



**BS 4870: Part 1 : 1981**

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Specification for

# Approval testing of welding procedures

Part 1. Fusion welding of steel

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Spécification de l'essai d'homologation des procédures de soudage  
Partie 1. Soudage par fusion de l'acier

Spezifikation für die Abnahmeprüfung von Schweißverfahren  
Teil 1. Schmelzschiweißen von Stahl

**British Standards Institution**

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## BS 4870: Part 1: 1981

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## Foreword

This revision of this British Standard has been prepared under the direction of the Welding Standards Committee. It incorporates new requirements for the grouping of parent metals and also embodies other technical changes developed from experience gained in the use of the standard since the first edition was published in 1974.

This revision does not invalidate welding procedures previously accepted according to the requirements of the 1974 edition, even where there has been a change in the number of specimens required for any test, provided the details of the procedures are still relevant to the production work on which they are to be employed. Also, where additional forms of test have to be carried out (see 8.3.1), such as by an application standard requiring impact tests, it is necessary to perform only those specific additional tests and not the entire range of tests required by this standard, the further test joint being made in accordance with the requirements of this revised edition. The extent of approval given by a previous test in accordance with the 1974 edition may now be related to those ranges indicated in this revised edition. All new approval testing of welding procedures is to be made in accordance with the requirements of this revised edition.

This British Standard is one of a series of standards on the approval testing of welders and welding procedures, the latter having a bearing on the former for certain applications. This link has been used as a means of arranging the series of standards into:

- (a) approval testing of welding procedures;
- (b) welder approval when approval of the welding procedure is required (see BS 4871 : Part 1);
- (c) welder approval when approval of the welding procedure is not required (for either technical or contract reasons) (see BS 4872 : Part 1).

For the purposes of this standard, the welder who makes the manual welding procedure test is considered to be sufficiently experienced in the appropriate welding process and hence already capable of passing training tests such as those given in BS 1295.

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:

- (1) 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;
- (2) 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;
- (3) 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 (1) and (2) 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 (3), 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 the requirements of 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 welders 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.

British Standard Specification for

# Approval testing of welding procedures

## Part 1. Fusion welding of steel

### 1. Scope

This British Standard specifies requirements for the approval testing of welding procedures for the fusion welding of ferritic steel or austenitic stainless steel. Cast-to-cast fabrications are not included\*.

NOTE. For the approval testing of welding procedures for the arc welding of tube to tube-plate joints, see BS 4870: Part 3.

Approval of a welding procedure to this standard does not imply that the procedure is suitable for all conceivable conditions of service; supplementary 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).

The welder who successfully completes a welding procedure test in accordance with this standard is approved to the extent given in clauses 5 and 6 of BS 4871: Part 1: 1982, without further testing.

### 2. References

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

### 3. Definitions

For the purposes of this British Standard the following definitions apply.

**3.1 welding procedure.** A specified course of action followed in welding, including a list of materials and, where necessary, tools to be used.†

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

NOTE 2. Sometimes an additional joint of a different type is welded in order to obtain relevant test data.

**3.3 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.

**3.4 test piece.** Components welded together in accordance with a specified welding procedure, or a portion of a welded joint detached from a structure for test.†

**3.5 test specimen.** A portion detached from a test piece and prepared as required for testing.†

**3.6 inspecting authority.** That competent independent body or association which verifies compliance with this standard.

### 4. Items in a welding procedure test

**4.1 General.** The items listed in 4.2 and the items in 4.3 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.

**4.2 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‡ the outside diameter or dimension;
- (c) whether shop or site welding;
- (d) edge preparation (sketch);
- (e) cleaning, degreasing etc.;
- (f) fit-up (sketch);
- (g) jiggling or tacking, backing, etc.;
- (h) welding position (including direction for vertical position);
- (i) make, brand and type of welding consumables;
- (j) filler material composition and size (diameter);
- (k) pre-heating and interpass temperature, including method and control;
- (l) travel speed (mechanized welding);
- (m) approximate number and arrangement of runs and weld dimensions (sketch);
- (n) welding sequence;
- (o) back gouging;
- (p) post-weld heat treatment, including method and control;
- (q) when applied, the temperature and time adopted for drying/baking of welding consumables before use;
- (r) any special features, including heat input control requirements, e.g. run-out length (R.O.L.).

\*See BS 4570 for requirements for welding procedure approval for steel castings.

†This definition is taken from BS 499: Part 1.

‡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.

**4.3 Items for particular welding processes.** Details relating to the items given in 4.3(a) to 4.3(f) shall be recorded for these particular processes in addition to the items in 4.2. For pipe welding, where back purging is used, the purge gas, flow rate of purge gas, and period shall be recorded.

(a) *Manual metal-arc welding*

- (1) a.c. or d.c. and polarity;
- (2) current;
- (3) for pulsed welding, the pulse time, pulse current, background current and background voltage.

(b) *MIG welding, solid or cored wire, including cored wire CO<sub>2</sub> and gasless welding*

- (1) shielding gas and flow rate;
- (2) nozzle diameter;
- (3) arc voltage;
- (4) wire feed speed or current.

Additional for dip transfer technique:

- (5) electrode extension (mechanized welding);
- (6) circuit inductance or setting;
- (7) for pulsed welding, the pulse time, pulse current, background current and background voltage.

(c) *TIG welding*

- (1) tungsten electrode diameter and type;
- (2) shielding gas and flow rate;
- (3) nozzle diameter;
- (4) a.c. or d.c. and polarity;
- (5) current;
- (6) arc length or voltage for mechanized welding;
- (7) for pulsed welding, the pulse time, pulse current, background current and background voltage.

(d) *Submerged arc welding and continuous covered electrode arc welding with or without CO<sub>2</sub> or flux shielding*

- (1) number and configuration of electrode wires and electrical connections;
- (2) shielding gas and flow rate;
- (3) electrode extension;
- (4) a.c. or d.c. and polarity;
- (5) current;
- (6) voltage;
- (7) power source characteristic.

(e) *Electroslag and consumable guide welding*

- (1) number of electrodes;
- (2) guide configuration;
- (3) oscillation width and dwell periods;
- (4) current (wire feed speed);
- (5) a.c. or d.c. and polarity;
- (6) voltage and vertical lift rate;
- (7) slag depth.

(f) *Gas welding*

- (1) oxygen pressure;
- (2) fuel gas and pressure;
- (3) nozzle size;
- (4) flame characteristic (oxidizing, reducing or neutral);
- (5) rightward or leftward technique.

## 5. Changes affecting approval

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

(a) any change in welding process; \*

NOTE. For multi-process procedures, each welding process may be approved separately or in combination with other processes. Similarly, one or more processes may be deleted from an approved welding procedure provided the joint thickness is within the thickness range of the remaining process or processes.

(b) any change in parent metal, thickness, pipe outside diameter or dimension, or type of joint subject to the extent of approval given in clause 6;

(c) any change in root detail which affects the welding procedure (gap, root face or backing). Where joints welded from both sides involve a back gouging operation, changes in gap or root face shall not necessitate re-approval;

(d) when impact tests are not required, a change to or from vertical-down;

(e) when impact tests are required, any change in fundamental welding position (flat, horizontal-vertical, vertical, overhead; see BS 499 : Part 1 for definitions).

Each fundamental welding position shall be separately approved, except that a welding procedure approved using vertical-up shall include approval for all other welding positions, other than when using vertical-down.

For plate these positions are directly applicable to the test weld. Approval on welds made in all four fundamental positions includes approval for all intermediate positions.

For pipe it is more convenient to define the pipe position and movement during the test as given below.

| Pipe position during test | Pipe movement during test | Welding positions for which approval is given |
|---------------------------|---------------------------|-----------------------------------------------|
| Horizontal                | Rotated                   | Flat                                          |
| Vertical                  | Rotated or fixed          | Horizontal-vertical                           |
| Horizontal                | Fixed                     | All (see 8.3.1 for impact testing)            |

(f) any change in welding technique (e.g. a change from rightward to leftward in gas welding);

(g) any change in type † of consumable electrode filler material, flux or shielding gas;

(h) any change in the size of a manual metal-arc welding electrode used for the root run of a weld made from one side only;

(i) any change of more than one-third in the size of a manual metal-arc welding electrode used for the root run of a backed weld;

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

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

\* This includes consideration of changes in the mode of transfer, arc characteristics and the number of electrodes or electrode wires utilized by the process.

† In respect of a consumable electrode or filler material 'type' means the compulsory part of the classification according to the standard with which it complies, but a change to a consumable electrode or filler material with a different classification does not necessitate re-approval of the welding procedure if the change is agreed between the contracting parties on the evidence of available mechanical test data.

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(l) any change in post-weld heat treatment temperature range.

Any change in the make, brand, drying/baking or size (other than under (h) or (i) above) of filler material or in the shielding or back purging gas shall be reported to the purchaser. By agreement between the contracting parties, re-approval of such changes may be waived.

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

## 6. Extent of approval

### 6.1 Parent metal

**6.1.1 Grouping system.** In order to minimize the unnecessary duplication of technically identical procedure tests, steels with similar metallurgical and welding characteristics shall be grouped for the purposes of welding procedure approval as shown in table 1. (See appendix A for examples of steels complying with British Standards in each group.)

In using the grouping system it shall be ensured that the requirements of clause 5 are met; in particular, it is emphasized that a change in the welding process, type of welding consumables or the post-weld heat treatment range requires the re-approval of a welding procedure.

Separate welding procedure approval shall be obtained for each steel not covered by the grouping system, or when autogenous welding is used.

When impact tests are required or there are hardness criteria, the use of the grouping system shall be agreed between the contracting parties.

NOTE 1. Although this standard excludes cast-to-cast fabrications, approval of a procedure for welding wrought steel to cast steel may be accepted by agreement between the contracting parties provided that the cast steel is reasonably similar to a wrought steel in one of the groups in the system.

NOTE 2. Where the grouping system is being applied, a separate welding procedure sheet should be issued for each parent metal/welding consumable combination which is derived from an approved procedure.

### 6.1.2 Grouping for joints between similar steels

(a) Approval on a steel within a particular group shall include approval for welding on any other steel within the same group.

(b) Approval on a group A2 steel shall include approval for welding in group A1 steels, but not the converse.

(c) Approval on a group B steel shall include approval for welding in groups A1 and A2 steels, but not the converse.

(d) Approval on a group K steel shall include approval for welding in groups A1 and A2 steels, but not the converse.

(e) Approval on a group D steel shall include approval for welding in group B steels, but not the converse.

(f) Approval on a group F steel shall include approval for welding in group E1 steels, but not the converse.

(g) Approval on a group T steel shall include approval for welding in group R steels, but not the converse.

(h) Approval on a group U steel shall include approval for welding in group R steels, but not the converse.

These requirements are summarized in table 2.

**6.1.3 Grouping for joints between dissimilar ferritic steels.** Provided the post-weld heat treatment requirements of

two steels are similar, grouping shall be applicable to joints between dissimilar ferritic steels according to the following.

(a) Approval on a joint between similar steels in either group A2 or group K shall include approval for welding any steel from the same group to any steel in the other group or group A1.

(b) Approval on a joint between similar steels in group B or group C or group D shall include approval for welding any steel from the same group to any steel in either of the other groups.

(c) Approval on a joint between similar steels in group F shall include approval for welding any group F steel to any group E1 steel.

(d) Approval on a joint between similar steels in either group G or group H shall include approval for welding any steel from the same group to any steel in the other group.

The above requirements are summarized in table 3.

**Table 1. Grouping system for welding steels**

| Group  | Type of steel*                                                                                                |
|--------|---------------------------------------------------------------------------------------------------------------|
| A1     | C and C-Mn steel with minimum tensile strength in the specification up to and including 430 N/mm <sup>2</sup> |
| A2     | C and C-Mn steel with minimum tensile strength in the specification over 430 N/mm <sup>2</sup> †              |
| B      | C-Mo steel                                                                                                    |
| C      | Mo-B steel and Mn (Ni) Cr Mo V steel                                                                          |
| D      | 1—1½ Cr ½ Mo steel                                                                                            |
| E1     | 2—3 Cr 1 Mo steel, normalized and tempered                                                                    |
| E2     | 2—3 Cr 1 Mo steel, quenched and tempered                                                                      |
| F      | ½ Cr ½ Mo ¼ V steel                                                                                           |
| G      | 5 Cr ½ Mo steel                                                                                               |
| H      | 9 Cr 1 Mo steel                                                                                               |
| J      | 12 Cr Mo V steel                                                                                              |
| K      | 3½ Ni steel                                                                                                   |
| L      | 9 Ni steel                                                                                                    |
| M      | 13 Cr ferritic stainless steel                                                                                |
| N      | 17—20 Cr ferritic stainless steel                                                                             |
| P to Q | Reserved for future allocation of other steel groups                                                          |
| R      | 304 type austenitic stainless steel‡                                                                          |
| S      | 310 type austenitic stainless steel                                                                           |
| T      | 316 type austenitic stainless steel‡                                                                          |
| U      | 321 and 347 type austenitic stainless steel‡                                                                  |
| V to Z | Reserved for future allocation of other steel groups                                                          |

\*Appendix A gives examples of generally recognized weldable steels in each group.

†Care is required in the welding of BS 4360 grade 55 steel with respect to the attainment of the minimum tensile properties with the welding consumables used.

‡Warm-worked and nitrogen-bearing varieties are excluded from the grouping system. For such steels separate welding procedure approval shall be obtained.

**Table 2. Grouping for joints between similar steels**

(X indicates applicability)

| Steel group of originally approved procedure | Steel group also approved |    |   |    |   |
|----------------------------------------------|---------------------------|----|---|----|---|
|                                              | A1                        | A2 | B | E1 | R |
| A2                                           | X                         | X  | — | —  | — |
| B                                            | X                         | X  | X | —  | — |
| D                                            | —                         | —  | X | —  | — |
| F                                            | —                         | —  | — | X  | — |
| K                                            | X                         | X  | — | —  | — |
| T or U.                                      | —                         | —  | — | —  | X |

NOTE. Approval on any steel within a group includes approval on any other steel within the same group.

**Table 3. Grouping for joints between dissimilar ferritic steels**

(X indicates applicability)

| Steel group of originally approved procedure | Steel groups also approved |         |         |        |        |        |         |        |
|----------------------------------------------|----------------------------|---------|---------|--------|--------|--------|---------|--------|
|                                              | A1 to A2                   | A1 to K | A2 to K | B to C | B to D | C to D | F to E1 | G to H |
| A2                                           | X                          | —       | X       | —      | —      | —      | —       | —      |
| B                                            | —                          | —       | —       | X      | X      | —      | —       | —      |
| C                                            | —                          | —       | —       | X      | —      | X      | —       | —      |
| D                                            | —                          | —       | —       | —      | X      | X      | —       | —      |
| F                                            | —                          | —       | —       | —      | —      | —      | X       | —      |
| G                                            | —                          | —       | —       | —      | —      | —      | —       | X      |
| H                                            | —                          | —       | —       | —      | —      | —      | —       | X      |
| K                                            | —                          | X       | X       | —      | —      | —      | —       | —      |

**6.1.4 Grouping for joints between dissimilar austenitic stainless steels.**

(a) Approval on a joint between similar steels in group S shall include approval for welding any group S steel to any steel in either group R or group T.

(b) Approval on a joint between similar steels in group T shall include approval for welding any group T steel to any steel in group R.

(c) Approval on a joint between similar steels in group U shall include approval for welding any group U steel to any steel in either group R or group T.

The above requirements are summarized in table 4.

**6.1.5 Grouping for joints between ferritic steels and austenitic stainless steels.** Provided the filler material is of type 309S94 as specified in BS 2901: Part 2 or class

23.12 as specified in BS 2926 or is a high nickel alloy (70 Ni 15 Cr), approval on a joint between a steel in any ferritic steel group and an austenitic stainless steel in group R, S, T or U shall include approval for welding any steel from the same ferritic steel group to any other austenitic stainless steel in group R, S, T or U. For the purposes of this requirement groups A1 and A2 shall be considered as a single group A.

**Table 4. Grouping for joints between dissimilar austenitic stainless steels**

(X indicates applicability)

| Steel group of originally approved procedure | Steel groups also approved |        |        |        |        |
|----------------------------------------------|----------------------------|--------|--------|--------|--------|
|                                              | S to R                     | S to T | T to R | U to R | U to T |
| S                                            | X                          | X      | —      | —      | —      |
| T                                            | —                          | —      | X      | —      | —      |
| U                                            | —                          | —      | —      | X      | X      |

**6.2 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 / shall include approval for leg lengths in the range 0.75/ to 1.5/ except that a test using a leg length of 20 mm or over shall give approval for all leg lengths above 15 mm.

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. Re-approval will only be required, however, if the differences in the procedures for welding other thicknesses in the same range are such that the requirements of clause 5 apply or, for materials in groups A1 and A2, if the requirements of BS 5135 for the avoidance of hydrogen cracking are not satisfied.