
British Standard Specification for

Covered carbon and carbon manganese steel electrodes for manual metal-arc welding

Electrodes enrobées en acier au carbone et au carbone manganèse pour soudage manuel à l'arc —
Spécifications

Umhüllte Stabelektroden aus Kohlenstoff- und Kohlenstoff-Mangan-Stählen
zum Metalllichtbogenhandschweißen

Foreword

This British Standard has been prepared under the direction of the Welding Standards Committee and supersedes BS 639 : 1976 which is withdrawn.

During the periodic review of the standard, when the opportunity was taken to consult all the contributing organizations, a majority was in favour of retaining the basic format and classification system of BS 639 but of subjecting the content to appropriate technical update, clarification and extension. Questions of principle were reconsidered during the preparation of this revision and the eventual consensus to make no fundamental changes was set against the background of the international activities regarding the classification of electrodes. The 1976 edition of BS 639 implemented ISO 2560 which the United Kingdom had supported and it was felt that any change from this standpoint should be deferred until the outcome of further international work in hand is known. Within this consideration, note was also taken of the extensive use of the American Welding Society (AWS) classification system but it was decided not to propose a metricated version of this system since the information it provides is in general less complete and does not give sufficient differentiation between electrodes of identical classification but of significantly different impact strength. The United Kingdom will continue to participate in the relevant international standards work in an endeavour to achieve a classification system that is adopted worldwide. The situation internationally, as it then is, will be reviewed at the time of any proposed changes to BS 639.

Low alloy steel electrodes and chromium and chromium nickel steel electrodes are covered in BS 2493 and BS 2926 and therefore the title of this standard has been modified to reflect that only carbon and carbon manganese steel electrodes are covered in BS 639.

Ordering electrodes complying with this standard gives an assurance of electrode quality and the classification has significance to the fabricator as a first step in selecting electrodes that may be suitable for a particular production joint. It should be noted that the impact and tensile strength of all-weld test specimens used to classify the electrodes will vary from those obtained in production joints because of differences in welding procedure such as electrode size, width of weave, welding position and material composition. The user is therefore advised to carry out welding procedure tests if notch toughness criteria have to be satisfied and these tests should be representative of the appropriate production joints as specified in BS 4870 : Part 1. Furthermore if a fabrication is to be heat treated after welding a similar post-weld heat

treatment should be applied to the welding procedure test pieces because heat treatment can affect both the tensile and impact strength.

This standard provides a classification system for electrodes using the criteria specified in the standard. Different manufacturers may have a number of electrodes with identical or very similar classifications and the user's choice may depend upon other factors such as ease of use, deslagging or welder appeal (weldability). Electrodes bearing identical codings may be expected to have generally similar characteristics and properties, even if made by different manufacturers, but some differences may exist between such electrodes. The selection of electrodes should be made on the basis of the particular application and the user should consult the electrode manufacturer or other appropriate authoritative sources for guidance.

If the classifications of this standard are used for purchasing it should be made clear that they represent minimum requirements since electrodes with higher toughness properties than the minimum required may also be appropriate for use on a production joint. Furthermore the manufacturer's brand name or identification number should also be quoted.

Electrode manufacturers have to comply with two different criteria for impact strength, a minimum average of 28 J for ISO 2560 and a minimum average of 47 J to meet the requirements of the unified rules of the classification societies. These different requirements are the origin of the two digits for impact strength in BS 639. In this revision the two digits for impact strength have been retained but the tables showing the requirements have been simplified and in table 3 has been extended to lower temperatures. The method of weld metal deposition has been modified to ensure greater uniformity of results. The method for the determination of diffusible hydrogen content has also been modified and is now published separately as BS 6693 : Part 2.

Since this standard has been updated from a technical aspect it is possible that the classification of some electrodes will differ from BS 639 : 1976 but this does not necessarily signify any change in the electrode itself. In cases where clarification is needed the electrode manufacturer should be consulted.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Specification

1 Scope

This British Standard specifies requirements for covered carbon and carbon manganese steel electrodes for manual metal-arc welding depositing weld metal having a tensile strength of not more than 650 N/mm².

NOTE 1. As this standard is primarily concerned with the mechanical properties of weld metal no limits are placed on chemical composition of weld metals (but see clause 2(e)). If weld metal with tensile strength higher than 650 N/mm² is required, reference should be made to BS 2493 or BS 2926.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Information to be supplied by the purchaser

When ordering electrodes that comply with the requirements of this standard, purchasers shall state:

- the number and date of this British Standard, i.e. BS 639 : 1986;
- the electrode classification (see clause 3), at least the strength, toughness and covering (STC) code and/or the manufacturer's trade designation;

NOTE. The continuity of a trade designation is not an assurance that the electrode classification is unchanged.

- whether a test certificate for the initial tests or for the most recent periodic check tests is required (see 7.1 and clause 9);
- whether mechanical test certificates are required for each batch of electrodes supplied (see clause 8);
- whether chemical analysis certificates are required and whether any elements have to be controlled to specific limits (see clause 8).

3 Classification

3.1 General

The classification of an electrode shall be indicated by the following coding, in the order stated.

- Strength, toughness and covering code (STC code)**
 - the letter E for a covered electrode for manual metal-arc welding;
 - two digits indicating the strength (tensile, yield and elongation properties of the weld metal) (see table 1);

- a digit indicating the temperature for a minimum average impact value of 28 J (see table 2);
- a digit indicating the temperature for a minimum average impact value of 47 J (see table 3);
- a letter or letters indicating the type of covering (see 3.3).

(b) Additional coding

The following additional coding shall be determined, and shall be used in parentheses in the manufacturer's literature following the STC coding.

- when appropriate, three digits, indicating the nominal electrode efficiency (see 3.4);
- a digit indicating the recommended welding positions for the electrode (see 3.5);
- a digit indicating the power supply requirement (see 3.6);
- when appropriate, a letter H indicating a hydrogen controlled electrode (see 3.7).

NOTE 1. Two examples, illustrating how electrode codings are established from initial test results, are given in appendix A.

NOTE 2. It is recommended that a space should be left between the different parts of both the STC and additional coding as shown in appendix A.

3.2 Weld metal properties (see also note 1 to clause 1)

That part of the classification which relates to mechanical properties from all-weld tests shall be allocated appropriately from tables 1, 2 and 3 depending on the particular combination of results obtained from the relevant tests as specified in clause 7.

3.3 Covering

The type of covering shall be indicated by the appropriate letter or letters as follows:

E — — — — B	basic
E — — — — BB	basic, high efficiency
E — — — — C	cellulosic
E — — — — R	rutile
E — — — — RR	rutile, heavy coated
E — — — — S	other types

Electrodes with coverings containing iron powder or other materials which would not affect the characteristics of the particular type of covering shall be classified by the letter or letters for that type of covering and not by the letter S.

NOTE. The characteristics of each of the types of covering are described in appendix B.

Table 1. Designation for tensile properties

Electrode designation digit	Tensile strength	Minimum yield stress	Minimum elongation		
			When digit of table 2 is 0 or 1	When digit of table 2 is 2	When digit of table 2 is 3, 4 or 5
E 43 — — —	430—550	330	20	22	24
E 51 — — —	510—650	360	18	18	20

Table 2. First digit for an impact value

Digit	Temperature for minimum average impact value of 28 J using 4 mm diameter electrodes only (see 7.3.1 and foreword)
E — — 0 — —	°C Not specified
E — — 1 — —	+20
E — — 2 — —	0
E — — 3 — —	-20
E — — 4 — —	-30
E — — 5 — —	-40

Table 3. Second digit for an impact value

Digit	Temperature for minimum average impact value of 47 J using 4 mm diameter and largest diameter electrodes submitted for classification (see 7.3.2 and foreword)
E — — — 0 —	°C Not specified
E — — — 1 —	+20
E — — — 2 —	0
E — — — 3 —	-20
E — — — 4 —	-30
E — — — 5 —	-40
E — — — 6 —	-50
E — — — 7 —	-60
E — — — 8 —	-70

3.4 Efficiency

The nominal electrode efficiency, which is the ratio of the mass of weld metal to the mass of nominal diameter core wire consumed for a given electrode, shall be determined on the largest diameter electrode covered by the classification in accordance with the method given in appendix C.

The value obtained by that method shall be rounded off to the nearest multiple of 10, with values ending in 5 being rounded up.

The rounded efficiency figure shall be included in the classification only if it is equal to or greater than 110.

3.5 Welding position

The welding position or positions (see BS 499 : Part 1 for definitions) in which the electrode can be used, as

recommended by the manufacturer, shall be indicated by the appropriate digit as follows:

- 1 all positions
- 2 all positions except vertical/down
- 3 flat and, for fillet welds, horizontal/vertical
- 4 flat
- 5 flat, vertical/down and, for fillet welds, horizontal/vertical
- 9 any position or combination of positions not classified above.

3.6 Welding current and voltage conditions

The welding current and open circuit voltage conditions at which the electrode can be operated, as recommended by the manufacturer, shall be indicated by the appropriate digit as given in table 4.

NOTE. The open circuit voltages given in table 4 apply to electrodes of at least 2.5 mm diameter; higher voltages may be necessary for smaller sizes.

Table 4. Welding current and voltage conditions

Digit	Direct current	Alternating current
	Recommended electrode polarity	Minimum open circuit voltage
0	Polarity as recommended by manufacturer	V Not suitable for use on a.c.
1	+ or -	50
2	-	50
3	+	50
4	+ or -	70
5	-	70
6	+	70
7	+ or -	80
8	-	80
9	+	80

3.7 Hydrogen controlled electrodes

The letter H shall be included in the classification for those electrodes which will deposit not more than 15 mL of diffusible hydrogen per 100 g of deposited weld metal when determined in accordance with the method given in BS 6693 : Part 2.

NOTE 1. Other methods of collection and measurement of the diffusible hydrogen may be used for batch testing provided they possess equal reproducibility with, and are calibrated against the method given in BS 6693 : Part 2.

The manufacturer shall provide information on the recommended drying conditions for achieving hydrogen levels determined in accordance with the method given in

BS 6693 : Part 2 within the following ranges, as appropriate.

Not exceeding 15 mL	} per 100 g of deposited weld metal.
Not exceeding 10 mL	
Not exceeding 5 mL	

NOTE 2. In practice, the appropriate hydrogen level will depend on the particular application and, to ensure that this is achieved, the relevant drying conditions recommended by the electrode manufacturer should be followed.

NOTE 3. The diffusible hydrogen evolved by the method given in BS 6693 : Part 2 will in general be higher than the hydrogen evolved in the method given in BS 6693 : Part 1. Users wishing to comply with BS 5135 should consult the manufacturer for appropriate information on hydrogen levels determined by the method given in BS 6693 : Part 1.

4 Dimensions and tolerances

4.1 Size

The size of an electrode shall be the specified nominal diameter of the core wire and shall be selected from the following range:

1.6, 2, 2.5, 3.2, 4, 5, 6, 6.3 and 8 mm.

The core wire diameter shall be within $\pm 3\%$ of the specified nominal diameter or within ± 0.1 mm, whichever is the smaller.

4.2 Length

The length of an electrode shall be within ± 2 mm of the nominal value given in table 5.

Table 5. Nominal lengths of electrodes

Diameter	Nominal length
mm	mm
1.6	200 250
2	200 250 300 350
2.5	250 300 350
3.2, 4, 5	350 450
6 to 8	350 450 500 600 700 900

5 Covering

The covering shall be free from defects, such as coating cracks and eccentricity of the core wire, which will adversely affect the operation of the electrode when used under the correct conditions.

The gripped end of each electrode shall be free from covering for a minimum distance of 15 mm and a maximum distance of 40 mm.

6 Electrode identification

The STC code (see clause 3) shall be marked on the covering of each electrode, except on electrodes of 1.6 mm and 2 mm diameter where it is not practicable, as near as possible to the gripped end.

When electrodes are used in accordance with the manufacturer's recommendations, the marking shall survive subsequent baking and contact incidental to normal handling, transport and storage and shall remain legible on electrodes and stub ends.

7 Initial tests

7.1 General

The initial tests to which electrodes are subjected are specified in this clause and although it is not expected that every batch of electrodes will be subjected to the initial tests, the manufacturer shall ensure that every batch is capable of passing the initial tests.

NOTE. The purchaser may require that some or all of the tests are carried out on batches supplied to him (see clause 8).

When electrodes of a nominal size are manufactured in a range of lengths, the electrodes used for the tests shall be the longest that are normally manufactured.

An electrode suitable for use on either a.c. or d.c. shall be tested on a.c.

If a test certificate giving the results of the initial tests carried out on the type of electrode supplied is requested by the purchaser at the time of order (see clause 2(c)), it shall be made available by the manufacturer.

7.2 Weld metal tensile test

Two weld metal tensile test specimens, one using 4 mm electrodes and one using the largest size electrode submitted for classification, shall be prepared and tested in accordance with the method described in appendix D.

The tensile properties from both test specimens shall comply with one of the sets of values given in table 1. If the requirements are not met, retests shall be carried out as specified in 10.1.

7.3 Weld metal impact tests

7.3.1 Temperature for a minimum average impact value of 28 J (see table 2). Six Charpy V-notch test specimens shall be prepared using 4 mm electrodes and tested in accordance with the method described in appendix D.

The average of the six impact values shall be at least 35 J at the appropriate testing temperature as given in table 2.

If the average of the six impact values is greater than 16 J but less than 35 J, twelve additional specimens, taken from a new test piece, shall be prepared and tested in accordance with the method described in appendix D and the results added to those previously obtained to form a new average that shall be at least 28 J.

If the average of the original six impact values does not exceed 16 J, retests shall be carried out as specified in 10.2.

NOTE. Table 2 is based on the requirements of ISO 2560 which assumes that 18 impact test specimens may be necessary to establish a statistically significant average. Advantage has been taken of the anticipated distribution of individual values to indicate initial levels above or below which it is considered unnecessary to test a complete set of 18 specimens in order to establish compliance or non-compliance.

7.3.2 Temperature for a minimum average impact value of 47 J (see table 3). Six Charpy V-notch test specimens, shall be prepared, three using 4 mm electrodes and three using the largest size electrode submitted for classification and tested in accordance with the method described in appendix D.

The average of the three impact values from each set of specimens shall be at least 47 J at the appropriate testing temperature as given in table 3.

If the average of the three impact values from either or both sets of specimens is below 47 J but not less than 40 J, three additional specimens for each set concerned, taken from the same test piece, shall be prepared and tested in accordance with the method described in appendix D and the results added to those previously obtained to form a new average that shall be at least 47 J.

If the average of the three impact values from either or both sets of specimens is below 40 J, if the average of six is below 47 J or if any single value is below 20 J, retests shall be carried out as specified in 10.3.

7.4 Transverse bend test

Two bend tests, one with the face and the other with the root in tension, shall be carried out for each welding position for which the electrode is classified by the manufacturer, except that, when the electrode is classified for welding in the flat position only, four tests shall be carried out.

The method of preparation of the test pieces and test specimens and the method of carrying out the tests shall be as described in appendix E.

On completion of the test, no crack or defect at the outer surface of the test specimen shall be greater than 3 mm measured in any direction. If this requirement is not met, retests shall be carried out as specified in 10.1.

8 Quality control*

The manufacturer shall have a quality control system to ensure that all electrodes supplied satisfy the requirements of this standard. The system shall be documented and provide for the ready detection of discrepancies and for timely and positive corrective action. The system shall provide records such that the identification number of each batch of electrodes shall provide references to the manufacturer's own documented records.

Tests and inspections shall be performed during manufacture so that continuous quality control of production is maintained and any departure from the accepted quality will be detected before despatch. From each batch of electrodes a sufficient quantity of finished electrodes shall be taken to allow execution of the quality control tests defined in the manufacturer's system.

At the time of placing the order, the purchaser shall indicate whether he requires 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 (see clause 2 (d) and (e)).

9 Periodic check tests

Periodic check tests shall consist of the tests specified in 7.2 and 7.3.2. Periodic check tests shall be repeated at intervals of not more than twelve months to provide evidence that the electrodes currently produced continue to represent the classification achieved in the initial tests.

If requested by the purchaser at the time of order (see clause 2(c)), the manufacturer shall produce the results of the most recent periodic check tests on electrodes representative of the electrodes supplied.

10 Retests

10.1 Retests as specified in 7.2 or 7.4

When any test specimen fails to satisfy the test requirements of 7.2 or 7.4, twice the number of specimens specified for the initial or periodic check tests shall be prepared from new test pieces made using the same number of layers with electrodes from the same batch and submitted to the test in which failure occurred. Provided that the tests of the additional specimens are satisfactory, the electrodes shall be accepted as having passed the test.

* Further guidance on general principles may be obtained from BS 4891.