AS 1858.1—2003

AS 1858.1

Australian Standard™

Electrodes and fluxes for submerged-arc welding

Part 1: Carbon steels and carbon-manganese steels

Standards Australia

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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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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).

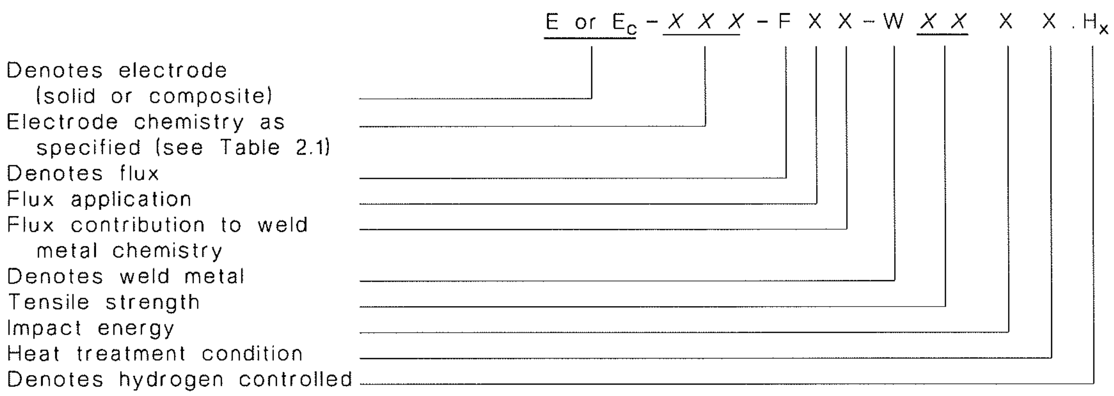


FIGURE 1.1 COMBINED DESIGNATIONS

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 equivalent (Note 3)	ISO Designation	Chemical composition, percent, by mass (Notes 1 & 2)						
			C	Mn	Si	S	P	Cu (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	0.03–0.17
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 number (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

millimetres

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

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 diameter mm	Nominal net mass kg	Dimension, mm		
		Inside dia. of liner	Max. width wound coil	Max. outside dia. 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.

2.10.2 General safety warning

A label shall be attached or a statement prominently displayed with at least the following warning:

WARNING: Protect yourself and others. Read and understand this label.

FUMES AND GASES—can be dangerous to your health.

ARC RADIATION—can injure eyes and burn skin.

ELECTRICAL SHOCK—can kill.

- **Read and understand the manufacturer's instructions, the material safety data sheet and your employer's safety practices.**
- **Keep your head out of the fumes.**
- **Use enough natural ventilation, exhaust ventilation at the fume source, or both, to keep fumes and gases from the breathing zone and the general area.**
- **Wear correct eye, ear and body protection.**
- **Do not touch live electrical parts.**
- **See AS 1674.1, AS 1674.2 and WTIA Technical Notes 7 and 22 or your consumable supplier's recommendations for further information.**

DO NOT REMOVE OR COVER THIS WARNING

Where the size or construction of the unit product is such as will prevent legible presentation of the complete warning as above, the following abbreviated warning may be used provided that the complete warning as above is displayed on the packaging:

WARNING: Protect yourself and others. Read and understand the warning on the packaging.

2.10.3 Additional marking of coils without support

In addition to the information specified in Clause 2.10.1, each coil without support shall have a tag, or similar device, attached to the inside end of the coil, in a manner that prevents easy or accidental removal, bearing the information specified in Items (a), (c), (d), (f) and (g) of Clause 2.10.1.

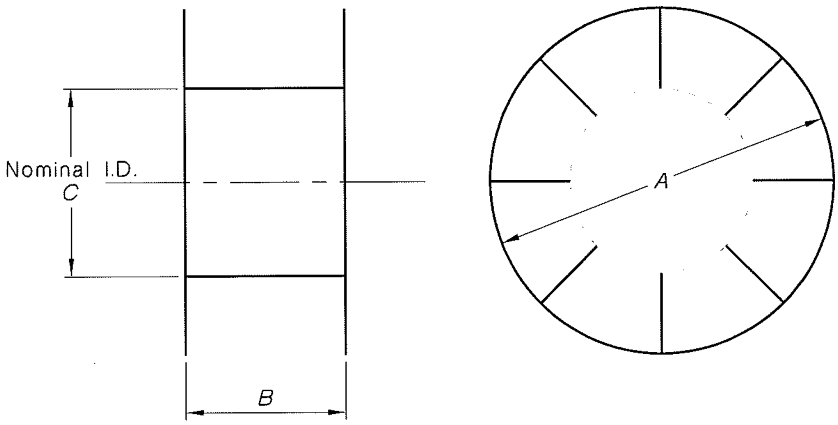
2.11 STORAGE

Where electrodes are stored by the manufacturer or distributor, the conditions of storage shall be such as will ensure that the electrodes comply with the requirements of Clause 2.7.1 at the time of delivery to the purchaser.

NOTES:

1 The purchaser should store the electrode in a dry store or as prescribed by the manufacturer.

2 Guidance on care and storage of welding consumables is given in WTIA Technical Note 3.

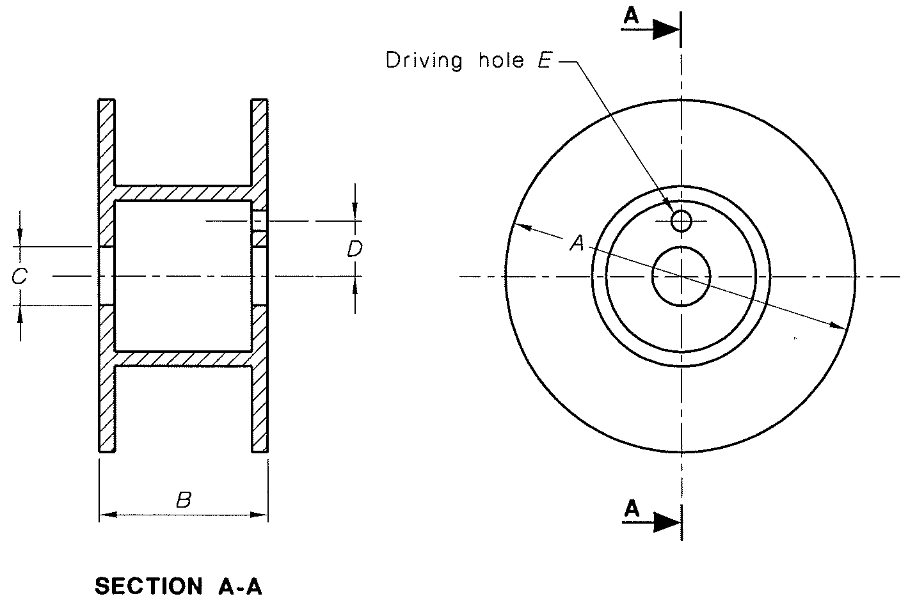


millimetres

Net mass kg	A		B		C	
	Diameter	Tolerance	Width	Tolerance	Inside dia.	Tolerance
≤ 20 ≤ 40	300 435	±5	98 100	+0, −3	188 308	+2.5, −0

NOTE: Dimensions *A* and *B* relate to wire-feeding equipment and should be adhered to. Dimension *C* for small baskets may vary to suit the adaptor.

FIGURE 2.1 BASKETS



millimetres

Net mass kg	A		B		C		D		E	
	Diameter	Tolerance	Width	Tolerance	Diameter	Tolerance	Distance between axes	Tolerance	Diameter	Tolerance
≤40	100	±2	45	+0, −2	16.0	+1, −0	—	—	—	—
	300	±5	103	+0, −3	50.5	+2.5, −0	44.5	±0.5	10	+1, −0
	350	±5	103	+0, −3	50.5	+2.5, −0	44.5	±0.5	10	+1, −0
	435	±5	103	+0, −3	50.5	+2.5, −0	44.5	±0.5	10	+1, −0
≥200 ±25 on nominal mass	760	+15, −10	300	+50, −25	32	+ 2, −1	63	+2, −1	19	+4, −2

FIGURE 2.2 DIMENSIONS OF SPOOLS AND REELS

SECTION 3 FLUXES

3.1 SCOPE OF SECTION

This Section sets out requirements for fluxes for submerged-arc welding of carbon steels and carbon-manganese steels. These fluxes may also be applicable for the welding of low and intermediate alloy steels.

3.2 CLASSIFICATION AND DESIGNATION

3.2.1 Basis of classification

Fluxes shall be classified according to the flux application (see Clause 3.2.3) and the flux contribution to weld metal chemistry (see Clause 3.2.4).

NOTE: Fluxes bearing an 'A' suffix (see Clause 3.2.4) are not completely specified by the flux specification. They need to be specified in conjunction with electrode and weld metal for complete description.

3.2.2 Designation systems

The designation of the flux shall be prefixed by the letter F (denoting flux), and shall consist of a letter representing the flux application, followed by either one or two letters representing the flux contribution to weld metal chemistry.

3.2.3 Flux application

The following letters shall be used to designate the flux application:

(a) S—single-run fluxes.

(b) M—multirun fluxes.

(c) B—basic fluxes.

(d) G—general purpose fluxes.

NOTE: For a fuller description of the classification system and examples of its use, see Appendix A.

3.2.4 Flux contribution to weld metal chemistry

The flux contribution to weld metal chemistry (see Appendix B, Paragraph B3) shall be designated by the following letters:

(a) L—little or no increase in the percentages of manganese and silicon in the weld metal.

(b) M—moderate increase in percentages of manganese and silicon in the weld metal.

(c) H—high increase in percentages of manganese and silicon in the weld metal.

(d) A—used as a suffix to L, M or H denotes the transference of specified alloying elements other than manganese and silicon from the flux into the weld metal (see also Clause 3.6(a)).

The values assigned to the letters L, M and H shall be as shown in Table 3.1 (see also Appendix A).

3.3 MANUFACTURE

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

3.4 FLUX FORM AND PARTICLE SIZE

A flux shall be granular in nature and capable of free flow through the flux feeding tubes, valves and nozzles of standard welding equipment.

NOTE: Particle size distribution is not specified in this Standard, but may be determined by agreement between purchaser and supplier.

3.5 PACKAGING

Fluxes shall be packaged to guard against damage during normal transportation, handling and storage, in such a manner as will ensure that they will be capable of complying with the test requirements of this Standard after being stored in accordance with Clause 3.7.

3.6 MARKING

The outside of each package of flux shall display the following information in a manner that prevents easy or accidental removal:

(a) The words 'Designation AS 1858.1' followed by the flux designation marking, e.g., 'Designation to AS 1858.1—FMM'. Where the classification marking includes the suffix 'A', nominal alloy contribution from the flux shall be stated, e.g., 'FMMA(0.5 Mo)'.

(b) Manufacturer's name.

(c) Manufacturer's trade designation of flux.

(d) Net mass of flux (in kilograms).

(e) Special recommendation for storage and/or conditioning, if applicable.

(f) Lot or batch number.

(g) Statement concerning the weld metal designation with appropriate electrodes (see Paragraph A3.1 of Appendix A).

(h) Safety warning (see Clause 2.10.2).

3.7 STORAGE

When stored by the manufacturer or distributor, the flux shall be kept sealed in its original packaging in a dry area, or under such conditions of special protection as are prescribed by the manufacturer.

NOTES:

1 The purchaser should store the fluxes in a dry store or as prescribed by the manufacturer.

2 Guidance on care and storage of welding consumable is given in WTIA Technical Note 3.

TABLE 3.1

FLUX CONTRIBUTION TO WELD METAL CHEMISTRY UNDER STANDARD TEST CONDITIONS

Letter	Manganese, percent	Silicon, percent	Total increase of both elements, percent
L,LA	0.30 max.	0.30 max.	≤ 0.60
M,MA	0.70 max.	0.50 max.	> 0.45 ≤ 1.10
H,HA	0.60 min.	0.40 min.	> 1.10

SECTION 4 WELD METAL

4.1 SCOPE OF SECTION

This Section sets out the classification and designation of weld metal deposited by an electrode that complies with Section 2 and a flux that complies with Section 3.

4.2 CLASSIFICATION AND DESIGNATION

4.2.1 Basis of classification

Weld metal shall be classified on the basis of its mechanical properties as determined from the all-weld-metal tests prescribed in Paragraph B4 of Appendix B. The tests may be conducted on weld metal in the as-welded condition or after postweld heat treatment and the weld metal may be classified in one condition or the other, or in both conditions.

4.2.2 Designation system

The designation of the weld metal shall be prefixed by the letter W (denoting weld), and shall consist of three-digits followed by either the letter A or the letter P. The first two digits represent one-tenth of the approximate minimum tensile strength of the weld metal in megapascals as given in Table 4.1, and the third represents the impact energy grade as given in column 6 of Table 4.1 for weld metal tested in accordance with Paragraph B4 of Appendix B.

When the weld metal is classified in the as-welded condition, the letter A shall be added after the three digit number. When the weld metal is classified after postweld heat treatment, the letter P shall be added after the three-digit number.

Heat treatment shall be in accordance with Appendix B.

The suffix H_{15}, H_{10}, or H_5, shall be added if the diffusible hydrogen content of deposited weld metal when determined in accordance with Paragraph B5, Appendix B is not greater than 15 mL, 10 mL, or 5 mL per 100 g of deposited weld metal, respectively.

NOTE: The mechanical properties obtained in all-weld-metal tests are not necessarily those that will be obtained with other procedures that may be used in practice.

4.3 EG AND ECG ELECTRODES

Where the weld metal deposited by EG and ECG is required to conform to a specified weld metal designation, the electrodes shall be tested with fluxes under the standard test procedure. The manufacturer shall nominate the actual flux and its designation and the weld metal designation.

TABLE 4.1

MECHANICAL PROPERTY REQUIREMENTS FOR WELD METAL CLASSIFICATION

1	2	3	4	5	6
Weld metal designation (see Note 1)	**Tensile strength MPa**	**Min. yield strength or proof stress at 0.2% offset MPa (see Note 2)**	**Min. elongation in 50 mm, percent**	**Charpy V-notch impact energy value**	**Impact energy grade number**
W40XY*	430 to 550	310	22	Not required	Z
				35 J at +20°C	A
				35 J at 0°C	0
				35 J at −20°C	2
				27 J at −30°C	3
				27 J at −40°C	4
				27 J at −50°C	5
				27 J at −60°C	6
W50XY*	490 to 660	360	22	Not required	Z
				40 J at +20°C	A
				40 J at 0°C	0
				40 J at −20°C	2
				40 J at −30°C	3
				40 J at −40°C	4
				40 J at −50°C	5
				40 J at −60°C	6

*X represents impact energy value grade number in accordance with column 6.

Y designates the condition of heat treatment in which the tests were conducted, i.e., A for as-welded condition and P for postweld heat treatment (see Clause 4.2.2).

NOTES:

1 If a specific electrode/flux combination complies with the requirements of a given W40XY classification, this combination also complies with the requirements of all lower number classifications in the W40XY series in the same heat treatment condition. For example, an electrode/flux combination complying with the requirements of the W405A designation also complies with the requirements of the W404A, W403A and W402A designations, etc. This applies also to the W40XP and W50XY series.

2 Where a definite yield is unlikely to be observed, a proof stress at 0.2% offset shall be used.

APPENDIX A

GUIDE TO THE AUSTRALIAN STANDARD CLASSIFICATION OF ELECTRODES AND FLUXES FOR SUBMERGED-ARC WELDING, AND FACTORS INFLUENCING THE SELECTION OF AN ELECTRODE/FLUX COMBINATION

(Informative)

A1 DESCRIPTION OF SUBMERGED-ARC PROCESS

In submerged-arc welding a continuous electrode is automatically fed to the weld pool.

The arc between electrode and work is covered by a granular flux, part of which fuses to form a protective slag over the weld. Under the slag, the weld characteristically solidifies to an almost ripple-free, smooth contour. The unfused flux can be recovered for use again, provided that it is not contaminated.

Since the arc is not visible, the operator is able to weld without protection against arc radiations, but special arrangements are necessary to track the hidden arc.

The submerged-arc welding process offers the advantages of high deposition rate, and high penetration welding, thus permitting economies in the design and manufacture of welded fabrications. It differs from other processes in the wide range of welding currents, voltages, and speeds that can be applied, along with independent selection of electrode size, electrode grade, and flux. Each of these factors can be varied to provide independent controls on weld shape and size, chemistry, and mechanical properties.

Extensions to the process include the use of—

(a) multiple electrodes (two or more);

(b) strip electrodes;

(c) metallic fill materials; and

(d) one-side welding techniques.

This Standard does not specifically cover such extensions, but the products classified in the Standard may be used for such purposes.

For many years, the problem of hydrogen cracking and the need for hydrogen control was not considered significant in the submerged-arc welding process. This was due in part to the relatively high heat input approach and acid type fluxes normally employed and the nature of the plain carbon steels being welded. For such applications, clean wires and dry fluxes still adequately meet these demands.

Submerged-arc welding is currently being used in higher tensile applications and in more critical areas on cleaner (low impurity) steels and where specific toughness requirements on the weld or HAZ may be paramount. Such applications may employ higher basicity fluxes and higher alloyed electrodes, and may require heat input limitations to achieve the desired joint property requirement. Under such conditions, hydrogen-controlled consumables and procedures may be mandatory.

A2 CLASSIFICATION OF ELECTRODES

Solid electrodes are classified according to their chemical composition, while classification of composite electrodes is based on the chemical composition of weld metal deposited by the electrode in combination with a specific flux.

The classification system closely follows the American National Standards Institute/American Welding Society (ANSI/AWS) system of classification and range of electrode compositions, but includes some additional compositions.

Use of the classification system is illustrated by the following example:

EM12K

The prefix E denotes an electrode. The letter M indicates that this electrode has a medium manganese content (in this instance 0.80% to 1.25% (see Table 2.1). The digits indicate the nominal carbon content, 0.12% (range 0.05% to 0.15%). The letter K indicates that the electrode is made from a heat of steel that has been silicon killed.

Provision is also made for EG and ECG (General Groups) of electrodes whose compositions are outside the composition limits of the other classifications of electrodes in Table 2. 1, but which are, in all other respects, manufactured to the Standard. These electrodes may be tested with fluxes under the standard test procedure to determine compliance with a specified weld metal classification standard.

A3 CLASSIFICATION OF FLUXES

A3.1 General

Submerged-arc fluxes are granular, fusible, mineral compounds which may be manufactured by several different methods. Most submerged-arc fluxes are either fused types, wherein the mineral components are pre-fused to form a molten glass which is subsequently cooled and crushed to size, or bonded types, wherein powdered components are held together in small composite particles by a suitable binder.

The flux classification system used in this Standard makes no distinction between fused and bonded fluxes, both of which are prefixed by the letter F. Fluxes in this system are classified according to—

(a) flux application; and

(b) flux contribution to weld metal chemistry.

Packages of fluxes tested under, and complying with, this Standard will carry marking relating to the ability of the flux to comply with specific weld metal requirements as required in Clause 3.6. This will assist the purchaser in selecting a flux suitable to his requirements. A typical marking is as follows.

Flux classification to AS 1858.1 FMM. The classifications of deposited weld metal yielded by this flux when used in conjunction with different electrodes under the conditions specified in AS 1858.1 are listed below:

Electrode trade name	Electrode designation	Weld metal designation
Brandex 1	EL12	W402 A
Brandex 2	EM12K	W502 P
Brandex 2N	EG	W504 A

A3.2 Flux application

Submerged-arc welding fluxes are formulated with specific applications in mind. To date, no flux formulation has been devised that will give superior performance in all applications.

This Standard classifies fluxes according to their major areas of application.

A3.3 Indices for flux application

A3.3.1 *Single-run fluxes*

Single-run fluxes are acid fluxes commonly of the manganese silicate or titanium dioxide/zirconium silicate type. They are mainly applicable to medium speed and high speed single-run or two-run welding procedures, exhibiting good weld profiles with minimum undercut and excellent porosity resistance. The manganese silicate fluxes have better resistance to porosity, principally derived from the deoxidants manganese and silicon, which they contain in relatively high concentrations. Under multirun welding conditions, these fluxes contribute significant amounts of manganese and silicon to the weld metal. For this reason, their use is normally restricted to single-run or two-run applications. They have high current-carrying capacity and are commonly selected for use with multiple electrodes.

A3.3.2 *Multirun fluxes*

Multirun fluxes are normally aluminate type fluxes with a basicity index in excess of 1 (see Paragraph A3.5). They are applicable to multirun welding and their transfer of manganese and silicon to the weld metal, even at higher arc voltages, is moderate. They are frequently used with EM12K electrodes to provide increased weld metal strength. They confer good impact properties to the deposited weld metal.

A3.3.3 *Basic fluxes*

Basic fluxes are highly basic fluxes, generally of the limefluorspar-magnesite type with a low silica content and a basicity index of 2 or greater (see Paragraph A3.5).

It has been found that, in general terms, chemically basic fluxes interact with the molten pool to produce better weld metal toughness than acid fluxes. Basic fluxes are principally designed to give weld metal with high impact properties.

Normally they contribute small amounts of manganese and silicon to the weld metal and are often used as a base for alloy additions through the flux or with alloy type electrodes where close control of weld metal analysis is required.

These fluxes are not normally suitable for high current, alternating current, tandem arc, or high-speed welding applications, and they lack tolerance to dirty or rusty plate.

They often require careful storage to avoid moisture absorption and may require rebaking prior to use.

A3.3.4 *General purpose fluxes*

General purpose fluxes are usually acid aluminate types with wide application due to good porosity resistance, slag release and weld appearance. Their good profile control is of value on horizontal fillets and rotated circumferential joints.

They are generally used where the special attributes of S, M or B fluxes are not dominant.

Although many general purpose fluxes contribute significant amounts of manganese and silicon to the weld metal, they are suitable for multirun applications used with EL8 and EL12 electrodes, when welding parameters are controlled to limit manganese and silicon build-up. These fluxes have good porosity resistance and arc stability.

Other fluxes in this group make a more moderate manganese and silicon contribution to the weld and may be used for multirun welding with excellent slag release.

A3.4 Flux contribution to weld metal chemistry

Most submerged-arc fluxes contain active deoxidants, usually manganese and silicon. These deoxidants react in the weld pool to eliminate porosity and improve weld metal quality.

Deoxidation reactions remove manganese and silicon from the weld metal by converting them to their oxides, which enter the slag. If the amounts of manganese and silicon in the flux exceed the levels necessary for deoxidation, these elements will transfer to the weld metal. In most cases, some transfer of manganese and silicon is highly desirable, especially if the electrode used is low in these alloys, but if the transfer is excessive, mechanical properties will be adversely affected. Thus, it is important to have some measure of the potential of a flux for contributing alloys to the weld metal (see also Clause 3.2.4).

A3.5 Basicity index

In this Appendix reference is made to the basicity index as an indicator of flux basicity. The basicity index B of a flux can be calculated from the percentage compositions in the equation:

$$B = \frac{CaO + MgO + CaF_2 + Na_2OK_2O + \frac{1}{2}\left(MnO + FeO\right)}{SiO_2 + \frac{1}{2}\left(Al_2O_3 + TiO_2 + ZrO2\right)}$$

as proposed by Tuliani, Boniszewski and Eaton.*

A basicity index of 2 is accepted as the minimum figure for a basic flux.

A3.6 Examples of use of the flux designation system

A3.6.1 *Designation FBL*

A flux, probably of the lime-fluorspar-magnesite type, having a basicity index of 2 or greater, which, in combination with an electrode of appropriate composition, will deposit weld metal with excellent impact properties. It is used mainly on well-prepared joints that are free of rust and other contaminants.

From an EL12 type electrode of composition manganese 0.45% and silicon 0.02%, the undiluted weld deposit will typically contain manganese less than 0.75% and silicon less than 0.32%.

In normal practice, this flux would be used with a more highly alloyed electrode such as EM13K.

A3.6.2 *Designation FSH*

A flux, of the manganese silicate or titanium dioxide/zirconium silicate type, designed for use in single-run application with the ability to accommodate high-speed, high-current welding. It confers excellent porosity resistance to the weld metal, but is not normally used for multirun applications.

From an EL12 type electrode of composition manganese 0.45% and silicon 0.02%, the undiluted weld deposit will exceed 1.05% manganese and 0.42% silicon. Also, the manganese plus silicon content will exceed 1.47% of the total.

A4 CLASSIFICATION OF WELD METAL

Weld metal produced by any given electrode/flux combination is classified in this Standard on the basis of mechanical properties with or without heat treatment (see Table 4.1). The mechanical properties symbolized in the classification system are tensile strength and Charpy impact energy value. The basic principles of the classification system are illustrated in the following example:

$$W402A.H_{10}$$

* TULIANI, S.S., BONISZEWSKI, T., and EATON, N.F. Notch Toughness of Commercial Submerged Arc Weld Metal, *Welding and Metal Fabrication,* August 1969: 327-339.

The prefix W denotes weld metal. The digits 40 indicate that the weld metal will have a tensile strength within the range 430 MPa to 550 MPa. (It is implicit in this classification that the weld metal will also have a minimum yield strength of 310 MPa, and a minimum elongation in 50 mm of 22%.) The third digit, 2, indicates that the average Charpy V-notch impact energy value for the weld metal will be 35 J minimum at −20°C and the A denotes that the properties will be obtained in as-welded condition and H_{10} denotes evolved hydrogen less than 10 mL/100 g of deposited weld metal.

In this Standard, weld metal properties are determined from specimens taken from test pieces prepared according to a standardized procedure with controlled heat input and minimum weld metal dilution.

Such standardized methods are desirable to ensure repeatability in testing for quality control and comparative purposes, and generally to reflect the intrinsic properties of the weld metal produced by any given electrode/flux combination.

A5 SELECTION OF ELECTRODE/FLUX COMBINATIONS

A5.1 Basis for choice of electrode

The basis for choice of an electrode is not easy to define as the electrode is usually selected after consideration of the type of flux to be employed. In broad terms, there are two opposing ways of producing weld metal of specific composition and properties.

One approach is to choose an electrode of relatively low manganese content such as classification EL8 and to use it in combination with a flux that contributes alloys to the weld metal. This approach offers lower cost but requires careful selection and control of welding parameters, as weld metal composition is substantially influenced by the proportion of flux to electrode melted, which is a factor particularly dependent on welding procedure and of increasing significance as the potential alloy contribution of the flux increases.

The other approach is to choose an electrode of relatively high manganese and silicon content such as classification EM13K and use it in combination with a flux that contributes little or no alloy to the weld metal. This approach minimizes the effects of changes in welding parameters, but it is generally more costly and less able to cope with unfavourable welding conditions such as rusty plate.

Many electrode/flux combinations that represent intermediate positions between these two extremes are available.

After the above factors are taken into account, electrodes to this Standard are chosen on the basis of their manganese and silicon contents. Both manganese and silicon assist in deoxidation of the weld pool, but silicon is the more effective. The principal function of manganese is to increase the strength and toughness of the weld metal. In increasing weld metal strength, manganese is assisted by increased carbon and to a lesser extent by silicon; however, by an increase in these elements, particularly carbon, an adverse effect on weld metal toughness may result.

The diameters of electrodes for submerged-arc welding are generally in the range 2 mm to 6.3 mm. Electrodes are generally lightly coated with copper during manufacture to provide protection against rust and to aid conductivity of welding current to the electrode from the contact nozzle.

Small diameter electrodes (up to 2.4 mm) are used in semi-automatic equipment. They provide arc stability at the lower currents normally in use, and the flexibility that is essential to feeding through the flexible cable to the gun. They may also be used in multiple-wire automatic equipment.

In automatic welding, an electrode of a specific diameter can operate over a wide current range. The overlap of the current ranges appropriate to the standard diameters makes it possible to use any of a number of diameters at a particular welding current. For example, a larger diameter may be selected to increase the width of the weld or to make tightness of fit-up less critical. A smaller diameter may be selected to increase depth of penetration or to improve arc initiation. Major usage in Australia is currently centred on the 3.2 mm to 4 mm sizes, the 2.4 mm and 5 mm sizes being the largest and smallest for general application. The commonly used electrodes in Australia are of the classification EL12 and EM12K.

A5.2 Basis for choice of flux

Many different fluxes are available and they are selected on the basis of job performance. Some of the observable factors that dictate this selection are as follows:

(a) Ability to cope with mill-scaled or rusty joints.

(b) Ability to support welding at high current.

(c) Ability to support welding with multiple arcs.

(d) Ability to weld at high speeds.

(e) Control of weld metal chemistry.

(f) Control of weld metal mechanical properties.

(g) Control of weld profile.

(h) Control of weld metal soundness.

(i) Detachability of slag (including detachability in narrow grooves).

(j) Flux consumption rate.

(k) Performance with d.c. or a.c. welding power at various open-circuit voltages.

(l) Resistance to cracking.

(m) Resistance to 'flash through' by the arc.

(n) Resistance to moisture absorption.

(o) Resistance to particle size attrition during recirculation.

The ability of a flux to cope with these and other factors peculiar to a given weldment is generally determined by the experience of the fabricator and the guidance of the supplier.

A5.3 Choice of electrode/flux combinations

The final choice of a combination of an electrode and a flux for a particular application will inevitably be a compromise between a number of factors with one or two requirements being dominant.

The user will be aiming at welding by the most practical and economical procedure. He will thus consider the desired welding rate (dictated by volume of production and available equipment), the quality of weld demanded by specification, and the procedural aspects arising from the geometry, thickness, and composition of the joint members.

Weld metal mechanical properties within the ranges classified in this Standard can usually be obtained by means of several combinations of electrode and flux. The large range of fluxes allows the designer's physical requirements for weld metal to be complied with by choice of a flux that also has characteristics suited to those aspects of procedure dictated by economy, quality, and practicability.

The above considerations will direct the user to one or possibly two of the flux types (S, M, G, or B). More detailed assessment leading to final choice of a flux will take into account the factors listed in Paragraph A5.2. An electrode will then be chosen which complements the flux in the attainment of the specified joint properties.

Further guidance on the choice of electrode/flux combinations should be provided by the manufacturer of the consumable. The manufacturer designates, by means of the weld metal classification, properties of the standard multirun deposit from appropriate combinations of electrodes and fluxes.

Because the mechanical properties are affected by many aspects of procedure (see Paragraph A5.4), the weld metal classification only reflects intrinsic properties for low dilution multirun procedures similar to the test procedure (see Appendix B, Paragraph B4.2.2). For example, for high-dilution or high-heat input procedures, compliance with the designer's specification of weld properties (tensile strength, ductility, fracture toughness) can be proved only by means of procedure qualification tests.

A5.4 Weld metal properties

Properties of weld deposits are determined to a large degree by their composition. Reactions during welding between the base metal, electrode and flux cause changes in the composition of the weld metal, depending on the compositions of the base metal, electrode and flux, and the time, temperature and mass involved in the reactions. Control of carbon, manganese, silicon, and oxygen in the weld is usually the prime concern.

Welding parameters can play a significant part in weld metal chemistry. The maximum flux usage to mass of electrode melted for a given electrode size is obtained when the current is at the lower end and the voltage at the higher end of the operating range. For alloy-contributing fluxes, this increases the alloy content of the weld metal, and procedure control is paramount in critical weldments. Other factors being constant, a decrease in current or an increase in voltage will cause an increase in manganese, silicon and other alloy contributions from a flux. Use of neutral fluxes with alloy electrodes minimizes the effect of welding procedures variations.

Comparative contribution by the flux of manganese and silicon to weld metal chemistry is defined by the grading L, M, or H in the flux classification. The application classifications S, M, B and G also give guidance on flux activity.

The weld metal fracture toughness transition temperature is markedly affected by oxygen and sulfur content of the weld metal. Basic fluxes tend to lower oxygen and sulfur in the weld, and thus lower the transition temperature. Acid fluxes tend to transfer oxygen into the weld metal.

The procedure must have due regard to base metal admixture. Single-run welds have a greater admixture with the base metal than multirun welds, where much of the previously deposited weld metal is remelted with only minimum penetration into the base metal.

Welding parameters also affect the amount of dilution. Maximum penetration and, therefore, dilution is obtained with d.c. electrode positive; minimum dilution is obtained with d.c. electrode negative. Alternating current gives an intermediate effect.

Within normal practical limits of operation, an increase in penetration is accomplished by an increase in current (most effective), a decrease in travel speed and a decrease in voltage.

The test procedures adopted for the classification of weld metal and the measurement of flux contribution to weld metal chemistry are multirun procedures with low dilution by base material when carried out under standardized conditions. The relationship between weld properties obtained in practice and the weld metal grades given in this Standard will depend on the similarity or otherwise of the respective welding procedures.

The metallurgical structure, and hence mechanical properties of the welded joint, are also affected by its thermal and strain history. High cooling rates, characteristic of small runs and low interrun temperature, tend to increase yield stress and affect fracture toughness. Furthermore, the heat-affected zone of each run of a multirun deposit becomes a zone of refined grain size, which also promotes fracture toughness. Lower temperature thermal cycles experienced further from the arc may degrade fracture toughness through a combination of strains and temperatures in an embrittling range (strain ageing).

In general, where M or B classification fluxes are used for superior fracture toughness, best results are obtained with multirun deposits, together with control of heat input and interrun temperature.

APPENDIX B
TESTING
(Normative)

B1 SCOPE

This Appendix sets out requirements for the testing of the electrodes, fluxes and weld metal specified in this Standard.

B2 TESTS ON SOLID ELECTRODES

The chemical composition of the electrode shall be determined in accordance with AS/NZS 1050, or other method not less accurate.

B3 TESTS ON FLUXES

Flux contribution to weld metal chemistry shall be determined by the difference between the analysis of the fourth layer (run No 10) of an analysis pad deposited on a steel plate in accordance with Table B1 and Figure B1 and the analysis of the electrode. The same method of chemical analysis shall be used for each analysis. Where a flux contains special alloying elements other than manganese and silicon (i.e., flux Class FXXA), analysis shall be made for these elements and the flux contribution shall be reported.

TABLE B1

CONDITIONS OF TEST FOR FLUX CONTRIBUTION

Parameter	Condition
Steel type	AS/NZS 3678 (any grade) or equivalent
Plate size	10 mm × 300 mm × 20 mm
Electrode type	EL12
Electrode diameter	4.0 mm
Current type	d.c. electrode positive
Current	600 ±25 A
Arc voltage	30 ±1 V (see Note 1)
Travel speed	400 ±25 mm/min
Run sequence	In accordance with Figure B1 (see Note 2)
Run analysed	Number 10
Run length	250 mm min. (see Note 3)
Electrical stick-out	25 mm to 30 mm, unless otherwise specified by manufacturer

NOTES:

1 Measured between contact assembly and plate.

2 The test piece shall be quenched to room temperature after runs 4, 7, 9.

3 Analysis shall be from the central 150 mm of the run.

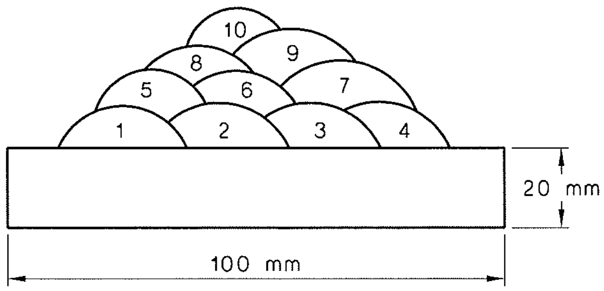


FIGURE B1 RUN SEQUENCE

B4 TESTS ON WELD METAL

B4.1 Material for test pieces

Material to be used for test pieces for mechanical tests shall be of not more than 0.22% carbon (ladle analysis) selected from AS/NZS 3678, Grade 250, Grade 300, or Grade 350, including L15 grade, or equivalent. In case of dispute, material to AS/NZS 3678 Grade 250 shall be used.

B4.2 Test pieces

B4.2.1 *Test piece preparation*

The test piece shall be prepared in accordance with Figure B3(a). The bevelling of the plate edges shall be carried out by machining or mechanized flame cutting. Where the edges are flame cut, any remaining scale shall be removed from the bevelled edges.

Where tests are to be carried out in both the as-welded and postweld heat-treated conditions, two such test pieces, or one test piece of sufficient length to provide the required specimens, shall be prepared.

B4.2.2 *Welding*

Welding of test pieces shall comply with Table B2 and Figure B3(a), and shall be as follows:

(a) The test piece shall be welded in the flat position and shall be preset or restrained to limit angular misalignment after welding to 5°.

(b) The direction of deposition of successive runs shall alternate from each end of the plate, and after completion of each run the flux and welding slag shall be removed.

(c) There shall be no preheat. Welding shall be continuous until an interpass temperature of 250°C is exceeded, when the assembly shall be left in still air until it has cooled to between 150°C and 250°C, the temperature being taken at the point shown in Figure B3(a).

TABLE B2

CONDITIONS FOR WELDING OF TEST PIECES FOR MECHANICAL PROPERTIES (See Notes 1 and 2)

Electrode diameter (see Note 2) mm	Current (see Note 3) A	Voltage (see Note 4) V	Current type (see Note 6)	Travel speed mm/min	Electrical stick-out (see Note 5) mm
1.6	300	29	a.c. or d.c. electrode positive	260	13 to 19
2.0	325	29		275	13 to 19
2.4	350	29		290	19 to 32
2.8	400 ±25	30 ±1		330 ±25	25 to 38
3.2	450	30		365	25 to 38
4.0	600	30		480	25 to 38
4.8	750	32		630	25 to 38

NOTES:

1 The first layer to penultimate layer shall be deposited in two runs. The last layer shall be deposited in three runs.

2 Classification is based on the properties of the weld metal with 4.0 mm electrodes, or the largest size manufactured if smaller than 4.0 mm. The conditions given above for sizes less than 4.0 mm shall be used where classification is based on those sizes, and for conformance testing of those sizes where specifically requested by the purchaser, e.g., in the case of lot or batch testing.

3 Lower current may be used for the first layer.

4 Voltage may be selected by the manufacturer and shall be reported if other than given above.

5 Where an electrode manufacturer recommends electrical stick-out outside the range shown, those recommendations shall be followed within ±6 mm.

6 In case of dispute, d.c. electrode positive shall be used as the referee current type.

B4.2.3 *Thermal treatment*

The test assemblies for materials classified in the as-welded condition shall not be given a postweld heat treatment. The test assemblies for materials classified in the postweld heat-treated condition shall be heated in a furnace to 620 ±15°C and held at that temperature for at least 1 h. Heat treatment may be carried out either before or after the radiographic examination, but it shall be completed before any impact or tensile test specimens are machined from the weld. The temperature of the furnace shall be not higher than 300°C at the time the test assembly is placed in it. The maximum heating rate above 300°C shall be 220 K/h. Upon completion of the holding time of 1 h at 620 ±15°C, the assembly shall be allowed to cool in the furnace to 300°C at a rate not exceeding 180 K/h. At any temperature below 315°C, the assembly may be removed from the furnace and allowed to cool to room temperature in still air.

B4.2.4 *Preparation for radiographic examination*

The assembly shall be prepared for radiographic examination as follows:

(a) The backing strip shall be removed prior to performing the radiography using mechanical means or any suitable process that does not heat the test piece above 200°C.

(b) Weld ripples or weld surface irregularities, both on the inside and outside of the weld, that would interfere with the satisfactory interpretation of the radiograph shall be removed by any suitable mechanical process. The weld surface shall merge smoothly into the plate surface.

B4.2.5 *Radiographic requirements*

The methods used for radiography of the weld shall be in accordance with AS 2177.1 and shall be one of XR1/S, XR2/S, GR1/S or GR2/S. The following requirements shall apply:

(a) Density of radiograph (as defined in AS 2177.1) corresponding to weld metal shall be in the range 2.0 to 3.0 with an allowable fog level of 0.3 maximum.

(b) IQI sensitivity level equal to or better than—

  (i) for a wire-type IQI .... 1.5%; or

  (ii) for a step/hole-type IQI .... 3.0%.

The completed radiograph shall be examined and shall comply with the porosity acceptance level shown in Figure B4. There shall be no indications of inclusions, cracks or zones of incomplete fusion.

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

B4.2.6 *Cutting*

After radiographic examination, the welded assembly shall be cut longitudinally at a distance of 30 mm from the edges of the weld as shown in Figure B3(c) and then cut transversely. Flame cutting shall not be used within 12 mm of the notch area of the impact test specimens.

B4.3 All-weld-metal tensile test

B4.3.1 *Selection of test specimen*

One all-weld-metal tensile test specimen, dimensioned in accordance with Figure B2, shall be machined from the test piece shown in Figure B3(a) and (c).

B4.3.2 *Thermal treatment*

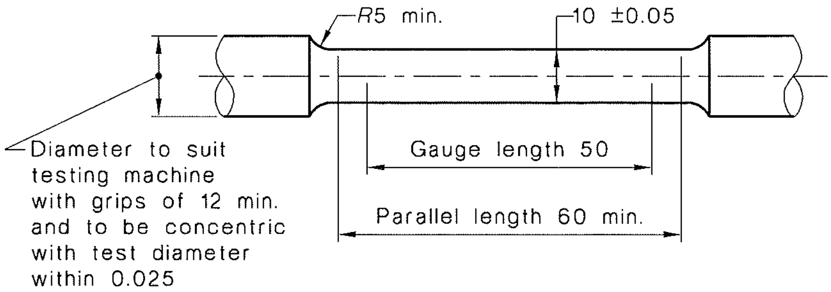
The as-welded tensile test specimens shall be subjected to a temperature not exceeding 250°C for a period not exceeding 16 h, for hydrogen removal, prior to testing, (See Paragraph A1 of Appendix A). The postweld heat-treated specimen shall have no further heat treatment (see Paragraph B4.2.3).

B4.3.3 *Testing*

The test specimen shall be tested in accordance with AS 2205.2.2.

B4.3.4 *Test requirements*

The tensile strength of the specimen shall be in accordance with Table 4.1. Should the specimen fail to reach the values given in Table 4.1, the manufacturer shall determine the cause of failure and rectify the fault before retesting.



DIMENSIONS IN MILLIMETRES

FIGURE B2 ALL-WELD-METAL TENSILE TEST SPECIMEN

B4.4 Impact test

B4.4.1 *Selection of test specimens*

Three Charpy V-notch impact test specimens shall be machined from the test piece, as shown in Figure B3(a), in accordance with AS 2205.7.1 and AS 1544.2. The notch shall be normal to the surface of plate and on the centre-line of the weld cross-section (see Figure B3(b)).

B4.4.2 *Thermal treatment*

No thermal treatment shall be performed on the as-welded or postweld heat-treated impact test specimens.

B4.4.3 *Testing*

The impact specimens shall be tested in accordance with AS 2205.7.1 and AS 1544.2.

B4.4.4 *Test and retest requirements*

The impact energy value of the three test specimens shall be in accordance with Table 4.1.

The impact energy retest requirements shall be as follows:

(a) Where the set of three test specimens has an average impact energy value that complies with Table 4.1 but contains one or more values less than those given in Column 2, Table B3, the set shall be discarded. A further set of three Charpy V-notch test specimens shall be prepared and tested in its place and this set shall comply with Tables 4.1 and B3.

(b) Where the set of three test specimens has an average impact energy value less than that given in Column 1, Table B3, but not less than in Column 3, Table B3, a set of three additional specimens shall be prepared and tested. The results, when added to those previously obtained to form a new average, shall comply with Columns 1 and 2, Table B3.

(c) Where the set of three test specimens has an average impact energy value less than that given in Column 3, Table B3, the set shall be discarded. Six additional test specimens shall then be prepared and tested. The average impact energy value of the six additional specimens shall comply with Table 4.1 and Columns 1 and 2, Table B3.

NOTE: The additional test specimens specified in Steps (a), (b), and (c) above may be taken from the same test piece, or may be taken from a new test piece welded with electrode and flux taken from the same batches as the electrode and flux used for the first test piece.

TABLE B3

IMPACT ENERGY VALUES RELATING TO RETESTS

Joules

1	2	3
Required minimum average impact energy value (from Table 4.1)	**Minimum value for an individual test specimen**	**Minimum average energy value before rejection**
27	18	23
35	23	30
40	26	34

B4.5 Chemical analysis

Chemical analysis for the elements listed in Table 2.2 shall be made in accordance with the methods of AS/NZS 1050 or by methods not less accurate.

The sample for chemical analysis of metal deposited by the flux/electrode combination shall be taken from the all-weld-metal test piece on the axis of the weld at its mid-height and within 5 mm of the axis, either—

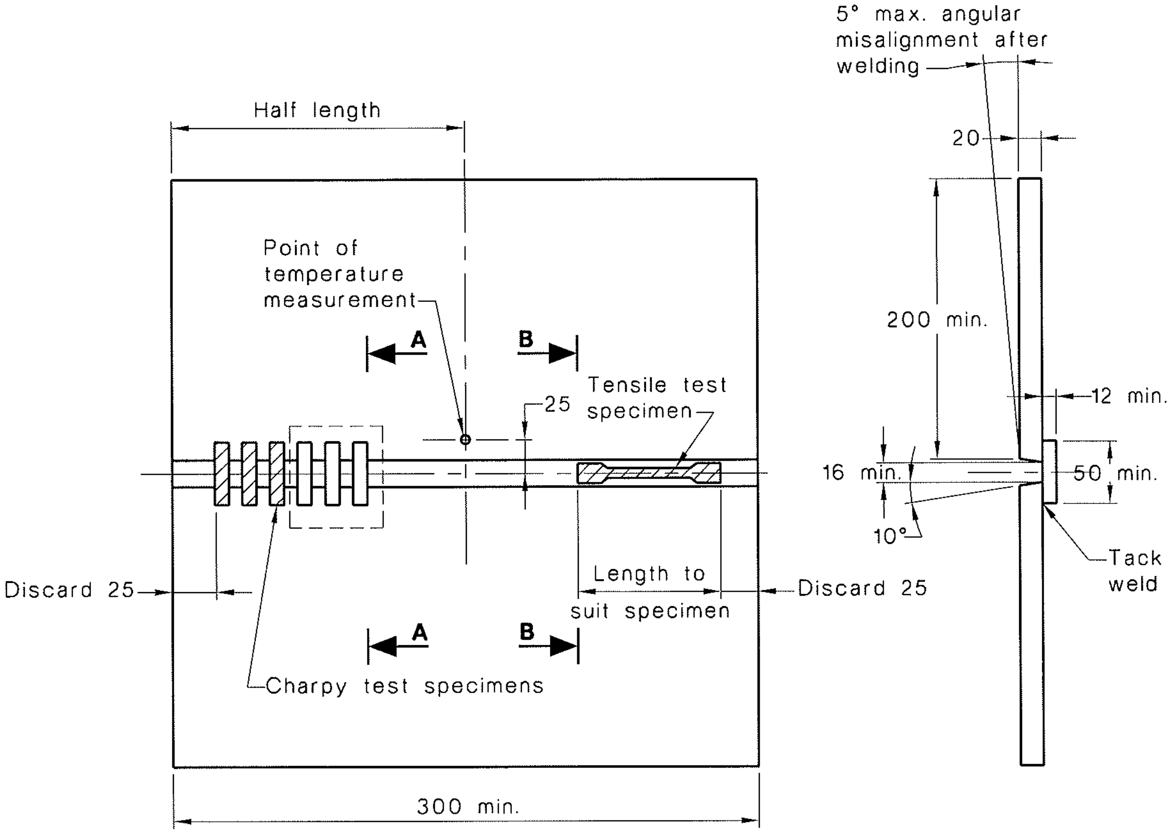
(a) from a test specimen specially cut for the purpose; or

(b) from the all-weld-metal tensile test specimen after fracture.

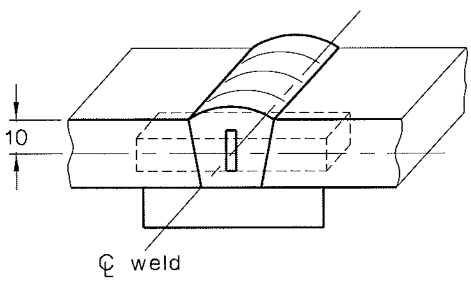
B5 METHODS FOR THE DETEMINATION OF DIFFUSIBLE HYDROGEN CONTENT

The methods for the determination of diffusible hydrogen content shall be in accordance with AS/NZS 3752.

NOTE: Further information on hydrogen control is given in Appendix C.

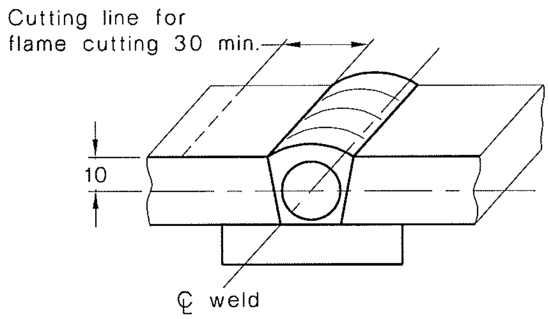


(a) Test piece showing location of test specimens



SECTION A-A

(b) Orientation of impact specimen

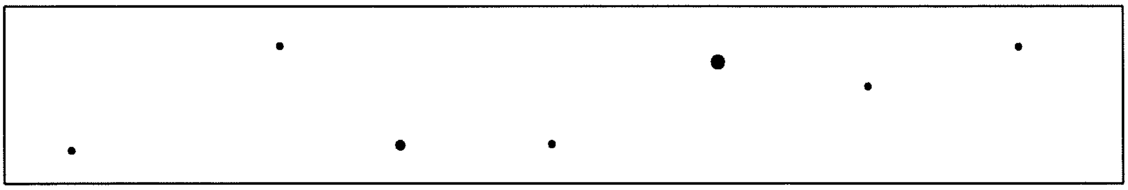


SECTION B-B

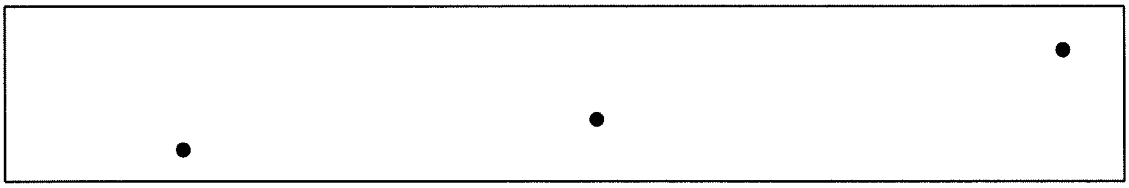
(c) Location of all-weld-metal tensile specimen

DIMENSIONS IN MILLIMETRES

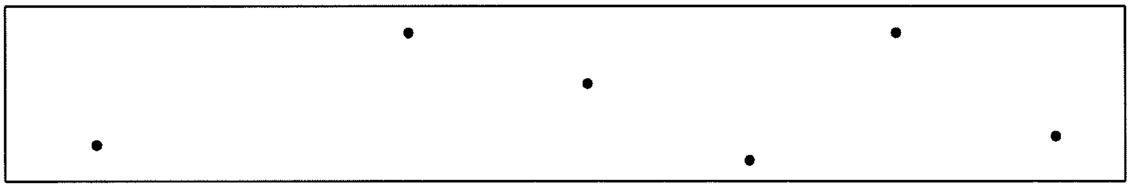
FIGURE B3 DETAILS OF ALL-WELD-METAL TEST PIECE FOR RADIOGRAPHIC TEST, ALL-WELD-METAL TENSILE TEST AND IMPACT TEST



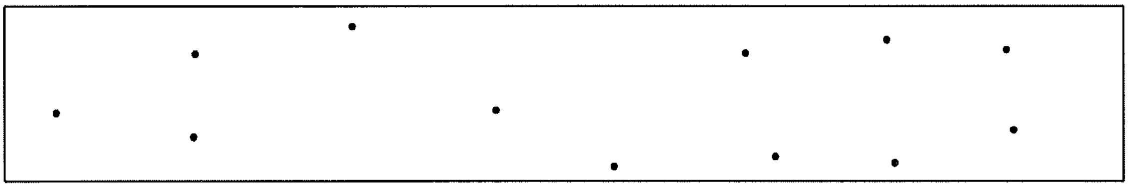
Assorted Porosity:
Size of porosity—0.4 to 1.6 mm dia.
Max. number of indications in any 150 mm of weld = 7, with following restrictions:
Large (1.2 or 1.6 mm dia.) ≤1.
Medium (0.8 to 1.2 mm dia.) ≤2.
Small (0.4 to 0.6 mm dia.) ≤4.



Large Porosity:
Size of porosity—1.2 to 1.6 mm dia.
Max. number of indications in any 150 mm of weld = 3.



Medium Porosity:
Size of porosity—0.8 to 1.2 mm dia.
Max. number of indications in any 150 mm of weld = 6.



Fine Porosity:
Size of porosity—0.4 to 0.8 mm dia.
Max. number of indications in any 150 mm of weld = 12.

NOTES:

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

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 that may be required for general fabrication.

FIGURE B4 POROSITY ACCEPTANCE STANDARDS

APPENDIX C

HYDROGEN CONTROL

(Informative)

This Standard provides for qualification and conformance testing of electrode/flux combinations to one of three levels of maximum acceptable weld-metal-diffusible hydrogen. The three qualification levels are 15 mL/100 g, 10 mL/100 g and 5 mL/100 g of deposited metal, and are designated H_{15}, H_{10}, and H_5 respectively.

The maximum acceptable level of hydrogen for any particular application will depend on a number of factors including steel composition, thickness and geometry of joint, degree of restraint, and preweld and postweld heat treatment. For example, some higher alloy steels will require deposition of weld metal having not more than 5 mL hydrogen per 100 g of deposited weld metal (i.e., H_5 grading). Manufacturers should make available on request any special precautions with regard to storage, conditioning, and use for hydrogen level control.

It is the user's responsibility to ensure that electrodes and fluxes are stored in accordance with the manufacturer's recommendation.

It is expected that manufacturers of fluxes and, where applicable, electrodes classified to this Standard give on the package and in the technical literature the recommended storage and redrying conditions for ensuring the following maximum levels of diffusible hydrogen content per 100 g of deposited weld metal:

(a) Not greater than 15 mL (IIW 'Medium' hydrogen).

(b) Not greater than 10 mL (IIW 'Low' hydrogen).

(c) Not greater than 5 mL (IIW 'Very Low' hydrogen).

The International Institute of Welding recommends that comparisons be made on fused metal rather than deposited metal. This takes into account the dilution effects of the larger weld nuggets associated with the higher penetration processes such as submerged arc and spray type gas shielded processes.

If the hydrogen content is required in terms of fused metal, it is necessary to derive a figure for the mass of fused metal. This may be done by following the procedure described in AS/NZS 3752.

NOTES

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