AWS A5.10/A5.10M:2021
(ISO 18273:2015 MOD)
An American National Standard

Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods

American Welding Society®

AWS A5.10/A5.10M:2021
(ISO 18273:2015 MOD)
An American National Standard

Approved by the
American National Standards Institute
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Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods

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Prepared by the
American Welding Society (AWS) A5 Committee on Filler Metals and Allied Materials

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification prescribes requirements for the classification of bare wrought, and cast aluminum-alloy electrodes and rods for use with the gas metal arc, gas tungsten arc, oxyfuel gas, and plasma arc welding processes.

This specification makes use of both U.S. Customary Units and the International System of Units (SI). Since these are not equivalent, each system must be used independently of the other.

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This standard is subject to revision at any time by the AWS A5 Committee on Filler Metals and Allied Materials. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS A5 Committee on Filler Metals and Allied Materials and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS A5 Committee on Filler Metals and Allied Materials to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Foreword

This Foreword is not part of this standard but is included for informational purposes only.

This is the third edition of this specification with modified adoption of ISO 18273, *Welding Consumables – Wire Electrodes, Wires and Rods for Welding of Aluminum and Aluminum-Alloys – Classification.* Classification in accordance with this document requires prescribed weld testing which is not a requirement of ISO 18273. Therefore, classification to ISO 18273, without additional testing specified herein, does not provide classification to this document. Annex C provides more information on the differences in the two documents.

This document makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore, each system must be used independently of the other, without combining values in any way. For selecting rational metric units, AWS A1.1, *Metric Practice Guide for the Welding Industry,* is used where suitable. Tables and figures make use of both U.S. Customary and SI units, which, with the application of the specified tolerances, provide for interchangeability of products in both U.S. Customary and SI Units.

The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights. By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

Substantive changes included in this revision include the addition of weld metal strength requirements, the addition of a "G" classification option and rules for the use of computed and digital radiography. These substantive changes are shown in *italic font* where possible.

This specification developed as follows:

ASTM B285-54T AWS A5.10-54T	*Tentative Specification for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes*
ASTM B285-57T AWS A5.10-57T	*Tentative Specification for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes*
AWS A5.10-61T ASTM B285-61T	*Tentative Specification for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes*
AWS A5.10-69 ANSI W5.10-1973	*Specification for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes*
ANSI/AWS A5.10-80	*Specification for Aluminum and Aluminum-Alloy Bare Electrodes and Rods*
ANSI/AWS A5.10-88	*Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*
ANSI/AWS A5.10-92	*Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*
AWS A5.10/A5.10M:1999	*Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*
AWS A5.10/A5.10M: 1999 (R2007)	*Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*
AWS A5.10/A5.10M:2012 (ISO 18273:2004 MOD)	*Welding Consumables—Wire Electrodes, Wires and Rods for Welding of Aluminum and Aluminum-Alloys – Classification*

AWS A5.10/A5.10M:2017 (ISO 18273:2004 MOD)	*Welding Consumables—Wire Electrodes, Wires and Rods for Welding of Aluminum and Aluminum-Alloys – Classification*

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS A5 Committee on Filler Metals and Allied Materials, American Welding Society, 8669 NW 36th St., # 130, Miami, FL 33166.

All errata to a standard shall be published in the Welding Journal and posted on the AWS website.

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Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods

1. Scope

1.1 This standard specifies requirements for classification of solid electrodes and rods for fusion welding of aluminum and aluminum alloys. The classification of the solid electrodes and rods is based on their chemical composition, operability testing and mechanical testing, when required.

1.2 This specification makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore, each system must be used independently of the other without combining in any way when referring to weld metal properties. The specification A5.10 uses U.S. Customary Units. The specification with the designation A5.10M uses SI units. The latter are shown within brackets [ ] or in appropriate columns in tables and figures. Standard dimensions based on either system may be used for the sizing of electrodes or packaging or both under specification A5.10 or A5.10M.

1.3 Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein. Some safety and health information can be found in Annex A Clauses A5 and A11.

Safety and health information is available from the following sources:

American Welding Society:

(1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

(2) AWS Safety and Health Fact Sheets

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Safety Data Sheets supplied by materials manufacturers

(2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments or revisions of the publications may not apply since the relevant requirements may have changed.

The following AWS standards are referenced in the mandatory clauses of this document:

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*

AWS A5.01M/A5.01, *Welding Consumables—Procurement of Filler Metals and Fluxes*

AWS A5.02/A5.02M, *Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*

AWS B4.0, *Standard Methods for Mechanical Testing of Welds*

The following ANSI standard is referenced in the mandatory clauses of this document:

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

The following ASTM standards are referenced in the mandatory clauses of this document:

ASTM B108, *Standard Specification for Aluminum-Alloy Permanent Mold Castings*

ASTM B209, *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E34, *Standard Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys*

ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*

ASTM E2033, *Standard Practice for Computed Radiology (Photostimulable Luminescence Method)*

ASTM E2698, *Standard Practice for Radiological Examination Using Digital Detector Arrays*

The following ISO standard is referenced in the mandatory clause of this document.

ISO 80000-1:2009, Quantities and units — Part 1: General. Corrected by ISO 80000-1:2009/Cor 1:2011, *Quantities and Units-Part I: General*

3. Classifications

3.1 The classification designation system is as shown in Figure 1 and the symbols and chemical composition are as shown in Table 1.

3.1.1 Any filler metal tested and classified as an electrode shall also be considered classified as a welding rod. Filler metal tested and classified only as a welding rod shall not be considered classified as an electrode.

3.1.2 The electrodes and rods classified under this specification are intended for gas metal arc, gas tungsten arc, oxyfuel gas, and plasma arc welding, but that is not to prohibit their use with any other process for which they are found suitable.

3.2 Electrodes and rods classified under one classification shall not be classified under any other classification in this specification.

4. Acceptance

Acceptance of the welding electrodes and rods shall be in accordance with the provisions of AWS A5.01M/A5.01. See Clause A3 in Annex A for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging or the classification designation to the product, the manufacturer certifies that the product meets the requirements of this specification. See Clause A4 in Annex A for further information concerning certification and the testing called for to meet this requirement.

6. Rounding Procedure

For the purpose of determining compliance with the requirements of this standard, the actual test values obtained shall be subjected to the rounding rules of ASTM E29 or Rule A in Clause B.3 of ISO 80000-1 (the results are the same). If the measured values are obtained by equipment calibrated in units other than those of the specified limit, the measured values shall be converted to the units of the specified limit before rounding. If an average value is to be compared to the specified limit, rounding shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 1000 psi (1 ksi) for tensile and yield strength for A5.10 [to the nearest 10 MPa for tensile and yield strength for A5.10M] and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities. The rounded results shall fulfill the requirements for the classification under test.

7. 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 filler metal, the soundness of the weld metal produced by gas metal arc welding electrodes, the deposition characteristics of welding rods, and *the strength of the weld metal, when required*. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required are given in Clauses 9 through 13.

8. Retest

If the result of any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original weld test assembly or test sample or from a new weld test assembly or from a new test sample. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test sample or test specimen(s), or in conducting the test, the test shall be considered invalid, without regard to whether the test was actually completed, or whether the test results met or failed to meet the requirement. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9. Weld Test Assemblies

9.1 One or two weld test assemblies are required:

a) The groove weld test assembly for the usability of electrodes and the soundness of the weld metal (see 9.3 and Figure 2).

b) The groove weld test assembly for mechanical properties (see 9.4 and Figure 3).

c) The bead-on-plate weld test assembly for the usability of rods (see 9.5).

9.2 Usability tests shall be made using electrodes and welding rods of each diameter. A filler metal that satisfactorily meets the requirements of the radiographic soundness test, when tested as an electrode, shall also be classified as a welding rod without being subjected to the bead-on-plate test required for a welding rod. A filler metal that satisfactorily meets the bead-on-plate weld test requirements, when tested as a welding rod, shall also be tested as an electrode, and meet the testing requirements to be classified as an electrode.

9.3 Groove Weld for Soundness and Usability of Electrodes

9.3.1 A test assembly shall be prepared and welded as specified in Figure 2 and Clause 9.3.2 through 9.3.4 using base metal of the appropriate type specified in Table 3. The welding position shall be as specified in Figure 2 for each electrode diameter. Testing of the assembly shall be as specified in Clause 11, Radiographic Test.

9.3.2 Welding of the test assembly shall be conducted using the gas metal arc welding process with techniques and procedures specified by the manufacturer for the factors not covered herein.

9.3.3 Dimensions of the groove weld joint and the position of welding shall be as specified in Figure 2 for the electrode diameter being tested. The backing material shall be of the same type as the test plate base metal.

9.3.4 The test assembly shall be at a temperature of not less than 60°F [16°C] when commencing the initial or subsequent weld passes. The preheat and interpass temperatures shall not exceed 250°F [120°C].

9.4 ***Groove Weld Test for Mechanical Properties***

9.4.1 *When required in Table 2, a groove weld test assembly shall be prepared and welded as specified in Figure 3 and Table 4.*

9.4.2 *The electrode diameter shall be 0.047 in [1.2 mm] or 0.062 in [1.6 mm], or the nearest size manufactured. The welding parameters shall be as specified in Table 4. Base plate and backing strip for 5xxx series classifications may be 1xxx series or 5xxx series. Base plate and backing strip for all other classifications shall be 1xxx series. Any other base plate used will require a minimum buttering thickness of 1/8 inch [3 mm] of the weld preparation face and backing strip, as shown in Figure 3, made with the same filler metal classification as that tested. Alternately, no buttering, but an increase in the root opening of 1/4 in [6 mm] minimum may be used, from that specified in Figure 3. The test assembly shall be at a temperature of not less than 60°F [16°C] when commencing the initial or subsequent weld passes. The preheat and interpass temperatures shall not exceed 250°F [120°C].*

9.4.3 *Welding shall be in the flat position. The assembly may be pre-set or restrained during welding to prevent excess warpage. Testing of the assemblies shall be as required in Clause 12, Tension Test.*

9.5 Bead-on-Plate Weld Test for Usability of Welding Rods

9.5.1 The test assembly shall consist of sheet, plate, or extrusion approximately 12 in [300 mm] in length upon which a weld shall be made as specified in 9.5.2, using base metal of the appropriate type specified in Table 3. Examination of the assembly shall be as specified in Clause 13, Bead-on-Plate Test.

9.5.2 The assembly shall be welded in the flat position with the gas tungsten arc welding process employing alternating current and argon gas shielding. The test plate thickness and the welding current shall be compatible with the rod size being tested.

9.5.3 The completed bead-on-plate welds shall be examined with the unaided eye (corrected to normal vision) and shall meet the requirements specified in Clause 13, Bead-on-Plate Test.

10. Chemical Analysis

10.1 A sample of the filler metal, or the stock from which it is made, shall be prepared for chemical analysis by any method that will not affect the chemical composition.

10.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E34.

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

11. Radiographic Test

11.1 The groove weld described in 9.3 and shown in Figure 2 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed and both surfaces of the weld shall be machined or ground smooth and flush with the original surfaces of the base metal or with a uniform reinforcement not exceeding 3/32 in [2.5 mm]. It is permitted on both sides of the test assembly to remove base metal to a depth of 1/16 in [1.5 mm] nominal below the original base metal surface in order to facilitate backing and/or buildup removal. The thickness of the weld metal shall not be reduced by more than 1/16 in [1.5 mm] so that the thickness of the prepared radiographic test specimen equals at least the thickness of the base metal minus 1/16 in [1.5 mm]. Both surfaces of the test assembly, in the area of the weld, shall be smooth enough to avoid difficulty in interpreting the radiograph.

11.2 The weld shall be radiographed in accordance with one of the following. The quality level of inspection shall be 2-2T.

(1) Film Radiology: ASTM E1032.

(2) Computed Radiology (CR): ASTM E2033 and the requirements of ASTM E1032 except where CR differs from film. The term film, as used within ASTM E1032, applicable to performing radiography in accordance with ASTM E2033, refers to phosphor imaging plate.

(3) Digital Radiology (DR): ASTM E2698 and the requirements of ASTM E1032 except where DR differs from film. The term film, as used within ASTM E1032, applicable to performing radiography in accordance with ASTM E2698, refers to digital detector array (DDA).

11.3 The soundness of the weld metal and the usability of the electrode meet the requirements of this specification if the radiograph shows no cracks, no incomplete fusion, and no rounded indications in excess of those permitted by the radiographic standards in Figure 4 for test assemblies welded in the overhead position for electrode sizes up to and including 1/16 in [1.6 mm], and in Figure 5 for test assemblies welded in the flat position for electrode sizes larger than 1/16 in [1.6 mm]. In evaluating the radiograph, the center 6 in [150 mm] of the test specimen shall be considered, and all extra weld shall be disregarded.

A rounded indication is an indication on the radiograph whose length is no more than three times its width. Rounded indications may be circular, elliptical, conical, or irregular in shape and they may have tails. The size of the rounded indication is the largest dimension of the indication including any tail that may be present. Indications whose largest dimension does not exceed 1/64 in [0.4 mm] shall be disregarded. Test assemblies with indications larger than the large indications permitted in the radiographic standards in Figure 4 and Figure 5 do not meet the requirements of this specification.

11.4 An electrode that produces a groove weld which satisfactorily meets these radiographic requirements may also be classified as a welding rod under this specification without conducting the test specified in 9.5.

12. *Tension Test*

12.1 *One all-weld-metal tension test specimen, as specified in the Tension Test Clause of AWS B4.0, shall be machined from the welded test assembly described in 9.4 and shown in Figure 3. The tensile specimen shall have a nominal diameter of 0.500 in [12.5 mm], and a nominal gage length to diameter ratio of 4:1. The specimen shall be tested in the manner described in the Tension Test Clause of AWS B4.0. The results of the all-weld-metal tension test shall meet the requirements specified in Table 5 for that classification.*

12.2 *An electrode that produces a groove weld which satisfactorily meets the tension test requirements of Table 5 and the other requirements for classification as an electrode may also be classified as a welding rod under this specification.*

13. Bead-on-Plate Test

13.1 Welding rod tested in accordance with 9.5 shall produce weld metal that flows freely and uniformly without sputtering or other irregularities. The resultant weld metal shall be smooth and uniform with no visible evidence of cracks or porosity.

13.2 If a filler metal satisfactorily meets the weld bead-on-plate test requirements when tested as a welding rod, it also shall be tested as an electrode if it is to be classified as an electrode.

14. Method of Manufacture

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

15. Standard Sizes

15.1 Standard sizes for round filler metal in the different package forms of straight lengths, coils without support, and spools are as shown in AWS A5.02/A5.02M. Diameters of cast rods in straight lengths are approximate with no specified tolerance.

15.2 Typical sizes for flattened shapes of straight length welding rod are shown in Table 6. The cross-sectional area of such shapes shall be equivalent to that of corresponding round rods of the same nominal diameter as listed in AWS A5.02/A5.02M.

16. Finish and Uniformity

Finish and uniformity shall be as specified as in AWS A5.02/A5.02M.

17. Standard Package Forms

Standard package dimensions and weights and other requirements for each form shall be as specified in AWS A5.02/A5.02M.

18. Winding Requirements

18.1 Winding requirements shall be as specified in AWS A5.02/A5.02M.

18.2 The cast and helix of the filler metal shall be as specified in AWS A5.02/A5.02M.

19. Filler Metal Identification

Filler metal identification, product information, and precautionary information shall be as specified in AWS A5.02/A5.02M.

20. Packaging

20.1 Filler metal in all product forms, except welding rods in straight lengths, shall be packaged in accordance with AWS A5.02/A5.02M.

20.2 Packaging of straight lengths of bare welding rods shall be as agreed upon between the purchaser and supplier.

21. Marking of Packages

The product information (as a minimum) that shall be legibly marked and visible from the outside of each unit package shall be as specified in AWS A5.02/A5.02M.

Table 1
Symbols and Chemical Composition Requirements for Electrodes and Rods

Alloy Symbol			Chemical Composition in Weight Percent[a]													
AWS Classification	ISO 18273 Chemical Composition Symbols		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ga, V	Ti	Zr	Al (minimum)	Be[b]	Other each	Other total
ALUMINIUM-LOW ALLOYED																
ER1070, R1070	Al 1070	Al99,7	0.20	0.25	0.04	0.03	0.03	—	0.04	V 0.05	0.03	—	99.70	0.0003	0.03	—
ER1080A, R1080A	Al 1080A	Al99,8(A)	0.15	0.15	0.03	0.02	0.02	—	0.06	Ga 0.03	0.02	—	99.80	0.0003	0.02	—
ER1100, R1100	Al 1100	Al99,0Cu	Si + Fe 0.95		0.05–0.20	0.05	—	—	0.10	—	—	—	99.00	0.0003	0.05	0.15
ER1188, R1188	Al 1188	*Al99,88*	0.06	0.06	0.005	0.01	0.01	—	0.03	Ga 0.03 V 0.05	0.01	—	99.88	0.0003	0.01	—
ER1200, R1200	Al 1200	Al99,0	Si + Fe 1.00		0.05	0.05	—	—	0.10	—	0.05	—	99.00	0.0003	0.05	0.15
ER1450, R1450	Al 1450	Al99,5Ti	0.25	0.40	0.05	0.05	0.05	—	0.07	—	0.10–0.20	—	99.50	0.0003	0.03	—
ALUMINIUM-COPPER																
R-206.0[c]	—	—	0.10	0.15	4.2–5.0	0.20–0.50	0.15–0.35	—	0.10	—	0.15–0.30	—	Rem	—	0.05	0.15
ER2319, R2319	Al 2319	AlCu6MnZrTi	0.20	0.30	5.8–6.8	0.20–0.40	0.02	—	0.10	V 0.05–0.15	0.10–0.20	0.10–0.25	Rem	0.0003	0.05	0.15
ALUMINIUM-MANGANESE																
ER3103, R3103	Al 3103	*AlMn1*	0.50	0.7	0.10	0.9–1.5	0.30	0.10	0.20	—	Ti + Zr 0.10		Rem	0.0003	0.05	0.15
ALUMINIUM-SILICON																
R-C355.0	—	—	4.5–5.5	0.20	1.0–1.5	0.10	0.40–0.6	—	0.10	—	0.20	—	Rem	—	0.05	0.15
R-A356.0	—	—	6.5–7.5	0.20	0.20	0.10	0.25–0.45	—	0.10	—	0.20	—	Rem	—	0.05	0.15
R-357.0	—	—	6.5–7.5	0.15	0.05	0.03	0.45–0.6	—	0.05	—	0.20	—	Rem	—	0.05	0.15
R-A357.0	—	—	6.5–7.5	0.20	0.20	0.10	0.40–0.7	—	0.10	—	0.04–0.20	—	Rem	0.04–0.07	0.05	0.15
ER4009, R4009	Al 4009	AlSi5Cu1Mg	4.5–5.5	0.20	1.0–1.5	0.10	0.45–0.6	—	0.10	—	0.20	—	Rem	0.0003	0.05	0.15
ER4010, R4010	Al 4010	AlSi7Mg	6.5–7.5	0.20	0.20	0.10	0.30–0.45	—	0.10	—	0.20	—	Rem	0.0003	0.05	0.15
R4011	Al 4011	AlSi7Mg0,5Ti	6.5–7.5	0.20	0.20	0.10	0.45–0.7	—	0.10	—	0.04–0.20	—	Rem	0.04–0.07	0.05	0.15
ER4018, R4018	Al 4018	AlSi7Mg	6.5–7.5	0.20	0.05	0.10	0.50–0.8	—	0.10	—	0.20	—	Rem	0.0003	0.05	0.15

(Continued)

Table 1 (Continued)
Symbols and Chemical Composition Requirements for Electrodes and Rods

Alloy Symbol			Chemical Composition in Weight Percent[a]													
AWS Classification	ISO 18273 Chemical Composition Symbols		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ga, V	Ti	Zr	Al (minimum)	Be[b]	Other each	Other total
ER4043, R4043	Al 4043	AlSi5	4.5–6.0	0.8	0.30	0.05	0.05	—	0.10	—	0.20	—	Rem	0.0003	0.05	0.15
ER4043A, R4043A	Al 4043A	AlSi5(A)	4.5–6.0	0.6	0.30	0.15	0.20	—	0.10	—	0.15	—	Rem	0.0003	0.05	0.15
ER4046, R4046	Al 4046	AlSi10Mg	9.0–11.0	0.50	0.03	0.40	0.20–0.50	—	0.10	—	0.15	—	Rem	0.0003	0.05	0.15
ER4047, R4047	Al 4047	AlSi12	11.0–13.0	0.8	0.30	0.15	0.10	—	0.20	—	—	—	Rem	0.0003	0.05	0.15
ER4047A, R4047A	Al 4047A	AlSi12(A)	11.0–13.0	0.6	0.30	0.15	0.10	—	0.20	—	0.15	—	Rem	0.0003	0.05	0.15
ER4145, R4145	Al 4145	AlSi10Cu4	9.3–10.7	0.8	3.3–4.7	0.15	0.15	0.15	0.20	—	—	—	Rem	0.0003	0.05	0.15
ER4643, R4643	Al 4643	AlSi4Mg	3.6–4.6	0.8	0.10	0.05	0.10–0.30	—	0.10	—	0.15	—	Rem	0.0003	0.05	0.15
ER4943, R4943	Al 4943	AlSi5Mg	5.0–6.0	0.40	0.10	0.05	0.10–0.50	—	0.10	—	0.15	—	Rem	0.0003	0.05	0.15
ALUMINIUM-MAGNESIUM																
ER5087, R5087	Al 5087	AlMg4,5MnZr*(A)*	0.25	0.40	0.05	0.7–1.1	4.5–5.2	0.05–0.25	0.25	—	0.15	0.10–0.20	Rem	0.0003	0.05	0.15
ER5183, R5183	Al 5183	AlMg4,5Mn0,7(A)	0.40	0.40	0.10	0.50–1.0	4.3–5.2	0.05–0.25	0.25	—	0.15	—	Rem	0.0003	0.05	0.15
ER5183A, R5183A	Al 5183A	AlMg4,5Mn0,7	0.40	0.40	0.10	0.50–1.0	4.3–5.2	0.05–0.25	0.25	—	0.15	—	Rem	0.0005	0.05	0.15
ER5187, R5187	Al 5187	AlMg4,5MnZr	0.25	0.40	0.05	0.7–1.1	4.5–5.2	0.05–0.25	0.25	—	0.15	0.10–0.20	Rem	0.0005	0.05	0.15
ER5249, R5249	Al 5249	AlMg2Mn0,8Zr	0.25	0.40	0.05	0.50–1.1	1.6–2.5	0.30	0.20	—	0.15	0.10–0.20	Rem	0.0003	0.05	0.15
ER5356, R5356	Al 5356	AlMg5Cr(A)	0.25	0.40	0.10	0.05–0.20	4.5–5.5	0.05–0.20	0.10	—	0.06–0.20	—	Rem	0.0003	0.05	0.15
ER5356A, R5356A	Al 5356A	AlMg5Cr	0.25	0.40	0.10	0.05–0.20	4.5–5.5	0.05–0.20	0.10	—	0.06–0.20	—	Rem	0.0005	0.05	0.15
ER5554, R5554	Al 5554	AlMg2,7Mn	0.25	0.40	0.10	0.50–1.0	2.4–3.0	0.05–0.20	0.25	—	0.05–0.20	—	Rem	0.0003	0.05	0.15

(Continued)

Table 1 (Continued)
Symbols and Chemical Composition Requirements for Electrodes and Rods

Alloy Symbol			Chemical Composition in Weight Percent[a]													
AWS Classification	ISO 18273 Chemical Composition Symbols		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ga, V	Ti	Zr	Al (minimum)	Be[b]	Other each	Other total
ER5556, R5556	Al 5556	AlMg5Mn1Ti*(A)*	0.25	0.40	0.10	0.50–1.0	4.7–5.5	0.05–0.20	0.25	—	0.05–0.20	—	Rem	0.0003	0.05	0.15
ER5556A, R5556A	Al 5556A	AlMg5Mn*(A)*	0.25	0.40	0.10	0.6–1.0	5.0–5.5	0.05–0.20	0.20	—	0.05–0.20	—	Rem	0.0003	0.05	0.15
ER5556B, R5556B	Al 5556B	AlMg5Mn*1*	0.25	0.40	0.10	0.6–1.0	5.0–5.5	0.05–0.20	0.20	—	0.05–0.20	—	Rem	0.0005	0.05	0.15
ER5556C, R5556C	Al 5556C	AlMg5Mn1Ti	0.25	0.40	0.10	0.50–1.0	4.7–5.5	0.05–0.20	0.25	—	0.05–0.20	—	Rem	0.0005	0.05	0.15
ER5654, R5654	Al 5654	AlMg3,5Ti*(A)*	Si + Fe 0.45	Si + Fe 0.45	0.05	0.01	3.1–3.9	0.15–0.35	0.20	—	0.05–0.15	—	Rem	0.0003	0.05	0.15
ER5654A, R5654A	Al 5654A	AlMg3,5Ti	Si + Fe 0.45	Si + Fe 0.45	0.05	0.01	3.1–3.9	0.15–0.35	0.20	—	0.05–0.15	—	Rem	0.0005	0.05	0.15
ER5754, R5754	Al 5754[d]	AlMg3	0.40	0.40	0.10	0.50	2.6–3.6	0.30	0.20	—	0.15	—	Rem	0.0003	0.05	0.15
GENERAL																
ERG, RG	—	—	*Chemical composition as agreed upon between supplier and user*													

[a] Single values shown in the table are maximum values, except for Al, which is a minimum. The results shall be rounded as specified in Clause 6.

[b] Metal containing greater than 0.0003% Be is typically not used as an electrode.

[c] For R-206.0, Ni = 0.05 max. and Sn = 0.05 max.

[d] Alloy Al 5754 also limits the sum (Mn + Cr): 0.10 to 0.6.

Table 2
Required Tests[a]

AWS Classification	Chemical Analysis	Soundness and Usability Test (Electrode) See 9.3 and Figure 2	*Weld Metal Tensile Test (Electrode) See 9.4 and Figure 3*	Bead-on-Plate Test (Rod) See 9.5
ER1070	X	X	*X*	—
R1070	X	—	—	X
ER1080A	X	X	*X*	—
R1080A	X	—	—	X
ER1100	X	X	*X*	—
R1100	X	—	—	X
ER1188	X	X	*X*	—
R1188	X	—	—	X
ER1200	X	X	*X*	—
R1200	X	—	—	X
ER1450	X	X	*X*	—
R1450	X	—	—	X
ER2319	X	X	*X*	—
R2319	X	—	—	X
ER3103	X	X	*X*	—
R3103	X	—	—	X
ER4009	X	X	*X*	—
R4009	X	—	—	X
ER4010	X	X	*X*	—
R4010	X	—	—	X
R4011	X	—	—	X
ER4018	X	X	*X*	—
R4018	X	—	—	X
ER4043	X	X	*X*	—
R4043	X	—	—	X
ER4043A	X	X	*X*	—
R4043A	X	—	—	X
ER4046	X	X	*X*	—
R4046	X	—	—	X
ER4047	X	X	*X*	—
R4047	X	—	—	X
ER4145	X	X	*X*	—
R4145	X	—	—	X
ER4643	X	X	*X*	—
R4643	*X*	—	—	*X*
ER4943	X	X	*X*	—
R4943	X	—	—	X
ER5087	X	X	*X*	—
R5087	X	—	—	X
ER5183	X	X	*X*	—
R5183	X	—	—	X
ER5183A	X	X	*X*	—
R5183A	X	—	—	X
ER5187	X	X	*X*	—
R5187	X	—	—	X
ER5249	X	X	*X*	—
R5249	X	—	—	X
ER5356	X	X	*X*	—
R5356	X	—	—	X
ER5356A	X	X	*X*	—
R5356A	X	—	—	X
ER5554	X	X	*X*	—
R5554	X	—	—	X
ER5556	X	X	*X*	—

(Continued)

Table 2 (Continued)
Required Tests[a]

AWS Classification	Chemical Analysis	Soundness and Usability Test (Electrode) See 9.3 and Figure 2	*Weld Metal Tensile Test (Electrode) See 9.4 and Figure 3*	Bead-on-Plate Test (Rod) See 9.5
R5556	X	—	—	X
ER5556A	X	X	*X*	—
R5556A	X	—	—	X
ER5556B	X	X	*X*	—
R5556B	X	—	—	X
ER5556C	X	X	*X*	—
R5556C	X	—	—	X
ER5654	X	X	*X*	—
R5654	X	—	—	X
ER5654A	X	X	*X*	—
R5654A	X	—	—	X
ER5754	X	X	*X*	—
R5754	X	—	—	X
R-206.0	X	—	—	X
R-C355.0	X	—	—	X
R-A356.0	X	—	—	X
R-357.0	X	—	—	X
R-A357.0	X	—	—	X
ERG	*X*	*X*	*X*	—
RG	*X*	—	—	*X*

[a] Filler metal meeting the classification requirements when tested as an electrode is not required to be tested as a rod, as specified in 9.2.

Table 3
Base Metal for Soundness and Usability Testing

Electrode and Rod (AWS Classification)	Base Metal
ER1070, R1070, ER1080A, R1080A, ER1100, R1100, ER1188, R1188, ER1200, R1200, ER1450, R1450	1060, 1100, 1350, or 3003
ER2319, R2319, ER4145, R4145	2014, 2219,3003, 6005 or 6061
ER4009, R4009, ER4010, R4010,R4011, ER4018, R4018, ER4043, R4043, ER4043A, R4043A, ER4046, R4046, ER4047, R4047, ER4047A, R4047A, ER4643, R4643, ER4943, R4943, ER3103, R3103	3003, 6005 or 6061
ER5087, R5087, ER5183, R5183, ER5183A, R5183A, ER5187, R5187, ER5249, R5249, ER5356, R5356, ER5356A, R5356A, ER5554, R5554, ER5556, R5556, ER5556A, R5556A, ER5556B, R5556B, ER5556C, R5556C, ER5654, R5654, ER5654A, R5654A, ER5754, R5754	3004, 5052, 5083, 5086, 5154, 5454, 5456, 6005 or 6061
R-206.0	206.0, 2014, 2219, 3003, 6005 or 6061
R-C355.0	355.0, C355.0, 3003, 6005 or 6061
R-A356.0, R357.0, R-A357.0	356.0, A356.0, 357.0, A357.0, 3003, 6005 or 6061

All wrought base alloys 1060, 1100, 2014, 2219, 3003, 3004, 5052, 5083, 5086, 5154, 5454, 6005, and 6061 are included in ASTM B 209. Cast base alloys 355.0, C355.0, 356.0, A356.0, 357.0, and A357.0 are included in ASTM B 108.

Table 4
Welding Parameters for Groove Weld Mechanical Testing

Standard Size[a]	*0.047 in [1.2 mm]*	*0.062 in [1.6 mm]*
Shielding Gas	*100% Ar*	*100% Ar*
Wire Feed Speed	*300 to 650 in/min [125 to 275 mm/sec]*	*150 to 350 in/min [65 to 150 mm/sec]*
Arc Voltage	*23 V to 28 V*	*23 V to 29 V*
Resulting Current, DCEP (DCEP = Electrode Positive)	*200 A to 300 A*	*200 A to 350 A*
Contact tip-to-work distance	*5/8 in to 7/8 in [16 mm to 22 mm]*	*3/4 in to 1 in [19 mm to 25 mm]*
Travel Speed	*20 in/min to 35 in/min [8.5 mm/sec to 15 mm/sec]*	*20 in/min to 35 in/min [8.5 mm/sec to 15 mm/sec]*

[a] *If sizes other than 0.047 in and 0.062 in [1.2 mm and 1.6 mm] are tested, wire feed speed (and resulting current), arc voltage, and tip-to-work distance shall be changed to follow the manufacturer's recommended settings.*

Table 5
Mechanical Testing Requirements[a]

AWS Classification	Tensile Strength, minimum (ksi) [MPa][c]	Yield Strength (ksi) [MPa][b]	Percent Elongation[b]
ER1100	11 [75]	Not specified	Not specified
R1100	11 [75]	Not specified	Not specified
ER2319	35 [240]	Not specified	Not specified
R2319	35 [240]	Not specified	Not specified
ER4043	24 [165]	Not specified	Not specified
R4043	24 [165]	Not specified	Not specified
ER4047	25 [170]	Not specified	Not specified
R4047	25 [170]	Not specified	Not specified
ER4145	40 [275]	Not specified	Not specified
R4145	40 [275]	Not specified	Not specified
ER4943	30 [205]	Not specified	Not specified
R4943	30 [205]	Not specified	Not specified
ER5183	40 [275]	Not specified	Not specified
R5183	40 [275]	Not specified	Not specified
ER5356	35 [240]	Not specified	Not specified
R5356	35 [240]	Not specified	Not specified
ER5554	31 [215]	Not specified	Not specified
R5554	31 [215]	Not specified	Not specified
ER5556	42 [290]	Not specified	Not specified
R5556	42 [290]	Not specified	Not specified
ER5654	30 [205]	Not specified	Not specified
R5654	30 [205]	Not specified	Not specified

[a] *Listed classification must meet the minimum tensile strength shown. For all other classifications, tensile testing is required to be reported, but minimum requirements have not yet been established for those classifications. As additional data is made available, alloys will be added to this table. Inclusion in this table may be necessary for use in some design codes.*
[b] *The Yield Strength and Percent Elongation shall be tested and reported on the test certificate.*
[c] *The minimum tensile strength of R classifications is addressed by the testing requirements of the same ER classification as prescribed in Table 2.*

Table 6
Typical Sizes of Flattened Rods

Equivalent Round Diameter		Thickness		Width	
in	mm	in	mm	in	mm
1/16	1.6	0.047	1.2	0.072	1.8
—	2.0	—	1.5	—	2.1
3/32	2.4	0.070	1.8	0.105	2.7
—	2.5	—	1.9	—	2.6
1/8	3.2	0.095	2.4	0.142	3.6
5/32	4.0	0.115	2.9	0.175	4.4
3/16	4.8	0.140	3.6	0.210	5.0
—	5.0	—	3.8	—	5.2
1/4	6.4	0.187	4.8	0.280	7.1

Note:
1. Standard length is 36 in, +0, -1/2 in [914 mm +0, -13 mm]. Custom lengths and applicable tolerances shall be as agreed by purchaser and supplier.

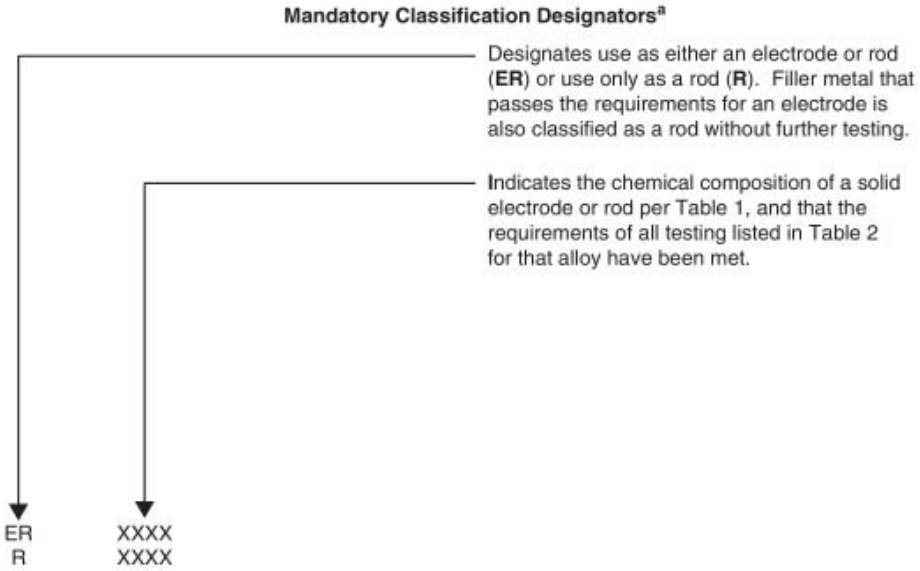
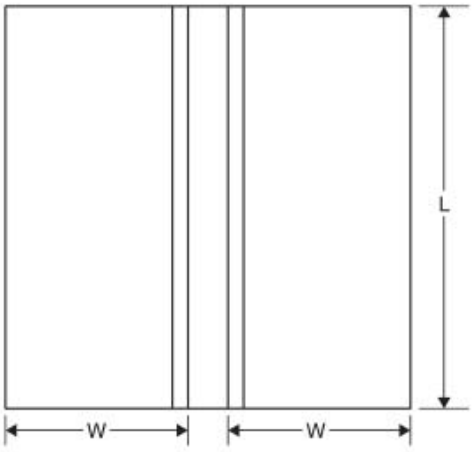
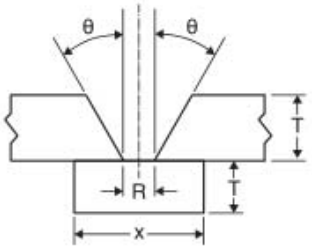


Figure 1—A5.10/A5.10M Classification System



(A) TOP VIEW



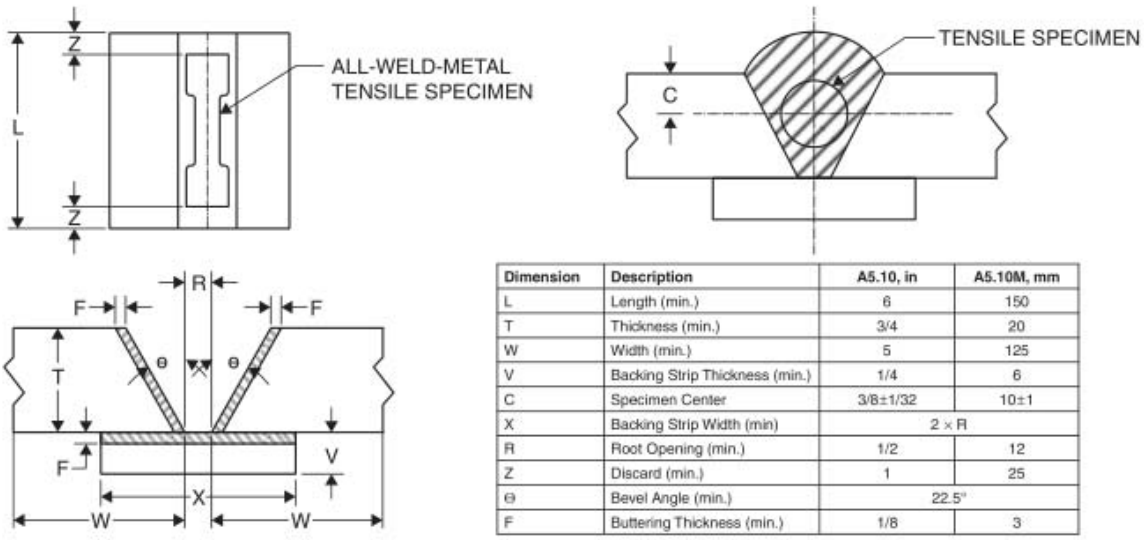
(B) SIDE VIEW

Electrode Diameter		Welding Position	Plate Thickness (T)[a]		Nominal Root Opening (R)	Length (L), min.	Width (W), typical	Bevel Angle (Θ)	Backing Width (X), min.
in	mm		in	mm	in [mm]	in [mm]	in [mm]	degrees	in [mm]
0.030	—	Overhead	3/16 or 1/4	5 or 6	1/4 [6]	10 [250]	5 [125]	30–35	1 [25]
—	0.8								
0.035	—								
—	0.9								
—	1.0	Overhead	1/4	6	1/4 [6]	10 [250]	5 [125]	30–35	1 [25]
3/64	1.2								
1/16	1.6	Overhead	3/8	10	3/8 [10]	10 [250]	5 [125]	30–35	1 [25]
—	2.0								
3/32	2.4	Flat	3/8	10	3/8 [10]	10 [250]	5 [125]	30–35	1 [25]
—	2.5								
1/8	3.2	Flat	3/8	10	1/2 [13]	10 [250]	5 [125]	30–35	1 [25]

[a] A variation of ±5 percent in the specified plate thickness is acceptable

Notes: 1) Assembly shall be welded employing the gas metal arc welding process.
2) Assembly may be machined or extruded as a single piece if the minimum dimensions shown are maintained for the specific electrode diameter being tested.

Figure 2—Groove Weld Test Assembly for Radiographic Test



Dimension	Description	A5.10, in	A5.10M, mm
L	Length (min.)	6	150
T	Thickness (min.)	3/4	20
W	Width (min.)	5	125
V	Backing Strip Thickness (min.)	1/4	6
C	Specimen Center	3/8±1/32	10±1
X	Backing Strip Width (min)	2 × R	
R	Root Opening (min.)	1/2	12
Z	Discard (min.)	1	25
θ	Bevel Angle (min.)	22.5°	
F	Buttering Thickness (min.)	1/8	3

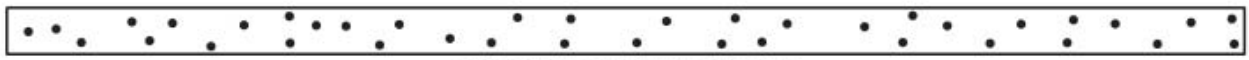
Figure 3—Groove Weld Test Assembly for Weld Metal Tension Properties

ASSORTED ROUNDED INDICATIONS

SIZE PERMITTED is 0.050 in [1.3 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 29 with the following restrictions:
LARGE (up to 0.050 in [1.3 mm])—6 permitted
MEDIUM (up to 0.030 in [0.8 mm])—5 permitted
SMALL (up to 0.020 in [0.5 mm])—18 permitted

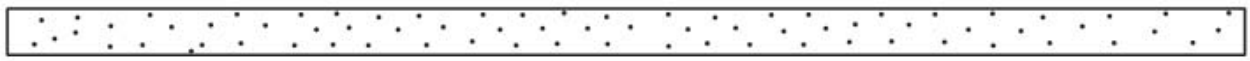
LARGE ROUNDED INDICATIONS

SIZE PERMITTED is 0.050 in [1.3 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 8



MEDIUM ROUNDED INDICATIONS

SIZE PERMITTED is 0.030 in [0.8 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 39

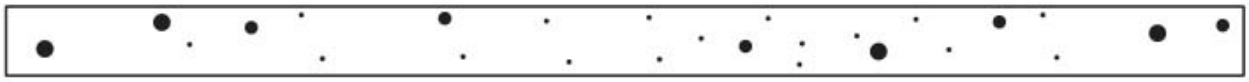


SMALL ROUNDED INDICATIONS

SIZE PERMITTED is 0.020 in [0.5 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 72

Notes:
1. In using these standards, the chart that is most representative of the size of the rounded indications present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.
2. Indications which do not exceed 1/64 in [0.4 mm] diameter or length, or both, shall be disregarded.
3. Total area of porosity in a 6 in [150 mm] length of weld is 0.0225 sq in [14.52 sq mm] based on 1.5% T per in [25 mm] where T is the base metal thickness.

Figure 4A—Radiographic Acceptance Standards for 3/16 in [5 mm] and 1/4 in [6 mm] Thick Test Assemblies—Overhead Welding Position

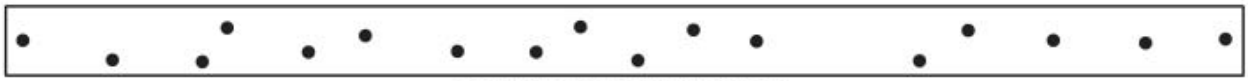


ASSORTED ROUNDED INDICATIONS

SIZE PERMITTED is 0.075 in [1.9 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 26 with the following restrictions:
LARGE (up to 0.075 in [1.9 mm])—4 permitted
MEDIUM (up to 0.050 in [1.3 mm])—5 permitted
SMALL (up to 0.020 in [0.5 mm])—17 permitted

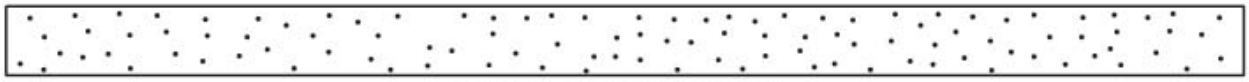
LARGE ROUNDED INDICATIONS

SIZE PERMITTED is 0.075 in [1.9 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 6



MEDIUM ROUNDED INDICATIONS

SIZE PERMITTED is 0.050 in [1.3 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 17

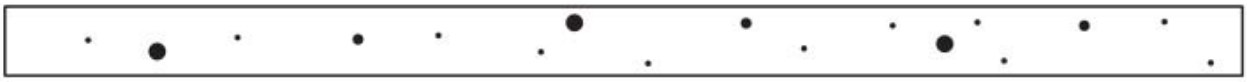


SMALL ROUNDED INDICATIONS

SIZE PERMITTED is 0.020 in [0.5 mm] maximum
NUMBER PERMITTED in any 6 in [150 mm] of weld is 108

Notes:
1. In using these standards, the chart that is most representative of the size of the rounded indications present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.
2. Indications which do not exceed 1/64 in [0.4 mm] diameter or length, or both, shall be disregarded.
3. Total area of porosity in a 6 in [150 mm] length of weld is 0.0337 sq in [21.7 sq mm] based on 1.5 percent T per in [25 mm] where T is the base metal thickness.

Figure 4B—Radiographic Acceptance Standards for 3/8 in [10 mm] Thick Test Assemblies—Overhead Welding Position



ASSORTED ROUNDED INDICATIONS

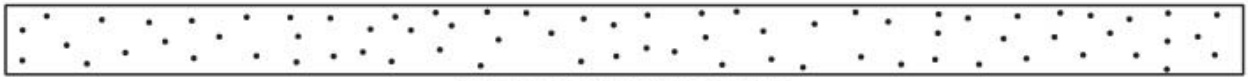
SIZE PERMITTED IS 0.075 in [1.9 mm] MAXIMUM
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 17 WITH THE FOLLOWING RESTRICTIONS:
LARGE: UP TO 0.075 in [1.9 mm]—3 PERMITTED
MEDIUM: UP TO 0.049 in [1.3 mm]—3 PERMITTED
SMALL: UP TO 0.020 in [0.5 mm]—11 PERMITTED
11 PERMITTED

LARGE ROUNDED INDICATIONS

SIZE PERMITTED IS 0.075 in [1.9 mm] MAXIMUM
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 5

MEDIUM ROUNDED INDICATIONS

SIZE PERMITTED IS 0.049 in [1.3 mm] MAXIMUM
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 11



SMALL ROUNDED INDICATIONS

SIZE PERMITTED IS 0.020 in [0.5 mm] MAXIMUM
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 72

Notes:
1. In using these standards, the chart that is most representative of the size of the rounded indications present in the test specimen radiograph shall be used for determining conformance to these radiographic standards.
2. Indications which do not exceed 1/64 in [0.4 mm] diameter or length, or both, shall be disregarded.
3. Total area of porosity in a 6 in [150 mm] length of weld is 0.0225 sq in [14.52 sq mm] based upon 1.0% T per in [25 mm] where T is the base metal thickness.

This radiographic acceptance standard is identical to that previously incorporated in MIL-E-16053L (Amendment 2, 20 October 1980) and as Class 1 in NAVSEA 0900-LP-003-9000. (See Annex Clause A5.)

Figure 5—Radiographic Acceptance Standard for Test Assemblies—Flat Welding Position

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Annex A (Informative)
Guide to Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods

This annex is not part of this standard but is included for informational purposes only.

A1. Introduction

The purpose of this guide is to correlate the filler metal classifications with their intended applications so the specification can be used more effectively. Reference to appropriate base metal alloys 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

A2.1 Both welding electrodes and rods are classified based on the chemical composition of the aluminum filler metal, a usability test, and when required a test of weld metal strength. The AWS classifications used in this specification are based as follows:

A2.1.1 The Aluminum Association alloy designation nomenclature is used for the numerical portion to identify the alloy based on chemical composition.

A2.1.2 A letter prefix designates usability of the filler metal. The letter system for identifying the filler metal classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The prefix "E" indicates the filler metal is suitable for use as an electrode and the prefix "R" indicates suitability as welding rod. Since some of these filler metals are used as electrodes in gas metal arc welding, and as welding rods in oxyfuel gas, gas tungsten arc, and plasma arc welding, both letters, "ER," are used to indicate suitability as an electrode or a rod. In all cases, a product which meets the test requirements for an electrode in this specification also meets the requirements for a welding rod. A product that meets the test requirements for a welding rod must also pass the test for an electrode before being classified as an electrode.

A2.1.3 *"G" Classification*

A2.1.3.1 *This specification includes filler metals classified as ERG and RG. The "G" indicates that the filler metal is of a "general" classification. It is general because not all of the particular requirements specified for each of the other classifications are specified for this classification. The intent in establishing this classification is to provide a means by which filler metal that differs in one respect or another (chemical composition, for example) from all other classifications (meaning that the composition of the filler metal—in the case of the example—does not meet the composition specified for any of the classifications in the specification) can still be classified according to the specification. The purpose is to allow a useful filler metal—one that otherwise would have to await a revision of the specification—to be classified immediately, under the existing specification. This means that two filler metals —each bearing the same "G" classification—may be quite different in some certain respect (chemical composition, again, for example).*

A2.1.3.2 *The point of difference between filler metal of a "G" classification and filler metal of a similar classification without the "G" (or even with it, for that matter) may be further clarified from the use of the words "not required" and "not specified" in the specification. The use of these words is as follows:*

Not Required is used in those areas of the specification that specify the tests that must be conducted in order to classify an electrode or rod. It indicates that that test is not required because the results for the particular test are not a requirement for that particular classification. When a test is "not required", it is not necessary to conduct the corresponding test in order to classify an electrode or rod to that classification. When a purchaser wants the information provided by that test in order to consider a particular product of that classification for a certain application, the purchaser will have to arrange for that information with the supplier of the product. The purchaser will have to establish with that supplier just what the testing procedure and the acceptance requirements are to be for that test. The purchaser may want to incorporate that information (via AWS A5.01M/A5.01) in the purchase order.

Not Specified is used in those areas of the specification that refer to the results of some particular test. It indicates that the requirements for that test are not specified for that particular classification. If the required results from a specific test are listed as "not specified" but the test in question is shown as "required" then the test results must be reported.

A2.2 Description of ISO Classification Designations

A2.2.1 The ISO classifications are divided into two parts:

a) the first part indicates the product form being solid wires or rods, see A2.2.2;

b) the second part gives a numerical symbol and optional chemical symbol indicating the chemical composition of the solid wire or rod, see Table 1.

A2.2.2 ISO Symbols for the Product Form The ISO symbol for the solid wire and rod shall be S.

Note: One product form may be used for more than one welding process.

A2.2.3 ISO Designation Examples The ISO designation of solid wires and rods shall follow the principle given in the example below.

EXAMPLE 1 A solid wire (S) for gas metal arc welding (GMAW), having a chemical composition within the limits for the alloy symbol Al 4043 (AlSi5) of Table 1, is designated:

Solid wire ISO 18273 – S Al 4043

or alternatively

Solid wire ISO 18273 – S Al 4043 (AlSi5)

EXAMPLE 2 A solid rod (S) for gas tungsten arc welding is designated

Solid rod ISO 18273 – S Al 4043

or alternatively

Solid rod ISO 18273 – S Al 4043 (AlSi5)

where:

ISO 18273 is the standard number;

S is the product form (see A2.2.2);

Al 4043 is the numerical symbol for the chemical composition of the welding consumable (see Table 1);

AlSi5 is the optional chemical symbol of welding consumable (see Table 1).

A2.3 Request for Filler Metal Classification

(1) When a filler metal cannot be classified other than as a "G" classification, a manufacturer may request that a new classification be established. The manufacturer shall do this using the following procedure:

(2) A request to establish a new filler metal classification must be submitted in writing. The request needs to provide sufficient detail to permit the Committee on Filler Metals and Allied Materials and the relevant Subcommittee to determine whether a new classification or the modification of an existing classification is more appropriate, or if neither is necessary. In particular, the request needs to include:

(a) A declaration that the new classification will be offered for sale commercially.

(b) All classification requirements as given for existing classifications, such as, chemical composition ranges, mechanical property requirements, and usability test requirements.

(c) Any conditions for conducting the tests used to demonstrate that the filler metal meets the classification requirements. (It would be sufficient, for example, to state that welding conditions are the same as for other classifications.)

(d) Information on Descriptions and Intended Use, which parallels that for existing classifications (for that clause of the Annex).

(e) Actual test data for all tests required for classification according to the requirements of the specification for a minimum of two production heats/lots must be provided. In addition, if the specification is silent regarding mechanical properties, test data submitted shall include appropriate weld metal mechanical properties from a minimum of two production heats/lots.

(f) A request for a new classification without the above information will be considered incomplete. The Secretary will return the request to the requester for further information.

(3) In order to comply with the AWS Policy on Patented Items, Trademarks, and Restraint of Trade, if the proposed new classification is patented, if a patent is pending for it, or if there is any intention to apply for a patent, the requester shall disclose this. In these cases, the patent holder must allow the use of this technology, such as by license. The Secretary will provide examples of acceptable wording to the patent holder, as required.

(4) The request should be sent to the Secretary of the Committee on Filler Metals and Allied Materials at AWS Headquarters for processing.

A2.4 Minor changes in procedures used in the manufacture of aluminum filler metals can affect their surface quality and significantly affect the resultant weld soundness. Usability testing of the electrode is desirable on a periodic basis to assure that the product classified in this specification continues to meet the soundness requirement. The supplier should perform the usability tests of this specification on an annual basis, as a minimum, to assure that the specified soundness and operating characteristics criteria are maintained. AWS A5.01M/A5.01, *Welding Consumables – Procurement of Filler Metals and Fluxes,* should be used by a purchaser for definition of lot and frequency of testing references when purchasing aluminum filler metals.

A2.5 Application of Military and Federal Specifications At the time of cancellation (June 7, 1982) of Military Specification MIL-E-16053L, Amendment 2 (October 20, 1980), *Electrodes, Welding, Bare, Aluminum Alloys*, the technical requirements were identical to those of AWS A5.10-80. They both covered the same aluminum alloys, compositions, welding tests, and radiographic standards. The MIL-E-16053L cancellation notice canceled the Qualified Products List QPL-16053 as well as the specification and stated, "Future acquisition of replacement electrodes should be made under ANSI/AWS A5.10-80, *Aluminum and Aluminum-Alloy Bare Welding Rods and Electrodes*."

Federal Specification QQ-R-566B, *Rods and Electrodes, Welding, Aluminum, and Aluminum Alloys*, was technically the same as AWS A5.10 when it was issued July 5, 1973 and was in the process of being updated at the time of the MIL-E-16053L cancellation. On November 29, 1982, Federal Specification QQ-R-566B was also canceled with the recommendation, "The AWS Standard A5.10, latest issue in effect, concerning Aluminum Alloy Bare Welding Rods and Electrodes should be used." Straight length, coiled, and spooled rod and wire for oxyfuel gas and gas tungsten arc welding were included in QQ-R-566B, as well as the spooled electrode for gas metal arc welding. Thus, the total coverage was the same as AWS A5.10.

AWS A5.10/A5.10M is a classification document, which defines tests and acceptance criteria to determine that the product meets the requirements for that classification. These tests need to be repeated only if a significant change is made in the manufacturing process. These tests become a part of the specific procurement only when used in combination with AWS A5.01M/A5.01, which identifies lot classifications, level of testing, and the frequency of tests.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with A5.01M/A5.01, as the specification states. Any additional testing required by the purchaser, for material shipped in accordance with this specification, shall be clearly stated in the purchase order, according to the provisions of A5.01M/A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing the supplier normally conducts on material of that classification, as specified in Schedule F, Table 1, of A5.01M/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 will 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 the requirements of the specification. The only testing requirement implicit in this certification is that the manufacturer has conducted the tests required by the specification on material that is representative of that being shipped and that the 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 made. 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 AWS A5.01M/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 involved

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

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

A5.2 ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, 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 sections of that document covering ventilation and confined spaces. See also AWS F3.2M/F3.2, *Ventilation Guide for Weld Fume,* for more detailed description of ventilation options.

A6. Welding Considerations

The electrodes and rods described in this specification are primarily for use with the inert gas arc welding processes; however, they may be used with other welding processes such as electron beam or oxyfuel gas welding.

A6.1 The gas metal arc welding process permits the successful welding of aluminum alloys that are crack-sensitive when welded by oxyfuel gas or other manual welding processes. The reasons for this might be described briefly as follows:

Distortion is reduced to a minimum because the increase in temperature of the parts being welded is confined to a narrow zone. Because aluminum alloys have high thermal conductivity, the reduction of distortion is greater than would be the case with ferrous base metals. Cracking of welds in the aluminum alloys is reduced if the cooling rate is high. The GMAW process permits the welding of alloys that have a wide melting range, which may be difficult to weld with higher heat input processes.

A6.2 The high melting and solidification rate of the weld metal from the gas metal arc welding process can result in hydrogen gas being entrapped in the welds. Control of this factor should be understood to obtain good results. Hydrogen gas entrapment within the weld metal results from the presence of hydrogen containing substances on the base metal, filler metal, or in the atmosphere immediately adjacent to the weld zone. Hydrocarbons such as grease or oil, hydrocarbon-based cleaning agents, and moisture, whether on a surface or within the stream of shielding gas itself, are all common contributors of hydrogen in the weld. The introduction of hydrogen gas in the weld metal from any of these causes will result in porosity, because the solidification rate is high, and the gas may not have time to escape before the molten metal solidifies. Precautions such as degreasing with acetone should be employed to mitigate the effects of these and other contaminants.

A6.3 Welds can be made in all positions with the gas metal arc welding process. Edge preparation similar to that used for gas tungsten arc welding is satisfactory. Either pure argon or argon/helium mixtures may be used as shielding gas. Semiautomatic welding, in which the welding gun is moved by a welder, may be difficult to control on metal thicknesses below 0.08 in [2 mm]. The use of a pulsed power source permits the welding of base metal as thin as 0.03 in [0.8 mm]. No upper limit on metal thickness has been established for the gas metal arc welding process. Welds in plate up to 8 in [200 mm] in thickness have been made.

A6.4 Gas metal arc welding is typically performed with direct current electrode positive (DCEP). Stabilization of the arc with high frequency current is not required. U-groove drive rolls and polymer gun liners are preferred in both manual and mechanized equipment in order to limit distortion, shaving, and contamination of the filler wire.

A6.5 Gas tungsten arc welds can be made in all positions. Welding travel speed is reduced compared to gas metal arc welding (GMAW), however, this reduction is beneficial in several aspects. The gas tungsten arc welding process is more maneuverable than GMAW for manually welding small tubes or piping; entrapment of gases is minimized to permit production of sound welds; short repair welds can be made more easily; and the reduced concentration of heat allows welding aluminum base metal thicknesses as thin as 0.02 in [0.5 mm] or less. Corner and edge joints in sheet gauges can be made more satisfactorily than with GMAW due to the better control of the filler metal additions.

A6.6 Gas tungsten arc welds are most commonly made with alternating current power and pure argon [AWS A5.32M (ISO 14175) – I1] gas shielding. Helium [AWS A5.32M (ISO 14175) – I2] additions to the extent of 25 percent of the mixture with argon are used to increase the rate of initial melting and the amount of melting in thick base metal. Helium additions of up to 75% can be very effective with square wave AC power sources and with AC frequencies up to 400 Hz. Pure tungsten (AWS A5.12M/A5.12 Class EWP) or zirconiated tungsten (AWS A5.12M/A5.12 Class EWZr-1) electrodes are preferred for AC-GTAW when using transformer or magnetic amplification power sources while ceriated (AWS A5.12M/A5.12 Class EWCe) and lanthanated (AWS A5.12M/A5.12 Class EWLa) tungsten electrodes with sharpened and truncated tips are preferred when using modern inverter power sources. The positive electrode polarity of the AC power provides an arc etching action to remove the surface oxide; however, thick aluminum oxides caused by weathering, thermal treatments, or anodic treatments need to be reduced by chemical or mechanical means prior to welding to obtain uniform results and proper fusion. As stated in A6.2, sources of hydrogen, such as moisture on the base or filler metals or in the gas shielding and residual hydrocarbons on the base or filler metals, must be removed to avoid porosity in the welds.

A6.7 Direct current power can also be used to gas tungsten arc weld aluminum. DCEP power can technically be used to weld sheet gauges; however, a 1/4 in [6.4 mm] diameter tungsten electrode is required to carry the 125 amperes needed to weld 1/8 in [3 mm] thickness, so this polarity is seldom used. DCEN power is used with helium (AWS A5.32 (ISO 14175) – I2) gas shielding and a thoriated, ceriated, or lanthanated tungsten electrode for welding aluminum-base alloys. This electrode negative polarity provides a deep, narrow melting pattern, which is advantageous for repair of thick weldments or castings and for increased welding speeds in all thicknesses. Higher as-welded strength is obtained with DCEN-GTAW welds in the heat treatable aluminum alloys due to the reduced heat input compared to AC-GTAW. Since no arc cleaning action occurs in the DCEN arc, special attention must be given to minimizing the oxide thickness immediately before welding, such as by mechanical scraping or arc cleaning all base metal surfaces within the fusion zone.

Additional information may be found in the aluminum chapter of the AWS Welding Handbook, Volume 5, Ninth Edition.

A7. Filler Metal Selection, Typical Usage, Cleanliness, Storage, and Handling of Aluminum Filler Metal

A7.1 Filler Metal Selection There are many aluminum base metals that can be welded successfully with any number of different filler metals. The base metal 6061-T6 for instance, is commonly welded with at least four different filler metals and can be welded successfully with even more. It is not possible to select, with any certainty, the most appropriate filler metal for a specific base metal without an understanding of the welded component application and expected performance in service. When choosing an aluminum filler metal, it is important to determine which of the criteria associated with weld performance are of most importance. The selection of a filler metal that is not recommended for a specific application may result in inadequate service performance and possibly premature failure of the welded joint. Filler metals for arc welding aluminum are often evaluated against the following criteria:

Strength of welded joint – Consideration of the tensile strength of groove welds and shear strength of fillet welds, when welded with different filler metals, can prove to be extremely important during welding design. Different filler metals, which may both exceed the as-welded tensile strength of the base material, can be significantly different in shear strength performance.

Crack Sensitivity – This is the relative freedom from weld cracking. By use of hot cracking sensitivity curves for the various aluminum alloys, and through the consideration of dilution between filler metal and base metal, a filler metal / base metal crack sensitivity rating can be established.

Ductility – This may be a consideration if forming operations are to be used during fabrication. Also, testing procedures for guided bend testing may vary based upon filler metal ductility.

Corrosion Resistance – A consideration for some environmental conditions is typically based on exposure to fresh and salt water.

Sustained Temperature Services – Some filler metals at sustained elevated temperature (above 150 deg. F) may promote premature component failure due to stress corrosion cracking.

Color Match – Base metal and filler metal color match after anodizing can be of major concern in some cosmetic applications.

As an example of the extent and complexity of this situation, we can take one of the many aluminum base metals and three of the many applications in which this base material may be used. If we consider the base metal 6061-T6, and its use in the following different applications, we can appreciate that the filler metal that we select for welding can seriously affect the welded component's performance.

Application 1. Using 6061-T6 extruded angle bar as a welded attachment bracket for a heating component that will be operating consistently at 250 deg. F.

In this application we would investigate those filler alloys that are suitable for elevated temperature service. We may consider 5554, 4043, 4943, or 4047 filler alloys, which are all suitable for elevated temperature service applications. If we were to use the 5356, 5183, or 5556 filler alloys, which are often shown as being suitable for this base material, we would introduce the possibility of sensitization of the magnesium in these alloys and run the risk of stress corrosion cracking and premature failure of the welded component.

Application 2. Using 6061-T6 base metal to fabricate a large safety-critical lifting device that is required to undergo extensive welding during fabrication, followed by post-weld solution heat treatment and artificial aging to restore strength and return the structure to the -T6 temper.

In this application our concerns may be the strength of our weld after it has been exposed to post-weld heat treatment. Most filler metals commonly used for welding this base material will not respond favorably to this type of heat treatment. The 5356, 5183, and 5556 filler alloys are non-heat treatable alloys which can undergo undesirable changes if subjected to this form of heat treatment. 4043 filler metal, on its own, is non-heat treatable and would be dependent on dilution with the base material to achieve any significant response to the heat treatment. In this application we should seriously consider the use of filler metals 4943, or 4643, which are both heat treatable filler metals and will, therefore, respond to the heat treatment after welding and provide a weld of comparable strength to that of the base material in the -T6 temper.

Application 3. Using 6061-T6 tubing for hand railing that is to be clear coat anodized after welding. In this application we must select the filler metal that is going to provide us with the best color match after anodizing. With color match as our prime consideration, the most appropriate filler for this application is 5356. If we were to select filler metal 4043, 4943, or 4047, which are often shown as being suitable for this base material, we would find that after anodizing, our weld would become dark gray in color and would not provide a suitable match to the bright silver appearance of the hand rail tubing.

A7.2 Using the Filler Metal Selection Chart (Table A.1 and Table A.2). By using Table A.1 Weld Metal Properties, and Table A.2 Aluminum Filler Metal Selection Chart, each of the weld metal attributes specific to an application can be evaluated to establish the most suitable filler metal. These charts have been developed through consideration of the most commonly required attributes and provide a relative rating system for each attribute to help with the selection process. In the absence of specific information, consultation with the material supplier is recommended.

Filler metal property ratings A, B, C, D and E are relative values for an attribute when welding the base metals that intersect in a specific box. For example, in the strength column an "A" rating designates the highest strength and an "E" rating the lowest strength that matches or exceeds that of the lower strength base metal listed. While an E rating may be suitable for a specific attribute, an A, B, or C, rating may be a better choice if that factor being evaluated is of prime importance. A "blank" rating indicates that the filler metal is not recommended for that specific weldment application property. All ratings listed are in the as welded condition. Ratings have comparative meaning within a single box only. For example, an "A" rating in one box does not have any comparative value to an "A" rating in another box.

A7.3 Typical Usage Filler metal in the form of straight lengths and coils without support is used as welding rod with several welding processes. These processes include oxyfuel gas welding, plasma arc welding, gas tungsten arc welding, and laser welding. The filler metal may be fed by hand, although mechanized welding in these processes may involve either manual feeding of the welding rod or use of a feeding mechanism for wire. Spooled filler metal is used most commonly as electrode for the gas metal arc welding process. It also is used as filler wire when mechanized feeding systems are employed for gas tungsten arc welding, plasma-arc welding and other processes. Finite lengths of filler metal can be removed from the spools for use as a high-quality, handfed filler rod with manual gas tungsten arc welding, plasma-arc welding, or oxyfuel gas welding processes.

A7.4 Cleanliness, Storage, and Handling of Aluminum Filler Metal The cleanliness and minimal surface oxidation of the filler metal are important with all welding processes. Oil, or other organic materials, as well as a heavy oxide film on the rod, will interfere with coalescence of the weld and are sources of porosity. Because of this, it is necessary to clean the welding rod and electrode before packaging.

Proper storage of welding rods and electrodes is essential to avoid contamination that may affect their performance. Packages of filler metal should not be left outdoors or in unheated buildings, because the greater variations in temperature and humidity increase the possibility of condensation to create hydrated surface oxides. Experience has demonstrated that undesirable storage conditions may adversely affect filler metal performance. Investigation of the effect of storage time on electrode performance indicates that packaged electrodes stored under good conditions (dry places in heated buildings) are satisfactory after extended storage.

A8. Special Tests

It is recognized that supplementary tests may be required for certain applications of aluminum and aluminum-alloy filler metals. In such cases, tests to determine specific properties such as corrosion resistance, mechanical properties at high and low temperature, wear resistance and suitability for welding combinations of dissimilar metals may be required. AWS A5.01M/A5.01 contains provisions for ordering such tests. This clause is included for the guidance of those who desire to specify such special tests. Those tests may be conducted as agreed upon between the purchaser and supplier.

A9. Chemical Analysis

The most widely used method for chemical analysis has been ASTM E227, *Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloy by the Point-to-Plane Technique (now withdrawn).* Other established analytical methods are acceptable. The ASTM E227 method analyzes a bulk sample and all elements simultaneously. The ASTM E34 standard method prescribes individual test methods for which each element is tested. The ASTM E34 test methods are used as referee methods if a dispute arises concerning a specific element analysis.

A10. Discontinued and Replaced Alloys

Classifications of bare aluminum and aluminum-alloy welding electrodes and rods have been discontinued and/or replaced as new editions of A5.10/A5.10M have been issued. These classifications are listed in Table A.3.

A11. General Safety Considerations

A11.1 Safety issues and concerns are addressed in this standard, although health issues and concerns are beyond the scope of this standard. Some safety and health information can be *found* in Clause A5. Safety and health information is

available from other sources including, but not limited to, Safety and Health Fact Sheets, ANSI Z49.1, and applicable federal and state regulations.

A11.2 Safety and Health Fact Sheets. Safety and Health Fact Sheets are published by the American Welding Society (AWS). They may be downloaded and printed directly from the AWS website at http://www.aws.org. The Safety and Health Fact Sheets are revised and additional sheets added periodically.

Table A.1
Weld Metal Properties – (To be used in conjunction with Table A.2)

STRENGTH

Strength ratings are for fillet weld and groove weld strength in the as welded condition.
Groove welds – Any specified filler metal with a rating can provide minimum transverse tensile strength in groove welds that will meet the as-welded strength of the base material. Any filler metal with no rating (blank rating) will typically not meet the minimum tensile strength.
Fillet welds – Ratings provided are for fillet weld shear strength.
See note under Table A.2 for additional information for 5XXX series strength ratings.

CRACK SENSITIVITY – The probability of hot cracking.
This rating is established through use of crack sensitivity curves and the consideration of filler metal and base metal chemical composition combinations. There are levels of various alloying elements within aluminum that have been identified as seriously affecting hot cracking susceptibility during weld solidification. This rating is primarily based on the probability of producing a cracked weld. An "A" rating will provide the lowest probability of solidification cracking.

DUCTILITY

This rating may be of consideration if forming operations are to be used on a completed weldment during fabrication.
Note: Testing procedure requirements for guided bend tests may need to be adjusted to accommodate the varying ductility of filler metals (guidelines for this are given in the welding code).

CORROSION RESISTANCE

This rating may be a consideration for some environmental conditions. The rating is based on exposure to fresh and salt water environments and is not associated with a specific chemical exposure. It gives an indication as to the possibility of galvanic corrosion due to the difference in the electrode potential between the base metal and the filler metal.

ELEVATED TEMPERATURE SERVICE

This rating is based on the reaction of some filler metals when exposed to sustained elevated temperature: 150ºF to 350ºF (66ºC to 180ºC). If 5xxx series base metal or filler metal with more than 3% magnesium content are subjected to prolonged exposure to these temperatures, precipitate can form within them that is highly anodic to the aluminum-magnesium matrix. It is this continuous grain boundary network of precipitate that produces susceptibility to stress corrosion cracking (SCC) and the potential for premature component failure.

COLOR MATCH AFTER ANODIZING

Base metal and filler metal color match after post-weld anodizing can be of major concern in some cosmetic applications. Some filler metals closely match the base metal color after anodizing and others will react to the anodizing process by changing to a color very different to that of the base metal.

Table A.2
Aluminum Filler Metal Selection Chart

BASE METAL →	Pure Aluminum						Al – Cu												Al – Mn												Al – Mg																		FILLER METAL ↓
	1100, 1060, 1070, 1080, 1350						2014, 2036						2219						3003, Alclad 3003						3004, Alclad 3004						5005, 5050, 5052, 5652						5083, 5086, 5456, 5383						511.0, 512.0, 513.0, 514.0, 535.0, 5154, 5254						
	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	
319.0, 333.0, 354.0, 355.0, C355.0, 380.0							A	B	A	A	A	A	A	B	A	A	A	A																															2319
	C	B	A	A	A	A	D	C	B	C	A	A	D	C	B	C	A	A	C	B	A	A	A	A	C	B	A	A	A	A	B	A	A	A	A	A													4043
	A	A	B	A	A	A	B	A	C	B	A	A	B	A	C	B	A	A	A	A	B	A	A	A	A	A	B	A	A	A																			4145
	B	B	A	A	A	A	C	C	B	C	A	A	C	C	B	C	A	A	B	B	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A													4943
413.0, 443.0, 444.0, 356.0, A356.0, 357.0, 359.0	C	A	A	A	A	A	C	B	A	A	A	A	C	B	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	C	A	A	A	A	A													4043
	A	A	B	B	A		A	A	B	A	A		A	A	B	A	A																																4145
	B	A	A	A	A	A	B	B	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	A	A	A													4943
																																																	A356.0
																																																	A357.0
																															A	B	B	B		A													5356
7005, 7021, 7039, 7046, 7146, 710.0, 711.0	D	A	C	A	A		C	B	A	A	A		C	B	A	A	A		D	A	C	A	A		D	A	C	B	A		D	B	C	B	A														4043
							A	A	B	A	A		A	A	B	A	A																																4145
	C	A	C	A	A		B	B	A	A	A		B	B	A	A	A		C	A	C	A	A		C	A	C	B	A		C	B	C	B	A														4943
	A	B	B	A	A														A	B	B	A		A	A	B	B	A		A	A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	5183
	B	B	A	A	A														B	B	A	A		A	B	B	A	A		A	B	A	A	A		A	B	A	A	A		A	B	A	A	A		A	5356
																									C	C	A	A	A	A	C	B	A	A	A	A							C	B	A	A		A	5554
	A	B	B	A	A														A	B	B	A		A	A	B	B	A		A	A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	5556
																									C	C	A	A		B	C	B	A	A		A							C	B	A	A		A	5654
6061, 6005, 6063, 6070, 6151, 6201, 6351, 6951, 6082	E	A	C	A	A		B	B	A	A	A		B	B	A	A	A		E	A	C	A	A		E	A	C	A	A		E	A	C	A	A														4043
	C	A	D	B	A		A	A	B	A	A		A	A	B	A	A		C	A	D	B	A		C	B	D	B	A																				4145
	D	A	C	A	A														D	A	C	A	A		D	A	C	A	A		D	A	C	A	A														4943
	A	B	B		A														A	B	B			A	A	B	B			A	A	B	B	C		B	A	A	B	A		A	A	B	B	C		A	5183
	B	B	A		A														B	B	A			A	B	B	A			A	B	B	A	C		A	B	A	A	A		A	B	B	A	C		A	5356
																															C	C	A	B	A	B	C	B	A	A		A	C	C	A	B		A	5554
	A	B	B		A														A	B	B			A	A	B	B			A	A	B	B	C		B	A	A	B	A		A	A	B	B	C		A	5556
																															C	C	A	B		A	C	B	A	A		B	C	C	A	B		A	5654
5454	A	B	B	B		A													A	B	B	A		A	A	B	B	B		A	A	A	B	B		A	A	A	B	B		A	A	A	B	B		A	5183
	B	B	A	B		A													B	B	A	B		A	B	B	A	B		A	B	A	A	B		A	B	A	A	B		A	B	A	A	B		A	5356
	C	C	A	A	A	A													C	C	A	A	A	A	C	C	A	A	A	A	C	C	A	A	A	A	C	B	A	A		A	C	B	A	A		A	5554
	A	B	B	B		A													A	B	B	B		A	A	B	B	B		A	A	A	B	B		A	A	A	B	B		A	A	A	B	B		A	5556
																															C	B	A	B		B							C	B	A	A		B	5654
511.0, 512.0, 513.0, 514.0, 535.0, 5154, 5254	A	B	B	B		A													A	B	B	B		A	A	B	B	B		A	A	A	B	B		B	A	A	B	A		A	A	A	B	B		B	5183
	B	B	A	B		A													B	B	A	B		A	B	B	A	B		A	B	A	A	B		A	B	A	A	A		A	B	A	A	B		A	5356
	C	C	A	A		A													C	C	A	A		A	C	C	A	A		A	C	C	A	A		B	C	B	A	A		A	C	B	A	A		B	5554
	A	B	B	B		A													A	B	B	B		A	A	B	B	B		A	A	A	B	B		B	A	A	B	A		A	A	A	B	B		A	5556
	C	C	A	A		B													C	C	A	A		B	C	C	A	A		B	C	B	A	A		A	C	B	A	A		B	C	B	A	A		A	5654

Table A.2 (continued)
Aluminum Filler Metal Selection Chart

BASE METAL	Pure Aluminum						Al – Cu												Al – Mn												Al – Mg												FILLER METAL
	1100, 1060, 1070, 1080, 1350						2014, 2036						2219						3003, Alclad 3003						3004, Alclad 3004						5005, 5050, 5052, 5652						5083, 5086, 5456, 5383						
	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	
5083	A	A	B	A		A													A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	B	A	B	A		A	5183
	B	A	A	A		A													B	A	A	A		A	B	A	A	A		A	B	A	A	A		A		A	A	A		A	5356
																															C	C	A	A		A							5554
	A	A	B	A		A													A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	A	A	B	B		A	5556
																															C	B	A	B		A							5654
5086	A	A	B	A		A													A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	B	A	B	A		A	5183
	B	A	A	A		A													B	A	A	A		A	B	A	A	A		A	B	A	A	A		A	C	A	A	A		A	5356
																															C	C	A	A		A							5554
	A	A	B	A		A													A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	A	A	B	B		A	5556
																															C	B	A	B		A							5654
5456, 5383	A	A	B	A		A													A	A	B	A		A	A	A	B	A		A	A	A	B	A		A		A	B	A		A	5183
	B	A	A	A		A													B	A	A	A		A	B	A	A	A		A	B	A	A	A		A		A	A	A		A	5356
																															C	C	A	A		A							5554
	A	A	B	A		A													A	A	B	A		A	A	A	B	A		A	A	A	B	A		A	A	A	B	B		A	5556
																															C	B	A	B		A							5654
5005, 5050, 5052, 5652	E	A	C	A	A														E	A	C	A	A		E	A	C	A	A		E	A	C	B	A								4043
	D	A	C	A	A														D	A	C	A	A		D	A	C	A	A		D	A	C	B	A								4943
	A	B	B			A													A	B	B			A	A	B	B			A	A	A	B	A		A							5183
	B	B	A			A													B	B	A			A	B	B	A			A	B	A	A	A		A							5356
																															C	C	A	A	A	A							5554
	A	B	B			A													A	B	B			A	A	B	B			A	A	A	B	A		A							5556
																															C	B	A	B		A							5654
3004, Alclad 3004	F	D	A	A	A	A														C	A	A	A	A																			1100
	E	A	C	A	A														E	A	C	A	A		D	A	D	A	A														4043
	C	B	D	B	A														C	B	D	B	A																				4145
	D	A	C	A	A														D	A	C	A	A		C	A	D	A	A														4943
	A	C	B			B													A	C	B	C		A	A	B	C	C		A													5183
	B	C	B			B													B	C	B	C		A	B	B	B	C		A													5356
																									C	C	A	B	A	A													5554
	A	C	B			B													A	C	B	C		A	A	B	C	C		A													5556
3003, Alclad 3003	D	B	A	A	A	A														B	A	A	A	A																			1100
	C	A	B	A	A		C	B	A	A	A		C	B	A	A	A		C	A	B	A	A																				4043
	A	A	C	B	A		A	A	B	A	A		A	A	B	A	A		A	A	C	B	A																				4145
	B	A	B	A	A		B	B	A	A	A		B	B	A	A	A		B	A	B	A	A																				4943
2219							A	B	A	A	A	A	A	A	A	A	A	A																									2319
	C	B	A	A	A		D	B	B	C	A		D	B	B	C	A																										4043
	A	A	B	A	A		B	A	C	B	A		B	A	C	B	A																										4145
	B	B	A	A	A		C	B	B	C	A		C	B	B	C	A																										4943
2014, 2036							A	C	A	A	A	A																																2319
	C	B	A	A	A		D	B	B	C	A																																4043
	A	A	B	A	A		B	A	C	B	A																																4145
	B	B	A	A	A		C	B	B	C	A																																4943
1100, 1060, 1070, 1080, 1350	C	B	A	A	A	B																																				1100
		C	A	A	A	A																																				1188
	B	A	B	A	A																																					4043
	A	A	B	A	A																																					4943

Table A.2 (continued)
Aluminum Filler Metal Selection Chart

BASE METAL	Al – Mg: 5454						Al – Mg_Si: 6061, 6005, 6063, 6070, 6151, 6201, 6351, 6951, 6082						Al – Zn: 7005, 7021, 7039, 7046, 7146, 710.0, 711.0						Aluminum Castings: 413.0, 443.0, 444.0, 356.0, A356.0, 357.0, 359.0						Aluminum Castings: 319.0, 333.0, 354.0, 355.0, C355.0, 380.0						FILLER METAL
	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	STRENGTH	CRACKING	DUCTILITY	CORROSION	TEMPERATURE	COLOR	
																									A	B	A	A	A	A	2319
319.0, 333.0, 354.0, 355.0, C355.0, 380.0							C	B	A	A	A	A	C	B	A	A	A	A	C	B	A	A	A	A							4043
							A	A	B	A	A	A	A	A	B	A	A	A	A	A	B	A	A	A	B	A	B	B	A	A	4145
							B	B	A	A	A	A	B	B	A	A	A	A	B	B	A	A	A	A							4943
413.0, 443.0, 444.0, 356.0, A356.0, 357.0, 359.0							C	A	A	A	A	A	D	A	B	A	A	A	D	A	A	A	A	A							4043
							A	A	B	B	A		B	A	B	B	A		B	A	B	B	A	B							4145
							B	A	A	A	A	A	C	A	B	A	A	A	C	A	A	A	A	A							4943
																			A	A	A	A	A	A							A356.0
																			A	A	A	A	A	A							A357.0
													A	A	A	A		B													5356
7005, 7021, 7039, 7046, 7146, 710.0, 711.0							E	A	C	B	A		E	B	C	B	A														4043
																															4145
							D	A	C	B	A		D	B	C	B	A														4943
	A	A	B	A		A	A	A	B	A		A	A	A	B	A		A													5183
	B	A	A	A		A	B	A	A	A		A	B	A	A	A		A													5356
	C	B	A	A	A	A	C	B	A	A	A	A	C	B	A	A	A	A													5554
	A	A	B	A		A	A	A	B	A		A	A	A	B	A		A													5556
	C	B	A	A		A	C	B	A	A		A	C	B	A	A		A													5654
6061, 6005, 6063, 6070, 6151, 6201, 6351, 6951, 6082							D	A	B	A	A																				4043
																															4145
							C	A	B	A	A																				4943
	A	B	B	C		A	A	B	A	C		A																			5183
	B	B	A	C		A	B	B	A	C		A																			5356
	C	C	A	A	A	A	C	C	A	B	B	A																			5554
	A	B	B	C		A	A	B	A	C		A																			5556
	C	C	A	B		B	C	C	A	B		B																			5654
5454	A	A	B	B		A																									5183
	B	A	A	B		A																									5356
	C	B	A	A	A	A																									5554
	A	A	B	B		A																									5556
	C	B	A	B		B																									5654

To use this chart: Find the base metals to be joined in the left and top of the chart and determine which weld metal properties are most important for your application. Follow the intersection of the row and column to the right to find the filler metal. An A indicates a very good choice for that attribute, with B, C, D and E following as still suitable. A blank indicates that the filler metal is not suitable for that attribute in that base metal combination. This chart is a tool designed to help select the most appropriate filler metal, taking into consideration base metal, and the desired weld metal properties for a given application.

Table A.3
Discontinued Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods

Discontinued		Replacement	
AWS A5.10		AWS A5.10/A5.10M	
Classification	Issue	Classification	Issue
ER1060	1961	—	—
ER1260	1980	ER1188	1988
ER2014	1961	—	—
ER3004	1961	—	—
ER5039	1980	—	—
ER5052	1967	—	—
ER5154	1969	ER5654	1969
ER5254	1969	ER5654	1969
ER5652	1969	ER5654	1969
R242.0	1988	—	—
R295.0	1988	—	—
R355.0	1988	R-C355.0	1988
R356.0	1988	R-A356.0	1988
R-990A	1957	ER1100	1992
E-990A	1957	ER1100	1992
R-996A	1957	ER1060	1957
E-996A	1957	ER1060	1957
R-C4A	1980	R295.0	1980
R-CN42A	1980	R242.0	1980
R-C541A	1957	ER2014	1957
E-C541A	1957	ER2014	1957
R-G1A	1961	—	—
E-G1A	1961	—	—
R-GM50A	1957	ER5356	1957
E-GM50A	1957	ER5356	1957
R-GR20A	1957	ER5052	1957
E-GR20A	1957	ER5052	1957
R-GR40A	1957	ER5154	1957
E-GR40A	1957	ER5154	1957
R-MG11A	1957	ER3004	1957
E-MG11A	1957	ER3004	1957
R-SG70A	1980	R356.0	1980

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Annex B (Informative)
Requesting an Official Interpretation on an AWS Standard

This annex is not part of this standard but is included for informational purposes only.

B1. Introduction

The following procedures are here to assist standard users in submitting successful requests for official interpretations to AWS standards. Requests from the general public submitted to AWS staff or committee members that do not follow these rules may be returned to the sender unanswered. AWS reserves the right to decline answering specific requests; if AWS declines a request, AWS will provide the reason to the individual why the request was declined.

B2. Limitations

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

B3. General Procedure for all Requests

B3.1 Submission. All requests shall be sent to the Managing Director, AWS *Standards Development*. For efficient handling, it is preferred that all requests should be submitted electronically through standards@aws.org. Alternatively, requests may be mailed to:

Managing Director
Standards Development
American Welding Society
8669 NW 36 St, # 130
Miami, FL 33166

B3.2 Contact Information. All inquiries shall contain the name, address, email, phone number, and employer of the inquirer.

B3.3 Scope. Each inquiry shall address one single provision of the standard unless the issue in question involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the request along with the edition of the standard (e.g., D1.1:2006) that contains the provision(s) the inquirer is addressing.

B3.4 Question(s). All requests shall be stated in the form of a question that can be answered 'yes' or 'no'. The request shall be concise, yet complete enough to enable the committee to understand the point of the issue in question. When the point is not clearly defined, the request will be returned for clarification. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annexes) that bear on the issue in question shall be cited.

B3.5 Proposed Answer(s). The inquirer shall provide proposed answer(s) to their own question(s).

B3.6 Background. Additional information on the topic may be provided but is not necessary. The question(s) and proposed answer(s) above shall stand on their own without the need for additional background information.

B4. AWS Policy on Interpretations

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all official interpretations are approved by the technical committee that is responsible for the standard. Communication concerning an official interpretation is directed through the AWS staff member who works with that technical committee. The policy requires that all requests for an official interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the procedures that must be followed, some requests for an official interpretation may take considerable time to complete.

B5. AWS Response to Requests

Upon approval by the committee, the interpretation is an official interpretation of the Society, and AWS shall transmit the response to the inquirer, publish it in the *Welding Journal*, and post it on the AWS website.

B6. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The *AWS Board Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

Annex C (Informative)
List of Deviations from ISO 18273:2015

This Annex is not part of this standard, but is included for informational purposes only

This document has significant differences from the original ISO document. ISO 18273 contains requirements for chemical composition of the filler material. This document adds requirements for soundness and strength testing of weld metal, conformance and acceptance requirements, product form, identification and manufacturing details. Clauses, tables and figures have been added to this end.

Editorial rewording and numbering of clauses, tables and figures in this document were updated to comply with AWS standards.

The title of the specification has changed to correspond to the historical title.

Decimal commas have been changed to decimal periods.

Replaced Al Z for a non-listed classification with RG and ERG, as is the norm in AWS standards.

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AWS Filler Metal Specifications by Material and Welding Process

	OFW	SMAW	GTAW GMAW PAW	FCAW	SAW	ESW	EGW	Brazing
Carbon Steel	A5.2	A5.1, A5.35	A5.18	A5.20	A5.17	A5.25	A5.26	A5.8, A5.31
Low-Alloy Steel	A5.2	A5.5	A5.28	A5.29	A5.23	A5.25	A5.26	A5.8, A5.31
Stainless Steel		A5.4, A5.35	A5.9, A5.22	A5.22	A5.9, A5.22, A5.39	A5.9, A5.22, A5.39	A5.9	A5.8, A5.31
Cast Iron	A5.15	A5.15	A5.15	A5.15				A5.8, A5.31
Nickel Alloys		A5.11, A5.35	A5.14, A5.34	A5.34	A5.14 A5.34, A5.39	A5.14 A5.34, A5.39		A5.8, A5.31
Aluminum Alloys		A5.3	A5.10					A5.8, A5.31
Copper Alloys		A5.6	A5.7					A5.8, A5.31
Titanium Alloys			A5.16					A5.8, A5.31
Zirconium Alloys			A5.24					A5.8, A5.31
Magnesium Alloys			A5.19					A5.8, A5.31
Tungsten Electrodes			A5.12					
Brazing Alloys and Fluxes								A5.8, A5.31
Surfacing Alloys	A5.21	A5.13	A5.21	A5.21	A5.21			
Consumable Inserts			A5.30					
Shielding Gases			A5.32	A5.32			A5.32	

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AWS Filler Metal Specifications and Related Documents

Designation	Title
A4.2M (ISO 8249 MOD)	*Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal*
A4.3	*Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
A4.4M	*Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings*
A4.5M/A4.5 (ISO 15792-3 MOD)	*Standard Methods for Classification Testing of Positional Capacity and Root Penetration of Welding Consumables in a Fillet Weld*
A5.01M/A5.01 (ISO 14344 MOD)	*Welding Consumables—Procurement of Filler Metals and Fluxes*
A5.02/A5.02M	*Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*
A5.1/A5.1M	*Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
A5.2/A5.2M	*Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding*
A5.3/A5.3M	*Specification for Aluminum and Aluminum-Alloy Electrodes for Shielded Metal Arc Welding*
A5.4/A5.4M	*Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*
A5.5/A5.5M	*Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
A5.6/A5.6M	*Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding*
A5.7/A5.7M	*Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes*
A5.8M/A5.8	*Specification for Filler Metals for Brazing and Braze Welding*
A5.9/A5.9M (ISO 14343 MOD)	*Welding Consumables—Wire Electrodes, Strip Electrodes, Wires, and Rods for Arc Welding of Stainless and Heat Resisting Steels—Classification*
A5.10/A5.10M (ISO 18273 MOD)	*Welding Consumables—Wire Electrodes, Wires, and Rods for Welding of Aluminum and Aluminum-Alloys—Classification*
A5.11/A5.11M	*Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding*
A5.12M/A5.12 (ISO 6848 MOD)	*Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting*
A5.13/A5.13M	*Specification for Surfacing Electrodes for Shielded Metal Arc Welding*
A5.14/A5.14M	*Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*
A5.15	*Specification for Welding Electrodes and Rods for Cast Iron*
A5.16/A5.16M (ISO 24034 MOD)	*Specification for Titanium and Titanium-Alloy Welding Electrodes and Rods*
A5.17/A5.17M	*Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.18/A5.18M	*Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.19	*Specification for Magnesium-Alloy Welding Electrodes and Rods*
A5.20/A5.20M	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
A5.21/A5.21M	*Specification for Bare Electrodes and Rods for Surfacing*
A5.22/A5.22M	*Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods*

A5.23/A5.23M	*Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.24/A5.24M	*Specification for Zirconium and Zirconium-Alloy Welding Electrodes and Rods*
A5.25/A5.25M	*Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding*
A5.26/A5.26M	*Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding*
A5.28/A5.28M	*Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.29/A5.29M	*Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
A5.30/A5.30M	*Specification for Consumable Inserts*
A5.31M/A5.31	*Specification for Fluxes for Brazing and Braze Welding*
A5.32M/A5.32 (ISO 14175 MOD)	*Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*
A5.34/A5.34M	*Specification for Nickel-Alloy Flux Cored and Metal Cored Welding Electrodes*
A4.35/A5.35M-AMD1	*Specification for Covered Electrodes for Underwater Wet Shielded Metal Arc Welding*
A5.39/A5.39M	*Specification for Flux and Electrode Combinations for Submerged Arc and Electroslag Joining and Surfacing of Stainless Steel and Nickel Alloys*