British Standard

BRITISH STANDARD

BS 4872-2: 1976

Specification

Approval testing of welders when welding procedure approval is not required —

Part 2: TIG or MIG welding of aluminium and its alloys

UDC 621.791.007.2:331.115.63 + 669.716:621.791.753.9 + 621.791.754

Co-operating organizations

The Welding Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Aluminium Federation*
Associated Offices Technical Committee*
British Constructional Steelwork Association*
British Mechanical Engineering Confederation
British Railways Board
British Steel Industry*
Crown Agents for Oversea Governments and Administrations
Department of Employment
Department of Trade
Institution of Civil Engineers
Institution of Electrical Engineers
Institution of Production Engineers
Institution of Structural Engineers
Lloyd's Register of Shipping
London Transport Executive
Ministry of Defence*
Process Plant Association
Shipbuilders' and Repairers' National Association*
Society of British Aerospace Companies Limited
Welding Institute*
Welding Manufacturers' Association*

The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Electricity Supply Industry in England and Wales
Engineering Equipment Users' Association
Heating and Ventilating Contractors' Association
Lloyds Register of Industrial Services
National Coal Board
Oil Companies' Materials Association
Stainless Steel Fabricators Association of Great Britain
United Kingdom Atomic Energy Authority
Water-tube Boilermakers' Association

This British Standard, having been prepared under the direction of the Welding Standards Committee, was published under the authority of the Executive Board on 30 April 1976

The following BSI references relate to the work on this standard:
Committee reference WEE/36
Draft for comment 73/43577 DC

ISBN 0 580 08599 6

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

Foreword

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 welding procedure approval is required,

c) welder approval when the welding procedure is not required to be approved for either technical or contract reasons.

This standard covers the simple approval of welders on sheet[1)], plate[1)] and pipe[2)] when no welding procedure approval is required. For the purposes of this standard, welders are considered to have already received training in the welding of aluminium and its alloys.

To complete the philosophy behind this series of standards, it is considered useful to give details of the practices relating to welding procedure approval even though they are not strictly relevant to this standard. Depending upon the emphasis placed on quality control in the production of welded components, the approval of welding procedures 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 subcontractor) may have proved by actual test pieces every weld form he wishes to use, in every thickness and material.

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

In respect of 1 and 2 above, 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 in the future for fully documented welding procedures, developed independently of the particular contractor, to be employed without the need for further approval tests.

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 20, 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)] In this standard the words "sheet" and "plate" are not used to indicate any precise difference in the thickness of the material.

[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.

1 Scope

This British Standard specifies requirements for the approval testing of welders to be engaged on the TIG or MIG welding of those aluminium and aluminium alloy fabrications for which the welding procedure itself does not have to be approved.

NOTE This link to the non-mandatory approval of the welding procedure will result in the use of this standard becoming defined more closely in respect of the particular fabrication, e.g. with regard to material, thickness and joint configuration.

2 References

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

3 Information to be given to the welder

The welder shall be provided with written instructions and information covering the following details:

a) parent metal (alloy type and condition);

b) welding process;

c) welding consumables (filler material specification and diameter, shielding gas composition and flow rate);

d) for TIG welding, the electrode diameter and type;

e) welding position;

f) metal thickness and, for pipe, the outside diameter or dimension;

g) pre-weld cleaning;

h) joint type, with sketch of weld preparation;

i) weld dimensions required.

The pulsed-arc versions of TIG and MIG welding shall be treated as separate welding processes for which minor changes may be necessary to the weld preparations for the test welds given in clause **4**.

Other factors shall be left to the choice of the welder but the relevant details shall be recorded (see also clause **5**).

4 Test welds[3)]

4.1 General. The welder shall make the test weld or welds from the following tests according to which is most representative of the type of work on which he will be employed. The welder shall make a further test weld or welds whenever the work on which he will be employed changes sufficiently (in respect of the items listed in clause **3** and as specified for the relevant test) to make the test weld or welds on which he has already obtained approval no longer representative of the new work.

Where tack welds are used, their location shall be identifiable after the test weld has been completed. Distortion or mis-alignment caused by tacking may be corrected before the test weld is made.

4.2 Parent metal. For the purposes of this standard, parent metals have been grouped as shown below. The approval of a welder to weld a particular type of material shall include approval for all the other materials in the same group. Approval between groups of materials is not permitted.

Group number	Parent metal (according to BS 1470 to BS 1475 inclusive and BS 4300 series)
1	1, 1A, 1B, 1C, N3
2	H9, H20, H30
3	N4, N41, N5, N51, N8
4	H17

4.3 Test 1: butt weld in sheet (without permanent backing)

4.3.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 1 provided that the test conditions listed have been met.

4.3.2 *Deposition of test weld.* The test weld shall be stopped and restarted within the central 50 mm of its length.

A sealing run on the reverse side is not permitted.

[3)] The test welds given in this standard permit the use of whatever sizes of material are readily available. The types of joint, however, are not necessarily the same as those that are met in practice.

Table 1 — Butt weld in sheet (without permanent backing)

	Test conditions	Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**	Only material group (see **4.2**) welding process and welding consumables of types used for the test
Welding position[a]	Flat	Flat
	Vertical-up	Vertical-up and flat
	Vertical-up and horizontal-vertical (two test welds)	Vertical-up, horizontal-vertical and flat
	Vertical-up and overhead (two test welds)	Vertical-up, overhead, horizontal-vertical and flat
Thickness t	3 mm max.	$0.75t$ to $1.5t$
Joint type	Square butt (see Figure 1)	Any butt weld without permanent backing in sheet in above thickness range

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

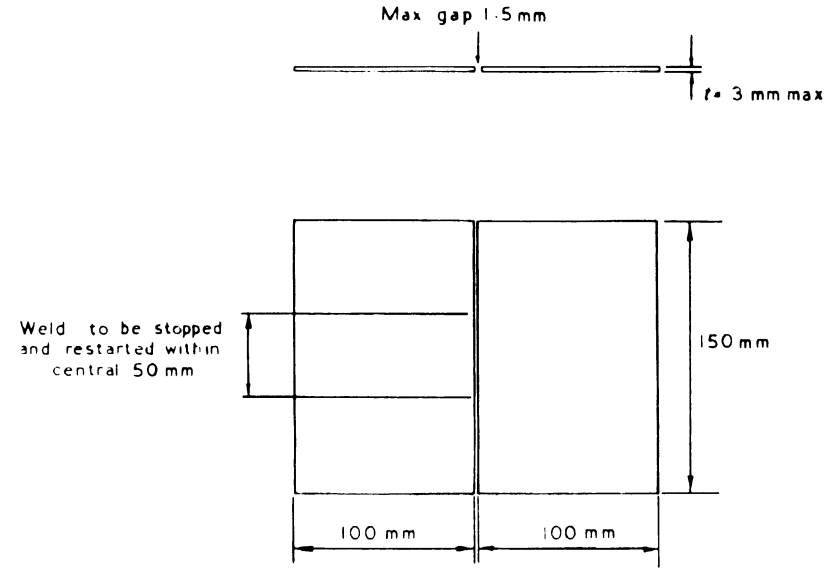

Figure 1 — Test piece for butt weld in sheet (without permanent backing)

4.4 Test 2: fillet weld in sheet

4.4.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 2 provided that the test conditions listed have been met.

4.4.2 *Deposition of test weld.* The test weld shall be made in a single run on only one side of the joint, with equal leg lengths of approximately 4 mm. The weld shall be stopped and restarted at about 75 mm from one end.

4.5 Test 3: butt weld in plate (without backing, welded from one side)

4.5.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 3 provided that the test conditions listed have been met.

4.5.2 *Deposition of test weld.* The final run of the test weld shall be stopped and restarted within the central 50 mm of its length.

A sealing run on the reverse side is not permitted.

Table 2 — Fillet weld in sheet

	Test conditions	Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**	Only material group (see **4.2**) welding process and welding consumables of types used for the test
Welding position[a]	Horizontal-vertical	Horizontal-vertical and flat
	Vertical-up	Vertical-up, horizontal-vertical and flat
	Overhead	Overhead, horizontal-vertical and flat
	Vertical-up and overhead (two test welds)	Vertical-up, overhead, horizontal-vertical and flat
Thickness t	3 mm max.	$0.75t$ to $1.5t$
Joint type	T joint (see Figure 2)	Any fillet weld in sheet in above thickness range

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

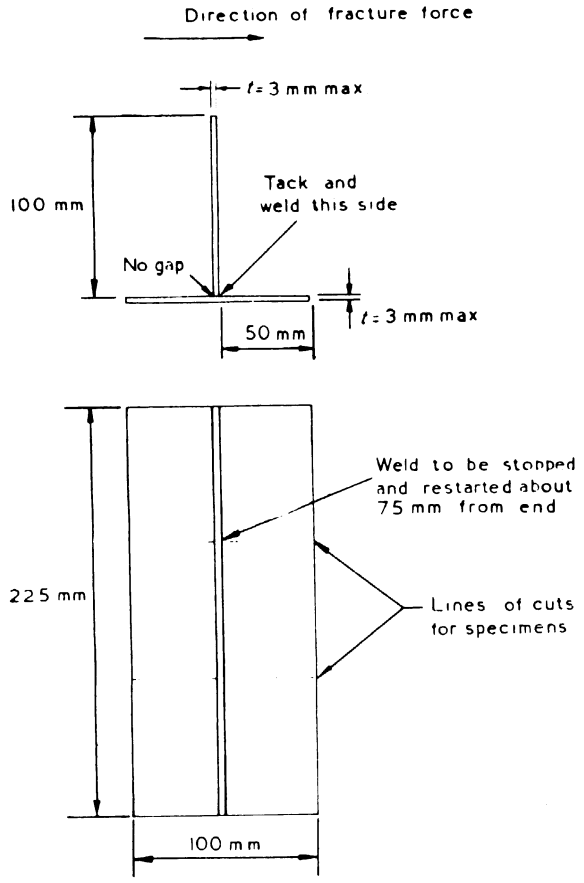

Figure 2 — Test piece for fillet weld in sheet

Table 3 — Butt weld in plate (without backing, welded from one side)

	Test conditions	Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**	Only material group (see **4.2**) welding process and welding consumables of types used for the test
Welding position[a]	Flat	Flat
	Vertical-up	Vertical-up and flat
	Vertical-up and horizontal-vertical (two test welds)	Vertical-up, horizontal-vertical and flat
	Vertical-up and overhead (two test welds)	Vertical-up, overhead, horizontal-vertical and flat
Thickness t	At least 6 mm but less than 12 mm	0.75t to 1.5t
	12 mm or thicker	8 mm and thicker
Joint type	Single-V butt, without backing (see Figure 3[b])	For plate in above thickness ranges:
		a) any single-sided butt weld preparation, with or without temporary backing, welded from one side only;
		b) any single-sided butt weld preparation welded from both sides without back gouging;
		c) any double-sided butt weld preparation

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

[b] The dimensions of the weld preparation are typical for welding in the flat position, but for other positions it may be necessary for modifications to be made. In all cases the details shall be recorded (see clause **3** and appendix B).

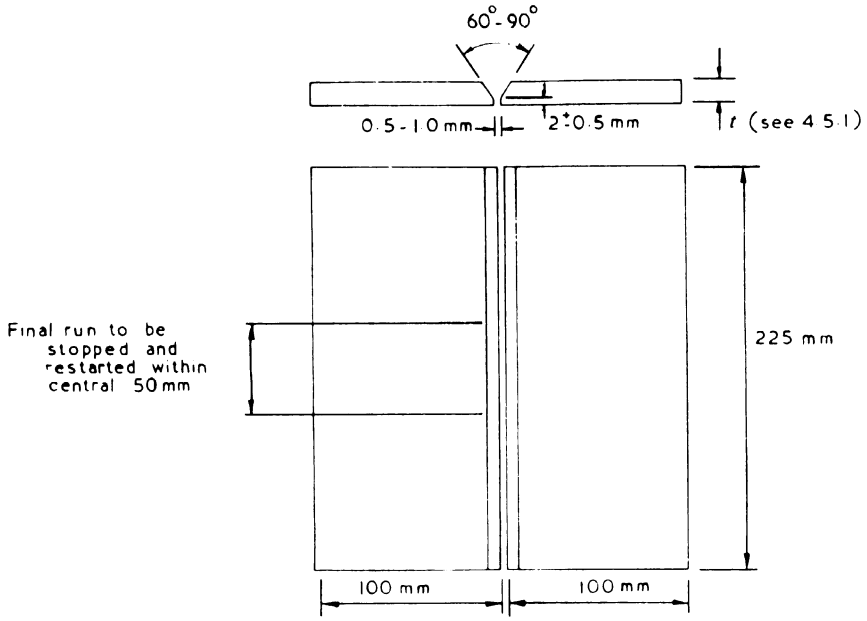

Figure 3 — Test piece for butt weld in plate (without backing, welded from one side)

4.6 Test 4: butt weld in plate (welded from both sides)

4.6.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 4 provided that the test conditions listed have been met.

4.6.2 *Deposition of test weld.* The final run on each side of the test weld shall be stopped and restarted within the central 50 mm of its length.

The back of the first run shall be gouged out by suitable means to clean, sound metal before welding is started on the gouged-out side, except where the "double operator" technique is used in the vertical-up position.

Table 4 — Butt weld in plate (welded from both sides)

	Test conditions			Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**			Only material group (see **4.2**), welding process and welding consumables of types used for the test
Welding position[a]	*First side*	*Second side*		
	Flat	Overhead		Flat, overhead, horizontal-vertical
	Vertical-up	Vertical-up		Vertical-up and flat
	Vertical-up (double operator)	Vertical-up (double operator)		Vertical-up (double operator) and flat
	Vertical-up	Vertical-up	Two test welds	Vertical-up, horizontal-vertical and flat
	Horizontal-vertical	Horizontal-vertical		
	Vertical-up	Vertical-up	Two test welds	Vertical-up, overhead, flat and horizontal-vertical
	Overhead	Flat		
Thickness t	At least 6 mm but less than 12 mm			0.75t to 1.5t
	12 mm or thicker			8 mm and thicker
Joint type	Double-V butt (see Figure 4[b])			For plate in above thickness ranges:
				a) any double-sided butt weld preparation;
				b) any single-sided butt weld preparation welded from both sides with back gouging

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

[b] The dimensions of the weld preparation are typical for welding in the flat and overhead positions, but for other positions it may be necessary for modifications to be made; for example, in the "double operator" technique in the vertical-up position a wider gap and sighting notches may be used. In all cases the details shall be recorded (see clause **3** and appendix B).

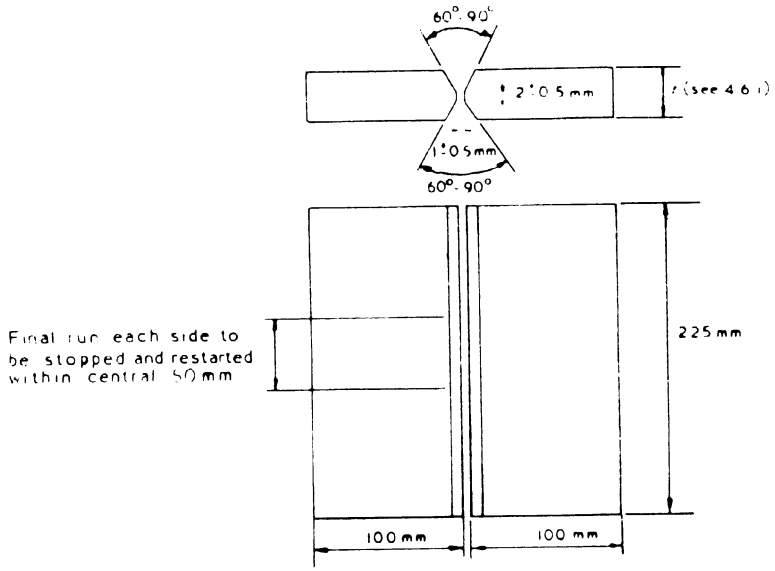

Figure 4 — Test piece for butt weld in plate (welded from both sides)

4.7 Test 5: butt weld in plate (with permanent backing)

4.7.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 5 provided that the test conditions listed have been met.

4.7.2 *Deposition of test weld.* The final run of the test weld shall be stopped and restarted within the central 50 mm of its length.

Table 5 — Butt weld in plate (with permanent backing)

	Test conditions	Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**	Only material group (see **4.2**) welding process and welding consumables of types used for the test
Welding position[a]	Flat	Flat
	Vertical-up	Vertical-up and flat
	Vertical-up and horizontal-vertical (two test welds)	Vertical-up, horizontal-vertical and flat
	Vertical-up and overhead (two test welds)	Vertical-up, overhead, horizontal-vertical and flat
Thickness t	At least 3 mm but less than 12 mm	$0.75t$ to $1.5t$
	12 mm or thicker	8 mm and thicker
Joint type	Square or single-V butt with backing (see Figure 5[b]) according to process and thickness	Any single-sided butt weld preparation with permanent backing in plate in above thickness ranges

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

[b] The dimensions of the weld preparation are typical for welding in the flat position, but for other positions it may be necessary for modifications to be made. In all cases the details shall be recorded (see clause **3** and appendix B).

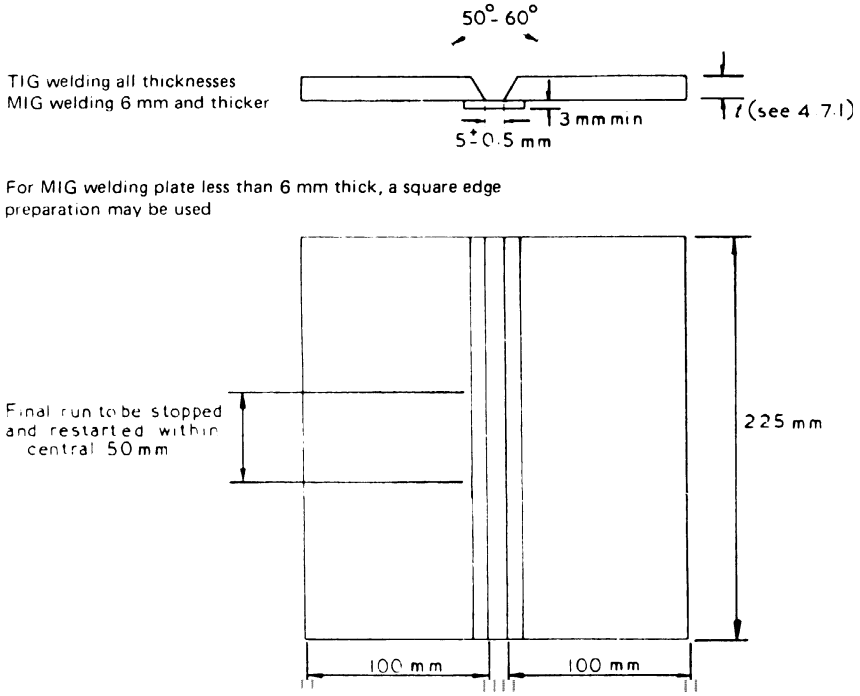

Figure 5 — Test piece for butt weld in plate (with permanent backing)

4.8 Test 6: butt weld in plate (with temporary backing)

4.8.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 6 provided that the test conditions listed have been met.

4.8.2 *Deposition of test weld.* The final run of the test weld shall be stopped and restarted within the central 50 mm of its length.

Table 6 — Butt weld in plate (with temporary backing)

	Test conditions	Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**	Only material group (see **4.2**) welding process and welding consumables of types used for the test
Welding position[a]	Flat	Flat
	Vertical-up	Vertical-up and flat
	Vertical-up and horizontal-vertical (two test welds)	Vertical-up, horizontal-vertical and flat
	Vertical-up and overhead (two test welds)	Vertical-up, overhead, horizontal-vertical and flat
Thickness t	At least 3 mm but less than 12 mm	$0.75t$ to $1.5t$
	12 mm or thicker	8 mm and thicker
Joint type	Square or single-V butt with backing (see Figure 6[b]) according to process and thickness	Any single-sided butt weld preparation with temporary backing in plate in above thickness ranges

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

[b] The dimensions of the weld preparation are typical for welding in the flat position, but for other positions it may be necessary for modifications to be made. In all cases the details shall be recorded (see clause **3** and appendix B).

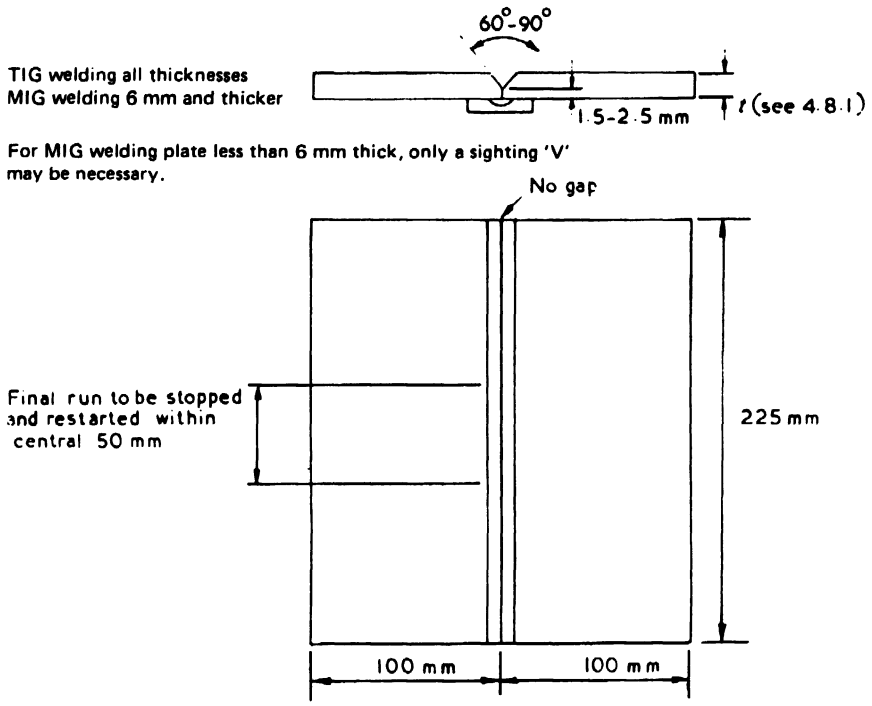

Figure 6 — Test piece for butt weld in plate (with temporary backing)

4.9 Test 7: fillet weld in plate

4.9.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 7 provided that the test conditions listed have been met.

4.9.2 *Deposition of test weld.* The test weld shall be made on only one side of the joint, with equal final leg lengths corresponding approximately to the thickness *t*. The root run shall be stopped and restarted at about 75 mm from one end.

Table 7 — Fillet weld in plate

	Test conditions	Applicability of test
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**	Only material group (see **4.2**) welding process and welding consumables of types used for the test
Welding position[a]	Horizontal-vertical	Horizontal-vertical and flat
	Vertical-up	Vertical-up, horizontal-vertical and flat
	Overhead	Overhead, horizontal-vertical and flat
	Vertical-up and overhead (two test welds)	Vertical-up, overhead, horizontal-vertical and flat
Thickness *t*	At least 6 mm but less than 12 mm	0.75*t* to 1.5*t*
	12 mm or thicker	8 mm and thicker
Joint type	T joint (see Figure 7)	Any fillet weld in plate in above thickness ranges

[a] If a combination of test positions other than those specified is used, the welder is approved only for that combination.

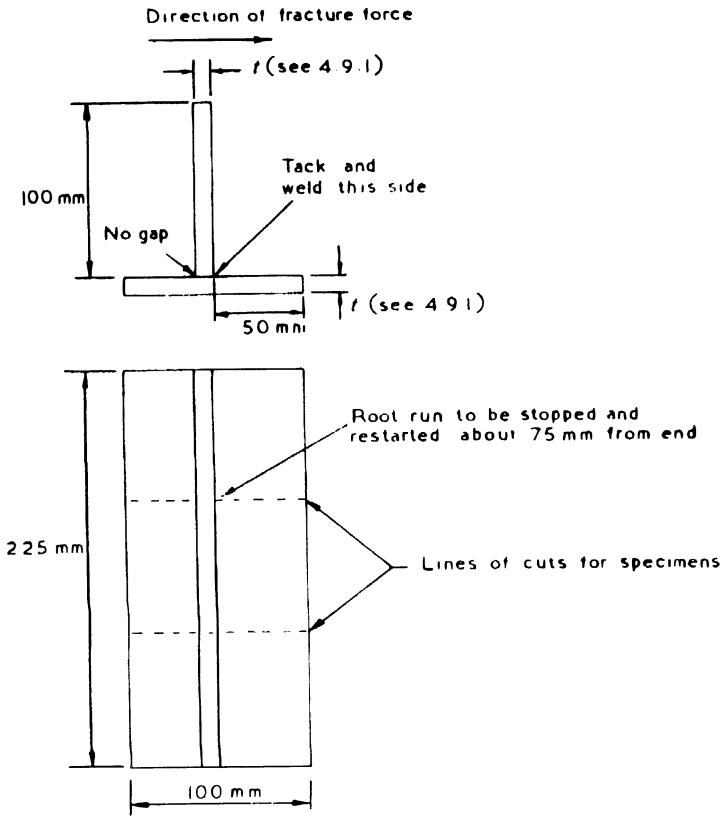

Figure 7 — Test piece for fillet weld in plate

4.10 Test 8: butt weld in pipe (without backing)

4.10.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 8 provided that the test conditions listed have been met.

4.11 Test 9: butt weld in pipe (with permanent backing)

4.11.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 9 provided that the test conditions listed have been met.

4.12 Test 10: butt weld in pipe (with temporary backing)

4.12.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 10 provided that the test conditions listed have been met.

4.13 Test 11: branch connection (fillet weld)

4.13.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 11 provided that the conditions listed have been met.

4.13.2 *Deposition of test weld.* The test weld shall change gradually from a fillet weld at the crotch to a butt weld at the flank. The fillet weld at the crotch shall have equal leg lengths corresponding to approximately the thickness t or 4 mm, whichever is the greater.

4.14 Test 12: branch connection (penetration weld)

4.14.1 *Applicability of test and test conditions.* The applicability of this test shall be as given in Table 12 provided that the conditions listed have been met.

Table 8 — Butt weld in pipe (without backing)

	Test conditions		Applicability of test	
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**		Only material group (see **4.2**) welding process and welding consumables of types used for the test	
Position[a]	Pipe positions	Axis horizontal, pipe rotating	Welding positions	Flat
		Axis horizontal, pipe fixed (vertical-up welding)		Overhead, vertical-up and flat
		Axis vertical		Horizontal-vertical and flat
		Axis inclined at 45°, pipe fixed (vertical-up welding) *or* Axis horizontal, pipe fixed (vertical-up welding) and axis vertical (two test welds)		Overhead, vertical-up, horizontal-vertical and flat
Thickness t	Less than 6 mm		0.75t to 1.5t	
	6 mm or thicker		4 mm and thicker	
Outside diameter or dimension D (for rectangular hollow sections D is dimension of smaller side)	Less than 50 mm		1D to 1.5D	
	At least 50 mm but less than 165 mm		0.5D to 1.5D	
	165 mm or larger		80 mm and larger	
Joint type	Single-V butt without backing (see Figure 8)		Any butt weld in pipe or plate, with or without backing, in above thickness and diameter ranges	

[a] If a combination of test pipe positions other than those specified is used, the welder is approved for the welding positions derived only from that combination.

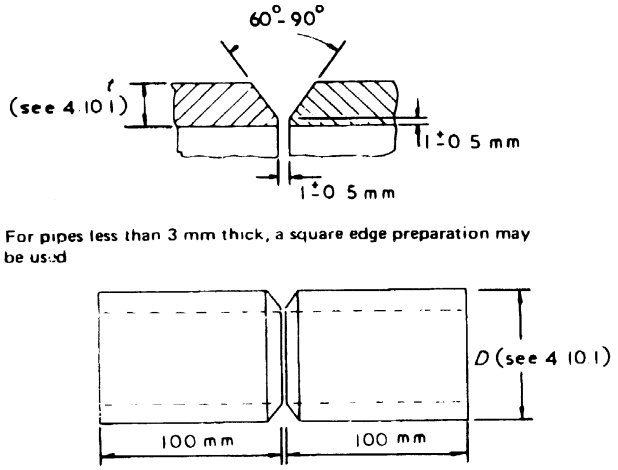

Figure 8 — Test piece for butt weld in pipe (without backing)

Table 9 — Butt weld in pipe (with permanent backing)

	Test conditions		Applicability of test	
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**		Only material group (see **4.2**) welding process and welding consumables of types used for the test	
Position[a]	Pipe positions	Axis horizontal, pipe rotating	Welding positions	Flat
		Axis horizontal, pipe fixed (vertical-up welding)		Overhead, vertical-up and flat
		Axis vertical		Horizontal-vertical and flat
		Axis inclined at 45°, pipe fixed (vertical-up welding) *or* Axis horizontal, pipe fixed (vertical-up welding) and axis vertical (two test welds)		Overhead, vertical-up, horizontal-vertical and flat
Thickness t	Less than 6 mm		0.75t to 1.5t	
	6 mm or thicker		4 mm and thicker	
Outside diameter or dimension D (for rectangular hollow sections D is dimension of smaller side)	Less than 50 mm		1D to 1.5D	
	At least 50 mm but less than 165 mm		0.5D to 1.5D	
	165 mm or larger		80 mm and larger	
Joint type	Single-V butt with backing (see Figure 9)		Any butt weld in pipe or plate with permanent backing in above thickness and diameter ranges	

[a] If a combination of test pipe positions other than those specified is used, the welder is approved for the welding positions derived only from that combination.

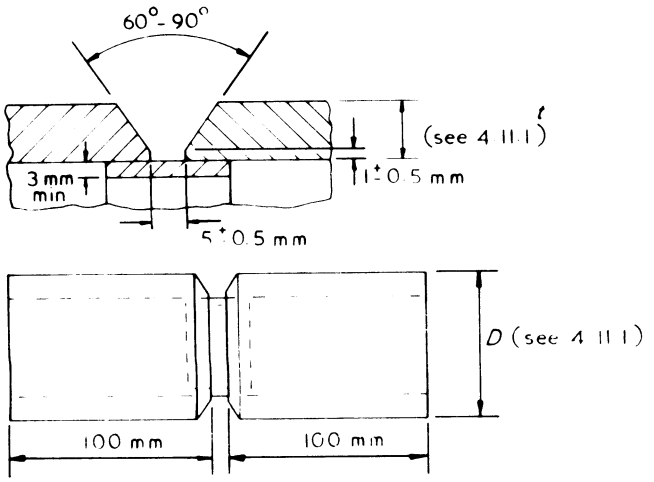

Figure 9 — Test piece for butt weld in pipe (with permanent backing)

Table 10 — Butt weld in pipe (with temporary backing)

	Test conditions		Applicability of test	
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**		Only material group (see **4.2**) welding process and welding consumables of types used for the test	
Position[a]	Pipe positions	Axis horizontal, pipe rotating	Welding positions	Flat
		Axis horizontal, pipe fixed (vertical-up welding)		Overhead, vertical-up and flat
		Axis vertical		Horizontal-vertical and flat
		Axis inclined at 45°, pipe fixed (vertical-up welding) *or* Axis horizontal, pipe fixed (vertical-up welding) and axis vertical (two test welds)		Overhead, vertical-up, horizontal-vertical and flat
Thickness t	Less than 6 mm		0.75t to 1.5t	
	6 mm or thicker		4 mm and thicker	
Outside diameter or dimension D (for rectangular hollow sections D is dimension of smaller side)	Less than 50 mm		1D to 1.5D	
	At least 50 mm but less than 165 mm		0.5D to 1.5D	
	165 mm or larger		80 mm and larger	
Joint type	Single-V butt with backing (see Figure 10)		Any butt weld in pipe or plate with temporary backing in above thickness and diameter ranges	

[a] If a combination of test pipe positions other than those specified is used, the welder is approved for the welding positions derived only from that combination.

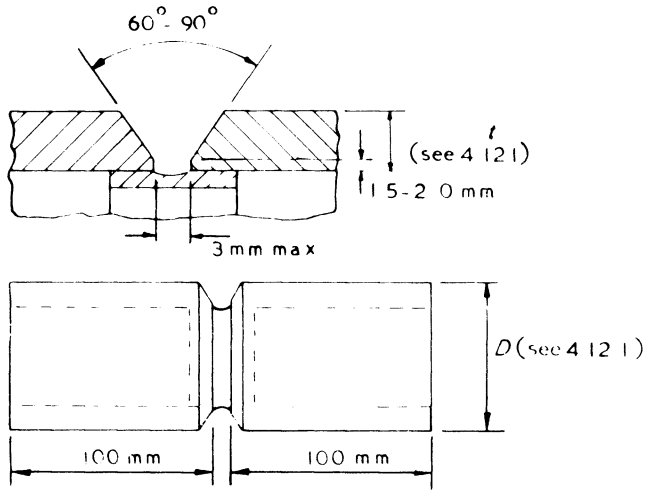

Figure 10 — Test piece for butt weld in pipe (with temporary backing)

Table 11 — Branch connection (fillet weld)

	Test conditions		Applicability of test	
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**		Only material group (see **4.2**) welding process and welding consumables of types used for the test	
Position[a]	Pipe positions	Axis of main and branch horizontal-fixed during welding but branch turned through 180° (vertical-up welding) (see Figure 11b)	Welding positions	Vertical-up, horizontal-vertical and flat
		Axis of main horizontal, axis of branch vertical-fixed above main		Flat and horizontal-vertical
		Axis of main and branch horizontal-fixed (vertical-up welding)		Overhead, vertical-up, horizontal-vertical and flat
Thickness t	Less than 6 mm		0.75t to 1.5t	
	6 mm or thicker		4 mm and thicker	
Outside diameter or dimension D (for rectangular hollow sections D is dimension of smaller side)	Less than 50 mm		1D to 1.5D	
	At least 50 mm but less than 165 mm		0.5D to 1.5D	
	165 mm or larger		80 mm and larger	
Joint type	Right angle branch (see Figure 11a)		Any fillet weld in pipe in above thickness and diameter ranges	

[a] If a combination of test pipe positions other than those specified is used, the welder is approved for the welding positions derived only from that combination.

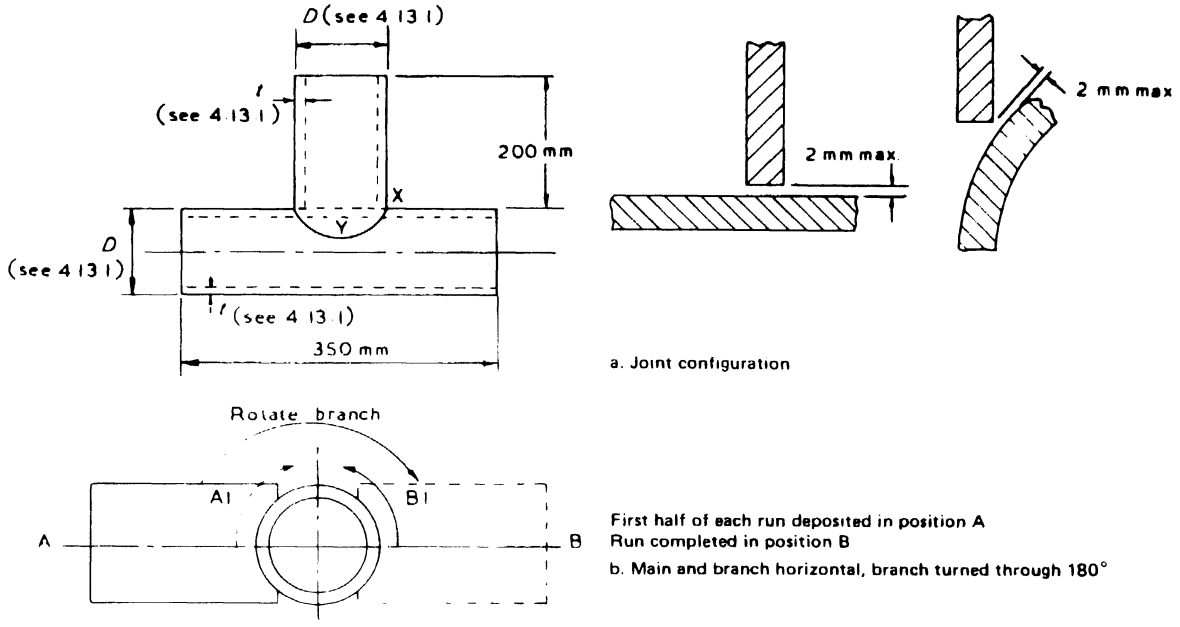

Figure 11 — Test piece for branch connection (fillet weld)

Table 12 — Branch connection (penetration weld)

	Test conditions		Applicability of test	
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with clause **3**		Only material group (see **4.2**) welding process and welding consumables of types used for the test	
Position[a]	Pipe positions	Axis of main and branch horizontal-fixed during welding but branch turned through 180° (vertical-up welding) (see Figure 12b)	Welding positions	Vertical-up, horizontal-vertical and flat
		Axis of main horizontal, axis of branch vertical-fixed above main		Flat and horizontal-vertical
		Axis of main and branch horizontal-fixed (vertical-up welding)		Overhead, vertical-up, horizontal-vertical and flat
Thickness t	Less than 6 mm		0.75t to 1.5t	
	6 mm or thicker		4 mm and thicker	
Outside diameter or dimension D (for rectangular hollow sections D is dimension of smaller side)	Less than 50 mm		1D to 1.5D	
	At least 50 mm but less than 165 mm		0.5D to 1.5D	
	165 mm or larger		80 mm and larger	
Joint type	Right angle branch (see Figure 12a)		Any penetration weld in a pipe branch connection in above thickness and diameter ranges	

[a] If a combination of test pipe positions other than those specified is used, the welder is approved for the welding positions derived only from that combination.

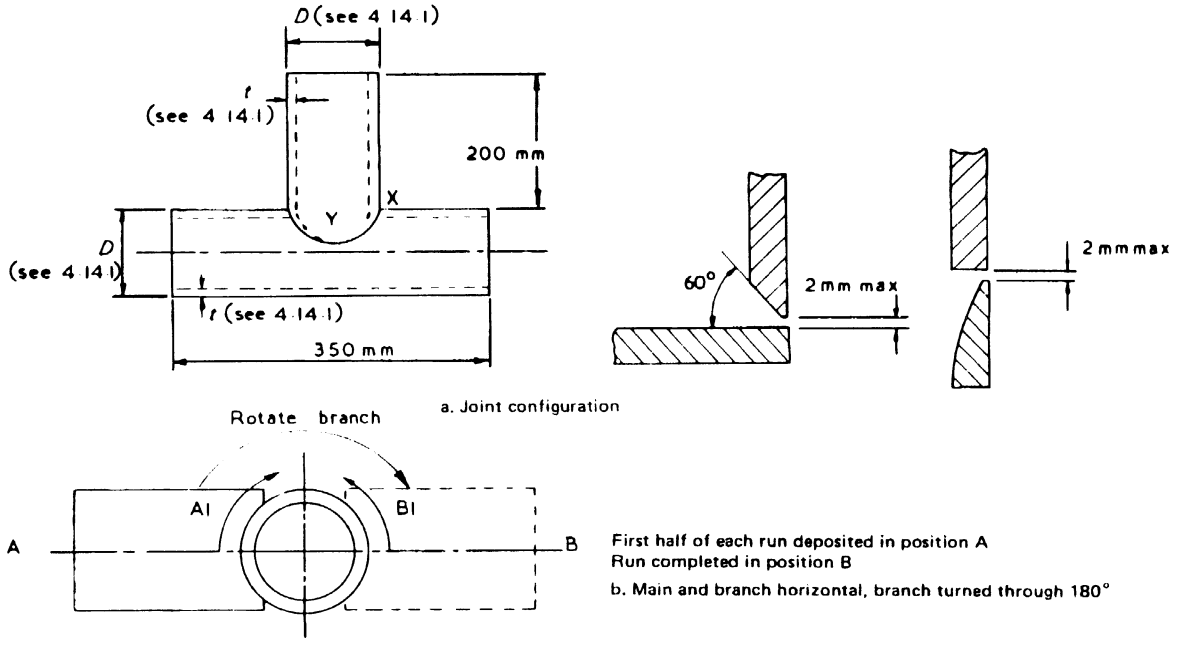

Figure 12 — Test piece for branch connection (penetration weld)

5 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 withold the submission of the test piece and make a second test weld. If the welder does choose to make a second test weld it is the second test piece that shall be examined and tested, the first test piece being scrapped.

6 Examination and testing

6.1 Visual examination. Each test piece shall be examined visually on completion of welding and before sectioning for destructive testing. The following points shall be assessed.

6.1.1 *Weld contour.* The weld metal shall be properly fused with the parent metal. The weld toes shall blend smoothly with the parent metal.

Fillet welds shall be of approximately equal leg length and free from overlap at the toes. The leg length dimensions shall be as specified for the test and the throat thickness shall be approximately 0.7 times the leg length.

Butt welds shall show uniform external excess weld metal not exceeding 25 % of the parent metal thickness or 5 mm, whichever is the smaller.

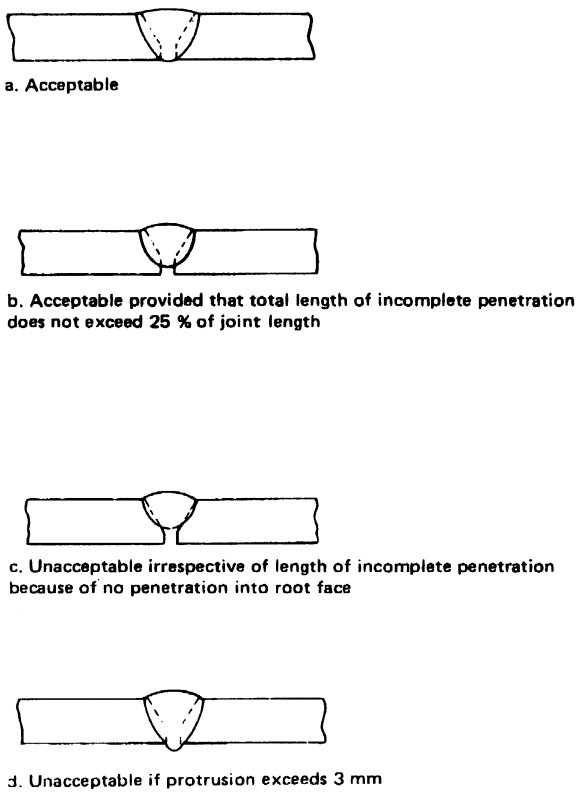

Figure 13 — Examples of acceptable and unacceptable penetration

6.1.2 *Undercut.* Any undercut shall not exceed 10 % of the material thickness or 1 mm, whichever is the smaller.

6.1.3 *Smoothness of joins where welding is restarted.* The stop/start position in a run shall merge smoothly and shall show no pronounced hump or crater in the weld surface.

6.1.4 *Penetration in butt joints without backing welded from one side only (see Figure 13)* Where an edge preparation is used, there shall be penetration into the root faces; but lack of penetration to the full depth of the root faces shall not be cause for rejection provided that it does not extend, for a total length of more than 25 % of the joint length.

A slight penetration bead may be present provided that it does not protrude more than 3 mm.

6.1.5 *Excessive penetration in butt joints with backing.* The backing material shall not have been pierced due to excessive penetration.

6.1.6 *Surface defects.* The weld surfaces shall be free from cracks, porosity and cavities.

6.2 Destructive tests[4)]

6.2.1 *Test specimens.* The test pieces produced in accordance with this standard shall always be tested destructively.

The following test specimens are required.

Test 1	1	transverse tensile test specimen
	1	macrosection at the stop/start position
Tests 3, 4, 5 and 6	1	transverse tensile test specimen
	1	bend test specimen (side or root, depending on thickness)
	1	macrosection at the stop/start position
Tests 2 and 7	3	fillet weld fracture test specimens, with the end face at the stop/start position used for macro-examination
Tests 8, 9 and 10	1	transverse tensile test specimen
	2	root bend test specimens
Tests 11 and 12	4	macrosections (1 at each crotch and flank)

6.2.2 *Transverse tensile test.* This test is not used to determine the tensile strength of the joint, but only to make a qualitative assessment of the fracture surfaces.

For joints without backing welded from one side only, the specimen shall be taken from a location where there is full penetration. For other joints any backing material shall be removed prior to testing.

The shape and dimensions of the specimen shall be as shown in Figure 14, the width being as given in Table 13. The upper and lower surfaces of the weld shall be dressed flush with the original surface of the material.

Table 13 — Dimensions of transverse tensile test specimen

Thickness of material t		
Over	**Up to and including**	**Width of specimen** *(b)*
mm	mm	mm
—	3	12
3	10	20
10	20	25
20	30	40

The specimen shall be tested in tension until fracture occurs, after which the fracture surfaces shall be assessed in accordance with the requirements of **6.2.7**.

6.2.3 *Macro-examination.* The specimen shall be the full thickness of the material at the welded joint; the excess weld metal and penetration bead, or permanent backing when used, shall be left intact. The specimen shall contain a length of the joint of at least 10 mm and shall extend on each side of the weld for a distance that includes the heat-affected zone and some parent metal. For tests 2 and 7 the end face of the fillet weld fracture test specimen at the stop/start position shall be used for macro-examination before the specimen is fractured.

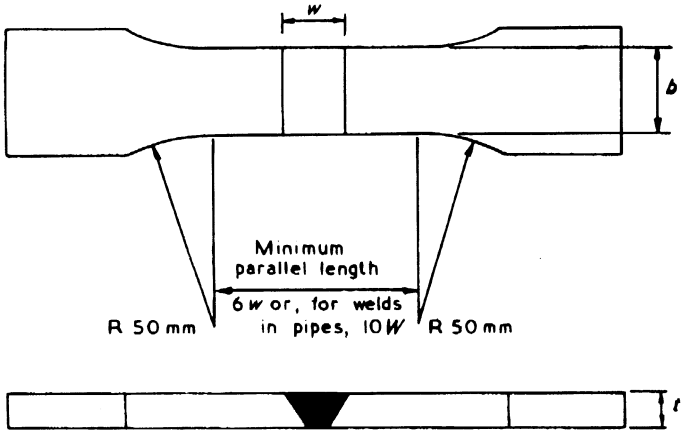

Figure 14 — Transverse tensile test specimen

[4)] For information on testing, see BS 3451.

The face of the specimen containing the weld cross section shall be prepared, polished and etched using an approved method and etching solution (see appendix A).

The etched face shall be examined visually, in conjunction with a hand lens of magnification not greater than 5 diameters if required.

6.2.4 *Side bend test (for plate at least 10 mm thick).* For joints without backing welded from one side only, the specimen shall be taken from a location where there is full penetration. For other joints any backing material shall be removed prior to testing.

The specimen shall be a parallel strip cut transversely to the weld containing a length of the joint of at least 10 mm. The width of the specimen shall be the full thickness of the material at the welded joint; the upper and lower surfaces of the weld shall be dressed flush with the original surface of the material. The edges of the specimen shall be rounded to a radius not exceeding 10 % of the specimen thickness.

The specimen shall be bent through 180° using only the controlled bend test type of apparatus over a former of a diameter appropriate for the material group (see Table 14) such that the cross section of the weld is in tension.

If the specimen bends through 180° without failure, slight opening-out at the corners or on the tension surface shall not be cause for rejection. If the specimen fails across the surface in tension, it shall be broken open and assessed in accordance with the requirements of **6.2.7**.

Table 14 — Bend test former diameter

Parent metal group number (see 4.2)	Former diameter
1	$3t$[a]
2	Not applicable
3	$6t$
4	$8t$
[a] t is the specimen thickness.	

6.2.5 *Root bend test (for plate less than 10 mm thick and for pipe butt weld).* For joints without backing welded from one side only, the specimen shall be taken from a location where there is full penetration. For other joints any backing material shall be removed prior to testing.

The specimen shall be a parallel strip cut transversely to the weld. For plate the specimen shall have a width of at least 30 mm and for pipe the specimen shall have a width of

$t + D/10$ for pipes up to and including 60.3 mm outside diameter;

$t + D/20$, with a maximum of 40 mm, for pipes over 60.3 mm outside diameter

where

t is the pipe thickness,

D is the outside diameter.

The specimen shall be the full thickness of the material at the welded joint; the upper and lower surfaces of the weld shall be dressed flush with the original surface of the material. The edges of the specimen shall be rounded to a radius not exceeding 10 % of the specimen thickness.

The specimen shall be bent through 180° using only the controlled bend test type of apparatus over a former of a diameter appropriate for the material group (see Table 14) such that the root of the weld is in tension.

If the specimen bends through 180° without failure, slight opening-out at the corners or on the tension surface shall not be cause for rejection. If the specimen fails across the surface in tension, it shall be broken open and assessed in accordance with the requirements of **6.2.7**.

6.2.6 *Fillet weld fracture test.* The test piece shall be cut to give at least three test specimens of equal length. Each specimen shall be fractured by bending or by blows applied in the direction indicated in Figure 2 or Figure 7. To ensure fracture in the weld a central saw cut approximately 2 mm deep shall be made along the length of the weld surface. The fracture surfaces shall be assessed in accordance with the requirements of **6.2.7**.

6.2.7 *Assessment of destructive tests.* The presence of any of the following defects as revealed by, and not due to, destructive testing shall be sufficient cause for rejection, unless it can be established that the defects are the result of metallurgical or extraneous causes and are not attributable to the welder's workmanship:

a) any type of crack;

b) any lack of fusion, except that in tests 11 and 12 slight lack of root fusion at the flank position shall not be cause for rejection;

c) on macro-examination, uniform or localized porosity, or tungsten or oxide inclusions greater than 3 mm diameter. For other tests, any oxide or tungsten inclusions or wormholes that in the plane of examination individually have a maximum dimension of more than 3 mm or collectively have a total dimension exceeding 25 % of the parent metal thickness;

d) copper inclusions.

6.3 Repeat tests. If the test piece fails to meet any of the requirements of **6.1** or **6.2.7**, two further test pieces shall be welded and subjected to the same tests. If either of these additional welds does not meet the required standard, the welder shall be regarded as not capable of meeting the requirements of this standard without further training.

7 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 under clause **3** shall be included together with details of any features that would be rejectable by the requirements of clause **6**. 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 weld shall be signed by the person conducting the test.

The welder's employer should hold and regularly maintain adequate records of all approval tests for each welder. A typical record sheet is shown in appendix B.

If an independent inspecting authority witnesses the welder approval tests carried out in accordance with this standard and if all the relevant provisions are fulfilled, it is recommended that such approval should be accepted by others.

8 Re-approval of welder

The re-approval of a welder shall be required if any of the following apply:

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

b) six months or more have elapsed since the welder undertook any welding of aluminium or aluminium alloys;

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

Appendix A Suggested method of preparing etched specimens

A.1 Preparation of surfaces for etching. The initial preparation of a cut surface may be by milling or turning. Alternatively, the surface should be filed with a coarse file until all deep marks are removed. It should then be filed at right angles to the original coarse file marks with a smooth file. The application of chalk to the teeth of the fine file will reduce the risk of surface scoring by metallic particles trapped on the teeth of the file.

The machined or smooth-filed surface is then abraded on successively finer grades of waterproof silicon carbide paper (see BS 872). A suitable sequence of grit sizes is 100, 240, 400 and 600. If the specimen is of suitable size to be conveniently handled, the most satisfactory procedure is to lay the appropriate sheet of abrasive paper, face up, on a flat surface such as plate glass, resin-impregnated paper laminate, etc. The abrasive paper is then lubricated either with water, industrial alcohol, or white spirit, and the specimen carefully rubbed on it, with the application of moderate pressure, until all traces of the surface scratching from the previous treatment are removed. The specimen is then washed to remove all traces of abrasive, and the procedure repeated with the next finer grade of abrasive paper, the direction of abrading in each case being at right angles to the marks made by the previous paper.

In cases where the specimen size is such that the above procedure is inconvenient, the abrading may be carried out by employing rotating abrasive disks in a suitable hand tool. This operation will of necessity be carried out dry, and successively finer grit sizes should be used, as in the wet method. Care should be taken to avoid exerting undue pressure on the surface, since this will cause metal to flow over and obscure any fine porosity that may be present.

A fine-machined surface, produced by sharp tools with adequate lubrication, is suitable for macro-etching without any further preparation, and the abrading of a filed surface need only be taken as far as 400 grade for a satisfactory etch to be obtained. Such machined surfaces are not, however, in the most suitable condition for the detection of fine porosity, for which purpose it is recommended that abrading down to 600 grade paper should be employed.

A.2 Etching for macro-examination. Suitable etchants for welds in pure aluminium and all wrought alloys are the following:

a) 45 % by volume of hydrochloric acid (d = 1.16)

15 % by volume of nitric acid (d = 1.42)

15 % by volume of hydrofluoric acid (40 % m/m HF)

25 % by volume of water;

b) sodium hydroxide (100 g/1) for 10 s to 20 s, less if warmed, followed by cleaning in nitric acid (d = 1.42).

NOTE Care should be exercised in handling these etchants. In particular hydrofluoric acid, even when very dilute, must not come into contact with fingernails.

Etching is carried out either by swabbing with cotton wool or by immersion. After this treatment wash the specimen in water, blot the surface with filter paper and dry in warm air.

Appendix B Typical welder approval test record

NOTE One sheet should be completed for each test.

Welder's name[a]	Welder's identity no.
Approval test no.	Date of test
Welding process	
Parent material	Welding consumables
Type	Filler material specification and diameter
Thickness	
	Shielding gas composition and flow rate
Pipe outside diameter or dimension	
	Type and diameter of tungsten electrode (where applicable)
Welding position	Pipe position
Type of joint and pre-weld cleaning with sketch of weld preparation	Weld dimensions required
	Other factors (welder's choice), e.g. current, voltage, wire-feed speed
Approval test results (state "Satisfactory", "Unsatisfactory" or "Not applicable")	
Visual examination	
Weld contour	
Undercut	
Stop/start	
Penetration (joints without permanent backing)	
Excessive penetration (joints with backing)	
Surface defects	
Assessment of destructive tests	
Cracks	
Lack of fusion	
Tungsten and oxide inclusions, porosity and wormholes	
Copper inclusions	
Result of test (passed or failed)	
Employer's certifying signature and status of signatory	Date
Inspecting authority's signature (when applicable)	Date
[a] Both names for double operator technique, for which approval applies only while the welders remain as a team.	

BSI publications referred to in this standard

This standard makes reference to the following British Standards:

BS 872, *Abrasive papers and cloths (technical products).*

BS 1470, *Wrought aluminium and aluminium alloys for general engineering purposes — plate, sheet end strip.*

BS 1471, *Wrought aluminium and aluminium alloys for general engineering purposes — drawn tube.*

BS 1472, *Wrought aluminium and aluminium alloys for general engineering purposes — forging stock and forgings.*

BS 1473, *Wrought aluminium and aluminium alloys for general engineering purposes — rivet, bolt and screw stock.*

BS 1474, *Wrought aluminium and aluminium alloys for general engineering purposes — bars, extruded round tubes and sections.*

BS 1475, *Wrought aluminium and aluminium alloys for general engineering purposes — wire.*

BS 3451, *Methods of testing fusion welds in aluminium and aluminium alloys.*

BS 4300, *Specification (supplementary series) for wrought aluminium and aluminium alloys for general engineering purposes.*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL