IS 7310-1 (1974): Approval Tests for Welders Working to Approved Welding Procedures, Part I: Fusion Welding of Steel [MTD 11: Welding General]

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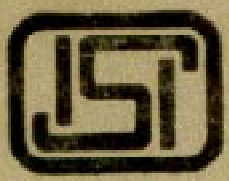
(Reaffirmed 2006)

Indian Standard

APPROVAL TESTS FOR WELDERS WORKING TO APPROVED WELDING PROCEDURES

PART I FUSION WELDING OF STEEL

UDC 621·791·65 : 658·386



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APPROVAL TESTS FOR WELDERS WORKING TO APPROVED WELDING PROCEDURES

PART I FUSION WELDING OF STEEL

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Indian Standard

APPROVAL TESTS FOR WELDERS WORKING TO APPROVED WELDING PROCEDURES

PART I FUSION WELDING OF STEEL

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 29 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 one 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) approval testing of welding procedures,

b) welder approval when welding procedure approval is required, and

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

0.3 For the purpose of this standard, a welder working to an approved procedure or a procedure being approved is considered to be sufficiently experienced in the appropriate welding process and hence already capable of passing training tests such as those contained in IS : 817-1966*.

0.4 To indicate the philosophy behind this series of standards, it is considered useful to give details of the practices relating to welding procedure approval. Depending upon the emphasis placed on quality control in the production of welded components, so may the approval of welding procedures 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:

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

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

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

c) Each individual contractor (or sub-contractor) need not make procedure test pieces provided 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 (a) and (b) it should be appreciated that once the welding procedure tests have been approved, they need never be repeated unless there is a change in certain variables. As an extension beyond (c), it may be possible in the future for fully documented welding procedures, developed independently of the particular contractor, to be employed without the need for further approval tests.

0.5 In preparing this standard the practices being followed in the country in this field have been kept in view. Assistance has also been derived from draft British Standard Specification for approval testing of welders working to approved welding procedures, Part 1: Fusion Welding of Steel, (Doc: 73/41348DC) issued by the British Standards Institution.

0.6 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 (Part I) specifies requirements for the approval testing of welders to be engaged on the manual, semi-automatic or automatic fusion welding of structural steel or austenitic stainless steel fabrications, except castings, for which an approved welding procedure is required.

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

a) Manual metal-arc,

b) Inert-gas tungsten arc (TIG),

c) Gas metal arc (MIG or CO_2),

d) Submerged-arc,

e) Electro-slag, and

f) Gas welding.

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

1.3 Where the approval of a welder and a welding procedure are to be covered in one test, the provisions contained in IS : 7307 (Part I)-1974* shall apply.

2. DEFINITIONS

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Welding Procedure† — A specified course of action followed in welding including a list of materials and, where necessary, tools to be used.

2.2 Welding Procedure Test — The making and testing of a welded joint representative of that to be used in production in order to prove the feasibility of a welding procedure.

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

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

2.4 Test Piece† — Components welded together in accordance with a specified welding procedure, or a portion of a welded joint detached from a structure, for test.

2.5 Test Specimen† — A portion detached from a test piece and prepared as required for testing.

3. INFORMATION TO BE GIVEN TO THE WELDER

3.1 The welder shall be provided with full written details according to **3** of IS : 7307 (Part I)-1974* of the approved welding procedure which he shall follow in making his test weld (*see* also **7**).

4. ITEMS TO BE RECORDED

4.1 The items according to **3** of IS : 7307 (Part I)-1974* shall be recorded for each welder approval test.

5. EXTENT OF APPROVAL

5.1 General — The extent of approval for a welder shall be the same as that for the approved welding procedure. When a change in the welding

*Approval tests for welding procedures: Part I Fusion welding of steel.

†This definition has been extracted from IS : 812-1957 'Glossary of terms relating to welding and cutting of metals'.

procedure according to **4** of IS : 7307 (Part I)-1974* requires a new welding procedure test, this shall entail re-approval of the welder except in the following cases:

a) A change in parent metal within the following group of steels:

Carbon steels and low alloy steels with less than 6 percent total alloy content.

b) A change in deposited metal composition for welding any of the steels within the group given in (a) above.

c) A change from a basic to a rutile covered electrode.

d) A reduction in preheating temperature.

e) A change in post-weld heat treatment.

5.2 Position — The approval of a welder on a test joint welded in one of the fundamental welding positions shall give approval for welding in the following positions:

a) A test in the flat position gives approval only for that position;

b) A test in the horizontal-vertical position includes approval for the horizontal-vertical and flat positions;

c) A test in the overhead position includes approval for the overhead, horizontal-vertical and flat positions;

d) A test in the vertical-up position includes approval for the vertical-up and flat positions; and

e) A test in vertical-down position gives approval only for that position.

In addition, the approval of a welder on a test joint inclined at 45° to the horizontal involving the overhead position, shall include approval for all welding positions.

5.3 Thickness — For gas welding, the approval of a welder on material of thickness t shall include approval for thicknesses in the range 0·5 t to 1 t.

For processes other than gas welding, the approval of a welder on material of thickness t shall include approval for thicknesses in the range 0·75 t to 1·5 t.

5.4 Pipe Outside Diameter or Dimension — The approval of a welder on pipe† of outside diameter or dimension D shall include approval for diameters or dimensions in the range 0·5 D to 1·5 D. For rectangular hollow sections D shall be the dimension of the smaller side.

*Approval tests for welding procedures: Part I Fusion welding of steel.

†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.

6. TEST PIECES

6.1 The welder shall make a test piece or pieces representative of each type of joint to which the welding procedure will relate in production preferably selected from the following:

a) A butt joint (plate or pipe) (*see* Fig. 1 or 2);

b) A fillet weld (plate) (*see* Fig. 3); and

c) A branch connection (pipes*) forming the minimum angle θ likely to be involved in production (*see* Fig. 4).

The test weld shall be stopped and restarted within the central 50 mm of the length of the test piece shown in Fig. 1 and at about 75 mm from one end of the test piece shown in Fig. 3. In the case of manual metal-arc welding the restart shall be made with a fresh electrode. Edge preparation and fit-up shall be as given in welding procedure (*see* **5.1**).

6.2 If the production joint design or application is such that none of the above types of test piece could be regarded as representative, for example, surfacing or attachment welds to thin pipes, then the welder shall make a special test piece which simulates the production joint in all essential features, such as dimensions, restraint, access, heat sink effects and any special surface protection.

6.3 Tack welds shall be made from the side to be welded and their location shall be identifiable after the test weld has been completed. Subsurface defects that break the surface or which are revealed as the result of any grinding specified in the welding procedure shall not be repaired and there shall be no other repair welding of a completed test piece.

7. SUBMISSION OF TEST WELD

7.1 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 withhold 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.

8. EXAMINATION AND TESTING

8.1 General — Test welds for welder approval shall be:

a) examined by non-destructive testing and assessed in accordance with **8.2.2**, supplemented by:

1) macro-examination if necessary to assist in the interpretation of the results of non-destructive testing; and

*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.

2) when radiography is used, the bend tests given in Table 1 to detect any lack of side fusion that could occur when the dip transfer technique, TIG welding or gas welding has been used; or

b) tested using the test specimens given in Table 1 when the test piece material is to the same specification as that to be used in production or when the use of non-destructive testing is not feasible.

8.1.1 When both non-destructive and destructive testing are to be applied, the same test piece(s) for the welder approval test shall satisfy the requirements for both methods of testing.

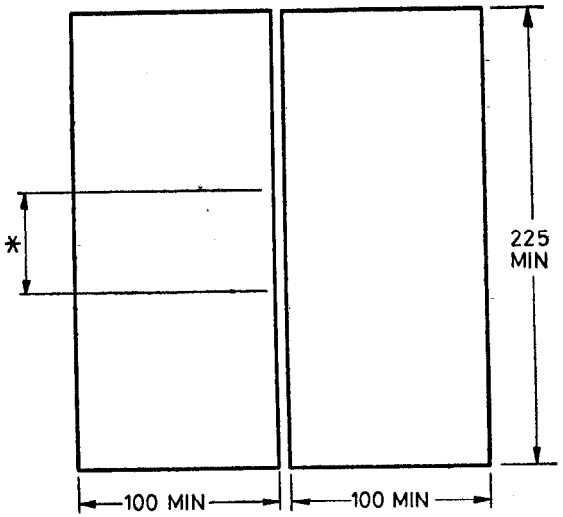
8.1.2 Unless otherwise specified, the first and last 25 mm of the length of a butt joint in plate shall be ignored in both non-destructive and destructive testing.

8.1.3 If the test piece fails to satisfy any of the requirements for non-destructive testing given in **8.2.2**, one further test piece shall be welded and subjected to the same examination. If this additional test piece does not meet the required standard, 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 not be regarded as capable of meeting the requirements of this standard without further training.

8.1.4 If any test specimen fails to satisfy the relevant requirements given in **8.3.3**, two further test specimens for each one that failed shall be obtained, either from the same test piece if there is sufficient material available or from a new test piece, and subjected to the same test. If either of these additional test specimens does not meet the required standard, 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 not be regarded as capable of meeting the requirements of this standard without further training.

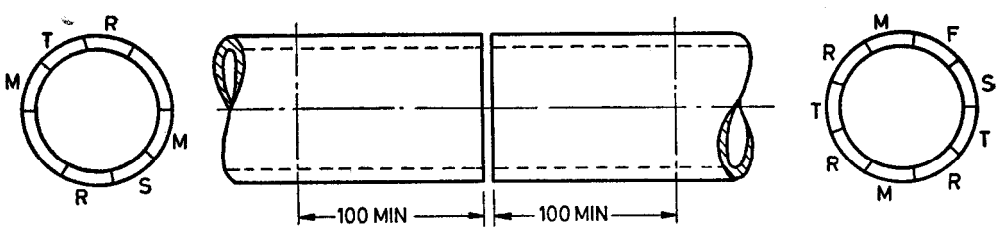
8.2 Non-destructive Testing

8.2.1 *Examination* — After any post-weld heat treatment and prior to the cutting of any test specimens, all test pieces shall be examined visually.



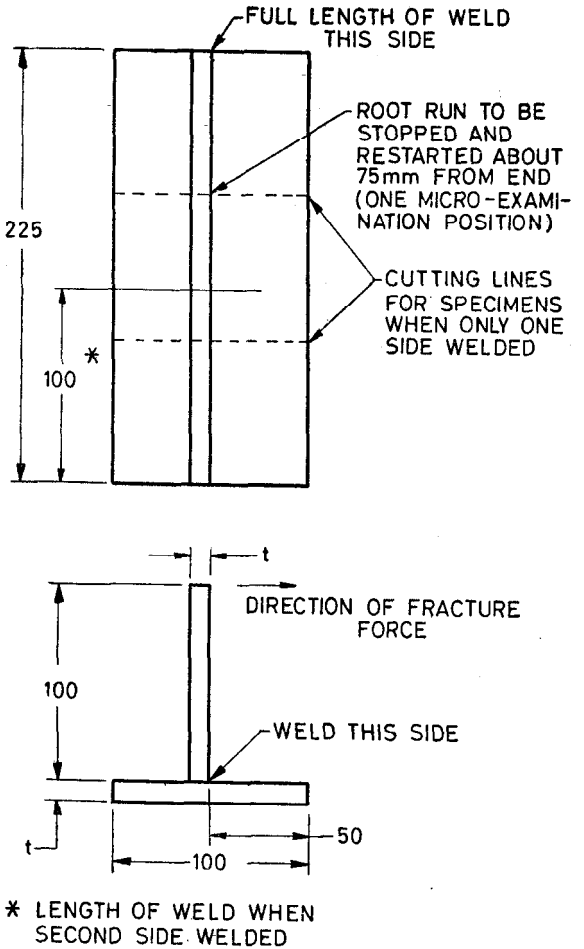
All dimensions in millimetres.

FIG. 1 TEST PIECE FOR BUTT WELD IN PLATE



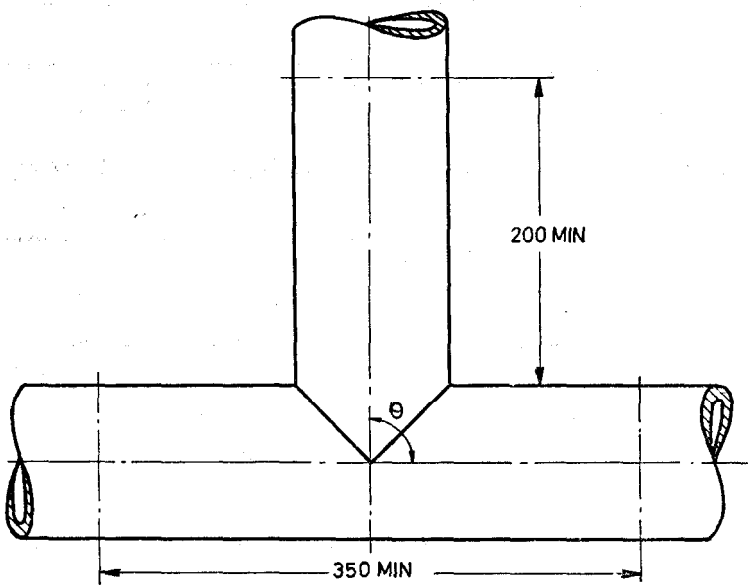
All dimensions in millimetres.

FIG. 2 TEST PIECE AND LOCATION OF TEST SPECIMENS FOR BUTT WELD IN PIPE



All dimensions in millimetres.

FIG. 3 TEST PIECE FOR FILLET WELD IN PLATE



All dimensions in millimetres.

FIG. 4 TEST PIECE FOR BRANCH CONNECTION IN PIPE

When non-destructive testing is to be used, visual examination shall be followed by:

a) magnetic particle (*see* IS : 5334-1969*) or penetrant testing (*see* IS : 3658-1966†); and/or

b) ultrasonic (*see* IS : 4260-1969‡) and/or radiographic examination (*see* IS : 1182-1967§ and IS : 4853-1968‖)

depending upon joint geometry, material and the requirements for production work, using the appropriate application standard where it exists.

8.2.2 *Acceptance Levels* — Defects that are detected by visual examination and the other relevant methods of non-destructive testing shall be assessed in accordance with the details specified in Table 2. The existence of any

* Code of practice for magnetic particle flaw detection of welds.

† Code of practice for liquid penetrant flaw detection.

‡ Recommended practice for ultrasonic testing of welds in ferritic steel.

§ Recommended practice for radiographic examination of fusion welded butt joints in steel plates (*first revision*).

‖ Recommended practice for radiographic examination of fusion welded circumferential joints in steel pipes.

defect greater than the maximum permitted by Table 2 shall be sufficient cause for rejection.

NOTE 1 — Multiple type faults contained with the same weld, either superimposed or interposed, which are individually acceptable as isolated imperfections may be considered acceptable provided that investigation shows that there is nothing fundamentally wrong with the welding procedure.

NOTE 2 — It should be appreciated that the details given in Table 2 may be different from those specified for a particular application.

TABLE 1 DESTRUCTIVE TESTS — NUMBER OF TEST SPECIMENS REQUIRED*

(*Clauses* 8.1 *and* 8.3.1)

Sl No.	Test Specimen	Butt Joint in Plate	Butt Joint in Pipe of Outside Dia or Dimension		Fillet Weld in Plate	Branch Connection in Pipe of Outside Dia or Dimension	
			Up to and Including 88·9 mm	Over 88·9 mm		Up to and Including 88·9 mm	Over 88·9 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Macro-examination	1	2	2	2	4†	8†
ii)	Root bend (for material less than 10 mm thick and for all welds made from one side only)	1	2	3	—	—	—
iii)	Face bend (for material less than 10 mm thick)	1	—	1	—	—	—
iv)	Side bend (for material at least 10 mm thick)	2	1	1	—	—	—
v)	Fillet weld fracture (only for single side weld)	—	—	—	3	—	—

*When more than one specimen of a particular type is required, the specimens shall be taken as far apart as possible, with one specimen for macro-examination taken from that part of the joint considered to have been welded in the most difficult welding position or from a stop/start position.

†For purely structural applications the number of specimens may be reduced to 2 and 4 respectively.

8.3 Destructive Tests

8.3.1 *Test Specimens* — The specimens to be obtained when certain destructive tests are required (*see* **8.1**) shall be as given in Table 1.

When the size and thickness of a pipe butt joint are such that the specified test specimens cannot be obtained, then some other method of test agreed between the contracting parties shall be used, for example, a full size tensile test or a pressure test.

TABLE 2 NON-DESTRUCTIVE TESTING — ACCEPTANCE LEVELS

(*Clause* 8.2.2)

Defect Type	Permitted Maximum
1) *Planar Defects*	
a) Cracks and lamellar tears	Not permitted
b) Lack of root fusion	Not permitted
c) Lack of side fusion	Not permitted
d) Lack of inter-run fusion	Not permitted
e) Lack of root penetration	Not permitted
2) *Cavities*	
a) Isolated pores (or individual pores in a group)	$\phi \geqslant t/4$ and ϕ 1·5 mm for t up to and including 25 mm ϕ 3·0 mm for t over 25 mm up to and including 50 mm ϕ 4·5 mm for t over 50 mm up to and including 75 mm ϕ 6·0 mm for t over 75 mm
b) Uniformly distributed or localised porosity	1 percent area (as seen in a radiograph) for $t \geqslant 25$ mm and pro rata for greater thicknesses
c) Linear porosity	Linear porosity parallel to the axis of the weld may indicate lack of fusion or lack of penetration and is therefore not permitted
d) Wormholes, isolated (as seen in the radiograph)	$l \geqslant 6$mm $w \geqslant 1{\cdot}5$ mm
e) Wormholes, aligned	As linear porosity
f) Crater pipes	As wormholes isolated
3) *Solid Inclusion (Slag Inclusions)*	
a) Individual and parallel to weld axis	$t \geqslant 1{\cdot}8$ mm $t > 18 \geqslant 75$ mm $t > 75$ mm $l \geqslant t/2$ 6 mm $l \geqslant t/3$ $l > 25$ mm $w \geqslant 1{\cdot}5$ mm $w \geqslant 1{\cdot}5$ mm $w \geqslant 1{\cdot}5$ mm (as seen in the radiograph)
b) Linear group*	Aggregate length should not exceed 8 percent of length of group, which in turn should not exceed 12 t in length
c) Individual and randomly orientated (not parallel to weld axis)	Maximum dimension in any direction 6 mm

(*Continued*)

TABLE 2 NON-DESTRUCTIVE TESTING — ACCEPTANCE LEVELS — *Contd*

DEFECT TYPE	PERMITTED MAXIMUM
4) *Tungsten Inclusions*	
a) Isolated	As isolated pores
b) Grouped	As uniformly distributed or localized porosity
5) *Copper Inclusions*	Not permitted
6) *Profile Defects*	
a) Undercut (detected by visual examination or radiography)	Slight intermittent undercut permitted provided it does not form a sharp notch; depth should not exceed 0·4 mm
b) Shrinkage grooves and root concavity	As for undercut, depth should not exceed 1·2 mm
c) Excess penetration	$h \not> 3$ mm. Occasional local slight excess is allowable
d) Reinforcement shape	The reinforcement shall blend smoothly with the parent metal and dressing is not normally required provided the shape does not interfere with the specified NDT techniques
e) Overlap	Not permitted
f) Linear misalignment	$h \not> t/10$, 3 mm *Max*

*Individual inclusions within the group should not exceed the sizes in 3(a) above. A linear group is defined as a number of inclusions in line and parallel to the weld axis where the spacing between their adjacent ends does not exceed 6 times the length of the longest inclusion within the group. With parallel groups, all inclusions count towards the aggregate.

Abbreviations used:

t = parent metal thickness. In the case of dissimilar thicknesses t applies to the thinner component.
w = width.
l = length.
h = height.
ϕ = diameter.

8.3.2 *Preparation and Testing* — The preparation, shape and dimensions of test specimens (except for dimensions of bend test specimens from pipe) and the methods of testing them shall be as specified in IS : 3600-1973*.

If backing material forms part of a butt joint, it shall be removed prior to bend testing. Each bend test specimen from a butt joint in pipe

*Code of procedure for testing of fusion welded joints and weld metal in steel.

shall be a parallel strip of width:

$t + \frac{D}{10}$, for pipes up to and including 60·3 mm outside diameter; and

$t + \frac{D}{20}$, with a maximum of 40 mm, for pipes over 60·3 mm outside diameter

where t is the wall thickness and D is the outside diameter of pipe.

Each bend test specimen shall be bent through at least 90° round a former of a diameter as specified below:

For Group FE1 steels (*see* IS : 7307 (Part I)-1974*	3t
For Group FE2 steels (*see* IS : 7307 (Part I)-1974*	4t
For other steels	Diameter equal to 1t greater than that required to test the parent metal of the same thickness

where t is the thickness of the specimen.

8.3.3 *Test Results*

a) *Macro-examination and fillet weld fracture test* — The etched face for macro-examination and the fracture surface from the fillet weld test shall be assessed in accordance with the requirements of **8.2.2.**

b) *Bend tests* — If the specimen bends through 90° without failure, slight opening-out (1·5 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 **8.2.2.**

9. STATEMENT OF RESULTS

9.1 A statement of the results of assessing each test piece, including repeat tests, shall be made for each welder. The item required under **4** shall be included together with details of any features that would be rejectable by the requirements of **8.2.2.** 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.

9.2 The welder's employer should hold and regularly maintain adequate records of all approval tests for each welder. A typical record sheet is given in Appendix A for information.

*Approval tests for welding procedures: Part I Fusion welding steels.

9.3 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.

10. RE-APPROVAL OF WELDER

10.1 A welder's approval to weld to a particular procedure shall remain valid provided that it can be shown, as certified at intervals of six 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 that procedure and has continued to produce satisfactory welds as verified by non-destructive examination. Re-approval shall be required if any of the following apply:

a) A new welding procedure is to be approved, except for the cases given in **5**.

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

c) Six months or more have elapsed since the welder was engaged in welding to the approval procedure or a similar procedure. Subject to the agreement of the inspecting authority, a re-approval test may be waived provided the first production weld by the welder is non-destructively tested and complies with the requirements of this standard.

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

APPENDIX A

(*Clause* 9.2)

TYPICAL WELDER APPROVAL TEST RECORD

NOTE — One sheet should be completed for each test.

Welder's Name	Welder's Identity No.
Approval test No.	Date of test Shop or site test
Welding procedure No.	Welding process and polarity
Parent material(s) : Type Thickness Pipe outside diameter or dimension	Welding consumables: Electrode or filler material Specification Type of flux or electrode covering Shielding gas composition
Welding position	Pipe position
Type of joint with sketch of weld preparation	Weld dimensions required Additional information

Approval test results

(State : Satisfactory, unsatisfactory or not applicable and clearly indicate any results of re-tests)

Non-destructive tests

Visual
Magnetic particle
Liquid penetrant
Radiography/ultrasonics

Destructive tests

Macro-examination
Root bend
Face bend
Side bend
Fillet weld fracture

Result of test with any remarks	
Inspecting authority Witnessed by Date	Employer's signature Position Date

Endorsements (intervals of six months)

(*Continued from page* 2)

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