

Australian Standard™

## **Electrodes and fluxes for submerged-arc welding**

### **Part 1: Carbon steels and carbon-manganese steels**



This Australian Standard was prepared by Committee WD-002, Welding Consumables. It was approved on behalf of the Council of Standards Australia on 31 January 2003 and published on 3 March 2003.

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The following are represented on Committee WD-002:

Australian Chamber of Commerce and Industry  
Australian Industry Group  
Australian Institute of Steel Construction  
Bureau of Steel Manufacturers of Australia  
Business New Zealand  
CSIRO Manufacturing Science and Technology  
Welding Technology Institute of Australia

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Australian Standard™

## **Electrodes and fluxes for submerged-arc welding**

### **Part 1: Carbon steels and carbon-manganese steels**

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## PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee WD-002, Welding Consumables, to supersede AS 1858.1—1986.

The objective of this Standard is to provide classification and designation systems, as well as requirements, for solid and composite welding electrodes and fluxes for submerged-arc welding of carbon steels and carbon manganese steels.

This Standard is based on ANSI/AWS A5.17, *Specification for Carbon Steel Electrodes and Fluxes for Submerged-arc Welding*.

The principle behind the classification and designation systems adopted was that each of the three factors involved, electrodes, flux and weld metal, should be capable of individual selection and identification. In particular, the concept of the classification of weld metal as a separate entity is regarded as being of great significance. For ease of selection, the weld metal is classified according to its tensile strength and divided into grades related to its Charpy V-notch impact energy value. The Standard, therefore, separately deals with electrodes, fluxes, weld metal and testing.

Because of the large number of electrode/flux combinations available, guidance is frequently needed on the suitability of the process for a specific weldment. The intent here is that the designer should only need to specify on the drawing the weld metal designation, thereby nominating the mechanical properties required for the satisfactory functioning of the welded joint. The fabricator, taking into account recommendations by the manufacturer of the consumables, can select the electrode/flux combination that are appropriate to the materials of construction and the conditions pertaining at the time.

If procedure qualification is called up in the relevant application code, it may be necessary for the chosen electrode/flux combination to be qualified by procedure testing.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

Statements expressed in mandatory terms in notes to tables are deemed to be requirements of this Standard.

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## STANDARDS AUSTRALIA

**Australian Standard****Electrodes and fluxes for submerged-arc welding****Part 1: Carbon steels and carbon-manganese steels**

## SECTION 1 SCOPE AND GENERAL

**1.1 SCOPE**

This Standard specifies requirements for solid and composite electrodes and fluxes for the submerged-arc welding of carbon steels and carbon manganese steels. It defines classification and designation systems for electrodes, fluxes and weld metal, and specifies their chemical and physical properties. It also specifies, where appropriate, requirements for testing, packaging, marking and storage.

## NOTES:

- 1 The electrodes and fluxes specified herein may also be used, under appropriate conditions, for the welding of certain alloy steels.
- 2 Guidance on the classification system and the selection of electrodes and fluxes is given in Appendix A.

**1.2 REFERENCED DOCUMENTS**

The following documents are referred to in this Standard:

## AS

- |          |                                                                     |
|----------|---------------------------------------------------------------------|
| 1544     | Methods for impact tests on metals                                  |
| 1544.2   | Part 2: Charpy V-notch                                              |
| 1674     | Safety in welding and allied processes                              |
| 1674.1   | Part 1: Fire precautions                                            |
| 1674.2   | Part 2: Electrical                                                  |
| 2177     | Non-destructive testing—Radiography of welded butt joints in metals |
| 2177.1   | Part 1: Methods of test                                             |
| 2205     | Methods of destructive testing of welds in metal                    |
| 2205.2.2 | Method 2.2: All-weld-metal tensile test                             |
| 2205.7.1 | Method 7.1: Charpy V-notch impact fracture toughness test           |
| 2812     | Welding, brazing and cutting of metals—Glossary of terms            |
- 
- |        |                                                                                                                     |
|--------|---------------------------------------------------------------------------------------------------------------------|
| AS/NZS |                                                                                                                     |
| 1050   | Methods for the analysis of iron and steel (all methods)                                                            |
| 3678   | Structural steel—Hot-rolled plates, floorplates and slabs                                                           |
| 3752   | Welding—Methods for determination of the diffusible hydrogen content of ferritic weld metal produced by arc welding |

## ANSI/AWS

- |                                                                   |                                     |
|-------------------------------------------------------------------|-------------------------------------|
| A5.01                                                             | Filler metal procurement guidelines |
| WTIA (Welding Technology Institute of Australia)                  |                                     |
| Technical Note 3—Care and conditioning of arc-welding consumables |                                     |
| Technical Note 7—Health and safety in welding                     |                                     |
| Technical Note 22—Welding—Electrical safety                       |                                     |

### 1.3 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 2812, and those below apply.

#### 1.3.1 Basket

A type of package consisting of a continuous length of electrode wound on a rigid open wire framework forming a cylinder, flanged at both ends.

#### 1.3.2 Shall

Indicates that a statement is mandatory.

#### 1.3.3 Should

Indicates a recommendation.

### 1.4 CLASSIFICATION AND DESIGNATION SYSTEMS

The classification and designation systems of the electrode, flux and weld metal shall consist of alphanumeric groups as described in Sections 2, 3 and 4 respectively.

A dot shall be used to separate the heat treatment condition and the hydrogen designation, where applicable.

NOTE: Combinations of electrode, flux, and weld metal designations should be set out in the order shown in Figure 1.1 and separated by a hyphen(s).

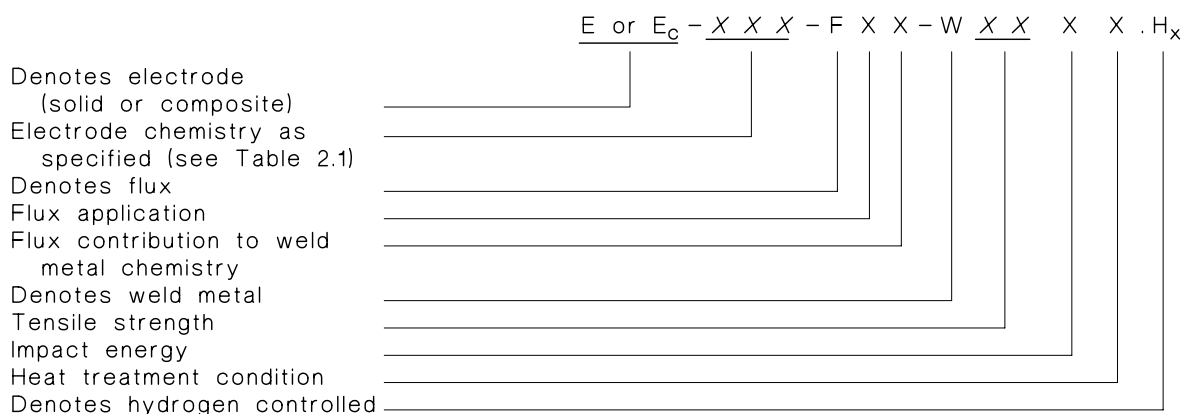


FIGURE 1.1 COMBINED DESIGNATIONS

### 1.5 TESTING

#### 1.5.1 Qualification tests

Electrodes, fluxes and weld metals shall be qualified by compliance with the requirements of this Standard appropriate to their classification, when tested in accordance with the schedule given in Table 1.1 by the methods described in Appendix B.

**TABLE 1.1**  
**TEST SCHEDULE**

| Type of test                 | Applicability  |                |
|------------------------------|----------------|----------------|
|                              | Qualification  | Conformance    |
| Chemical (electrode)         | ✓              | ✓              |
| Chemical (flux)              | ✓              | —              |
| Chemical (all-weld-metal)    | ✓ (See Note 1) | ✓ (See Note 1) |
| Radiography (all-weld-metal) | ✓              | —              |
| Tensile (all-weld-metal)     | ✓              | ✓              |
| Impact (all-weld-metal)      | ✓              | ✓              |
| Hydrogen (all-weld-metal)    | ✓ (See Note 2) | ✓ (See Note 2) |

✓ indicates applicable

NOTES:

1 Applicable for composite electrodes only.

2 Applicable only when optional hydrogen designator is quoted.

### 1.5.2 Conformance tests

Tests in accordance with Table 1.1 should be carried out at intervals not exceeding 1 year to ensure that electrodes and weld metals continue to comply with the requirements of this Standard.

### 1.5.3 Reporting

Results of tests shall be recorded and reported on the relevant qualification certificate or conformance certificate, and shall be available on request.

## SECTION 2 ELECTRODES

### 2.1 SCOPE OF SECTION

This Section sets out requirements for electrodes for the submerged-arc welding of carbon steels and carbon-manganese steels.

### 2.2 CLASSIFICATION AND DESIGNATION

#### 2.2.1 Solid electrodes

##### 2.2.1.1 *Basis of classification*

Electrodes shall be classified on the basis of their chemical composition as manufactured (see Table 2.1).

##### 2.2.1.2 *Designation system*

The designation of a solid electrode shall be prefixed by the letter E (denoting electrode), and shall consist of a letter representing the basic chemical composition followed by a number representing the carbon content and, finally, if applicable, a further letter representing the silicon content (see Table 2.1).

#### 2.2.2 Composite electrodes

##### 2.2.2.1 *Basis of classification*

Composite electrodes shall be classified on the basis of chemical composition of deposited weld metal (see Table 2.2).

##### 2.2.2.2 *Designation system*

The designation of the composite electrode shall be by letter prefixes EC (denoting electrode composite) followed by letter(s) and number(s) indicating weld metal composition (see Table 2.2).

**TABLE 2.1**  
**CHEMICAL COMPOSITION REQUIREMENTS FOR ELECTRODE**

| Designation                 | UNS<br>equivalent<br>nt<br>(Note 3) | ISO<br>Designation | Chemical composition, percent, by mass (Notes 1 & 2) |           |           |       |       |                |               |
|-----------------------------|-------------------------------------|--------------------|------------------------------------------------------|-----------|-----------|-------|-------|----------------|---------------|
|                             |                                     |                    | C                                                    | Mn        | Si        | S     | P     | Cu<br>(Note 4) | Ti            |
| Low-manganese electrodes    |                                     |                    |                                                      |           |           |       |       |                |               |
| EL8                         | K01008                              | S1100              | 0.10                                                 | 0.25–0.60 | 0.07      | 0.030 | 0.030 | 0.35           | —             |
| EL8K                        | K01009                              | S1110              | 0.10                                                 | 0.25–0.60 | 0.10–0.25 | 0.030 | 0.030 | 0.35           | —             |
| EL12                        | K01012                              | S1000              | 0.04–0.14                                            | 0.25–0.60 | 0.10      | 0.030 | 0.030 | 0.35           | —             |
| Medium-manganese electrodes |                                     |                    |                                                      |           |           |       |       |                |               |
| EM11K                       | KO1111                              | —                  | 0.07–0.15                                            | 1.00–1.50 | 0.65–0.85 | 0.030 | 0.025 | 0.35           | —             |
| EM12                        | KO1112                              | S2000              | 0.06–0.15                                            | 0.80–1.25 | 0.10      | 0.030 | 0.030 | 0.35           | —             |
| EM12K                       | KO1113                              | S2010              | 0.05–0.15                                            | 0.80–1.25 | 0.10–0.35 | 0.030 | 0.030 | 0.35           | —             |
| EM13K                       | KO1313                              | S2030              | 0.06–0.16                                            | 0.90–1.40 | 0.35–0.75 | 0.030 | 0.030 | 0.35           | —             |
| EM14K                       | KO1314                              | —                  | 0.06–0.19                                            | 0.90–1.40 | 0.35–0.75 | 0.025 | 0.025 | 0              | 0.03–<br>0.17 |
| EM15K                       | KO1515                              | S2210              | 0.10–0.20                                            | 0.80–1.25 | 0.10–0.35 | 0.030 | 0.030 | 0.35           | —             |
| High-manganese electrodes   |                                     |                    |                                                      |           |           |       |       |                |               |
| EH10K                       | K01210                              |                    | 0.07–0.15                                            | 1.30–1.70 | 0.05–0.25 | 0.025 | 0.025 | 0.35           | —             |
| EH11K                       | K11140                              |                    | 0.06–0.15                                            | 1.40–1.85 | 0.80–1.15 | 0.030 | 0.030 | 0.35           | —             |
| EH12K                       | K01213                              |                    | 0.06–0.15                                            | 1.50–2.00 | 0.20–0.65 | 0.025 | 0.025 | 0.35           | —             |
| EH14                        | K11585                              |                    | 0.10–0.20                                            | 1.70–2.20 | 0.10      | 0.030 | 0.030 | 0.35           | —             |
| EG                          | Not specified                       |                    |                                                      |           |           |       |       |                |               |

## NOTES:

- 1 The electrode shall be analysed for the specific elements for which values are shown in this Table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total (excluding iron) does not exceed 0.50 %.
- 2 Single values are maximum.
- 3 SAE/ASTM Unified Numbering System for Metals and Alloys.
- 4 The copper limit includes any copper coating that may be applied to the electrode.

**TABLE 2.2**  
**CHEMICAL COMPOSITION FOR COMPOSITE ELECTRODE WELD METAL**

| Designation | UNS<br>number<br>(Note 2) | Chemical composition, maximum percent by mass (Note 1) |      |      |       |       |      |
|-------------|---------------------------|--------------------------------------------------------|------|------|-------|-------|------|
|             |                           | C                                                      | Mn   | Si   | S     | O     | Cu   |
| EC1         | W06041                    | 0.15                                                   | 1.80 | 0.90 | 0.035 | 0.035 | 0.35 |
| ECG         | Not specified             |                                                        |      |      |       |       |      |

## NOTES:

- 1 The Weld metal shall be analyzed for the specific elements for which values are shown in this Table. If the presence of other elements is indicated, in the course of this work, the amount of those elements shall be determined to ensure that their total (excluding iron) does not exceed 0.50 %.
- 2 SAE/ASTM Unified Numbering System for Metals and Alloys.

**2.3 MANUFACTURE**

The electrode may be made by any method that will yield a product complying with the requirements of this Standard.

## 2.4 CHEMICAL COMPOSITION OF SOLID ELECTRODES

### 2.4.1 Specified elements

When determined by the method prescribed in Paragraph B2 of Appendix B, the chemical composition of solid electrode shall comply with the limits given in Table 2.1.

### 2.4.2 Analysis for other elements

Elements that are intentionally added (except iron), other than those shown in Table 2.1, shall be reported. The total of these elements and other elements not intentionally added shall not exceed 0.5%.

## 2.5 SIZES

Diameters and tolerances of electrode shall be in accordance with the values given in Table 2.3.

NOTE: Other sizes, forms (including strips) and tolerances may be supplied as agreed between the purchaser and the supplier.

**TABLE 2.3**  
**DIAMETERS AND TOLERANCES OF ELECTRODES**

| Diameter | millimetres           |              |
|----------|-----------------------|--------------|
|          | Tolerance on diameter |              |
|          | Solid                 | Composite    |
| 1.2      | ±0.04                 | +0.04, −0.05 |
| 1.3      |                       |              |
| 1.6      |                       |              |
| 2.0      |                       |              |
| 2.4      |                       |              |
| 2.5      |                       |              |
| 2.8      |                       |              |
| 3.0      | ±0.06                 | +0.06, −0.08 |
| 3.2      |                       |              |
| 4.0      |                       |              |
| 4.8      |                       |              |
| 5.0      |                       |              |
| 5.6      |                       |              |
| 6.0      |                       |              |
| 6.3      |                       |              |

## 2.6 VOIDS IN CORE OF COMPOSITE ELECTRODE

Composite electrode shall have the core ingredients distributed throughout its length with sufficient uniformity to ensure that the performance of the electrode and the properties of the weld metal deposited thereby are not adversely affected.

## 2.7 FINISH AND TEMPER

### 2.7.1 Finish

The electrode shall have a smooth finish, free from slivers, depressions, seams (except composite electrode), laps (except composite electrode), scratches, scale, rust or any other defect, and from other foreign matter including drawing lubricant that would adversely affect the weld metal properties or the operation of the welding equipment. Copper or other suitable coatings may be used.

### 2.7.2 Temper

The electrode shall be suitable for uniform uninterrupted feeding on automatic or semi-automatic welding equipment.

## 2.8 COILING OF ELECTRODE

### 2.8.1 General

The electrode shall be coiled in accordance with Clauses 2.8.2 to 2.8.9.

### 2.8.2 Coils with support

Coils with support shall conform to the dimensions and nominal net mass given in Table 2.4. Liners shall be of such material and design as will provide adequate protection against damage or distortion due to normal handling and use. Liners shall be sufficiently clean and dry to maintain the cleanness of the electrodes.

NOTE: Dimensions and net mass of coils without support should be determined by negotiation between the purchaser and the supplier.

**TABLE 2.4**  
**ELECTRODE COILS WITH SUPPORT**

| Electrode<br>diameter<br><br>mm | Nominal<br>net mass<br><br>kg | Dimension, mm           |                          |                                 |
|---------------------------------|-------------------------------|-------------------------|--------------------------|---------------------------------|
|                                 |                               | Inside dia.<br>of liner | Max. width<br>wound coil | Max. outside dia.<br>wound coil |
| 1.2 to 6.3                      | ≤30                           | 300 +15, -0             | 120                      | 430                             |
| 2.4 to 6.3                      | ≥100                          | 610 +20, -0             | 130                      | 800                             |

### 2.8.3 Baskets (see Figure 2.1)

Small baskets may require an adaptor to fit machines equipped for arbor type spools. Larger baskets can be placed direct on coil or rim type machine spiders.

### 2.8.4 Spools and reels

Spools and reels should conform to the dimensions given in Figure 2.2. They shall be of such material and design as will provide adequate protection against damage or distortion of themselves or of the electrode due to normal handling or use. Spools and reels shall be sufficiently clean and dry to maintain the cleanness of the electrode.

### 2.8.5 Drums

Outside diameters of standard drums should be 400 mm, 500 mm or 580 mm. Drums shall be of such material and design as will provide adequate protection against damage or distortion of the electrode due to normal handling, transportation and use. Drums shall be sufficiently clean and dry to maintain the cleanness of the electrode.

### 2.8.6 Length

Each coil or drum shall contain one continuous length of electrode made from heats of material with similar chemical analysis.

### 2.8.7 Butt welds

Butt welds in the electrode shall be made so as not to interfere with the uniform uninterrupted feeding of the electrode on automatic and semi-automatic equipment.

### 2.8.8 Winding

The electrode shall be wound evenly so as to prevent the formation of kinks, waves, sharp bends or out-of-balance conditions which would interfere with the feeding of the electrode, and so that it is free to unwind without restriction. The starting end of the electrode shall be secured and be readily identifiable.

### 2.8.9 Cast and helix

The cast and helix of the electrode shall be such as will not interfere with the uniform, uninterrupted feeding and accurate placement of the electrode on automatic or semi-automatic welding equipment.

## 2.9 PACKAGING

The coil of electrode shall be packaged to guard against damage during normal transportation, handling and storage to ensure compliance with the test requirements of this Standard after the electrode is stored in accordance with the manufacturer's recommendations for a period of at least 6 months from date of despatch by the manufacturer or distributor.

## 2.10 MARKING

### 2.10.1 Information to be displayed

The following information shall be marked on each coil, drum, reel, spool or basket of electrode or be securely attached thereto so that at least Items (a), (c), (d), (f), and (g) shall remain intact with the electrode after wrapping has been removed to allow unwinding:

- (a) The number of this Standard and the electrode designation marking in accordance with Clause 1.4, e.g., AS/NZS 1858.1—EL12.
- (b) Manufacturer's or supplier's name.
- (c) Trade designation of electrode.
- (d) Electrode diameter (in millimetres).
- (e) Net mass (in kilograms) of electrode.
- (f) Lot or batch number. (The manufacturer shall ensure that the manufacturing history, including the heat number, can be traced from lot or batch number.)  
NOTE: Procurement guidelines for electrodes are given in ANSI/AWS A5.01.
- (g) Safety warning (see Clause 2.10.2).

NOTE: Manufacturers making a statement of compliance with this Australian Standard on a product, packaging, or promotional material related to that product are advised to ensure that such compliance is capable of being verified.