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Indian Standard

SPECIFICATION FOR LOW AND MEDIUM
ALLOY STEEL COVERED ELECTRODES
FOR MANUAL METAL ARC WELDING

(*Third Revision*)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

SPECIFICATION FOR LOW AND MEDIUM ALLOY STEEL COVERED ELECTRODES FOR MANUAL METAL ARC WELDING

(*Third Revision*)

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Indian Standard

SPECIFICATION FOR LOW AND MEDIUM ALLOY STEEL COVERED ELECTRODES FOR MANUAL METAL ARC WELDING

(Third Revision)

0. FOREWORD

0.1 This Indian Standard (Third Revision) was adopted by the Indian Standards Institution on 11 May 1982, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was first published in 1959 under the title 'Specification for molybdenum and chromium-molybdenum-vanadium low alloy steel electrodes for metal arc welding' and was subsequently revised in 1964 and 1971.

0.3 In recent years, there has been a considerable increase in the industrial usage of the molybdenum and chromium-molybdenum steel electrodes intended for use at elevated service temperatures and a growing use of nickel steel and other low alloy steels for service applications at low ambient temperatures.

0.4 This revision covers a wide variety of low and medium alloy steel covered electrodes which were not included in the earlier standard, but which are being manufactured indigenously and having industrial standardization. The title of the standard has also been changed accordingly.

0.5 The practice of using an appropriate alloyed core wire or mild steel core wire with alloying elements added in the coating in the manufacture of low alloy electrodes is prevalent in different parts of the world.

0.5.1 When the transfer of alloying elements from mild steel cored electrodes with alloys added to the coating is intended, extreme care is necessary to ensure that the electrode flux covering is intact during striking, restriking of arc and fusion. A synthetic electrode with damaged coating will not provide uniform alloy recovery. It is, therefore, recommended that individual electrode manufacturers clearly mention in their

product leaflets about the two variants of electrodes, for example, synthetic type and alloyed core wire type.

0.6 This standard keeps in view the manufacturing and trade practices followed in the country in the field. Assistance has also been derived from the following publications:

AWS: A-5.5-1969 Specification for low-alloy steel covered arc-welding electrodes, Americal Welding Society.

BS 2493-1971 Specification for low-alloy steel electrodes for manual metal arc welding. British Standards Institution.

ISO 3580-1975 Covered electrodes for manual arc welding of creep resisting steels — Code of symbols for identification. International Organization for Standardization.

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

1. SCOPE

1.1 This standard covers the requirements for low and medium alloy steel covered electrodes for manual metal arc welding. The range of electrodes covered in this standard and the chemical composition of all weld metal have been given in Table 1.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 812-1957† shall apply.

3. SUPPLY OF MATERIALS

3.1 General requirements relating to supply of electrodes shall be as laid down in IS : 1387-1967‡.

4. CLASSIFICATION

4.1 Electrodes are classified in the following order on the basis of the usability characteristics, the mechanical properties of the deposited weld metal, type of flux covering as well as the chemical composition of the deposited weld metal (see Tables 1 and 4) and recommended welding positions and current conditions.

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

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

‡General requirements for the supply of metallurgical materials (*first revision*).

TABLE 1 CHEMICAL COMPOSITION OF ALL WELD METAL DEPOSIT*

(Clauses 1.1, 4.1, 10.1 and 13.5)

IS CLASSIFICATION†	CONSTITUENT, PERCENT								
	Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Vanadium
Carbon-Molybdenum Steel Electrodes									
E49 C — A1	0.10	0.35 <i>Min</i>	0.030	0.030	0.35	—	—	0.40-0.65	—
E49 R — A1	0.10	0.35 <i>Min</i>	0.030	0.030	0.35	—	—	0.40-0.65	—
E49 O — A1	0.10	0.35 <i>Min</i>	0.030	0.030	0.35	—	—	0.40-0.65	—
E49 B — A1	0.10	0.90	0.030	0.030	0.80	—	—	0.40-0.65	—
Chromium Molybdenum Steel Electrodes									
E55 R — B1	0.10	0.35 <i>Min</i>	0.030	0.030	0.45	—	0.40-0.65	0.40-0.65	0.50
E55 B — B1	0.10	0.90	0.030	0.030	0.80	—	0.40-0.65	0.40-0.65	0.50
E55 R — B2	0.10	0.35 <i>Min</i>	0.030	0.030	0.45	—	1.00-1.50	0.40-0.65	—
E55 R — B2L	0.05	0.35 <i>Min</i>	0.030	0.030	0.45	—	1.00-1.50	0.40-0.65	—
E55 B — B2	0.10	0.90	0.030	0.030	0.80	—	1.00-1.50	0.40-0.65	—
E55 B — B2L	0.05	0.90	0.030	0.030	0.80	—	1.00-1.50	0.40-0.65	—
E63 R — B3	0.10	0.35 <i>Min</i>	0.030	0.030	0.45	—	2.00-2.50	0.90-1.20	—
E63 R — B3L	0.05	0.35 <i>Min</i>	0.030	0.030	0.45	—	2.00-2.50	0.90-1.20	—
E63 B — B3	0.10	0.90	0.030	0.030	0.80	—	2.00-2.50	0.90-1.20	—
E63 B — B3L	0.05	0.90	0.030	0.030	0.80	—	2.00-2.50	0.90-1.20	—
E55 B — B4	0.10	0.90	0.030	0.030	1.00	—	1.75-2.25	0.40-0.65	—
E55 B — B4L	0.05	0.90	0.030	0.030	1.00	—	1.75-2.25	0.40-0.85	—
E55 B — B5	0.10	0.40-0.70	0.030	0.030	0.30-0.60	—	0.40-0.60	1.00-1.25	0.10
E55 B — B5L	0.05	0.40-0.70	0.030	0.030	0.30-0.60	—	0.40-0.60	1.00-1.25	0.10
E41 R — B6	0.10	1.0	0.030	0.030	0.90	0.40	4.0-6.0	0.45-0.65	—
E41 B — B6	0.10	1.0	0.030	0.030	0.90	0.40	4.0-6.0	0.45-0.65	—
E41 R — B7	0.10	1.0	0.030	0.030	0.90	0.40	6.0-8.0	0.45-0.65	—
E41 B — B7	0.10	1.0	0.030	0.030	0.90	0.40	6.0-8.0	0.45-0.65	—
E41 R — B8	0.10	1.0	0.030	0.030	0.90	0.40	8.0-10.5	0.85-1.20	—
E41 B — B8	0.10	1.0	0.030	0.030	0.90	0.40	8.0-10.5	0.85-1.20	—
Nickel Steel Electrodes									
E55 B — C1	0.10	1.20	0.030	0.030	0.80	2.0 -2.75	—	—	—
E55 B — C2	0.10	1.20	0.030	0.030	0.80	3.0 -3.75	—	—	—
E55 B — C3	0.10	0.40-1.25	0.030	0.030	0.80	0.80-1.10	0.15	0.15-1.35	0.05
Manganese Molybdenum Steel Electrodes									
E63 B — D1	0.10	1.25-1.75	0.030	0.030	0.80	—	—	0.25-0.45	—
E68 B — D2	0.10	1.65-2.00	0.030	0.030	0.80	—	—	0.25-0.45	—
All other Alloy Steel Electrodes									
EX C — G1	0.10	1.0 <i>Min</i> ‡	0.030	0.030	0.80‡	0.50 <i>Min</i> ‡	0.30 <i>Min</i> ‡	0.20 <i>Min</i> ‡	0.10 <i>Min</i> ‡
EX R — G1	0.10	1.0 <i>Min</i> ‡	0.030	0.030	0.80‡	0.50 <i>Min</i> ‡	0.30 <i>Min</i> ‡	0.20 <i>Min</i> ‡	0.10 <i>Min</i> ‡
EX O — G1	0.10	1.0 <i>Min</i> ‡	0.030	0.030	0.80‡	0.50 <i>Min</i> ‡	0.30 <i>Min</i> ‡	0.20 <i>Min</i> ‡	0.10 <i>Min</i> ‡
EX B — G1	0.10	1.0 <i>Min</i> ‡	0.030	0.030	0.80‡	0.50 <i>Min</i> ‡	0.30 <i>Min</i> ‡	0.20 <i>Min</i> ‡	0.10 <i>Min</i> ‡
E63 B — M1	0.10	0.60-1.25	0.030	0.030	0.60-0.80	1.40-1.80	0.15	0.35	0.05
E68 B — M2	0.10	0.75-1.70	0.030	0.030	0.60-0.80	1.40-2.10	0.35	0.25-0.50	0.05
E76 B — M3	0.10	1.30-1.80	0.030	0.030	0.60-0.80	1.25-5.00	0.40	0.25-0.50	0.05
E83 B — M4	0.10	1.30-2.25	0.030	0.030	0.60-0.80	1.75-5.00	0.30-1.50	0.30-0.55	0.05

NOTE 1 — Single values shown are maximum percentages, except where otherwise specified.

NOTE 2 — The letters 'X' used in this table stand to show the strength levels of various electrode types.

*For determining the chemical composition of the weld metal, the electrode should be used with dc, the electrode being negative.

†Suffixes A1, B2, C1, etc, designate the chemical composition of the electrode weld metal.

‡In order to meet the alloy requirements of the G group, the weld deposit need have the minimum as specified in the table, of only one of the elements listed.

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4.1.1 Part One — Prefix letter E indicates the suitability of the electrodes for manual metal arc welding.

4.1.2 Part Two — Minimum tensile properties of the weld metal are indicated by two digits as follows:

Digits	41	49	55	63	68	76	83
Tensile strength, <i>Min</i> , MPa	410	490	550	630	680	760	830

4.1.3 Part Three Type of Flux Covering — The type of flux covering is indicated by a letter symbols as follows:

<i>Letter</i>	<i>Flux Covering of Type</i>
C	Cellulosic
R	Rutile (medium coated)
O	Oxidizing
B	Basic

The characteristics of these types of flux covering are given in Appendix A.

4.1.4 Part Four Chemical Composition — The electrodes are divided into six groups A, B, C, D, G and M followed by a digit and/or a digit and a letter L (in cases where low carbon deposits are required) to indicate the chemical composition group and sub-groups as shown in Table 1.

4.1.5 Part Five — The fifth part of the classification system comprises of a one digit code indicating the different positions of welding in which the electrode can be used:

<i>Symbol</i>	<i>Position(s) of Welding</i>
1	All positions
2	All positions except vertical down
3	Flat butt, flat fillet, horizontal/ vertical
4	Flat butt, flat fillet
5	Similar to 3, and recommended for vertical downward

4.1.6 Part Six — The sixth part is a symbol for the welding characteristics of the electrodes.

4.1.6.1 The welding current and open circuit voltage are symbolized by a digit as given below corresponding to the characteristics of the welding equipment required in order to ensure working conditions free of incidents, such as instability or interruptions of the arc:

<i>Symbol</i>	<i>Direct Current Recommended Polarity</i>	<i>Alternating Current Minimum Open-Circuit Voltage, V</i>
0	+	(See Note 1)
1	+ or -	50
2	-	50
3	+	50
4	+ or -	70
5	-	70
6	+	70
7	+ or -	90
8	-	90
9	+	90

NOTE 1 — Symbol reversed for electrodes used exclusively on direct current.

NOTE 2 — Positive polarity +, negative polarity -.

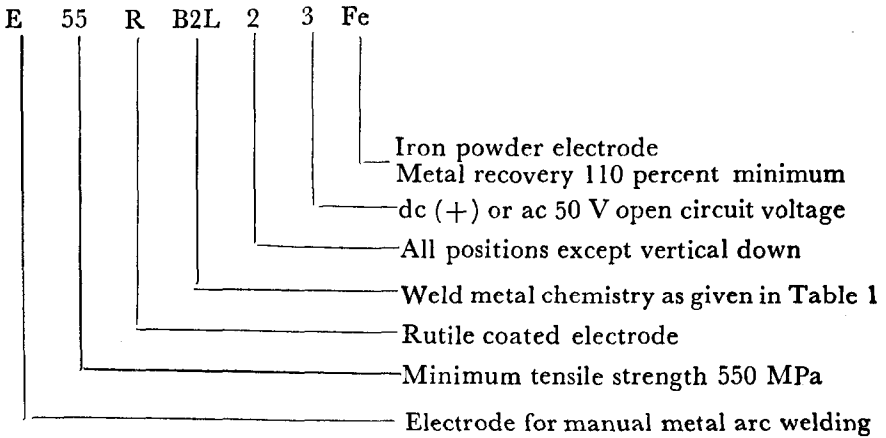
The open circuit voltage necessary for striking the arc varies according to the diameter of the electrode. A reference diameter is required for symbolization. The current conditions given above applies to electrode diameters greater than or equal to 2.5 mm. If electrodes of smaller diameter are used, a higher voltage may be necessary.

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

4.1.7 Part Seven — The following suffixes shall be used to indicate the presence of iron powder and the metal recovery:

- Fe Iron powder covering giving metal recovery of minimum 110 percent
- J Iron powder covering giving a metal recovery of 110 to 130 percent
- K Iron powder covering giving a metal recovery of 130 to 150 percent
- L Iron powder covering giving a metal recovery of over 150 percent

4.1.8 Example of a complete coding: E 55 R B2L 2 3 Fe



4.1.9 Any electrode classified under one classification shall not be classified under any other classification.

5. SIZE AND TOLERANCES

5.1 The designation and size of the electrode shall be as follows:

<i>Designation of the Electrode Size</i>	<i>Diameter of the Electrode Core Wire</i>
	mm
2	2.00
2.5	2.50
3.15	3.15
4	4.00
5	5.00
6.3	6.30
8	8.00

5.2 Tolerance on the specified diameter of the core wire of the electrode shall be ± 0.05 mm.

5.3 Length — The length of various sizes of electrodes shall be as given below:

<i>Electrode Size</i>	<i>Length</i>
	mm
2	250
	300
	350
2.5	250
	300
	350
Above 2.5	350
	450

5.4 The tolerance on the length of individual electrodes shall be ± 3 mm.

6. GENERAL REQUIREMENTS

6.1 The gripping end of the electrodes shall be bare and clean to a length of 20 to 30 mm.

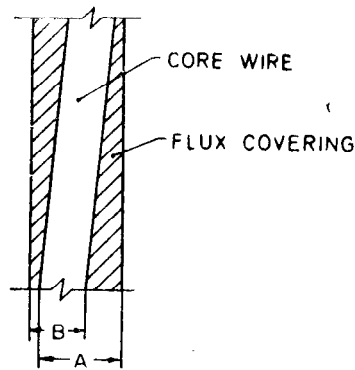
6.2 The arc striking end of the electrodes shall be sufficiently bare, the flux covering evenly tapered to permit easy striking of the arc. The distance from the arc end to the first point where the full cross section of the covering prevails shall in no case exceed 1 mm in synthetic type and low-hydrogen type electrodes. For non-low-hydrogen type coverings and where alloyed core wire is used, this distance shall not exceed a maximum of 1.5 mm.

6.3 Covering — The flux covering shall comply with the following requirements.

6.3.1 Strength — The covering shall be sufficiently strong to withstand without damage normal conditions of handling, storage and use.

6.3.2 Uniformity — The covering shall be uniform in outside diameter and in thickness. The tolerance permitted for uniformity of covering shall be such that maximum core-plus-one covering dimension (*see Fig. 1*) shall not exceed the minimum core-plus-one covering dimension by more than:

- a) 5 percent of the mean of two dimensions for basic-coated electrodes,
- b) 4 percent of the mean of two dimensions for rutile and oxidizing types, and
- c) 3 percent of the mean of two dimensions for cellulosic type electrodes.



$$A - B \leq \frac{5}{100} \cdot \frac{(A + B)}{2} \text{ for flux covering Type 'B',}$$

$$A - B \leq \frac{4}{100} \cdot \frac{(A + B)}{2} \text{ for flux covering Type 'R' and 'Q',}$$

$$A - B \leq \frac{3}{100} \cdot \frac{(A + B)}{2} \text{ for flux covering Type 'C'.$$

where

A = maximum core-plus-one covering dimension, and

B = minimum core-plus-one covering dimension.

FIG. 1 PERMISSIBLE TOLERANCE FOR FLUX COVERING

6.3.3 The covering shall fuse or burn evenly during welding.

7. SPECIFIC REQUIREMENTS AND TESTS

7.1 The following tests shall be carried out to demonstrate the chemical composition, mechanical properties, soundness of the weld metal and the usability of electrodes:

- a) Initial tests,
- b) Periodic check tests, and
- c) Production control tests.

7.2 Initial Tests — These are qualification or proving tests for a particular type or modified types of electrodes, the initial tests shall comprise of all the requirements prescribed in Table 2 in addition to chemical analysis.

TABLE 2 SUMMARY OF MECHANICAL TESTS REQUIRED*

IS CLASSIFICATION†	ELECTRODE SIZE	(Clause 7.2)		
		RADIOGRAPHIC TEST ‡, § WELD METAL TENSION TEST ‡,	IMPACT TEST ‡, ¶	FILLET WELD TEST ‡, **
E41R — X	4 and 5	F††	Not required‡‡	V, 0
E41B — X				
E49C — X		F	Not required‡‡	V, 0
E55C — X				
E63C — X				
E68C — X	4 and 5	F	Not required‡‡	V, 0
E49R — X				
E55R — X				
E63R — X				
E68R — X				
E49 — X	4.5 and 6.3	F	Not required‡‡	V, 0
E50B — X	4	F	F‡‡	H, HF
E55B — X				
E63B — X				
E68B — X				
E76B — X	5	F	F‡‡	H
E83B — X				
	6.3	F	F‡‡	H

NOTE — Impact test for the classifications not mentioned in this table may be carried out if agreed between the manufacturer and the user.

*For electrodes smaller than 4 mm, the results may be judged on the basis of 4 mm size.

†The letter suffix 'X' stands for the suffixes as A1, B1, B2 etc (see Table 1).

‡The abbreviations F, V, O, Hf indicate the welding positions in which the tests are to be conducted — F = Flat, V = Vertical, O = Overhead, H = Horizontal and Hf = Horizontal Fillet.

§See 10.1.1 and 14

||See 10.1.2 and 15

¶See 10.1.3 and 16

**See 10.1.4 and 17

††Radiographic test is not required for E41RX and E41BC classifications.

‡‡Impact tests are required only for E55B-C1, E55B-C2, E55B-C3, E63B-D1 E68B-D2, E63B-M1, E68B-M2, E76B-M3 and E83-M4 classifications.

7.3 Periodic Check Tests — These comprise a few of the tests selected from among the initial tests and are meant to be repeated at intervals to provide evidence that the electrodes currently produced possess the properties proved in the initial tests. Such tests shall be conducted at least once a year. These check tests shall not apply to the electrodes not manufactured during that period. When the production of a type of electrodes after stoppage of production for more than 6 months is restarted, the periodic check tests shall be conducted.

7.3.1 The periodic check tests shall comprise of the following:

- a) Chemical analysis,
- b) Radiographic test,
- c) All weld tensile test, and
- d) All weld impact test.

7.4 Production Control — By means of a suitable system of control, the manufacturer shall satisfy himself that the composition and quality of all the electrodes currently produced are similar to those of the electrodes subjected to the initial tests (*see 7 and 10*). He shall ensure that the result of production control tests and the date of manufacture is traced from the batch number or the relevant details, or both.

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

7.5 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 purchaser and the manufacturer.

8. PACKING AND STORAGE

8.1 The net mass of an individual bundle or carton of electrodes for manual operation shall not exceed 7 kg.

8.2 Electrodes shall be suitably packed to guard against damage during transportation. The packing shall be suitable to ensure that under normal store room conditions, the electrodes shall, for a period of at least 6 months after the despatch from the manufacturer's stores, be capable of giving results in accordance with the provisions of this standard and that if the flux covering is of 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 in the marking of the bundle or box of electrodes. The electrodes shall be stored in a dry store room.

8.3 Each bundle or package shall contain the manufacturer's certificate guaranteeing that the electrodes therein comply with the physical and performance requirements set forth in this standard.

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

8.3.2 If the marking on the bundle includes the ISI Certification Mark (*see 8.4.1*) the manufacturer's certificate need not be included.

8.4 Marking — Each bundle or package of electrodes shall be clearly marked with the following information:

- a) Classification (*see 4.1* and Table 1),
- b) Name of manufacturer,
- c) Trade designation of electrodes,
- d) Size and quantity of electrodes,
- e) Batch number,

NOTE — For the purpose of this standard, a batch is defined as being of the same dry mix, core wire and the same cast number.

- f) Date of manufacture,
- g) Recommended current range and polarity,
- h) Recommendations for special storage condition if required, and
- j) Any other significant information on characteristics or limitation on use.

8.4.1 The bundle or package of electrodes may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

9. TEST RESULTS AND MANUFACTURER'S CERTIFICATE

9.1 On request, as evidence that the electrodes supplied comply with the requirements of this specification, the manufacturer shall produce the results of the most recent periodic check tests carried out within the preceding 12 months on the electrodes representative of the electrodes supplied.

9.2 If a test certificate giving the results of the initial tests carried out on the type of electrode supplied is requested, it shall be made available by the manufacturer (*see 7.5*).

9.3 If required by the purchaser, the manufacturer shall furnish a test certificate by mutual agreement for each batch of electrode supplied (*see also 7.5*).

10. TEST REQUIREMENTS

10.1 In order to be classified under this specification, an electrode shall be capable of yielding the following test results, in addition to the chemical requirements prescribed in Table 1.

10.1.1 Radiographic Requirements

10.1.1.1 The completed radiograph shall be examined and shall meet the porosity acceptance standards prescribed in Table 3 and shown in Fig. 2.

TABLE 3 RADIOGRAPHIC REQUIREMENTS

IS CLASSIFICATION*	RADIOGRAPHIC STANDARD†
EXXO — X } EXXB — X }	Grade 1
EXXC — X } EXXR — X }	Grade 2

*The letter XX following the prefix E used in this table stand for various strength levels and the letter suffix ' X ' stands for the suffixes A1, B2, C2, etc.

†See Fig. 2.

10.1.1.2 The radiographs of the test assembly shown in Fig. 3 and 4 shall reveal no inclusions, cracks or zones of incomplete fusion.

10.1.2 Tensile Strength and Ductility Requirements — The results of the all weld metal tension tests shall conform to the mechanical property requirements prescribed in Table 4.

10.1.3 Impact Requirements — The results of the impact tests shall conform to the impact property requirements prescribed in Table 5. The results of the impact tests are assessed as detailed in **10.1.3.1**.

10.1.3.1 The average \bar{X}_3 of the results of the three impact tests shall be assessed as follows:

$\frac{\bar{X}_3}{\bar{J}}$	Assessment
Up to and including 21	Requirement not fulfilled
Including and over 27	Requirement fulfilled

If the value of \bar{X}_3 lies between 21 and 27 \bar{J} three additional specimens for each set shall be prepared and tested, and the results added to those previously obtained to form a new average \bar{X}_6 . If the value of \bar{X}_6 is 27 and over the electrodes shall be deemed to have fulfilled the requirements. If \bar{X}_6 is less than 27 \bar{J} further six specimens for each set shall be prepared and tested, and the result added to those previously obtained to form a new average \bar{X}_{12} the value of which shall be not less than 27 \bar{J} for the electrode to fulfil the requirements.

10.1.4 Fillet Weld Test Requirements — The completed fillet weld test specimen shall be examined visually and the weld shall be free of cracks. The specimen shall be reasonably free of undercut, overlap, trapped slag and surface porosity.

10.1.4.1 The convexity (of convex fillet welds, refer Fig. 7) shall be in accordance with the requirements of Table 6. The difference in length of the two legs of each fillet weld shall be in accordance with the requirements of Table 6.

10.1.4.2 The two fractured specimens when examined visually shall be free of cracks. Incomplete fusion at the root of the weld shall not be greater than 20 percent of the total length of weld. In no case shall any continuous area of incomplete fusion be greater than 25 mm, in length as measured along the longitudinal weld axis.

NOTE — The fillet weld test is not intended for the determination of surface porosity under the conditions normally encountered because variations in base metals, welding procedures, welders skill etc, will affect the porosity level.

10.1.5 Moisture Test Requirements — Moisture test shall be carried out as specified in 18 to determine the moisture content of the flux coreing which shall not exceed the limits percent prescribed in Table 7. The test shall be conducted after the electrodes are dried as per electrode manufacturer's recommendations.

11. RETESTS

11.1 Where any test specimen fails to satisfy the test requirements, twice the number of the test specimens made for that test shall be prepared (using electrodes from the same batch where possible) and submitted to the tests in which failure occurred. The electrodes shall not be accepted as having passed that test unless the tests on the additional specimens are satisfactory.

12. PARTICULARS OF TESTS

12.1 The test specified in 10 shall be conducted in accordance with the provisions contained in 13 to 18.

12.2 Parent Material For Tests

12.2.1 Steel to be used for test plates for chemical, radiographic, tensile and impact test, steel shall conform to IS : 226-1975*, IS : 2002-1962† or IS : 2062-1969‡ or equivalent.

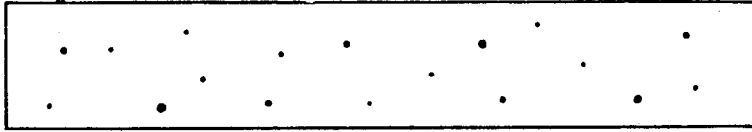
12.2.2 For Fillet Weld Test — Any high strength low or medium alloy steel conforming to IS : 8500-1972§ having a tensile strength equal to or greater than the tensile strength specified for the deposited weld metal of the electrode classification being tested except for E41R and E41B classifications, or steels conforming to IS : 2062-1969‡ or IS : 2002-1962† may be used.

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

†Specification for steel plates for boilers.

‡Specification for structural steel (fusion welding quality) (*first revision*).

§Specification for weldable structural steel (medium and high strength quality).

Grade 1*Assorted Porosity*

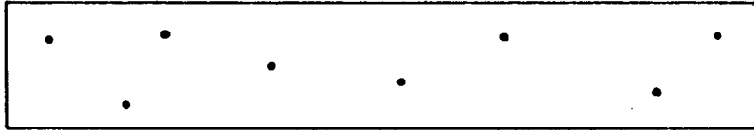
Size of porosity — 0.4 to 1.6 mm in diameter.

Maximum number of indications in any 150 mm of weld = 18, with the following restrictions:

Maximum number of large (1.2 to 1.6 mm dia) indications = 3.

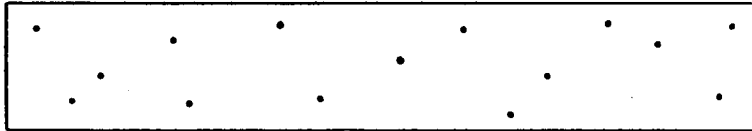
Maximum number of medium (0.8 to 1.2 mm dia) indications = 5.

Maximum number of small (0.4 to 0.8 mm dia) indications = 10.

*Large Porosity*

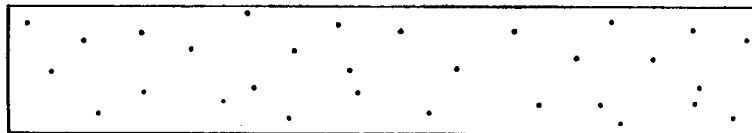
Size of Porosity — 1.2 to 1.6 mm in diameter.

Maximum number of indications in any 150 mm of weld = 8.

*Medium Porosity*

Size of Porosity — 0.8 to 1.2 mm in diameter.

Maximum number of indications in any 150 mm of weld = 15.

*Fine Porosity*

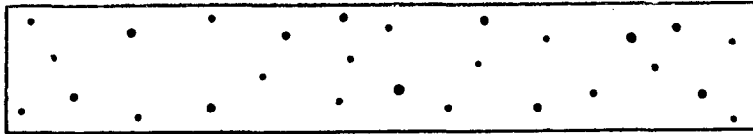
Size of Porosity — 0.4 to 0.8 mm in diameter. Maximum number of indications in any 150 mm of weld = 30.

NOTE 1 — In using these porosity standards, the chart which is most representative of the size of the porosity present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.

NOTE 2 — Since these are test welds specifically made in the laboratory for classification purposes, the radiographic requirements for these test welds are more rigid than those which may be required for general fabrication.

FIG. 2 POROSITY STANDARDS FOR RADIOGRAPHIC TEST — *Contd*

Grade 2



Assorted Porosity

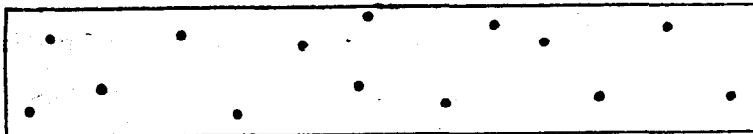
Size of porosity 0.4 to 2 mm in diameter.

Maximum number of indications in any 150 mm of weld = 27, with the following restrictions.

Maximum number of large (1.6 to 2 mm dia) indications = 3.

Maximum number of medium (1.2 mm to 1.6 mm dia) indications = 8.

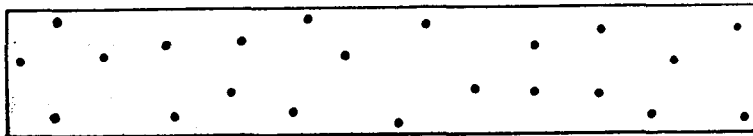
Maximum number of small (0.4 to 1.2 mm dia) indications = 16.



Large Porosity

Size of Porosity 1.6 to 2 mm in diameter.

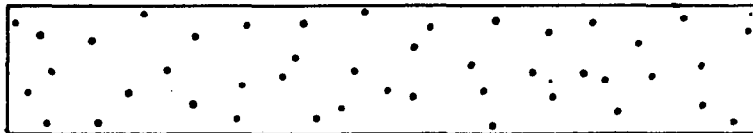
Maximum number of indications in any 150 mm of weld = 14.



Medium Porosity

Size of porosity 1.2 to 1.6 mm diameter.

Maximum number of indications in any 150 mm of weld = 22.



Fine Porosity

Size of porosity 0.4 to 1.2 mm in diameter. Maximum number of indications in any 150 mm of weld = 44.

NOTE 1 — In using these porosity standards, the chart which is most representative of the size of the porosity present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.

NOTE 2 — Since these are test welds specifically made in the laboratory for classification requirement purposes, the radiographic requirements for these test welds are more rigid than those which may be required for general fabrication.

FIG. 2 POROSITY STANDARDS FOR RADIOGRAPHIC TEST

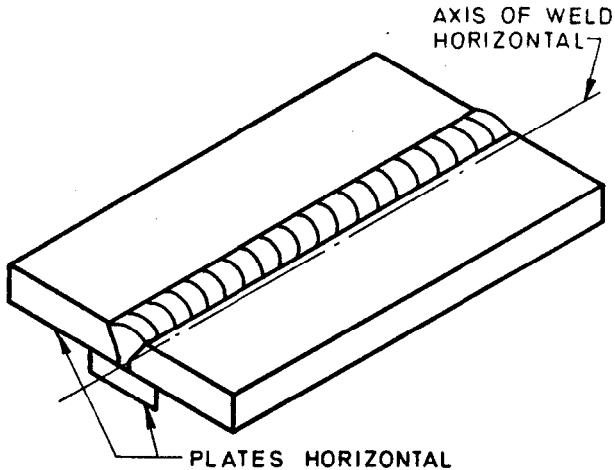


FIG. 3 POSITION OF TEST PLATES FOR RADIOGRAPHIC TEST AND ALL-WELD METAL TEST

12.3 Conditioning of Electrodes for Test

12.3.1 Electrodes should be tested in the as-received condition except in the case of the basic coated hydrogen controlled electrodes. The basic coated hydrogen controlled electrodes shall be dried and/or baked before use at temperatures and for the period recommended by the supplier.

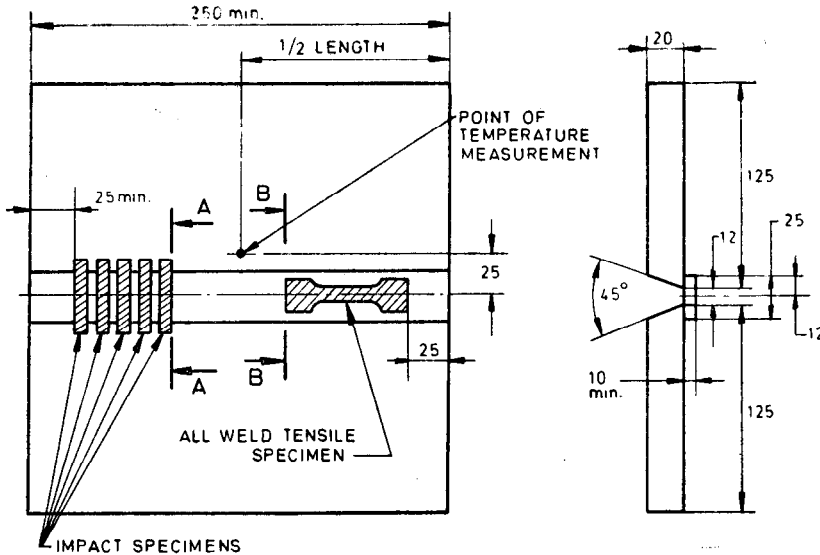
12.3.2 In case of unfavourable storage conditions and moisture pick-up, certain amount of drying of electrodes of other classification may be necessary in which case such drying can be effected in accordance with agreement between the supplier and the user.

13. CHEMICAL ANALYSIS OF WELD METAL

13.1 Chemical analysis sample shall be prepared for each size of electrodes, using the current conditions recommended by the manufacturer and the base metal specified in 12.2. All welding shall be done in the flat position.

13.2 Samples for chemical analysis may be obtained either from a welded pad prepared as per the dimensions given in Table 8 and details in clause 13.3 or from the all weld metal test specimen or any suitable method provided produces results equivalent to those obtained from the weld pad.

ELECTRODE SIZE, mm	FULL WEAVE FOR LAYER NO.	SPLIT WEAVE		NUMBER OF LAYERS
		Layer No.	Passes per Layer	
4	1	2 to top	2	7 to 9
5	1 and 2	3 to top	2	6 to 8
6.3	1.2 and 3	4 to top	2	5 to 7

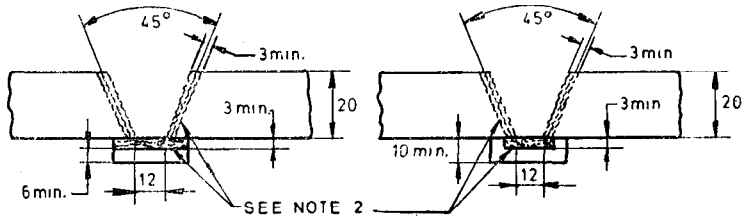


4A Test Plate Showing Location of Test Specimens

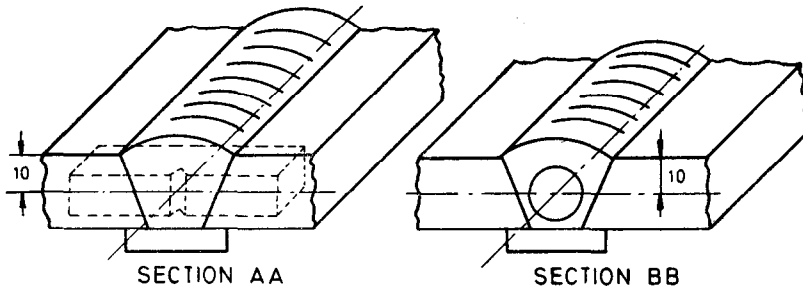
NOTE 1 — Either one of the backings shown in Fig. 4B may be used to test any diameter electrode.

NOTE 2 — The fusion faces of plates and the contact face of the backing shall be surfaced as shown by any size of the electrode being tested, before welding. For E41 R-XX and E41 B-XX electrodes a minimum preheat temperature of 150°C shall be used during surfacing.

NOTE 3 — Each layer shall be approximately 3 mm thick.



4B Edge Preparation of Test Plate



4C Orientation of Impact Specimen

4D Location of All-Weld-Metal
Tension SpecimenFIG. 4 DETAILS OF TEST ASSEMBLY FOR RADIOGRAPHIC TEST,
ALL-WELD-METAL TENSION TEST AND IMPACT TEST

13.3 Pad shall be deposited in layers. The width of each bead of each layer shall measure 1.5 to 2.5 times the diameter of the core wire. After each layer has been deposited, the pad shall be cooled by immersion in water (temperature unimportant) and then dried before welding is resumed.

13.4 The top surface of the pad shall be removed and discarded and sample sufficient for analysis shall be taken in such a manner that no metal is removed closer to the surface of the base plate than the distance shown in Table 8.

13.5 When the sample is analysed in accordance with IS : 228* and its relevant parts and the chemical analysis of the weld metal of the electrode type under test shall conform to the weld analysis provided in Table 1.

*Methods of chemical analysis of steels.

TABLE 4 TENSILE STRENGTH, YIELD STRENGTH AND ELONGATION REQUIREMENTS FOR ALL WELD METAL TENSION TEST*, †

(Clauses 4.1 and 10.1.2)

IS CLASSIFICATION ‡	TENSILE STRENGTH, <i>Min</i>		0.2 PERCENT PROOF STRESS§		ELONGATION PERCENT, <i>Min</i>	
	MPa	(kgf/mm ²)	MPa	(kgf/mm ²)	$4\sqrt{S_0}$	$5.65\sqrt{S_0}$
	E41 R — X E41 B — X } E49 C — X E49 R — X E49 O — X E49 B — X } E55 C — X E55 R — X E55 B — X } E55 B — C3 E63 C — X E63 R — X E63 B — X } E63 B — M1 E68 C — X E68 R — X E68 B — X } E68 B — M2 E76 B — X E76 B — M3 E83 B — X E83 B — M4	410 490 550 550 630 630 680 680 760 760 830 830	(42) (50) (56) (56) (64) (64) (70) (70) (77) (77) (84) (84)	— 390 460 470-550 530 540-630 600 610-685 665 675-755 735 745-825	— (40) (47) (48-56) (54) (55-64) (61) (62-70) (68) (69-77) (75) (76-84)	20 22 22 25 25 19 16 19 24 17 14 17 20 15 20 14 18

*For the E49 B-G, E55 B-C3, E55 B-G, E63 B-M1, E68 B-M2, E76 B-M3 and E83 B-M4 electrode classification the values shown are for specimens which are tested in the as-welded condition. Specimens tested for all other classifications are in the stress relieved condition (see Table 9).

†See Table 2 for sizes to be tested.

‡The letter ' X ' stands for all the classes, for example A1, B2, C1, etc.

§Single values shown are the minimum.

||For the as-welded condition the required yield strength is 415 MPa/(42 kgf/mm²).

¶Percentage elongation values on gauge length $5.65\sqrt{S_0}$ are approximate.

TABLE 5 IMPACT TEST REQUIREMENTS**(Clauses 10.1.3 and 16.2)*

IS CLASSIFICATION	MINIMUM CHARPY-V-NOTCH IMPACT VALUE
E55 B — C3	27 J at — 40°C†
E63 B — D1	27 J at — 50°C‡
E68 B — D2	
E63 B — M1	
E68 B — M2	27 J at — 50°C‡
E76 B — M3	
E83 B — M4	
E55 B — C1	27 J at — 60°C‡
E55 B — C2	27 J at — 75°C‡
All other classifications	Not Required§

*The impact test results shall be assessed as per **10.1.3.1**.

†As-welded impact properties.

‡Stress relieved impact properties.

§If it is desired to carry out impact test of the electrode classes not mentioned in this table, the same can be done as per the mutual agreement between the manufacturer and the supplier. In the event of impact tests being carried out for any other electrode types not included in the table, the temperatures for the test and impact values are to be chosen from the table in accordance with the service needs of the weldments.

27 J = 2.8 kgf.m.

14. RADIOGRAPHIC TEST

14.1 Radiographic test assemblies as detailed in Fig. 4 shall be made in the flat position (*see* Fig. 3 for welding position) using the types of current for each type of electrodes, recommended current (amps) for each size of electrodes, recommended by the manufacturer and the base metal specified in **13**. When the manufacturers' recommendation permits its use with more than one type of current, the electrode shall be tested using each type of current.

14.2 The test assembly shall be tack welded and shall be insulated from the welding bench by 12 mm thick asbestos during welding. After tack welding, the assembly shall be heated to the preheat temperature prescribed in Table 9 (measured by temperature indicating crayons or surface thermometers at the point specified in Fig. 4) for the electrode classification being tested. This preheat or interpass temperature shall be maintained during welding.

14.3 The welding sequence shall be as shown in Fig. 4. Each pass shall include at least one electrode start and stop within the length of the weld which must meet radiographic requirements. The direction of welding for each electrode used to complete a pass shall not vary; however, the direction of welding for different passes may be alternated.

TABLE 6 DIMENSIONAL REQUIREMENTS FOR FILLET WELDS

(Clause 10.1.4.1)

SIZE OF FILLET WELD	MAXIMUM CONVEXITY	MAXIMUM DIFFERENCE BETWEEN LENGTH OF FILLET LEGS
		mm
mm	mm	mm
3.15	1.1	1.0
4.0	1.2	1.2
5.0	1.5	1.5
5.6	1.6	2.0
6.3	1.5	2.5
7.0	1.5	2.8
8.0	2.0	3.15
9.0	2.0	3.6
10.0	2.0	4.0

TABLE 7 COVERING MOISTURE CONTENT REQUIREMENTS

(Clause 10.1.5)

IS CLASSIFICATION*	MAXIMUM MOISTURE CONTENT, PERCENT BY WEIGHT
E50 B — X	0.6
E55 B — X, E63 B — X	0.4
E63 B — X, E76 B — X, E83 B — X	0.2

*The letter ' X ' used in this table stands for all the suffixes (A1, B2, C3, etc.)

TABLE 8 WELD PAD DIMENSIONS AND DETAILS

(Clause 13.2)

ELECTRODE SIZE mm	MINIMUM PAD SIZE	MINIMUM DISTANCE OF SAMPLES FROM SURFACE OF BASE PLATE mm
2.5	25 × 25 × 12 mm	6
3.15, 4.5	40 × 40 × 16 mm	8
6.3, 8	50 × 50 × 20 mm	10

TABLE 9 PREHEAT, INTERPASS AND STRESS RELIEF TEMPERATURE

IS CLASSIFICATION*	(Clauses 14.2 and 14.4) PREHEAT AND INTERPASS TEMPERATURE, °C	STRESS RELIEF TEMPERATURE, °C		
E41 R — X E41 B — X	150-260	†		
E49 C — X† E49 R — X E49 O — X E49 B — X E55 B — X E63 B — X E68 B — X E76 B — X E83 B — X				
E55 C — X† E55 R — X E63 C — X E63 R — X E68 C — X E68 R — X	165 to 190§	620 ± 15§		
E55 C — B2 E55 C — B2L E55 R — B2 E55 R — B2L E55 B — B2 E55 B — B2L E63 B — B3 E63 B — B3L E55 B — B4 E55 B — B4L E55 B — B5 E55 B — B5L				
E55 B — B2 E55 B — B2L E63 B — B3 E63 B — B3L E55 B — B4 E55 B — B4L E55 B — B5 E55 B — B5L			165 to 190	690 ± 15
E55 B — B3 E55 B — B3L E55 B — B4 E55 B — B4L E55 B — B5 E55 B — B5L				
E55 B — C3 E63 B — M1 E68 B — M2 E76 B — M3 E83 B — M4			95 to 120	—
E55 B — C3 E63 B — M1 E68 B — M2 E76 B — M3 E83 B — M4				

*The letter suffix 'X' as used in this table stands for all the suffixes (A1, B1, etc) except the B2, B3, B4, C3 and M suffixes.

†Specimen shall be heated to between 840°C and 870°C and held for 2 hours, furnace cooled at a rate not exceeding 40°C per hour to 580°C and air cooled.

‡Stress relief not required for classification E49 C-G and E55 C-G.

§These temperatures apply to all electrodes of the classifications, shown, except electrodes of classification EXXX — B2, EXXX — B3, EXXX — B4, EXXX — B6, EXXX — B7, EXXX — B8, EXXX — C3 and EXXX — M suffixes.

14.4 If it is necessary to interrupt the welding procedure prescribed in **14.3** the assembly shall be allowed to cool in still air to room temperature. When ready to resume work, the assembly shall be pre-heated to a temperature within the preheat and interpass temperature range prescribed in Table 9. The procedure used for completing the work shall be as prescribed in **14.3**.

14.5 The assembly shall be prepared for radiographic inspection as follows.

14.5.1 The weld ripples or weld surface irregularities on both faces of the weld shall be removed by any suitable mechanical process to a degree such that the resulting radiographic contrast due to any remaining irregularities cannot mask or be confused with that of any objectionable defect. Also the weld faces shall merge smoothly into the plate surface. The finished surface of the re-enforcement may be flush with plate or have a reasonably uniform reinforcement, not exceeding 2.5 mm.

14.5.1.1 The backing material shall be removed prior to radiography.

14.5.1.2 The radiographs shall be obtained in accordance with the recommendations stipulated in IS : 1182-1967* for controlling quality of radiographic testing.

14.5.1.3 When evaluating the completed radiographs, 25 mm lengths on both ends of the test welds shall be disregarded.

15. ALL-WELD METAL TENSION TEST

15.1 Either before or after the radiographic examination (but before any impact or tensile test specimens are machined from the test assembly), those test assemblies made with electrodes of all except the E55 B-C3, and EXXB-M classifications, shall be stress-relieved according to the following schedule.

15.1.1 The temperature of the assembly shall be raised in a suitable furnace at the rate of 60 to 260°C per hour until the temperature prescribed in Table 9 for the electrode classification being tested has been attained. This temperature shall be maintained for 1 hour. The assembly shall then be cooled in the furnace at a maximum rate of 170°C per hour. The assembly may be removed from the furnace when the temperature has reached 310°C.

15.2 No thermal treatment shall be employed on assemblies which have been welded with electrodes of the E55-B — C3, and EXXB-M classifications.

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

15.3 One all weld tension test specimen shall be machined from the test assembly (*see* Fig. 4).

15.4 The all weld metal tension test specimen shall be machined and tested in accordance with IS : 1608-1972*.

16. IMPACT TEST

16.1 Three 'V' notch impact specimen shall be machined from the same test assembly (*see* Fig. 4) from which the all weld metal tension test specimen was machined.

16.2 The impact test specimens shall be tested in accordance with the methods prescribed in IS : 1757-1973† at the test temperature specified in Table 5 for the classification being tested. The temperature shall be controlled to within $\pm 1^{\circ}\text{C}$. The test specimens shall be brought to the test temperature and shall be maintained at that temperature for a sufficient length of time (minimum 5 minutes). The specimen shall then be quickly transferred to the testing machine and the test conducted within a time lapse of not more than 5 seconds.

17. FILLET WELD TEST

17.1 Test assemblies as detailed in Table 10 and Fig. 5 shall be made using the base metal, specified in 12.2.2 and types of current and welding position (*see* Fig. 6 for welding positions) recommended for each size of electrode by the supplier. When an electrode classification permits its use with more than one type of current, the electrode shall be tested using each type of current.

17.2 The test plates shall be assembled as shown in Fig. 5. Both ends of the plates shall be secured by tack welds. Before assembly the standing member (web) shall have one edge machined throughout its length so that when the web is set upon the base plate (flange), which shall be straight and smooth there will be intimate contact along the entire length of the joint.

17.3 A single pass fillet weld shall be deposited on one side of the joint for approximately the full length of the test plates. The minimum temperature of the assembly during welding shall be 20°C. At least one electrode (and as many more the weld length permits) shall be continuously consumed to within maximum permissible stub length of 50 mm.

17.4 When welding in the vertical position, the welding shall progress upwards.

*Method for tensile testing of steel products (*first revision*).

†Method for beam impact test (V-notch) on steel (*first revision*).

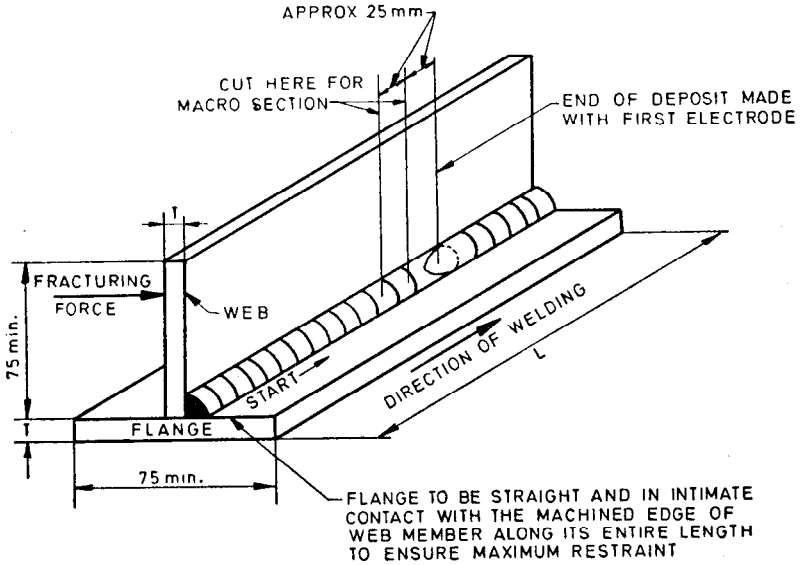
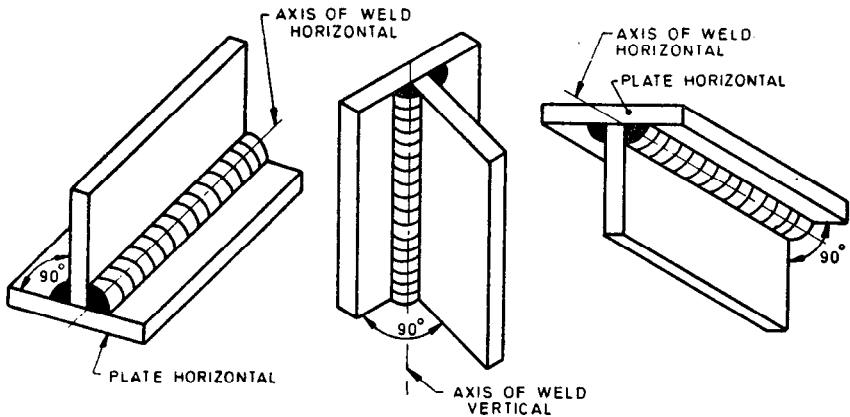


FIG. 5 PREPARATION OF FILLET WELD TEST SPECIMEN



6A Horizontal Fillet Welds 6B Vertical Fillet Welds 6C Overhead Fillet Welds

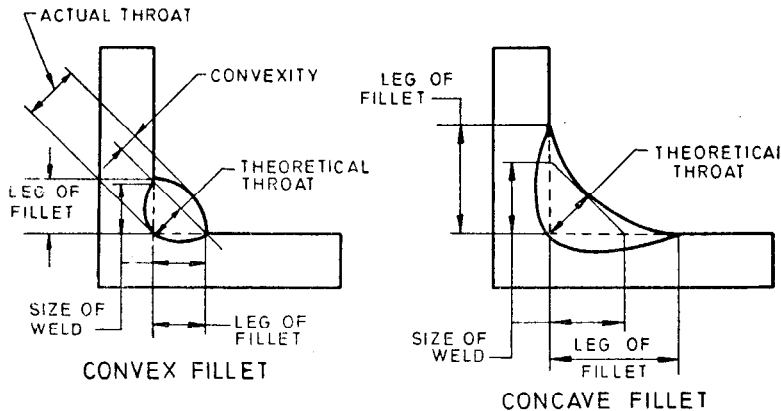
FIG. 6 POSITIONS OF TEST PLATES FOR WELDING FILLET WELDS

17.5 The completed weld shall first be visually examined. Then a macro section approximately 25 mm wide, shall be removed from a point approximately 25 mm back from the crater end of the deposit made with the first electrode. One surface of the macro section shall be polished, etched and scribed as shown in Fig. 7. The size, convexity (of convex fillet welds), and leg lengths of the fillet weld shall be determined to the nearest 0.5 mm by actual measurement of the polished and etched macro section (see Fig. 7).

17.6 The remaining two joint sections shall be broken longitudinally through the fillet weld by a force exerted in the direction as shown in Fig. 5. The fractured surfaces shall be examined. If, during bending, the weld pulls out of the test plate it shall be considered as no test.

17.7 If necessary to facilitate fracture, one or more of the following procedure may be used:

- a) Reinforcing weld as shown in Fig. 8A, may be added to each leg of the weld.
- b) The position of the web on the flange may be changed as shown in Fig. 8 B.
- c) The face of the weld may be notched as shown in Fig. 8 C.



NOTE — Size of fillet weld = leg length of largest inscribed isosceles right angled triangle. Fillet weld size, convexity, and leg lengths shall be determined by actual measurement (to nearest 0.5 mm) on section laid out with scribed lines as shown.

FIG. 7 DIMENSIONS OF FILLET WELDS

TABLE 10 REQUIREMENTS FOR PREPARATION OF FILLET WELD TEST ASSEMBLIES

(Clause 17.1)

IS CLASSIFICATION*	ELECTRODE SIZE†	PLATE SIZE, mm			POSITION OF WELDING‡	SIZE OF FILLET WELD
		Thickness T	WIDTH Min	LENGTH‡ Min L		
		mm	mm	mm		
EXXC — X	4	10	75	300	V, O	6 Max
	5	10	75	300	V, O	6 Max
	6.3	12	75	300	H	6 Min
EXXR — X	4	10	75	300	V, O	6 Max
	5	12	75	300	V, O	10 Max
EXXO — X	5	10	75	300	H	6 Min
	6.3	12	75	300	H	8 Min
EXXB — X	4	10	75	300	V, O	8 Max
	5	10	75	300	H	6 Min
	6.3	12	75	300	H	8 Min

*The letter 'XX' following the prefix 'E' used in this table stands for the various strength levels in MPa: 410, 490, 550, 630, 680, 760 and 830. The letter suffix 'X' stands for the chemical composition suffixes A1, B1, B2 etc.

†When using 350 mm long electrodes, the minimum length shall be 300 mm, when using 450 mm electrodes, the minimum length shall be 450 mm.

‡In the event the end of the weld deposit made with the first electrode is closer than 100 mm from the end of the test plate, a starting tab or a longer test plate may be used.

§The abbreviations V, O, H indicate the welding positions: V = vertical, O = overhead, and H = Horizontal.

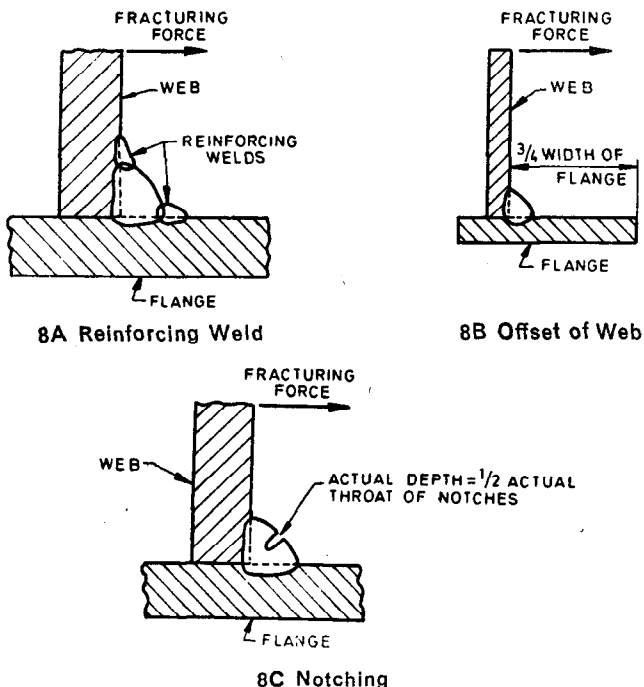


FIG. 8 ALTERNATE METHODS OF FACILITATING
FILLET WELD FRACTURE

18. MOISTURE TEST

18.1 The following method shall be used to determine moisture content in an electrode covering. Oxygen shall be passed over the sample of covering in a nickel or clay boat placed in a fused silica or high-temperature ceramic-type combustion tube which is then heated. Liberated water is collected in a weighed absorption U-tube and weight of water determined by the increase in the weight of the U-tube. The moisture content shall be expressed as a percentage of the weight of the covering sample.

18.2 The apparatus shall be as shown in Fig. 9 and shall consist of the following.

18.2.1 A tube furnace with a heating element of sufficient length to heat at least 203 mm of the middle portion of the combustion tube to 1 095°C.

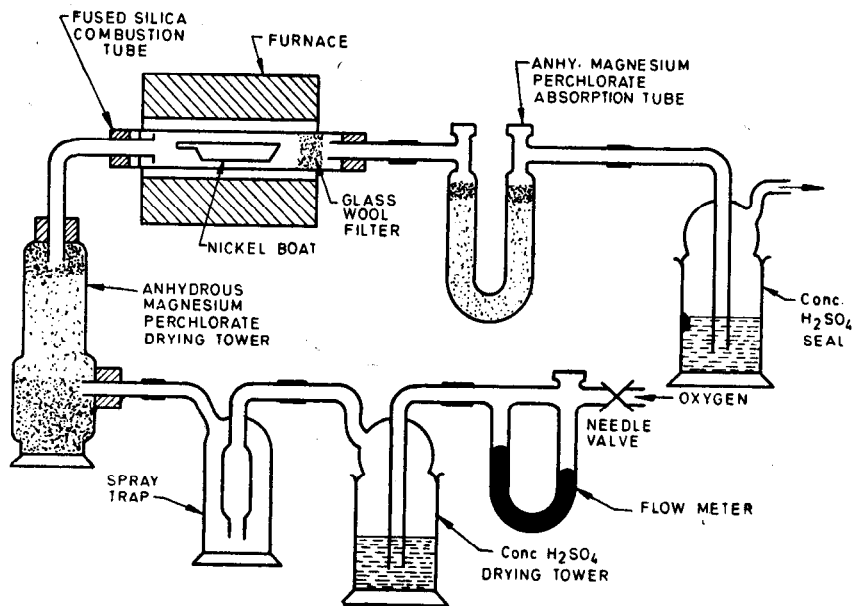


FIG. 9 SCHEMATIC OF TRAIN FOR MOISTURE DETERMINATION

18.2.2 An oxygen purifying train consisting of a needle valve, flow meter, 98 percent sulphuric acid wash bottle, spray trap, and anhydrous magnesium perchlorate drying tower.

18.2.3 Fused silica combustion tube 22.2 mm inside diameter with plain ends and a devitrification point above 1095°C. (A high-temperature ceramic-type tube can be used, but a higher blank value will result.) A plug of fine glass wool to filter the gases shall be inserted far enough into the exit end of the combustion tube to be heated to a temperature of 204-260°C.

18.2.4 Water absorption train consisting of a U-tube (Schwartz tube) filled with anhydrous magnesium perchlorate and a concentrated sulphuric acid gas-sealing bottle.

18.3 The covering sample of approximately 4 g shall be a composite of the middle portions of covering from three electrodes from the same package and shall be removed by bending or with clean, dry forceps. The sample shall be transferred immediately to a dried, stoppered vial or sample bottle.

18.4 The furnace shall be operated at 900 to 930°C with an oxygen flow of 200 to 250 ml per min. The nickel boat shall be placed in the combustion tube for drying and the absorption U-tube shall be attached to the system for 'conditioning'. After 30 min, the absorption U-tube shall be removed and placed in a desiccator in which anhydrous magnesium perchlorate is used as the desiccant. After a cooling period of 20 min, the absorption U-tube shall be weighed.

18.5 Immediately after weighing the absorption U-tube, the sample covering shall be weighed on the balance dish and quickly transferred to the boat. The combustion tube shall be opened, the weighed absorption U-tube attached, the boat and sample transferred to the combustion tube, and the tube closed. After an ignition period of 30 min the absorption U-tube shall be removed from the combustion tube and transferred to the balance case. If another sample is to be run, the boat shall be taken from the combustion tube, the ignited sample removed, and the boat transferred to the desiccator. The absorption U-tube shall be weighed after the 20 min cooling period. Another determination may be started immediately and it is not necessary to repeat the blank determination since the same combustion boat can be used.

18.6 In the blank determination, the procedure for an actual moisture determination shall be followed step-by-step with a single exception of omitting the sample. The nickel boat shall be removed from the desiccator and exposed to the atmosphere for a period approximating the time required to transfer the sample from the balance pan to the boat. The combustion tube shall be opened, the weighed absorption U-tube attached, the boat placed in the combustion tube, and the tube closed. After a heating period of 30 min, the absorption U-tube shall be removed and placed in the balance case and the nickel boat shall be transferred to the desiccator. After the 20 min cooling period, the absorption U-tube shall be weighed and the gain in weight shall be taken as the blank value.

18.7 The calculation shall be made according to the following formula:

$$\text{Percent moisture} = \frac{A - B}{\text{Weight of sample}} \times 100$$

where

A = gain in weight of absorption U-tube in moisture determination, and

B = gain in weight of absorption U-tube in blank determination.

18.8 Modifications of Moisture Test Apparatus

18.8.1 The moisture test apparatus as per the following modifications may also be used for determining the moisture content of electrode coverings.

18.8.2 Nickel boats are used rather than clay boats because lower blank values can be obtained. Some laboratories use zirconium silicate combustion tube in preference to fused silica or mullite because zirconium silicate will not devitrify or allow the escape of combustible gases at temperature up to 1370°C. Some combustion tubes are reduced at the exit end and a separate dust trap is used. This dust trap consists of a 200 mm drying tube filled with glass wool which is inserted between the schwartz absorption bulb and the combustion tube. A suitable 150°C heater is mounted around the dust trap to keep the evolved water from condensing in the trap. The dust trap is filled with glass wool which can be easily inspected to determine when the glass wool should be replaced.

18.8.3 On the ingoing side of the combustion tube, a pusher rod can be used consisting of a 3.2 mm stainless steel rod mounted in a 6.4 mm copper tee fitting. This is used at the entrance of the combustion tube and permits gradual introduction of the sample into the tube while oxygen is passing over the sample. In this way, any free moisture will not be lost, which can happen if the sample is introduced directly into the hot zone before closing the end of the tube.

APPENDIX A

(Clause 4.1.3)

CHARACTERISTICS OF ELECTRODE COVERINGS

Type of Covering

Characteristics

C

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

This type of electrode is characterized by a highly penetrating arc and fairly high fusion rate. Spatter losses are fairly large and the weld surface is somewhat coarse, with unevenly spaced ripples. These electrodes are usually suitable for welding in all positions.

*Type of Covering**Characteristics*

R Rutile type electrodes have a covering containing a large quantity of rutile or components derived from titanium oxide. Usually this amounts to 50% by mass (not taking into account cellulosic material).

The R type can be distinguished from the other types by its heavier slag. Sometimes this difference is not readily discernible, especially with electrodes having a medium covering, but the amount of rutile in the covering is well above 45 percent.

Because of the difference in application and also mechanical properties, a subdivision is made according to the thickness of the covering.

The covering is of medium thickness. Small amounts of cellulosic material, up to the maximum of 15 percent may be present in the covering. These electrodes are particularly suitable for welding in the vertical and overhead positions.

Although the susceptibility to solidification cracking because of dilution by the parent metal is not so high as that of the acid type, care has to be taken in view of the fact that usually a weld is made with a much smaller throat thickness than with acid electrodes. .

O Electrodes of the oxidizing type have a thick covering composed mainly of iron oxides with or without manganese oxides. The covering gives a slag so that the deposited metal contains only small amounts of carbon and manganese. The slag is heavy, compact that often self-detaching. This type of electrode gives poor penetration and a fluid molten pool, and is particularly suitable when only a small weld is required. Usually its use is restricted to welding in the horizontal-vertical fillet weld and flat fillet weld positions.

These electrodes are used mainly for welding steels when the appearance of the weld is more important than the mechanical strength of the joint.

B

Electrodes of the basic type usually have a thick covering containing considerable 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 generally suitable for welding in all positions. This type of electrode is often used, on direct current, electrode positive, but there are electrodes that can be used on alternating current.

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

The coverings of basic electrodes have to be very dry : consequently electrodes used to be stored in a very dry place or, if they have already absorbed moisture, to be dried before use, according to the recommendation of the manufacturer. This ensures that the deposited metal will have a low hydrogen content, and there is less risk of under-head cracking when welding steels likely to show a marked hardening in the heat-affected zone.

(Continued from page 2)

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INDIAN STANDARDS

ON

WELDING CONSUMABLES

IS:

- 814 (Part I)-1974 Covered electrodes for metal arc welding of structural steel : Part I For welding products other than sheets (*fourth revision*)
- 814 (Part II)-1974 Covered electrodes for metal arc welding of structural steel : Part II For welding sheets (*fourth revision*)
- 815-1974 Classification and coding of covered electrodes for metal arc welding of structural steels (*second revision*)
- 1278-1972 Filler rods and wires for gas welding (*second revision*)
- 2927-1975 Brazing alloys (*first revision*)
- 3613-1974 Acceptance tests for wire-flux combinations for submerged-arc welding of structural steels (*first revision*)
- 5206-1969 Corrosion-resisting chromium and chromium-nickel steel covered electrodes for manual metal arc welding (with Amendments No. 1 and 2)
- 5462-1969 Colour code for identification of covered electrodes for metal arc welding
- 5511-1969 Covered electrodes for manual metal arc welding of cast iron (with Amendment No. 1)
- 5856-1970 Corrosion and heat-resisting chromium-nickel steel solid welding rods and bare electrodes
- 5857-1970 Nickel and nickel alloy bare solid welding rods and electrodes
- 5897-1970 Aluminium and aluminium alloy welding rods and wires and magnesium alloy welding rods
- 5898-1970 Copper and copper alloy bare solid welding rods and electrodes
- 6419-1971 Welding rods and bare electrodes for gas shielded arc welding of structural steel
- 6560-1972 Molybdenum and chromium-molybdenum low alloy steel welding rods and base electrodes for gas shielded arc welding
- 7280-1973 Base wire electrodes for submerged arc welding of structural steels
- 7303-1974 Covered electrodes for surfacing of metal by manual metal arc welding
- 8363-1976 Bare wire electrodes for electroslag welding of steels
- 8666-1977 Copper and copper alloy covered electrodes for manual metal arc welding
- 8736-1977 Nickel and nickel alloy covered electrodes for metal arc welding
- 9495-1980 Test for brazeability of brazing alloys

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

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

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

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

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 26 60 21, 27 01 31

Telegrams : Manaksanstha

Regional Offices:

		Telephone
Western : Novelty Chambers, Grant Road	BOMBAY 400007	37 97 29
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