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(Reaffirmed 1998)

Indian Standard

CODE OF PRACTICE FOR WELDING OF MILD
STEEL PLAIN AND DEFORMED BARS FOR
REINFORCED CONCRETE CONSTRUCTION

(*First Revision*)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

CODE OF PRACTICE FOR WELDING OF MILD STEEL PLAIN AND DEFORMED BARS FOR REINFORCED CONCRETE CONSTRUCTION

(*First Revision*)

Structural Welding Sectional Committee, SMDC 15

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(*Continued on page 2*)

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Indian Standard

CODE OF PRACTICE FOR WELDING OF MILD STEEL PLAIN AND DEFORMED BARS FOR REINFORCED CONCRETE CONSTRUCTION

(*First Revision*)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 15 February 1979, after the draft finalized by the Structural Welding Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was first published in 1966. In this revision the following modifications have been effected:

- a) Mild steel deformed bars have been brought under the purview of the standard;
- b) Use of flash butt welding, thermit welding and gas pressure welding processes have been permitted;
- c) Provisions regarding the quality of welds and inspection of welds have been included; and
- d) A bend test has been specified as initial test.

0.3 This standard keeps in view the practices being followed in the country in this field. Assistance has also been derived from the following publications:

CSA W 186-1970 Welding of reinforcing bars in reinforced concrete construction, Canadian Standards Institution, Ontario, Canada.

AWS D 12.1-1961 Recommended practices for welding reinforcing steel, metal inserts and connection in reinforced concrete construction, American Welding Society, New York (USA).

0.4 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, 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 lays down requirements for welding of mild steel round and deformed bars conforming to the following standards:

Mild steel, Grade I conforming to IS : 432 (Part I)-1966†.

Mild steel deformed bars conforming to IS : 1139-1966‡.

1.1.1 This standard is not applicable to welding of medium tensile and high tensile steel bars and hard drawn steel wires for concrete reinforcement.

1.1.2 Welding of cold-twisted bars will be covered in a separate standard.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 812-1957§ shall apply. Definitions of some of the common terms extracted from that standard are given in Appendix A.

3. PLANS AND DRAWINGS

3.1 Plans and drawings for welding of reinforcing bars shall be prepared in accordance with IS : 696-1972||.

4. SYMBOLS

4.1 Symbols for welding used in plans and shop drawings shall conform to IS : 813-1961¶.

4.1.1 If symbols other than those given in IS : 813-1961¶ are used a complete explanation of their meaning shall be given in the drawings.

*Rules for rounding off numerical values (revised).

†Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement, Part I Mild steel and medium tensile steel bars (second revision).

‡Specification for hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcements (revised).

§Glossary of terms relating to welding and cutting of metals.

||Code of practice for general engineering drawings (second revision).

¶Scheme of symbols for welding.

5. WELDING EQUIPMENT AND ACCESSORIES

5.1 Welding equipment and accessories used in welding of reinforcing steel bars shall conform to the requirements of the appropriate Indian Standards wherever available. Where an Indian Standard is not available, equipment and accessories used shall be of the best available quality. Their capacity shall be adequate for the welding procedure laid down. A general guidance for selection of equipment and accessories is included in Appendix B.

6. WELDING PROCESSES

6.1 The reinforcement bars may be welded by any of the following processes:

- a) Flash butt welding,
- b) Manual metal-arc welding,
- c) Oxy-acetylene process,
- d) Gas pressure welding, and
- e) Thermit welding.

7. PARENT METAL

7.1 The parent metal to be welded shall conform to the following:

Mild steel Grade I bars conforming to IS : 432 (Part I)-1966*.

Mild steel deformed bars conforming to IS : 1139-1966†.

8. ELECTRODES AND FILLER RODS

8.1 Covered electrodes for manual metal arc welding shall conform to IS : 814 (Part I)-1974‡ and IS : 814 (Part II)-1974§.

8.2 Mild steel filler rods for oxy-acetylene welding shall conform to type S-FS7 of IS : 1278-1972|| provided they are capable of giving a minimum butt weld tensile strength of 410 MPa.

*Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement. Part I Mild steel and medium tensile steel bars (*second revision*).

†Specification for hot-rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcements (*revised*).

‡Specification for covered electrodes for metal arc welding of structural steel: Part I For welding products other than sheets (*fourth revision*).

§Specification for covered electrodes for metal arc welding of structural steel: Part II For welding sheets (*fourth revision*).

||Specification for filler rods for gas welding (*second revision*).

8.3 Mixtures for thermit welding shall be capable of yielding weld metal of the required composition and the tensile strength shall be at least 410 MPa.

NOTE — 1 MPa = 10·197 kgf/cm².

9. WELDER'S QUALIFICATIONS

9.1 In the case of manual metal arc welding, only welders who have passed the qualifying tests prescribed in Appendix C shall be employed.

9.2 In the case of oxy-acetylene welding, only welders who have passed the qualifying tests prescribed in Appendix D shall be employed.

10. FLASH BUTT WELDING

10.0 Electric flash butt welding may be adopted if a number of welds have to be done at the same place and when the electric supply is available of the required capacity in respect of the cross-sectional area of the maximum size of bar to be welded.

10.1 Preparation for Welding — The ends of the bars to be welded shall be sheared off so that fresh steel surfaces are available for welding. The surfaces of the ends of the bars to be clamped shall be cleaned free from rust to enable free flow of electricity in the bars.

10.2 Procedure

10.2.0 The procedure for flash butt welding shall generally be in accordance with the 'Indian Standard Recommended procedure for flash butt welding' (*under preparation*).

10.2.1 The ends of the bars to be welded are placed in proper alignment in the clamps so that bent or eccentric joints do not result. The clamps should be cleaned before each welding operation to avoid current losses and also to eliminate harmful notches or grooves due to burning in of spots of arcing.

10.2.2 Welding should be done without any preheating of bars. The bar ends shall be uniformly pushed against each other from the moment of contact up to the upsetting. The transformer regulator should be so set that the current at the contact area is between 85 and 90 A/mm².

10.2.3 If the butt welding machine or the available power is not sufficient to take the load for welding the bar in the cold condition, welding may be done after preheating. By repeated making and breaking of the contact arc, heat can be made to spread over the entire cross section of the bar. The number of short circuits (contacts and reversing) should be kept to the minimum possible so that the welding time and

spread of heat in the longitudinal directions in the bar is minimum. Satisfactory joints with only slight reduction in the original strength of the bar can be achieved with current densities up to 25 A/mm²

10.2.4 In automatic machines, the flash rate should be so set that a continuous flash without interruption can be achieved. If too high a rate is set, then additional short circuits are required leading to a heat spreading. If the rate is too low, the flash will be interrupted, consequently air penetrating into the joint will form oxides. If the machine is hand operated the flash should be maintained to avoid interruption.

10.2.5 Burn-Off Length — For bars with sheared ends a burn-off (flash-off) length of about 10 mm is required, this length being practically independent of the bar diameter. Very short burn off length leads to defective welding because all the impurities will not have been removed from the place of welding. Increase in the burn off length of the bar thus reducing the strength of the bar.

10.2.6 Upsetting — The upsetting should result from the burning off, that is without interruption in the rain of sparks. The electric supply should be switched off about 1/3 to 1 second after the start of the upsetting or in the case of automatic machine, after 1 to 3 minutes of upset travel.

The voltage and frequency of the current should be checked before commencing the welding operation. Such deviations from the nominal value or large fluctuations during the operation may lead to gross defects in the welding. Wherever possible welding should be done in periods of the day when the total load on the network is fairly balanced.

11. FUSION WELDING OF MILD STEEL BARS

11.0 General — Steel bars shall be either butt welded or lap welded using any of the following fusion welding processes:

- a) Manual metal-arc welding,
- b) Oxy-acetylene welding,
- c) Gas pressure welding, and
- d) Thermit welding.

11.0.1 Thermit welding shall be generally in accordance with the 'Indian Standard recommended practice for fusion welding of ferrous metals by alumino-thermic process' (*under preparation*).

11.1 Butt Welding of Mild Steel Bars

11.1.0 Bars may be spliced by butt welding them directly or through a splice member such as angle, sleeve, bars, etc.

11.1.1 The preparation of edges for different types of butt welds shall be in accordance with Table 1. In Appendix E are given recommendations regarding choice of electrodes, number of runs and welding technique for typical details of butt welds given in Table 1.

TABLE 1 EDGE PREPARATION FOR MANUAL METAL ARC WELDING

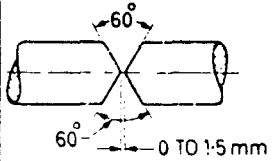
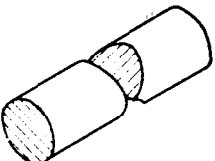
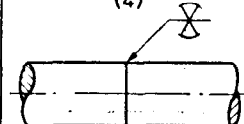
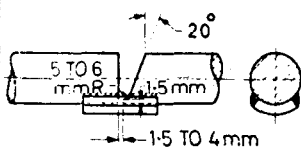
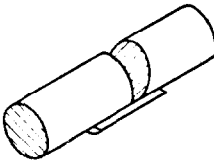
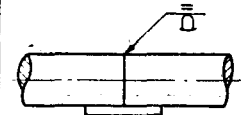
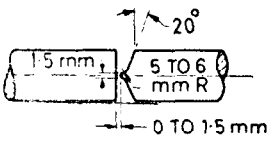
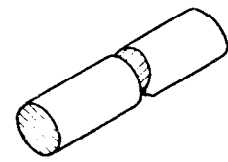
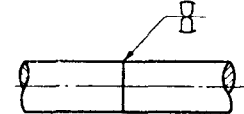
(Clause 11.1.1)

SI No.	DETAIL	TYPE OF JOINT	SYMBOLIC REPRESENTATION	SIZE RANGE	APPLICATION
(1)	(2)	(3)	(4)	(5)	(6)
1				20 to 25 mm	Where the root is accessible for back-chipping and application of a sealing run.
2				Smaller bar 20 to 25 mm welded to larger bar	Where the root is accessible for back-chipping and application of a sealing run.
3				20 to 50 mm	Where access to the root of the weld is unobtainable. Alternatively a removable copper backing bar may be used in place of the integral steel backing shown.

(Continued)

TABLE 1 EDGE PREPARATION FOR MANUAL METAL ARC WELDING - *Contd*

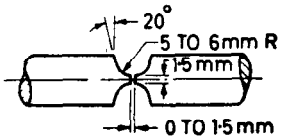
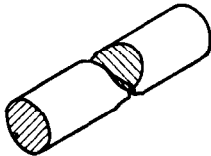
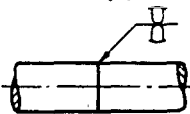
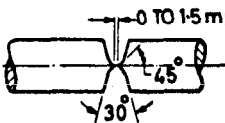
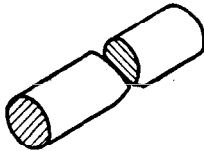

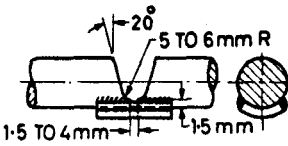
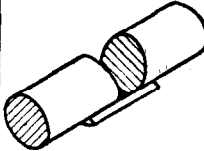
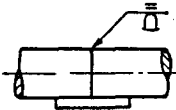
(Clause 11.1.1)

Sl No.	DETAIL	TYPE OF JOINT	SYMBOLIC REPRESENTATION	SIZE RANGE	APPLICATION
4	<p>(2)</p>  <p>60° 60° 0 TO 1.5 mm</p>	<p>(3)</p> 	<p>(4)</p> 	<p>(5)</p> <p>25 to 50 mm</p>	<p>(6)</p> <p>For general use Horizontal bars should be turned for flat position welding wherever possible.</p>
5	 <p>20° 5 TO 6 mm R 1.5 mm 1.5 TO 4 mm</p>			<p>40 to 50 mm</p>	<p>Where access to the root of the weld is unobtainable.</p>
6	 <p>20° 1.5 mm 5 TO 6 mm R 0 TO 1.5 mm</p>			<p>40 to 55 mm</p>	<p>For general use : Horizontal bars should be turned for flat position welding wherever possible.</p>

(Continued)

TABLE 1 EDGE PREPARATION FOR MANUAL METAL ARC WELDING - *Contd*

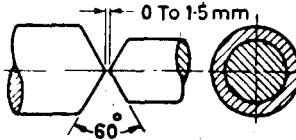
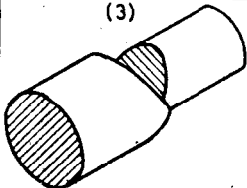
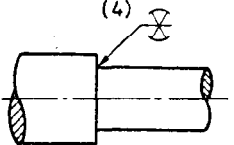
(Clause 11.1.1)

Sl No.	DETAIL	TYPE OF JOINT	SYMBOLIC REPRESENTATION	SIZE RANGE	APPLICATION
(1)	(2)	(3)	(4)	(5)	(6)
7	 <p>20° 5 TO 6mm R 1.5 mm 0 TO 1.5 mm</p>			40 to 50 mm	Where access to the root of the weld is unobtainable.
8	 <p>0 TO 1.5 mm 45° 30°</p>			40 to 50 mm	Where the increased difficulty of preparation will be offset by the reduction in welding cost.
9	 <p>20° 5 TO 6mm R 1.5 TO 4mm 1.5 mm</p>			40 to 50 mm	Where access to the root of the weld is unobtainable.

(Continued)

TABLE 1 EDGE PREPARATION FOR MANUAL METAL ARC WELDING - *Contd*

(Clause 11.1.1)

Sl No.	DETAIL	TYPE OF JOINT	SYMBOLIC REPRESENTATION	SIZE RANGE	APPLICATION
(1)	<p>(2)</p>  <p>0 To 1.5 mm</p> <p>60°</p>	<p>(3)</p> 	<p>(4)</p> 	<p>(5)</p> <p>Smaller bar over 25 mm welded to larger bar</p>	<p>(6)</p> <p>For general use: Horizontal bars should be turned for flat position wherever possible.</p>

11.1.2 The edges shall be prepared by shearing, machining or oxy-acetylene flame cutting. Bevelling may be done by chipping, machining, grinding, or oxygen cutting. The joint faces and the surrounding portion of the bars shall be free from scale, dirt, grease, paint, rust and contaminants.

11.1.3 *Direct Butt-Welding of Bars of Unequal Cross Section*

11.1.3.1 In butt welding steel parts in line with each other and which are intended to withstand dynamic, repeating or alternating forces, and which are of unequal cross-section where the difference in size of parts exceeds 25 percent of the size of the thinner part or 3 mm, whichever is greater the size of the smaller part, the slope being not steeper than 1 in 5 (see Fig. 1).

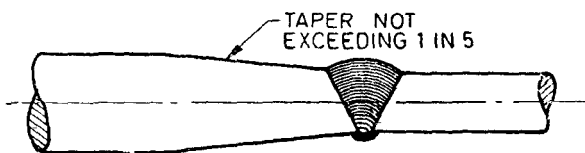


FIG. 1 BUTT WELDING BARS OF UNEQUAL SIZE

11.1.3.2 Where the reduction of the size is impracticable, and/or where the structure is not designed to withstand dynamic, repeating or alternating forces, the weld metal should be built up at the junction with the thicker bar to the size of the thicker member.

11.1.4 When it is not possible to rotate the bars for welding in flat position the axis of the bars shall be horizontal and the respective axes of welds shall be vertical, that is, welds being carried out in the vertical position.

11.1.5 In the case of inclined bars, the edge preparation shall be such that welding is done only on sides (see Fig. 2). Different positions of welding are defined in Appendix F.

11.1.6 All the bars to be welded should be aligned and set up in position with their axes in one straight line. The joints may not be out-of-alignment by more than 25 percent of the thickness of the thinner material for material up to and including 12 mm thick, or by more than 3 mm for thicker material. Alignment may be accomplished in a jig, or by means of a clamp or by using guides. Rotation of the bars should be avoided until they are adequately welded, so that no disturbance to the alignment is caused and no twist is introduced in the bars during the process of welding.

11.1.7 In the case of details 4, 6, 7, 8, and 10 of Table 1, back chipping in the root is recommended before welding is commenced on second side. The root run and one further run should be deposited on the first side. Where possible the back chipping and root run on the second side should then follow and the remaining runs should preferably be deposited on alternate sides of the joint to assist in controlling distortion.

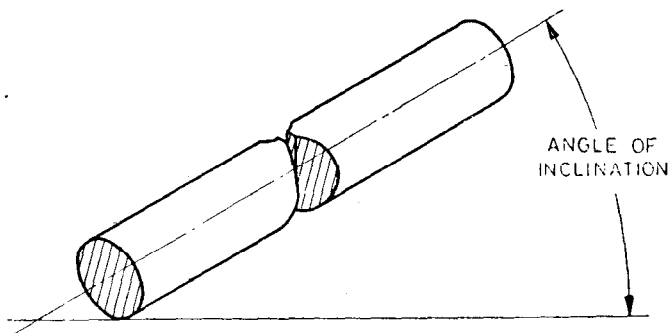
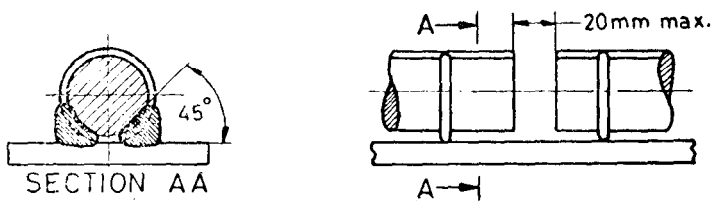
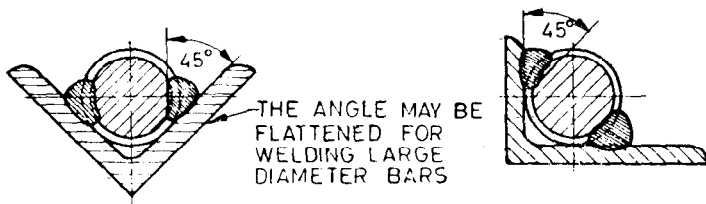


FIG. 2 EDGE PREPARATION OF INCLINED BARS

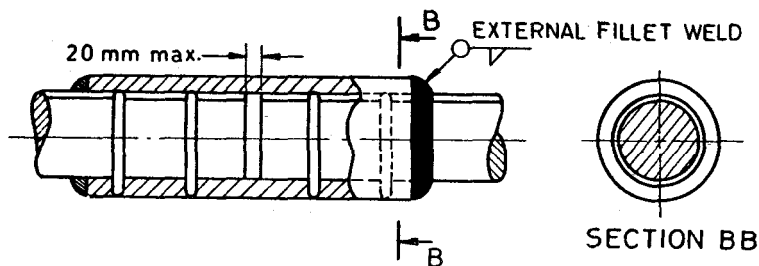


3A Indirect Butt-Splice Using A Plate

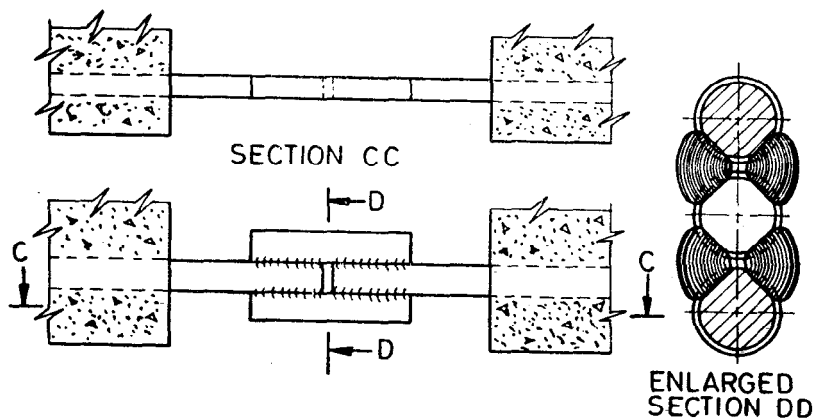


3B Indirect Butt-Splice Using An Angle

(Continued)



3C Indirect Butt-Splice Using A Sleeve



3D Indirect Butt-Splice Using Two Bars

FIG. 3 INDIRECT BUTT SPLICES

11.1.8 Indirect butt splices may be made by welding bars to splice plate, angle, sleeve, etc, using single or double fillet welds (flarebevel groove welds in American terminology) as shown in Fig. 3. The splice member used, that is plate, angle, bar, sleeve, etc, should have a cross-sectional area such that its strength is at least 5 percent higher than the strength of the bars being welded. The bars shall not be eccentric by more than 3 percent of the bars joined. The angles when used may be flattened to suit for welding higher size bars.

11.2 Lap Welding of Mild Steel Bars

11.2.1 Edge preparation is not necessary for lap welds. The length of bars to be welded should be free from scale, dirt, grease, paint, rust and contaminants.

11.2.2 The bars may be lap welded using the details given in Fig. 4. Detail (a) is used when the bars are in contact with each other. If the bars are bent the maximum gap shall be 6 mm.

When the gap between bars is more than 6 mm the joint should be made using a splice bar or plate [see Fig. 4 (b)]. The gap between the bar and splice plate should not exceed 0.25 times the diameter of the bar or 5 mm whichever is less. The area of the splice material shall be at least 5 percent more than the area of the higher size bar being welded.

Some information regarding throat thickness and reinforcement is given in Table 2.

TABLE 2 DETAILS FOR LAP WELDED JOINTS

BAR DIAMETER	THROAT THICKNESS <i>Min</i>	REINFORCEMENT (APPROX)
(1) mm	(2) mm	(3) mm
Up to 12	3	1.5
Over 12 up to 16	3	3
Over 16	5	3

NOTE 1 — If any overhead weld is required, it should be made prior to the flat welds.

NOTE 2 — If the bars are bent, the maximum gap should not exceed 6 mm.

11.2.3 The dimensions of the fillet welds (length and throat thickness) shall be capable of developing the full strength of the bar. The eccentricity in the joint should be taken into consideration in the design calculations.

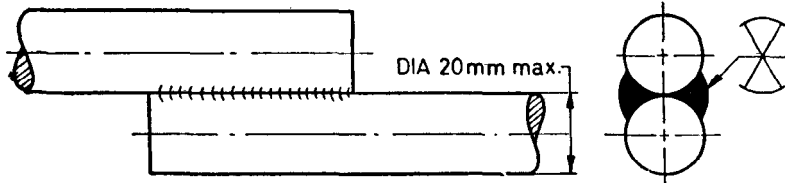
11.3 Square-Butt Welds — Square butt welds may be used for direct butt welding and shall be made using hydrogen controlled electrodes or the thermit welding process.

12. SELECTION OF WELDED JOINTS

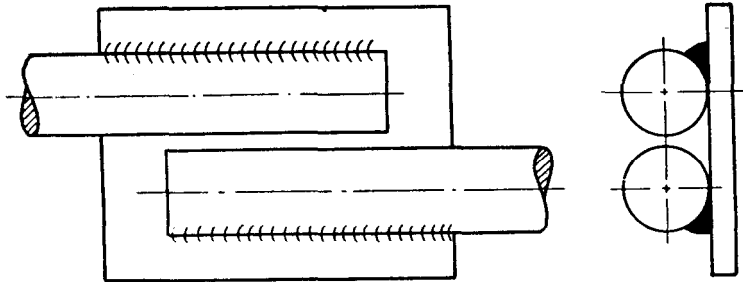
12.1 Direct butt splices (Table 1) and as a second choice indirect butt splices (see Fig. 2) should be specified for bars of diameter 20 mm and over in order to reduce eccentricity effects.

12.2 For bars of diameter up to 20 mm indirect splicing (see Fig. 2) may be used although lap welds are normally adopted for such bars.

12.3 Square Butt Welds — The bars may be directly jointed with square-butt welds provided the welds are made using hydrogen controlled electrodes or thermit welding process.



4A Lap Welding Bars in Contact



4B Lap Welding Bars With Bars Separated by a Distance

FIG. 4 LAP WELDING OF MILD STEEL BARS

13. LOCATION OF WELDED JOINTS

13.1 Welded joints should be staggered in the length of the reinforced concrete components. The joints should also not be positioned in highly stressed areas.

14. INITIAL TESTS

14.1 **Butt Welds** — Test pieces containing butt welds at the centre in the 'as welded' condition shall be selected at the rate of one for tensile test and one for nick break test for every 500 joints.

14.1.1 *Tensile Test* — The selected pieces when subjected to a tensile test shall have a tensile strength not less than 410 MPa (42 kgf/mm²).

14.1.2 *Nick Break Test* — The test specimen shall be notched as given in Fig. 5 and shall be broken open along the weld, the fractured surface visually examined for fusion, root penetration, gas cavities and quality of weld metal. The surface should be reasonably free from cavities, inclusions, etc. There shall be no lack of fusion. Small porosity may, however, be permitted.

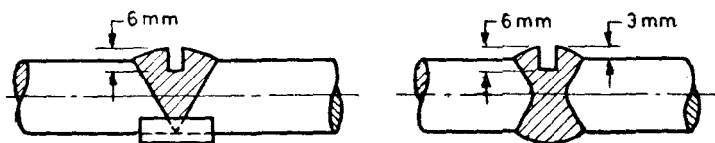


FIG. 5 NICK BREAK TEST SPECIMENS

14.1.3 Bend Test — The specimen shall be bent using any suitable jig. The weld joint should be capable of being bent to an angle of 60° around a mandrel of diameter equal to diameter of bar before any crack appears.

14.2 Lap Joints — Test pieces containing lap joints at their centre shall be selected at the rate of 1 per 500 joints.

14.2.1 Tensile Test — The load required to shear the joint shall be at least equal to the tensile load required to fracture the bar.

NOTE — When pulling lap weld specimens to determine the tensile strength, a jig should be used to prevent distortion due to secondary stresses. The jig may be of design and detail preferred by the testing agency but should prevent change in geometry of the specimen as it is being pulled.

15. RETESTS

15.1 If a sample selected for testing fails to meet the requirements given under 11.1 or 11.2, the purchaser or his representative shall select two further samples from the same lot. If on testing, either of the samples fails to meet the specified requirements, the whole lot shall be rejected.

16. INSPECTION

16.0 For purpose of inspection reference shall be made to IS : 822-1970*.

16.1 The weld size, length and location shall be as stipulated in the drawings, and the metal designated shall be free from cracks, excessive slag inclusions and excessive porosity.

16.2 The weld metal shall be properly fused with the parent metal without overlapping at the toes of the weld.

16.3 There shall be no cracks in the heat affected zones of the reinforcing bars or splice members.

16.4 There shall be no serious undercuts in joint subjected to tension.

16.5 All craters shall be filled to the cross section of the welds.

*Code of procedure for inspection of welds.

16.6 The visible surfaces of all welds shall be free from entrapped slag and shall be regular and of consistently uniform contour.

16.7 All direct butt welds shall be of full cross section with maximum reinforcement of 3 mm and shall blend smoothly into the face of bars.

16.8 The profile of fillet welds shall be substantially flat or slightly convex.

APPENDIX A

(Clause 2.1)

DEFINITIONS

The definitions of some of the common terms extracted from IS: 812-1957* and definitions of some of the other common terms as applicable to this code are given below:

Back Chipping — Chipping into back side of first bead before welding any beads from the back side.

Bead — A single run of weld metal deposited on a surface without transverse oscillation (Fig. 6).

Butt Weld — A weld in which the weld metal lies substantially within the extension of the planes of the surfaces of the parts joined or within the extension of the planes of the smaller of the two parts of different sizes (Fig. 7).

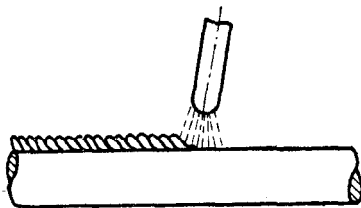


FIG. 6 BEAD WELDING

*Glossary of terms relating to welding and cutting of metals.

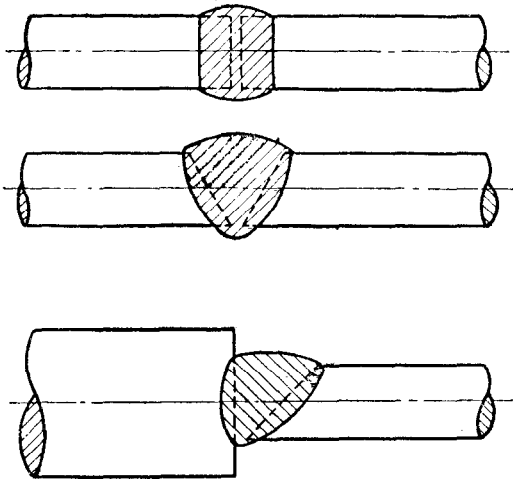


FIG. 7 EXAMPLES OF BUTT WELDS

Edge Preparation— Squaring, grooving or bevelling an edge in preparation for fusion welding (Fig. 8).

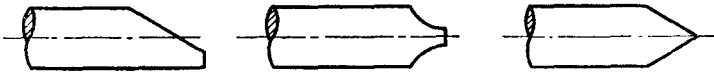


FIG. 8 EXAMPLES OF EDGE PREPARATION

Fusion— The melting together of filler metal and base metal, or of base metal only, which results in coalescence.

Lap Weld— A lap weld is one in which the two bars are set side by side and the welding material so applied as to bind one bar to the face of the other bar (Fig. 9).

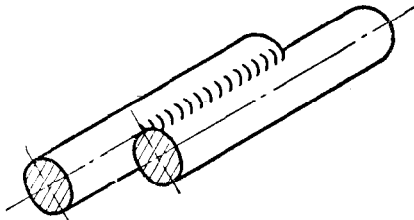


FIG. 9 EXAMPLE OF LAP WELD

Parent Metal — The metal to be joined or cut.

Quality of Weld Metal — Metal intended to be welded and having a suitable chemical composition.

Root — The zone at the bottom of the cross section space provided to contain a fusion weld.

Root Penetration — The depth a groove weld extends into the root of a joint measured on the centre line of the root cross section.

Root Run — A deposit of single width and thickness made in one pass of the electrode.

Rotation — The angle between the upper portion of the vertical reference plane passing through the line of a weld root, and a line drawn through the same root intersecting the weld surface at a point equidistant from either toe of the weld.

Sealing Run — The final run deposited on the root side of a fusion weld.

Slope — The angle between the line of the root of a weld and the horizontal (Fig. 10).

Throat Thickness — The minimum thickness of weld metal in a fusion weld (Fig. 11) measured as under:

- a) For a fillet weld or V-, U-, J- or a bevel butt-weld — Along a line passing through the root;
- b) For a close square butt-weld — In the plane of the abutting faces, and
- c) For an open square butt-weld — At the centre of the original gap in a plane paralalled to the fusion faces.

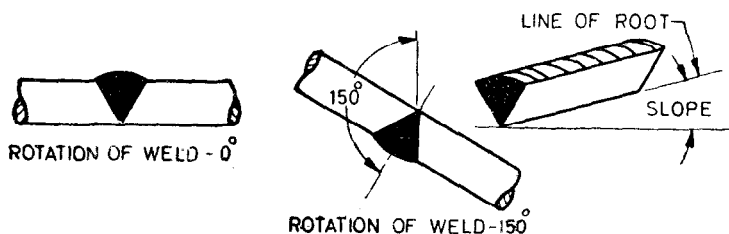
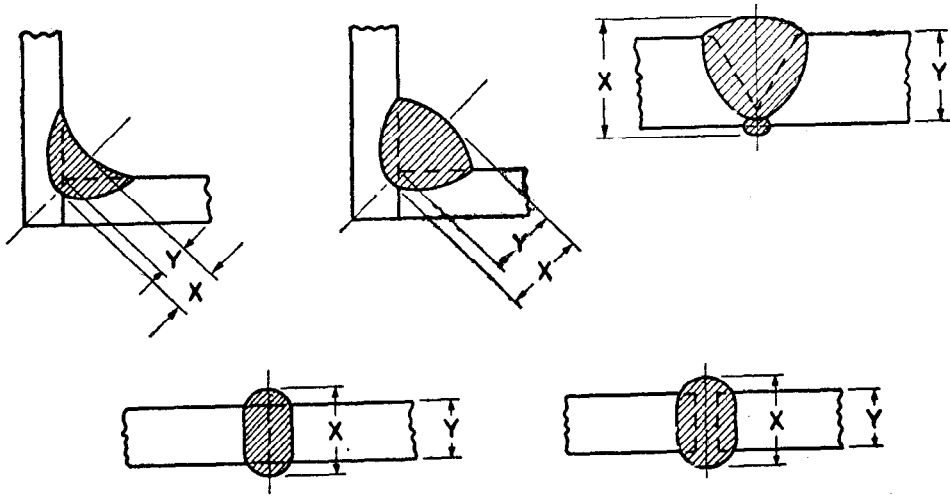


FIG. 10 SLOPE



$X =$ Throat Thickness

$Y =$ The Effective Throat Thickness
as usually adopted

FIG. 11 THROAT THICKNESS

Weaving — Transverse oscillation of the arc end of an electrode or of a blowpipe nozzle during the deposition of weld metals (Fig. 12).

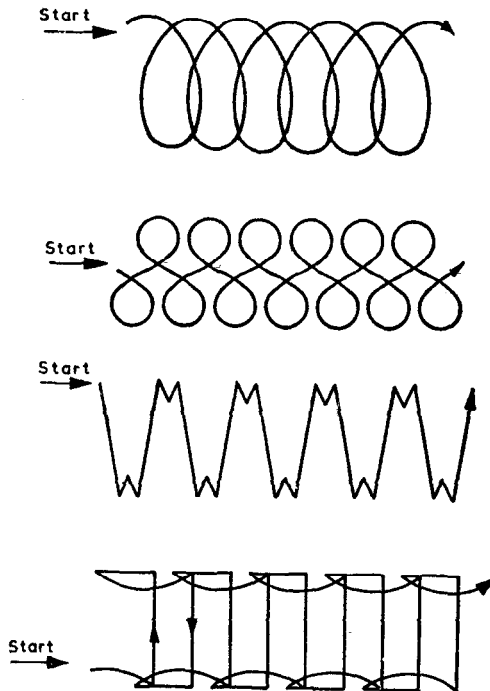


FIG. 12 WEAWE MOTIONS

APPENDIX B

(Clause 5.1)

SELECTION OF EQUIPMENT AND ACCESSORIES FOR WELDING MILD STEEL BARS USED FOR REINFORCED CONCRETE CONSTRUCTION

B-0. GENERAL

B-0.1 The methods of welding covered in this appendix are (a) manual metal arc welding with covered electrodes, and (b) manual oxy-acetylene welding.

B-1. MANUAL METAL ARC WELDING EQUIPMENT

B-1.1 In its simplest form, equipment required for manual metal arc welding of mild steel bars for concrete reinforcing consists of:

- a) a welding power source;
- b) accessories, such as electrode holders, earth clamp, welding cable, connectors, chipping hammer and wire brush;
- c) protective equipment for the operator, such as hand screen or helmet, gloves, apron, etc; and
- d) suitable electrode storage and drying equipment, where necessary.

B-1.2 Welding Power Source — The current for welding may be alternating or direct. There is little to choose between them for work involving mild steel welding. Electricity from the mains is usually at too high a voltage for arc welding. Various types of equipment are used for reducing this voltage and delivering a welding current of the right characteristics.

B-1.2.1 Alternating current transformer equipment of the oil-cooled or air-cooled type have the advantage of being low in initial cost and requiring very little maintenance. Various types of controls for varying the current to suit conditions are in common use. Some of these are: (a) a static choke with tappings, (b) a choke the value of which may be varied by means of movements of the core, (c) a choke with a saturable core, and (d) a variable flux linkage transformer. Being essentially a single phase load, welding transformers when connected to 3-phase supply mains may cause slightly unbalanced load conditions. Condensers of adequate rating may also be connected across the input lines for improving the power factor.

B-1.2.2 Rotary machines, such as motor generators suitable for use on alternating-current mains give a direct current output of the required characteristics. They have the advantage that they impose a balanced load on 3-phase supply mains. They are, however, initially more expensive and require more maintenance than transformers.

B-1.2.3 Where the mains supply is direct current, a motor generator designed for direct current mains use has to be selected.

B-1.2.4 Rectifier welding sets which are relatively high in initial cost, require very little maintenance because of elimination of most moving parts. They also impose a balanced load on 3-phase supply mains.

B-1.2.5 For work at sites where mains power supply is not available, a petrol or diesel engine driven welding generator may be selected. Such machines are often mounted on trailers for easy portability.

B-1.2.6 Other points to be considered when selecting the equipment are (a) that the machine is designed to work satisfactorily in the climatic conditions that will be met with in service; (b) that it is well made and conforms to national standards, wherever these exist; and (c) that the current capacity is adequate for welding with the sizes of electrodes expected to be used.

B-1.2.6.1 Transformer welding equipment are covered in IS : 1851-1966* and motors generator equipment for manual metal arc welding are covered in IS : 2635-1966†.

B-1.2.6.2 Electrode holders shall conform to the requirements laid down in IS : 2641-1964‡ for this accessory and be of suitable rating for welding with electrodes in sizes expected to be used.

B-1.2.6.3 Welding cables shall conform to specifications laid down in IS : 434 (Part I)-1964§ if cables with copper conductors are used. Cables with aluminium conductors shall be of a quality proved for performance. Two lengths of cables are required, one from the welding set to the electrode holder and the other from the work piece to the welding set.

B-1.2.6.4 All cable terminal connections, such as sockets, earth clamp, etc, shall also conform to the requirements specified in IS : 2641-1964‡.

B-1.2.6.5 A well-made chipping hammer with a hardened and tough cutting edge and a narrow type wire brush which may reach the root of the weld would also be required for deslagging and cleaning the weld.

B-1.3 Protective Equipment — A non-conducting hand screen or helmet fitted with protective filter lens will be required to protect the face and eyes of the operator from the ultra-violet and infra-red rays emitted by the arc. The filter lens has the double function of securing good vision of the arc and giving effective protection by cutting off the harmful rays. The eye and face protection equipment should conform to the appropriate stipulations laid down in IS : 1179-1967||.

*Specification for single operator type arc welding transformer (*first revision*).

†Specification for dc electric welding generators (*revised*).

‡Specification for electrical welding accessories.

§Specification for rubber-insulated cables: Part I With copper conductors (*revised*).

||Specification for equipment for eye and face protection during welding (*first revision*).

B-1.3.1 Aprons and leather gloves should be of a standard that has been proved adequate for welders' use. Shoulder guards, leggings and other such protective garments may be necessary when the operator has to do positional welding in conditions where freedom of movement is restricted.

B-1.4 Storage — The condition of the electrodes used has an important bearing on the ultimate quality of the weld produced. Particularly, when moist ambient conditions are envisaged, for instance at site work, the storage of electrodes has to be given much attention. Heated storage cabinets or drying ovens are a 'must' when low hydrogen type electrodes are being used for site work. Other types of electrodes also are preferably stored before use in such cabinets, when ambient conditions are unfavourable.

B-2. MANUAL OXY-ACETYLENE WELDING EQUIPMENT

B-2.1 In its simplest form, the equipment required for oxy-acetylene welding of mild steel bars comprises the following:

- a) Supplies of oxygen and acetylene gases;
- b) Pressure regulators;
- c) A welding blowpipe;
- d) Lengths of welding hose, one each for oxygen and acetylene;
- e) Accessories, such as connections, hose clips, keys, spanners and spark lighters; and
- f) Protective equipment for the welder, such as gloves and goggles.

B-2.2 Supplies of Oxygen and Acetylene Gases — Oxygen for the type of welding work involved in this application (*see* IS : 309-1974*), is most conveniently obtained in steel cylinders in which it is filled at high pressures usually of the order of 133·37 kPa. Cylinders having a nominal capacity of approximately 6 cubic metres are the most convenient.

B-2.2.1 Acetylene may either be obtained from industrial gas manufacturers in steel cylinders in which it is stored at high pressure or generated at site. High pressure acetylene in cylinders, which is commonly known as 'Dissolved Acetylene' since the gas is kept dissolved in acetone under pressure, is in a form ready for use and free from impurities which would be detrimental to weld quality. Since the gas is available at a pressure, a simple mixer type welding blowpipe is adequate.

B-2.2.2 Generation of acetylene at site may be done by using either a carbide-to-water or a water-to-carbide generator. Poorly designed or made

*Specification for compressed oxygen gas (*second revision*).

acetylene generators may be a source of considerable danger to life and property. The generator used shall be of a design and manufacture approved by authorities concerned with industrial safety. It shall also incorporate safety devices and purifying arrangements.

B-2.2.2.1 Site generation of acetylene would require maintenance of an adequate stock of calcium carbide. Since it would come into the category of hazardous materials, certain precautions have to be taken in storing this material. Where principally it is more economical or convenient to generate at site because of the distance from supply points of high pressure acetylene cylinders, this method of supply is preferred.

B-2.3 Pressure Regulators — Actual working pressures of the welding equipment are much lower than the storage pressure of the gases in cylinders. It is the function of pressure regulators to ensure that the gases are supplied from the cylinders at a steady regulated pressure. For welding, a two-stage regulator capable of maintaining accurate pressures over a wide range of output conditions is recommended. For oxygen, a regulator with an outlet pressure range up to 0.2 MPa and for acetylene (when high pressure dissolved acetylene cylinders are used), a regulator with a maximum outlet pressure of 0.1 MPa is adequate (see also IS : 6901-1973*).

B-2.4 Welding Blowpipe — Welding blowpipes are usually of two types (a) low pressure blowpipes incorporating an injector arrangement to enable the equipment to be used with low pressure generated acetylene, and (b) high pressure blowpipe suitable for use with high pressure acetylene in cylinders. From the welding performance point of view there is little to choose between the two. If generated acetylene is to be used, a low pressure blowpipe is to be chosen. A high pressure blowpipe which is simpler in design and less expensive compared to the low pressure blowpipe should be preferred, if acetylene supply is from cylinders only. A low power blowpipe is suitable for use with acetylene cylinders also but high power equipment shall not be used with low pressure generated acetylene (see IS : 7653-1975†).

B-2.4.1 The choice between high pressure and low pressure having been made the next point to consider is the size of blowpipe. The welding involved in joining mild steel bars, not being of a heavy nature, requires a light duty blowpipe with a maximum output of 708 litres/h (0.708 m³/h) of each gas. A range of interchangeable nozzles or welding heads are usually available for these blowpipes for covering the various sizes of bars to be welded.

*Specification for pressure regulators for gas cylinders used in welding, cutting and related process.

†Specification for manual blowpipes for welding and cutting.

B-2.5 Welding Hoses — For conveying the gases from the regulators to the blowpipes, rubber hoses specially designed for welding use are necessary. Hoses conforming to IS : 447-1968* are recommended. Hose with 5 mm bore is generally used with light duty equipment and 8 mm bore hose with medium and heavy duty equipment. Hoses should be fitted at the ends with appropriate connections of good design to enable secure fitting of the assembly to the blowpipe and regulator. Properly designed hose clips or clamps should be used to achieve a leak-tight joint between the hose and connections.

B-2.5.1 Using long lengths of hose is generally not a good practice but where this is unavoidable, fitted lengths of hoses shall be joined up by the use of suitable connectors or adaptors.

B-2.6 Accessories — Screwed connections for acetylene (or other combustible gas) use are always left-hand threaded and the colour of the hose used is red. Oxygen connections are right-hand threaded and black hose is used. This is to avoid dangers due to inadvertent mistakes when connecting up.

B-2.7 Protective Equipment — Protective equipment that shall necessarily be provided to the welding operator are (a) a pair of good quality leather gloves, designed for welding use; and (b) a pair of good quality welders' goggles conforming to IS : 1179-1967† fitted with filter lenses of approved quality which are known to be capable of protecting the user from the injurious effects of ultra-violet and infra-red emissions during welding. A lens with a light tint is to be preferred when welding reinforcing bars. To protect the lenses from damage by molten metal and sparks, clear protective glasses are usually fitted over the lenses in the goggles.

B-2.7.1 Leather aprons, leggings and shoulder guards may also be required, if working conditions warrant these.

B-2.7.2 Suitable spanners for the various connections in the outfit, a key for opening the cylinder valves, a spark lighter for igniting the gases and a cylinder trolley which may accommodate the cylinders and equipment and make the outfit portable would complete the set.

*Specification for welding and cutting hose of rubber with woven textile reinforcement (*second revision*).

†Specification for equipment for eye and face protection during welding (*first revision*).

APPENDIX C

(Clause 9.1)

QUALIFYING TESTS FOR METAL ARC WELDERS

C-1. GENERAL

C-1.1 The tests shall comprise two butt weld specimens, one for tensile test and the other for nick break test.

C-1.2 The welder is to be tested for work in one or more of the following joint positions:

- Flat (slope 0° , rotation 0°),
- Horizontal-vertical (slope 0° rotation 90°),
- Vertical (upwards, slope 90°), and
- Overhead (slope 0° , rotation 180°).

C-1.2.1 A test taken by a welder successfully in a particular position will normally qualify him for work in that position only. A welder who has qualified in the horizontal-vertical or vertical or overhead positions may, however, be permitted to do work in the flat position also without having to undergo a test in that position.

C-2. MATERIALS

C-2.1 The parent metal used for this test shall be mild steel round bar conforming to IS : 226-1975* or IS : 432-1966† and be reasonably free from scale, rust, oil, paint and other defects which adversely affect welding.

C-2.2 The electrodes used shall conform to IS : 814 (Part I)-1974 and IS : 814 (Part II)-1974‡. It is recommended that the same type of electrode that is intended to be used on the work for which the operator is being tested be used for preparing the test pieces.

C-3. TEST PIECE

C-3.1 The test piece shall be in 25 mm diameter bar and the joint details shall conform to those illustrated in Sl No. 4 of Table 1. Beveling may be

*Specification for structural steel (standard quality) (*fifth revision*).

†Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part I Mild steel and medium tensile steel bars (*second revision*).

‡Specification for covered electrodes for metal arc welding of structural steel:

Part I For welding products other than sheets (*fourth revision*).

Part II For welding sheets (*fourth revision*).

done by chipping, machining, grinding or oxygen cutting. The joint faces and the surrounding materials shall be free from scale, dirt, grease, paint, rust and contaminants.

C-3.2 The bars should be aligned and set up in position with their axes in one straight line. This may be done in a jig or by means of a clamp or by using guides.

C-4. DEPOSITION OF TEST WELD

C-4.1 The root run and one further run should be deposited on the first side. Back-chipping in the root is recommended before welding is commenced on the second side. The sealing run on the second side should then be deposited and the remaining runs should preferably be deposited on alternate sides of the joint to assist in controlling distortion.

C-4.2 For all root runs, the electrode size used shall be 3.2 or 4 mm, the larger size being preferred wherever possible. Four-millimetre electrodes shall be used for the sealing runs and 5 mm for all other runs except in the case of welds in the vertical and overhead positions where 4-mm electrodes shall be used for other runs as well.

C-4.3 For the joint being prepared in the flat position, it is permissible to turn the specimen over for depositing the sealing run.

C-5. ASSESSMENT

C-5.1 Visual Examination — The welds shall be visually examined for the following:

- a) *Shape of Profile* — The profile of the welds shall be uniform, slightly convex and free from overlap at the toes of the welds. The amount of reinforcement shall not exceed 3 mm.
- b) *Uniformity of Surface* — The weld face shall be uniform in appearance throughout its length.
- c) *Degree of Undercut* — The welded joint shall be free from undercut, but slight intermittent occurrences may be disregarded.
- d) *Smoothness of Joints Where Welding is Recommended* — The joints in the weld run, where welding has been recommended, shall be as smooth as practicable and shall show no pronounced, hump or crater in the weld surface.
- e) *Freedom from Surface Defects* — The surface of the weld shall be free from porosity, cavities and trapped slag.

C-5.2 Tensile Test — The upper and lower surfaces of the welds shall be filed round or machined level with the surface of the bar. The specimen

when subjected to a tensile test shall have a tensile strength not less than 410 MPa.

C-5.3 Nick Break Test — The butt welded test specimen shall be notched as given in Fig. 5 and shall be broken open along the weld. The fractured surfaces shall be visually examined for fusion, root penetration, gas cavities and quality of weld metal. The surface should be reasonably free from cavities, inclusions, etc, and there shall be no lack of fusion. Small porosity may, however, be permitted.

C-6. RETESTS

C-6.1 If a sample selected for testing fails to meet the requirements given under **C-4.1**, **C-4.2** and **C-4.3**, the operator should be asked to prepare two more specimens for retest for requirements of the particular clause. If on testing either of the samples fails to meet the specified requirements, the operator is considered to have failed in the test.

APPENDIX D

(*Clause 9.2*)

QUALIFYING TESTS FOR OXY-ACETYLENE WELDERS

D-1. GENERAL

D-1.1 The test shall comprise a plate butt weld specimen for nick break test.

D-1.2 The parent metal used for this test shall conform to IS : 226-1975* and be reasonably free from scale, rust, oil, paint and other defects which adversely affect welding.

D-2. TEST PIECE

D-2.1 The test piece shall be made from two pieces of the bar 20 or 25 mm in diameter and 100 mm long and shall be in accordance with Fig. 13.

D-3. FILLER ROD

D-3.1 The filler rod shall be between 3·15 and 5 mm diameter (*see* IS : 1278-1972†.)

*Specification for structural steel (standard quality) (*fifth revision*).

†Specification for filler rods and wires for gas welding (*second revision*).

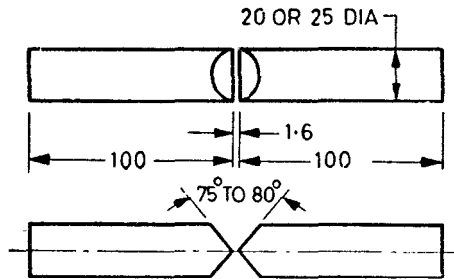


FIG. 13 BUTT WELD TEST PIECE

D-4. ASSESSMENT

D-4.1 The weld shall be visually examined for the following:

- a) *Dimensions of Weld Deposit*
- b) *Shape of Profile* — The profile of the weld shall be uniform, slightly convex and free from overlap at the toes of the weld. The amount of reinforcement shall not exceed 3 mm.
- c) *Uniformity of Surface* — The weld face shall be uniform in appearance throughout its length.
- d) *Degree of Undercut* — The welded joint shall be free from undercut, but slight intermittent occurrences may be disregarded.
- e) *Smoothness of Joints where Welding is Recommended* — The joints in the weld run, where welding has been recommenced, shall be as smooth as practicable and shall show no pronounced hump or crater in the weld surface.
- f) *Freedom from Surface Defects* — The surface of the weld shall be free from porosity, cavities and trapped slag.
- g) *Disposition of Runs.*
- h) *Penetration Bend.*

D-4.2 Nick Break Test — If the visual examination is satisfactory, the test piece shall be sawn across the transverse centre line of the weld to a depth of 6 mm approximately, bent until broken, and the fracture surfaces visually examined for the following:

- a) Degree of fusion,
- b) Degree of root penetration, and
- c) Non-metallic inclusions and gas cavities.

APPENDIX E

(Clause 10.1.1.2)

RECOMMENDED BAR POSITION, WELD POSITION, ELECTRODE SIZE AND WELDING TECHNIQUE FOR BUTT WELDING OF MILD STEEL BARS

E-0. GENERAL

E-0.1 The procedure given in this appendix is for Type 2 and Type 3 electrodes when classified according to IS : 815-1974* the procedure for Type 6 electrodes (low-hydrogen) shall be similar to above. This appendix is not applicable in the case of iron powder electrodes in these classes.

E-1. RECOMMENDATIONS

E-1.1 The recommended size of electrode for root runs is 3.2 mm diameter. However, as far as practicable, maximum size of electrode shall be used for root runs.

E-1.2 In the case of details 1 and 2, back chipping and the application of a sealing run with a 4-mm electrode is recommended, wherever possible.

E-1.3 In the case of details 1, 3 and 6, the recommended technique is a full-width weave except on the final layer on larger diameter bars where it may be desirable to split this into two runs to avoid an excessive width of weave.

E-1.4 The recommended bar position, weld position, electrode size and welding technique for the various weld details specified in Table 1 are given in Table 3.

*Classification and coding of covered electrodes for metal arc welding of structural steel (*second revision*).

TABLE 3 RECOMMENDED BAR POSITION, WELD POSITION ELECTRODE SIZE AND WELDING TECHNIQUE

(Clause E-1.4)

DETAIL	BAR DIA	BAR POSITION	WELD POSITION	ELECTRODE SIZE	WELDING TECHNIQUE
(1)	(2)	(3)	(4)	(5)	(6)
	mm			mm	
1	20	Horizontal	F	4	Weave
1	20	Vertical	H	4	Bead
2	25	Vertical	H	4	Bead
	(Smaller bar)				
3	25	Horizontal	F	5 or 4	Weave
5	40	Horizontal	V	4	Bead
5	40	Vertical	H	4	Bead
6	50	Horizontal	F	4 and 5	Weave
6	50	Horizontal	V	4	Bead
8	Up to 10	Horizontal	H	4	Bead
8	Over 10	Horizontal	H	4	Bead
8	Up to 10	Vertical	V	4	Weave
9	Up to 25	Horizontal	F	5	Weave
9	Over 25	Horizontal	F	5	Weave
9	Up to 25	Vertical	V	4	Weave
10	Over 25	Horizontal	H	4	Weave

F = Flat H = Horizontal V = Vertical

APPENDIX F

(Clause 10.1.1.4)

WELDING IN DIFFERENT POSITIONS

F-1. Welding in different positions is explained below.

- a) *Downhand (Flat) Position* — A position in which the slope and the weld rotation do not exceed 10° (Fig. 14).

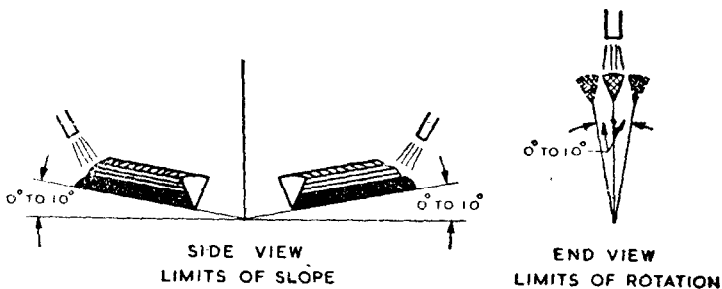


FIG. 14 DOWNHAND (FLAT) POSITION

- b) *Inclined Position* — A position in which the weld slope exceeds 10° but not 45° and in which the weld rotation does not exceed 90° (Fig. 15).

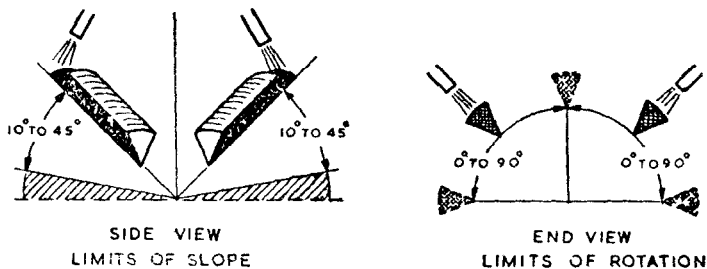


FIG. 15 INCLINED POSITION

- c) *Horizontal-Vertical Position* — A position in which the weld slope does not exceed 10° and the weld rotation is greater than 10° , but does not exceed 90° (Fig. 16).



FIG. 16 HORIZONTAL-VERTICAL POSITION

- d) *Overhead Position* — A position in which the weld slope does not exceed 45° and the weld rotation is greater than 90° (Fig. 17).

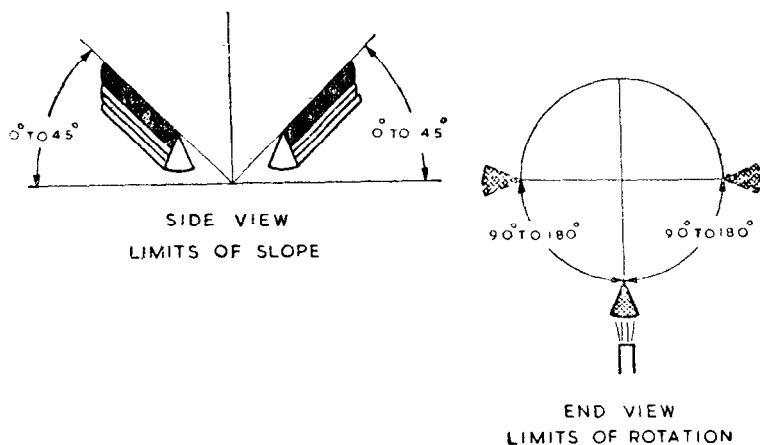


FIG. 17 OVERHEAD POSITION

- e) *Reinforcement* — Weld metal lying outside the plane joining the toes (Fig. 18).

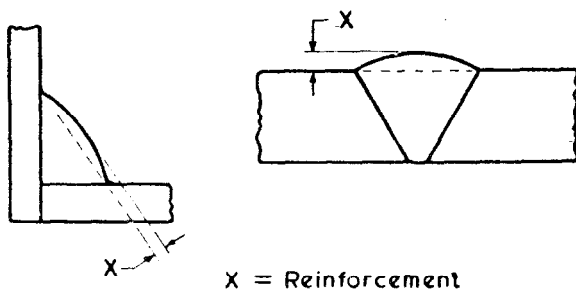


FIG. 18 EXAMPLES OF REINFORCEMENT

f) *Vertical Position* — Any position in which the weld slope exceeds 45° and the weld rotation is greater than 90° (Fig. 19).

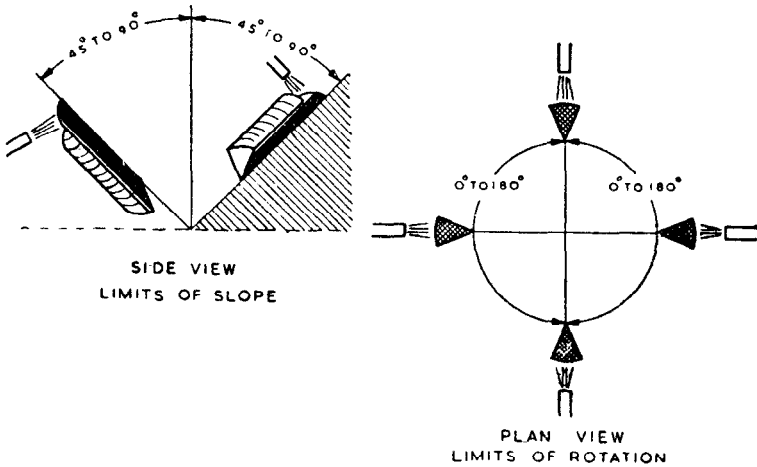


FIG. 19 VERTICAL POSITION

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