

भारतीय मानक

वेल्डरों के लिए प्रशिक्षण — रीति संहिता

भाग 1 मैन्युल धातु आर्क वेल्डिंग

(दूसरा पुनरीक्षण)

Indian Standard

TRAINING OF WELDERS — CODE OF
PRACTICE

PART 1 MANUAL METAL ARC WELDING

(*Second Revision*)

UDC 621.791.753 : 658.386

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BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Welding General Sectional Committee had been approved by the Metallurgical Engineering Division Council.

As a part of steel economy programme, it was recommended that welding should be used as a mode of fabrication in preference to riveting. This standard was first prepared in 1957 to lay down a scheme for training and testing in welding to a trainee in order to enable him to undertake normal welding jobs.

The standard was first revised in 1966 simplifying the course and making directly related to the actual requirement of the job. As a result Section 3 of the standard was split into the following three sub-sections:

- | | |
|----------------|--|
| Sub-section 3A | Butt welds in flat position and fillet welds in flat and horizontal-vertical positions; |
| Sub-section 3B | Butt and fillet welds in vertical up and down position and butt welds in horizontal vertical position; and |
| Sub-section 3C | Butt welds and fillet welds in overhead position. |

In view of the experience gained and to cater the needs of the welding industry more effectively the Committee has decided to revise this standard.

In this revision provisions relating to training of welders for manual metal arc welding only have been covered. Additional parts of the standard as under are proposed to be formulated in due course:

- Part 2 Oxyfuel Welding
- Part 3 TIG Welding
- Part 4 MIG/MAG Welding
- Part 5 Mechanised Welding

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 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard***TRAINING OF WELDERS — CODE OF PRACTICE****PART 1 MANUAL METAL ARC WELDING***(Second Revision)***1 SCOPE**

1.1 This code prescribes minimum requirements for a course of instruction in the training of a welder for manual metal arc welding as applied to mild steel and also stipulates certain standard tests, at the end of the course of instruction.

1.2 The principal objectives for the course of instruction covered by the code are :

- a) to coach the trainee in the fundamental techniques and the safe practices of Manual Metal Arc Welding;
- b) to give the trainee of a good understanding of the proper methods of manual metal arc welding as applied to mild steel using rutile, low hydrogen and cellulose class of electrodes;
- c) to enable the trainee to acquire enough skills in welding to pass the qualification tests prescribed in this code; and
- d) to provide the trainee with a basic knowledge of welding theory.

1.2.1 The course of instruction is not expected to produce an experienced welder, but rather a welder with enough skill and knowledge so that he will have immediate value of industry as a welder on less difficult work, and will be able, by gaining experience in industry, to progress rapidly to works of greater difficulty and responsibility.

SECTION 1 GENERAL**2 REFERENCES**

<i>IS No.</i>	<i>Title</i>
812 : 1957	Glossary of terms relating to welding and cutting of metal
813 : 1986	Scheme of symbols for welding (<i>revised</i>)
814 : 1991	Covered electrodes for metal arc welding of mild steels

*IS No.**Title*

818 : 1968

Code of practice for safety and health requirements in electric and gas welding and cutting operations

2062 : 1984

Specification for welding structural steel (*third revision*)**3 TERMINOLOGY**

For the purpose of this code, all terms relating to arc welding, unless otherwise defined in this code, shall have the meaning assigned to them in IS 812 : 1957.

4 SYMBOLS

For the purpose of this code the symbols used shall have the meaning assigned to them in IS 813 : 1986 unless defined in this code.

5 MATERIAL**5.1 Steel**

Steel used as parent metal for testing, according to the provisions of this code, shall conform to IS 2062 : 1984.

5.2 Electrodes

Electrodes, used for all tests, according to provision of this code, shall conform to the requirements of IS 814 : 1991.

6 SELECTION OF TRAINEES

Trainees selected to receive the instruction recommended in this code shall have the following qualifications:

- a) ability to understand the language of instruction;
- b) no physical or metal disability that precludes safe operation of welding equipment or interferes with full performance of duties in industry; and
- c) the minimum age requirements prescribed in the State and Central Labour Laws applicable in the State in which the instruction is conducted.

7 LENGTH OF COURSE, HOURS OF INSTRUCTION AND TRIAL PERIOD INSTRUCTION

7.1 Length of Course

It is recommended that each trainee is put to a minimum of 8 weeks of training for subsections 3A, 3B and 3C.

NOTE — The above time is to be spent only on receiving practical instructions, joint taking and welding.

7.2 Length of Instruction in Welding Theory

It is recommended that each trainee devotes 48 hours total to theoretical instruction in welding theory prescribed in Section 3.

7.3 Trial Period of Instruction

In the beginning of the course there shall be a trial or probationary period not exceeding 3 hours. Trial period other than the stipulated may however be determined by the training department, during which the instructor shall observe the aptitude and interest of the trainee and determine whether in the interest of all concerned, the trainee shall continue the course.

SECTION 2 EQUIPMENT AND FACILITIES FOR THE TRAINING ESTABLISHMENT

8 EQUIPMENT, ACCESSORIES AND CONSUMABLES

8.1 Welding Booths

Each welding booth shall have a minimum area of 3 square meter. All four sides of the welding station shall provide complete protection to persons and property on the outside against fire, personal injury or other damage. Internally each booth shall be so constructed, lighted and ventilated as to provide ease of demonstration and practice and also protection to trainee. Suitable ventilation, adequate to prevent the accumulation of welding fumes shall be provided. Any state or local regulations that are applicable shall be complied with.

8.2 Positioning Jig

Suitable positioning jigs shall be provided to facilitate the execution of the welding tests.

8.3 Arc Welding Machine

The training establishment shall be equipped with as many ac/dc arc welding machines (power sources) as there are trainees in the

shop class (*see* 7.1 for actual welding time for trainees). Each welding machine shall have a rated current of 200 A or more. It is desirable that at least one machine having a manual continuous hand welding current rating of 300 A at minimum of 55 percent duty cycle or more be available.

8.4 Electrodes

There shall be an adequate supply of covered metal arc welding electrodes of the types and sizes required for the exercises prescribed in Section 3.

8.5 Material for Welding

An adequate supply of mild steel plate of the required quality shall be provided for the exercises prescribed in Section 3.

8.6 Testing Apparatus

The training establishment shall possess apparatus suitable for preparing and testing the test specimens as prescribed in Section 3 or shall have facilities for having these test specimens prepared and tested elsewhere.

8.7 Miscellaneous

In addition to the foregoing, the training establishment shall provide all other apparatus and equipment necessary for the safe and proper execution of the welding course prescribed herein. A list of accessories and equipment recommended for a training establishment is given in Annex A.

9 SUPERVISION

9.1 Number of Trainees per Instructor

Each shop class should be restricted to not more than 12 trainees in attendance per instructor.

9.2 Record of Trainees Progress

A record shall be kept of each trainee's progress, showing the number of hours of individual practice and the results of all test prescribed in Section 3. A recommended form of trainee progress chart is given in Annex B.

10 REFERENCE MATERIALS

10.1 Outline of the Course

At the start of the course a prepared outline indicating the syllabus of the course, the tests required, subjects to be covered and the related

instruction shall be made available to the trainees. A specimen syllabus for the course is given in Annex C.

10.2 Welding Publications

The training establishment shall make available for trainee's use suitable reference material consisting of books, manuals, periodicals, code, standards, etc.

11 QUALIFICATIONS AND DUTIES OF INSTRUCTOR

11.1 General

The instructions prescribed in this code may be given by one or more instructors, provided each instructor in welding practice possesses the qualifications prescribed under **11.2.1** and each Instructor in welding theory possesses the qualification prescribed under **11.2.2**. In addition, each instructor shall have the ability to present effective demonstrations and explanation of those portions of the course which he is to teach.

11.2 Qualification of Instructor

11.2.1 Each instructor giving any portion of the instruction in welding practice (*see* 13) shall possess the following qualifications:

- a) A minimum of three years experience in welding technology with basic educational qualification equivalent to SSC;
- b) A practical knowledge of the physical properties of the metals and the welding process;
- c) Familiarity with the topics in welding theory covered in Section 3; and
- d) Familiarity with the codes and specifications used in welding and capability to read simple drawings relating to welding of structures.

11.2.2 Each instructor giving any portion of the instruction in welding theory shall have a thorough knowledge of the subject on which he gives instructions.

11.3 Duties of Instructor

The instructional staff shall be charged with the responsibility of giving instruction in welding practice and welding theory, as prescribed in Section 3. The duties shall include the following:

- a) Planning instruction in accordance with the course outlined in this code keeping

in view the following four basic steps of instruction :

- 1) Preparing the trainee for new instruction;
 - 2) Using appropriate methods for presenting the new instruction (demonstration, illustration, explanation, discussion, etc);
 - 3) Providing proper supervision and criticism as the trainee applies his new knowledge and skill; and
 - 4) Supervising the check tests assigned to trainees.
- b) Instructing the trainee to work safely, emphasizing the training establishment's safety regulations.
 - c) Observing acceptable shop management practice, such as (i) care, control and conservation of materials and equipment, and (ii) shop cleanliness and orderliness.
 - d) Keeping attendance records and recording trainees progress.

SECTION 3 COURSE OF INSTRUCTION

12 GENERAL

12.1 The instruction shall consist of welding practice and lectures in theory. The practical and theoretical training should be suitably interspersed and related one to the other. The training shall start with instruction in safety precautions, protection of person and protection and care of equipment. This instruction coming at the very commencement of the course will reduce the risk of disablement of the trainees from such causes as are-eye, electrical shocks, etc, and help in preventing damage to equipment which might be caused by ignorance of its proper use.

12.1.1 The instruction in safety shall be given before the trainees are permitted to use any regular welding equipment. A list of recommended safety rules is given in Annex D, and should be used in this instruction.

12.1.2 For detailed instructions for safety and health requirements in electric and gas welding cutting operations reference should be made to IS 818 : 1968.

13 INSTRUCTION IN WELDING PRACTICE

13.1 Instruction in welding practice shall be given by means of a series of exercises which shall conform at least to the requirement

prescribed in this section. The exercise shall be performed on steel plates of various thicknesses as appropriate for each individual exercise. The steel shall be reasonably free from scale, rust, paint and other defects which adversely affect welding. For the execution of each exercise, the trainee shall have a welding unit for his exclusive use.

13.1.1 The importance of maintaining uniformity of voltage and current condition in order to attain uniformity and good quality of welds and the importance of proper cleaning and deslagging during the welding process shall be emphasized during each exercise. The trainee should select the current, polarity and OCB as recommended by the electrode manufacturer on the carton under the guidance of welding instructions.

13.1.2 In the list of suggested welding exercise no specific recommendations are made with respect to the number of times each exercise should be repeated. The trainee should be required to perform each exercise to the satisfaction of the instructor before being allowed to advance to the next exercise.

13.1.3 It is recommended that the trainee should test as many of his welds as possible as soon as they have been cooled in still air. Further, the instructor should inspect the tested weld and point out to the trainee any defects that may be in evidence and the reason for such defect or failure of the joint. The techniques of testing shall be as prescribed for the check tests (*see 14*).

13.1.4 It is recommended that the size of specimen as indicated in the various illustrations, be maintained wherever possible.

13.1.5 It is recommended that the pieces be set up and tack welded before welding.

13.1.6 After completing each group of exercises the trainees shall be required to pass the check tests prescribed for that group designed to demonstrate whether he has acquired a satisfactory degree of skill in the techniques covered by that group of exercises.

SUB-SECTION 3A BUTT WELDS IN FLAT POSITION AND FILLET WELDS IN FLAT AND HORIZONTAL-VERTICAL POSITION

13.2 Group A Exercises

Striking Arc and Bead Welding — Exercises in Group A shall be designed to instruct the trainee to readily strike the arc, maintain the correct arc length, achieve full control of slag

and weld metal, and deposit consistently beads of the correct length, width and profile with various sizes of electrodes. All the exercises shall be performed with electrodes of sizes ranging from 3.15 mm to 6.3 mm. The following exercise shall be included in this group:

<i>Welding Lesson</i>	<i>Welding Procedure</i>
a) Striking the arc	Tapping method and scratch method (<i>see Fig. 1</i>)
b) Running beads (flat position)	With 3.15, 4.5 and 6.3 mm electrodes, deposit continuous beads with craters properly filled and without excessive deposits of metals at the points of restriking arc, then practice making long continuous beads in all directions (<i>see Fig. 2B and 3</i>)
c) Bead welds-weaving (flat position)	Practice different weaving techniques (<i>see Fig. 4</i>) advancing in all directions, that is, from left to right, right to left, towards and away from the operator, using 3.15, 4.5 and 6.3 mm electrodes.
d) Resurfacing	Resurfacing on a mild steel plate by depositing a metal pad with three layers using four or five mm size electrodes. The area to be built up may be fixed as 200 mm × 100 mm. While carrying out this pad weld deposit in such a way so that 1/3 portion of a weld run falls on the preceding run and crater groove, if any, must be filled up. The trainee should produce pad free from porosity and inclusions and more or less of uniform width and height with ± 1 mm tolerance. While welding the pad, weaving should be restricted to minimum

13.2.1 All the exercise in Group A shall be performed in the flat position.

13.2.2 Check Tests on Exercise in Group A — No specific tests are prescribed for this group. The trainee should be able to strike the arc by either method at any desired point. He should be able to apply the different and weaving techniques (*see Fig. 4*) advancing from left to right, right to left and towards and away from the operator, and obtain beads of uniform width. He should be able to deposit a weld metal pad with several layers, using different weaving techniques and obtain fair uniformity in thickness, width and appearance.

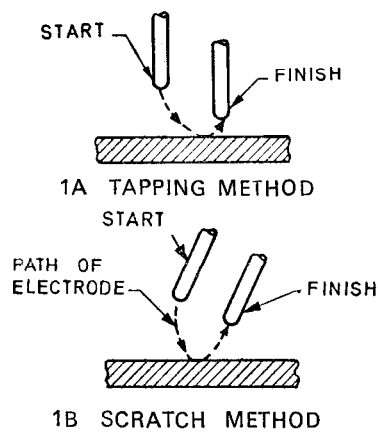


FIG. 1 STRIKING THE ARC

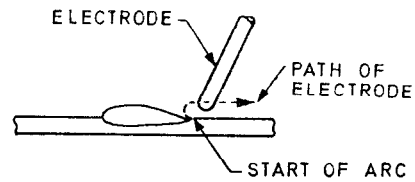


FIG. 3 RESTRIKING THE ARC

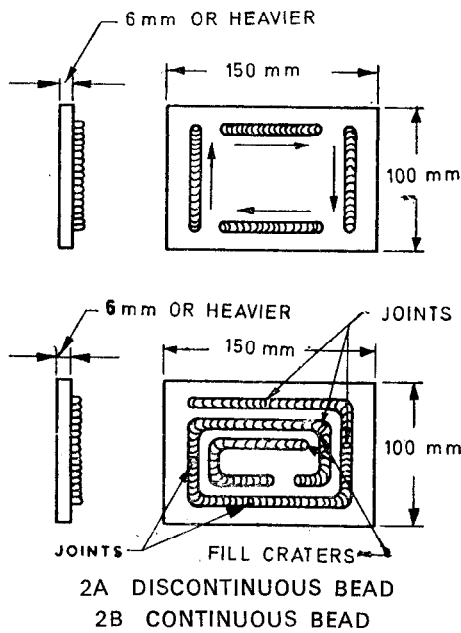


FIG. 2 BEAD TECHNIQUE

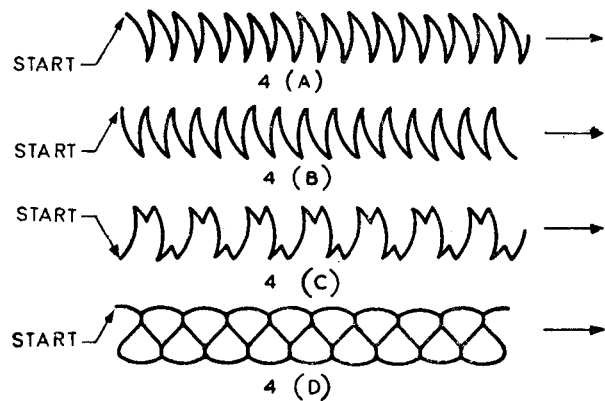


FIG. 4 WEAVING TECHNIQUE

13.3 Group B Exercises**13.3.1 Welding of Butt Joints and Fillet Joints in Flat Position**

The exercises in Group B shall be designed to instruct the trainee in the technique of making corner, fillet, and butt welds in the flat position. Exercises as given in Table 1 for types of welds shall be included in this group.

13.3.2 Check Tests on Exercises in Group B

The trainee shall be required to make two specimen welds conforming to the requirements stated in Table 2.

13.3.2.1 The weld shall be inspected visually for appearance, checked for size and contour

with a suitable weld gauge and then ruptured for internal examination (*see* Fig. 9). Each weld shall be assessed on the basis of provisions under 14.

13.4 Group C Exercises**13.4.1 Welding of Fillet Joints in the Horizontal-Vertical Position**

The exercises in Group C shall be designed to instruct the trainee in the technique of making fillet welds in the horizontal-vertical position. All the exercises shall be performed with 3.15 mm or larger electrodes, leading to the use of 4 and 5 mm electrodes for check tests. Exercises as given in Table 3 for types of welds shall be included in this group.

Table 1 Exercises for Corner, Fillet and Butt Welds in Flat Position

(Clause 13.3.1)

Types of Welds	Position of Welding	Joint Preparation	Procedure of Welding
a) Corner welds	As illustrated in Fig. 5B	As illustrated in Fig. 8B	Weld the joint with two runs first with a 4 mm electrode and the second one with a 5-mm electrode using weaving technique
b) Fillet welds single run	As illustrated in Fig. 5C or 5D	As illustrated in Fig. 7	Weld the joint with a 4-mm electrode to obtain a 6-mm fillet
c) Fillet welds multi-run	As illustrated in Fig. 5C or 5D	As illustrated in Fig. 7	Weld the joint with a 4-mm electrode for the first run and a 6.3 mm electrode for the second run to obtain a 10-mm fillet
d) Butt-welds	As illustrated in Fig. 5A	As illustrated in Fig. 8A	Weld the joint in three runs first run with a 4-mm/3.15 mm electrode and the subsequent runs with 5-mm electrodes
e) Butt welds multi-run	As illustrated in Fig. 5A	As illustrated in Fig. 6	Made the joint by welding one run on each side using a 5-mm electrode

Table 2 Specimen Welds for Check Tests on Exercises in Group B

(Clause 13.3.2)

Specimen No.	Joint Preparation	Position of Welding	Procedure of Welding
1	As illustrated in Fig. 7	As illustrated in Fig. 5C or 5D	Welds to be made in a single-run with a 5-mm electrode
2	As illustrated in Fig. 8A	As illustrated in Fig. 5A or 5B	Weld to be made in multi-runs with a 4-mm electrode for the root-run and a 5-mm electrode for the succeeding runs

Table 3 Exercises for Fillet Joints to Horizontal-Vertical Position
(Clause 13.4.1)

Types of Welds	Position of Welding	Joint Preparation	Procedure of Welding
a) Fillet welds	As illustrated in Fig. 5G and 5H	As illustrated in Fig. 7	Deposit a single run fillet of 6 mm size using 4-mm and 5-mm electrodes
b) Fillet welds multi-run	As illustrated in Fig. 5G and 5H	As illustrated in Fig. 7	Deposit a 10 mm filled weld in three runs with 4-mm electrodes


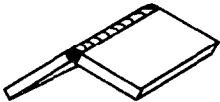

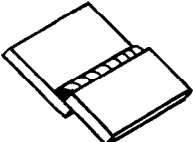
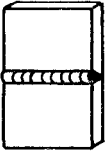
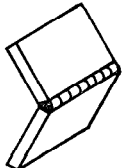
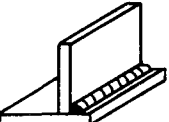

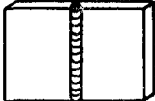
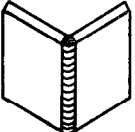
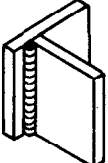
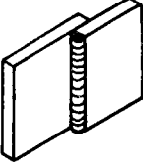


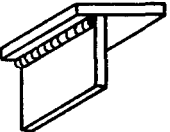

POSITION OF WELDING	BUTT WELD		FILLET WELD	
	BUTT JOINT	CORNER JOINT	TEE JOINT	LAP JOINT
FLAT	 5 (A)	 5 (B)	 5 (C)	 5 (D)
HORIZONTAL	 5 (E)	 5 (F)	 5 (G)	 5 (H)
VERTICAL	 5 (J)	 5 (K)	 5 (L)	 5 (M)
OVERHEAD	 5 (N)	 5 (P)	 5 (Q)	 5 (R)

FIG. 5 ILLUSTRATIONS OF POSITIONS OF WELDING

13.4.2 Check Tests of Exercises in Group C

The trainee will be required to make two specimen welds conforming to requirements stated in Table 4.

13.4.2.1 Each weld shall be inspected visually

for appearance and checked for size and contour with a suitable weld gauge and ruptured for internal examination (see Fig. 9) Each weld shall be assessed on the basis of provisions mentioned under 14.

Table 4 Specimen Welds for Check Tests on Exercises in Group C

(Clause 13.4.2)

Specimen No.	Joint Preparation	Position of Welding	Procedure of Welding
3	As illustrated in Fig. 7	As illustrated in Fig. 5G and 5H	Weld to be made in a single run with a 4-mm electrode
4	As illustrated in Fig. 7	As illustrated in Fig. 5G and 5H	Weld to be made in a single run with 5-mm electrode

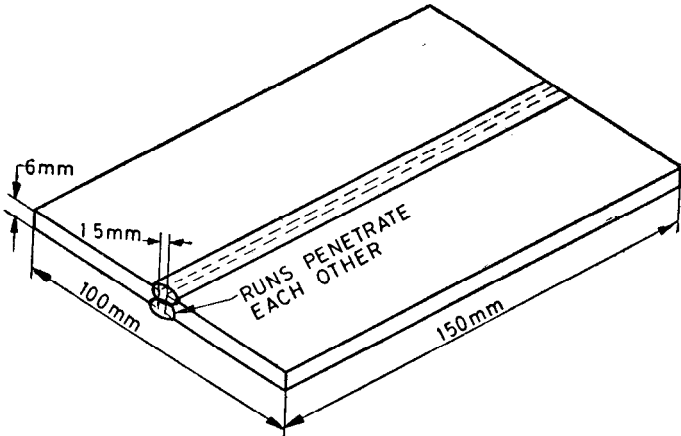


FIG. 6 BUTT WELD (SQUARE EDGE)

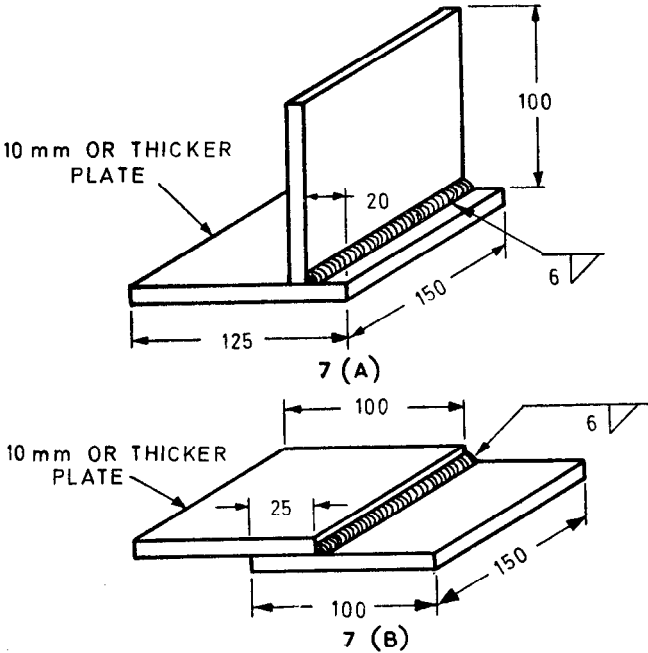
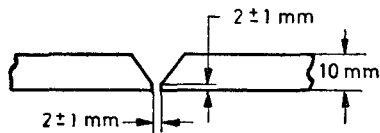
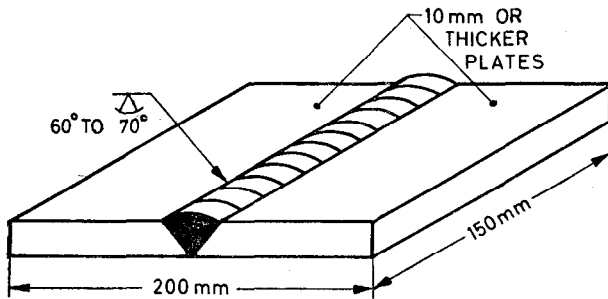
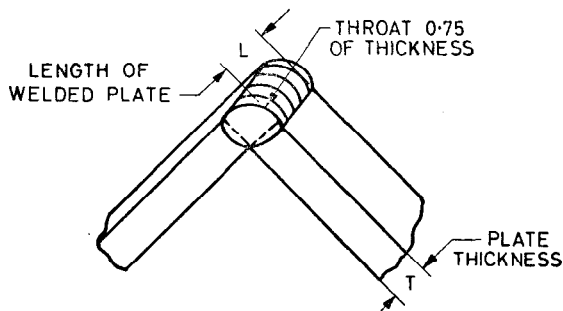


FIG. 7 FORMS OF JOINT FOR FILLET WELD SPECIMEN



8A SINGLE V-BUTT JOINT



8B DETAIL OF CORNER JOINT

FIG. 8 FORMS OF JOINT FOR BUTT WELD SPECIMEN

SUB-SECTION 3B BUTT AND FILLET WELDS IN VERTICAL UP AND DOWN POSITION AND BUTT WELDS IN HORIZONTAL-VERTICAL POSITION

13.5 Group D Exercises

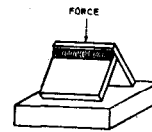
13.5.1 Welding in Vertical Position

The exercises in Group D, shall be designed to instruct the trainee in the technique of making

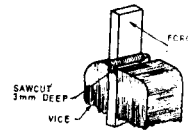
bead, fillet and butt welds in the vertical position. All the exercises shall be performed with 3.15 mm or larger electrodes, leading to the use of 4-mm electrodes for the check tests. For the exercises requiring welding in the vertical down direction, electrodes suitable only for this purpose shall be selected. Exercises as given in Table 5 types of welds shall be included in this group.

Table 5 Exercises for Butt and Fillet Welds in Vertical Up and Down Position and Butt Welds in Horizontal-Vertical Position

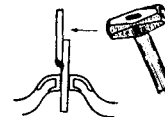
Types of Welds	Position of Welding	Joint Preparation	Procedure of Welding
a) Bead welds vertical up and vertical down	As illustrated in Fig. 2	As illustrated in Fig. 2	Practice bead welds both vertical and down and using 3.15 mm, 4-mm and 5-mm electrodes
b) Fillet welds single-run, vertical-up	As illustrated in Fig. 5L and 5M	As illustrated in Fig. 7	Weld the joint with a 6.3 mm fillet weld using a 4-mm electrode
c) Fillet welds multi-run, vertical-up	As illustrated in Fig. 5L and 5M	As illustrated in Fig. 7	Weld the joint in two runs to obtain a 10-mm fillet-first run with 4-mm electrode and the second with a 5-mm electrode
d) Butt welds	As illustrated in Fig. 5J	As illustrated in Fig. 8A	Weld the joint in three runs first run with 3.15 mm, second and third with 4-mm electrodes
e) Corner welds down direction	As illustrated in Fig. 5K	As illustrated in Fig. 8B	Weld vertical down with a 3.15 mm and 4-mm electrode



9A FOR FORM OF JOINT ILLUSTRATED IN FIG. 7A



9B FOR FORM OF JOINT ILLUSTRATED IN FIG. 8



9C FOR FORM OF JOINT ILLUSTRATED IN FIG. 7B

FIG. 9 METHOD OF RUPTURING CHECK TEST SPECIMENS

13.5.2 Check Tests on Exercises in Group D

The trainee shall be required to make two specimen welds conforming to the requirements stated in Table 6.

13.5.2.1 The weld shall be inspected visually for appearance, checked for size and contour with a suitable weld gauge and then ruptured for internal examination (*see* Fig. 9). Each weld shall meet the requirements specified under 14.

13.6 Group E Exercises**13.6.1 Welding in Horizontal-Vertical Position for Butt Welds**

The exercises in Group E shall be designed to instruct the trainee in the technique of making bead and butt welds in horizontal vertical position. All the exercises shall be performed with 3.15 mm or larger electrodes, leading to the use of 3.15 mm and 4-mm electrodes for check tests. Exercises as given in Table 7 for types of welds shall be included in this group.

13.6.2 Check Tests in Exercises in Group E

The trainee shall be required to make one specimen weld conforming to the following requirements stated in Table 8.

Table 6 Specimen Welds for Check Tests Exercises in Group D
(Clause 13.5.2)

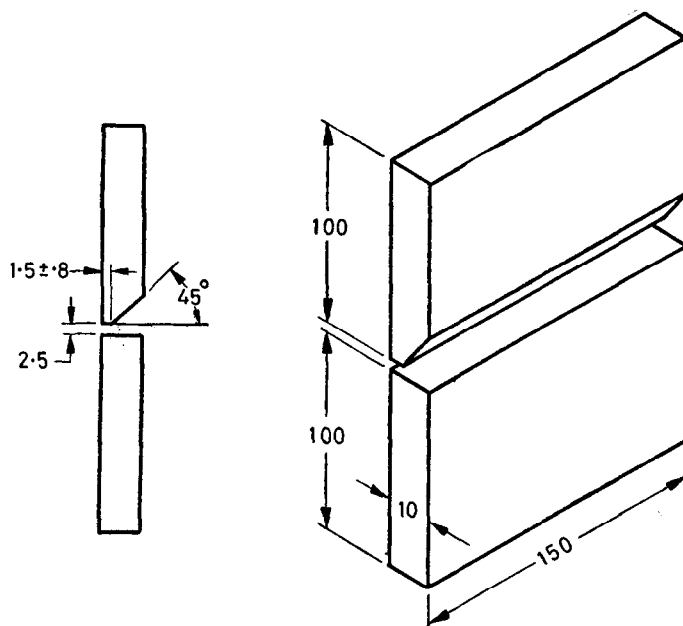
Specimen No.	Joint Preparation	Position of Welding	Procedure of Welding
5	As illustrated in Fig. 7	As illustrated in Fig. 5L and 5M	Weld as specified in Fig. 7 to be made in a single-run with a 4-mm electrode. After visual inspection and gauging, weld shall be increased in size by one or more additional runs to form a 10-mm fillet weld
6	As illustrated in Fig. 8A	As illustrated in Fig. 5J and 5K	Weld to be made in multi-runs with a 3.15 mm electrode for the first run and 4-mm electrode for the subsequent runs

Table 7 Exercises for Butt Welds in Horizontal-Vertical Position
(Clause 13.6.1)

Types of Welds	Position of Welding	Joint Preparation	Procedure of Welding
a) Bead welds and reinforcing pad in horizontal/vertical position	As illustrated in Fig. 2	As illustrated in Fig. 2	Practice deposition of beads using 3.15 mm and 4-mm electrodes
b) Butt welds	As illustrated in Fig. 5E	As illustrated in Fig. 10	Weld the joint by building up the weld with required number of straight beads (approximately 4) deposited without weaving. First run to be made with 3.15 mm and the subsequent runs with 4-mm electrodes
c) Butt welds	As illustrated in Fig. 5E	As illustrated in Fig. 14 (alternative horizontal vertical position)	Weld the joint by building up the weld with the required number of runs (approximately 3) deposited without weaving first run with 3.15 mm and the subsequent runs with 4-mm electrodes

Table 8 Specimen Welds for Check Tests Exercises in Group E
(Clause 13.6.2)

Specimen No.	Joint Preparation	Position of Welding	Procedure of Welding
7	As illustrated in Fig. 10	As illustrated in Fig. 5E and 5F	Weld to be made in multi-runs with 3.15 mm electrode for the first run and 4-mm electrode for the subsequent runs



All dimensions in millimetres.

FIG. 10 EDGE PREPARATION FOR BUTT WELDS

13.6.2.1 Each weld shall be inspected visually for appearance and checked for size and contour with a suitable weld gauge and ruptured for internal examination (see Fig. 9B). Each weld shall be assessed on the basis of provisions mentioned under 14.

SUB SECTION 3C BUTT WELDS AND FILLET WELDS IN OVERHEAD POSITION

13.7 Group F Exercises

13.7.1 Welding in the Overhead Position

The exercises in Group F shall be designed to

instruct the trainee in the technique of making bead, fillet and butt welds in the overhead position. All the exercises shall be performed with 3.15 mm or 4-mm electrodes, leading to the use of 4-mm electrodes for the check tests. Exercise as given in Table 9 types of welds shall be included in this group.

13.7.2 Check Tests on Exercises in Group F

The trainee shall be required to make two specimen welds conforming to the requirements stated in Table 10.

Table 9 Exercises for Butt Welds and Fillet Welds in Overhead Position

(Clause 13.7.1)

Types of Welds	Position of Welding	Joint Preparation	Procedure of Welding
a) Bead welds overhead position	As illustrated in Fig. 2	As illustrated in Fig. 2	Practice striking the arc and depositing beads with 3.15 mm and 4-mm electrodes
b) Fillet welds single run	As illustrated in Fig. 5Q and 5R	As illustrated in Fig. 7	Make a 5-mm fillet weld with 4-mm electrode
c) Fillet welds multirun	As illustrated in Fig. 5Q and 5R	As illustrated in Fig. 7	Make a 10-mm fillet weld building up the weld in three runs using 4-mm electrode
d) Butt welds	As illustrated in Fig. 5N	As illustrated in Fig. 8A	Weld the joint in three layers using weaving techniques for the last two layers. Initial two layers with 3.15 mm electrode and the final layer with 4-mm electrode

Table 10 Specimen Welds for Check Tests on Exercises in Group F

(Clause 13.7.2)

Specimen No.	Joint Preparation	Position of Welding	Procedure of Welding
8	As illustrated in Fig. 7	As illustrated in Fig. 5Q and 5R	Weld as specified in Fig. 7 to be made in a single-run with a 4-mm electrode After visual inspection and gauging, weld shall be increased in size by one or more additional runs to form a 10-mm fillet weld
9	As illustrated in Fig. 8	As illustrated in Fig. 5N and 5P	Weld to be made with 3.15-mm electrode for first run and 4-mm electrode for subsequent runs in multi-runs

13.7.2.1 The weld shall be inspected visually for appearance, checked for size and contour with suitable weld gauge and then ruptured for internal examination (see Fig. 9). Each weld shall be assessed on the basis of the provisions specified under 14.

14 ASSESSMENT OF CHECK TEST WELDS

14.1 Inspection Before Fracture

14.1.1 Factor 1 Shape of Profile

The shape of the profile shall be checked by measuring dimensions of the weld. The finished weld may be slightly over rather than under the specified size.

14.1.2 Factor 2 Shape of Profile

The profile of the weld is affected by the type of filler material or electrode used, the position of joint and the welding technique.

14.1.2.1 In butt welds the surface should be slightly convex. Typical profile views for butt welds have been illustrated in Fig. 11.

14.1.2.2 In fillet welds the contour may vary from concave to convex, according to the type of electrode or filler material, the welding position and technique. Typical profile views for normal fillet welds have been illustrated in Fig. 12.

14.1.3 Factor 3 Uniformity of Surface

Uniformity of height and spacing of the 'ripples' are an indication of the quality of workmanship. The shape and appearance of ripples in the weld surface vary according to the class of welding.

14.1.4 Factor 4 Degree of Undercut

Undercutting is a particularly undesirable fault. When present it is evident as a notch of depression parallel and adjacent to the sides of the weld. The welded joint should be reasonably free from undercut, but slight intermittent

occurrences may be disregarded, provided that such undercut is not in the form of a sharp notch.

14.1.5 Factor 5 Smoothness of Joint where Welding is Recommended

The joint in a weld run where welding has been recommended should show no pronounced lump or recess in the weld surface.

14.1.6 Factor 6 Freedom from Surface Cavities and Trapped Slag

Smoothness of finish and general freedom from surface cavities and trapped slag are desirable. Surface cavities in a weld deposit may be caused by lack of fusion, gas bubbles or trapped slag, due to the use of unsuitable material of incorrect technique. Where suitable materials are used, the presence of those defects may be considered attributable to the quality of workmanship.

14.1.7 Factor 7 Disposition of Runs, Single and Multiple

Where multiple runs are deposited they should at the surface, be of approximately equal width and there should be no deep notch or groove between adjacent runs nor should the edge of one run produce a sharp ridge or recess in the surface of another run.

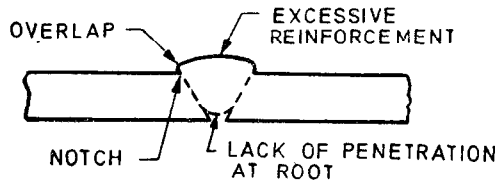
14.1.7.1 The disposition of the lower runs in a multiple run weld can only be ascertained by examination of an etched cross section of the weld.

14.1.8 Factor 8 Penetration Bead in Butt Welds

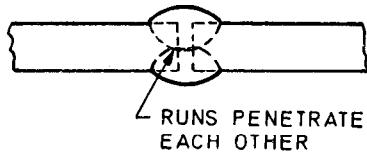
The size of the penetration bead, that is, fused metal projecting on the reverse side of the joint, varies according to the materials being welded, the type of joint, the welding process the welding technique and the skill of the welder. Where a penetration bead is required, it should be reasonably uniform in width and appearance (see Fig. 13).



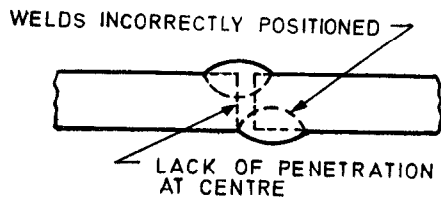
11A DESIRABLE PROFILE IN V-BUTT



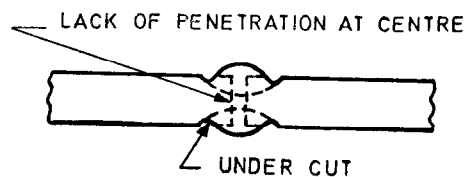
11B UNDESIRABLE PROFILE IN V-BUTT



11C DESIRABLE PROFILE IN UNPREPARED BUTT WELD EACH SIDE

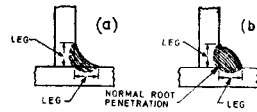


11D UNDESIRABLE PROFILE IN UNPREPARED BUTT



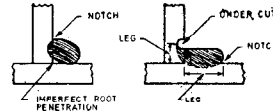
11E UNDESIRABLE PROFILE IN UNPREPARED BUTT

FIG. 11 TYPICAL PROFILE IN BUTT WELD



a) Concave, Equal Leg Lengths
b) Convex, Equal Leg Lengths

12A DESIRABLE PROFILES



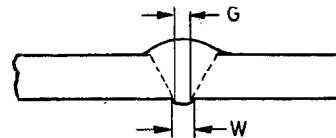
Too Convex
No root penetration
Notch effect at sides of weld

12B UNDESIRABLE PROFILE

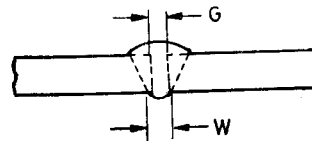
Undercut
Notch effect due to overlap at lower toe
Unequal leg lengths

12C UNDESIRABLE PROFILE

FIG. 12 TYPICAL PROFILES IN FILLET WELDS



13A SINGLE VEE JOINT



13B SQUARE BUTT

1.6 mm to 6.5 mm one run where no backing is deposited

FIG. 13 TYPICAL SHAPE OF PENETRATION BEADS IN BUTT WELD

14.1.9 Factor 9 Quality of Weld Metal for Metal Arc Welding

In the case of weld deposits on good quality material made with covered electrodes, the use of incorrect current or incorrect arc length usually made evident by porosity both in the body of the weld and in the crater accompanied by a poor surface finish and an irregular profile. A deep crater is not itself a criterion of overheating nor of the use of excessive current but may depend upon the characteristics of the electrode.

14.2 Inspection of Weld Fracture

Inspection of weld fractures gives information concerning the disposition of runs and the following faults, if present at the section or fracture: incorrect profile, undercut, slag inclusions, poor root penetration and other lack of fusion, as described in the following factors.

14.2.1 Factor 10 Degree of Fusion

Fusion should be complete over the whole area of the joint surfaces.

14.2.1.1 The fracture should be inspected for lack of fusion. This may occur at the surfaces to be joined between layers of weld metal. Lack of fusion at the joint surfaces is indicated by the retention of the original form and surface markings; between layers of weld metal it will appear as lines between the layers.

14.2.2 Factor 11 Degree of Root Penetration for Butt and Fillet Welds

Defects are most likely to occur at the root of the weld in this position they are liable to have the maximum effect in reducing the strength of the weld. A close examination of the root shall, therefore, be made. In V-butt welds the first run should normally penetrate right to the underside of the plates, producing a penetration bead of the size required. In normal fillet welds with good root penetration the weld metal should reach the corner (see Fig. 11 and 12).

14.2.3 Factor 12 Nonmetallic (slag) Inclusion and Gas Cavities

Nonmetallic inclusions may consist of matter from the rod and flux used or from electrodes. Unless they are caused by use of unsuitable materials, they are attributed to the quality of workmanship, the desired result being to achieve a uniform appearance and freedom from cavities.

14.2.4 Factor 13 Quality of Weld Metal

Inferior quality of weld metal may be caused by incorrect welding technique. In metal arc welding the defects may generally be due to the excessive arc length or speed or incorrect current. The fracture does not possess its customary clean appearance but reveals voids, oxide films and slag inclusions. If present to a considerable extent, they may result in a rough, porous, discoloured and lusterless appearance in the fracture.

SECTION 4 ASSESSMENT OF TEST WELDS

15 PENETRATION OF TEST PIECES

15.1 General

15.1.1 The steel shall be reasonably free from scale, rust, oil, paint and other defects which may adversely affect welding.

15.1.2 Position of welding for the test pieces may be decided according to the subsections 3A, 3B or 3C, as relevant.

15.2 Butt Weld Test Piece

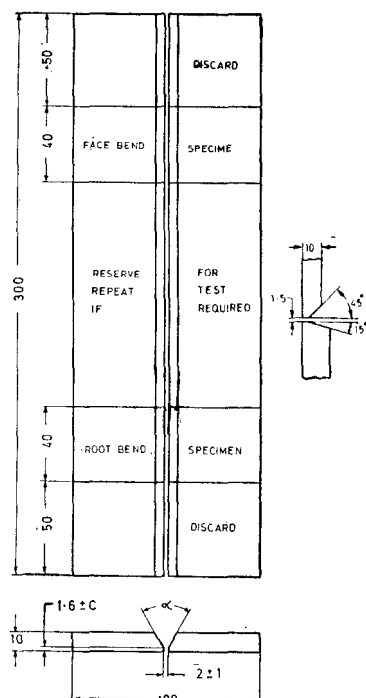
The test pieces shall conform to the requirements of Fig. 14. The edges to be welded shall be prepared preferably by machining or by smooth flame cutting. The joint preparation shall be unbacked V.

The plates should be slightly preset so that they are reasonably flat after welding. The runs should be deposited as per the guidelines of the respective sub-sections namely 3A, 3B and 3C. The plate welds are to be back chipped or flame gouged to a semicircular groove to a depth of 3 mm. The center line of the 'back chip groove' should essentially coincide with weld center line. After back chipping the sealing run shall be deposited. Each run of weld shall be stopped and restarted with a fresh filler rod within the central 50 mm of the test piece.

15.3 Fillet Weld Break Test Piece

The test piece shall conform to the requirements of Fig. 15. The test weld should be deposited using 4 mm filler rods to deposit a weld of 6 mm leg length. The weld should be stopped and restarted with a fresh filler rod within the central 50 mm of the test piece.

NOTE — Weld to be stopped and restarted with a fresh electrode within central 50 mm.



Position	α
F	60° — 65°
H—V	60° — 65°
V (UP)	70° — 75°
V (DOWN)	70° — 75°
O	80° — 85°

Weld to be Stopped and Restricted with a Fresh Electrode within Central 50 mm

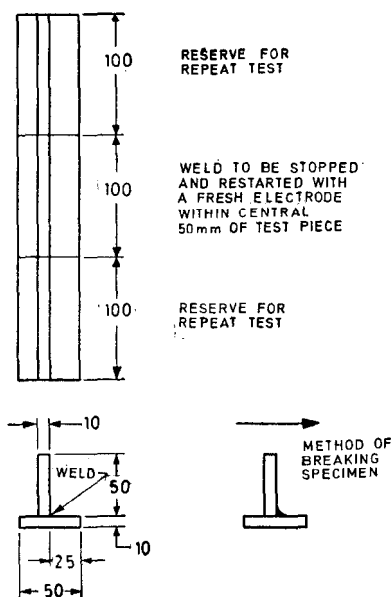
All dimensions in millimetres.

FIG. 14 METHOD OF MAKING BUTT WELD BEND TEST SPECIMEN FOR INITIAL QUALIFICATION TEST AND ANNUAL TEST

16 MARKING OF TEST PIECES

16.1 Each completed test plate shall be indelibly marked in such a manner as to identify each specimen that will be removed therefrom. The marking shall identify:

- the trainee,
- the position of welding, and
- the size of electrodes used.



All dimensions in millimetres.

FIG. 15 METHOD OF MAKING FILLET WELD BREAK TEST SPECIMEN

17 ASSESSMENT

17.1 By Visual Examination

Test pieces shall be visually examined for the following:

- Dimensions of Weld Deposit** — The dimensions of the weld shall be checked. The finished weld should be slightly over rather than under the specified size.
- Shape of Profile** — In butt welds, the surface should be slightly convex. Typical profile views for butt welds have been illustrated in Fig. 11.
In fillet welds the contour may vary from concave to convex, according to the type of electrode or filler material, the welding position and technique. Typical profile views for the normal fillet welds have been shown in Fig. 12.
- Uniformity of Surface** — The height and spacing of ripples shall be uniform.
- Degree of Undercut** — The welded joint shall be free from undercut, but slight intermittent occurrences may be disregarded provided that such undercut is not in the form of a sharp notch.

e) *Smoothness of Joint where Welding is Recommended* — The joint in the weld run where welding has been recommended shall be as smooth as practicable and shall show no pronounced lump or recess in the weld surface.

f) *Freedom from Surface Cavities and Trapped slag* — The surface of the weld shall be free from porosity, cavities and trapped slag.

17.2 By Testing

17.2.1 Butt Welds

After external visual assessment of the butt weld test pieces, two bend test specimens each 40 mm wide shall be cut from the test piece by sawing or machining (see Fig. 14). The upper and lower surfaces of the weld shall be filed ground or machined, level with respective original surfaces of the plates. Tool marks should be avoided as they lead to localization of stresses and may cause premature failure. For this reason the direction of machining of the surfaces should be along the specimen and transverse to the weld. The sharp corners of the test specimen shall be rounded to a radius not exceeding 1 mm. The specimen shall then be bent to an angle of 180° over a former having a diameter equal to four times the thickness of the specimen as shown in Fig. 16. One test specimen shall be

tested with the face of weld in tension and the other with the root of the weld in tension. A good weld should show no crack or defect of a dimension greater than 3 mm measured along the weld and 1.6 mm measured across the weld. Premature failure at the corner of test specimen should not be regarded as cause for rejection. Prior to bending, the edges should be etched to reveal the weld, if this is not sufficiently discernible to ensure that the bending takes place at the center line on the weld.

17.2.2 Fillet Weld Break Test

After external-visual assessment of the fillet weld break test piece, the test piece shall be cut into three equal portions by sawing or machining and break open along the weld and the weld fracture examined (see Fig. 15). The weld fracture shall be examined, keeping in view the following factors:

a) *Degree of fusion* — Fusion should be complete over the whole area of the joint surfaces. The fracture should be inspected for lack of fusion. This may occur at the surfaces to be joined and between layers of weld metal. Lack of fusion at the joint surfaces is indicated by the retention of the original form and surface markings; between layers of weld metal it would appear as lines between the layers.

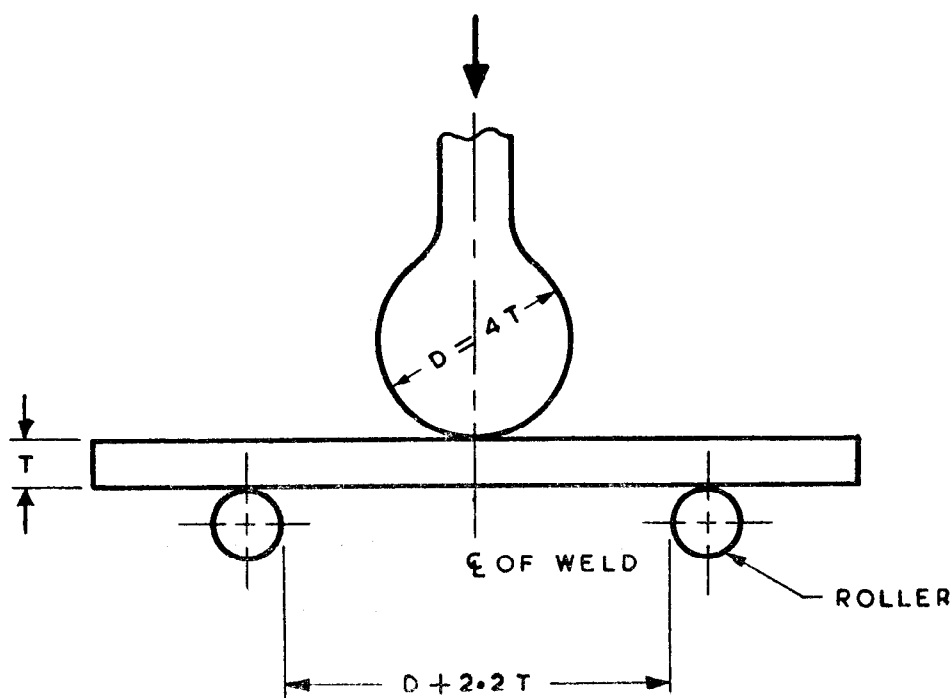


FIG. 16 METHOD OF CARRYING OUT BEND TEST

- b) *Degree of root penetration* — Defects are most likely to occur at the root at the weld. In normal fillet welds with good root penetration the weld metal should reach the corner (see Fig. 11 and 12).

The fracture shall have a clean uniform appearance and the weld metal should be free from cavities and slag inclusions.

ANNEX A

(Clause 8.7)

ACCESSORIES AND EQUIPMENT RECOMMENDED FOR TRAINING ESTABLISHMENT FOR WELDERS

A-1 SHOP MACHINES AND ACCESSORY EQUIPMENT

A-1.1 The training establishment shall be provided with the following shop and accessory equipment:

- a) Heavy work bench with machinist's or blacksmith's vice weighing 30 kg or more;
- b) Gas cutting torch (manual or machine type) or plate shear for preparing plates for welding and for cutting test specimen;
- c) Two-ended pedestal grinder with 25×3 cm (or larger) coarse wheels and wheel dresser;
- d) Heavy power hacksaw (preferably 25 mm width capacity) or horizontal metal band saw;
- e) Portable or flexible shaft grinder;
- f) Equipment for machining test specimens;
- g) Guided-bend test device with hydraulic jack of 8 tones or larger capacity;
- h) Break or rupture device with hydraulic jack of 8 tones or larger capacity;
- j) Fire extinguishers, chemical type;
- k) Fire buckets with water;
- m) Sand bags of fire protection;
- n) Scrap box $90 \times 60 \times 30$ cm;
- p) Chartboard for progress chart, instructional charts and notices;
- q) Small platform scales for weighing electrodes, etc;

- r) First aid kit;
- s) Provisions for sterilizing welding helmets;
- t) Anvil 45 kg or heavier;
- u) Display board for sample specimens of welding exercises; and
- v) Hot metal quenching tank.

NOTE — Facilities for showing motion pictures, film strips and slides have been found to be of assistance.

A-2 SMALL TOOLS AND ACCESSORIES

A-2.1 While welding, each trainee shall be supplied with the following equipment:

- a) Sledge hammer for rupturing check test specimens;
- b) Ball peen hammer;
- c) C-clamps;
- d) Cold chisels;
- e) Center punches;
- f) Scribes;
- g) Metal rules;
- h) Try squares;
- j) Sets of metal marking steel stamps (letters and figures of 5 mm height);
- k) Small steel wedges;
- m) Medium coarse files for rounding edges of test specimen; and
- n) Soapstone marking crayon.

A-3 REQUIREMENTS FOR EACH TRAINEE WHILE WELDING

A-3.1 While welding, each trainee shall be supplied with the following equipment:

- a) Helmet or hand shield with suitable coloured filter lens and clear cover glass;
- b) Welding and cutting torches;
- c) Ground clamp (where necessary leather gloves, or gauntlets);
- d) Safety goggles for use while chipping and cleaning welds and for flash protection;
- e) Wire scratch brush;

f) Slag-chipping hammer; and

g) Pair of short pick-up tongs or heavy gas pipe pliers.

A-4 EQUIPMENT FOR TRAINEE OBSERVERS AND INSTRUCTORS WHILE OBSERVING

A-4.1 While welding each instructor and trainee shall be supplied with the following equipment:

- a) Helmet or hand shield with suitable coloured filler glass and clear cover glass, and
- b) Weld gauges (*see* BIS Handbook of Manual Metal Arc Welding for Welders).

ANNEX B

(*Clause 9.2*)

RECOMMENDED FORM OF TRAINEE PROGRESS CHART

Sl No.

Name.....
Address.....
Local Address.....
Employer's Name & Address.....
.....

Courses required (*see* Note):

1. Butt Welds in Flat Position and Fillet Welds in Flat and Horizontal-Vertical Position,
2. Butt and Fillet Welds in Vertical Position and Butt Welds in Horizontal-Vertical Position, and
3. Butt Welds in Fillet Welds in Overhead Position.

NOTE — These courses correspond to Sub-section 3A, 3B, and 3C of Section 3.

Special remarks, if any.....

Terms of payment — Cash/Credit/Free

Date in.....Date out.....Total Period (weeks).....

Lesson 1 Butt Welds in Flat Position and Fillet Welds in Flat and Horizontal-Vertical Position	Dates	Days	Total No. of Hours of Actual Welding Practice	Estimated Time Observing Weld and Test Specimens
Striking the arc and bead welding				
Striking the arc				
Running beads (flat position				
Bead welds weaving technique (flat position)				
Status of progress				
Welding of butt joints and fillet joints in flat position				
Corner weld				
Single-run fillet weld				
Multi-run fillet weld				
Butt weld (see Fig. 8A)				
Butt weld (see Fig. 6)				
Making check test specimen No. 1				
Making check test specimen No. 2				
Status of progress				
Welding of fillet joints in the horizontal-vertical position				
Single-run fillet weld				
Multi check test specimen No. 3				
Making check test specimen No. 4				
Status of progress				

Lesson 2 Butt and Fillet Weld in Vertical Position Welds in Flat and Horizontal-Vertical Position	Dates	Days	Total No. of Hours of Actual Welding Practice	Estimated Time Observing Weld and Test Specimens
Welding in vertical position				
Bead welds and reinforcing pad in horizontal-vertical position				
Butt welds (see Fig. 10)				
Butt welds (see Fig. 14)				
Making check test specimen No. 5				
Making check test specimen No. 6				
Status of progress				
Welding in horizontal-vertical position for butt welds				
Bead welds-vertical up and vertical down				
Single-run fillet welds- vertical up				
Multi-run fillet welds- vertical up				
Butt welds				
Corner welds-down direction				
Making check test specimen No. 7				
Status of progress				

Lesson 3 Welding in Overhead Position Welds in Flat and Horizontal- Vertical Position	Dates	Days	Total No. of Hours of Actual Welding Practice	Estimated Time Observing Weld and Test Specimens
Bead welds in overhead position				
Single-run fillet weld				
Multi-run fillet weld				
Butt weld				
Making check test specimen No. 8				
Making check test specimen No. 9				
Status of progress				

ANNEX C

(Clause 10.1)

RECOMMENDED SYLLABUS FOR A 8-WEEK TRAINING COURSE IN
VARIOUS SUB-SECTIONS OF SECTION 3**C-1 BUTT WELDS IN FLAT POSITION AND
FILLET WELDS INITIAL AND HORIZON-
TAL-VERTICAL POSITIONS (See 13)****Periods:**

1 Actual welding practice 72 hrs

2 Theory

2.1 Safety of oxy-acetylene, electric weld- 4 hrs
ing and cutting and other operations2.2 Blue print reading, welding symbols, 4 hrs
etc

2.3 Basic electricity for welding 4 hrs

**C-2 BUTT AND FILLET WELDS IN VERTI-
CAL POSITIONS AND BUTT WELDS IN
HORIZONTAL-VERTICAL POSITION
(See 13)****Periods:**

1 Actual welding practice 72 hrs

2 Theory

2.1 Manual metal arc welding, arc charac- 6 hrs
teristics, power sources, electrodes
and techniques of air arc gouging2.2 Oxy-acetylene welding and gas 2 hrs
cutting**C-3 WELDING IN OVERHEAD POSITION
(See 13)****Periods:**

1 Actual welding practice 48 hrs

2 Theory

2.1 Classification of steels, basic 4 hrs
welding metallurgy, macro and
micro examinations2.2 Effect of various weld defects, 4 hrs
their causes and remediesNOTE — The number of hours mentioned are for
guidance only.

ANNEX D

(Clause 12.1.1)

RECOMMENDED SAFETY RULES

DO

- 1 Wear leather gloves, adequate clothing and heavy shoes, tightly laced.
- 2 Wear a helmet or use a shield when in the vicinity of welding or flash arc.
- 3 Remove combustible materials from the vicinity of welding or gas cutting operations.
- 4 Get prompt first aid if burned or if your eyes have been injured by a flash or flying scale.
- 5 Wear safety goggles when chipping, grinding, peening or removing slag.
- 6 Keep booth and floor clean and clear of electrode stubs, scraps of metal and carelessly disposed tools.
- 7 Know how to use the fire extinguishers and memorize their location.
- 8 See that hose connections are tight and that cables do not become hot.
- 9 Make proper provision for venting exhaust gases when operating the tip of the torch in confined spaces.

DON'T

- 1 Look at a welding flash with the naked eye.
- 2 Use cracked or defective helmets or shields.
- 3 Hang a torch with its hose on regulators or cylinder valves.
- 4 Pick up hot objects.
- 5 Use electrode holders with defective jaws.
- 6 Leave the electrode holder on the table or in contact with a grounded metallic surface. Replace it on the support provided for that purpose.
- 7 Weld on closed containers or on containers that have held combustible materials. Secure permission from the instructor before welding on any container.
- 8 Weld in the vicinity of flammable or combustible materials.

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{ 632 92 95, 632 78 58,
632 78 91, 632 78 92

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