

Australian/New Zealand Standard®

**Welding—Electrodes—
Gas metal arc**

Part 1: Ferritic steel electrodes

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Division of Manufacturing and Technology, CSIRO
Lloyd's Register of Shipping
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Gas metal arc**

Part 1: Ferritic steel electrodes

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee WD/2 on Welding Consumables, to supersede AS 2717.1—1984.

The objective of this Standard is to specify requirements for carbon steel electrodes and low or intermediate alloy ferritic steel electrodes for gas metal arc welding.

The classification and designation system adopted is compatible with Australian Standards for cored electrodes and submerged-arc welding electrodes, and similarly, has mechanical requirements complying with the ship classification societies' unified rules.

To assist designers and for ease of selection, the weld metal is classified according to its tensile strength and is divided into grades related to its Charpy V-notch impact energy value. The intent here is that the designer needs only to specify on the drawing the weld metal classification which will thereby nominate 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 or electrode/gas combination appropriate to the materials of construction and the conditions prevailing at the time.

This edition takes cognizance of the 1993 edition of ANSI/AWS A5.18, *Specification for carbon steel electrodes and rods for gas shielded arc welding*, and incorporates the following significant technical changes:

- (a) The heat treatment condition has been added to the weld metal classification and the thermal treatment requirements have been reviewed.
- (b) Conformance tests have been made non-mandatory.
- (c) The impact test grades and requirements have been revised.
- (d) The marking and storage requirements have been reviewed.

In addition, editorial changes and adjustments have been made, including the following:

- (i) Updating of reference Standards.
- (ii) Alignment with current Standards Australia and Standards New Zealand policies.

Statements expressed in mandatory forms in notes to tables and figures are deemed to be requirements of this Standard.

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.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Welding—Electrodes—Gas metal arc

Part 1: Ferritic steel electrodes

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard specifies requirements for the following solid electrodes for gas metal arc welding:

- (a) Carbon steel electrodes.
- (b) Low or intermediate alloy ferritic steel electrodes.

NOTE: Additional information concerning electrodes is given in Appendix A.

1.2 REFERENCED DOCUMENTS The documents referred to in this Standard are listed in Appendix B.

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 Rim—a type of package consisting of a continuous length of electrode wound on a flanged liner of the type shown in Figure 2.4.

1.3.3 Shall—indicates that a statement is mandatory.

1.3.4 Should—indicates a recommendation.

1.4 CLASSIFICATION AND DESIGNATION

1.4.1 Basis of classification Electrodes shall be classified on the basis of their chemical composition. Provision is made in the designation for specification of the type of external shielding gas and the mechanical properties of the deposited weld metal.

1.4.2 Designation The designation system shall consist of three groups of elements separated by hyphens, each group comprising letters or letters and figures. The letters used in the system are given below in their group subdivisions and the figures used are given in Table 2.2. (See Clause 1.4.3 for examples of the use of the system.)

- (a) *First group*—chemical composition of electrode:

ES = electrode, solid, followed by an alphanumeric code taken from Table 2.2 indicating chemical composition.

- (b) *Second group*—type of external shielding:

G = gas shielding, followed by a letter as follows:

C = shielding with carbon dioxide.

M = shielding with mixed gases.

I = shielding with inert gas.

The gas used in the qualification tests shall be specified by trade name or by composition (percentage of constituents).

(c) *Third group*—mechanical properties of the weld metal:

W = weld metal. This is followed by a three-digit number indicating the weld metal properties. This number is extracted from Tables 2.3 and 2.4, as follows:

- (i) *The first two digits*—are approximately 0.1 of the specified minimum tensile strength of the weld metal, in megapascals, as listed in Table 2.3.
- (ii) *The third digit*—for carbon steel electrodes, indicates the impact energy grade letter or number as listed in Table 2.4. For low alloy ferritic steel electrodes, the third digit is 9 and the minimum impact value shall be as stated in Table 2.4.

This is then followed by the letter 'A' or 'P' indicating the heat treatment condition as follows:

A = classified in the as-welded condition.

P = classified after postweld heat treatment.

H = the gas metal arc welding process is hydrogen controlled, i.e. contains not more than 15 mL of diffusible hydrogen per 100 g of deposited weld metal.

1.4.3 Use of designation system

1.4.3.1 Order of expression Where an electrode, shielding gas and the resultant weld metal classification are to be quoted in combination, they should be set out in the order illustrated in Figure 1.1 and separated by hyphens. In Figure 1.1 the letter 'X' indicates a variable.

1.4.3.2 Examples of use of designation system (with values)

Example 1: ES2-GC-W50ZAH

A plain carbon steel electrode of the composition shown in Table 2.2 that, when deposited with carbon dioxide shielding gas, produces weld metal with the following properties, in the as-welded condition:

Yield strength (or proof stress at 0.2 percent offset)	360 MPa min.
Tensile strength	500 MPa min.
Elongation in 50 mm	22 percent min.
Charpy V-notch impact value	Not required.
Maximum hydrogen per 100 g of weld metal	15 mL.

Example 2: ESNi3-GM-W559PH

A low alloy steel electrode of the composition containing approximately 3.5 percent nickel and the other elements shown in Table 2.2 that, when deposited with a specified mixed gas, produces weld metal with the following mechanical properties after post-weld heat treatment:

Yield strength (or proof stress at 0.2 percent offset)	470 MPa min.
Tensile strength	550 MPa min.
Elongation in 50 mm	19 percent min.
Charpy V-notch impact value	27 J at -73°C.
Maximum hydrogen per 100 g of weld metal	15 mL.

Example 3: ESM4-GM-W839AH

A low alloy steel electrode of the composition shown in Table 2.2 that, when deposited with a specified mixed gas, produces weld metal with the following mechanical properties in the as-welded condition:

- Yield strength (or proof stress at 0.2 percent offset) 730 MPa to 840 MPa.
- Tensile strength 830 MPa min.
- Elongation in 50 mm 14 percent min.
- Charpy V-notch impact value 68 J at –50°C.
- Maximum hydrogen per 100 g of weld metal 15 mL.

1.4.3.3 Designer’s requirement Where a designer wishes to specify weld properties for a particular joint, an abbreviated form of the designation system may be used as illustrated in Figure 1.2. In this abbreviation, the mechanical property group is followed by a hyphen and then the electrode composition group if required.

Use of an electrode of the composition stipulated by the designer shall be deemed to fulfil the chemical requirements of the designer without recourse to chemical analysis of weld metal. Examples are as follows:

- (a) ES2-GC-W50ZAH shall be deemed to fulfil the designer’s requirement W50ZAH-2.
- (b) ESNi3-GM-W559PH shall be deemed to fulfil the designer’s requirement W559PH-Ni3.
- (c) ESM4-GM-W839AH shall be deemed to fulfil the designer’s requirement W839AH-M4.

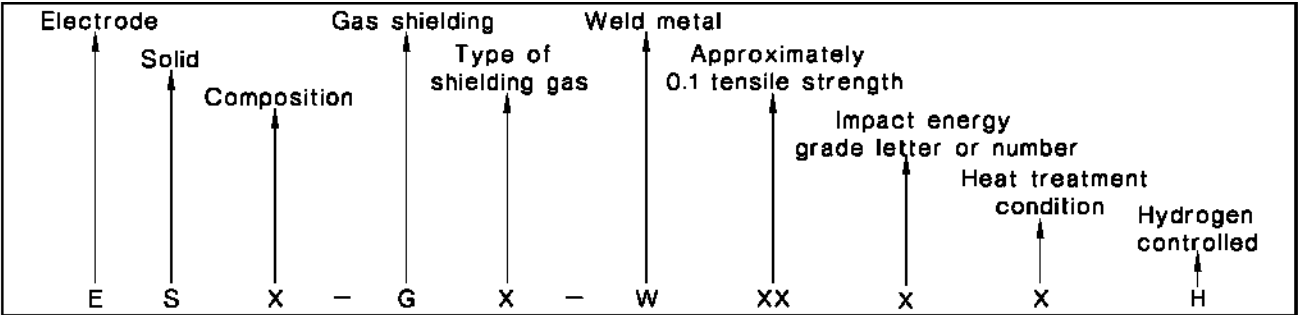


FIGURE 1.1 ORDER OF EXPRESSION FOR DESIGNATION SYSTEM

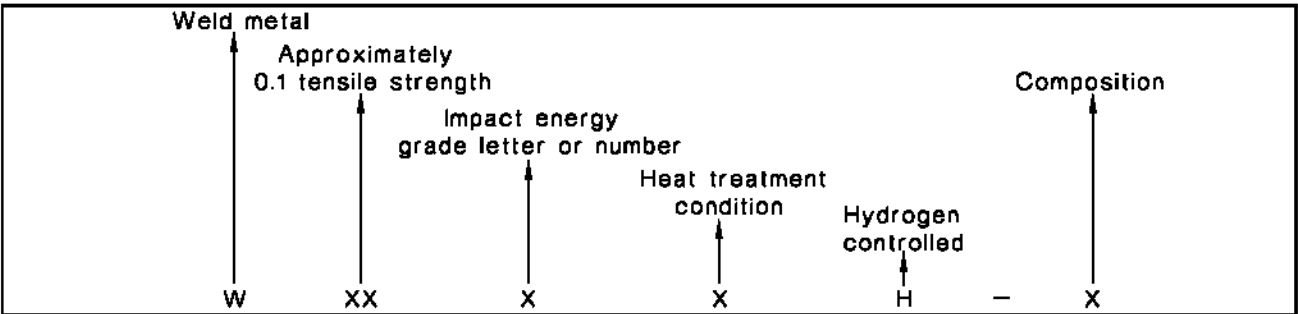


FIGURE 1.2 DESIGNER'S REQUIREMENT

SECTION 2 PROPERTIES AND REQUIREMENTS

2.1 SHIELDING GAS A gas or gas mixture used for shielding in gas metal arc welding shall be of a welding grade having a dew point of -35°C or lower. It should be suitable for the intended application.

2.2 ELECTRODES

2.2.1 Qualification tests Electrodes shall be qualified by compliance with the requirements of this Section, appropriate to their classification, when tested in accordance with Table 2.1 by the methods of test given in Appendix C. Electrodes shall be qualified by testing with each shielding gas or gas mixture for which classification is desired.

TABLE 2.1
TESTS REQUIRED FOR ELECTRODES

Type of test	Applicability	
	Qualification	Conformance
Chemical	✓	✓
Radiography	✓	—
Tensile	✓	✓
Charpy	✓	✓

LEGEND: ✓ indicates applicability.

2.2.2 Conformance tests Tests in accordance with Table 2.1 should be carried out at intervals not exceeding 1 year to ensure that previously qualified electrodes continue to comply with the requirements of the Standard.

Results of tests should be recorded and should be available on request.

2.2.3 Test pieces required For qualification tests, two all-weld-metal test pieces shall be welded, one using a 0.8 mm diameter electrode or the nearest size manufactured above 0.8 mm, the other using the largest diameter electrode manufactured of the type to be tested. Where only one diameter is manufactured, only one all-weld-metal test piece is required.

For conformance tests, one all-weld-metal test piece should be welded in the flat position using an electrode with a diameter of not less than 0.8 mm.

2.2.4 Retests Where a specimen fails a test other than the Charpy V-notch test for which special retest provisions apply (see Clause 2.4.3), two more test specimens shall be tested and shall comply with the Standard.

Additional test specimens may be taken from the same test piece, or may be taken from a new test piece welded with electrodes taken from the same batch as the electrodes used for the first test piece.

TABLE 2.2
CHEMICAL COMPOSITION OF ELECTRODES

Classification	Chemical composition, percent by mass*													
	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Nickel†	Chromium†	Molybdenum†	Vanadium†	Copper‡	Titanium	Zirconium	Aluminium	Total other elements§
Carbon steel electrodes														
ES2	0.07	0.90 to 1.40	0.40 to 0.70	0.025	0.035	—	—	—	—	0.50	0.05 to 0.15	0.02 to 0.12	0.05 to 0.15	0.50
ES3	0.06 to 0.15	0.90 to 1.40	0.45 to 0.75			—	—	—	—		—			
ES4	0.07 to 0.15	1.00 to 1.50	0.60 to 0.85			—	—	—	—		—			
ES5	0.07 to 0.19	0.90 to 1.40	0.30 to 0.60			—	—	—	—		—			
ES6	0.06 to 0.15	1.40 to 1.85	0.80 to 1.15			—	—	—	—		—			
ES7¶	0.07 to 0.15	1.50 to 2.00	0.50 to 0.80			—	—	—	—		—			
Chromium-molybdenum steel electrodes														
ESB2	0.07 to 0.12	0.40 to 1.2	0.40 to 0.70	0.025	0.025	0.20	1.20 to 1.50	0.40 to 0.65	—	0.35	—	—	—	0.50
ESB2L	0.05	0.40 to 1.2	0.40 to 0.70	0.025	0.025	0.20	1.20 to 1.50	0.40 to 0.65	—	0.35	—	—	—	
ESB3	0.07 to 0.12	0.40 to 1.2	0.40 to 0.70	0.025	0.025	0.20	2.30 to 2.70	0.90 to 1.2	—	0.35	—	—	—	
ESB3L	0.05	0.40 to 1.2	0.40 to 0.70	0.025	0.025	0.20	2.30 to 2.70	0.90 to 1.2	—	0.35	—	—	—	
ES5Cr	0.10	1.0	0.90	0.03	0.03	0.40	4.5 to 6.0	0.45 to 0.65	—	0.75	—	—	—	
ES7Cr	0.10	1.0	0.90	0.04	0.03	0.40	6.0 to 8.0	0.45 to 0.65	—	0.75	—	—	—	
ES9Cr	0.10	1.0	0.90	0.04	0.03	0.40	8.0 to 10.5	0.85 to 1.20	—	0.75	—	—	—	
Nickel-molybdenum steel electrodes														
ESNi1	0.12	1.25	0.40 to 0.80	0.025	0.025	0.80 to 1.10	0.15	0.35	0.05	0.35	—	—	—	0.50
ESNi2	0.12	1.25	0.40 to 0.80	0.025	0.025	2.0 to 2.75	—	—	—	0.35	—	—	—	
ESNi3	0.12	1.25	0.40 to 0.80	0.025	0.025	3.0 to 3.75	—	—	—	0.35	—	—	—	
Manganese-molybdenum steel electrodes														
ESD2	0.07 to 0.12	1.60 to 2.10	0.50 to 0.80	0.025	0.025	0.15	—	0.40 to 0.60	—	0.50	—	—	—	0.50

(continued)

Classifi- cation	Chemical composition, percent by mass*													
	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Nickel†	Chromium†	Molyb- denum†	Vanadium†	Copper‡	Titanium	Zirconium	Aluminium	Total other elements§
Other low alloy steel electrodes														
ESM2	0.08	1.25 to 1.80	0.20 to 0.50	0.010	0.010	1.40 to 2.10	0.30	0.25 to 0.55	0.05	0.25	0.10	} 0.10	} 0.10	} 0.50
ESM3	0.09	1.25 to 1.80	0.20 to 0.55	0.010	0.010	1.90 to 2.60	0.50	0.25 to 0.55	0.04	0.25	0.10			
ESM4	0.10	1.25 to 1.80	0.20 to 0.60	0.010	0.010	2.00 to 2.80	0.60	0.30 to 0.65	0.03	0.25	0.10			
ESM5	0.12	1.25 to 1.80	0.20 to 0.60	0.010	0.010	0.80 to 1.25	0.30	0.20 to 0.55	0.05	0.35 to 0.65	0.10			
ESMG	Subject to agreement between supplier and purchaser#													

* Single values shown are maxima.

† These elements may be present in carbon steel electrodes but are not intentionally added.

‡ The percentage of copper by mass due to any coating plus the residual copper content in the steel.

§ Other elements, if intentionally added, shall be reported.

■ In this classification the maximum manganese may exceed 2.0 percent. If it does, the maximum carbon shall be reduced by 0.01 percent for each 0.05 percent or part thereof increase in manganese.

In order to comply with the requirements of the G classification, the electrode shall have as a minimum one of the following: 1 percent manganese, 0.50 percent nickel, 0.30 percent chromium, or 0.20 percent molybdenum.