

Specification for

Low alloy steel electrodes for manual metal-arc welding

UDC 621.791.753.037.2:669.15 – 194.2

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Welding Standards Committee (WEE/-) to Technical Committee WEE/39, upon which the following bodies were represented:

- Associated Offices Technical Committee
- British Association for Brazing and Soldering
- British Railways Board
- British Shipbuilders
- British Steel Industry
- British Steel Industry (Wire Section)
- Electricity Supply Industry in England and Wales
- Engineering Equipment and Materials Users' Association
- Process Plant Association
- Society of Motor Manufacturers and Traders Limited
- Water-tube Boilermakers' Association
- Welding Institute
- Welding Manufacturers' Association (BEAMA Ltd.)
- Coopted member

The following body was also represented in the drafting of the standard, through sub-committees and panels:

- British Constructional Steelwork Association

This British Standard, having been prepared under the direction of the Welding Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 January 1985

© BSI 03-1999

First published December 1954
First revision May 1958
Second revision July 1971
Third revision January 1985

The following BSI references relate to the work on this standard:
Committee reference WEE/39
Draft for comment 82/70403 DC

ISBN 0 580 14254 X

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Information to be supplied by the purchaser	1
3 Classification	1
4 Dimensions and tolerances	1
5 Covering	1
6 Electrode identification	1
7 Initial tests	2
8 Quality control	6
9 Retests	6
10 Packing, storage and marking	6
Appendix A Method for the determination of diffusible hydrogen content	7
Appendix B Methods of test	8
Appendix C Suggested method of preparing etched specimens	16
Appendix D Safety references	16
Figure 1 — Jig and test piece assembly for hydrogen sampling of weld deposits	10
Figure 2 — Diffusible hydrogen collecting apparatus	11
Figure 3 — All-weld test piece and all-weld tensile and impact test specimens	13
Figure 4 — Longitudinal bend test piece	15
Figure 5 — Longitudinal bend test specimen	15
Table 1 — Tests required	2
Table 2 — Composition of deposited weld metal	3
Table 3 — Mechanical properties	5
Table 4 — Dimensions of all-weld test piece and all-weld tensile test specimen	9
Table 5 — Pre-heating and interpass temperatures and post-weld tempering conditions	14
Publications referred to	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Welding Standards Committee. It was first published in 1954 and revised in 1958 and 1971. This edition supersedes BS 2493:1971 which is withdrawn.

Since 1958 there has been a considerable increase in the industrial use of molybdenum and chromium-molybdenum steel electrodes falling within the scope of this standard. There has also been an increasing interest in the welding of other chromium-molybdenum steels intended for service at elevated temperatures and a growing use of nickel and other low alloy steels for cryogenic applications.

This standard was therefore revised in 1971 with these factors in mind. Some changes were made in the composition ranges of the molybdenum and chromium-molybdenum electrodes retained from the previous editions in order to align them with current views on good practice and two additional electrodes of higher alloy content were incorporated. Recognition was also made of the current commercial practice of utilizing electrode coverings of fundamentally differing characteristics such as cellulosic, rutile and basic hydrogen controlled types for depositing weld metal of similar molybdenum or chromium-molybdenum content. Composition ranges suitable for each type of electrode were specified and provision made for the covering types to be identified.

The increasing use of steels for service at low temperatures has resulted in a greater interest in nickel-bearing low alloy electrodes. Three types of electrode suitable for this application were incorporated in the 1971 edition.

The present edition has an enlarged section on hydrogen controlled electrodes and has updated the quality control aspects. The opportunity has also been taken to introduce high strength low alloy steel electrodes and to bring the layout more in line with other British Standards for 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.

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.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies requirements for a range of low alloy steel electrodes of the molybdenum, chromium-molybdenum, nickel, manganese-molybdenum and high strength types, for manual metal-arc welding.

NOTE 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:

- a) the number and date of this British Standard, i.e. BS 2493:1985;
- b) the electrode classification (see clause 3), i.e. composition code plus covering code;
- c) whether any residual elements have to be controlled to specific limits;
- d) whether chemical and/or mechanical test certificates are required for each batch of electrodes supplied (see clause 8).

3 Classification

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

- a) *Composition code.* The chemical symbols Mn, Ni, Cr, Mo, W and V shall be used as appropriate to indicate the required alloying additions of the elements manganese, nickel, chromium, molybdenum, tungsten and vanadium respectively (see Table 2). A prefix figure shall indicate the approximate percentage content of the first element listed as an alloying addition.

To indicate a low carbon version the letter L shall be added after the last chemical symbol.

- b) *Covering code.* The general characteristics of the covering shall be indicated by:

- the letter B for basic type coverings;
- the letter R for rutile type coverings;
- the letter C for cellulosic type coverings.

- c) *Code for hydrogen controlled electrodes.* The letter H shall be included in the classification for those electrodes which deposit not more than 15 mL of diffusible hydrogen per 100 g of deposited weld metal, determined in accordance with the method given in Appendix A, when stored in accordance with the manufacturer's recommendations.

NOTE The drying conditions given in Appendix A are to ensure that all hydrogen controlled electrodes are assessed in the same way for classification purposes. 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.

The manufacturer shall give on the packet and in his literature the recommended drying conditions for achieving hydrogen levels per 100 g of deposited weld metal within the following ranges, as appropriate:

- over 10 mL, up to and including 15 mL
- over 5 mL, up to and including 10 mL
- up to and including 5 mL

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:

- 2, 2.5, 3.2, 4, 5, 6 and 6.3 mm.

The core wire diameter shall be within $\pm 3\%$ of the 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 specified by the manufacturer.

5 Covering

The covering shall be free from defects which would 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 electrode composition and covering codes (see clause 3) or the trade designation shall be printed or imprinted on the covering of each electrode as near as possible to the gripped end.

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

7 Initial tests

7.1 General

All tests using electrodes suitable for use on a.c. or d.c. shall be carried out on a.c. supply at the minimum open circuit voltage claimed by the manufacturer. Tests on all other electrodes shall be carried out on d.c. supply electrode positive. 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.

7.2 Initial tests required

The initial tests specified in Table 1 shall be carried out by the methods given in Appendix B. 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).

7.3 Test results

7.3.1 Chemical analysis. The material obtained by the method described in **B.1** shall show on analysis a chemical composition that complies with Table 2.

7.3.2 All-weld tensile and impact tests. The mechanical properties obtained from the test specimens prepared as described in **B.2** shall be in accordance with Table 3.

7.3.3 Longitudinal bend test. On examination after bending, the outer surface of each test specimen prepared as described in **B.3** shall be free from cracks or other defects.

7.3.4 Fillet weld test. The prepared and etched faces of the weld and parent metal from the test piece obtained by the method described in **B.4** shall be free from cracks and the weld metal shall have penetrated to or beyond the junction of the fusion faces and be reasonably free from undercutting, overlap, porosity and slag inclusions.

Table 1 — Tests required

Size of electrode	Position of welding				
	Chemical analysis	All-weld tensile test	All-weld impact test ^a	Longitudinal bend tests (face bend and root bend)	Fillet weld test
mm					
2	Flat	—	—	—	—
2.5					
3.2	Flat	Flat	Flat	—	—
4	Flat	Flat	Flat	Vertical	Horizontal/ vertical
5 or largest size submitted for approval	Flat	Flat	Flat	Flat	—

^a Impact tests are necessary where impact requirements are given in Table 3. By agreement between the purchaser and the manufacturer this test may also be used for molybdenum steel and chromium-molybdenum steel electrodes, in which case the acceptance limits should also be agreed.

Table 2 — Composition of deposited weld metal

NOTE 1 The following details do not relate to core wire compositions.															
Composition code and covering code (see clause 3)	Nearest equivalent AWS/ASME classification ^b	Chemical composition (% by mass) ^c													
		C max.	Si max.	Mn min. max.		P max.	S max.	Cr min. max.		Mo min. max.		Ni min. max.		W min. max.	
Molybdenum steel electrodes															
MoB ^a	E70XX – A1	0.10	0.60	0.75	1.20	0.035	0.030			0.40	0.70				
MoC	E70XX– A1	0.10	0.80	0.35	1.20	0.035	0.030			0.40	0.70				
MoR	—														
Chromium-molybdenum steel electrodes															
NOTE 2 For creep applications a maximum copper level of 0.15 % is recommended.															
1CrMoLB ^a	E80XX–B2L	0.05	0.50	0.50	1.20	0.025	0.025	1.0	1.8	0.40	0.70				
1CrMoB ^a	E80XX–B2	0.10	0.50	0.50	1.20	0.035	0.030	1.0	1.5	0.40	0.70				
1CrMoR	—	0.10	0.30	0.35	1.20	0.035	0.030	1.0	1.5	0.40	0.70				
2CrMoLB ^a	E90XX–B3L	0.05	0.50	0.50	1.20	0.025	0.025	2.0	2.5	0.90	1.20				
2CrMoB ^a	E90XX–B3	0.10	0.50	0.50	1.20	0.035	0.030	2.0	2.5	0.90	1.20				
2CrMoR	—	0.10	0.30	0.35	1.20	0.035	0.030	2.0	2.5	0.90	1.20				
5CrMoB	E502	0.10	0.50	0.50	1.00	0.035	0.030	4.0	6.0	0.40	0.70				
7CrMoB	E7Cr	0.10	0.80	0.50	1.00	0.035	0.030	6.0	8.0	0.40	0.70				
9CrMoB	E505	0.10	0.80	0.50	1.00	0.035	0.030	8.0	10.0	0.90	1.20				
12CrMoB	—	0.23	0.80	0.30	1.00	0.025	0.025	11.0	12.5	0.80	1.20	0.3	0.8		0.30
12CrMoVB		0.23	0.80	0.30	1.00	0.030	0.030	11.0	13.0	0.80	1.20				0.50
12CrMoWVB		0.28	0.80	0.50	1.50	0.030	0.030	11.0	13.0	0.80	1.20	0.3	0.8	0.7	1.0
Nickel steel electrodes															
1NiLB	E70XX–C3L	0.07	0.60	0.30	1.10	0.030	0.030					0.80	1.20		
2NiLB	E70XX–C1L	0.07	0.60	0.30	1.10	0.030	0.030					2.00	2.75		
3NiLB	E70XX–C2L	0.07	0.60	0.50	1.10	0.030	0.030					2.80	3.75		
1NiB	E80XX–C3	0.10	0.80	0.50	1.80	0.035	0.030					0.80	1.10		
2NiB	E80XX–C1	0.10	0.80	0.50	1.20	0.035	0.030					2.00	2.75		
3NiB	E80XX–C2	0.10	0.80	0.50	1.20	0.035	0.030					2.80	3.75		
1NiC	E70XX–C3	0.15	0.80	0.50	1.20	0.035	0.030					0.80	1.20		
2NiC	E70XX–C2	0.15	0.80	0.50	1.20	0.035	0.030					2.00	2.75		