IS 814 (2004): Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel [MTD 11: Welding General]

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भारतीय मानक

हस्त्य धातु आर्क वेल्डिंग के लिए आवृत्त कार्बन और कार्बन मैंगनीज इस्पात इलैक्ट्रोड — विशिष्टि

(छठा पुनरीक्षण)

Indian Standard

COVERED ELECTRODES FOR MANUAL METAL ARC WELDING OF CARBON AND CARBON MANGANESE STEEL — SPECIFICATION

(Sixth Revision)

ICS 25.160.20;77.080.20

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

September 2004

Price Group 9

AMENDMENT NO. 1 OCTOBER 2005
TO
IS 814 : 2004 COVERED ELECTRODES FOR MANUAL METAL ARC WELDING OF CARBON AND CARBON MANGANESE STEEL — SPECIFICATION

(Sixth Revision)

[*Foreword, para* 3(a)] — Substitute the following for the existing line:

'Semibasic type (SB) of covering has been included and 'S' type of covering has been deleted.'

(*Foreword, para* 3) — Add 'd)' as follows:

'd) Transverse bend test has been deleted'

[*Page* 2, *clause* 5.1.2(a), *and page* 4, *clause* 5.7] — Substitute 'H_1, H_2, H_3' *for* 'H1, H2 and H3' wherever it appears.

[*Page* 2, *clause* 5.1.2(b), *lines* 1 *to* 4] — Substitute the following for the existing:'

"Letters J, K and L indicating increased metal recovery, as 'effective electrode efficiency (EE)' as per IS 13043 in the following range (*see* 5.8)".

(*Page* 2, *clause* 5.5) — Substitute '1,2,3.....' *for* 'a),b),c),.....'.

(*Page* 5, *Table* 5, *col* 2) — Substitute 'As per manufacturers declaration' *for* 'Not specified'.

(*Page* 6, *clause* 8.4, *line* 2) — Substitute '*see* 8.3' *for* '*see* 8.2'.

[*Page* 6, *clause* 8.4(a)] — Substitute 'tensile and impact' *for* 'tensile or impact'.

(*Page* 7, *Table* 6, *col* 3) — Substitute '400' *for* '360' for all EX5.....classifications.

(*Page* 9, *Table* 8, *col* 1 *and* 2) — Substitute the following for the existing classifications:

EA 42	XX	
EB 542	X	
EB 542		
EB 562	X	Grade 1
EB 562	X	
EB 541	X	
EB 552	X	

EC 4 X 10	- X	
EC 4 X 16	- X	
ER 4 XXX	- X	
ERR 4 XXX	- X	
ER 5 XXX	- JX	Grade 2
ERR 5 XXX	- JX	
ERR 5 XXX	- KX	
ERR 5 XXX	- LX	
EB 5 XXX	- HXX	
EB 5 XXX	- HLX	
ER 41 XX	Not	
ER 42 XX	required	

(*Page* 11, *Table* 9, *col* 4 *row* 1) — Substitute '410-540' *for* '410-510'.

(*Page* 11, *Table* 9, *col* 5, *row* 2) — Substitute '400' *for* '360'.

(*Page* 11, *Table* 9, *col* 6, *row* 2) — Substitute the following for the existing:

'Satisfactory for EX4XXX and unsatisfactory for EX5XXX classes'

(*Page* 11, *Table* 9, *col* 1, *row* 6) — Substitute 'Elongation' *for* 'Elogation'.

(*Page* 12, *Table* 10, *col* 4, *row* 1) — Substitute '410-540' *for* '410-510'.

(*Page* 12, *Table* 10, *col* 6, *row* 1) — Substitute the following for the existing:

'Satisfactory for both EX4XXX and EX5XXX classes'

(*Page* 12, *Table* 10, *col* 6, *row* 4) — Substitute the following for the existing:

'Unsatisfactory for both EX5XXX and EX4XXX classes'

(*Page* 12, *Table* 10, *col* 1, *row* 5) — Substitute 'Elongation' *for* 'Elogation'.

(*Page* 12, *Table* 10, *col* 5, *row* 2) — Substitute '400' *for* '360'.

(*Page* 12, *Table* 10, *line diagram for classification EB 5426H1JX5, symbol* 5) — Substitute 'YS-400' *for* 'YS - 360'.

(*Page* 12, *Table* 10, *last line below line diagram*) — Substitute 'EB 5426 H, JX' *for* 'EB 5426H1JX '.

(*Page* 18, *Annex* F, *clause* **F-2.7**, *line* 5) — Substitute 'Fig. 10' *for* 'Fig. 9'.

(*Page* 19, *Table* 16, *col* 6, *heading*) — Substitute '**Depth Below Notch**' *for* '**Depth Between Notch**'.

(*Page* 24, *Fig.* 16) — Delete '**THIS 15 mm FROM START SHOULD NOT BE CONSIDERED FOR VISUAL INSPECTION**'.

(MTD 11)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 2 MARCH 2008
TO
IS 814 : 2004 COVERED ELECTRODES FOR MANUAL METAL ARC WELDING OF CARBON AND CARBON MANGANESE STEEL — SPECIFICATION

(Sixth Revision)

(*Page* 4, *clause* **7.1.2**) **—** Add the following at the end of the para:

'The testing procedure and other parameters in such cases shall be as per the nearest sizes already mentioned in Table 4. For example, for 3.2 mm electrode all testing and other parameters indicated for 3.15 mm size shall be followed.'

(MTD 11)

Reprography Unit, BIS, New Delhi, India

Welding General Sectional Committee, MTD 11

FOREWORD

This Indian Standard (Sixth 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.

This standard was first published in 1957 and subsequently revised in 1963, 1967, 1970, 1974 and 1991. While reviewing the standard in the light of experience gained during these years, the Committee decided to revise it to bring it in line with the present practices being followed by the Indian and overseas industry.

In this revision, the following changes have been made:

a) Semibasic type of covering has been included.

b) Chemical analysis of basic and semibasic classification has been provided.

c) Percentage elongation for 'O' designating digit has been included.

In the formulation of this standard due weightage has been given to international co-ordination among the standards prevailing in different countries in addition to relating it to the practices in the field in this country. This has been met by deriving assistance from the following publications:

a) ISO 2560 : 1973	Covered electrodes for manual arc welding of mild steel and low alloy steel—Code of symbols for identification
b) BS 639 : 1986	Covered carbon and carbon manganese steel electrodes for manual metal arc welding
c) ANSI/AWSA 5.1-1991	Covered carbon steel arc welding electrodes — Specification

In reporting the results of a test or analysis, made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

COVERED ELECTRODES FOR MANUAL METAL ARC WELDING OF CARBON AND CARBON MANGANESE STEEL — SPECIFICATION

(Sixth Revision)

1 SCOPE

This standard specifies the requirements for covered carbon and carbon manganese steel electrodes for carbon and carbon manganese steel, including hydrogen controlled electrodes for manual metal arc welding of mild and medium tensile steels including structural steels, depositing weld metal having a tensile strength not more than 610 MPa.

Electrodes designed specifically for repair welding, often marketed in India as 'low heat input' electrodes are not covered in this standard.

Ilmenite type electrodes are being used fairly widely in few other countries. There appears to be a trend to use ilmenite as an ingredient of the covering in our country also. Provision for a separate class for such electrode may be considered at a later stage.

NOTE — For weld metal with tensile strength higher than 610 MPa, a reference may be made of IS 1395.

2 REFERENCES

The following standards contain provisions which through reference in this text constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
812 : 1957	Glossary of terms relating to welding and cutting of metals
1182 : 1983	Recommended practice for radiographic examination of fusion welded butt joints in steel plates (*second revision*)
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
1395 : 1982	Low and medium alloy steel covered electrodes for manual metal arc welding (*third revision*)
1599 : 1985	Method for bend test (*second revision*)
1608 : 1995	Mechanical testing of metals — Tensile testing (*second revision*)
1757 : 1988	Method for charpy impact test (V-notch) for metallic materials (*second revision*)
1977 : 1996	Low tensile structural steel (*third revision*)
2002 : 1992	Steel plates for pressure vessels for intermediate and high temperature service including boilers (*second revision*)
2062 : 1999	Steel for general structural purposes (*fifth revision*)
2879 : 1998	Mild steel for metal arc welding electrodes (*third revision*)
3039 : 1988	Structural steel for construction of hulls of ship (*second revision*)
8500 : 1991	Structural steel—Micro-alloyed (medium and high strength qualities) — Specification (*first revision*)
11802 : 1986	Method for determination of diffusible hydrogen content of deposited weld metal from covered electrodes in welding mild and low alloy steels
13043 : 1991	Covered manual metal arc welding electrodes — Determination of efficiency, metal recovery and deposition coefficient
13851 : 1993	Storage and redrying of covered electrodes before use — Recommendations

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 812 and the following definitions shall apply.

3.1 Weld Slope — It is the angle formed between the lines of the weld root and a horizontal reference plane. Slope may be measured either clockwise or anticlockwise and either above or below the horizontal plane between 0° and 90°.

3.2 Weld Rotation — The rotation of weld is the angle

formed between upper portion of vertical reference plane passing through the weld root and a point on the face of weld equidistant from both the edges of weld. Rotation may be measured either clockwise or anticlockwise between 0° and 180°.

3.3 Weld Position — The welding position is given by the combination of weld slope and weld rotation (*see* 5.5.1).

4 SUPPLY OF MATERIALS

General requirements relating to the supply of covered electrodes for metal arc welding shall be as laid down in IS 1387.

5 CLASSIFICATION

5.1 Coding

Classification of electrodes shall be indicated by the coding system of letters and numerals as given in 5.1.1and 5.1.2 to indicate the specified properties or characteristics of the electrodes.

5.1.1 *Main Coding*

It consists of the following letters and numerals and shall be followed in the order stated:

a) A prefix letter 'E' shall indicate a covered electrode for manual metal arc welding, manufactured by extrusion process;

b) A letter indicates the type of covering (*see* 5.2);

c) first digit indicates ultimate tensile strength in combination with the yield stress of the weld metal deposited (*see* 5.3);

d) Second digit indicates percentage elongation in combination with the impact values of the weld metal deposited (*see* 5.4);

e) Third digit indicates welding position(s) in which the electrodes may be used (*see* 5.5) and;

f) Fourth digit indicates the current conditions in which the electrode is to be used (*see* 5.6).

5.1.2 *Additional Coding*

The following letters indicating the additional properties of the electrodes may be used, if required:

a) Letters H1, H2 and H3 indicating hydrogen controlled electrodes (*see* 5.7);

b) Letters J, K and L indicating increased metal recovery, as effective electrode;

'Efficiency (EE)' as per IS 13043 in the following range (*see* 5.8)

J = 110-129 percent;

K = 130-149 percent; and

L = 150 percent and above.

c) Letter 'X' indicating the radiographic quality (*see* 5.9).

NOTE — Examples illustrating for establishing electrodes coding from the initial test results have been given in Annex A.

5.2 Type of Covering

Type of covering shall be indicated by the following letters:

A – Acid
B – Basic
C – Cellulosic
R – Rutile
RR – Rutile, heavy coated
SB – Semibasic

NOTE — The characteristics of each type of the covering and coating ratio are described in Annex B for guidance only.

5.3 Strength Characteristics

The combination of ultimate tensile strength and yield strength of the weld metal deposited shall be indicated by the digit 4 and 5 (*see* Table 1).

Table 1 Designation of Strength Characteristics

Designating Digit	Ultimate Tensile Strength MPa	Yield Strength MPa, *Min*
(1)	(2)	(3)
4	410-540	330
5	510-610	400

5.4 Elongation and Impact Properties

The combination of percentage elongation and impact properties of the weld metal deposited for the two tensile ranges (*see* Table 1) shall be as given in Table 2.

5.5 Welding Position

The welding position or positions in which the electrode can be used as recommended by the manufacturer shall be indicated by the appropriate designating digits as follows:

a) All positions;

b) All positions except vertical down;

c) Flat butt weld, flat fillet weld and horizontal/ vertical fillet weld;

d) Flat butt weld and flat fillet weld;

e) Vertical down, flat butt, flat fillet and horizontal and vertical fillet weld; and

f) Any other position or combination of positions not classified above.

5.5.1 Welding positions in detail have been described in Annex C.

5.5.2 Where an electrode is coded as suitable for vertical

and overhead positions, it may be considered that sizes larger than 4 mm are not normally used for welding in these positions.

5.5.3 An electrode shall not be coded as suitable for a particular welding position unless it is possible to use it satisfactorily in the position to comply with test requirements of this standard.

5.6 Welding Current and Voltage Conditions

The welding current and open circuit voltage conditions on which the electrodes can be operated as recommended by the manufacturer shall be indicated by the appropriate designation digits as given in Table 3. Welding current and voltage conditions have been described in Annex D.

Table 2 Combination of Percentage Elongation and Impact Strength

(*Clauses* 5.4 *and* 8.3; and *Table* 9)

Designating Digit	Percentage Elongation on Gauge Length $5.65\sqrt{S_o}$, *Min*	Impact Strength *J*/°C, *Min*
(1)	(2)	(3)
	For Tensile Range 410-510 MPa	
0	16	No impact requirements
1	20	47 J/+27°C
2	22	47 J/+0°C
3	24	47 J/–20°C
4	24	27 J/–30°C
	For Tensile Range 510-610 MPa	
0	16	No impact requirements
1	18	47 J/+27°C
2	18	47 J/+0°C
3	20	47 J/–20°C
4	20	27 J/–30°C
5	20	27 J/–40°C
6	20	27 J/–46°C

NOTE — $\sqrt{S_o}$ is the cross-sectional area of test piece.

Table 3 Welding Current and Voltage Conditions

(*Clause* 5.6; and *Table* 10)

Designating Digit	Direct Current Recommended Electrode Polarity[1]	Alternating Current Open Circuit Voltage V, *Min*
(1)	(2)	(3)
0[2]	+	Not recommended
1	+ or –	50
2	–	50
3	+	50
4	+ or –	70
5	–	70
6	+	70
7	+ or –	90
8	–	90
9	+	90

NOTE – The frequency of the alternating current is assumed to be 50 or 60 Hz. The necessary open circuit voltage when electrodes are used on direct current is closely related to dynamic characteristics of the welding power source. Consequently no indication of the minimum open circuit voltage for direct current is given.

[1] Positive polarity (+) Negative polarity (–).

[2] Symbol 0 is reserved for electrodes used exclusively on direct current.

5.7 Hydrogen Controlled Electrodes

The letters H1, H2 and H3 shall be included in the classification as a suffix for those electrodes which will give diffusible hydrogen in ml/100 g when determined in accordance with IS 11802 as given below:

H1 = Up to 15 ml diffusible hydrogen

H2 = Up to 10 ml diffusible hydrogen

H3 = Up to 5 ml diffusible hydrogen

NOTE — For H3, glycerin method shall not be used.

5.8 Increased Metal Recovery

The letters J, K and L shall be included in the classification as a suffix for those electrodes which have appreciable quantities of metal powder in their coating and give increased metal recovery with respect to that of core wire melted in accordance with the range given in 5.1.2(b).

The metal recovery shall be determined as effective electrode efficiency (EE as per the method given in IS 13043).

5.9 Radiographic Quality Electrodes

The letter 'X' shall be included in the classification as a suffix for those electrodes which deposit radiographic quality welds (*see* 9.6).

6 CORE WIRE FOR ELECTRODES

The core wire used for the manufacture of electrodes shall conform to IS 2879.

7 DIMENSIONS AND TOLERANCES

7.1 Size and Length

The size of an electrode shall be designated by the nominal diameter of the core wire expressed in millimetres. Sizes of electrode and corresponding lengths of electrodes shall be as given in Table 4.

7.1.1 The tolerance on the specified diameter of core wire shall be ± 0.05 mm. The tolerance on the specified length of electrode shall be ±3 mm.

7.1.2 Sizes and lengths of electrode other than those mentioned in Table 4 may be supplied subject to mutual agreement between the manufacturer and the purchaser. The tolerance in such cases shall be agreed to between the manufacturer and the purchaser.

7.2 Bare Length

7.2.1 *Contact End*

The contact end of the electrode shall be clean and free from covering for enabling it to be gripped by the electrode's holder as specified below:

Electrode Size	*Bare Length*	
	Minimum	Maximum
mm	mm	mm
1.6 to 3.15	15	30
4.0 to 8.0	20	40

7.2.2 *Arc Striking End*

The arc striking end of the electrode shall be bare and permits easy striking of the arc. The distance from the arc end to the first point where the full cross-section of the covering prevails shall not exceed the following limits:

For all classifications — 1/2 core wire diameter or 2.0 mm, whichever is less

Table 4 Sizes and Lengths of Electrode

(*Clauses* 7.1 *and* 7.1.2)

Size	Length
mm	mm
(1)	(2)
1.6	150 or 200 or 250
2.0	200 or 250 or 300 or 350
2.5	250 or 300 or 350
3.15	350 or 450
4.0	350 or 450
5.0	350 or 450
6.3	350 or 450
8.0	350 or 450

7.3 Concentricity of Flux Covering with Core Wire — Tolerance

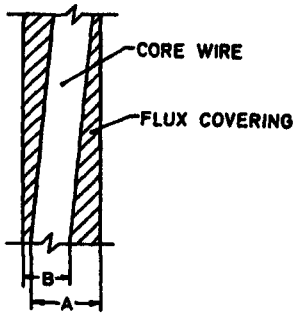
The flux covering on the electrode shall be uniform and concentric with the core wire. The tolerance for concentricity of the covering (*see* Fig. 1) shall be such that the maximum core plus one covering dimension shall not exceed the minimum core plus one covering dimension by more than:

a) 5 percent of the mean of two dimensions for EBXXXX and ESBXXXX class electrodes,

b) 4 percent of the mean of two dimensions for ERXXXX, ERRXXXX and EAXXXX class electrodes, and

c) 3 percent of the mean of two dimensions for ECXXXX class electrodes.

7.4 Core wire and coverings shall be free from defects which would interfere with the uniform welding performance of the electrode.



All dimensions in millimetres.

FIG. 1 PERMISSIBLE TOLERANCES FOR FLUX COVERING

A = maximum core plus one covering dimension, and

B = minimum core plus one covering dimension.

$$A - B \leq \frac{5}{100} \times \frac{(A+B)}{2}$$ for

EBXXXX and ESBXXXX class electrodes

$$A - B \leq \frac{4}{100} \times \frac{(A+B)}{2}$$ for

ERXXXX, ERRXXXX and EAXXXX class electrodes

$$A - B \leq \frac{3}{100} \times \frac{(A+B)}{2}$$ for

ECXXXX class electrodes

8 TESTS FOR ELECTRODE PROPERTIES

8.1 General

Electrode shall be subjected to the following tests for assessing the mechanical properties of the deposited weld metal and the usability of an electrode for a particular welding position:

a) Initial tests,

b) Periodic tests, and

c) Quality control tests.

8.1.1 An electrode suitable for operation on a.c. or d.c. shall be tested on a.c.

8.1.2 When an electrode of a particular nominal size is manufactured in more than one lengths, the electrode used for the tests shall be longest manufactured.

8.1.3 The parent metal used for test plates shall conform to the requirements specified in Annex E.

8.2 Chemical Analysis

The sample for analysis shall be taken from weld metal obtained with the electrode. The result of the analysis shall meet the requirements of Table 5.

8.3 Initial Tests

These are qualifying or proving tests for each type or modified type of electrodes and shall comprise the following:

a) All weld metal mechanical tests as given in Table 2 (*see* also 9.1);

b) Butt weld bend test (*see* 9.2);

c) Running performance test (for sizes up to and including 2.5 mm) (*see* 9.3);

d) Increased metal recovery tests for electrode claiming recovery 110 percent and above (*see* 9.4);

e) Diffusible hydrogen estimation test for hydrogen controlled electrodes (*see* 9.5); and

f) Radiographic quality test for radiographic quality electrodes (*see* 9.6).

8.4 Periodic Check Tests

These comprise of the following tests selected from

Table 5 Chemical Composition — Requirements for Weld Metal

(*Clause* 8.2)

Classification	Weight, Percent, *Max*									Combined Limit for Mn+Ni+Cr+Mo+V
	C	Mn	Si	P	S	Ni	Cr	Mo	V	
EAXXXX			Not specified							
ECXXXX			do							
ERXXXX			do							
ERRXXXX			do							
EBXXXX	0.12	1.6	0.75	0.035	0.035	0.30	0.20	0.30	0.08	1.75
ESBXXXX			Same as EBXXXX							

among the initial tests (*see* 8.2) and are meant to be repeated at intervals to provide evidence that the electrodes currently produced possess the properties proved in the initial tests:

a) All weld metal mechanical tests for tensile or impact (*see* 9.1); and

b) Running performance test (for sizes up to and including 2.5 mm) (*see* 9.3).

Such tests shall be conducted at least once in a year. These tests shall not apply to the electrodes not manufactured during the year. When production of a particular type of electrode after stoppage of production for more than six months is restored, the periodic tests shall be conducted.

8.5 Quality Control Tests

By means of suitable system of control, the manufacturer shall satisfy himself that the composition and quality of all the electrodes currently produced are similar to those electrodes which were subjected to initial tests. He shall ensure that the result of quality control tests and date of manufacture of electrodes is traced from the batch number of the relevant details, or both.

NOTES

1 For the purpose of this standard, a batch is defined as a lot of covered electrodes of any one size and classification produced from coating identified by a dry mix or more than one dry mix of controlled chemical composition and core wire identified by a heat number or controlled chemical composition.

2 Identification of electrode core wire:

a) Solid core wire for manufacture of electrodes identified by heat number shall consist of material from a single heat of metal.

b) Solid core wire identified by controlled chemical composition rather than by heat number, shall consist of mill coils of one or more heat from which samples have been taken for chemical analysis. The results of the analysis must be within the composition limits as specified in IS 2879.

3 Identification of covering mix:

a) A dry mix is the quantity of dry coating ingredients mixed at one time in one mixing vessel. A dry mix may be divided into smaller quantity for production of wet mixes in using a liquid binder.

b) Covering identified by a dry mix shall consist of electrode produced from a single dry mix of coating ingredients.

c) Covering identified by controlled composition rather than by dry mix shall consist of one or more dry mixes and shall be subjected to sufficient tests to assure that all dry mixes within the lot are equivalent. These tests shall include chemical analysis of the weld metal, the results of which must fall within the manufacturers acceptance limits. The identification of the test procedure and the test results shall be recorded.

8.5.1 The manufacturer on request shall make available to the approving and certifying authorities the records maintained for quality control, for ensuring that the composition and quality of all the electrodes currently produced are similar to those electrodes subjected to initial and periodic check tests.

8.6 Additional Tests

Subject to agreement with the manufacturer, the purchaser may request for additional tests to be made or certificates to be provided for each batch of electrodes supplied. If so, the tests and batch definition shall be agreed between the manufacturer and the purchaser.

9 DETAIL OF TESTS

9.1 All Weld Metal Mechanical Tests for Tensile and Impact

9.1.1 *Weld Assembly*

Two all weld test assemblies shall be prepared, one using 4.0 mm and the other using the highest size manufactured in accordance with the method described in Annex F. If the highest size produced by any manufacturer is 4.0 mm, then two weld test assemblies using 4.0 and 3.15 mm size respectively shall be prepared.

NOTE — In case 3.15 mm is the highest size manufactured, only one weld test assembly shall be prepared with this size.

9.1.2 *All Weld Tensile Tests*

Two all weld tensile test specimens, one from each of the assemblies as given in 9.1.1, shall be prepared and tested in accordance with the method described in Annex F. The ultimate tensile strength and yield stress shall comply with the values given in Table 6. When particular ductile properties are claimed or specified, the minimum percentage elongation shall comply with the appropriate value given in Table 6.

NOTE — The all weld tensile test is for quality control purpose only. It is not intended to imply that values obtained in all weld tests should be used for design purposes.

9.1.3 *All Weld Impact Tests*

Five charpy V-notch impact test specimens shall be machined from the same test assembly and tested in accordance with the method described in Annex F at the temperature specified in Table 6 and shall comply with the values given in Table 6 at specified temperature. The results of the impact test from five test specimens shall be assessed as specified in 9.1.3.1, 9.1.3.2 and 9.1.3.3.

9.1.3.1 When computing the average values of the impact properties from the set of five specimens, the lowest value and the highest value obtained shall be disregarded.

9.1.3.2 For classification EXX1XX, EXX2XX and EXX3XX, two of the three remaining values shall be greater than the specified 47 joules; one of the three values may be lower but shall not be less than 41 joules.

The computed average value of the three values shall be equal to or greater than 47 joules.

9.1.3.3 For classification EXX4XX, EXX5XX and EXX6XX, two of the three remaining values shall be greater than the specified 27 joules; one of the three values may be lower but shall not be less than 23 joules. The computed average value of the three values shall be equal to or greater than 27 joules.

9.2 Butt Weld Bend Test

Butt weld assemblies shall be prepared in different welding positions for the various electrode classifications as per the recommendations given in Table 7 and the procedures given in Annex G. If 2.5 mm size electrode is manufactured then this size shall be used for the root run for the butt weld assembly wherever option of 2.5 or 3.15 mm is given in Table 7.

9.2.1 From each butt weld assembly two bend tests, one with face and one with root in tension shall be carried out. The test specimens shall be bent through 180° over a mandrel having a diameter equal to three times the thickness of the specimen in accordance with IS 1599. The electrode shall be deemed to be satisfactory, if on completion of the test no crack or defect at the outer surface of the test specimen is greater than 3 mm measured across the test specimen or 1.5 mm measured along the length of the test specimen. Premature failure at corners of the test specimen shall not be considered as a case for rejection.

9.3 Running Performance Test (for Electrode Sizes Up to and Including 2.5 mm)

This test is to be carried out for electrodes of 2.5 mm size and below to assess the welding performance. The test shall be conducted using three electrodes as per the details given in Annex H. The bead should be visually inspected and should be free from porosities, slag inclusions, cracks, etc, in the main portion of the bead as given in Annex H. The bead shall be reasonably straight and evenly rippled. The slag should be removed with little effort.

9.4 Increased Metal Recovery Test

The metal recovery shall be determined for the electrodes classified under EXXXXXJ, EXXXXXK and EXXXXXL or EXXXXXHJ, EXXXXXHK and EXXXXXHL on the largest size electrode manufactured but not lower than 4.0 mm in accordance with the method given in IS 13043. The value obtained by the method shall be rounded off to the nearest multiple of 5.

The rounded recovery figure shall conform to the requirements of 5.1.2(b) for the respective classification.

9.5 Diffusible Hydrogen Evaluation Test

This test shall be carried out for all electrodes classified under EXXXXXH and EXXXXXHL preferably using

Table 6 Mechanical Properties of Weld Metal

(*Clauses* 9.1.2 *and* 9.1.3)

Classification	Ultimate Tensile Strength	Yield Stress	Percentage Elongation on Gauge Length $5.65\sqrt{S_o}$	Temperature for Impact, °C	Impact Strength
	MPa	MPa, *Min*	*Min*		J, *Min*
(1)	(2)	(3)	(4)	(5)	(6)
EX40XX	410-540	330	16	No impact requirement	
EX41XX	410-540	330	20	+27	47
EX42XX	410-540	330	22	0	47
EX43XX	410-540	330	24	-20	47
EX44XX	410-540	330	24	-30	27
EX50XX	510-610	360	16	No impact requirement	
EX51XX	510-610	360	18	+27	47
EX52XX	510-610	360	18	0	47
EX53XX	510-610	360	20	-20	47
EX54XX	510-610	360	20	-30	27
EX55XX	510-610	360	20	-40	27
EX56XX	510-610	360	20	-46	27

NOTE — In view of the possible scatter in welding and testing, the upper limit of ultimate tensile strengths may be exceeded by 40 MPa.

Table 7 Welding Procedure for Preparation of Butt Weld Bend Test Pieces

(*Clauses* 9.2 *and* G-1.4)

Positional Classification	Number of Butt Weld Assemblies	Position	Welding Procedure
(1)	(2)	(3)	(4)
EXXX1X	2	Flat (Weld slope 0°) (Weld rotation 0°)	a) First run with 3.15 mm or 4.0 mm b) Subsequent runs (except last two layers) with 4.0 mm or 5.0 mm according to normal practice of the electrode. c) Runs of last two layers with the largest size submitted for approval
	1	Vertical up (Weld slope 0°)	a) First run with 2.5 mm or 3.15 mm b) Subsequent runs with one of the following: 1) With 4.0 mm or if recommended by the manufacturer with 5.0 mm 2) With 3.15 mm when the increased metal recovery exceeds 110 percent
	1	Vertical down (Weld slope 0°)	a) First run with 2.5 mm or 3.15 mm b) Subsequent runs with one of the following: 1) With 4.0 mm or if recommended by the manufacturer with 5.0 mm 2) With 3.15 mm when the increased metal recovery exceeds 110 percent
	1	Overhead (Weld slope 0°) (Weld rotation 180°)	a) First run with 2.5 mm or 3.15 mm b) Subsequent runs with one of the following: 1) With 4.0 mm or if recommended by the manufacturer with 5.0 mm 2) With 3.15 mm when the increased metal recovery exceeds 110 percent
EXXX2X	2	Flat	Same as EXXX1X
	1	Vertical up	Same as EXXX1X
	1	Overhead	Same as EXXX1X
EXXX3X	2	Flat	Same as EXXX1X
	1	Horizontal Vertical (Weld slope 0°) (Weld rotation 0°)	a) First run with 3.15 mm or 4.0 mm and b) Subsequent runs with 5.0 mm
EXXX4X	2	Flat	Same as EXXX1X
EXXX5X	2	Flat	Same as EXXX1X
	1	Vertical down	Same as EXXX1X
EXXX6X	As required	In all positions specified by the manufacturer	a) If the position comes nearer to flat position: 1) First run with 3.15 mm or 4.0 mm 2) Subsequent runs (except last two layers) with 4.0 mm or 5.0 mm 3) Last two layers with the largest size submitted for approval b) For other position(s): 1) First run with 2.5 mm or 3.15 mm 2) Subsequent runs with 4.0 mm or if recommended by the manufacturer with 5.0 mm

3.15 mm or 4.0 mm size. The test shall be carried out in accordance with IS 11802.

9.6 Radiographic Test

All welded test assemblies after the removal of backing strip, shall be machined or ground smooth so as to avoid difficulty in interpretation of radiograph of weld. It shall then be subjected to radiographic test as per IS 1182. The radiograph shall not show crack or incomplete fusion. The radiograph acceptance standard in respect of porosity and slag inclusions is indicated in Table 8.

In making the evaluation for radiographic acceptance standard, a length of 25 mm of the welded assembly shall be excluded from both ends.

10 RETESTS

Where any test specimen fails to fulfil the test requirements, twice the number of the test specimens made for that test for the initial or periodic test shall be prepared by using electrode from the same batch wherever possible and submitted only for the tests in which failure occurred. The electrode shall not be accepted as having passed that test unless the tests on additional specimen are satisfactory.

11 PACKING AND STORAGE

11.1 The net mass of an individual bundle or carton of electrodes shall not exceed 7 kg.

11.2 Electrodes shall be suitably packed to guard against any damage during transportation. The packing shall be suitable to ensure that under normal store room conditions, the electrodes shall, for a period of six months after the date of manufacture, be capable of giving results in accordance with the provisions of this standard and that if the flux covering is a type requiring special protection during storage, the details of such special protection shall be furnished by the manufacturer and reference to this should be included

Table 8 Radiographic Acceptance Standard in Respect of Porosity and Slag Inclusion

(*Clause* 9.6)

IS Classification of Electrode	Radiographic Acceptance Standard	Type of Porosity and/or Slag Inclusion	Acceptance		Restriction, If Any
			Size (Diameter or Length) mm	Quantity in Numbers (in 150 mm)	
(1)	(2)	(3)	(4)	(5)	(6)
EA 42XX-X EB 542X-HX EB 542-HJX EB 562X-HX EB 562X-HJX EB 541X-HJX EB 552X-HJX	Grade 1	Assorted	0.4 to 1.6	18	a) Large size indications (1.2 to 1.6 mm) = 3 No. *Max* b) Medium size indications (0.8 to 1.2 mm) = 5 No. *Max* c) Small size indications (0.4 to 0.8 mm) = 10 No. *Max*
		Large	1.2 to 1.6	8	Nil
		Medium	0.8 to 1.2	15	Nil
		Fine	0.4 to 0.8	30	Nil
EC 4X10-X EC 4X16-X ER 4XXX-X ERR 4XXX-X ER 5XXX-JX ERR 5XXX-JX ERR 5XXX-LX	Grade 2	Assorted	0.4 to 2.0	27	a) Large size indications (1.6 to 2.0 mm) = 3 No. *Max* b) Medium size indications (1.2 to 1.6 mm) = 8 No. *Max* c) Small size indications (0.4 to 1.2 mm) = 16 No. *Max*
EB 5XXX-HXX		Large	1.6 to 2.0	14	Nil
EB 5XXX-HLX		Medium	1.2 to 1.6	22	Nil
		Fine	0.4 to 1.2	44	Nil
ERR 5XXX-LX EB 5XXX-HXX EB 5XXX-HLX	Not Required				

in the marking of bundle or carton of electrodes. The electrodes shall be stored in a dry room condition (*see also* IS 13851).

11.3 The batch of electrodes represented by the electrodes tested shall not be certified as complying with this standard unless the test results obtained satisfy the requirements specified in 8.3 and the manufacturer has performed the tests at intervals in accordance with the requirements of this standard.

12 TEST RESULTS

12.1 On request, as evidence that the electrodes supplied comply with the requirements of this standard, the manufacturer shall produce the results of most recent periodic check tests on electrodes representative of the electrodes supplied.

12.2 If required by the purchaser, the manufacturer shall furnish a test certificate for each batch of electrode supplied.

13 MARKING

13.1 As agreed to between the manufacturer and the purchaser, brand name/classification shall be printed on all the electrodes.

13.1.1 Each bundle or carton of electrodes shall be clearly marked with the following information:

a) Classification (*see* 5);
b) Indication of the source of manufacture;
c) Trade name and brief description of the electrodes;
d) Size and quantity of electrodes;
e) Batch number;
f) Recommended current range, polarity and open circuit voltage;
g) Date of manufacture;
h) Recommendation for special storage conditions and redrying temperature; and
j) A cautionary notice on safety during welding.

13.1.2 *BIS Certification Marking*

The bundle or carton of electrodes may also be marked with Standard Mark.

13.1.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clause* 5.1.2)

EXAMPLES OF ELECTRODE CLASSIFICATIONS

A-1 The examples given in A-2 and A-3 illustrate the way in which the coding and the complete classification is expressed.

A-2 EXAMPLE 1

The electrode is a covered electrode having a light rutile covering.

The electrode may be used for welding in all positions and it weld satisfactorily on a.c. with a minimum open circuit voltage of 50 V and on d.c. with both positive and negative polarity.

The electrodes are not designed to give hydrogen controlled weld metal. The electrode is not meant for radiographic application.

The electrode deposits weld metal with the properties given in Table 9, when tested in accordance with standard and when the manufacturer submits 8 mm electrode as the maximum size to be classified. The table of results shows that the manufacturer carried out sets of impact tests at +27°C, 0°C and –20°C in order to determine the appropriate classification.

A-3 EXAMPLE 2

A covered electrode having a basic covering with an increased metal recovery of 120 percent and depositing weld metal containing 7 millilitres of diffusible hydrogen per 100 g of deposited weld metal.

The electrode may be used for welding in all positions except vertical down and operate on a.c. with a minimum open circuit voltage of 70 V and on d.c. with positive polarity. The electrode deposit weld metal gives radiographic quality weld.

The electrode deposits weld metal with the properties given in Table 10 when tested in accordance with this standard and when the manufacturer submits 6.3 mm electrode as the maximum size to be classified. The table of results shows that the manufacturer carried out sets of impact tests at –30°C and –40°C in order to determine the appropriate classification.

Table 9 Test Results for Example 1

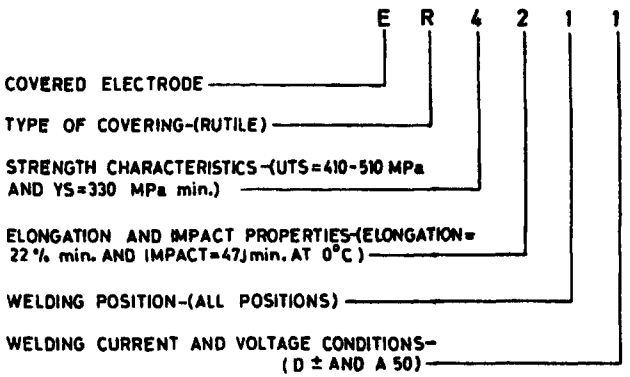
(*Clause* A-2)

Property	Electrode Size		Requirement for Class		Remarks
	4 mm	8 mm	EX4XXX	EX5XXX	
(1)	(2)	(3)	(4)	(5)	(6)
Ultimate tensile strength, MPa	480	465	410-510	510-610	Satisfactory for EX4XXX but unsatisfactory for EX5XXX class
Yield strength, Mpa	365	350	330 *Min*	360 *Min*	Satisfactory for both EX4XXX and EX5XXX classes
Impact strength at +27°C, J (average)	80, 78 70, 69 62	72, 69 65, 64.6 60	47 *Min*	47 *Min*	Satisfactory for both EX4XXX and EX5XXX classes
Impact strength at 0°C, J (average)	65, 58 50, 50 49	62, 58 50, 49 43	47 *Min*	47 *Min*	Satisfactory for both EX4XXX and EX5XXX classes
Impact strength at -20°C, J (average)	46, 45 40, 40 35	40, 37 33, 32 30	47 *Min*	47 *Min*	Unsatisfactory for both EX4XXX and EX5XXX classes
Elogation, percent at 5.65 $\sqrt{S_o}$	26	25	22 *Min*	18 *Min*	Satisfactory for both EX4XXX and EX5XXX classes

NOTES

1 Elogation incorporated here from Table 2 after establishment of impact property at specified temperature.

2 So is the cross-sectional area of test piece.



Complete classification is therefore ER 4211.

Table 10 Test Results for Example 2

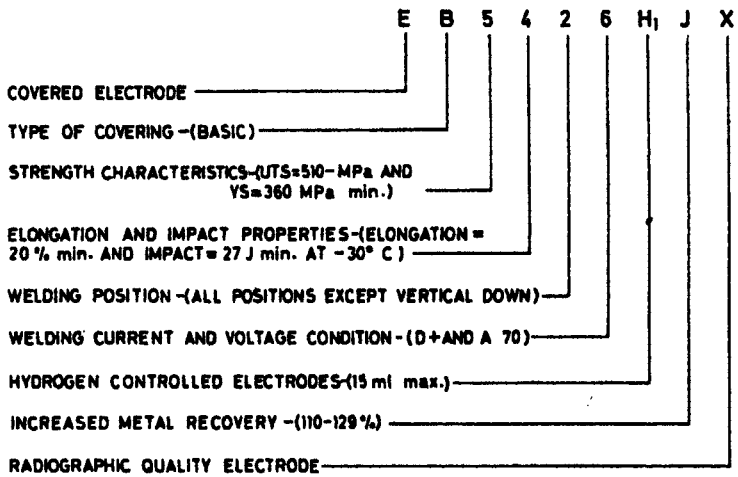
(*Clause* A-3)

Property	Electrode Size		Requirement for Class		Remarks
	4 mm	6.3 mm	EX4XXX	EX5XXX	
(1)	(2)	(3)	(4)	(5)	(6)
Ultimate tensile strength, MPa	570	550	410-510	510-610	Satisfactory for EX5XXX but unsatisfactory for EX5XXX class
Yield strength, MPa	420	400	330 *Min*	360 *Min*	Satisfactory for both EX4XXX and EX5XXX classes
Impact strength at –30°C, J (average)	65, 62 58, 56.6 50	55, 52 46, 40 37	27 *Min*	27 *Min*	Satisfactory for both EX4XXX and EX5XXX classes
Impact strength at –20°C, J (average)	30, 24 21, 20 16	22, 20 16, 14 17.6	47 *Min*	47 *Min*	Unsatisfactory for EX5XXX classes
Elogation, percent at 5.65 $\sqrt{S_o}$	26	25	24 *Min*	20 *Min*	Satisfactory for both EX4XXX and EX5XXX classes

NOTES

1 Elogation incorporated here from Table 3 after establishment of impact property at specified temperature.

2 So is the cross-sectional area of test piece.



Complete classification is therefore EB 5426H1JX.

ANNEX B

(*Clause* 5.2)

CHARACTERISTICS OF COVERING AND COATING RATIO

B-1 ACID (A)

Electrode of acid type have a medium or thick covering and produce an iron oxide, manganese oxide, silica rich slag (with some titania in some cases), the metallurgical characteristics of which is acidic. The covering contains, besides oxides, of iron and/or manganese (with some titania in some cases), a fairly high percentage of ferro-manganese and/or other deoxidisers. The slag generally solidifies in a characteristic honeycomb structure and is easily detached.

This type of electrode usually has a high fusion rate may be used with high current intensities. Penetration can be good, particularly if the covering is thick. These electrodes are most suitable for welding in flat position but can be used in other positions and can be operated both on a.c. and d.c.

B-2 BASIC (B)

Electrodes of basic type usually have a covering containing appreciable quantities of calcium or other basic carbonates and fluorspar so that metallurgically they are basic in character. There is a medium quantity of dense slag, which often has a brown to dark-brown colour and a glossy appearance. It is easily detached, and as it rises to the surface of the weld very quickly, slag inclusions are not likely to occur. This type of electrode gives an arc of average penetration, and is suitable for welding in all positions. These electrodes are used both on a.c. and d.c. where d.c. positive polarity is generally preferred for critical applications.

As the weld metal is highly resistant to hot and cold cracking, these electrodes are particularly suitable for welding heavy sections and very rigid mild steel structures. They are also recommended for welding low alloy steels and steels of which carbon and sulphur content are higher than those of mild steel of good weldable quality.

These electrodes must be stored in a reasonably dry place and should be dried before use, according to the recommendations of the manufacturer. This ensures that the weld metal will have a low hydrogen content and there is a less risk of under bead cracking when welded steel is likely to show a marked hardening in the heat affected zone.

B-3 CELLULOSIC (C)

The coverings of the cellulosic type contains a large quantity of combustible organic substances, so that the decomposition of the latter in arc produces a voluminous gas shield. The amount of slag produced is small and the slag is easily detached.

This type of electrode is characterised by a highly penetrating arc and fairly high fusion rate. Spatter losses are fairly high and the weld bead is somewhat coarse, with unevenly spaced ripples. These electrodes are usually suitable for welding in all positions. Generally, this type of electrodes are suitable for use on d.c. with positive polarity, but some electrodes are also available which are suitable for use on a.c..

B-4 RUTILE (R)

These electrodes have a covering containing a large quantity of rutile or components derived from titanium oxide. The electrodes have smooth arc characteristics and normally produce very little spatter and are comparatively easy to use. This type of electrode can be generally used in all positions. These electrodes are used both on a.c. and d.c. The slag detachability is generally good.

B-5 RUTILE, HEAVY COATED (RR)

These electrodes are generally similar in characteristics to rutile type but having a higher coating ratio (over 1.5). Applicationwise, it is usually preferred for flat and horizontal vertical position though welding in other positions can also be possible.

B-6 SEMIBASIC (SB)

The electrodes of semibasic type shall be a combination of rutile and basic covering.

B-7 COATING RATIO

The coating ratio of an electrode is the ratio of the standard outer diameter of the covering and the nominal diameter of the core wire both expressed in millimeters.

For guidance, coating ratio for various types of coating is given below:

Type of Coating	*Coating Ratio*
Light coating	Up to 1.3
Medium coating	Over 1.3 up to and including 1.5
Heavy coating	Over 1.5

ANNEX C

(*Clause* 5.5.1)

WELDING POSITION

C-1 WELDING POSITION

The welding position of a weld is defined by its slope and rotation as indicated in Table 11.

Table 11 Welding Position

Position	Slope (Degree)	Rotation (Degree)	Illustration (Ref to Fig.)
(1)	(2)	(3)	(4)
Flat	0-5	0-10	2
Horizontal/Vertical	0-5	30-90	3
Vertical-up	80-90	0-180	4
Vertical-down	80-90	0-180	5
Overhead	0-15	115-180	6

NOTE — Any intermediate position not specified above is undefined, but the general term inclined is sometimes used.

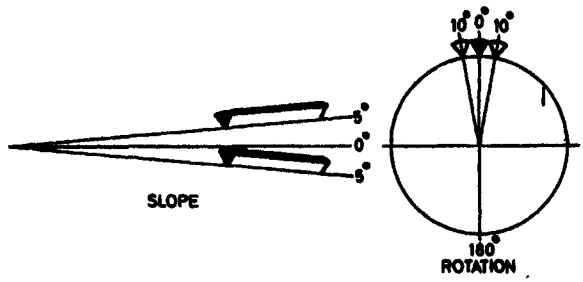


FIG. 2 FLAT POSITION

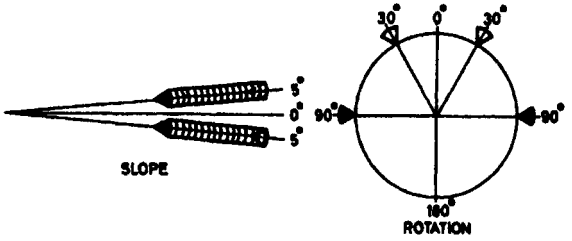


FIG. 3 HORIZONTAL/VERTICAL POSITION

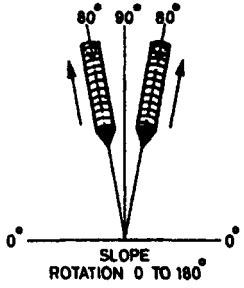


FIG. 4 VERTICAL-UP POSITION

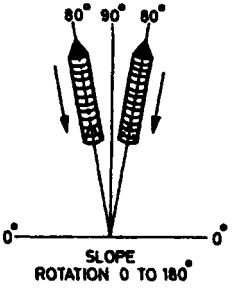


FIG. 5 VERTICAL-DOWN POSITION

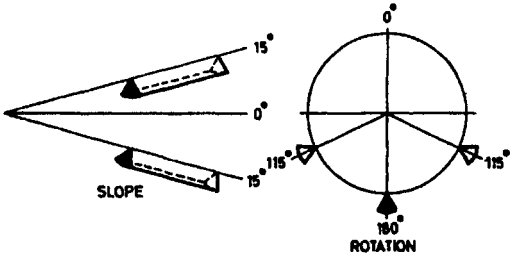


FIG. 6 OVERHEAD POSITION

ANNEX D

(*Clause* 5.6)

STANDARD WELDING CURRENT AND VOLTAGE CONDITION

D-1 STANDARD WELDING CURRENT AND VOLTAGE CONDITION

Specific welding current and open circuit voltage conditions are denoted by symbols given in Table 12. When an electrode is meant for use with either d.c. or a.c., combination of symbols given in Table 12 shall be used.

NOTES

1 The electrode may not function satisfactorily at a lower voltage than that for which it is classified but a higher voltage may be used in service with advantage.

2 The open circuit voltage for striking the arc varies according to size of the electrode. Table 12 applies to the sizes 2.5 mm and above. The reference size for coding of welding current and voltage condition should be 4 mm or 5 mm. If electrodes of size less than 2.5 mm are used, a high voltage may be necessary. Within the range of sizes 2.5 mm to 8 mm, the open circuit voltage necessary may be expected to vary approximately as follows:

Code Voltage	*Variation in Voltage*
V	V
90	100 to 80
70	80 to 60
50	60 to 40

Table 12 Welding Current and Open Circuit Voltage

Description	Symbol
(1)	(2)
d.c. with electrode positive	D+
d.c. with electrode negative	D−
d.c. with electrode positive and negative	D±
a.c. with an open circuit voltage not less than 90 V	A 90
a.c. with an open circuit voltage not less than 70 V	A 70
a.c. with an open circuit voltage not less than 50 V	A 50

ANNEX E

(*Clauses* 8.1.3, F-1.1 *and* F-1.2)

PARENT METAL FOR TEST PIECES

E-1 PARENT METAL

The parent metal and its mechanical properties, to be used for preparing different test pieces from all weld assembly and butt weld assembly for different class of electrodes is given in Table 13. The mechanical properties shall be verified from tests on the plate before the test pieces are prepared. The chemical composition shall also be verified from plates before the test.

The plate may be in as rolled or normalized condition.

Table 13 Parent Metal for Weld Assembly

Class of Electrode	Test for Electrode	Parent Metal		
		Indian Standard	Tensile Strength Range, MPa	Percentage Elongation on Gauge Length $5.65\sqrt{S_o}$ *Min*
(1)	(2)	(3)	(4)	(5)
EX4XXX	All weld and butt weld	IS 1977, IS 2002, IS 2062, IS 3039 or any other steel considered equivalent to any of these standards	410 - 530	22
EX5XXX	All weld and butt Weld	IS 8500 Grade Fe 540HT or any other steel considered equivalent to this standard	510 - 660	19

ANNEX F

(*Clauses* 9.1.1, 9.1.2, 9.1.3, G-1.1 *and* H-1.1)

ALL WELD TESTS FOR TENSILE AND IMPACT

F-1 PREPARATION OF TEST PIECES

F-1.1 Parent Metal

The parent metal for plates used in test pieces shall be in accordance with Annex E. The test specimens shall not be subjected to any mechanical or thermal treatment other than that required under this Annex.

F-1.2 All weld metal test pieces shall be prepared by depositing weld metal between the chamfered edges of two plates placed on a backing strip as shown in Fig. 7. The backing strip shall be tack welded to the test assembly.

The backing strip shall also be made from the material used for all weld metal assemblies described in Annex E.

F-1.3 The dimensions of test assembly are shown in Fig. 7 and given in Table 14. The length of the plate shall be enough to accommodate a tensile test specimen and at least six charpy V-notch impact test specimens as shown in Fig. 7.

F-1.4 The plate edges shall be bevelled by machining or machine gas cutting. In the later case, any remaining scale should be removed from bevelled edges. The surface of the backing strip should be free from rust or scale.

F-1.5 In order to counteract shrinkage deformation, the test assembly should be preset as shown in Fig. 8 in such a way so that after completion of welding a level joint is obtained.

F-2 WELDING PROCEDURE

F-2.1 The assembly shall be welded in flat position unless the electrode is not recommended in the flat position in which case welding position shall be one that is recommended by the manufacturer.

F-2.2 The test assembly shall be preheated to 110 ± 15°C. Welding shall be continued with an interpass temperature of not less than 110°C and not more than 180°C as measured by temperature indicating crayons or surface thermometers at the area specified in Fig. 7.

F-2.3 Pass Sequence

The weld metal shall be deposited in layers made up of two passes as shown in Fig. 9. The welding speed shall be adopted to obtain the number of layers given in Table 15. The direction of welding to complete a pass and a layer shall be same. The direction of deposition of each layer shall alternate from each end of the plate.

NOTE — The test specimens to be located on the centre line *A-A*.

F-2.4 Each electrode shall be consumed completely up to a stub end of not more than 50 mm.

F-2.5 The welding current used shall always be less than the maximum value and within the range recommended by the manufacturer. The open circuit voltage shall not be less than that specified by the manufacturer.

The welding current shall be a.c., if the electrode can be used with both a.c. or d.c. The welding current shall be d.c. with positive polarity, if the electrode can be used with d.c. positive or negative polarity.

F-2.6 If it is necessary to interrupt the welding procedure, the assembly shall be allowed to cool in still air to room temperature. When welding is resumed, the assembly shall be preheated to a temperature of 110 ± 15°C.

F-2.7 When the assembly has been welded completely, it shall be allowed to cool in still air to room temperature. The portion including the weld shall then be removed by cutting away the excess plate at the places indicated in Fig. 9. Cutting along the chain lines (shown by - - - - -) may be done mechanically or by machine gas cutting. Along the longitudinal boundaries (shown by broken lines as (- - - - - - - - - - - - - - - - - - - -) of the parts to be machined into impact test pieces cutting should be done by mechanical methods only.

F-3 HEAT TREATMENT OF ALL WELD TENSILE TEST PIECE

F-3.1 The all weld test pieces shall be heat treated in a furnace at a temperature of 250°C for a period of 12±1 hrs. After the soaking period, the specimen shall be withdrawn from the furnace and allowed to cool slowly, protected from drought and chilling.

F-3.2 The purpose of heat treatment is to remove hydrogen from weld metal.

F-3.3 The impact test pieces shall not be heat treated.

F-4 ALL WELD TENSILE TEST

The tensile test specimen shall be machined from the weld metal test pieces in accordance with IS 1608, care being taken that the longitudinal axis of the test specimen coincides with the central line of the weld and the mid thickness of the plate (*see* Fig. 10). The dimensions of the specimen shall be as shown in Fig. 11 and Fig. 12. The specimen shall be tested in accordance with IS 1608.

F-5 ALL WELD IMPACT TEST

The impact test specimen shall be machined from

the weld metal test pieces to the dimensions given in Table 16 in accordance with IS 1757. Care being taken that the longitudinal axis of the specimen are perpendicular to the weld axis and upper surface of the plate. The notch shall be positioned in the centre of the weld and is to be cut on the face of the test piece perpendicular to the surface of the plate (*see* Fig.13A, 13B and 13C) the tests are to be conducted at the test temperature on an approved impact machine.

Table 14 Dimensions of Test Assembly

(*Clause* F-1.3)

All dimensions in millimetres.

Electrode Size	Plate Width, *C*	Plate Thickness, *T*	Width of Welding Gap, *A*	Backing Strip	
				Width *B, Min*	Thickness *S, Min*
(1)	(2)	(3)	(4)	(5)	(6)
3.15	90 ± 10	15 ± 3	12 ± 1	A + 10	6.5
4.0	90 ± 10	20 ± 2	16 ± 1	A + 10	10.0
5.0	120 ± 10	20 ± 2	18 ± 1	A + 10	10.0
6.3	120 ± 10	20 ± 2	20 ± 1	A + 10	10.0
8.0	150 ± 10	25 ± 2	20 ± 1	A + 10	12.5

Table 15 Welding Details

(*Clause* F-2.3)

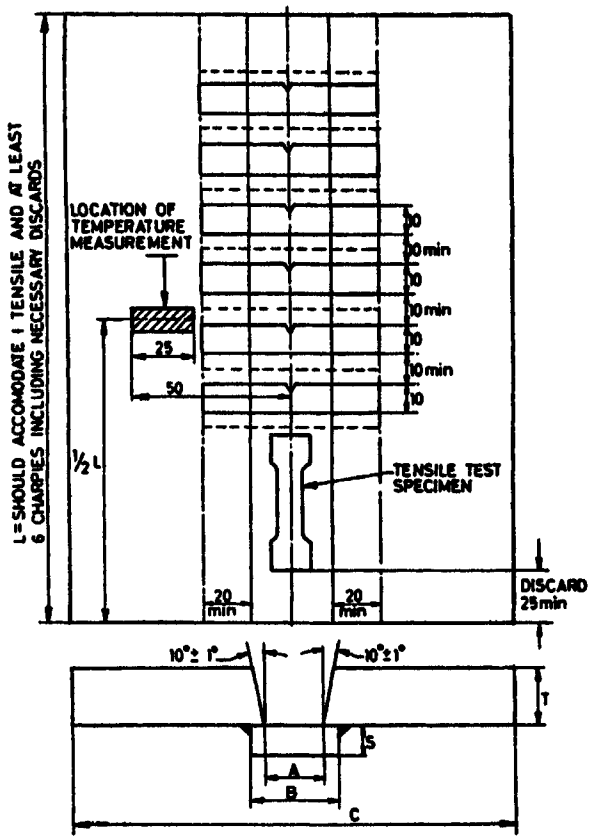
Electrode Size mm	Split Weave Layer No.	Passes for Layer	Number of Layers
(1)	(2)	(3)	(4)
3.15	1 to top	2	6 to 9
4.0	1 to top	2	7 to 10
5.0	1 to top	2	6 to 9
6.3	1 to top	2	6 to 9
8.0	1 to top	2	8 to 12

Table 16 Dimensions of Impact Test Specimen

(*Clause* F-5)

All dimensions in millimetres.

Length	Width	Thickness	Angle of Notch	Root Radius of Notch	Depth Between Notch (Measured at the Both Ends)	Distance from Either End of Test Piece
(1)	(2)	(3)	(4)	(5)	(6)	(7)
55 ± 0.6	10 ± 0.11	10 ± 0.11	45° ± 2°	0.25 ± 0.025	8 ± 0.11	27.5 ± 0.42



All dimensions in millimeters.

FIG. 7 DIMENSIONS OF TEST ASSEMBLY AND POSITION OF CUTTING OF TEST PIECES

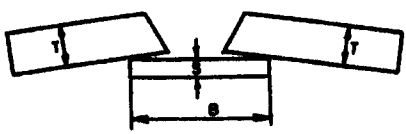


FIG. 8 PRESETTING OF TEST ASSEMBLY

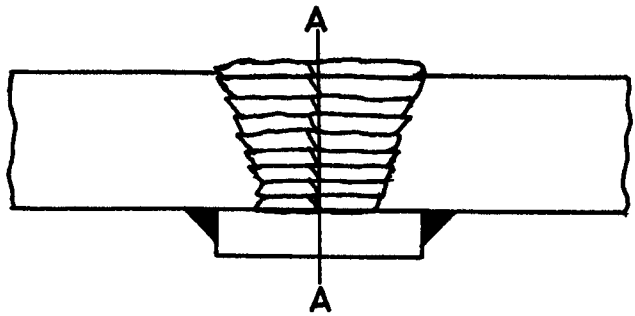


FIG. 9 WELD GEOMETRY

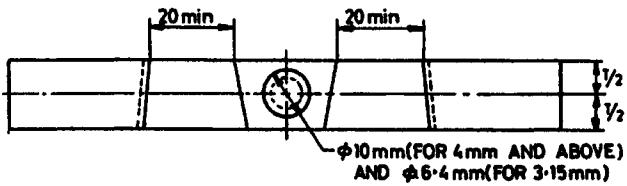


FIG. 10 CUTTING OF TENSILE TEST PIECE

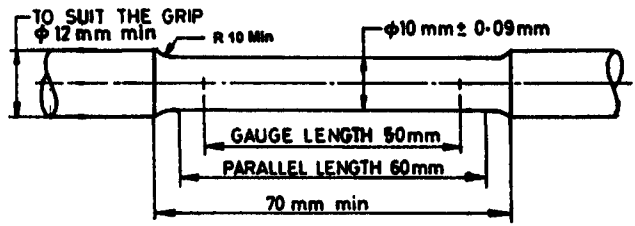


FIG. 11 TENSILE TEST PIECE FOR SIZES 4 mm AND ABOVE

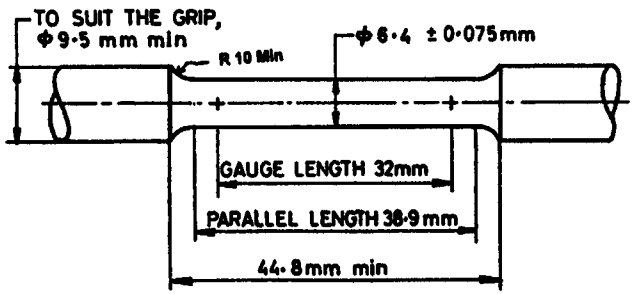
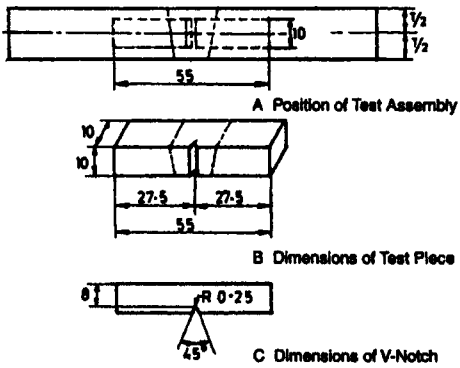


FIG. 12 TENSILE TEST PIECE FOR SIZES 3.15 mm



All dimensions in millimeters.

FIG. 13 IMPACT TEST PIECES/ASSEMBLY

ANNEX G

(Clause 9.2)

BUTT WELD BEND TEST

G-1 PREPARATION OF TEST PIECE

G-1.1 Parent Metal

The parent metal for plates used in preparing test pieces shall be in accordance with Annex F. The test specimen shall not be subjected to any mechanical or thermal treatment other than that required under this Annex.

G-1.2 Test pieces shall be prepared as shown in Fig. 14 by welding together two plates of suitable length to allow the cutting out of test specimens of specified size. The dimensions of test assembly are given in Table 17.

G-1.3 Plates may be preset to allow for slight distortion after welding.

G-1.4 Welding Procedure

The welding procedure followed in making the test pieces should be as set out in Table 7 according to the position of welding. In all cases the backing runs shall be made with 4.0 mm electrodes in the weld position applicable to each test piece after cutting out a groove to a depth of 3 mm if such groove is considered necessary (*see* Fig. 15).

G-1.5 The welding current used shall be within the appropriate range recommended by the manufacturers. The open circuit voltage shall not be less than that specified by the manufacturer. The welding current shall be a.c. if the electrode can be used with positive polarity, when the electrode can be used with both d.c. negative and positive polarity.

G-1.6 After welding the test piece shall be cut by sawing or machining to form one face bend and one root bend test specimen as indicated in Fig. 15. The specimen shall then be subjected to a temperature of 250°C for a period of 12 ± 1 h for hydrogen removal prior to testing. After the soaking period, the specimen shall be withdrawn from the furnace and allowed to cool slowly, protected from droughts and chilling.

G-2 BEND TEST

G-2.1 Each bend test specimen shall be 30 mm in width. The upper and lower surface of the weld shall be filed ground or machined level with the respective original surface of the plates, where the surface of the plates are not level with each other, provided that the thickness of the plate is not reduced by more than a total of 1 mm. Tool marks should be avoided as they lead to localization of stresses and may cause premature failure. For this reason, direction of machining of surfaces should be along the specimen and transverse of the weld. The sharp corners of the test specimens shall be rounded to a radius not exceeding 10 percent of the specimen thickness.

G-2.2 The test specimen shall be bent through an angle of 180° in accordance with IS 1599. Method for bend test over a mandrel having a diameter equal to three times the thickness of the specimen. One test specimen should be tested with face of the weld in tension and one with the root of the weld in tension. The electrode should be deemed to be satisfactory, if on completion of the test no crack or defect at the outer surface of the test specimen is greater the 3 mm measured across the test specimen or 1.5 mm measured along the length of the test specimen. Premature failure at corners of the specimen shall not be considered a cause for rejection.

Table 17 Dimensions of Bend Test Assembly

(*Clause* G-1.2)

All dimensions in millimetres.

Length *Max*	Width, *W* *Min*	Angle	Root Face, *F* *Max*	Root Gap, *G*	Thickness, *d*
(1)	(2)	(3)	(4)	(5)	(6)
180	100	60° – 70°	3	3	15 - 20

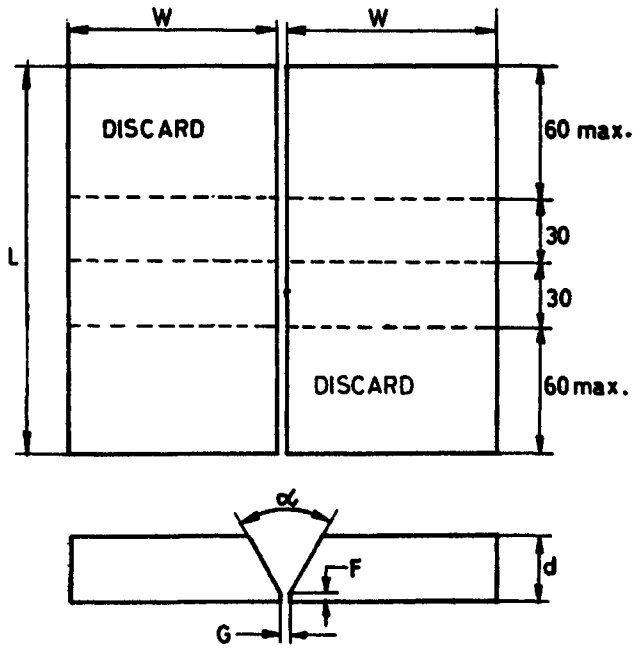


FIG. 14 PREPARATION OF BEND TEST PIECE

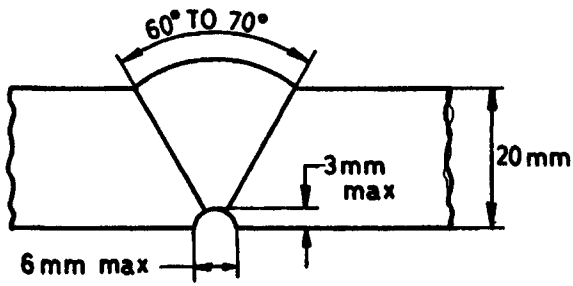


FIG. 15 GROOVE PREPARATION FOR DEPOSITION OF SEALING RUN

ANNEX H

(*Clause* 9.3)

RUNNING PERFORMANCE TEST

H-1 PREPARATION OF TEST PIECE

H-1.1 Parent Metal

The parent material should be chosen from any of the steels prescribed in Annex F. The length of parent material for this test should be such that at least one full straight run of the electrode can easily be accommodated on it. The thickness of the plate/sheet should be within 2 to 3 times the diameter of the core wire of the electrode. If sheet of suitable thickness is not available, plates can be shaped to desired thickness. The plate/sheet should be free from any rust, dirt, moisture, oil, grease or any other contamination before welding.

H-1.2 Welding Procedure

Welding should be done in downhand position by stringer bead or, light weaving technique either by touch welding or by keeping the arc slightly open. The weaving should be restricted to 1.5 times the diameter of the electrode (the final diameter including coating). Three full electrodes of the particular size keeping not more than 50 mm stub end should be burnt over the parent metal by using a suitable current within the current range prescribed by the manufacturer. When the electrode can be used both on d.c. and a.c; a.c. should be used with OCV not less than that prescribed by the manufacturer. When the electrode can be used in d.c. only, the d.c. positive polarity should be adopted. If all the three beads are made on the same plate/sheet, care should be taken that no portion of any bead overlaps with any portion of other beads. The electrodes may be redried before welding as directed by the manufacturer.

H-2 RUNNING PERFORMANCE TEST

The beads shall be visually inspected and shall be free from porosities, slag inclusions, cracks, etc, in the main portion of the beads given in Fig. 16. The beads should be fairly straight and evenly rippled. The slag should be removed with little effort. A length of 15 mm from the start and from finish of the bead should not be considered for visual inspection.

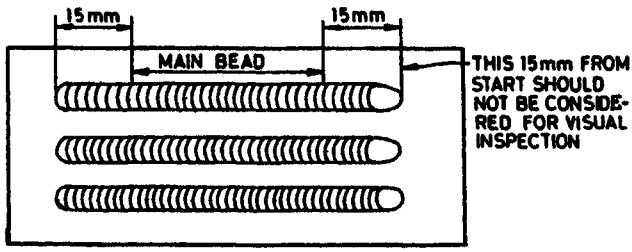


FIG. 16 RUNNING PERFORMANCE TEST

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Amendments Issued Since Publication

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