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APPROVAL TEST FOR WELDERS WHEN WELDING PROCEDURE APPROVAL IS NOT REQUIRED

PART I FUSION WELDING OF STEEL

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Indian Standard

APPROVAL TESTS FOR WELDERS WHEN WELDING PROCEDURE APPROVAL IS NOT REQUIRED

PART I FUSION WELDING OF STEEL

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Indian Standard

APPROVAL TESTS FOR WELDERS WHEN WELDING PROCEDURE APPROVAL IS NOT REQUIRED

PART I FUSION WELDING OF STEEL

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 15 March 1974, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard is the first of a series of Indian 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) welder approval when the welding procedure is not required to be approved (for either technical or contract reasons),

b) approval testing of welding procedures, and

c) welder approval when welding procedure approval is required.

The simple approval of welders on sheet, plate and pipe* when no welding procedure approval is required is covered by this standard and as such it supersedes IS : 1181-1967†. It is assumed, however, that persons being tested

0.3 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, so may the approval of welding procedures be administered in several ways, namely:

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

*In this standard the word 'pipe', alone or in combination, is used to mean 'pipe' or 'tube' or 'circular structural hollow section', although these terms are often used for different categories of product by different industries.

†Qualifying tests for metal-arc welders (engaged in welding structures other than pipes) (*first revision*).

‡Code of practice for training and testing of metal arc welders (*revised*).

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

c) each individual contractor (or sub-contractor) need not make procedure test pieces provided he can prove by authentic documentation of an independent nature that he has previously welded the type of joint and material in question giving satisfactory service behaviour; or

d) a contractor need not make procedure test pieces provided it is established that exactly similar joints have been welded in that country using the same materials and methods; or

e) provided it can be shown on an international basis, that a procedure has been proved by independent tests or service, experience, a contractor need not weld any test pieces to that particular procedure.

At the present time, it is considered that (a) and (b) above represent the most practical basis for procedure approval, bearing in mind that the tests, once certified, need never be repeated unless there is a change in certain variables.

0.4 In the preparation of this standard assistance has been derived from BS 4872: Part 1: 1972 'Specification for approval testing of welders when welding procedure approval is not required: Part 1 Fusion welding of steel' issued by British Standards Institution.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies requirements for the approval testing of welders to be engaged on the manual or semi-automatic fusion welding of those structural or austenitic steel fabrications for which the welding procedure does not itself 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, for example, with regard to material, thickness, joint configuration.

1.2 This standard is applicable to the following manual and semi-automatic welding processes:

a) Manual-metal-arc,

b) Inert-gas tungsten arc (TIG),

*Rules for rounding off numerical values (*revised*).

c) Gas-metal arc (MIG or CO_2),
d) Submerged-arc, and
e) Gas welding.

2. INFORMATION TO BE GIVEN TO THE WELDER

2.1 The welder shall be provided with written instructions and information on how to make his test welds. Details of the following shall be given:

a) Parent metal;
b) Welding process or combination of welding process and polarity;
c) Welding consumables (electrode or filler material specification, type of flux, shielding gas composition);
d) Welding position;
e) Metal thickness and, for pipe, the diameter;
f) Joint type; and
g) Weld dimensions required.

3. TEST WELDS*

3.1 General — The welder shall make the test weld, or welds, selected from the following 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 2 to make the test weld, or welds, on which he has already obtained approval no longer representative of the new work.

3.1.1 Tack welds shall be made from the side to be welded. No other method of restraint shall be used. Distortion or misalignment caused by tacking may be corrected before the test weld is made. The test piece shall be so positioned that the work bench or any other material does not act as backing.

3.1.2 Tack welds shall be rounded before depositing the test weld unless they conform to the same requirements as for final welds. The extremities of tack welds shall be dressed by grinding or chipping to facilitate proper fusion when they are incorporated in the final weld.

3.2 Test 1 — Butt Weld in Sheet

3.2.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as follows provided that the test conditions listed have been met.

*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.

	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 **2**	Only material, welding process and welding consumables of types used for the test except that approval using a basic coated electrode includes approval for a rutile covered electrode
Welding position*	Flat (F)	Flat (F)
	Vertical-up (V)	Flat and vertical-up (F and V)
	Vertical-up and horizontal-vertical (V and H) (2 test welds)	Flat, horizontal-vertical and vertical-up (F, H and V)
	Vertical-up and overhead (V and O) (2 test welds) (F, H, V and O)	Flat, horizontal-vertical, vertical-up and overhead (F, H, V and O)
	Vertical-down (D)	Vertical-down (D)
Thickness, t	3 mm *Max*	0·75 t to 1·5 t
Joint type	Square butt as in Fig. 1	Any butt weld in sheet in above thickness range

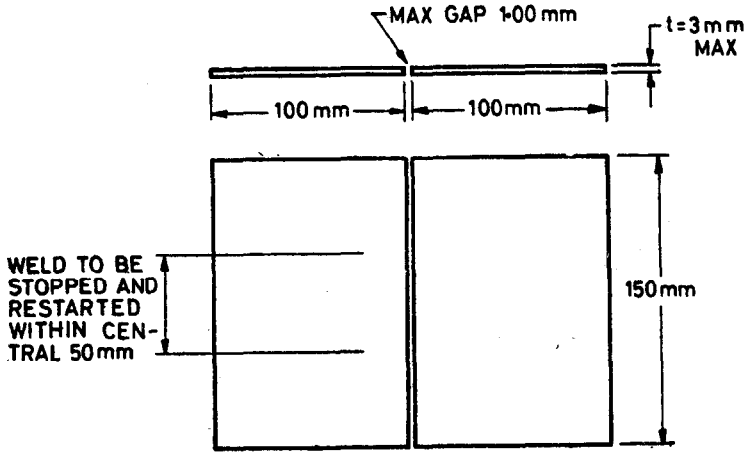


FIG. 1 TEST PIECE FOR BUTT WELD IN SHEET

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

3.2.2 *Deposition of Test Weld* — The test weld shall be stopped and restarted within the central 50 mm of its length. In the case of manual metal-arc welding the restart shall be made with a fresh electrode.

A sealing run on the reverse side is not permitted.

3.3 Test 2 — Butt Weld in Plate (Without Backing, Welded from One Side)

3.3.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as given below provided that the test conditions listed have been met.

	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 **2**	Only material, welding process and welding consumables of types used for the test
Welding position*	F	F
	V†	F and V
	V and H (2 test welds)	F, H and V
	V and O (2 test welds)	F, H, V and O
	D	D
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	Single-V butt as in Fig. 2‡	For pipe in above thickness and diameter ranges: a) Any butt weld in pipe with or without backing b) Any branch joint with a hole in the main pipe

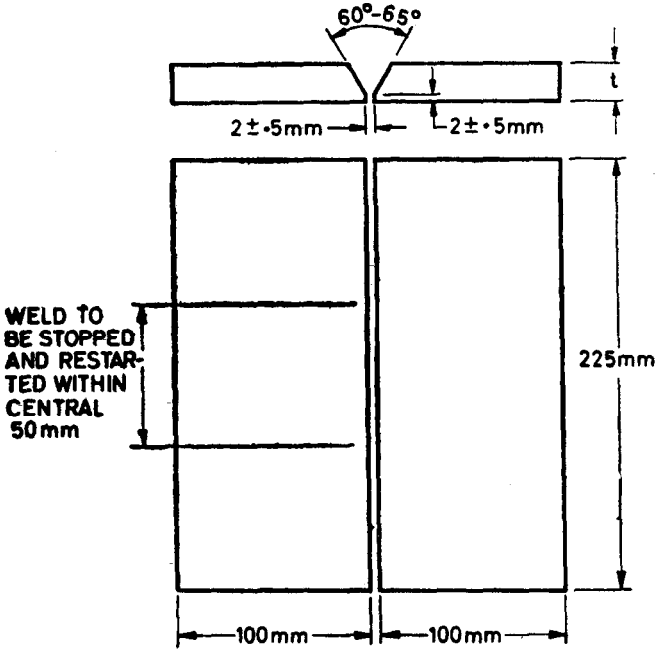
*If a combination of test positions other than those specified is used, the welder is approved only for that combination.

†For MIG welding the root run may be deposited in the vertical-down position.

‡The dimensions of the weld preparations are typical for manual metal-arc welding in the flat position but for other processes or positions it may be necessary for modifications to be made. In all cases the details shall be recorded (*see* **2** and Appendix B).

3.3.2 *Deposition of Test Weld* — Each run of the test weld shall be stopped and restarted within the central 50 mm of its length. In the case of manual metal-arc welding the restarts shall be made with fresh electrodes.

A sealing run on the reverse side is not permitted.



NOTE — *See* **3.3.1** for plate thickness '*t*'.

FIG. 2 TEST PIECE FOR BUTT WELD IN PLATE (WITHOUT BACKING, WELDED FROM ONE SIDE)

3.4 Test 3 — Butt Weld in Plate (Welded from Both Sides)

3.4.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as follows provided that the test conditions listed have been met.

	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 2			Only material, welding process and welding consumables of types used for the test, except that approval using a basic covered electrode includes approval for a rutile covered electrode
Welding position*	First side	Second side		
	F	O		F, O and H
	V†	V†		V and F
	V†	V†	2 test welds	V, H and F
	H	H		
	V†	V†		V, O, F and H
	O	F		
	D	D		D
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	Double-V butt as in Fig. 3‡			For plate in above thickness ranges: a) Any double side butt weld preparation b) Any single sided butt weld preparation welded from both sides with back gouging

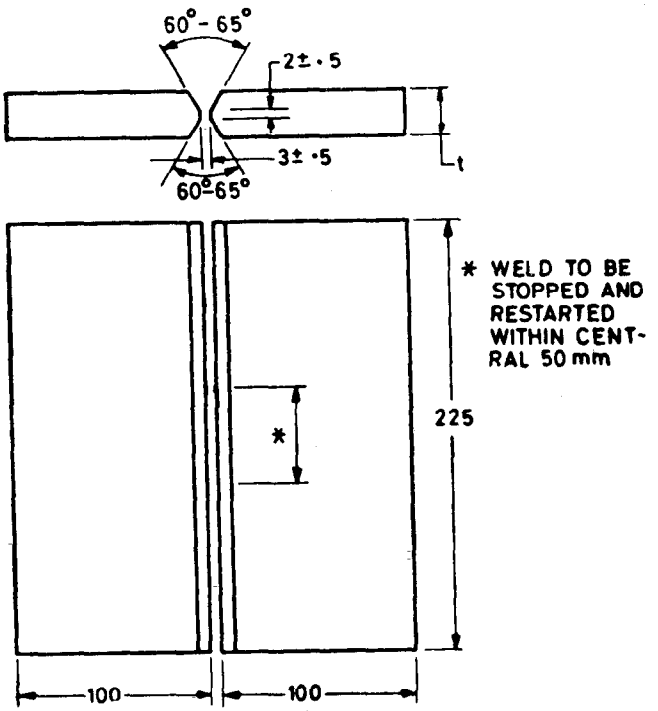
*If a combination of test positions other than those specified is used, the welder is approved only for that combination.

†For MIG welding the root run may be deposited in the vertical-down position.

‡The dimensions of the weld preparation are typical for manual metal-arc welding in the flat and overhead positions, but for other processes or positions it may be necessary for modifications to be made. In all cases the details shall be recorded (*see* 2 and Appendix B).

3.4.2 *Deposition of Test Weld* — Each run of the test weld shall be stopped and restarted within the central 50 mm of its length. In the case of manual metal-arc welding the restarts shall be made with fresh electrodes.

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.



NOTE — *See* **3.4.1** for plate thickness '*t*'.

All dimensions in millimetres.

FIG. 3 TEST PIECE FOR BUTT WELD IN PLATE (WELDED FROM BOTH SIDES)

3.5 Test 4 — Butt Weld in Plate (with Backing)

3.5.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as follows provided that the test conditions listed have been met.

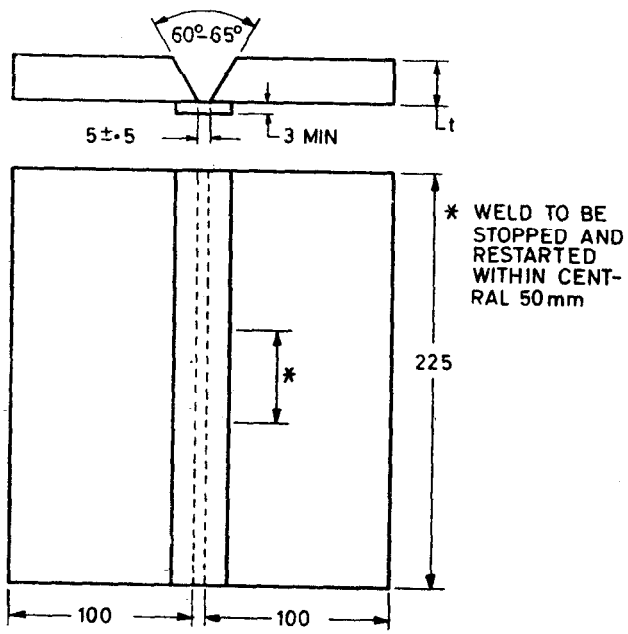
	Test Conditions	*Applicability of Test*
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with 2	Only material, welding process and welding consumables of types used for the test, except that approval using a basic covered electrode includes approval for a rutile covered electrode
Welding position*	F	F
	V†	V and F
	V† and H (2 test welds)	V, H and F
	V† and O (2 test welds)	V, O, H and F
	D	D
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	Single-V butt, with backing, as in Fig. 4‡	Any single sided butt weld preparation with backing in plate in above thickness ranges

3.5.2 *Deposition of Test Weld* — Each run of the test weld shall be stopped and restarted within the central 50 mm of its length. In the case of manual metal-arc welding the restarts shall be made with fresh electrodes.

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

†For MIG welding the root run may be deposited in the vertical-down position.

‡The dimensions of the weld preparation are typical for manual metal-arc welding in the flat position but for other processes or positions it may be necessary for modifications to be made. In all cases the details shall be recorded (*see* 2 and Appendix B).



NOTE — *See* **3.5.1** for plate thickness '*t*'.

All dimensions in millimetres.

FIG. 4 TEST PIECE FOR BUTT WELD IN PLATE (WITH BACKING)

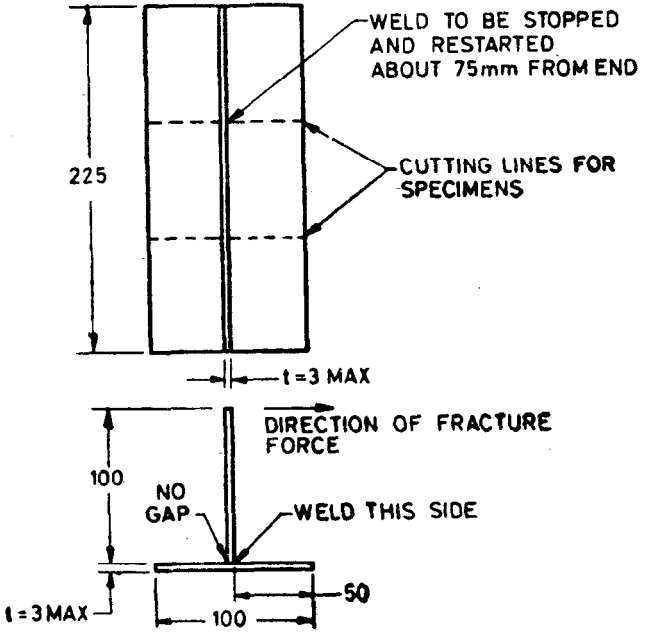
3.6 Test 5 — Fillet Weld in Sheet

3.6.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as given below provided that the test conditions listed have been met.

	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 2	Only material, welding process and welding consumables of types used for the test except that approval using a basic covered electrode includes approval for a rutile covered electrode
Welding position*	H	F and V
	V	F, H and V
	O	F, H and O
	V and O (2 test welds)	F, H, V and O
	D	D
Thickness, t	3 mm, *Max*	0·75 t to 1·5 t
Joint type	*T* fillet as in Fig. 5	Any fillet weld in sheet in above thickness range

3.6.2 *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 about 4 mm. The weld shall be stopped and restarted at about 75 mm from one end. In the case of manual metal-arc welding the restart shall be made with a fresh electrode.

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



All dimensions in millimetres.

FIG. 5 TEST PIECE FOR FILLET WELD IN SHEET

3.7 Test 4 — Fillet Weld in Plate

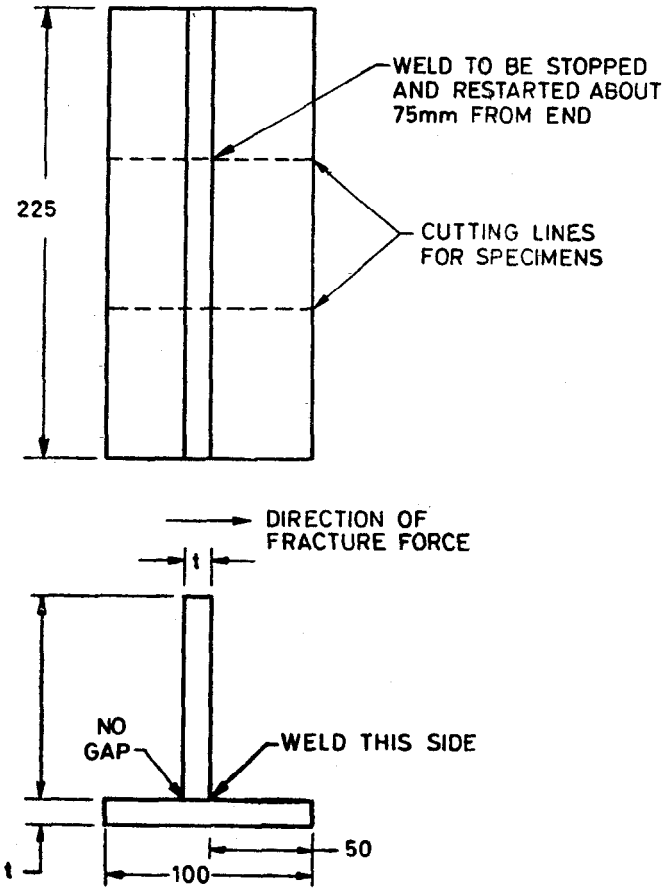
3.7.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as given below provided that the test conditions listed have been met.

	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 2	Only material, welding process and welding consumables of types used for the test except that approval using a basic covered electrode includes approval for a rutile covered electrode
Welding position*	H	F and H
	V†	F, H and V
	O	F, H and O
	V† and O (2 test welds)	F, H, V and O
	D	D
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 as in Fig. 6	Any fillet weld in plate in above thickness ranges

3.7.2 *Deposition of Test Weld* — The test weld shall be made with at least three runs on only one side of the joint, with equal final leg lengths corresponding to about the thickness t. Each run shall be stopped and restarted at about 75 mm from one and the same end. In the case of manual metal-arc welding the restarts shall be made with fresh electrodes.

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

†For MIG welding the root run may be deposited in the vertical-down position.



NOTE — *See* **3.7.1** for plate thickness '*t*'.

All dimensions in millimetres.

FIG. 6 TEST PIECE FOR FILLET WELD IN PLATE

3.8 Test 7 — Butt Weld in Pipe (Without Backing)

3.8.1 *Applicability of Test and Test Conditions* — The applicability of this test shall be as given below provided that the test conditions listed have been met.

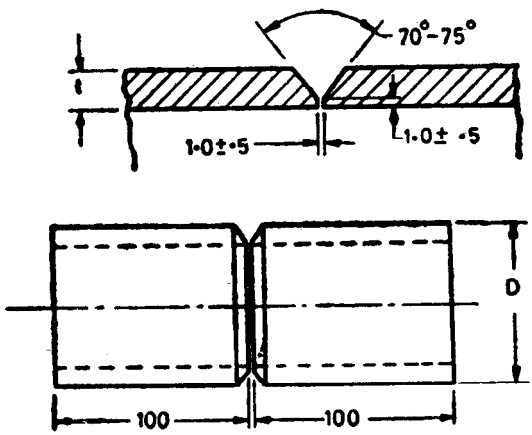
		Test Conditions		*Applicability of Test*
Parent metal, welding process and welding consumables		As to be used for work on which welder will be employed and to be specified in accordance with **2**		Only material, welding process and welding consumables of types used for the test except that approval using a basic covered electrode includes approval for a rutile covered electrode
Position*	Pipe positions	Axis horizontal-pipe rotating	Welding positions	F
		Axis horizontal-pipe fixed (vertical-up†)		F, V and O
		Axis horizontal-pipe fixed (vertical-down)		F, V and O
		Axis vertical		F and H
		Axis inclined at 45°-pipe fixed (vertical-up†) or Axis horizontal-pipe fixed (vertical-up†) and axis vertical (2 test welds)		F, H, V and O
Thickness, *t*		Less than 20 mm		0·75 *t* to 1·5 *t*
		20 mm or thicker		15 mm and thicker
Diameter, *D*		Less than 165 mm‡		0·50 to 1·5 *D*
		165 mm or larger		80 mm and larger
Joint type		Single - V butt as in Fig. 7§		For pipe in above thickness and diameter ranges: a) Any butt weld in pipe with or without backing b) Any branch joint with a hole in the main pipe

*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.

†For MIG welding, the root run in a multi-run weld or a single run weld for '*t*' thin pipe may be deposited in the vertical-down position. In the case of the single run weld approval would then be for the vertical-down position.

‡For MIG welding the test pipe diameter shall be at least 100 mm.

§The dimensions of the weld preparation are typical for manual metal-arc welding, but for other process it may be necessary for modifications to be made. In all cases the details shall be recorded (*see* **2** and Appendix B).



NOTE — *See* **3.3.1** for dimensions '*t*' and '*D*'.

All dimensions in millimetres.

FIG. 7 TEST PIECE FOR BUTT WELD IN PIPE (WITHOUT BACKING)

3.9 Test 8 — Butt Weld in Pipe (with Backing)

3.9.1 *Applicability of Test Conditions* — The applicability of this test shall be as follows provided that the test conditions listed have been met.

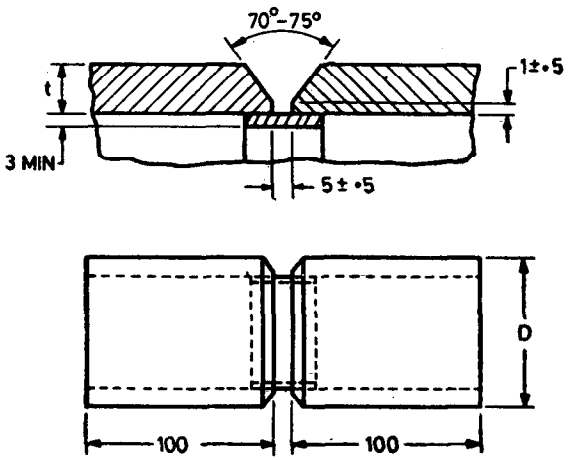
	Test Conditions	*Applicability Test*
Parent metal, welding process and welding consumables	As to be used for work on which welder will be employed and to be specified in accordance with **2**	Only material, welding process and welding consumable of types used for the test, except that approval using a basic covered electrode includes approval for a rutile covered electrode
Position*	Axis horizontal-pipe rotating	F
	Axis horizontal-pipe fixed (vertical-up†)	O, V and F
	Axis horizontal-pipe fixed (vertical-down)	F, D and O
	Axis vertical	H and F
	Axis inclined at 45°-pipe fixed (vertical-up†) or Axis horizontal-pipe fixed (vertical-up†) and axis vertical (2 tests welds)	O, V, H and F
Thickness, t	Less than 20 mm	0·75 t to 1·5 t
	20 mm or thicker	15 mm and thicker
Outside diameter or dimension, D (for rectangular hollow sections D is dimension of smaller side)	Less than 165 mm‡	0·5 D to 1·5 D
	165 mm or larger	80 mm and larger
Joint type	Single-V butt with backing, as in Fig. 8§	Any butt weld in pipe with backing in above thickness and diameter ranges

*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.

†For MIG welding, the root run in a multi-run weld or a single run weld for thin pipe may be deposited in the vertical-down position. In the case of the single run weld approval would then be for the vertical-down position.

‡For MIG welding the test pipe diameter shall be at least 100 mm.

§The dimensions of the weld preparation are typical for manual metal-arc welding but for other processes it may be necessary for modifications to be made. In all cases the details shall be recorded (*see* **2** and Appendix B).



NOTE — *See* **3.9.1** for dimensions '*t*' and '*D*'.

All dimensions in millimetres.

FIG. 8 TEST PIECE FOR BUTT WELD IN PIPE (WITH BACKING)

3.10 Test 9 — Fillet Weld (Branch Joint) in Pipe

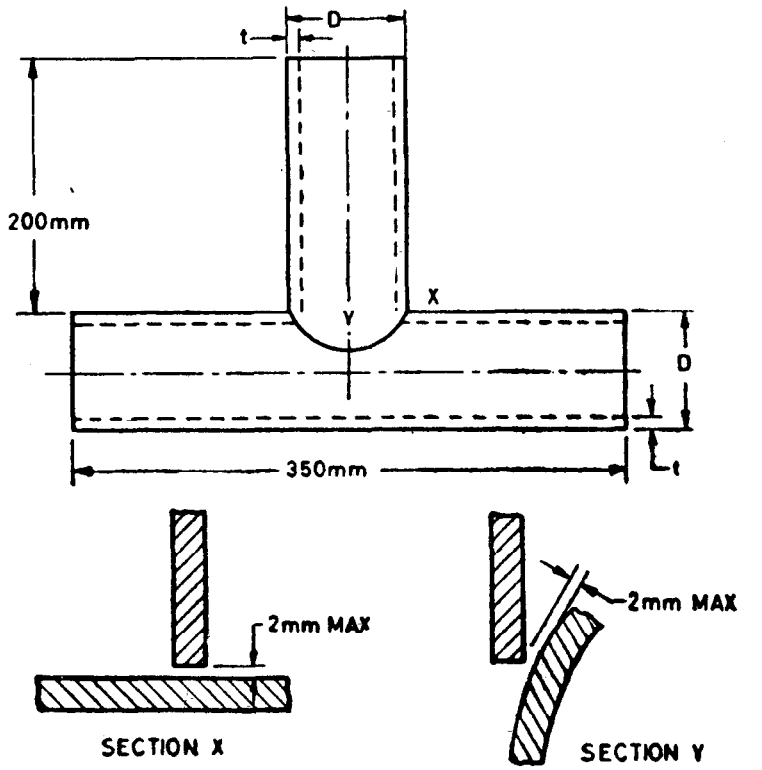
3.10.1 *Applicability of Test and Test Conditions*— The applicability of this test shall be as given below provided that the test conditions listed have been met.

		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 2		Only material, welding process and welding consumables of types used for the test, except that approval using a basic covered electrode includes approval for a rutile covered electrode
Position*	Pipe positions	Axis of main and branch horizontal-fixed during welding but branch turned through 180° (vertical-up†) (*see* Fig. 9B		F, H and V
		Axis of main horizontal, axis of branch vertical-fixed	Welding positions	F, H and O
		Axis of main and branch horizontal-fixed (vertical-up†)		F, H, V and O
		Axis of main and branch horizontal-fixed (vertical-down)		F, H, V and O
Thickness, *t*		Less than 20 mm		0·75 *t* to 1·5 *t*
		20 mm or thicker		15 mm and thicker
Diameter, *D*		Less than 165 mm‡		0·5 *D* to 1·5 *D*
		165 mm or larger		80 mm and larger
Joint type		Right angle branch as Fig. 9(A)		Any fillet weld in pipe in above thickness and diameter ranges

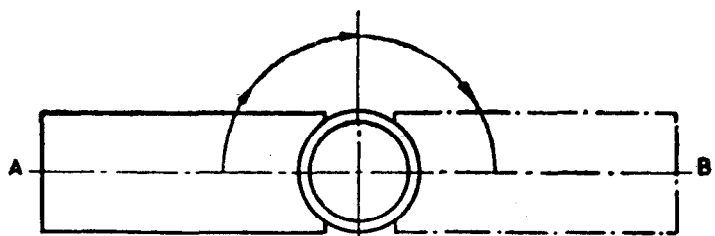
*If a combination of test pipe positions other than those specified is used, the welder is approved for the welding positions derived only from that combination.

†For MIG welding, the root run in a multi-run weld or a single run weld for thin pipe may be deposited in the vertical-down position. In the case of the single run weld approval would then be for the vertical-down position.

‡For MIG welding the test pipe diameter shall be at least 100 mm.



(A) JOINT CONFIGURATION



(B) MAIN AND BRANCH HORIZONTAL, BRANCH TURNED THROUGH 180°.

NOTE — *See* **3.10.1** for dimensions of '*t*' and '*D*'.

FIG. 9 TEST PIECE FOR FILLET WELD (BRANCH JOINT) IN PIPE

3.10.2 *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 about the thickness t or 4 mm whichever is the greater.

4. SUBMISSION OF TEST WELD

4.1 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.

5. EXAMINATION AND TESTING

5.1 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 bearing in mind whether full or toe grinding is to be applied to the production work on which the welder will be engaged.

5.1.1 *Weld Contour*

a) The weld metal shall be properly fused with the parent metal. The weld toes shall blend smoothly with the parent metal.

b) 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.

c) Butt welds shall show uniform external reinforcement weld metal not exceeding 10 percent of the parent metal thickness.

5.1.2 *Undercut* — Any intermittent undercut shall not exceed 10 percent of the material thickness of 1 mm whichever is the smaller.

5.1.3 *Smoothness of Joints Where Welding is Restarted* — The stop/start position of each run shall merge smoothly and shall show no pronounced hump or crater in the weld surface.

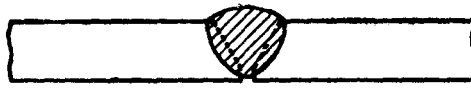
5.1.4 *Penetration in Butt Joints (Without Backing, Welded from One Side only)* (*see* Fig. 10)

a) There shall be penetration into the root face but intermittent lack of penetration to the full depth of the root face is not cause for rejection, provided that it does not extend for a total length of more than 25 percent of the joint length.

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

5.1.5 *Surface Defects* — The weld surfaces shall be free from cracks, porosity, cavities and trapped slag.

(a) ACCEPTABLE



(b) ACCEPTABLE PROVIDED THAT THE TOTAL LENGTH OF INCOMPLETE PENETRATION DOES NOT EXCEED 25 % OF JOINT LENGTH

(c) UNACCEPTABLE IRRESPECTIVE OF LENGTH OF INCOMPLETE PENETRATION BECAUSE OF NO PENETRATION INTO ROOT FACES

(d) UNACCEPTABLE IF PROTRUSION EXCEEDS 3mm

FIG. 10 EXAMPLES OF ACCEPTABLE AND UNACCEPTABLE PENETRATION

5.2 Destructive Tests

5.2.1 *Test Specimens* — The test pieces produced in accordance with this standard shall always be tested destructively.

The following test specimens are required:

Test 1 — One macro-section at the stop/start position
Test 2 — One bend test specimen (root or side depending on thickness)
Tests 3 and 4 — One macro-section at the stop/start position
Tests 5 and 6 — Three fillet weld fracture test specimens, with the end face at the stop/start position used for macro-examination
Tests 7 and 8 — Two root bend test specimens
Test 9 — Four macro-sections (One at each crotch and flank)

5.2.2 *Macro-examination* — The specimen shall be the full thickness of the material at the welded joint and the excess weld metal and penetration

bead 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 3 and 4 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.

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 if required. The macro-section shall show good penetration and freedom from significant defects.

5.2.3 *Root Bend Test (for Plate less than 10 mm Thick and for Pipe Butt Weld)* — The specimen shall be a parallel strip cut transversely to the weld, its width being at least 30 mm. The specimen shall be the full thickness of the material at the welded joint and 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 percent of the specimen thickness.

The specimen shall be bent through at least 90° over a former of a diameter equal to about four times the specimen thickness such that the root of the weld is in tension.

If the specimen bends through 90° without failure, slight opening-out (1·6 mm, *Max*) 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 **5.2.6**.

5.2.4 *Side Bend Test (for Plate at least 10 mm Thick)* — 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 and 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 percent of the specimen thickness.

The specimen shall be bent through at least 90° over a former of a diameter equal to about four times the specimen thickness such that the cross section of the weld is in tension.

If the specimen bends through 90° without failure, slight opening-out (1·6 mm, *Max*) 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 **5.2.6**.

5.2.5 *Fillet Weld Fracture Test* — The test piece shall be cut to give three test specimens of equal length. To ensure fracture in the weld a central saw cut 2 mm deep shall be made along the length of the weld surface.

The specimens shall be fractured by bending or by blows applied in the direction indicated in Fig. 5 and 6.

5.2.6 *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 Test 6 slight lack of root fusion at the flank position shall not be cause for rejection.
c) Slag inclusions and wormholes exceeding 10 mm in length or 3 mm in width. The total length of such defects shall not exceed the thickness of the parent metal except when the distance between imperfections exceeds 6 times the length of the longest single defect in the group.
d) Copper inclusions.
e) Stop/start or general porosity attributable to welder manipulation.

5.3 Repeat Tests — If the test piece fails to meet any of the requirements of **5.1** or **5.2.6**, 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.

6. STATEMENT OF RESULTS

6.1 A statement of the results of assessing each test piece, including repeat tests, shall be made for each welder. The items required under **2** shall be included together with details of any features that would be rejectable by the requirements of **5.** 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.

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

7. RE-APPROVAL OF WELDER

7.1 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 process.
c) There is some specific reason to question the welder's ability.

APPENDIX A

(*Clause* 5.2.2)

SUGGESTED METHOD OF PREPARING ETCHED SPECIMENS

A-0. GENERAL

A-0.1 The following method of preparing etched specimens is suggested for convenience and is in no way intended to be a rigid requirement of this standard.

A-1. PREPARATION OF SURFACE FOR ETCHING

A-1.1 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 smooth filed surface should be polished down with successively finer grades of waterproof silicon carbide paper, for example, 280, 320, 400, 500, the direction of polishing being at right angles to the marks made by the previous paper in each case, polishing being continued until the scratches of the previous paper have been removed before proceeding to the next finer grade. This procedure is indicated in order to show the means by which a first-class finish may be obtained.

A-2. ETCHING FOR MACRO-EXAMINATION

A-2.1 In general for steel a 400-grade finish will be smooth enough for a satisfactory etch to be obtained for macro-examination. Suitable etching solutions are as follows:

a) *For Ferritic Steels:*

10 to 15 ml nitric acid (70 percent m/m) (16N)
85 to 90 ml alcohol (industrial spirit)

NOTE — Great care should be exercised in the preparation of this solution as the mixing of concentrated nitric acid and alcohol can be extremely dangerous. The acid should be added slowly to the alcohol and the mixture should be constantly stirred. The solution should be stored in a stoppered container to avoid concentration by evaporation.

b) *For Austenitic Steels:*

40 ml hydrochloric acid (36 percent m/m) (11N)
30 ml nitric acid (70 percent m/m) (16N)
30 ml water

APPENDIX B

(*Clause* 6.2)

TYPICAL WELDER APPROVAL TEST RECORD

NOTE — One sheet should be completed for each test.

Welder's Name.....	Welder's Identity Card No.....
Approval Test No.....	Date of Test.....
Welding process and polarity	
Parent material:	Welding consumables:
Type.....	Electrode or filler material specification.....
Thicknes.....	Type of flux or electrode covering .....
Diameter (pipe)	Shielding gas composition.....
Welding position.....	Pipe position .....
Type of joint.....	Weld dimensions required.....

APPROVAL TEST RESULTS

(State: Satisfactory, Unsatisfactory or Not Applicable)

Visual Examination:
Weld contour
Undercut
Stop/Start
Penetration
Surface defects

Assessment of Destructive Tests:
Cracks
Lack of fusion
Slag inclusions and wormholes
Copper and tungsten inclusions
Stop/Start porosity

Result of test (passed or failed)	
Employer's certifying signature	Date

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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