

Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding



American Welding Society



**AWS A5.6/A5.6M:2008
An American National Standard**

**Approved by the
American National Standards Institute
November 6, 2007**

Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding

9th Edition

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

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification prescribes the requirements for classifications of copper and copper-alloy electrodes for shielded metal arc welding. Classification is based on chemical composition, mechanical properties, and usability of the electrodes. Additional requirements are included for manufacture, sizes, lengths, and packaging. A guide is appended to the specification as a source of information concerning the classification system employed and intended use of the electrodes.

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.



American Welding Society

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Foreword

This foreword is not part of AWS A5.6/A5.6M:2008, *Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding*, but is included for informational purposes only.

This document is the ninth revision of AWS A5.6, first published in 1948. The revision was prepared by the Subcommittee on Copper and Copper-Alloy Filler Metals. This specification describes the most common copper and copper-alloy electrodes for shielded metal arc welding. Since the applications for copper and copper-alloy electrodes are so diverse, i.e., surfacing and joining, discussion on intended uses and suggested welding parameters are included. The reader will find the data describing weld deposit hardness particularly useful when selecting an electrode for surfacing a wear-resistant bearing surface.

This document is the first of the A5.6 specifications which 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. In selecting rational metric units the AWS A1.1, *Metric Practice Guide for the Welding Industry*, and ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials — Type of product, dimensions, tolerances and markings*, are used as guides. 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.

This revision makes adjustments in the chemical composition ranges for classifications ECu, ECuAl-A2, ECuAl-B, ECuNiAl, and ECuMnNiAl to meet with current industry practice. These modified ranges are shown in *Italic* font in Table 1. It also eliminates the bend test requirements for ECuAl-B, ECuNiAl, and ECuMnNiAl whose elongation in the all-weld metal tension test is less than 20%. The nomograph in the previous document intended to allow bend tests of these classifications has also been removed.

Document Development

ASTM B225-48T AWS A5.6-48T	<i>Tentative Specifications for Copper and Copper-Alloy Metal-Arc-Welding Electrodes</i>
ASTM B225-53T AWS A5.6-53T	<i>Tentative Specifications for Copper and Copper-Alloy Welding Electrodes</i>
ASTM B225-57T AWS A5.6-57T	<i>Tentative Specifications for Copper and Copper-Alloy Arc-Welding Electrodes</i>
AWS A5.6-66T ASTM B225-66T	<i>Tentative Specifications for Copper and Copper-Alloy Arc-Welding Electrodes</i>
AWS A5.6-69 ANSI W3.6-73	<i>Specifications for Copper and Copper Alloy Arc-Welding Electrodes</i>
ANSI/AWS A5.6-74 (Addendum)	<i>Specifications for Covered Copper and Copper Alloy Arc-Welding Electrodes</i>
AWS A5.6-76	<i>Specification for Copper and Copper Alloy Covered Electrodes</i>
ANSI/AWS A5.6-84 ANSI/AWS A5.6-84R	<i>Specification for Covered Copper and Copper Alloy Arc Welding Electrodes</i> Reaffirmed March 10, 2000

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, 550 N.W. LeJeune Road, Miami, FL 33126.

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Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of covered copper and copper-alloy electrodes for shielded metal arc welding. It includes compositions in which the copper content exceeds that of any other element.¹

1.2 Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. Some safety and health information can be found in the Informative Annex Clauses A5 and A10. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and applicable federal and state regulations.

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 material properties. The specification with the designation A5.6 uses U.S. Customary Units. The specification A5.6M 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 sizing of filler metal or packaging or both under A5.6 or A5.6M specifications.

2. Normative References

2.1 The following AWS standards² are referenced in the mandatory sections of this document:

¹ No attempt has been made to provide for the classification of all grades of copper and copper-alloy welding electrodes. Only the more commonly used grades have been included.

² AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

AWS A5.01, *Filler Metal Procurement Guidelines*

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

2.2 The following ANSI standard³ is referenced in the mandatory sections of this document:

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

2.3 The following ASTM standards⁴ are referenced in the mandatory sections of this document:

ASTM B 96/B 96M, *Standard Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels*

ASTM B 103/B 103M, *Standard Specification for Phosphor Bronze Plate, Sheet, Strip, and Rolled Bar*

ASTM B 122/B 122M, *Standard Specification for Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar*

ASTM B 148, *Standard Specification for Aluminum-Bronze Sand Castings*

ASTM B 152/B 152M, *Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar*

ASTM B 169/B 169M, *Standard Specification for Aluminum Bronze Sheet, Strip, and Rolled Bar*

ASTM E 29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E 75, *Standard Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys*

³ This ANSI standard is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

⁴ ASTM standards are published by the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 478, *Standard Test Methods for Chemical Analysis of Copper Alloys*

ASTM E 1032, *Standard Test Method for Radiographic Examination of Weldments*

2.4 The following ISO standard⁵ is referenced in the mandatory sections of this document:

ISO 544, *Welding consumables—Technical delivery conditions for welding filler materials—Type of product, dimensions, tolerances and markings*

3. Classification

3.1 The welding materials covered by the A5.6/A5.6M specification are classified using a system that is independent of U.S. Customary Units and the International System of Units (SI). Classifications are according to the chemical composition of the undiluted weld metal as specified in Table 1.

3.2 Material classified under one classification shall not be classified under any other classification in this specification. However, material may be classified under both A5.6 and A5.6M.

3.3 The materials classified under this specification are intended for shielded metal arc welding, but that is not to prohibit their use with any other process for which they are found suitable.

4. Acceptance

Acceptance⁶ of the material shall be in accordance with the provisions of AWS A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging or the AWS classification to the product, the manufacturer certifies that the product meets the requirements of this specification.⁷

⁵ ISO standards are published by the International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland.

⁶ See Annex Clause A3 for further information concerning acceptance, testing of the material shipped, and AWS A5.01, *Filler Metal Procurement Guidelines*.

⁷ See Annex Clause A4 for further information concerning certification and testing called for to meet this requirement.

6. Rounding-Off Procedure

For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the nearest 1000 psi [10 MPa] for tensile strength, and to the “nearest unit” in the last right-hand place of figures used in expressing the limiting value for other quantities in accordance with the rounding-off method given in ASTM E 29.

7. Summary of Tests

The tests required for each classification are specified in Table 2. The purpose of the tests is to determine the chemical composition, mechanical properties, and soundness of the weld metal. 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 any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need only be for the specific elements which 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 assembly or test specimens or in conducting the test, the test shall be considered invalid without regard to whether the test was actually completed, or whether test results met, or failed to meet, the requirement. That test shall be repeated, following prescribed procedures. In this case the requirement for doubling of the number of test specimens does not apply.

9. Weld Test Assemblies

9.1 Two test assemblies are required for all classifications except ECuNi, which may require three test assemblies (see Figure 3). The three test assemblies are as follows:

(1) The weld pad in Figure 1 for chemical analysis of undiluted weld metal

Table 1
Chemical Composition Requirements for Undiluted Weld Metal

AWS Classification	UNS Number ^c	Common Name	Composition, weight-percent ^{a, b}											Total Other Elements
			Cu Including Ag	Zn	Sn	Mn	Fe	Si	Ni ^d	P	Al	Pb	Ti	
ECu	W60189	Copper	Remainder	f	f	0.10	0.20	0.10	f	f	0.10	0.01	—	0.50
ECuSi	W60656	Silicon bronze (copper-silicon)	Remainder	f	1.5	1.5	0.50	2.4–4.0	f	f	0.01	0.02	—	0.50
ECuSn-A	W60518	Phosphor bronze (copper-tin)	Remainder	f	4.0–6.0	f	0.25	f	f	0.05–0.35	0.01	0.02	—	0.50
ECuSn-C	W60521		Remainder	f	7.0–9.0	f	0.25	f	f	0.05–0.35	0.01	0.02	—	0.50
ECuNi ^e	W60715	Copper nickel (70/30)	Remainder	f	f	1.00–2.50	0.40–0.75	0.50	29.0–33.0	0.020	—	0.02	0.50	0.50
ECuAl-A2	W60614	Aluminum bronze	Remainder	f	f	f	0.50–5.0	1.5	f	—	6.5–9.5	0.02	—	0.50
ECuAl-B	W60619	Aluminum bronze	Remainder	f	f	f	2.5–5.0	1.5	f	—	9.5–11.5	0.02	—	0.50
ECuNiAl	W60632	Nickel aluminum bronze	Remainder	f	f	0.50–3.5	3.0–6.0	1.5	4.0–6.0	—	8.0–9.5	0.02	—	0.50
ECuMnNiAl	W60633	Manganese-nickel aluminum bronze	Remainder	f	f	11.0–14.0	2.0–4.0	1.5	1.5–3.0	—	6.0–8.5	0.02	—	0.50

^a Analysis shall be made for the elements for which specific values or an “f” are shown in this table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine that the total of other elements is not present in excess of the limits specified for “total other elements” in the last column in the table.

^b Single values shown are maximum.

^c ASTM D5-56/SAE HS-1086, *Metals & Alloys in the Unified Numbering System*.

^d Includes cobalt.

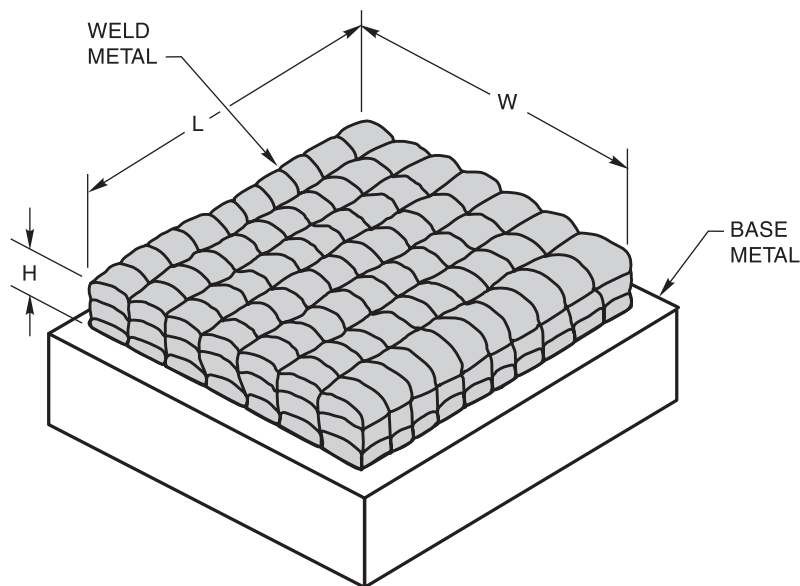
^e Sulfur shall be restricted to 0.015% maximum for the ECuNi classification.

^f This element must be included in total other elements.

Table 2
Required Tests for Classification^a

AWS Classification	Chemical Analysis	Tension Test	Transverse Side-Bend Test	Radiographic Test
ECu	Required	Required	Required	Not Required
ECuSi	Required	Required	Required	Not Required
ECuSn-A	Required	Required	Required	Not Required
ECuSn-C	Required	Required	Required	Not Required
ECuNi	Required	Required	Required	Required
ECuAl-A2	Required	Required	Required	Not Required
ECuAl-B	Required	Required	Not Required	Not Required
ECuNiAl	Required	Required	Not Required	Not Required
ECuMnNiAl	Required	Required	Not Required	Not Required

^a All welding for chemical analysis, all-weld-metal tension tests, and transverse side-bend tests shall be done with the test plates in the flat position.



Electrode Size		Weld Pad Size, Minimum				Minimum Distance of Sample from Surface of Base Plate		
in	mm		in	mm		in	mm	
3/32	2.4	}	L	1-1/2	38	}	3/8	10
			W	1/2	13			
	2.5		H	1/2	13			
1/8 5/32 3/16	3.2	}	L	2	50	}	1/2	13
	4.0		W	1/2	13			
	4.8		H	5/8	16			
	5.0							
	6.0							

Figure 1—Pad for Chemical Analysis of Undiluted Weld Metal

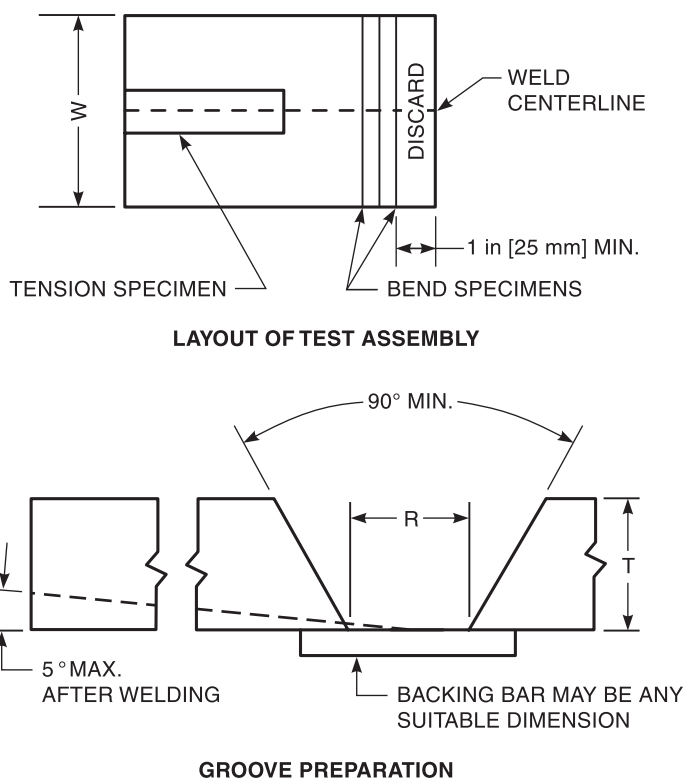
(2) The groove weld in Figure 2 for mechanical properties and soundness of the weld metal

(3) The groove weld in Figure 3 for the usability of ECuNi electrodes

The sample for chemical analysis may be taken from the reduced section of the fractured tension specimen or from a corresponding location (or any location above it) in Fig-

ure 2, thereby avoiding the need to make the weld pad. In case of dispute, the weld pad shall be the referee method.

9.2 Preparation of each weld test assembly shall be as prescribed in 9.3 and 9.4. The base metal for each assembly shall be as required in Table 3 according to the tests to be conducted and shall meet the requirements of the appropriate ASTM specification shown there, or an



Electrode Size in [mm]	Root Opening, R ^a		Test Plate Thickness, T, min.		Number of Layers ^b	Width of Test Plate, W, min.	
	in	mm	in	mm		in	mm
1/8 [3.2] and less	1/4	6.4	1/2	12	—	6	150
5/32 [4.0] and larger	1/2	13	3/4	20	6 to 9	6	150

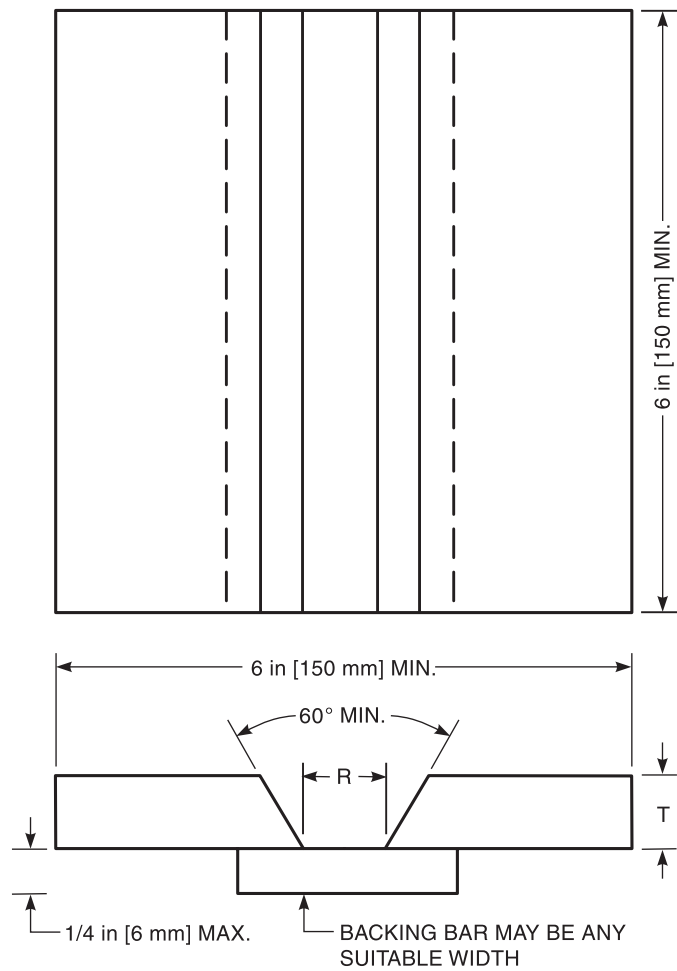
^a Root tolerance is $\pm 1/16$ in [1.5 mm].

^b For the ECuNi classification, the minimum groove angle shall be 60°. For all classifications, the number of layers for the 1/8 in [3.2 mm] and smaller electrodes shall be recorded and reported. The 5/32 in [4.0 mm] and larger electrodes shall have a minimum of six layers and a maximum of nine layers.

Notes:

1. Weld test plates for all-weld-metal tension and bend specimens shall be prepared using the plate base metal shown in Table 3.
2. The surfaces to be welded shall be clean.
3. Welding shall be performed with the plates in the flat position, using the current values and welding techniques recommended by the electrode manufacturer.
4. Preheat temperature shall be 60°F [15°C] minimum. The interpass temperature shall not exceed 300°F [150°C]. For ECuSi classification, the interpass temperature shall not exceed 150°F [65°C].
5. The weld metal shall have a maximum bead width equal to six (6) times the core wire diameter. The completed weld shall be at least flush with the surface of the test plate.
6. Tests shall be conducted in the as welded condition.

Figure 2—Test Assembly for Tension and Bend Test



Electrode Size		Root Opening, R ^a		Test Plate Thickness, T, min.	
in	mm	in	mm	in	mm
3/32	2.4, 2.5	1/4	6.4	1/4	6
1/8	3.2	5/16	8	3/8	10
5/32	4.0	3/8	9.5	1/2	12
3/16	4.8, 5.0, 6.0	1/2	12	1/2	12

^a Root opening tolerance is $\pm 1/16$ in [± 1.5 mm].

Notes:

1. Welding shall be conducted in the vertical position or flat position as prescribed in 9.4.2
2. Base metal shall be in accordance with Table 3.
3. The surfaces to be welded shall be clean.
4. Each weld bead shall contain a start in the area to be evaluated. The weld metal shall have a maximum bead width equal to six (6) times the core wire diameter. The root layer for a test of 5/32 [4.0 mm] electrode or larger may be deposited with a 3/32 in [2.4 mm or 2.5 mm] or 1/8 in [3.2 mm] electrode.
5. The completed weld shall be at least flush with the surface of the test plate.
6. Preheat temperature shall be 60°F [15°C] minimum. The interpass temperature shall not exceed 300°F [150°C].
7. After completion of the weld, the weld reinforcement and backing strip shall be removed flush with the base plate surfaces and the assembly shall be radiographed.

Figure 3—Groove Weld for Radiographic Test (ECuNi Only)

Table 3
Base Metals for Test Assemblies

Base Metal (ASTM Specification and UNS Numbers)				
AWS Classification	UNS Number ^a	Chemical Analysis	All-Weld-Metal Tension Test	Transverse Side-Bend Test
ECu	C12200	B152	B152	B152
ECuSi	C65500	B96	B96	B96
ECuSn-A	C51100	B103	B103	B103
ECuSn-C	C52100	B103	B103	B103
ECuNi ^b	C71500	B122	B122	B122
ECuAl-A2	C61400	B169	B169	B169
ECuAl-B	C95400	B148	B148	—
ECuNiAl	C95800	B148	B148	—
ECuMnNiAl	C95700	B148	B148	—

^a ASTM DS-56/SAE HS-1086, *Metals & Alloys in the Unified Numbering System*.

^b Groove weld usability tests shall be conducted for the ECuNi classification as per Figure 3 using B122 base metal (UNS C71500).

equivalent specification. Testing of the assemblies shall be as prescribed in Clause 10, Chemical Analysis, Clause 11, Radiographic Test, and Clause 12, Tension Test, and Clause 13, Bend Test.

9.3 Weld Pad. A weld pad shall be prepared as specified in Figure 1, except when the alternative in 10.1 (taking the sample from the broken tension test specimen or the corresponding location in the groove weld) is selected. Base metal of any convenient size, of the type specified in Table 3 (including notes a and b to that table) shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple beads to obtain undiluted weld metal. The pre-heat temperature shall not be less than 60°F [15°C] and the interpass temperature shall not exceed 300°F [150°C]. The slag shall be removed after each pass. The pad may be quenched in water of a temperature above 60°F [15°C] between passes. The dimensions of the completed pad shall be as shown in Figure 1 for each size of electrode. Testing of this assembly shall be as specified in Clause 10, Chemical Analysis.

9.4 Groove Weld

9.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Figure 2 using base metal of the appropriate type specified in Table 3. Testing of the assembly shall be as specified in Clause 12, Tension Test, and Clause 13, Bend Test. The test specimens shall be tested in the as welded condition.

9.4.2 Usability Test. A test assembly shall be prepared for electrodes of the ECuNi classification and welded as shown in Figure 3, using base metal of the

appropriate type specified in Table 3. The welding position shall be vertical for the 3/32 in [2.4 mm or 2.5 mm] and 1/8 in [3.2 mm] diameter electrodes or flat for the 5/32 in [4.0 mm] and 3/16 in [4.8 mm, 5.0 mm, or 6.0 mm] diameter electrodes. Testing of the assembly shall be as specified in Clause 11, Radiographic Test.

10. Chemical Analysis

10.1 The sample for analysis shall be taken from weld metal produced with the electrode. The sample shall be taken from a weld pad (see Figure 1), from the reduced section of the fractured all-weld-metal tension specimen (see Figure 2), or from a corresponding location in the groove weld (see Figure 2 or Figure 3). The top surface of the pad described in 9.3 and shown in Figure 1 shall be removed and discarded, and a sample for analysis shall be obtained by any appropriate mechanical means. The sample shall be free from slag.

10.2 The sample from the reduced section of the fractured tension test specimen, or from the corresponding location in the groove weld in Figure 2 or Figure 3, shall be prepared for analysis by any suitable mechanical means.

10.3 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E 478. For classification ECuNi, where titanium may be intentionally added up to 0.50%, the element titanium should be analyzed by using ASTM E 75.

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

11. Radiographic Test

11.1 When required in Table 2, the groove weld described in 9.4.2 and shown in Figure 3 shall be radiographed to evaluate the soundness of the weld metal and the usability of the electrode. 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 machined thickness of the 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 ASTM E 1032.

11.3 The soundness of the weld metal and the usability of the electrode meet the requirements of this specification if the radiograph shows:

- (1) No cracks, no incomplete fusion or incomplete joint penetration
- (2) No slag inclusions in excess of those permissible in Note 4 in the radiographic standards of Figure 4A, 4B, 4C, or 4D
- (3) No rounded indications in excess of those permitted by the radiographic standards in Figures 4A, 4B, 4C, and 4D.

In evaluating the radiograph, 1 in [25 mm] of the weld on each end of the test assembly shall be disregarded.

11.3.1 A rounded indication is an indication (on the radiograph) whose length is no more than three times its width. Rounded indications may be circular, or irregular in shape, and they may have tails. The size of a rounded indication is the largest dimension of the indication, including any tail that may be present.

11.3.2 The indications may be of porosity or slag. 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 do not meet the requirements of this specification.

12. Tension Test

12.1 One all-weld-metal tension test specimen, as specified in the Tension Test section of AWS B4.0 or B4.0M, shall be machined from the groove weld described in 9.4.1 and shown in Figure 2. The tensile specimen shall have a nominal diameter of 0.500 in [12.5 mm] for test assemblies 3/4 in [20 mm] thick, or 0.250 in [6 mm] for test assemblies 1/2 in [12 mm] thick. All tensile specimens shall have a nominal gage-length-to-diameter ratio of 4:1. Other dimensions of the tension test specimen shall be as specified in AWS B4.0 or B4.0M.

12.2 The specimen shall be tested in the as-welded condition in the manner described in the tension test section of AWS B4.0 or AWS B4.0M.

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

13. Bend Test

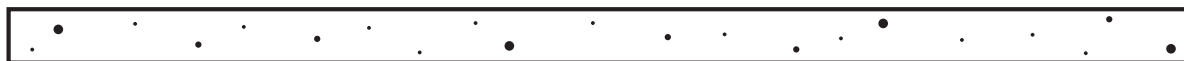
13.1 Two transverse side bend specimens as required in Table 2 shall be machined from the groove weld described in 9.4.1 and shown in Figure 2.

13.2 The specimens (in the as-welded condition) shall be tested in the manner described in the bend test section of AWS B4.0 or AWS B4.0M. A 3/8 in [10 mm] thick specimen shall be uniformly bent 180 degrees over a 3/4 in [19 mm] radius. Any suitable fixture, as specified in the Bend Test section of AWS B4.0 or AWS B4.0M, may be used. Positioning of the specimen shall be such that the side of the specimen with the greater discontinuities, if any, is in tension.

13.3 Each specimen, after bending, shall conform to the specified radius, with appropriate allowance for spring back, and the weld metal shall exhibit no cracks or open discontinuities exceeding 1/8 in [3.2 mm] measured in any direction. Small checks or cracks at the edges of the test specimen shall be disregarded.

14. Method of Manufacture

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

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.050 in [0.4 mm TO 1.3 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 21, WITH THE FOLLOWING RESTRICTIONS:

MAXIMUM NUMBER OF LARGE 0.031 in TO 0.050 in [0.8 mm TO 1.3 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 4

MAXIMUM NUMBER OF MEDIUM 0.020 in TO 0.031 in [0.5 mm TO 0.8 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 5

MAXIMUM NUMBER OF SMALL 1/64 in TO 0.020 in [0.4 mm TO 0.5 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 12

**(B) LARGE ROUNDED INDICATIONS**

SIZE 0.031 in TO 0.050 in [0.8 mm TO 1.3 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 8

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE 0.020 in TO 0.031 in [0.5 mm TO 0.8 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 19

**(D) SMALL ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.020 in [0.4 mm TO 0.5 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 48

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in [0.4 mm] and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
3. When using the alternative method of evaluation described in 11.3.1, the total cross sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.015 in² [10 mm²] in any 6 in [150 mm] of weld.
4. The acceptance standard for slag inclusions in this assembly is the following:
 - (a) Length of each individual slag indication: 5/32 in [4.0 mm] maximum
 - (b) Total length of all slag indications: 1/4 in [6.4 mm] maximum

Figure 4A—Radiographic Acceptance Standard for 1/4 in [6 mm] Test Plate

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.075 in [0.4 mm TO 1.9 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 17, WITH THE FOLLOWING RESTRICTIONS:

MAXIMUM NUMBER OF LARGE 0.049 in TO 0.075 in [1.3 mm TO 1.9 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 3

MAXIMUM NUMBER OF MEDIUM 0.020 in TO 0.049 in [0.5 mm TO 1.3 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 3

MAXIMUM NUMBER OF SMALL 1/64 in TO 0.020 in [0.4 mm TO 0.5 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 11

**(B) LARGE ROUNDED INDICATIONS**

SIZE 0.049 in TO 0.075 in [1.3 mm TO 1.9 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 5

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE 0.020 in TO 0.049 in [0.5 mm TO 1.3 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 11

**(D) SMALL ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.020 in [0.4 mm TO 0.5 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 72

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in [0.4 mm] and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those usually encountered in general fabrication.
3. When using the alternative method of evaluation described in 11.3.1, the total cross sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.023 in² [15 mm²] in any 6 in [150 mm] of weld.
4. The acceptance standard for slag inclusions in this assembly is the following:
 - (a) Length of each individual slag indication: 7/32 in [5.6 mm] maximum.
 - (b) Total length of all slag indications: 3/8 in [10 mm] maximum

Figure 4B—Radiographic Acceptance Standard for 3/8 in [10 mm]

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.10 in [0.4 mm TO 2.5 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 45, WITH THE FOLLOWING RESTRICTIONS:

MAXIMUM NUMBER OF LARGE 0.031 in TO 0.10 in [0.8 mm TO 2.5 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 1

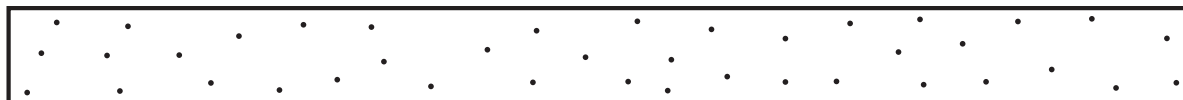
MAXIMUM NUMBER OF MEDIUM 0.020 in TO 0.031 in [0.5 mm TO 0.8 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 9

MAXIMUM NUMBER OF SMALL 1/64 in TO 0.020 in [0.4 mm TO 0.5 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 35

**(B) LARGE ROUNDED INDICATIONS**

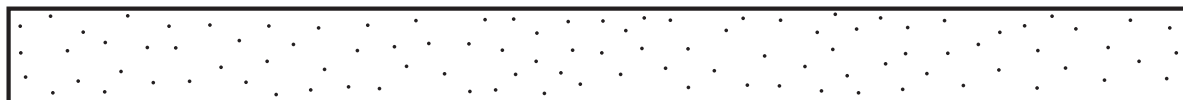
SIZE 0.031 in TO 0.10 in [0.8 mm TO 2.5 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 4

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE 0.020 in TO 0.031 in [0.5 mm TO 0.8 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 40

**(D) SMALL ROUNDED INDICATIONS**

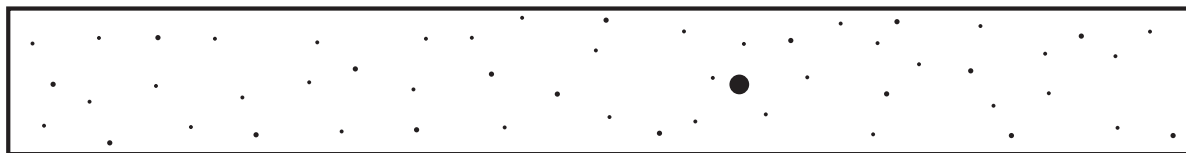
SIZE 1/64 in TO 0.020 in [0.4 mm TO 0.5 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 101

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in [0.4 mm] and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those normally encountered in general fabrication.
3. When using the alternative method of evaluation described in 11.3.1, the total cross sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.030 in² [20 mm²] in any 6 in [150 mm] of weld.
4. The acceptance standard for slag inclusions in this assembly is the following:
 - (a) Length of each individual slag indication: 7/32 in [5.6 mm] maximum.
 - (b) Total length of all slag indications: 7/16 in [11 mm] maximum

Figure 4C—Radiographic Acceptance Standard for 1/2 in [12 mm] Test Plate

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.125 in [0.4 mm TO 3.2 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER OF INDICATIONS IN ANY 6 in [150 mm] OF WELD = 53, WITH THE FOLLOWING RESTRICTIONS:

MAXIMUM NUMBER OF LARGE 0.034 in TO 0.125 in [0.9 mm TO 3.2 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 1

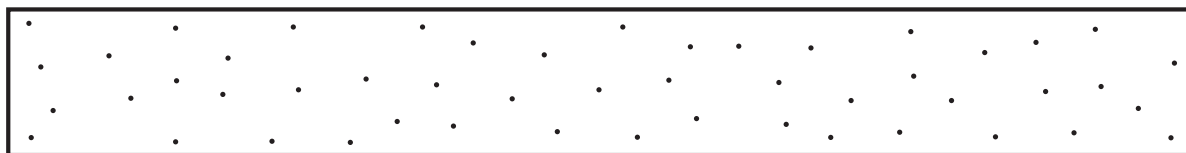
MAXIMUM NUMBER OF MEDIUM 0.024 in TO 0.034 in [0.6 mm TO 0.9 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 17

MAXIMUM NUMBER OF SMALL 1/64 in TO 0.024 in [0.4 mm TO 0.6 mm] IN DIAMETER OR IN LENGTH INDICATIONS = 35

**(B) LARGE ROUNDED INDICATIONS**

SIZE 0.034 in TO 0.1 in [0.9 mm TO 2.5 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 4

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE 0.024 in TO 0.034 in [0.6 mm TO 0.9 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 50

**(D) SMALL ROUNDED INDICATIONS**

SIZE 1/64 in TO 0.024 in [0.4 mm TO 0.6 mm] IN DIAMETER OR IN LENGTH

MAXIMUM NUMBER INDICATIONS IN ANY 6 in [150 mm] OF WELD = 90

Notes:

1. The chart that is most representative of the size of the rounded indications in the radiograph of the test assembly shall be used to determine conformance with this specification. Rounded indications 1/64 in [0.4 mm] and smaller shall be disregarded. The largest dimension of the indication (including any tail) is the size of the indication.
2. These radiographic requirements are for test welds made in the laboratory specifically for classification purposes. They are more restrictive than those normally encountered in general fabrication.
3. When using the alternative method of evaluation described in 11.3.1, the total cross sectional area of the rounded indications (calculated from measurements taken from the radiograph) shall not exceed 0.045 in² [30 mm²] in any 6 in [150 mm] of weld.
4. The acceptance standard for slag inclusions in this assembly is the following:
 - (a) Length of each individual slag indication: 5/16 in [7.9 mm] maximum.
 - (b) Total length of all slag indications: 15/32 in [11.9 mm] maximum

Figure 4D—Radiographic Acceptance Standard for 3/4 in [20 mm] Test Plate

Table 4
Mechanical Property Requirements

AWS Classification	Tensile Strength, min.		Elongation Percent, min.
	ksi	MPa	
ECu	25	170	20
ECuSi	50	350	20
ECuSn-A	35	240	20
ECuSn-C	40	280	20
ECuNi	50	350	20
ECuAl-A2	60	410	20
ECuAl-B	65	450	10
ECuNiAl	72	500	10
ECuMnNiAl	75	520	15

15. Standard Sizes and Lengths

15.1 Standard sizes and lengths of electrodes are shown in Table 5. Other sizes shall be as agreed upon between the purchaser and manufacturer.

15.2 Diameter of the core wire shall not vary more than ± 0.003 in [± 0.1 mm] from the diameter specified. Length shall not vary more than $\pm 1/4$ in [$\pm 2\%$ of the nominal mm length].

16. Core Wire and Covering

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

16.2 The core wire and covering shall be concentric to the extent that the maximum core-plus-one covering dimension shall not exceed the minimum core-plus-one covering dimensions by more than:

(1) 7% of the mean dimension for 3/32 in [2.4 mm and 2.5 mm]

(2) 5% of the mean dimension for sizes 1/8 in and 5/32 in [3.2 mm and 4.0 mm]

(3) 4% of the mean dimension for 3/16 in [4.8 mm, 5.0 mm, and 6.0 mm].

Concentricity may be measured by any suitable means.

17. Exposed Core

17.1 The grip end of each electrode shall be bare (free of covering) for a distance of not less than 1/2 in [12 mm] nor more than 1-1/4 in [30 mm] for electrodes 5/32 in [4.0 mm] and smaller, and not less than 3/4 in [19 mm] nor more than 1-1/2 in [38 mm] for electrodes 3/16 in [4.8 mm] and larger, to provide for electrical contact with the electrode holder.

Table 5
Standard Sizes and Lengths

Standard Size (Core Wire Diameter)		Standard Length ^{a, b}			
		Classification		Classification	
		ECuAl-B ECuNiAl		All Others	
in	mm	in	mm	in	mm
3/32	2.4 ^c	—	—	9 or 12	250 or 300
—	2.5				
1/8	3.2	14	350	14	350
5/32	4.0	14 or 18	350 or 450	14 or 18	350 or 450
3/16	4.8 ^c				
—	5.0				
—	6.0				

^a Lengths other than these shall be as agreed upon between purchaser and supplier.

^b In all cases, end-gripped electrodes are standard.

^c Not included in ISO 544.

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

18. Electrode Identification

All electrodes shall be identified as follows:

18.1 At least one imprint of the electrode classification shall be applied to the electrode covering beginning within 2-1/2 in [65 mm] of the grip end of the electrode. The prefix letter “E” in the classification may be omitted from the imprint.

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

18.3 The ink used for imprinting shall provide sufficient contrast with the electrode covering so that, in normal use, the numbers and letters are legible, both before and after welding.

19. Packaging

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

19.2 Standard package weights shall be as agreed upon by the supplier and purchaser.

20. Marking of Packaging

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

- (1) AWS specification and classification designations (year of issue may be excluded)
- (2) Supplier’s name and trade designation
- (3) Size and net weight
- (4) Lot, control, or heat number

20.2 The appropriate precautionary information⁸ given in ANSI Z49.1, latest edition (as a minimum), or its equivalent, shall be prominently displayed in legible print on all packages, including individual unit packages within a larger package.

⁸Typical examples of “warning labels” are shown in figures in ANSI Z49.1 for some common or specific consumables used with certain processes

Annex A (Informative)

Guide to AWS Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding

This annex is not part of AWS A5.6/A5.6M:2008, *Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding*, but is included for informational purposes only.

A1. Introduction

The purpose of this guide is to correlate the electrode classifications with their intended applications so the specification can be used effectively. Appropriate base metal specifications are referred to 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 electrode is suitable.

A2. Classification System

A2.1 The system for identifying the electrode classification in this specification follows the standard pattern used in other AWS filler metal specifications, namely:

(1) The letter E at the beginning of each classification designation indicates a covered electrode.

(2) The chemical symbol Cu is used to identify the electrodes as copper-base alloys, and the additional chemical symbol, such as Si in ECuSi, Sn in ECuSn, etc., indicates the principal alloying element of each classification or group of similar classifications. Where more than one classification is included in a basic group, the individual classifications in the group are identified by the letters A, B, C, etc., as in ECuSn-A. Further subdividing is done by using a 1, 2, etc., after the last letter, as the 2 in ECuAl-A2.

A2.2 Request for Filler Metal Classification

A2.2.1 A request to establish a new electrode classification must be written, and it needs to provide sufficient detail to permit the A5 Committee on Filler Metals and Allied Materials or the Subcommittee to determine whether a new classification or a modification of an

existing classification is more appropriate, and whether either is necessary to satisfy the need.

In particular the request needs to include:

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

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

(3) Information on Description and Intended Use, which parallels existing classifications for that section in the Annex.

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

A2.2.2 The request should be sent to the Secretary of the Committee on Filler Metal and Allied Materials at AWS Headquarters. Upon receipt of the request, the Secretary will:

(1) Assign an identifying number to the request. This number will include the date the request was received.

(2) Confirm receipt of the request and give the identification number to the person who made the request.

(3) Send a copy of the request to the Chair of the Committee on Filler Metals and Allied Materials and the Chair of the particular Subcommittee involved.

(4) File the original request.

(5) Add the request to the log of outstanding requests.

A2.2.3 All necessary action on each request will be completed as soon as possible. If more than 12 months lapse, the Secretary shall inform the requestor of the status of the request, with copies to the Chairs of the Committee and the Subcommittee. Requests still outstanding after 18 months shall be considered not to have been answered in a timely manner, and the Secretary shall report these to the Chair of the A5 Committee on Filler Metals and Allied Materials for action.

A2.2.4 The Secretary shall include a copy of the log of all requests pending and those completed during the preceding year with the agenda for each A5 Committee on Filler Metals and Allied Materials meeting. Any other publication of requests that have been completed will be at the option of the American Welding Society, as deemed appropriate.

A2.3 Compositions of bare welding filler metal in AWS A5.7 similar to those in this specification are shown in Table A.1.

A2.4 An international system for designating welding filler metals is under development by the International Institute of Welding (IIW) for use in future specifications to be issued by the International Standards Organization (ISO). Table A.1 shows the proposed designations for

copper-alloy filler metals. To understand the proposed international designation system, refer to Table 12A and the Annex of AWS publication IFS 2002, *International Index of Welding Filler Metal Classifications*.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with AWS A5.01, *Filler Metal Procurement Guidelines*, as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this specification, needs to be clearly stated in the purchase order, according to the provisions of AWS 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 AWS A5.01. Testing in accordance with any other Schedule in that Table must be specifically required by the purchase order. In such cases, acceptance of the material shipped 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 of the requirements of the specification. The only testing requirement implicit in this "certification" is that the manufacturer has actually conducted the tests required by the specification on material that is representative of that being shipped and that the tested material met the requirements of the specification. Representative material, in this case, is any production run of that classification using the same formulation. "Certification" is not to be construed to mean that tests of any kind were necessarily conducted on samples of the specific material shipped. Tests on such material may or may not have been conducted. The basis for the "certification" required by the specification is the classification test of "representative material" cited above, and the "Manufacturer's Quality Assurance System" in AWS A5.01.

Table A.1 Comparison of Specifications		
Covered Electrodes A5.6/A5.6M	Bare Rods and Electrodes A5.7/A5.7M ^a	Proposed ISO Designations ^b
ECu	ERCu	EC1898
ECuSi	ERCuSi-A	EC6560
ECuSn-A	ERCuSn-A	EC5180
ECuSn-C	ERCuSn-C	EC5210
ECuNi	ERCuNi	EC7158
—	ERCuAl-A1	EC6100
ECuAl-A2	ERCuAl-A2	EC6180
—	ERCuAl-A3	EC6240
ECuAl-B	—	EC6220
ECuNiAl	ERCuNiAl	EC6328
ECuMnNiAl	ERCuMnNiAl	EC6338

^a AWS A5.7/A5.7M, *Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes*.

^b AWS Publication IFS:2002, *International Index of Filler Metal Classifications*, Table 12A. Also, Table 12B of that document covers bare welding materials which carry the initial letter, "SC," in place of "EC" for the comparable grades.

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. These are:

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

(2) Number of welders working in that space

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

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

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

A5.2 American National Standard 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 Section on Ventilation in that document. Further information concerning ventilation in welding can be found in AWS F3.2, *Ventilation Guide for Weld Fume*.

A6. Welding Considerations

A6.1 Before welding or heating any copper-base alloy, the base metal should be clean. Oil, grease, paint, lubricants, marking pencils, temperature indicating materials, threading compounds, and other such materials frequently contain sulfur, lead, or silver, that may cause cracking (embrittlement) of the base metal or the weld metal if present during welding or heating.

A6.2 Electrodes of some of the classifications are used for dissimilar metal welds. When making such welds, it is important to obtain as little dilution as possible from the dissimilar metal member (steels, for example). This can be done by traveling slowly to deposit a thicker bead and to dissipate the energy of the arc against the molten weld metal or the copper base metal, rather than the dissimilar metal member.

A6.3 Most of the electrodes in this specification are intended to be used with direct current, electrode positive (dcep) polarity. Some electrodes may be designated to operate also on alternating current, which makes them desirable for minimizing arc blow. The electrode manufacturer should be consulted to determine if the particular product is designed to be used with alternating current.

A7. Description and Intended Use of Electrodes

A7.1 Copper and copper-alloy electrodes generally operate with DCEP and the coverings often are hygroscopic.

A7.1.1 The supplier should be consulted regarding the following:

(1) Specific operating parameters and positions

(2) Recommended storage conditions and reconditioning temperatures.

A7.1.2 The weld area should be free from moisture and other contaminants.

A7.2 ECu Classification (Copper Electrodes). ECu electrodes are generally manufactured from deoxidized copper wire (essentially pure copper with small amounts of de-oxidizers added) and may be used for shielded metal arc welding (SMAW) of deoxidized coppers, oxygen-free coppers, and tough pitch (electrolytic) coppers.

The electrodes are also used to repair or surface these base metals as well as to surface steel and cast iron. Mechanically and metallurgically sound joints can best be made in deoxidized coppers.

Reactions with hydrogen in oxygen-free copper, and the segregation of copper oxide in tough pitch copper may detract from joint efficiency. However, when highest quality is not required, ECu electrodes may be successfully used on these base metals.

The high thermal conductivity of unalloyed coppers in thick sections may require preheat and interpass temperatures up to 1000°F [540°C].

A7.3 ECuSi Classification (Silicon Bronze). ECuSi electrodes contain approximately 3% silicon plus small percentages of manganese and tin. They are used primarily for welding copper-silicon alloys. ECuSi electrodes are occasionally used for the joining of copper, dissimilar metals, and some iron base metals. Silicon bronze weld metal seldom is used to surface bearing surfaces, but often is used to surface areas subject to corrosion.

A7.4 ECuSn Classification (Phosphor Bronze). ECuSn electrodes are used to join phosphor bronzes of similar compositions. They are also useful for joining brasses and, in some cases, for welding them to cast iron and carbon steel. ECuSn weld metals tend to flow sluggishly, requiring preheat and interpass temperatures of at least 400°F [200°C] on heavy sections. Post-weld heat treatment may not be necessary, but it is desirable for maximum ductility, particularly if the weld metal is to be cold worked.

A7.4.1 ECuSn-A electrodes are used primarily to join base metals of similar composition. They also may be used to weld copper if the resultant weld metal has adequate electrical conductivity and corrosion resistance for the specific application.

A7.4.2 ECuSn-C electrodes have higher tin content resulting in weld metals of higher hardness, tensile strength, and yield strength compared to ECuSn-A weld metal.

A7.5 ECuNi Classification (Copper-Nickel). Electrodes of the ECuNi classification are used for shielded metal arc welding (SMAW) of wrought or cast 70/30, 80/20, and 90/10 copper-nickel alloys to themselves or to each other. They also are used for welding the clad side of copper-nickel clad steel. Preheating generally is not necessary.

A7.6 ECuAl Classification (Aluminum Bronze)

A7.6.1 The copper-aluminum electrodes are used only in the flat position. For butt joints, a 90° single V-groove is recommended for plate thicknesses up to and including 7/16 in [10 mm]. A modified U- or double V-groove is recommended for heavier plate thicknesses. Preheat and interpass temperature should be as follows:

- (1) For iron-base materials, 200°F to 300°F [100°C to 150°C]
- (2) For bronzes, 300°F to 400°F [150°C to 200°C]
- (3) For brasses, 500°F to 600°F [250°C to 300°C]

A7.6.2 ECuAl-A2 electrodes are used in joining aluminum bronzes of similar composition, high strength copper-zinc alloys, silicon bronzes, manganese bronzes, some nickel alloys, many ferrous metals and alloys, and combinations of dissimilar metals. The weld metal is also suitable for surfacing wear- and corrosion-resistant bearing surfaces.

A7.6.3 ECuAl-B electrodes deposit weld metal having a higher tensile strength, yield strength, and hardness (with a correspondingly lower ductility) than ECuAl-A2 weld metal. ECuAl-B electrodes are used for repairing aluminum bronze and other copper-alloy castings. ECuAl-B weld metal also is used for wear- and corrosion-resistant bearing surfaces.

A7.6.4 ECuNiAl electrodes are used to join or repair cast or wrought nickel-aluminum bronze materials. These weld metals also may be used for applications requiring high resistance to corrosion, erosion, or cavitation in salt and brackish water.

A7.6.5 ECuMnNiAl electrodes are used to join or repair cast or wrought manganese-nickel-aluminum bronze materials. These weld metals exhibit excellent resistance to corrosion, erosion, and cavitation.

A8. Special Testing

A8.1 It is recognized that supplementary tests may be necessary to determine the suitability of these electrodes

for applications involving properties not considered in this specification. In such cases, additional tests to determine such specific properties as corrosion resistance, mechanical properties at low and high temperatures, and suitability for welding combinations of dissimilar metals may be required upon agreement between the purchaser and supplier.

A8.2 Tests for hardness are not included in this specification. For reference, however, a chart of typical hardness values is included as Table A.2.

A9. Discontinued Classifications

Some classifications have been discontinued from one revision of this specification to another. This results either from changes in commercial practice or changes in the classification system used in the specification. The classifications that have been discontinued are listed in Table A.3, along with the year in which they were last included in the specification.

A10. General Safety Considerations

A10.1 Safety and health issues and concerns are beyond the scope of this standard and, therefore, are not fully addressed herein. Some safety and health information can be found in Annex Clause A5. Safety and health informa-

Table A.2
Hardness of Copper
and Copper-Alloy Weld Metal

AWS Classification	Hardness ^a			
	Brinell		Vickers	
	HBS	Load, kgf	HV	Load, kgf
ECu	25 ^b	—	38	1
ECuSi	80–100	500	94–110	1
ECuSn-A	70–85	500	76–98	1
ECuSn-C	85–100	500	98–110	1
ECuNi	60–80	20	64–94	1
ECuAl-A2	130–150	3000	130–150	10
ECuAl-B	130–180	3000	140–184	10
ECuNiAl	160–200	3000	163–205	10
ECuMnNiAl	160–200	3000	163–205	10

^a These values are average values for an as-welded deposit made with the filler metal specified. This table is included for information only.

^b Rockwell F-scale (HRF).

Table A.3
Discontinued Classifications

Discontinued Classification	Last Year Published
ECuA1-A (Note a)	1948
ECuA1-C (Note b)	1948
ECuA1-D (Note c)	1948
ECuA1-E (Note d)	1948
ECuA1-A1 (Note a)	1969

^a This electrode classification was reclassified as ECuA1-A1 with a wider aluminum content by dropping the minimum allowable. That classification was later discontinued in 1977.

^b This older electrode classification, together with the old version of ECuA1-B, was reclassified into a new single electrode classification ECuA1-A2 with a combined wider range of aluminum, and is currently listed in this current revision. This older classification continues in the A5.13 specification, but with a higher aluminum content than was specified in A5.6-48T.

^c This older electrode classification became the newer version of ECuA1-B and still continues in the current specification. This older classification continues in the A5.13 specification, but with a higher aluminum content than was specified in A5.6-48T.

^d This older electrode classification was reclassified as ECuA1-C in the A5.13-56T specification. This older classification continues in the A5.13 specification, but with higher aluminum content than was specified in A5.6-48T.

tion is available from other sources, including, but not limited to, Safety and Health Fact Sheets listed in A10.3, ANSI Z49.1 *Safety in Welding, Cutting, and Allied Processes*, and applicable federal and state regulations.

A10.2 Safety and Health Fact Sheets. The Safety and Health Fact Sheets listed below 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.

A10.3 AWS Safety and Health Fact Sheets Index (SHF)⁹

No.	Title
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1	<i>Fumes and Gases</i>
2	<i>Radiation</i>
3	<i>Noise</i>
4	<i>Chromium and Nickel in Welding Fume</i>
5	<i>Electrical Hazards</i>
6	<i>Fire and Explosion Prevention</i>
7	<i>Burn Protection</i>
8	<i>Mechanical Hazards</i>
9	<i>Tripping and Falling</i>
10	<i>Falling Objects</i>
11	<i>Confined Spaces</i>
12	<i>Contact Lens Wear</i>

No.	Title
-----	-------

13	<i>Ergonomics in the Welding Environment</i>
14	<i>Graphic Symbols for Precautionary Labels</i>
15	<i>Style Guidelines for Safety and Health Documents</i>
16	<i>Pacemakers and Welding</i>
17	<i>Electric and Magnetic Fields (EMF)</i>
18	<i>Lockout/Tagout</i>
19	<i>Laser Welding and Cutting Safety</i>
20	<i>Thermal Spraying Safety</i>
21	<i>Resistance Spot Welding</i>
22	<i>Cadmium Exposure from Welding & Allied Processes</i>
23	<i>California Proposition 65</i>
24	<i>Fluxes for Arc Welding and Brazing: Safe Handling and Use</i>
25	<i>Metal Fume Fever</i>
26	<i>Arc Viewing Distance</i>
27	<i>Thoriated Tungsten Electrodes</i>
28	<i>Oxyfuel Safety: Check Valves and Flashback Arrestors</i>
29	<i>Grounding of Portable and Vehicle Mounted Welding Generators</i>
30	<i>Cylinders: Safe Storage, Handling, and Use</i>
31	<i>Eye and Face Protection for Welding and Cutting Operations</i>

⁹ AWS documents are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Annex B (Informative)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS A5.6/A5.6M:2008, *Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding*, but is included for informational purposes only.

B1. Introduction

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 interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

B2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

B2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry

along with the edition of the standard that contains the provision(s) the inquirer is addressing.

B2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

B2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

B2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

B3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS technical committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon approval by the committee, the interpretation is an official

interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

B4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

B5. 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 of Directors' policy 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.

B6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. 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.

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	A5.18	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	A5.9, A5.22	A5.22	A5.9	A5.9	A5.9	A5.8, A5.31
Cast Iron	A5.15	A5.15	A5.15	A5.15				A5.8, A5.31
Nickel Alloys		A5.11	A5.14	A5.34	A5.14			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
FMC	<i>Filler Metal Comparison Charts</i>
IFS	<i>International Index of Welding Filler Metal Classifications</i>
UGFM	<i>User's Guide to Filler Metals</i>
A4.2M (ISO 8249:2000 MOD)	<i>Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal</i>
A4.3	<i>Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding</i>
A4.4M	<i>Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings</i>
A5.01	<i>Filler Metal Procurement Guidelines</i>
A5.02/A5.02M	<i>Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes</i>
A5.1/A5.1M	<i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i>
A5.2/A5.2M	<i>Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding</i>
A5.3/A5.3M	<i>Specification for Aluminum and Aluminum-Alloy Electrodes for Shielded Metal Arc Welding</i>
A5.4/A5.4M	<i>Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding</i>
A5.5/A5.5M	<i>Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding</i>
A5.6/A5.6M	<i>Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding</i>
A5.7/A5.7M	<i>Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes</i>
A5.8/A5.8M	<i>Specification for Filler Metals for Brazing and Braze Welding</i>
A5.9/A5.9M	<i>Specification for Bare Stainless Steel Welding Electrodes and Rods</i>
A5.10/A5.10M	<i>Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods</i>
A5.11/A5.11M	<i>Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding</i>
A5.12/A5.12M	<i>Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting</i>
A5.13	<i>Specification for Surfacing Electrodes for Shielded Metal Arc Welding</i>
A5.14/A5.14M	<i>Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods</i>
A5.15	<i>Specification for Welding Electrodes and Rods for Cast Iron</i>
A5.16/A5.16M	<i>Specification for Titanium and Titanium Alloy Welding Electrodes and Rods</i>
A5.17/A5.17M	<i>Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding</i>
A5.18/A5.18M	<i>Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding</i>
A5.19	<i>Specification for Magnesium Alloy Welding Electrodes and Rods</i>
A5.20/A5.20M	<i>Specification for Carbon Steel Electrodes for Flux Cored Arc Welding</i>
A5.21	<i>Specification for Bare Electrodes and Rods for Surfacing</i>
A5.22	<i>Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding</i>
A5.23/A5.23M	<i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i>
A5.24/A5.24M	<i>Specification for Zirconium and Zirconium Alloy Welding Electrodes and Rods</i>
A5.25/A5.25M	<i>Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding</i>
A5.26/A5.26M	<i>Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding</i>
A5.28/A5.28M	<i>Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding</i>
A5.29/A5.29M	<i>Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding</i>
A5.30/A5.30M	<i>Specification for Consumable Inserts</i>
A5.31	<i>Specification for Fluxes for Brazing and Braze Welding</i>
A5.32/A5.32M	<i>Specification for Welding Shielding Gases</i>
A5.34/A5.34M	<i>Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding</i>

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