British Standard

BRITISH STANDARD

BS 4871-3: 1985

Specification for

Approval testing of welders working to approved welding procedures —

Part 3: Arc welding of tube to tube-plate joints in metallic materials

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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
British Gas Corporation
British Railways Board
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
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Stainless Steel Fabricators' Association of Great Britain
United Kingdom Atomic Energy Authority
Water-tube Boilermakers' Association
Welding Institute
Welding Manufacturers' Association (BEAMA Ltd.)
Coopted member

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Contents

		Page
Committees responsible		Inside front cover
Foreword		ii
1	Scope	1
2	Definitions	1
3	Information to be given to the welder	1
4	Items to be recorded	1
5	Changes not affecting approval (other than mechanized or automatic welding)	1
6	Extent of approval	3
7	Test pieces	4
8	Submission of test weld	4
9	Examination and testing	4
10	Statement of results	6
11	Re-approval of welder	6
Appendix A Record of approval test of welder		8
Figure 1 — Test piece for tube ends on triangular pitch		4
Figure 2 — Test piece for tube ends on square pitch		5
Figure 3 — Typical examples of macro-examination specimens		6
Table 1 — Weld metal/parent metal combinations		2
Table 2 — Extent of approval for weld metal groups		2
Table 3 — Acceptance levels		7
Publications referred to		Inside back cover

Foreword

This Part of BS 4871 has been prepared under the direction of the Welding Standards Committee to cover the particular requirements for the approval testing of welders for tube to tube-plate joints. While there is no limitation on the metallic materials to be used, extra considerations not covered in this standard may need to be taken into account for some materials.

This Part of BS 4871 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 Parts of the standards for tube to tube-plate joints into:

a) approval testing of welding procedures (see BS 4870-3);

b) welder approval when approval of the welding procedure is required.

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

Depending upon the emphasis placed on quality control in the production of welded components, the approval of welding procedures covered in this series of standards may be administered in one of several ways which should be stipulated at the enquiry and/or order stage. The alternatives 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; or

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; or

3) each individual contractor (or sub-contractor) need not make procedure test pieces provided he can prove by appropriate 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.

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 10, 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 4871 specifies requirements for the approval testing of welders to be engaged on the manual, semi-automatic, automatic or mechanized arc welding of those tube to tube-plate joints in metallic materials for which an approved welding procedure has to be employed.

The welder who successfully completes a welding procedure test in accordance with BS 4870-3 is approved to the extent given in clauses **5** and **6** of this standard without further testing.

NOTE 1 This Part of BS 4871 does not cover welding processes such as explosive welding, 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 Part of BS 4871 may be used as the framework for such agreement.

NOTE 2 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 4871, 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 which the welding procedure applies

2.4
welder approval test

a documented test, which has been approved by an inspecting authority, carried out by a welder working to an approved welding procedure

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

3 Information to be given to the welder

The welder shall be provided with full written details according to clause **3** of BS 4870-3:1985 of the approved welding procedure (which may be modified as permitted by clause **5** of this standard) which he shall follow in making his test weld (see also clause **8** of this standard).

For mechanized or automatic processes, the welder shall be provided with full written details and training on how to operate the equipment and of the relevant checks that have to be made.

4 Items to be recorded

The items given in appendix A shall be recorded for each welder approval test.

NOTE Details of the welding procedure used should have been recorded previously by approval testing in accordance with BS 4870-3.

5 Changes not affecting approval (other than mechanized or automatic welding)

The following changes between the approved welding procedure and the procedure used for the welder approval test shall **not** entail re-approval of the welder for other than mechanized or automatic welding.

NOTE Clause **4** of BS 4870-3:1985 states the changes affecting an approved welding procedure, but for welder approval purposes more latitude is permitted as only the welder's ability is being tested.

a) A change in parent metal within one of the following ranges of steels (see also Table 1).

1) Carbon steels and low alloy steels with less than 6 % total alloy.

NOTE This range corresponds to groups A1, A2, B, C, D, E1, E2, F, G and K of Table 1 of BS 4870-3:1985.

2) When high alloy ferritic weld metal is specified, a change in parent metal within the range 11 % to 20 % chromium.

NOTE This range corresponds to groups M and N of Table 1 of BS 4870-3:1985.

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

3) When austenitic or high nickel alloy weld metal is specified, a change in parent metal or combinations of parent metal within the ranges of carbon, low alloy, high alloy ferritic and austenitic steels.

NOTE This range corresponds to groups A1, A2, B, C, D, E1, E2, F, G, H, J, K, L, M, N, R, S, T, U and V of Table 1 of BS 4870-3:1985.

b) A change in weld metal composition within one of the groups given in Table 1[2)] or a change within the extent of approvals given in Table 2.

c) A change from either:

1) a basic to a rutile covered electrode[2)] for group W1 weld metal; or

2) one electrode type to another[2)] for other than group W1 weld metal.

d) A change in pre-heating temperature.

e) A change in post-weld heat treatment.

Table 1 — Weld metal/parent metal combinations

Weld metal		Examples of British Standard designations for welding consumables	Parent metal options for test joint
Group	Nominal composition		
W1	< 6 % total alloy	BS 639: all types[a] BS 2493: all types[a] except 7 Cr Mo B and 9 Cr Mo B BS 2901-1: all types BS 4165: all types	Carbon or low alloy steel with less than 6 % total alloy
W2	≥ 6 % Cr ≤ 20 % Cr ferritic/martensitic steels	BS 2493: 7 Cr Mo B, 9 Cr Mo B BS 2926: 13 and 17	Ferritic/martensitic steel within the range 11 % to 20 % chromium
W3	Austenitic/ferritic or austenitic stainless steels in the following ranges 6 to 29 % Cr 5 to 22 % Ni 0 to 4 % Mo 0 to 1.5 % Nb 0 to 1.5 % Ti	BS 2926: all types except 13 and 17 BS 2901-2: all types BS 5465: all types	Carbon, low alloy, high alloy ferritic or austenitic steel
W4	High nickel alloy	BS 2901-5: NA 35, NA 39	

[a] A change from a rutile electrode to a basic electrode requires re-approval (see item c) of clause **5**).

Table 2 — Extent of approval for weld metal groups

Test joint weld metal group (see Table 1)	Extent of approval			
	W1	W2	W3	W4
W1	X			
W2	X	X		
W3			X	
W4			X	X

NOTE X indicates applicability.

[2)] A welder may need some period of training when changing from one electrode type to another.

6 Extent of approval

6.1 Other than mechanized or automatic welding

6.1.1 *Position.* The approval of a welder on a test joint in one of the fundamental welding positions shall give approval for welding in the following positions:

a) a test with the tube-plate in the horizontal position gives approval only for that position;

b) a test with the tube-plate in the vertical position gives approval for welding with the tube-plate in the vertical or horizontal position;

c) a test with the tube-plate in the overhead position gives approval for welding with the tube-plate in the overhead or horizontal position;

d) a welder who has carried out tests in accordance with b) and c) is approved for any position, horizontal, vertical, overhead or any intermediate position.

6.1.2 *Tube pitch.* The approval of a welder on a test joint using a particular pitch of tubes shall include approval for any other type or pitch provided that the ligament dimension (see Figure 1 and Figure 2) is not reduced to below that given in the approved welding procedure.

6.1.3 *Cladding.* Irrespective of the tube-plate thickness, when welding a clad tube-plate any reduction in nominal cladding thickness shall entail re-approval of the welder.

6.1.4 *Thickness.* For the purposes of this clause, T shall mean the nominal tube-plate thickness and t shall mean the nominal tube thickness.

The approval of a welder on these thicknesses shall include approval for thicknesses in the following ranges:

Thickness, *T*	**Range approved**
less than 10 mm	T to $2T$
10 mm up to but not including 35 mm	10 mm to $2T$
35 mm or over	20 mm and above
Thickness, *t*	**Range approved**
less than 1.6 mm	t to 2 t
1.6 mm up to and including 3 mm	1.6 mm to 2 t
greater than 3 mm	0.5 t to 2 t

6.1.5 *Tube diameter.* For approval to weld diameters less than 19 mm, a test made on tube of nominal outside diameter D less than 19 mm shall include approval for diameters in the range D to 19 mm.

For approval to weld diameters 19 mm and above, a test made on tube of nominal outside diameter D of 19 mm or above shall include approval for diameters in the range of $0.5D$ to $2D$ with a minimum nominal diameter of 19 mm.

6.1.6 *Type of joint.* The approval of a welder on a butt weld tube end joint with added filler metal shall also include approval for butt and fillet weld joints. Separate approval shall be obtained for autogenous welding.

NOTE The exact joint details, such as angles and radius, do not affect welder approval, as long as the procedure has been approved in accordance with BS 4870-3.

6.1.7 *More than one welder.* When more than one welder is employed on making a complete test weld, the satisfactory testing of the test weld shall result in the approval of each welder for his respective portion for that particular procedure only. When there are unacceptable defects present in a test weld and they can be attributed to one welder, this shall not adversely affect the approval of the other welders.

6.2 Mechanized or automatic welding

For mechanized or automatic welding, most changes in the welding parameters do not affect the approval of the welder; they only affect the welding procedure approval range that is covered in BS 4870-3.

A welder who has successfully welded a test piece specified in clause **7** shall be approved for all tube to tube-plate welds using the same or identical equipment for the period specified in clause **11**.

This approval shall cover:

a) all parent metal compositions;

b) all tube and tube-plate thicknesses and all tube outside diameters;

c) all welding positions (e.g. tube-plate vertical, flat or overhead).

Re-approval shall be obtained for major changes in joint geometry or configuration. Separate approval shall be obtained for the following four main types of joint:

1) front face butt weld with filler metal addition;

2) front face butt weld without filler metal addition (autogenous welding);

3) front face fillet weld with filler metal addition;

4) back face bore welds (autogenous welding).

The approval of a welder on a test joint of type 1) shall include approval for type 2) but the converse shall not apply.

7 Test pieces

Except as permitted by **6.1.6**, the welder shall weld a test piece as shown in Figure 1 or Figure 2, whichever is the most representative of the welding procedure to be used in production.

The root run start positions shall be identified and positioned as shown in Figure 1 or Figure 2 to permit sectioning through these positions. For manual metal-arc welding the re-start shall be made with a fresh electrode.

NOTE The test piece may need positioning to facilitate sectioning through start positions.

Subsurface defects that break the surface or which are revealed as the result of grinding specified in the welding procedure shall not be repaired. There shall be no repair welding of a completed test piece.

8 Submission of test weld

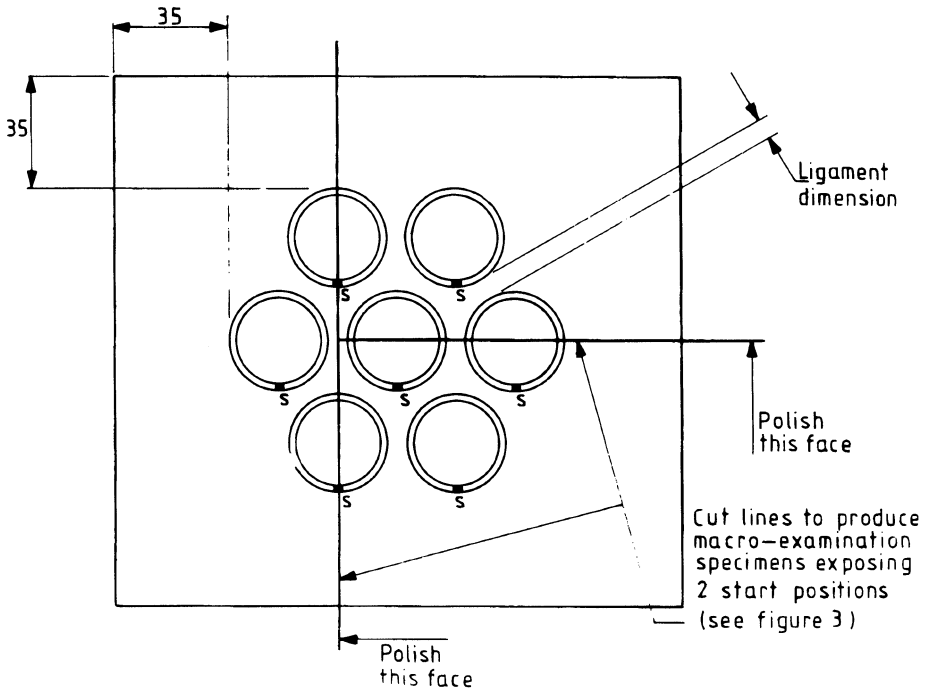
If the welder realizes that, for some reason, the test weld he has made is likely to fail the subsequent examination and testing, he may withhold the test piece and make a second test weld. If the welder does choose to make a second test weld, it is the second piece that shall be examined and tested, the first test piece being scrapped.

9 Examination and testing

9.1 General

All test pieces shall be examined visually in the as-welded condition, augmented if necessary by liquid penetrant testing (see BS 4416) or magnetic particle inspection (see BS 6072). If acceptable in accordance with **9.2**, they shall be radiographed prior to sectioning as shown in Figure 1 or Figure 2. The existence of any defects or parameters outside the acceptance levels given in Table 3 shall be sufficient cause for rejection.

If a test piece fails to comply with any of the requirements in **9.2** to **9.4**, a further complete test piece shall be welded and subjected to the same examination. If this additional test piece does not comply with the relevant requirements, the cause of failure shall be established. If this failure is established as being the result of metallurgical or extraneous causes and is not attributable to the welder's workmanship, then a further repeat test shall be undertaken. If the failure is established as being attributable to the welder's workmanship, then the welder shall be regarded as incapable of complying with this standard without further training.



All welds to have a root run start at the position marked 'S'.
All dimensions are in millimetres.

Figure 1 — Test piece for tube ends on triangular pitch

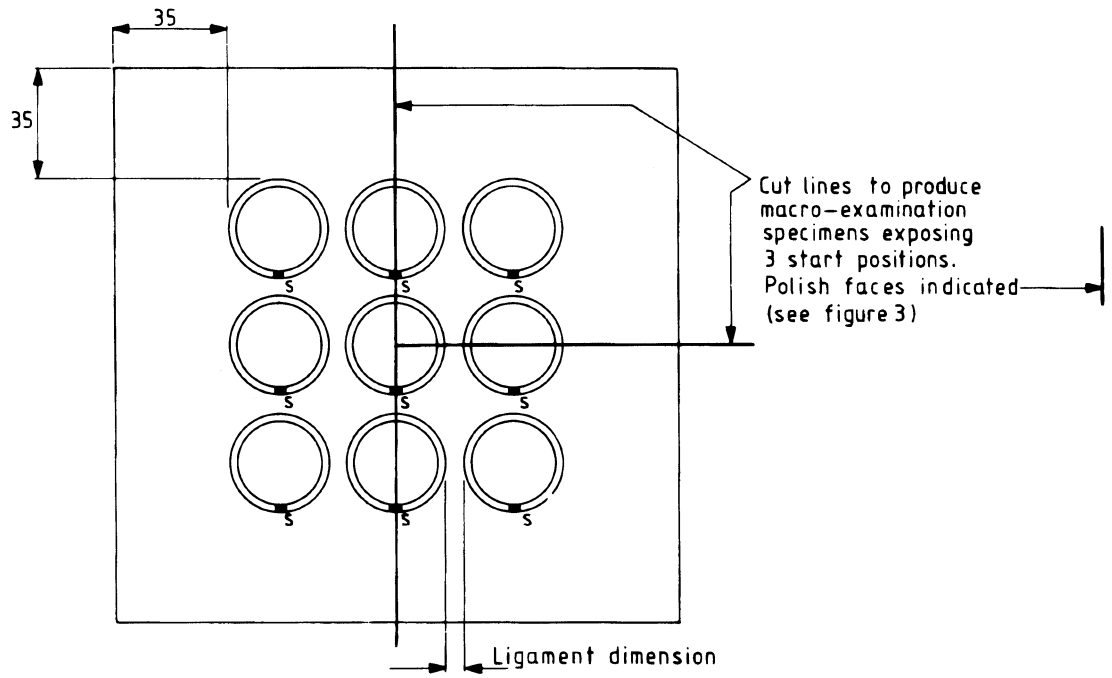


Figure 2 — Test piece for tube ends on square pitch

9.2 Visual examination

After any post-weld heat treatment and prior to sectioning, the test piece shall be examined visually.

The welds shall show uniform contour without excessive reinforcement with the bores of the tubes free from any spatter or burn through. Weld spillage into the bore shall be assessed in accordance with Table 3.

9.3 Radiographic examination

All test welds shall be radiographed.

For front face welds, the tube-plate shall be reduced in thickness to not less than the maximum weld depth into the tube-plate plus 2.5 mm, but in any case the resultant thickness shall be not less than 6.5 mm. Sensitivity shall be 2 % or better when using a wire type image quality indicator in accordance with BS 3971. General requirements for the method of examination shall be in accordance with BS 2600-1.

NOTE 1 It is recommended that technique 2 in BS 2600-1:1983 should be used.

For back face welds, sensitivity shall be 5 % or better when using a wire type image quality indicator in accordance with BS 3971. General requirements for the method of examination shall be in accordance with BS 2910.

NOTE 2 It is recommended that technique 11 in BS 2910:1973 should be used.

9.4 Macro-examination

After visual examination and radiographic examination the test piece shall be sectioned as shown in Figure 1 or Figure 2 by sawing or machining. The macro-examination specimens (see Figure 3) shall be prepared and examined in accordance with BS 709.

NOTE Where radiography reveals defects other than gas pores, it may be necessary to carry out macro-examination of additional sections to assess compliance with the acceptance levels in Table 2.

The minimum throat thickness or potential leak path of each weld shall be assessed in accordance with Table 3.

10 Statement of results

A statement of the results of assessing each test piece, including repeat tests, shall be made for each welder. The items required in clause **4** shall be included together with details of any features that would be rejectable by the requirements of clause **9**. If no rejectable features are found, a statement that the test piece made by the particular welder satisfied the requirements of this standard in respect of that type of test piece shall be signed by the person conducting the test. A separate approval record shall be made for a welder who has successfully carried out a welding procedure test.

NOTE 1 The welder's employer should hold and regularly maintain adequate records of all approval tests for each welder. It is recommended that the form given in appendix A be used to record details of the approval test and the results in order to facilitate uniform presentation and assessment of the data.

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

11 Re-approval of welder

A welder's approval shall remain valid provided that it can be shown, as signified at intervals of 6 months by a senior responsible person in the firm that employs the welder, that the welder has, subsequent to the test, been employed with reasonable continuity on work within the extent of his approval and has continued to produce satisfactory welds as verified by means appropriate to the type of production work. Re-approval shall be required if any of the following apply:

a) the welder is to be employed on work outside the extent of his current approval;

b) the welder changes his employer without the transfer of his test records;

c) 6 months or more have elapsed since the welder was engaged in welding on work within the extent of his approval;

d) there is some specific reason to question the welder's ability.

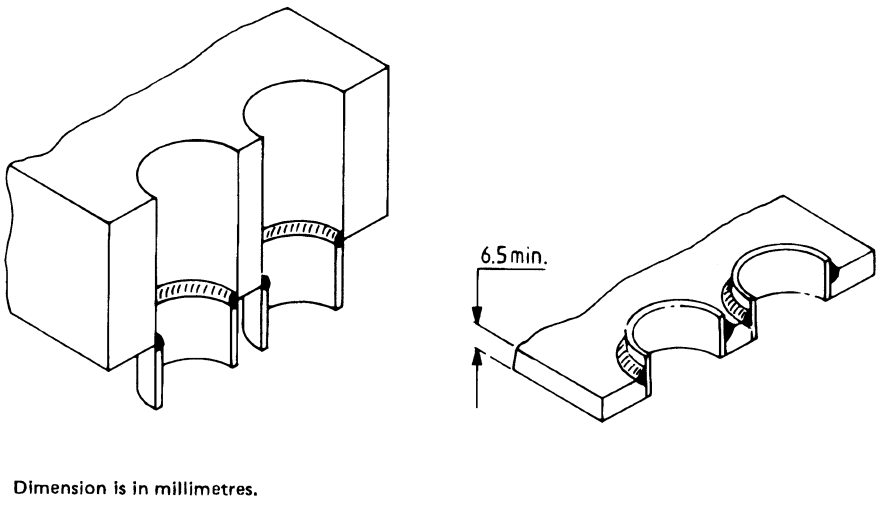


Figure 3 — Typical examples of macro-examination specimens

Table 3 — Acceptance levels

Defects and parameters		Acceptance levels
Planar defects	(a) Cracks and lamellar tears	Not permitted
	(b) Lack of side fusion Lack of inter-run fusion	Not permitted
Throat thickness or barrier to leakage		Minimum throat thickness: (a) 0.7 t for single run weld (b) t for multi-run welds
Burn through of tube wall		Not permitted
Weld spillage		Not to exceed 0.5 mm for tubes up to and including 25 mm diameter and 1 mm for tubes over 25 mm
Slag inclusions or other solid inclusions (e.g. tungsten)		Individual inclusions length < t width < 0.25 t The through thickness dimension of the inclusion shall not reduce the minimum throat thickness or barrier to leakage below that specified
Cavities	(a) Isolated pores	Diameter < 0.25 t The through thickness dimension of the pores shall not reduce the minimum throat thickness or barrier to leakage below that specified
	(b) Wormhole and pipes	Length < 0.5 t The through thickness dimension of the wormhole or pipe shall not reduce the minimum throat thickness or barrier to leakage below that specified
	(c) Linear porosity	For back face welds this may indicate lack of fusion and is therefore not permitted NOTE For front face welds lack of fusion is usually inherent because of the joint design
	(d) Uniformly distributed or localized porosity	The sum of all the pores at one section shall not reduce the minimum throat thickness or barrier to leakage below that specified
Burn down of tube end		Not permitted where it reduces the weld below its required dimensions

NOTE 1 t is the nominal thickness of the tube.
NOTE 2 For definitions of defect types, see BS 499-1.
NOTE 3 It should be appreciated that the details given in Table 3 are being used for the approval testing of welders and as such may be different from those specified for a particular application.

Appendix A Record of approval test of welder

The recommended form for recording details of the approval test and the results for a welder is as follows.

Page 1 of

(Organization's symbol or logo)	Welder approval test certificate (BS 4871-3)	Test record no.
Manufacturer's name	**Welder's name and identity no.**	**Issue no.**

Approved welding procedure no. NOTE The parent metal used may differ from that used in the above approved welding procedure.	**Date of test**

Test piece details	**Extent of approval**
Welding process	Welding process(es)
Parent material(s)	Materials range
Thickness of tube-plate (*T*)	Tube-plate thickness range
Thickness of cladding	Minimum cladding thickness
Joint type	Joint type
Type of pitch and ligament dimension	Minimum ligament dimension
Tube outside diameter (*D*)	Tube thickness range
Tube thickness (*t*)	Welding position(s)
Welding position(s)	Consumables
Test piece position	**Remarks**
Welding consumables	
Filler material	
Make and type	**Weld preparation** (dimensioned sketch)
Composition	
Specification	
Size(s)	
Shielding gas/flux	
Make and type	
Composition/specification	

Test results

State "acceptable", "non-acceptable" (with reasons) or "not required".

Non-destructive tests

Visual	*Radiography*

Destructive test: macro-examination

Remarks

The statements in this certificate are correct. The test weld was prepared, welded and tested in accordance with BS 4871-3.

Manufacturer's representative	Inspecting authority
Position	Witnessed by
Date	Date

Page 2 of

(Organization's symbol or logo)	Welder approval test certificate (BS 4871-3)	Test record no.
Manufacturer's name	Welder's name and identity no.	Issue no.

Declaration

I, the undersigned, declare that the welder named above has been regularly and satisfactorily employed on work covered by this certificate during the 6 months preceding the date of my signature.

Date	Personal signature	Position or title

Publications referred to

BS 499, *Welding terms and symbols.*

BS 499-1, *Welding, brazing and thermal cutting glossary.*

BS 639, *Covered electrodes for the manual metal-arc welding of carbon and carbon manganese steels.*

BS 709, *Methods of destructive testing fusion welded joints and weld metal in steel.*

BS 2493, *Low alloy steel electrodes for manual metal-arc welding.*

BS 2600, *Radiographic examination of fusion welded butt joints in steel.*

BS 2600-1, *Methods for steel 2 mm up to and including 50 mm thick.*

BS 2901, *Filler rods and wires for gas-shielded arc welding.*

BS 2901-1, *Ferritic steels.*

BS 2901-2, *Austenitic stainless steels.*

BS 2901-5, *Nickel and nickel alloys.*

BS 2910, *Methods for radiographic examination of fusion welded circumferential butt-joints in steel pipes.*

BS 2926, *Specification for chromium and chromium nickel steel electrodes for manual metal arc welding.*

BS 3971, *Specification for image quality indicators for industrial radiography (including guidance on their use).*

BS 4165, *Electrode wires and fluxes for the submerged arc welding of carbon steel and medium-tensile steel.*

BS 4416, *Method for penetrant testing of welded or brazed joints in metals.*

BS 4870, *Specification for approval testing of welding procedures.*

BS 4870-3, *Arc welding of tube to tube-plate joints in metallic materials.*

BS 5465, *Specification for electrode wires and fluxes for the submerged arc welding of austenitic stainless steels based on weld metal composition.*

BS 6072, *Method for magnetic particle flaw detection.*

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