British Standard

BRITISH STANDARD

BS 4870-4: 1988

Approval testing of welding procedures —

Part 4: Specification for automatic fusion welding of metallic materials, including welding operator approval

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Welding Standards Committee (WEE/-) to Technical Committee WEE/36, upon which the following bodies were represented:

Aluminium Federation
Associated Offices Technical Committee
Association of Consulting Scientists
British Constructional Steelwork Association Ltd.
British Gas plc
British Nuclear Fuels Limited
British Railways Board
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Heating and Ventilating Contractors' Association
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Stainless Steel Fabricators' Association of Great Britain
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Water-tube Boilermakers' Association
Welding Institute
Welding Manufacturers' Association (BEAMA Ltd.)

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Contents

Foreword

This Part of BS 4870 has been prepared under the direction of the Welding Standards Committee. It is one of the series of standards, consisting of BS 4870, BS 4871 and BS 4872, on the approval testing of welding procedures and welders. Unlike the other standards in the series, for automatic fusion welding the functions of the welding operator have been included with those of the equipment itself as they are closely linked.

The requirements in this Part of BS 4870 are based on existing known materials and data. For reasons of compatibility and keeping the requirements up to date, cross references to other Parts of BS 4870 have been made, when relevant, instead of repeating extracts from those Parts.

It should be appreciated that the non-destructive testing acceptance levels given in this standard are for the purposes of the approval testing of welding procedures and as such are not necessarily the same as those which might be specified for work on which approved welding procedures will be employed.

The method of administration of the approval of welding procedures covered in this series of standards has to be stipulated at the enquiry and order stages. The main options currently employed are the following:

a) each individual contractor (or sub-contractor) may have proved, by actual test pieces, every weld form he wishes to use, in every thickness and material; or

b) each individual contractor (or sub-contractor) may have proved, by actual test pieces, a set of welds representative on a group basis of all the various thicknesses and materials to be used in production; or

c) each individual contractor (or sub-contractor) need not make procedure test pieces, providing he can prove by appropriate authentic documentation of an independent nature that he has previously satisfactorily welded the type of joint and material in question.

In respect of a) and b) it should be appreciated that once the welding procedure tests have been approved, they need never be repeated unless there is a change in certain variables. As an extension beyond c), it may be possible by agreement between the contracting parties for fully documented welding procedures, developed independently of the particular contractor, to be employed without the need for further approval tests.

The need for a welding procedure to be approved in accordance with this standard should be specified in the application standard or be agreed between the contracting parties. Although a welding procedure may already have been approved, each manufacturer has responsibility for the procedure used on a contract and for the ability of the welding operator to apply the procedure.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 4, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 4870 specifies requirements for the approval testing of welding procedures, welding programs, welding systems and welding operators for automatic or robotic fusion welding of joints in metallic materials. It does not apply to tube to tube-plate joints, which are covered by BS 4870-3 and BS 4871-3.

Approval of a welding procedure to this standard does not imply that the procedure is suitable for all conceivable conditions of service; supplementary mechanical tests may be required for particular applications.

The standard does not stipulate the method to be adopted for the administration of welding procedure approvals as this has to be agreed between the contracting parties at the enquiry and order stages (see foreword).

NOTE 1 It is recommended that welding procedures, welding programs, welding systems or welding operators that have been approved, documented and verified by an independent inspecting authority, prior to the publication of this standard, in accordance with a recognized standard for welding procedures, e.g. BS 4870-1, be regarded as acceptable within the approval range covered by clauses **4** and **5** of this standard unless otherwise agreed between the contracting parties.

NOTE 2 It is recommended that approval tests carried out in accordance with this standard and verified by an independent inspecting authority be accepted by other inspecting authorities provided that all the provisions have been fulfilled.

NOTE 3 This standard does not cover welding processes such as laser welding or electron-beam welding. The parameters to be recorded and the acceptance levels for such processes would, therefore, have to be agreed between the contracting parties, but this standard may be used as the framework for such agreement.

NOTE 4 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 4870, the following definitions apply.

2.1
welding procedure

a specific course of action followed in welding, including a list of materials and, where necessary, tools to be used[1)]

2.2
welding procedure test

the making and testing of a welded joint, representative of that to be used in production, in order to prove the feasibility of a welding procedure

NOTE This term is not usually applied to any tests that may have been made during the development of a welding procedure.

2.3
approved welding procedure

a documented welding procedure that has been approved by an inspecting authority either by means of a welding procedure test or as a result of authentic documented experience gained with the welding of joints similar to that to which the welding procedure applies

2.4
welding operator

a person who operates equipment or a machine which performs the welding

2.5
test piece

components welded together in accordance with a specified welding procedure

2.6
test specimen

a portion detached from a test piece and prepared as required for testing

2.7
inspecting authority

that competent independent body or association which verifies compliance with this standard

2.8
welding program

the series of instructions that are programmed into the system controller to obtain the required output from the welding system in order to make the required weld

2.9
automatic welding

machine welding in which the relative movement of the welding head and welding parameters are controlled by a welding program although the facility for adaptive control or a limited amount of manual control may exist

2.10
adaptive control

a system that measures a welding or dimensional parameter, compares this with a reference and, if necessary, takes appropriate action

2.11
robotic welding

automatic welding using a manipulator that can be pre-programmed to different welding paths and fabrication geometries

[1)] This definition is taken from BS 499-1.

2.12
welding system

that assembly of components which enables a weld to be performed by automatic welding

NOTE A welding system may comprise a controller, welding head, wire feed unit, power source and the means of controlling relative movement of the welding head and workpiece.

3 Items in a welding procedure test

3.1 General

The items listed in **3.2** and the items in **3.3** relevant to the particular welding process shall be recorded for each welding procedure test.

NOTE Not all of these items need be included in the approved welding procedure documentation.

3.2 Items for all welding processes

Details relating to the following items shall be recorded for all welding processes:

a) welding process, or processes when more than one is used in making a complete joint;

b) parent metal specification, thickness and for pipe[2)] the outside diameter or dimension;

c) joint geometry and fit-up tolerance (sketch);

d) cleaning and degreasing;

e) jigging or tacking and backing;

f) welding position (including welding direction for vertical position);

g) make, trade name, type, specification and size of welding consumables including fusible inserts and any metal powder or cut wire additions;

h) pre-heating and interpass temperature, including method of control;

i) travel speed, degree of overlap and the start position where relevant;

j) arc length or arc voltage;

k) where filler metal is used, its rate of addition or wire feed speed;

l) other pre-programmed welding variables, such as

1) pre-and post-gas purge times,

2) changes in current level,

3) current slope up and down rates;

m) purge gas composition;

n) oscillation or weaving parameters;

o) approximate number and arrangement of runs and weld dimensions (sketch);

p) welding sequence;

q) back gouging (if applicable);

r) post-weld heat treatment including method and control;

s) when applied, the temperature and time adopted for drying/baking of welding consumables before use;

t) any special features, including heat input control requirements.

Where machine settings are quoted, they shall be backed up with documented calibration that enables the true value of the parameter to be assessed, e.g. wire feed setting shall be related to actual wire feed speed.

3.3 Items for particular welding processes

Details relating to the items given in **3.3** a) to **3.3** c) shall be recorded for these particular processes, in addition to the items in **3.2**.

a) *MIG and MAG welding, solid wire or continuous tubular metal or flux cored electrodes, with or without separate gas shield*

1) shielding gas and flow rate;

2) nozzle diameter;

3) arc voltage;

4) wire feed speed and current;

5) for pulsed welding, the pulse time and interval, pulse current and background current;

6) wire angle relative to major axis of component and direction of travel.

b) *TIG welding*

1) tungsten electrode diameter, type and tip included angle;

2) shielding gas and flow rate;

3) nozzle diameter;

4) electrode and wire angles relative to major axis of component and direction of travel;

5) a.c. or d.c. and polarity;

6) current;

7) for pulsed welding, the pulse time and interval, pulse current and background current;

8) whether filler metal is used;

9) hot wire feed details.

c) *Submerged-arc welding*

1) number and configuration of electrode wires and electrical configuration;

2) electrode extension;

3) current;

[2)] In this standard the word "pipe", alone or in combination, is used to mean "pipe" or "tube" or "structural hollow section" (circular or rectangular), although these terms are often used for different categories of product by different industries.

4) feed rate of any metal powder or cut wire additions;

5) hot wire feed details.

4 Changes affecting welding procedure approval

A welding procedure test shall be carried out when any of the following changes are made to an approved welding procedure:

a) any changes in welding process including changes in the mode of transfer, arc characteristics and the number of electrodes or electrode wires utilized by the process;

b) any change in type of parent metal, thickness, or pipe outside diameter or dimension, subject to the extent of approval given in clause **5**;

c) any change in joint geometry that would affect the welding procedure;

d) any change in type of filler metal or shielding gas;

NOTE In respect of a filler metal, "type" means the essential part of the classification according to the standard with which it complies, but a change to a filler metal with a different classification does not necessitate reapproval of the welding procedure if the change is agreed between the contracting parties on the evidence of available mechanical test data.

e) any change in type or specification of the welding flux;

f) any change in type of welding current, e.g. from d.c. to a.c. or change in polarity;

g) any change in pre-heating temperature except for an increase of not more than 100 °C;

h) any change in welding position (see BS 499-1 for definitions of welding position);

i) any change in heat input outside the limits specified for applications where heat input is required to be controlled;

j) any change in post-weld heat treatment temperature range;

k) the addition or deletion of filler metal, e.g. a change to or from autogenous welding.

In the absence of any of the changes set out above, an approved welding procedure shall remain in force indefinitely.

NOTE Although a different welding program may be required for joints of different dimensions, it is not necessary to approve each programme (see clause **7**).

5 Extent of approval of welding procedure

5.1 Parent metal

For the purposes of this standard, the type of parent metal shall be grouped according to the grouping systems given in BS 4870-1 and BS 4870-2. Separate welding procedure approval shall be obtained for each material not covered by these grouping systems.

5.2 Thickness

For the purposes of this clause, thickness t shall have the following meanings:

a) for a butt joint, the parent metal thickness, which for joints between dissimilar thicknesses is that of the thicker material;

b) for a fillet weld, the parent metal thickness, which for joints between dissimilar thicknesses is that of the thicker material but for each thickness range approved there is an associated range of approved leg lengths as given below;

c) for a set-on branch connection, the thickness of the branch;

d) for a set-in or set-through branch connection, the thickness of the main pipe.

The approval of a welding procedure on thickness t shall include approval for thicknesses in the following ranges:

thickness, t	**range approved**
less than 1.6 mm	t to $2t$
1.6 mm up to but not including 10 mm	1.6 mm to $2t$
10 mm up to and including 200 mm	4.8 mm to $2t$ (maximum 200 mm) but only $1.1t$ (maximum 200 mm) for single run welds or for multi-run welds made by processes giving a heat input greater than 5 kJ/mm
over 200 mm	$0.5t$ to $1.1t$

For each parent metal thickness range approved as given above, the approval of a fillet weld of leg length l shall include approval for leg lengths in the range $0.75\ l$ to $1.5\ l$ except that a test using a leg length of 20 mm or over shall give approval for all leg lengths above 15 min.

NOTE Although procedures for all thicknesses in one of the above ranges may be approved by tests on only one thickness, it does not follow that all the details of the welding procedure will be the same for other thicknesses in the range.

5.3 Pipe outside diameter or dimension

The approval of a welding procedure for pipe of outside diameter or dimension *D* shall include approval for diameters or dimensions in the range 0.5*D* to 2*D*, except that a test made on pipe of outside diameter or dimension 168.3 mm or larger shall give approval for welding outside diameters or dimensions 88.9 mm and above. For rectangular structural hollow sections, *D* shall be the dimension of the smaller side. For branch connections, *D* shall be the diameter or dimension of the branch.

6 Test pieces, examination and testing for welding procedure approval

Test pieces shall be made, examined and tested as specified in either BS 4870-1 or BS 4870-2, as appropriate.

NOTE Welding procedure, welding program, welding system and welding operator approvals may be performed on the same set of test specimens.

7 Welding program approval

The approval of a welding procedure shall include approval of the welding program used in making the test pieces. Although a separate welding program may be required for each type of material, size or thickness range included in the extent of approval of the welding procedure, a full procedure approval test in accordance with clause **6** is not necessary unless the provisions of clauses **4** and **5** require it.

Each additional welding program shall be demonstrated by making a weld with the program. The weld shall be subjected to visual examination and to either:

a) volumetric non-destructive testing; or

b) where volumetric non-destructive testing is not feasible, macro-examination, using four specimens to demonstrate joint quality. The test results shall be recorded.

NOTE 1 These results do not form part of the welding procedure.

NOTE 2 Where volumetric non-destructive testing is not a normal production requirement, consideration should be given to taking a representative number of test specimens for visual examination, surface non-destructive testing or macro-examination as appropriate, from each production shift.

NOTE 3 The detailed welding program should be available for inspection by the inspecting authority and may be stored in the memory of the equipment, on cassette tape or disc or other such suitable means.

8 Welding system approval

Each welding system shall be approved for each approved welding procedure by the performance of a single welding program covered by that approved welding procedure. This shall approve the system for the extent of approval of the relevant welding procedure.

Each welding system shall be approved by making a weld with the system. The weld shall be subjected to visual examination and to either:

a) volumetric non-destructive testing; or

b) where volumetric non-destructive testing is not feasible, macro-examination, using four specimens to demonstrate joint quality. The tests shall be witnessed and the results verified by the inspecting authority.

NOTE 1 These results do not form part of the welding procedure.

NOTE 2 Where volumetric non-destructive testing is not a normal production requirement, consideration should be given to taking a representative number of test specimens for visual examination, surface non-destructive testing or macro-examination as appropriate, from each production shift.

9 Welding operator approval

Each welding operator shall be approved on a weld made using an approved welding system, which shall include approval to weld on any similar system.

The weld shall be subjected to visual examination and to either:

a) volumetric non-destructive testing; or

b) where volumetric non-destructive testing is not feasible, macro-examination, using four specimens to demonstrate joint quality.

Approval testing shall approve the welding operator to weld with any approved program within the range of the system. The tests shall be witnessed and the results verified by the inspecting authority.

NOTE 1 With some of the more complex systems it may be necessary for the welding operator to undergo a familiarization scheme. Details of such a scheme should be available for inspection but not approval or comment by the inspecting authority.

NOTE 2 Where volumetric non-destructive testing is not a normal production requirement, consideration should be given to taking a representative number of test specimens for visual examination, surface non-destructive testing or macro-examination as appropriate, from each production shift.

Publications referred to

BS 499, *Welding terms and symbols.*
BS 499-1, *Glossary for welding, brazing and thermal cutting.*
BS 4870, *Specification for approval testing of welding procedures.*
BS 4870-1, *Fusion welding of steel.*
BS 4870-2, *TIG or MIG welding of aluminium and its alloys.*
BS 4870-3, *Arc welding of tube to tube-plate joints in metallic materials.*
BS 4871, *Specification for approval testing of welders working to approved welding procedures.*
BS 4871-3, *Arc welding of tube to tube-plate joints in metallic materials.*
BS 4872, *Specification for approval testing of welders when welding procedure approval is not required*[3)].

[3)] Referred to in the foreword only.

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