

SPECIFICATION FOR ALUMINUM AND ALUMINUM ALLOY ELECTRODES FOR SHIELDED METAL ARC WELDING



SFA-5.3



(Identical with AWS Specification A5.3-91)

1. Scope

This specification prescribes requirements for the classification of aluminum and aluminum alloy electrodes for shielded metal arc welding.

SECTION A — GENERAL REQUIREMENTS

2. Classification

2.1 The electrodes covered by this specification are classified according to the chemical composition of the core wire as specified in Table 1, and mechanical properties of a groove weld.

2.2 An electrode classified under one classification shall not be classified under any other classification in this specification.

3. Acceptance

Acceptance¹ of the electrode shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.²

4. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to

the product, the manufacturer certifies that the product meets the requirements of this specification.³

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. Customary Units are the standard units of measure in this specification. The SI Units are given as equivalent values to the U.S. Customary Units. The standard sizes and dimensions in the two systems are not identical, and for this reason conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the nearest 1000 psi (7 MPa) for tensile and yield strength, and to the "nearest unit" in the last right-hand place of figures used in expressing the limiting value for other quantities in accordance with the rounding-off method given in ASTM E29, *Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.⁴

¹ See A3, Acceptance (in the Appendix), for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

² AWS Standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135

³ See A4, Certification (in the Appendix), for further information concerning certification and the testing called for to meet this requirement.

⁴ ASTM Standards can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103

TABLE 1
CHEMICAL COMPOSITION REQUIREMENTS FOR CORE WIRE (WEIGHT PERCENT)^{a,b}

AWS Classification	UNS Designation ^c	Si	Fe	Cu	Mn	Mg	Zn	Ti	Be	Other Elements	
										Each	Total
E1100	A91100	(d)	(d)	0.05-0.20	0.05	—	0.10	—	0.0008	0.05	0.15
E3003	A93003	0.6	0.7	0.05-0.20	1.0-1.5	—	0.10	—	0.0008	0.05	99.00 min ^e Remainder
E4043	A94043	4.5-6.0	0.8	0.30	0.05	0.05	0.10	0.20	0.0008	0.05	0.15 Remainder

NOTES:

- The core wire, or the stock from which it is made, 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 work, the amount of those elements shall be determined to ensure that they do not exceed the limits specified for "Other Elements."
- Single values are maximum, except where otherwise specified.
- SAE/ASTM Unified Numbering System for Metals and Alloys.
- Silicon plus iron shall not exceed 0.95 percent.
- The aluminum content for unalloyed aluminum is the difference between 100.00 percent and the sum of all other metallic elements present in amounts of 0.010 percent or more each, expressed to the second decimal before determining the sum.

TABLE 2
REQUIRED TESTS

Electrode		Chemical Analysis ^a	Tension Test ^b	Bend Test ^c
AWS Classification	Size in. mm			
E1100, E3003, and E4043	$\frac{3}{32}$ 2.4	X	d	d
	$\frac{1}{8}$ 3.2	X		
	$\frac{5}{32}$ 4.0	X		
	$\frac{3}{16}$ 4.8	X		
	$\frac{1}{4}$ 6.4	X	e	e
	$\frac{5}{16}$ 8.0	X		
	$\frac{3}{8}$ 9.5	X		

NOTES:

- Chemical analysis of the core wire or the stock from which it is made.
- Two transverse specimens (Figure 2).
- Two transverse specimens — one face and one root (Figure 3).
- Electrodes $\frac{5}{32}$ in. (4.0 mm) and smaller shall be classified on the basis of the results obtained with the $\frac{5}{32}$ in. (4.0 mm) size of the same classification.
- Electrodes $\frac{3}{16}$ in. (4.8 mm) and larger shall be classified on the basis of the results obtained with the $\frac{1}{4}$ in. (6.4 mm) size of the same classification.

SECTION B — TESTS, PROCEDURES, AND
REQUIREMENTS

6. Summary of Tests

The tests required for each classification are specified in Table 2. The purpose of these tests is to determine the chemical composition of the core wire and the mechanical properties of the weld. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required, are given in Sections 8 through 11.

7. Retest

If the results of any tests fail to meet the requirement, that test shall be repeated twice. The results of both tests shall meet the requirement. Specimens or samples for retest may be taken from the original test assembly or sample, or from a new test assembly or sample. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement.

8. Weld Test Assembly

8.1 One weld test assembly is required. It is the groove weld in Fig. 1 for mechanical properties of the welded joint.

8.2 Preparation of the weld test assembly shall be as prescribed in 8.3, Fig. 1, and Table 2 (Footnotes d

and e) using base metal of the appropriate type specified in Table 3. Testing of the assembly shall be as specified in Sections 10, Tension Test, and 11, Bend Test.

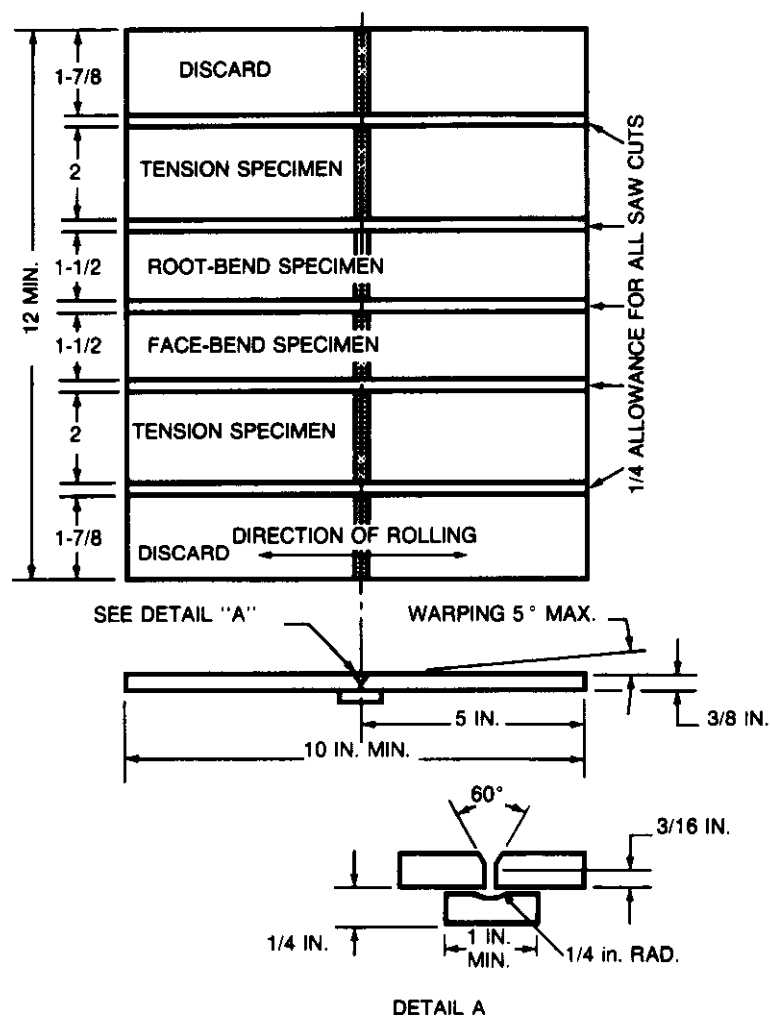
8.3 The test assembly shall be preheated to a temperature between 350°F and 400°F (175°C and 205°C), and shielded metal arc (SMA) welded from one side, in the flat position. The test assembly should be precambered or restrained so that warping due to welding will not cause the finished test assembly to be out-of-plane by more than 5 degrees. If the completed test assembly is more than 5 degrees out-of-plane it shall be straightened at room temperature.

9. Chemical Analysis

9.1 A sample of the core wire, or the stock from which it is made, shall be prepared for chemical analysis.

9.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E34, *Standard Methods for Chemical Analysis of Aluminum and Aluminum Alloys*.

9.3 The results of the analysis shall meet the requirements of Table 1 for the classification of electrode under test.



ALL DIMENSIONS IN INCHES

Notes:

1. Root Opening = 1/16 in.
2. Backing material shall be the same alloy as the base metal.
3. Test specimen blanks shall be removed from the locations shown.

SI EQUIVALENTS

in.	mm	in.	mm
1/16	1.6	1-7/8	48
3/16	4.8	2	51
1/4	6.4	5	127
3/8	9.5	10	254
1	25	12	305
1-1/2	38		

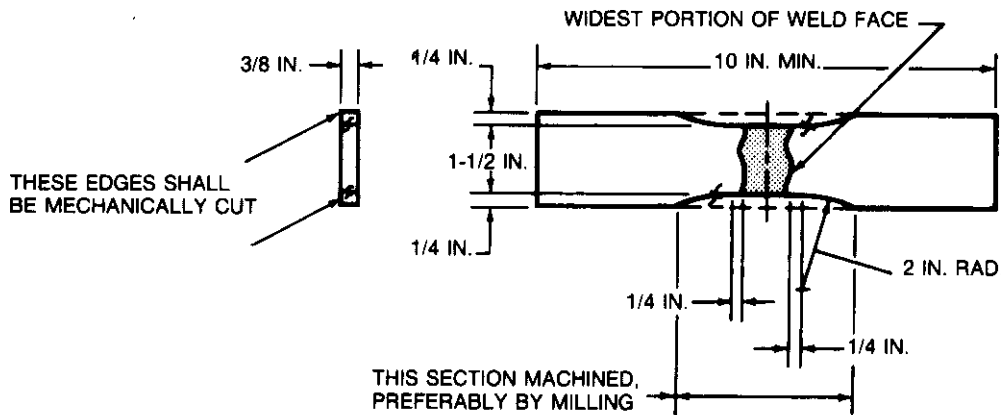
FIG. 1 GROOVE WELD TEST ASSEMBLY FOR MECHANICAL PROPERTIES

TABLE 3
BASE METAL FOR TEST ASSEMBLIES

Electrode	Base Metal		
AWS Classification	Aluminum Alloy ^a	ASTM Specification	UNS Designation
E1100	1100	B209	A91100
E3003, E4043	3003 ^b	B209	A93003

a. Aluminum Association Registration Numbers.
The Aluminum Association, Inc.
900 19th Street, N.W.
Suite 300
Washington, DC 20006

b. When welding 3003 with E4043 electrodes, 3003-0 (annealed temper) plate is preferred.



SI EQUIVALENTS

in.	mm
1/4	6.4
3/8	9.5
1-1/2	38
2	51
10	254

Notes:

1. Weld reinforcement shall be removed flush with the base metal. Undercut shall not be removed. All machining shall be done transverse to the weld.
2. All specimens shall be plainly identified on both ends.

FIG. 2 TENSION TEST SPECIMEN

10. Tension Test

10.1 Two transverse tension test specimens shall be machined from the groove weld described in Section 8, Weld Test Assembly, and shown in Fig. 1. The dimensions of the specimens shall be as specified in Fig. 2.

10.2 The specimens shall be tested in the manner described in the tension test section of ANSI/AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

10.3 The results of the tension test shall meet the requirements specified in Table 4.

11. Bend Test

11.1 One transverse face and one transverse root bend specimen, as required in Table 2, shall be machined from the groove weld test assembly described in Section 8 and shown in Fig. 1. The dimensions of the specimens shall be as shown in Fig. 3.

TABLE 4
TENSION TEST REQUIREMENTS

AWS Classification	Tensile Strength, Min.	
	psi	MPa
E1100	12000	82.7
E3003	14000	96.5
E4043	14000	96.5

* Fracture may occur in either the base metal or the weld metal.

11.2 The specimens shall be tested in the manner described in the guided bend test section of ANSI/AWS B4.0 by bending them uniformly through 180° over a 1-1/4 in. (32 mm) radius in any suitable jig. Two standard bend test jigs are shown in Fig. 4. Positioning of the face bend specimen shall be such that the face of the weld is in tension. Positioning of the root bend specimen shall be such that the root of the weld is in tension. For both types of transverse bend specimen, the weld shall be at the center of the bend.

11.3 Each specimen, after bending, shall conform to the 1-1/4 in. (32 mm) radius, with an appropriate allowance for springback, and the weld metal shall show no crack or other open defect exceeding 1/8 in. (3.2 mm) measured in any direction on the convex surface, when examined with the unaided eye. Cracks that occur on the corners of a specimen during testing

which show no evidence of inclusions or other fusion-type discontinuities, shall not be a basis for rejection.

SECTION C — MANUFACTURE, IDENTIFICATION, AND PACKAGING

12. Method of Manufacture

The electrodes classified according to this specification may be manufactured by any method that will produce electrodes that meet the requirements of this specification.

13. Standard Sizes and Lengths

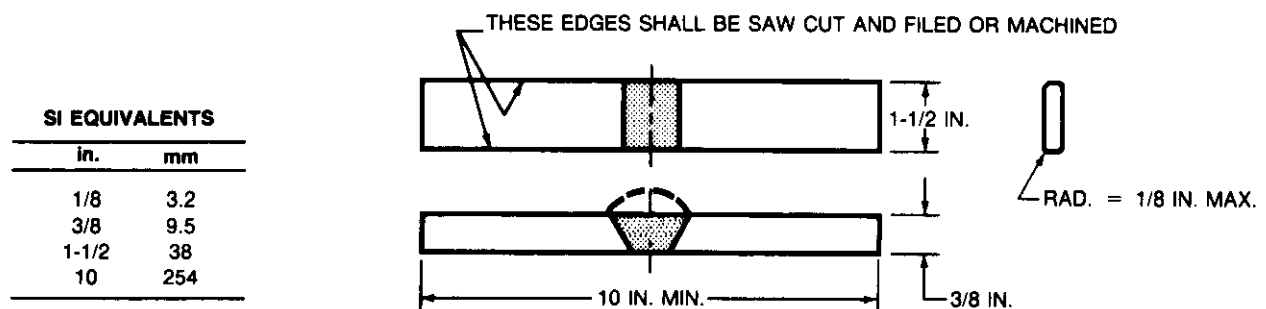
13.1 Standard sizes (diameter of the core wire) and lengths of electrodes are shown in Table 5.

13.2 The diameter of the core wire shall not vary more than ± 0.002 in. (± 0.05 mm) from the diameter specified. The length shall not vary more than $\pm 3/8$ in. (± 9.5 mm) from that specified.

14. Core Wire and Covering

14.1 The core wire and covering shall be free of defects that would interfere with uniform deposition of the electrode.

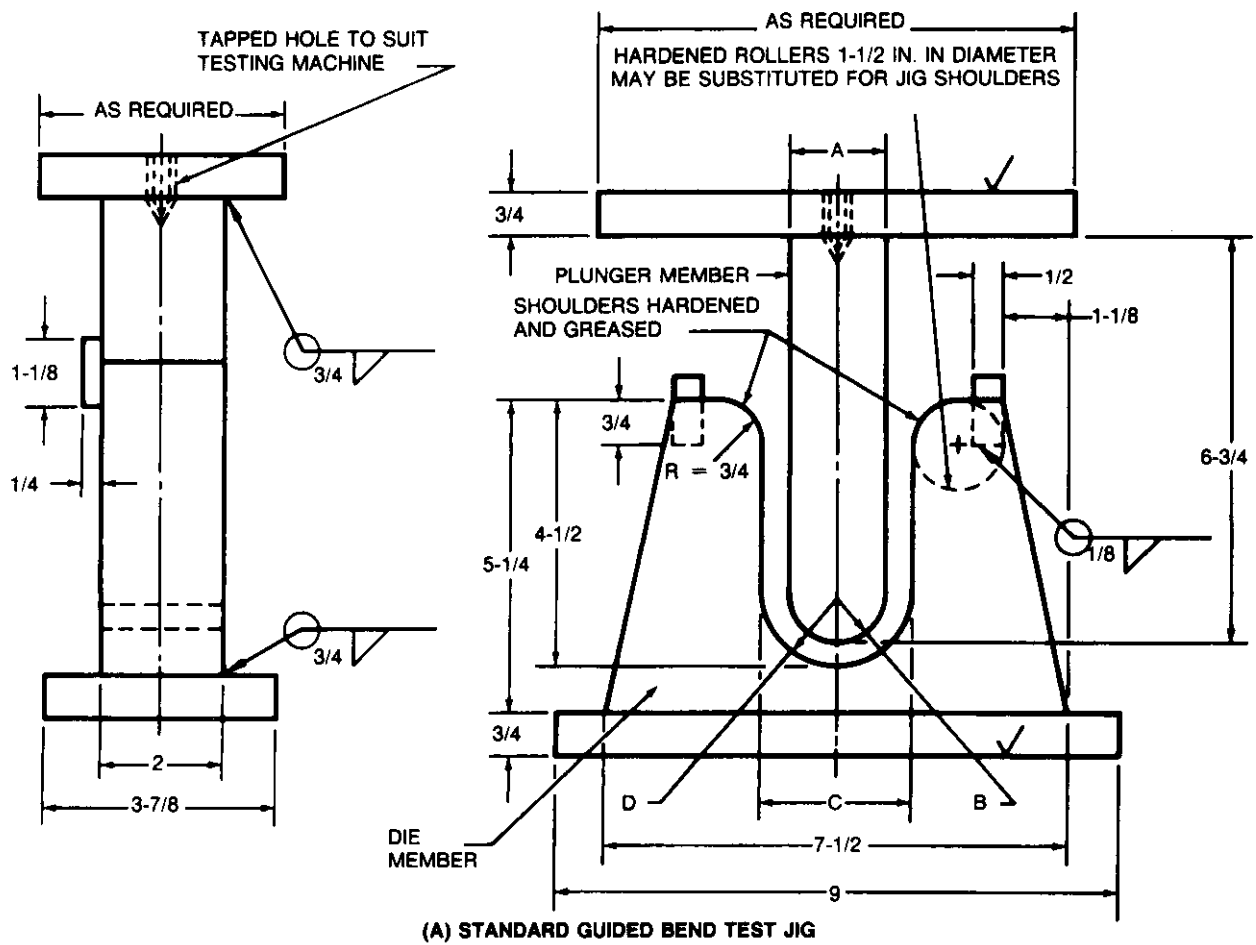
14.2 The core wire and the covering shall be concentric to the extent that the maximum core-plus-one-covering dimension shall not exceed the minimum



Notes:

1. Weld reinforcement shall be removed flush with the base metal. Undercut shall not be removed. All machining shall be done transverse to the weld.
2. Corners of the bend specimens shall be rounded.
3. All specimens shall be plainly identified on both ends.

FIG. 3 BEND TEST SPECIMEN



All dimensions in inches.

A	B	C	D
in.	in.	in.	in.
2-1/2	1-1/4	3-3/8	1-11/16

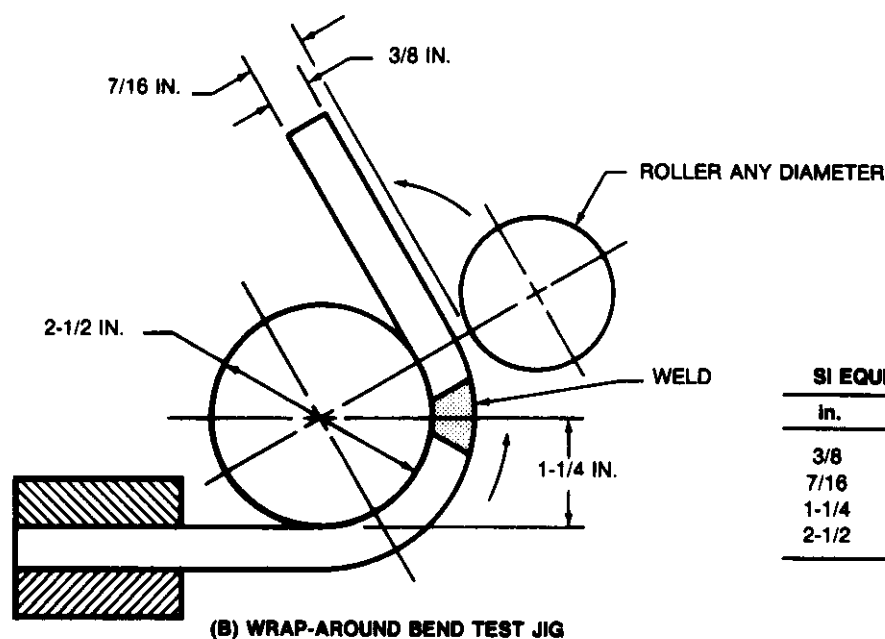
Notes:

1. Plunger and interior die surfaces shall have a machined surface.
2. All dimensions are in inches.
3. Specific dimensions are given for a 3/8 in. (9.5 mm) thick specimen.
4. The side of the specimen turned toward the die shall be the weld face for the face-bend specimens and the weld root for the root-bend specimen.

SI EQUIVALENTS

in.	mm	in.	mm
1/8	3.2	2	51
1/4	6.4	2-1/2	64
1/2	12.7	3-3/8	86
3/4	19	3-7/8	98
1-1/8	28	4-1/2	113
1-1/4	32	5-1/4	133
1-11/16	43	6-3/4	171
		7-1/2	191
		9	229

FIG. 4 BEND TEST JIGS



SI EQUIVALENTS

in.	mm
3/8	9.5
7/16	11.1
1-1/4	32
2-1/2	64

Notes:

1. All dimensions are in inches.
2. Dimensions not shown are the option of the designer. It is essential for the jig to have adequate rigidity so that the parts will not spring during the bending operation.
3. One end of the specimen shall be firmly clamped to the jig so that the specimen does not slide during bending.
4. The weld and heat-affected zone of the transverse bend specimen shall be completely within the bent portion of the specimen after testing.
5. The side of the specimen turned toward the roller shall be the weld face for the face-bend specimens and the weld root for the root-bend specimens.
6. The specimens shall be removed from the jig when the outer roll has been rotated 180° from the starting point.

FIG. 4 BEND TEST JIGS (CONT'D)

TABLE 5
STANDARD SIZES

AWS Classification	Diameter of Core Wire,		Standard Lengths	
	in.	mm	in.	mm
E1100, E3003, and E4043	$\frac{3}{32}$ (0.094)	2.4	14	350
	$\frac{1}{8}$ (0.125)	3.2		
	$\frac{5}{32}$ (0.156)	4.0		
	$\frac{3}{16}$ (0.188)	4.8		
	$\frac{1}{4}$ (0.250)	6.4	18	450
	$\frac{5}{16}$ (0.312)	8.0		
	$\frac{3}{8}$ (0.375)	9.5		

core-plus-one covering dimension by more than the following:

(1) Seven percent of the mean dimension in size 3/32 in. (2.4 mm)

(2) Five percent of the mean dimension in sizes 1/8 in. (3.2 mm) and 5/32 in. (4.0 mm)

(3) Four percent of the mean dimension in sizes 3/16 in. (4.8 mm) and larger

Concentricity may be measured by any suitable means.

14.3 The coverings shall be such that they are not readily damaged by ordinary handling, and they shall not blister when heated to 400°F (200°C). They shall be consumed uniformly during welding and shall not blister or melt back from the core wire. The flux residue they produce shall be readily removable.

15. Exposed Core

15.1 The grip end of each electrode shall be bare (free of covering) for a distance of not less than 1/2 in. (13 mm), nor more than 1-1/4 in. (30 mm), for electrodes 5/32 in. (4.0 mm) and smaller, and not less than 3/4 in. (19 mm) nor more than 1-1/2 in. (35 mm) for electrodes 3/16 in. (4.8 mm) and larger, to provide for electrical contact with the electrode holder.

15.2 The arc end of each electrode shall be sufficiently bare and the covering sufficiently tapered to permit easy striking of the arc. The length of the bare portion (measured from the end of the core wire to the location where the full cross section of the covering is obtained) shall not exceed 1/8 in. (3 mm) or the diameter of the core wire, whichever is less. Electrodes with chipped coverings near the arc end, baring the core wire no more than the lesser of 1/4 in. (6 mm) or twice the diameter of the core wire, meet the requirements of this specification, provided no chip uncovers more than 50 percent of the circumference of the core.

16. Electrode Identification

All electrodes shall be identified as follows:

16.1 At least one imprint of the electrode classification shall be applied to the electrode covering within 2-1/2 in. (65 mm) of the grip end of the electrode.

16.2 The numbers and letters of the imprint shall be of bold block type of a size large enough to be legible.

16.3 The ink used for imprinting shall provide sufficient contrast with the electrode covering so that, in

normal use, the numbers and letters are legible both before and after welding.

16.4 The prefix letter "E" in the electrode classification may be omitted from the imprint.

16.5 In lieu of imprinting, electrodes may be identified by the following:

(1) Attaching to the bare grip end of each electrode a pressure sensitive tape bearing the classification number.

(2) Embossing the classification number on the bare grip end of each electrode. In this case, a slight flattening of the grip end will be permitted in the area of the embossing.

17. Packaging

17.1 Electrodes shall be suitably packaged to protect them from damage during shipment and storage under normal conditions.

17.2 Standard package weights shall be 1 lb (0.45 kg), 5 lb (2.3 kg) and 10 lb (4.5 kg) net weight. Other package weights meet the requirements of this specification when agreed by the purchaser and supplier.

18. Marking of Packages

18.1 The following product information (as a minimum) shall be legibly marked on the outside of each unit package:

(1) AWS specification and classification designation (year of issue may be excluded)

(2) Supplier's name and trade designation

(3) Size and net weight

(4) Lot, control, or heat number

18.2 The following precautionary information (as a minimum) shall be prominently displayed in legible print on all packages of electrodes, including individual unit packages enclosed with a larger package.

WARNING:

PROTECT yourself and others.

READ and understand this information.

FUMES AND GASES can be dangerous to your health.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can kill.

- Before use, read and understand the manufacturer's instructions, manufacturer's Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both to keep fumes and gases away from your breathing zone and the general area.
- Wear corrective eye, ear and body protection.
- See American National Standard Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135; *OSHA Safety and Health Standards, 29 CFR 1910*, available from the U.S. Government Printing Office, Washington, DC 20402

DO NOT REMOVE THIS INFORMATION

Appendix

Guide to Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding

(This Appendix is not a part of ANSI/AWS A5.3-91, *Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding*, but is included for information purposes only.)

A1. Introduction

The purpose of this guide is to correlate the electrode classifications with their intended applications so the specification can be used effectively. Reference to appropriate base metal specifications is made whenever that can be done and when it would be helpful. Such references are intended only as examples rather than complete listings of the materials for which each filler metal is suitable.

A2. Classification System

The system for identifying the electrode classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The letter E at the beginning of each classification designation stands for electrode. The numerical portion of the designation in this specification conforms to the Aluminum Association registration for the composition of the core wire used in the electrode.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*, as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this Specification, shall be clearly stated in the purchase order, according to the provisions of ANSI/AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing normally is performed on material of that classi-

fication, as specified in Schedule F, Table 1, of ANSI/AWS A5.01. Testing in accordance with any other Schedule in that Table must be specifically required by the purchase order. In such cases, acceptance of the material shipped shall be in accordance with those requirements.

A4. Certification

The act of placing the AWS specification and classification designations on the packaging enclosing the product, or the classification on the product itself, constitutes the supplier's (manufacturer's) certification that the product meets all of the requirements of the specification.

The only testing requirement implicit in this certification is that the manufacturer has actually conducted the tests required by the specification on material that is representative of that being shipped and that material met the requirements of the specification. Representative material, in this case, is any production run of that classification using the same formulation. "Certification" is not to be construed to mean that tests of any kind were necessarily conducted on samples of the specific material shipped. Tests on such material may or may not have been conducted. The basis for the certification required by the specification is the classification test of "representative material" cited above, and the "Manufacturer's Quality Assurance Program" in ANSI/AWS A5.01.

A5. Ventilation During Welding

A5.1 Five major factors govern the quantity of fumes in the atmosphere to which welders and welding operators are exposed during welding:

(1) Dimensions of the space in which welding is done (with special regard to the height of the ceiling)

(2) Number of welders and welding operators working in that space

(3) Rate of evolution of fumes, gases, or dust, according to the materials and processes used

(4) The proximity of the welders or welding operators to the fumes as the fumes issue from the welding zone, and to the gases and dusts in the space in which they are working

(5) The ventilation provided to the space in which the welding is done

A5.2 American National Standard Z49.1, *Safety in Welding and Cutting* (published by the American Welding Society), discusses the ventilation that is required during welding and should be referred to for details. Attention is drawn particularly to the Section of that document on Health Protection and Ventilation.

A6. Welding Consideration

A6.1 Welding aluminum by the shielded metal arc process is a well established practice. However, development of the gas shielded arc welding processes and the many advantages of these processes offer has caused a shift away from the use of covered electrodes. This shift is expected to continue and the use of SMAW for aluminum will dwindle. When shielded metal arc welding, a flux covered electrode is held in the standard electrode holder and welding is done with direct current, electrode positive (DCEP). Important factors to be considered when welding aluminum with covered electrodes are moisture content of the electrode covering, and cleanliness of the electrode and base metal. Preheat is usually required to obtain good fusion and to improve soundness of the weld. Residual flux removal between passes is required to provide improved arc stability and weld fusion. Complete removal of the residual flux after welding is necessary to avoid corrosive attack in service.

A6.2 The presence of moisture in the electrode covering is a major cause of weld porosity. Dirt, grease, or other contamination of the electrode can also contribute to porosity. The absorption of moisture by the covering can be quite rapid, and the covering can deteriorate after only a few hours exposure to a humid atmosphere. For this reason, the electrodes should be

stored in a dry, clean location. Electrodes taken from previously opened packages or those exposed to moisture should be "conditioned" by holding them at 350°F to 400°F (175°C to 205°C) for an hour before welding. After conditioning, they should be stored in a heated cabinet at 150°F to 200°F (66°C to 94°C) until used.

A6.3 The minimum base metal thickness recommended for shielded metal arc welding of aluminum is 1/8 in. (3.2 mm). For thicknesses less than 1/4 in. (6.4 mm), no edge preparation other than a relatively smooth, square cut is required. Material over 1/4 in. (6.4 mm) should be beveled to a single-V-groove with a 60 to 90 degree included angle. On very thick material, U-grooves may be used. Depending upon base metal gauge, root-face thicknesses range between 1/16 in. (1.6 mm) and 1/4 in. (6.4 mm). A root opening of 1/32 in. to 1/16 in. (0.8 to 1.6 mm) is desirable for all groove welds.

A6.4 Because of the high heat conductivity of aluminum, preheating to 250°F to 400°F (120°C to 205°C) is nearly always necessary on thick material to maintain the weld pool and proper fusion. Preheating will also help to avoid porosity due to too rapid cooling of the weld pool at the start of the weld. On complicated welds, preheating is useful in avoiding distortion. Preheating may be done by a torch using oxygen and acetylene or other suitable fuel gas, or by electrical resistance heating. Mechanical properties of 6XXX series aluminum alloy weldments can be reduced significantly if the higher preheating temperatures [350°F (177°C) or higher] are applied.

A6.5 Single-pass SMA welds should be made whenever possible. However, where thicker plates require multiple passes, thorough cleaning between passes is essential for optimum results. After the completion of any welding, the weld and work should be thoroughly cleaned of residual flux. The major portion of the residual flux can be removed by mechanical means, such as a rotary wire brush, slag hammer, or peening hammer, and the rest by steaming or a hot-water rinse. The test for complete removal of residual flux is to swab a solution of five percent silver nitrate on the weld areas. Foaming will occur if residual flux is present.

A6.6 Interruption of the arc when shielded metal arc welding aluminum can cause the formation of a fused flux coating over the end of the electrode. Re-establishing a satisfactory arc is impossible unless this formation is removed.

A7. Description and Intended Use of Electrodes

A7.1 Electrodes of the E1100 classification produce weld metal of high ductility, good electrical conductivity, and a minimum tensile strength of 12 000 psi (82.7 MPa). E1100 electrodes are used to weld 1100, 1350(EC), and other commercially pure aluminum alloys.

A7.2 Electrodes of the E3003 classification produce weld metal of high ductility and a minimum tensile strength of 14 000 psi (96.5 MPa). E3003 electrodes are used to weld aluminum alloys 1100 and 3003.

A7.3 The E4043 classification contains approximately five percent silicon, which provides superior fluidity at welding temperatures, and for this reason is preferred for general purpose welding. The E4043 classification produces weld metal with fair ductility and a minimum tensile strength of 14 000 psi (97 MPa). E4043 electrodes can be used to weld the 6XXX series aluminum alloys, the 5XXX series aluminum alloys (up to 2.5 percent Mg content), and aluminum-silicon casting alloys, as well as aluminum base metals 1100, 1350(EC), and 3003.

A7.4 For many aluminum applications, corrosion resistance of the weld is of prime importance. In such cases, it is advantageous to choose an electrode with a composition as close as practical to that of the base metal. For this use, covered electrodes for base metals

other than 1100 and 3003 usually are not stocked and must be specially ordered. For application where corrosion resistance is important, it may be advantageous to use one of the gas shielded arc welding processes for which a wider range of filler metal compositions is available.

A8. Special Tests

It is recognized that supplementary tests may be necessary to determine the suitability of the electrodes for certain applications. In such cases, tests to determine specific properties such as corrosion resistance, electrical conductivity, mechanical properties at elevated or cryogenic temperatures, and suitability for welding different combinations of aluminum base alloys may be required.

A9. Chemical Analysis

The accepted and most widely used method for chemical analysis is found in ASTM E227, *Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloy by the Point-to-Plane Technique*. This method analyzes a bulk sample and all elements simultaneously. The ASTM E34, *Test Method for Chemical Analysis of Aluminum and Aluminum Alloy* prescribes individual test methods for which each element is tested. The ASTM E34 test methods are used as a referee method if a dispute arises concerning a specific element analysis.