschweißausrüstung
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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the British Standard BS 7570:1992 was submitted to the CENELEC questionnaire and vote and was approved as ENV 50184 on 1996-06-15.

The following date was fixed:

- latest date by which the existence of the ENV has to be announced at national level (doa) 1996-10-01

Endorsement notice

The text of the British Standard BS 7570:1992 was approved by CENELEC as a European Prestandard without any modification.

Contents

Foreword

This standard was prepared under the direction of the Welding Standards Policy Committee. The need for an improved specification for the calibration, validation and accuracy of welding equipment was foreseen by the committee and this voluntary code of practice has been written to fulfil that need.

It is well known that the maintenance of the required accuracy of outputs of power sources and other equipment is vital in the production of satisfactory welds particularly with those processes where the welder does not manually control the application of the arc.

The urgent need for guidance and standardization having been recognized, this standard was produced after detailed consultations with users and manufacturers of arc welding equipment. (It was considered that all other aspects required to ensure the production of satisfactory welds were already covered by compliance with existing process and procedure standards, codes of practice, etc.) Many manufacturers of arc welding equipment realize the vital role of the equipment and hence the need to test and maintain the performance of their products. In the absence of any other guidance, they operate their own quality control and maintenance schedules. In addition they build equipment with accuracies of performance superior to those required by national and international standards at present in general use.

This standard sets out to regularize the equipment calibration and validation requirements for all arc welding processes ranging from the least demanding to the most sophisticated. It is intended to serve all areas of the arc welding industry and to simplify the preparation of quality assurance documentation.

Summarizing the functions of the code, it:

a) states the required accuracy of operation for a particular task;

b) shows how the equipment can be validated or checked to that accuracy;

c) shows how to record and label the equipment to prove it has been validated or checked;

d) contains information about practical and economic means of achieving good welding instrumentation.

BS 7570 is intended to serve all areas of industry that manufacture or use welding equipment. It is expected to play a key part in quality assurance of electric arc welding.

It is not intended to supersede the requirements of BS 638, IEC 974-1 or any other relevant construction or safety standard for welding equipment.

The selection of the grade of validation and the implementation of validation methods should always be entrusted to appropriately qualified and experienced staff.

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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Code of practice

0 Introduction

0.1 The integrity and reliability of a weld is a function of the materials and the equipment used to make the weld. It can be demonstrated that the variability in the output of the welding equipment will directly affect the quality of the weld. The maintenance of the accuracy and the consistency of the performance of the welding equipment is a key component in the final quality of the weld.

0.2 The primary standard for the production of accurate and reliable welding equipment is the appropriate national, European or international standard. The relevant standard for the construction of welding equipment referred to in this standard is BS 638 : Part 10. It sets the reference level for the accuracy and consistency of the output of welding equipment in the United Kingdom.

0.3 The construction standard BS 638 : Part 10 derives its specification for performance accuracy from the requirements of manual welding. In manual welding the welder[1)] 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.

0.4 Machine welding methods lack the skilled adaptability of the manual welder and requires 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 638 : Part 10, etc.

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

0.6 The improvement in equipment construction, the adoption of machine 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 machine performance.

0.7 This standard seeks to address this need by considering the following:

a) the accuracy of calibration or validation for each category of welding equipment (see clauses **4** and **5**);

b) the frequency of calibration or validation necessary to maintain the standard of operation of the equipment (see clause **6**);

c) the authorities competent to calibrate and validate welding equipment (see clause **7**);

d) the calibrating and validating tests necessary to maintain the standard of operation of the equipment (see clause **8**);

e) the documentation necessary to prove that the recommended standard has been achieved (see clause **9**);

f) the practical means whereby the foregoing recommendations can be realized (see annexes A to H);

g) provision for the calibrator or validator with the means to determine the optimum route, relevant to the available resources, to achieve the recommended standard (see annexes A to H).

0.8 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. A piece 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.

1) The term 'welder' is used in this context to distinguish the operator of manual welding equipment from the 'welding operator' of mechanized welding equipment.

0.9 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.

0.10 It is implicit in the introduction of a more rigorous standard of 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 derived directly from BS 638 : Part 10 and this is called grade 1 or standard grade. A higher level of accuracy for more exacting welding applications is defined and called grade 2 or precision grade; this is dependent upon the welding application.

The use of grade 2 (precision grade) is determined by one of the following:

a) the maker of the welding equipment;

b) the welding procedure requirements;

c) the weld quality standard or code;

d) the quality assurance programme.

Pre-eminent among these is the developer of the welding procedure.

0.11 If the grade 2 accuracy is specified in a welding procedure or a quality control document it will be necessary for the user of the equipment first to determine that the equipment can operate to the required standard and then to validate the operation of the equipment.

0.12 The items of welding equipment covered in this standard have been selected as those with the most significant effect on the quality of the weld. Other items of equipment considered for inclusion were weld head tractors, orbital welding heads, robotic manipulators, arc length control devices, rotators and gas flow controls. The production of a weld, whether by manual welding or a complex welding machine, should be regarded as a complete operational system and care should be exercised with maintenance and calibration of all parts. To assist in this operation some guidance on the preparation and maintenance of equipment outside the scope of this standard is given in annex B.

0.13 It is intended that the use of the calibration and validation methods given in this standard should follow a simple route.

a) Select the validation grade, using clause **1** and figure 1, aided by the relevant notes in this introduction.

b) Select the validation accuracy value, using clauses **4** and **5**.

c) Select the validation method, using clause **8** and figure 2.

d) Select the measuring instruments appropriate to the task and to the validator's resources, using clause **8** and figure 3 in conjunction with annexes D, E, F, G and H. Also consult annexes A, B, and C to ensure safe operation of the equipment.

0.14 Welding power sources may supply direct or alternating current or both. 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 current with respect to time. Moving iron instruments measure the r.m.s. value of current. The r.m.s. value is the square root of the average or mean value of the square of the instantaneous value of the current with respect to time. The r.m.s. measurement is proportional to the heating effect of the current.

The straightforward measurement of welding current 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) There is a wider range of meters and sensing devices in use now which enable more complex measurements and instant operations and computations on the measurement.

c) 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.

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.

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

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.

0.15 The method and scope of the validation of welding power sources will depend on the type of welding power source. The type of welding power source will determine the type of output control and meters fitted to the power source. Welding power sources may be characterized by the following two classifications.

a) *Constant current or drooping characteristic power sources*. This type of power source is used for manual metal arc welding, TIG welding, plasma welding, and, occasionally, submerged arc

welding. The welding output is usually adjusted by a current control. The power source may or may not be fitted with current and voltage meters.

The current controls and the current and voltage meters on constant current power sources can be validated using this standard. Guidance for the validator is given in **0.16**.

b) *Constant voltage or flat characteristic power sources*. This type of power source is used for MIG, MAG, MOG and submerged arc welding. The welding output is usually adjusted by a combination of a voltage control and the wire feed speed control. The wire feed speed control effectively regulates the current output of the power source by the self-adjusting arc mechanism. The power source may or may not be fitted with current and voltage meters.

The voltage controls and the current and voltage meters on constant voltage power sources may be validated using this standard. The notes in **0.16** will guide the validator.

0.16 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). The welding equipment may be fitted with meters which measure the output of the equipment. The following points will guide the validator in the validation of equipment.

a) Equipment with controls which are scaled with recognized units of measurement that are described in this standard can be validated.

b) Equipment with controls that are scaled in arbitrary units cannot be validated using this standard.

c) The meters on any equipment can be validated using this standard.

d) The repeatability and consistency of any control can be validated using this standard.

0.17 Equipment without controls scaled in standard units or without fitted meters may be fitted with measuring instruments covered in this standard in order to gain a validation certificate. The measuring instruments are covered in clause **8**. The measuring instrument appropriate to that equipment may be selected from the full range described in clause **8**.

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

1 Scope

This British Standard recommends validation grades and validation methods for the following two classes of arc welding power sources, equipment and accessories:

a) equipment constructed, calibrated and used to the accuracy specified in BS 638 : Part 10 : 1990; this equipment classification is called grade 1 (standard grade);

b) equipment constructed in accordance with BS 638 : Part 10 : 1990 but calibrated to a higher standard of accuracy than required by BS 638 : Part 10 : 1990 and applied to tasks requiring greater precision of operation; this classification is called grade 2 (precision grade). The use of grade 2 (precision grade) validation or calibration is primarily determined by the requirements of the welding procedure and is to be specified by those responsible for the development or application of the welding procedure.

The welding equipment covered in this standard includes:

1) welding power sources;

2) wire feeders;

3) welding instrumentation.

2 References

2.1 Normative references

This British Standard incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this British Standard only when incorporated into it by updating or revision.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard, the following definitions apply. For other technical terms applicable to this standard the definitions given in BS 499 : Part 1 : 1991 apply.

3.1 calibration

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

3.2 validation
All the 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 monitoring
The use of a measuring device to check, record or indicate the output or performance of a welding equipment or welding system.

3.4 accuracy
The closeness of an observed quantity to the defined or true value.

3.5 arc length
The distance between the cathode and the anode of the welding arc or the distance between the welding electrode and the piece being welded during welding.

3.6 arc voltage
The potential difference between the cathode and the anode during welding or the potential difference between the welding electrode and the piece being welded during welding.

3.7 portable welding monitor ('brief case monitor')
An assembly of measuring instruments packaged in a portable case used to measure, record and/or analyse the welding equipment output.

3.8 chart recorder
A measuring instrument which continuously records the measured value in a graphical form on a continuous roll or sheet of paper or similar medium.

3.9 data logger
A device for recording the measured welding variables in discrete steps on an electronic or magnetic storage medium and reproducing the measurements in numerical or graphical form. The device may be portable or transportable.

3.10 wire feed speed
The rate of delivery of a consumable welding electrode or the rate of delivery of a separate filler wire to the welding arc.

3.11 repeatability test
A test to determine the error of the equipment output when the relevant control on the equipment is set to a position, altered and returned to the same apparent position.

NOTE. A repeatability validation certificate can be issued when the error between the two output readings is less than the accuracy figures given in clauses 4 and 5 for each point in the validation range selected for that control.

3.12 MOG welding
Arc welding using a consumable flux-cored wire electrode without shielding gas from an external source.

3.13 class
A designation according to the accuracy of a measuring instrument conforming to BS 89 : Part 1 : 1990, BS 89 : Part 2 : 1990 or BS 90 : 1975.

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

4 Validation accuracies for the equipment classified as grade 1 (standard grade)

4.1 Repeatability
It is recognized that the repeatability of the equipment is important and in clause 8 tests for repeatability are shown. The same value as is given there should be used in this test unless an alternative is given.

4.2 Welding power sources
The validation accuracies for grade 1 power sources should conform to table 1.

Table 1. Validation accuracies for grade 1 power sources

Quantity	Accuracy
Current	± 10 %[1]
Rated no-load voltage	± 5 %
No-load voltage (MIG/MAG/MOG)[2]	±10 %

[1] This value is valid unless the maximum output current exceeds 10 times the minimum output current, in which case the accuracy at minimum current should be $\pm I_{max.}/I_{min.}$ % and the accuracy at maximum current should be ± 10 %, with the accuracy varying linearly between these two values.

[2] The conventional load voltage U_2 at the output terminals of the power source is given by the following equation, in which I_2 is the conventional welding current in amperes:

$$U_2 = (14 + 0.05\ I_2)\ \text{V}$$

up to 44 V at 600 A, after which U_2 remains constant. (See BS 638 : Part 10 : 1990.)

4.3 Instrumentation
The welding equipment may be fitted with indicating meters. The measuring equipment should be validated to the standard shown for grade 1 welding equipment, as given in table 2.

Table 2. Validation accuracies for grade 1 instruments

Quantity	Accuracy
Indicating instruments conforming to BS 89 : Part 1 : 1990 and BS 89 : Part 2 : 1990	Class 2.5

5 Validation accuracies for the equipment classified as grade 2 (precision grade)

5.1 Repeatability

It is recognized that the repeatability of the equipment is important and in clause 8 tests for repeatability are shown. The same percentage value should be used in this test unless an alternative is given.

5.2 Welding power sources

The validation accuracies for grade 2 power sources should conform to table 3.

Table 3. Validation accuracies for grade 2 power sources

Quantity	Accuracy
Current	± 2.5 %[1]
Time (pulse width[2])	± 5 %
Slope up/down time[3]	± 5 %
Rated no-load voltage	± 5 %
No-load voltage (MIG/MAG/MOG)[4]	±5 %

[1] The current control should be validated for a range of values as specified in the welding procedure, by the equipment manufacturer or by the equipment user. (See 8.2.5.9.)

[2] The term pulse width covers any variable voltage or current transient for which an individual control is provided, e.g. time at peak current, time at background current, total cycle time. In most cases the measured interval will be from the start of the change of the variable to the end of the change of the variable though this may present problems in some cases. (See clause 8 and figure 4.)

[3] Sometimes called ramp up and ramp down or crater out.

[4] The conventional load voltage U_2 at the output terminals of the power source is given by the following equation, in which I_2 is the conventional welding current in amperes:

$$U_2 = (14 + 0.05\ I_2)\ \text{V}$$

up to 44 V at 600 A, after which U_2 remains constant. (See BS 638 : Part 10 : 1990.)

5.3 Wire feed equipment

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 to ensure the consistency and repeatability of MIG/MAG/MOG welding, the wire feed rate should conform to the accuracy given in table 4.

Table 4. Validation accuracies for grade 2 wire feeders

Quantity	Accuracy
Wire feed speed	± 2.5 %

5.4 Instrumentation

The equipment may be fitted with indicating meters, recording meters or instruments, data loggers and connections for the use of external instrumentation. The validation accuracy for grade 2 instruments should conform to table 5.

Table 5. Validation accuracies for grade 2 instrumentation

Quantity	Accuracy
Indicating instruments conforming to BS 89 : Part 1 : 1990 and BS 89 : Part 2 : 1990	Class 1
Chart recorders conforming to BS 90 : 1975	Class 1
Data loggers	± 1 %

6 Frequency of validation and calibration

The welding equipment should be validated or recalibrated at the intervals shown in table 6. Where there is a proven record of repeatability and reliability the frequency of validation may be reduced.

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. In the case of grade 2 equipment, calibration should always be carried out after any repair or operation liable to affect the calibration.

Table 6. Frequency of validation

Grade	Frequency years
1 (standard)	1
2 (precision)	0.5