

ANSI/AWS A5.14/A5.14M-97
An American National Standard

**Specification for
Nickel and
Nickel-Alloy Bare
Welding Electrodes
and Rods**



American Welding Society

Key Words—Nickel, nickel-alloy, bare welding electrodes, strip, rods, filler metal specifications

ANSI/AWS A5.14/A5.14M-97
An American National Standard

Approved by
American National Standards Institute
December 8, 1997

Specification for

Nickel and Nickel-Alloy Bare

Welding Electrodes and Rods

Supersedes ANSI/AWS A5.14-89

Prepared by
AWS Committee on Filler Metals

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

The chemical compositions of more than thirty nickel and nickel-alloy welding electrodes and rods are specified, including ten compositions not previously classified. Major topics include general requirements, testing, packaging and application guidelines.

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

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

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International Standard Book Number: 0-87171-543-0

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Foreword

(This Foreword is not a part of AWS A5.14/A5.14M-97, *Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*, but is included for information purposes only.)

This document is the first of the A5.14 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 values in any way. In selecting rational metric units the ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry*, and International Standard ISO 864, *Solid Wires for Gas Shielded Metal Arc Welding of Mild Steel — Dimensions of Wires, Spools, Rims and Coils*, are used where suitable. Tables and figures make use of both U.S. Customary and SI Units, which with the application of the specified tolerances provides for interchangeability of products in both the U.S. Customary and SI Units.

The first specification for bare nickel and nickel-alloy welding electrodes and rods was prepared by a joint committee of the American Society for Testing and Materials and the American Welding Society and was issued in 1956. Eight years later, the first revision was prepared by the joint committee. This is the fifth revision prepared exclusively by the AWS Committee on Filler Metals.

Document Development

ASTM B304-56T	Tentative Specification for Nickel and
AWS A5.14-56T	Nickel-Base Alloy Bare Welding Filler Metals
AWS A5.14-64T	Tentative Specification for Nickel and
ASTM B304-64T	Nickel Alloy Bare Welding Rods and Electrodes
AWS A5.14-69T	Specification for Nickel and Nickel
ANSI W3.14-1973	Alloy Bare Welding Rods and Electrodes
ANSI/AWS A5.14-76	Specification for Nickel and Nickel Alloy Bare Welding Rods and Electrodes
ANSI/AWS A5.14-83	Specification for Nickel and Nickel Alloy Bare Welding Rods and Electrodes
ANSI/AWS A5.14-89	Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, Committee on Filler Metals, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures.

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

1. Scope

This specification prescribes requirements for the classification of bare nickel and nickel-alloy welding electrodes, strip electrodes, and welding rods. It includes those compositions where the nickel content exceeds that of any other element.

Part A *General Requirements*

2. Normative References

2.1 The following ANSI/AWS standards¹ are referenced in the mandatory sections of this document:

(1) ANSI/AWS A1.1, *Metric Procedure Guide for the Welding Industry*.

(2) ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

2.2 The following ASTM standards² are referenced in the mandatory sections of this document:

(1) ASTM E29, *Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.

(2) ASTM E38, *Standard Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys*.

(3) ASTM E76, *Standard Methods for Chemical Analysis of Nickel-Copper Alloys*.

1. AWS standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

2. ASTM standards can be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

3. Classification

3.1 The welding filler metals covered by the A5.14/A5.14M-97 specification are classified using a system that is independent of U.S. Customary Units and the International System of Units (SI). Classification is according to the chemical composition of the filler metal, as specified in Table 1.

3.2 A filler metal classified under one classification shall not be classified under any other classification in this specification.

3.3 The filler metals classified under this specification are intended for use with the plasma arc, gas metal arc, gas tungsten arc, and submerged arc welding processes, but this is not to prohibit their use with any other process for which they are found suitable.

4. Acceptance

Acceptance³ of the filler metal shall be in accordance with the provisions of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

5. Certification

By affixing the AWS Specification and Classification designations to the packaging, or the classification to the

3. See Annex Section A3, Acceptance, for further information concerning acceptance and testing of the material shipped, and ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

Table 1
Chemical Composition Requirements for Nickel and Nickel-Alloy Electrodes and Rods

AWS Classification ^m	UNS Number ^c	Weight-Percent ^{a,b}											Nb(Cb) plus Ta	Cr	Ti	Mo	V	W	Other Elements Total
		C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	2.0 to 3.5							
ERNi-1 ^k	N02061	0.15	1.0	1.0	0.03	0.015	0.75	0.25	93.0 min.	—	1.5	2.0 to 3.5	—	—	—	—	—	—	0.50
ERNiCu-7 ^k	N04060	0.15	4.0	2.5	0.02	0.015	1.25	Rem	62.0 to 69.0	—	1.25	1.5 to 3.0	—	—	—	—	—	—	0.50
ERNiCu-8 ^k	N05504	0.25	1.5	2.0	0.03	0.015	1.00	Rem	63.0 to 70.0	—	2.0 to 4.0	0.25 to 1.00	—	—	—	—	—	—	0.50
ERNiCr-3 ^{k,l}	N06082	0.10	2.5 to 3.5	3.0	0.03	0.015	0.50	0.50	67.0 min.	(e)	—	0.75	18.0 to 22.0	2.0 to 3.0 ^f	—	—	—	—	0.50
ERNiCr-4	N06072	0.01 to 0.10	0.20	0.50	0.02	0.015	0.20	0.50	Rem	—	—	0.3 to 1.0	42.0 to 46.0	—	—	—	—	—	0.50
ERNiCr-6 ^k	N06076	0.08 to 0.15	1.00	2.00	0.03	0.015	0.30	0.50	75.0 min.	—	0.40	0.15 to 0.50	19.0 to 21.0	—	—	—	—	—	0.50
ERNiCrFe-5 ^k	N06062	0.08	1.0	6.0 to 10.0	0.03	0.015	0.35	0.50	70.0 min.	(e)	—	—	14.0 to 17.0	1.5 to 3.0 ^f	—	—	—	—	0.50
ERNiCrFe-6 ^k	N07092	0.08	2.0 to 2.7	8.0	0.03	0.015	0.35	0.50	67.0 min.	—	—	2.5 to 3.5	14.0 to 17.0	—	—	—	—	—	0.50
ERNiCrFe-7 ⁱ	N06052	0.04	1.0	7.0 to 11.0	0.02	0.015	0.50	0.30	Rem	—	1.10	1.0	28.0 to 31.5	0.10	0.50	—	—	—	0.50
ERNiCrFe-8 ^k	N07069	0.08	1.0	5.0 to 9.0	0.03	0.015	0.50	0.50	70.0 min.	—	0.4 to 1.0	2.00 to 2.75	14.0 to 17.0	0.70 to 1.20	—	—	—	—	0.50

(continued)

Table 1 (Continued)

AWS Classification ^m	UNS Number ^c	Weight-Percent ^{a,b}															Other Elements Total	
		C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	Ti	Cr	Nb plus Ta	Mo	V		W
ERNiCrFe-11	N06601	0.10	1.0	Rem	0.03	0.015	0.50	1.0	58.0 to 63.0	—	1.0 to 1.7	—	21.0 to 25.0	—	—	—	—	0.50
ERNiFeCr-1 ^k	N08065	0.05	1.0	22.0 min.	0.03	0.03	0.50	1.5 to 3.0	38.0 to 46.0	—	0.20	0.6 to 1.2	19.5 to 23.5	—	2.5 to 3.5	—	—	0.50
ERNiFeCr-2 ⁸	N07718	0.08	0.35	Rem	0.015	0.015	0.35	0.30	50.0 to 55.0	—	0.20 to 0.80	0.65 to 1.15	17.0 to 21.0	4.75 to 5.50	2.80 to 3.30	—	—	0.50
ERNiMo-1	N10001	0.08	1.0	4.0 to 7.0	0.025	0.03	1.0	0.50	Rem	2.5	—	—	1.0	—	26.0 to 30.0	0.20 to 0.40	1.0	0.50
ERNiMo-2	N10003	0.04 to 0.08	1.0	5.0	0.015	0.02	1.0	0.50	Rem	0.20	—	—	6.0 to 8.0	—	15.0 to 18.0	0.50	0.50	0.50
ERNiMo-3	N10004	0.12	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	4.0 to 6.0	—	23.0 to 26.0	0.60	1.0	0.50
ERNiMo-7	N10665	0.02	1.0	2.0	0.04	0.03	0.10	0.50	Rem	1.0	—	—	1.0	—	26.0 to 30.0	—	1.0	0.50
ERNiMo-8	N10008	0.10	1.0	10.0	0.015	0.015	0.50	0.50	60.0 min.	—	—	—	0.5 to 3.5	—	18.0 to 21.0	—	2.0 to 4.0	0.50
ERNiMo-9	N10009	0.10	1.0	5.0	0.015	0.015	0.50	0.3 to 1.3	65.0 min.	—	1.0	—	—	—	19.0 to 22.0	—	2.0 to 4.0	0.50
ERNiMo-10 ⁿ	N10675	0.01	3.0	1.0 to 3.0	0.03	0.01	0.10	0.20	65.0 min.	3.0	0.50	0.20	1.0 to 3.0	0.20	27.0 to 32.0	0.20	3.0	0.50

(continued)

Table 1 (Continued)

		Weight-Percent ^{a,b}																		
AWS Classification ^m	UNS Number ^c	C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	Ti	Cr	Nb plus Ta	Mo	V	W	Other Elements Total		
ERNiCrMo-1	N06007	0.05	1.0 to 2.0	18.0 to 21.0	0.04	0.03	1.0	1.5 to 2.5	Rem	2.5	—	—	21.0 to 23.5	1.75 to 2.50	5.5 to 7.5	—	1.0	0.50		
ERNiCrMo-2	N06002	0.05 to 0.15	1.0	17.0 to 20.0	0.04	0.03	1.0	0.50	Rem	0.5 to 2.5	—	—	20.5 to 23.0	—	8.0 to 10.0	—	0.2 to 1.0	0.50		
ERNiCrMo-3 ^k	N06625	0.10	0.50	5.0	0.02	0.015	0.50	0.50	58.0 min.	—	0.40	0.40	20.0 to 23.0	3.15 to 4.15	8.0 to 10.0	—	—	0.50		
ERNiCrMo-4	N10276	0.02	1.0	4.0 to 7.0	0.04	0.03	0.08	0.50	Rem	2.5	—	—	14.5 to 16.5	—	15.0 to 17.0	0.35	3.0 to 4.5	0.50		
ERNiCrMo-7	N06455	0.015	1.0	3.0	0.04	0.03	0.08	0.50	Rem	2.0	—	0.70	14.0 to 18.0	—	14.0 to 18.0	—	0.50	0.50		
ERNiCrMo-8	N06975	0.03	1.0	Rem	0.03	0.03	1.0	0.7 to 1.2	47.0 to 52.0	—	—	0.70 to 1.50	23.0 to 26.0	—	5.0 to 7.0	—	—	0.50		
ERNiCrMo-9	N06985	0.015	1.0	18.0 to 21.0	0.04	0.03	1.0	1.5 to 2.5	Rem	5.0	—	—	21.0 to 23.5	0.50	6.0 to 8.0	—	1.5	0.50		
ERNiCrMo-10	N06022	0.015	0.50	2.0 to 6.0	0.02	0.010	0.08	0.50	Rem	2.5	—	—	20.0 to 22.5	—	12.5 to 14.5	0.35	2.5 to 3.5	0.50		
ERNiCrMo-11	N06030	0.03	1.5	13.0 to 17.0	0.04	0.02	0.80	1.0 to 2.4	Rem	5.0	—	—	28.0 to 31.5	0.30 to 1.50	4.0 to 6.0	—	1.5 to 4.0	0.50		
ERNiCrMo-13	N06059	0.010	0.5	1.5	0.015	0.005	0.10	—	Rem	0.3	0.1 to 0.4	—	22.0 to 24.0	—	15.0 to 16.5	—	—	0.50		

(continued)

Table 1 (Continued)

AWS Classification ^m	UNS Number ^c	Weight-Percent ^{a,b}													Nb plus Ta	Mo	V	W	Other Elements Total
		C	Mn	Fe	P	S	Si	Cu	Ni ^d	Co	Al	Ti	Cr						
ERNiCrMo-14	N06686	0.01	1.0	5.0	0.02	0.02	0.08	0.5	Rem	—	0.5	0.25	19.0 to 23.0	—	15.0 to 17.0	—	3.0 to 4.4	0.50	
ERNiCrMo-15	N07725	0.03	0.35	Rem	0.015	0.01	0.20	—	55.0 to 59.0	—	0.35	1.0 to 1.7	19.0 to 22.5	2.75 to 4.00	7.0 to 9.5	—	—	0.50	
ERNiCrCoMo-1	N06617	0.05 to 0.15	1.0	3.0	0.03	0.015	1.0	0.50	Rem	10.0 to 15.0	0.8 to 1.5	0.60	20.0 to 24.0	—	8.0 to 10.0	—	—	0.50	
ERNiCrWMo-1 ^{h,i}	N06231	0.05 to 0.15	0.3 to 1.0	3.0	0.03	0.015	0.25 to 0.75	0.50	Rem	5.0	0.2 to 0.5	—	20.0 to 24.0	—	1.0 to 3.0	—	13.0 to 15.0	0.50	

Notes:

- The weld metal shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of the work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "Other Elements, Total" in the last column of the table.
- Single values are maximum, except where otherwise specified. Rem = remainder.
- ASTM/SAE Unified Numbering System for Metals and Alloys.
- Includes incidental cobalt.
- Co is 0.12 maximum when specified by the purchaser.
- Mil-E-21562E type; Ta is 0.30 maximum.
- Boron is 0.006 maximum.
- Boron is 0.003 maximum.
- La is 0.050 maximum.
- Al + Ti is 1.5 maximum.
- Mil-E-21562E type; Pb < 0.010. "Other Elements Total" shall include Pb, Sn, Zn.
- When EN82H or RH82H is specified, Carbon is 0.03 to 0.10.
- For strip, the classification designator "P" shall be replaced with "Q."
- Ni + Mo is 94.0 to 98.0; Ta is 0.02 max; Zr is 0.10 max.

product, the manufacturer certifies that the product meets the requirements of this specification.⁴

6. Units of Measure and Rounding-Off Procedure

6.1 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 values in any way. The specification with designation A5.14-97 uses U.S. Customary Units. The specification with the designation A5.14M-98 uses SI Units. The latter are shown in appropriate columns in tables and in figures, and within brackets [] when used in text.

6.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value in accordance with the rounding-off method given in ASTM E29, *Standard Practice for Using Significant Digits in Tests to Determine Conformance with Specifications*.

Part B *Tests, Procedures, and Requirements*

7. Summary of Tests

Chemical analysis of the filler metal, or the stock from which it was made, is the only test required for classification of a product under this specification.

8. Retest

If the results of any test fail to meet the requirement of that test, that test shall be repeated twice. The results of both retests shall meet the requirement. Material for retest may be taken from the original test sample or from a new sample. 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

⁴ See Annex Section A4, Certification, for further information concerning certification and the testing called for to meet this requirement.

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 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 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 of the number of test specimens does not apply.

9. Chemical Analysis

9.1 A sample of the filler metal, or the stock from which it was made, shall be prepared for chemical analysis.

9.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be either ASTM E38, *Standard Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys*, or ASTM E76, *Standard Methods for Chemical Analysis of Nickel-Copper Alloys*, as appropriate.

9.3 The results of the analysis shall meet the requirements set forth in Table 1, for the classification of filler metal under test.

Part C *Manufacture, Identification, and Packaging*

10. Method of Manufacture

The filler metals classified according to this specification may be made by any method that will produce material that meets the requirements of this specification.

11. Standard Sizes

11.1 Standard sizes for filler metal in the different package forms (straight lengths, coils with support, coils without support, and spools (see Section 13) are shown in Table 2.

11.2 Standard sizes for strip electrodes in coils (see Section 13) are shown in Table 3.

Table 2
Standard Sizes of Electrodes and Rods^a

Standard Package Form	Diameter		Tolerance ^b	
	in.	mm	in.	mm
Straight length ^c , coils with supports and coils without supports	1/16	1.6	±0.002	+0.01, -0.07
	3/32	2.4		
	—	2.5		
	1/8	3.2		
	5/32	4.0		
	3/16	4.8 ^d		
Spools	—	5.0	+0.001, -0.002	+0.01, -0.04
	1/4	6.4 ^d		
	0.020	0.5		
	0.030	0.8		
	0.035	0.9		
	0.045	1.14 ^d		
	—	1.2		
	0.062	1.6		
	(1/16)			

Notes:

- a. Dimensions, sizes, tolerances, and package forms other than those shown shall be agreed upon by the purchaser and supplier.
b. Out of roundness (the difference between the major and minor diameters) shall not exceed one-half of the tolerance.
c. Length shall be 36 in. +0, -1/2 in. [900 mm ± 2%].
d. Metric sizes not shown in ISO 864.

Table 3
Standard Sizes of Strip Electrodes^{a,b}

Width		Thickness	
in.	mm	in.	mm
1.18	30	0.020	0.5
2.36	60		
3.54	90		
4.72	120		

Notes:

- a. Other sizes shall be as agreed upon by the purchaser and supplier.
b. Strip electrodes shall not vary more than ±0.008 in. [±0.20 mm] in width and more than ±0.002 in. [±0.05 mm] in thickness.

12. Finish and Uniformity

12.1 All filler metal shall have a smooth finish that is free from slivers, depressions, scratches, scale, seams, laps, and foreign matter that would adversely affect the welding characteristics, the operation of the welding equipment, or the properties of the weld metal.

12.2 Each continuous length of filler metal shall be from a single heat of material, and welds, when present, shall have been made so as not to interfere with the uniform, uninterrupted feeding of the filler metal on automatic and semiautomatic equipment.

13. Standard Package Forms

13.1 Standard package forms are straight lengths, coils with support, coils without support, and spools. Standard package dimensions and weights for each form are given in Table 4. Package forms, sizes and weights other than these shall be as agreed between purchaser and supplier.

13.2 The liners in coils with support shall be designed and constructed to prevent distortion of the coil during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the filler metal.

13.3 Spools shall be designed and constructed to prevent distortion of the filler metal during normal handling and use and shall be clean and dry enough to maintain the cleanliness of the filler metal (See Figure 1).

14. Winding Requirements

14.1 Filler metal on spools and in coils shall be wound so that kinks, waves, sharp bends, overlapping, or wedging are not encountered, leaving the filler metal free to unwind without restriction. The outside end of the filler metal (the end with which welding is to begin) shall be identified so that it can be readily located and shall be fastened to avoid unwinding.

14.2 The cast and helix of filler metal in coils shall be such that the filler metal will feed in an uninterrupted manner on automatic and semiautomatic equipment.

14.3 The cast and helix of filler metal on 4-in. [100-mm] spools shall be such that a specimen long enough to produce a single loop, when cut from the spool and laid unrestrained on a flat surface, will do the following:

- (1) form a circle not less than 2.5 in. [60 mm] nor more than 15 in. [380 mm] in diameter, and
- (2) rise above the flat surface no more than 1/2 in. [13 mm] at any location.

14.4 The cast and helix of filler metal on 8-in. [200-mm] spools shall be such that a specimen long enough to produce a single loop, when cut from the spool and laid unrestrained on a flat surface, will do the following:

- (1) form a circle not less than 10 in. [250 mm] nor more than 35 in. [890 mm] in diameter, and
- (2) rise above the flat surface no more than 3/4 in. [19 mm] at any location.

14.5 The cast and helix of filler metal on 12-in. [300-mm] spools shall be such that a specimen long enough to produce a single loop, when cut from the spool and laid unrestrained on a flat surface, will do the following:

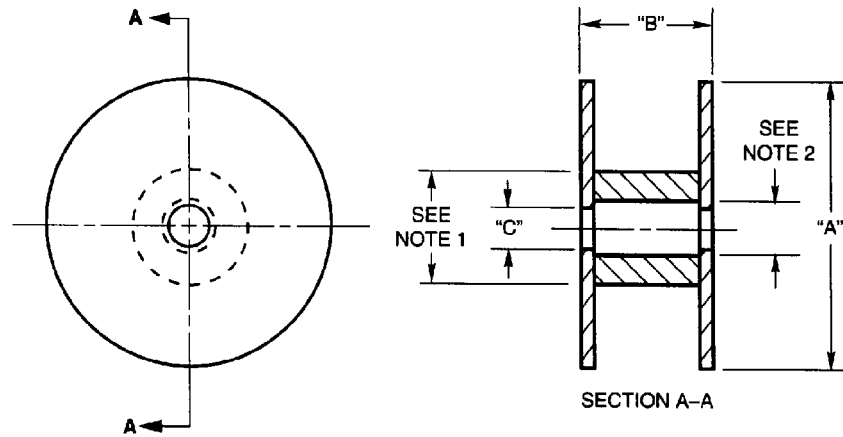
- (1) form a circle not less than 15 in. [380 mm] nor more than 50 in. [1300 mm] in diameter, and

Table 4
Standard Package Dimensions and Weights^a

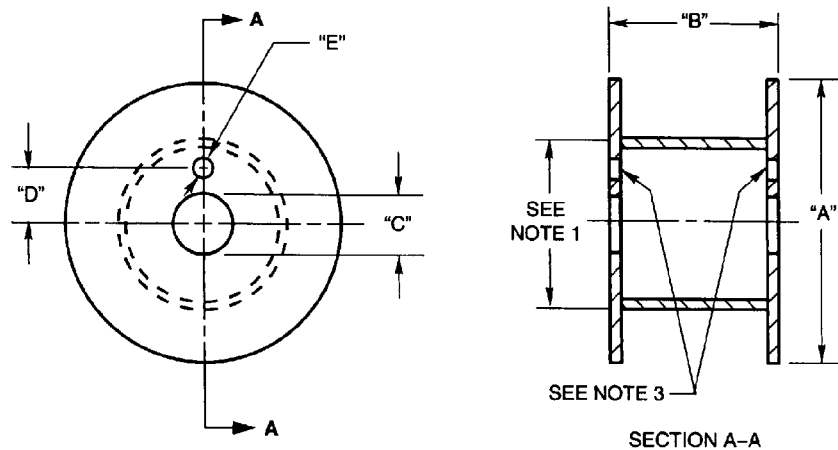
Bare Wire, Rods									
Electrode Size ^b		Net Weight ^c		Width		Diameter ^h Inside		Outside, Max	
in.	mm	lb	kg	in.	mm	in.	mm	in.	mm
Straight Lengths									
1/16-1/4	1.6-6.4	5	2.2	—	—	—	—	—	—
		10	4.5	—	—	—	—	—	—
		25	11	—	—	—	—	—	—
Coils with Support									
1/16-1/4	1.6-6.4	25	11	2.5	65	12	305	17.5	445
		50	23						
1/16-1/4	1.6-6.4	60	27	4.6	120	12	305	17	430
1/16-1/4	1.6-6.4	100	45	5	125	— Not Specified ^d —		31.5	800
		150	68						
		200	91						
Coils without Support									
1/16-1/4	1.6-6.4	— as agreed by the purchaser and supplier —							
Spools ^e									
0.020-0.062	0.5-1.6	2	0.9 ^f					4	102
		10	4.5 ^f					8	203
		25	11.0 ^g					12	305
Strip Electrodes									
Strip Width		Net Weight ^c		Diameter ^h Inside					
in.	mm	lb	kg	in. mm					
1.18	30	60	30	12 300					
2.36	60	60	30						
3.54	90	120	55						
4.72	120	120	55						

Notes:

- a. Sizes, weights and dimensions other than those listed above shall be agreed upon by the purchaser and supplier.
b. The range is inclusive, as shown in Table 2.
c. Net weights shall not vary more than ± 10 percent.
d. The inside diameter of the liner shall be agreed upon by the purchaser and the supplier.
e. The dimensions of standard spools are specified in Figure 1.
f. Tolerance is ± 20 percent.
g. Tolerance is ± 20 percent, except that 20 percent of any lot may contain spools that vary in net weight from 5.7 to 9.1 kg.
h. Tolerance is $\pm 1/8$ in. [± 3 mm].



DIMENSIONS OF STANDARD 4 in. (100 mm) SPOOL



DIMENSIONS OF STANDARD 8 AND 12 in. (200 AND 300 mm) SPOOLS

Spool Size	"A" Diameter, maximum ⁴		"B" Width		"C" Diameter		"D" Distance Between Axes		"E" Diameter ³	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
4 in. [100 mm]	4	102	1.75	46	0.63	16	—	—	—	—
Tolerance	—	—	±0.03	+0, -2	+0.01, -0	+1, -0	—	—	—	—
8 in. [200 mm]	8	203	2.16	56	2.03	50.5	1.75	44.5	0.44	10
Tolerance	—	—	±0.03	+0, -3	+0.06, -0	+2.5, -0	±0.02	±0.5	+0, -0.06	+1, -0
12 in. [300 mm]	12	305	4.0	103	2.03	50.5	1.75	44.5	0.44	10
Tolerance	—	—	±0.06	+0, -3	+0.06, -0	+2.5, -0	±0.02	±0.5	+0, -0.06	+1, -0

Notes:

1. Outside diameter of barrel shall be such as to permit proper feeding of the filler metals.
2. Inside diameter of the barrel shall be such that swelling of the barrel or misalignment of the barrel and flanges will not result in the core of the spool being less than the inside diameter of the flange (dimension "C").
3. Holes are provided on each flange, but they need not be aligned.
4. Metric dimensions and tolerances conform to ISO 864 except that "A" specifies ± tolerances on the nominal diameter, rather than a plus tolerance only, which is shown here as a maximum.

Figure 1—Dimensions of Standard Spools

(2) rise above the flat surface no more than 1 in. [25 mm] at any location.

15. Filler Metal Identification

15.1 The product information and the precautionary information required in Section 17 for marking each package shall also appear on each coil and spool.

15.2 Coils without support shall have a tag containing this information securely attached to the filler metal at the inside end of the coil.

15.3 Coils with support shall have the information securely affixed in a prominent location on the support.

15.4 Spools shall have the information securely affixed in a prominent location on the outside of at least one flange of the spool.

16. Packaging

Filler metal shall be suitably packaged to ensure against damage during shipment and storage under normal conditions.

17. Marking of Packages

17.1 The following product information (as a minimum) shall be legibly marked so as to be visible from the outside of each unit package:

- (1) AWS specification and classification designation (year of issue may be excluded)
- (2) Supplier's name and trade designation
- (3) Size and net weight

- (4) Lot, control, or heat number

17.2 The following precautionary information, or its equivalent (as a minimum), shall be prominently displayed in legible print on all packages of filler metal, including individual unit packages enclosed within a larger package.

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES and GASES can be hazardous to your health.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can KILL.

- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases away from your breathing zone and the general area.
- Wear correct eye, ear, and body protection.
- Do not touch live electrical parts.
- See American National Standard ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126; and OSHA Safety and Health Standards, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, DC 20402.

DO NOT REMOVE THIS INFORMATION

Annex

Guide to AWS Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods

(This Annex is not a part of ANSI/AWS A5.14/A5.14M-97, *Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*, but is included for information purposes only.)

A1. Introduction

The purpose of this guide is to correlate the nickel and nickel-alloy bare welding electrodes and rods classifications with their intended applications so they can be used effectively. Reference to appropriate base-metal specifications is made whenever that can be done and when it would be helpful. Such references are intended only as examples rather than a complete listing of the materials for which each filler metal is suitable.

A2. Classification System

A2.1 The system for classifying the filler metals in this specification follows the standard pattern used in other AWS filler metal specifications. The letters "ER" at the beginning of each classification designation stand for electrode and rod, indicating that the filler metal may be used either way. The substitution of the letters "EQ" for "ER" at the beginning of a classification indicates that the product is being supplied as strip electrode (see Table 1, Note m).

A2.2 Since the filler metals are classified according to their chemical composition, the chemical symbol "Ni" appears immediately after the "ER" (or "EQ") as a means of identifying the filler metal as a nickel-base alloy. The other symbols (Cr, Co, Cu, Fe, Mo, and W) in the designations are intended to group the filler metals according to their principal alloying elements. The individual designations are made up of these symbols plus a number at the end of the designation (ERNiMo-1 or ERNiMo-2, for example). These numbers separate one

composition from another within a group and are not repeated within that group.

A2.3 From an application point of view, most of the filler metal classifications in this specification have a corresponding classification in ANSI/AWS A5.11/A5.11M, *Specification for Nickel and Nickel-Alloy Covered Welding Electrodes*. For those cases in which there is a corresponding application for a bare electrode or rod "ER" and a covered electrode "E," Table A1 correlates the "ER" classification in this edition with those in the previous edition of this specification and with the corresponding covered electrode "E" classification in ANSI/AWS A5.11/A5.11M. It also lists the current designation for each classification as it is given in Military Specification MIL-E-21562E, when such a designation exists.

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 A1 shows the proposed designations for nickel-alloy filler metals. In that system, the initial "S" designates a solid wire or rod, the letter "N" the alloy system, followed by a four-digit number. For nickel alloys, the four-digit number is based upon the UNS number (see Table 1), one of the five digits of which has been eliminated.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with ANSI/AWS

Table A1
Comparison of Classifications

Present Classification	UNS Number	Military Designation ^a	Corresponding Classification in A5.11/A5.11M	Proposed ISO Designation ^b
ERNi-1	N02061	EN61 & RN61	ENi-1	SN2061
ERNiCu-7	N04060	EN60 & RN60	ENiCu-7	SN4060
ERNiCu-8 ^c	N05504	EN64 & RN64	—	—
ERNiCr-3	N06082	EN82 & RN82 EN82H & RN82H	ENiCrFe-3	SN6082
ERNiCr-4 ^c	N06072	—	—	—
ERNiCr-6 ^c	N06076	EN6N & RN6N	—	—
ERNiCrFe-5	N06062	EN62 & RN62	ENiCrFe-1	SN6062
ERNiCrFe-6	N07092	EN6A & RN6A	ENiCrFe-2	SN6092
ERNiCrFe-7 ^c	N06052	—	ENiCrFe-7	SN6052
ERNiCrFe-8 ^c	N07069	RN69	—	—
ERNiCrFe-10 ^c	N06601	—	—	SN6601
ERNiFeCr-1	N08065	RN65	—	SN8065
ERNiFeCr-2	N07718	—	—	SN7718
ERNiMo-1	N10001	—	ENiMo-1	—
ERNiMo-2	N10003	—	—	—
ERNiMo-3	N10004	—	ENiMo-3	—
ERNiMo-7	N10665	—	ENiMo-7	SN1066
ERNiMo-8 ^c	N10008	—	ENiMo-8	—
ERNiMo-9 ^c	N10009	—	ENiMo-9	—
ERNiMo-10 ^c	N10675	—	ENiMo-10	—
ERNiCrMo-1	N06007	—	ENiCrMo-1	—
ERNiCrMo-2	N06002	—	ENiCrMo-2	SN6002
ERNiCrMo-3	N06625	EN625 & RN625	ENiCrMo-3	SN6625
ERNiCrMo-4	N10276	—	ENiCrMo-4	SN6276
ERNiCrMo-7	N06455	—	ENiCrMo-7	SN6455
ERNiCrMo-8	N06975	—	—	—
ERNiCrMo-9	N06985	—	ENiCrMo-9	SN6985
ERNiCrMo-10	N06022	—	ENiCrMo-10	SN6022
ERNiCrMo-11	N06030	—	ENiCrMo-11	SN6030
ERNiCrMo-13 ^c	N06059	—	ENiCrMo-13	SN6059
ERNiCrMo-14 ^c	N06686	—	ENiCrMo-14	SN6686
ERNiCrMo-15 ^c	N07725	—	—	—
ERNiCrCoMo-1	N06617	—	ENiCrCoMo-1	—
ERNiCrWMo-1 ^c	N06231	—	—	—

Notes:

a. MIL E-21562E

b. IIW Doc XII-1466-96

c. New classification

A5.01, as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this specification, shall be clearly stated in the purchase order, according to the provisions of ANSI/AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing is normally conducted on material of that classification, as specified in Schedule F, Table 1, of ANSI/AWS A5.01. Testing in accordance with any other Schedule in that Table must be specifically required by the purchase order. In such cases, acceptance of the material shipped 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 material met the requirements of the specification. Representative material, in this case, is any production run of that classi-

fication 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 tests of "representative material" cited above, and the "Manufacturer's Quality Assurance System" in ANSI/AWS A5.01.

A5. Ventilation During Welding

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

- (1) Dimensions of the space in which welding is done (with special regard to the height of the ceiling), and
- (2) Number of welders and welding operators working in the space, and
- (3) Rate of evolution of fumes, gases, or dust, according to the materials and processes involved, and
- (4) The proximity of the welder or welding operator to the fumes as they issue from the welding zone and to the gases and dust in the space in which the welder is working, and
- (5) The ventilation provided to the space in which the welding is done.

A5.2 American National Standard ANSI/ASC 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 of that document dealing with ventilation.

A6. Welding Considerations

A6.1 The filler metals in this specification can be used with any of a variety of welding processes. Most notable among them are gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), submerged arc welding (SAW), and plasma arc welding (PAW). SAW and PAW are quite specialized, and the supplier of the filler metals should be consulted for recommendations concerning their use. General suggestions are given below for the other two processes.

A6.2 Before welding or heating any nickel-base alloy, the base metal must be clean. Oil, grease, paint, lubricants, marking pencils, temperature indicating materials, threading compounds and other such materials frequently contain sulfur or lead that may cause cracking (embrittlement) of the base metal or the weld metal if present during welding or heating.

A6.3 For GTAW, direct current-electrode negative (dcen) is used. High-purity grades of either argon or helium (or a combination of the two) are used as a shielding gas.

A6.4 For GMAW, direct current-electrode positive (dcep) is employed. Argon shielding gas is often used, but mixtures of argon and helium are also commonly used.

A7. Description and Intended Use of Electrodes and Rods

A7.1 ERNi-X Classification (ERNi-1). The nominal composition (wt.-%) of weld metal of this classification is 96 Ni, 3 Ti. Filler metal of this classification is intended for welding wrought and cast forms of commercially pure nickel alloy (ASTM B160, B161, B162, and B163 having UNS numbers N02200 or N02201) to itself using the GTAW, GMAW, SAW, and PAW processes. The filler metal contains sufficient titanium to control weld-metal porosity with these welding processes.

A7.2 ERNiCu-X Classifications

A7.2.1 ERNiCu-7 Classification. The nominal composition (wt.-%) of weld metal of this classification is 65 Ni, 30 Cu, 3 Mn, 2 Ti. Filler metal of this classification is used for welding nickel-copper alloy (ASTM B127, B163, B164, and B165 having UNS number N04400) to itself using the GTAW, GMAW, SAW, and PAW processes. The filler metal contains sufficient titanium to control porosity with these welding processes.

A7.2.2 ERNiCu-8 Classification. The nominal composition (wt.-%) of weld metal of this classification is 66 Ni, 29 Cu, 3 Al, 1 Fe, 0.5 Ti. Filler metal of this classification is used for welding age-hardening nickel-copper alloy (ASTM F467, and F468 having UNS number N05500) to itself using the GTAW, GMAW, SAW, and PAW processes. The filler metal will age harden on heat treatment. For specific information concerning age hardening, consult the supplier or the supplier's technical literature.

A7.3 ERNiCr-X Classifications

A7.3.1 ERNiCr-3. The nominal composition (wt.-%) of weld metal of this classification is 72 Ni, 20 Cr, 3 Mn, 2.5 Nb plus Ta. Filler metal of this classification is used for welding nickel-chromium-iron alloy (ASTM B163, B166, B167, and B168 having UNS number N06600) to itself, for the clad side of joints in steel clad with nickel-chromium-iron alloy, for surfacing steel with nickel-chromium-iron weld metal, for dissimilar welding of nickel-base alloys, and for joining steel to nickel-base

alloys using the GTAW, GMAW, SAW, and PAW processes.

A7.3.2 ERNiCr-4. The nominal composition (wt.-%) of weld metal of this classification is 55 Ni, 44 Cr. Filler metal of this classification is used for GTAW of 50/50 nickel/chromium alloy, cladding nickel/chromium alloy onto nickel-iron-chromium tubing, and casting repair. The filler metal is resistant to high-temperature corrosion, including fuel-ash corrosion in atmospheres containing sulfur and vanadium.

A7.3.3 ERNiCr-6. The nominal composition (wt.-%) of weld metal of this classification is 78 Ni, 20 Cr, 1 Fe, 0.4 Ti. Filler metal of this classification is used for welding nickel-chromium-iron alloy (ASTM B163, B166, B167, and B168 having UNS number N06600) to itself, for the clad side of joints in steel clad with nickel-chromium-iron alloy, for surfacing steel with nickel-chromium-iron weld metal, and for joining steel to nickel-base alloys using the GTAW, GMAW, SAW, and PAW processes.

A7.4 ERNiCrFe-X Classifications

A7.4.1 ERNiCrFe-5. The nominal composition (wt.-%) of weld metal of this classification is 74 Ni, 16 Cr, 8 Fe, 2 Nb plus Ta. Filler metal of this classification is used for welding nickel-chromium-iron alloy (ASTM B163, B166, B167, and B168 having UNS number N06600) to itself using the GTAW, GMAW, SAW, and PAW processes. The higher niobium content of the filler metal is intended to minimize cracking where high welding stresses are encountered, as in thick-section base metal.

A7.4.2 ERNiCrFe-6. The nominal composition (wt.-%) of weld metal of this classification is 71 Ni, 16 Cr, 6 Fe, 3 Ti, 2.5 Mn. Filler metal of this classification is used for cladding steel with nickel-chromium-iron weld metal and for joining steel to nickel-base alloys using the GTAW, GMAW, SAW, and PAW processes. The weld metal will age harden on heat treatment. For specific information concerning age hardening, consult the supplier or the supplier's technical literature.

A7.4.3 ERNiCrFe-7. The nominal composition (wt.-%) of weld metal of this classification is 60 Ni, 29 Cr, 9 Fe. Filler metal of this classification is used for welding nickel-chromium-iron alloy (ASTM B163, B166, B167, and B168 having UNS number N06690) to itself, to steels, to overlay on steels, and to weld steels clad with the nickel-chromium-iron alloys using the GTAW, GMAW, SAW, and PAW processes.

A7.4.4 ERNiCrFe-8. The nominal composition (wt.-%) of weld metal of this classification is 73 Ni, 15.5 Cr, 7 Fe, 2.4 Ti, 1 Nb, 0.7 Al. Filler metal of this classification is used for cladding steel with nickel-chromium-iron

weld metal and for joining steel to nickel-base alloys using the GTAW, GMAW, SAW, and PAW processes. The weld metal will age harden on heat treatment. For specific information concerning age hardening, consult the supplier or the supplier's technical literature.

A7.4.5 ERNiCrFe-11. The nominal composition (wt.-%) of weld metal of this classification is 61 Ni, 23 Cr, 14 Fe, 1.4 Al. Filler metal of this classification is used for welding nickel-chromium-iron-aluminum alloy (ASTM B166, B167, and B168 having UNS number N06601) to itself and to other high-temperature compositions using the GTAW process. It is used for severe applications where the exposure temperature can exceed 2100°F [1150°C].

A7.5 ERNiFeCr-X Classifications

A7.5.1 ERNiFeCr-1. The nominal composition (wt.-%) of weld metal of this classification is 42 Ni, 30 Fe, 21 Cr, 3 Mo, 2 Cu. Filler metal of this classification is used for welding the nickel-iron-chromium-molybdenum-copper alloy (ASTM B423 having UNS number N08825) to itself using the GTAW and GMAW processes.

A7.5.2 ERNiFeCr-2. The nominal composition (wt.-%) of weld metal of this classification is 52 Ni, 18 Fe, 19 Cr, 5 Nb plus Ta, 3 Mo, 1 Ti. Filler metal of this classification is used for welding nickel-chromium-niobium-molybdenum alloy (ASTM B637 and AMS 5589 having UNS number N07718) to itself using the GTAW processes. The weld metal will age harden on heat treatment. For specific information concerning age hardening, consult the supplier or the supplier's technical literature.

A7.6 ERNiMo-X Classifications

A7.6.1 ERNiMo-1. The nominal composition (wt.-%) of weld metal of this classification is 66 Ni, 28 Mo, 5.5 Fe. Filler metal of this classification is used for welding nickel-molybdenum alloy (ASTM B333 having UNS number N10001) to itself using the GTAW and GMAW processes.

A7.6.2 ERNiMo-2. The nominal composition (wt.-%) of weld metal of this classification is 71 Ni, 16 Mo, 7 Cr, 3 Fe. Filler metal of this classification is used for welding nickel-molybdenum alloy (ASTM B366, B434, and B573 having UNS number N10003) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-molybdenum weld metal using the GTAW and GMAW processes.

A7.6.3 ERNiMo-3. The nominal composition (wt.-%) of weld metal of this classification is 63 Ni, 24 Mo, 6 Fe, 5 Cr. Filler metal of this classification is used for

weld repair of various nickel-, cobalt-, and iron-base alloys and for dissimilar joining applications of nickel-, cobalt-, and iron-base alloys.

A7.6.4 ERNiMo-7. The nominal composition (wt.-%) of weld metal of this classification is 69 Ni, 28 Mo. Filler metal of this classification is used for welding nickel-molybdenum alloy (ASTM B333 and B335 having UNS number N10665) to itself and for cladding steel with nickel-molybdenum weld metal using the GTAW and GMAW processes.

A7.6.5 ERNiMo-8. The nominal composition (wt.-%) of filler metal of this classification is 70 Ni, 19 Mo, 5 Fe, 3 W, 2 Cr. Filler metal of this classification is used for welding 9% nickel steel (ASTM A333, A334, A353, A553 having UNS number K81340) to itself using the GTAW and SAW processes.

A7.6.6 ERNiMo-9. The nominal composition (wt.-%) of filler metal of this classification is 70 Ni, 20 Mo, 1 Fe, 3 W. Filler metal of this classification is used for welding 9% nickel steel (ASTM A333, A334, A353, A553 having UNS number K81340) to itself using the GTAW and SAW processes.

A7.6.7 ERNiMo-10. The nominal composition (wt.-%) of weld metal of this classification is 68 Ni, 28.5 Mo, 1.5 Cr, 1.5 Fe and low carbon. Filler metal of this classification is used for welding nickel-molybdenum alloy (ASTM B333, B335, B366, B564, B619, B622, and B626 having UNS number N10675) to itself, for welding the clad side of joints in steel clad with nickel-molybdenum alloy and for welding nickel-molybdenum alloys to steel and to other nickel-base alloys using the GTAW, GMAW, and PAW processes.

A7.7 ERNiCrMo-X Classifications

A7.7.1 ERNiCrMo-1. The nominal composition (wt.-%) of weld metal of this classification is 44 Ni, 22 Cr, 20 Fe, 6.5 Mo, 2 Nb plus Ta, 2 Cu, 1.5 Mn. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B581 and B582 having UNS number N06007) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW, GMAW, and PAW processes.

A7.7.2 ERNiCrMo-2. The nominal composition (wt.-%) of weld metal of this classification is 47 Ni, 22 Cr, 18 Fe, 9 Mo, 1.5 Co. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B366, B435, and B572 having UNS number N06002) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW, GMAW, and PAW processes.

A7.7.3 ERNiCrMo-3. The nominal composition (wt.-%) of weld metal of this classification is 61 Ni, 22 Cr, 9 Mo, 3.5 Nb plus Ta. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B443, B444, and B446 having UNS number N06625) to itself, to steel, to other nickel-base alloys, for cladding steel with nickel-chromium-molybdenum weld metal, and for welding the clad side of joints in steel with nickel-chromium-molybdenum alloy using the GTAW, GMAW, SAW, and PAW processes. This filler metal is recommended for applications where the operating temperature ranges from cryogenic to 1000°F [540°C].

A7.7.4 ERNiCrMo-4. The nominal composition (wt.-%) of weld metal of this classification is 57 Ni, 16 Cr, 15.5 Mo, 5.5 Fe, 4 W. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B574, B575, B619, B622, and B628 having UNS number N10276) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW and GMAW processes.

A7.7.5 ERNiCrMo-7. The nominal composition (wt.-%) of weld metal of this classification is 65 Ni, 16 Cr, 15.5 Mo, 2 Fe. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B574, B575, B619, B622, and B628 having UNS number N06455) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW, GMAW, and PAW processes.

A7.7.6 ERNiCrMo-8. The nominal composition (wt.-%) of weld metal of this classification is 50 Ni, 25 Cr, 17 Fe, 6 Mo, 1 Cu. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B581, B582, B619, B622 and B626 having UNS number N06975) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW, GMAW, and PAW processes.

A7.7.7 ERNiCrMo-9. The nominal composition (wt.-%) of weld metal of this classification is 44 Ni, 22 Cr, 20 Fe, 7 Mo, 2 Co, 2 Cu. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B581, B582, B619, B622, and B626 having UNS number N06007 or N06985) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW, GMAW, and PAW processes.

A7.7.8 ERNiCrMo-10. The nominal composition (wt.-%) of weld metal of this classification is 56 Ni, 22 Cr, 13 Mo, 4 Fe, 3 W. Filler metal of this classification is

used for welding nickel-chromium-molybdenum alloy (ASTM B574, B575, B619, B622 and B628 having UNS number N06022) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the gas tungsten arc, gas metal arc, and plasma arc welding processes.

A7.7.9 ERNiCrMo-11. The nominal composition (wt.-%) of weld metal of this classification is 43 Ni, 30 Cr, 15 Fe, 5 Mo, 2 Co, 3 W, 2 Cu. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B581, B582, B619, B622, and B626 having UNS number N06030) to itself, to steel, to other nickel-base alloys, and for cladding steel with nickel-chromium-molybdenum weld metal using the GTAW, GMAW, and PAW processes.

A7.7.10 ERNiCrMo-13. The nominal composition (wt.-%) of weld metal of this classification is 59 Ni, 23 Cr, 16 Mo, 1 Fe, low carbon. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (B564, B574, B575, B619, B622, and B626 having UNS number N06059) to itself, to steel, to other nickel-base alloys, and for cladding steel using the GTAW, GMAW, SAW, and PAW processes.

A7.7.11 ERNiCrMo-14. The nominal composition (wt.-%) of the weld metal of this classification is 57 Ni, 21 Cr, 16 Mo, 4 W. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B574, B575, B619, B622, and B628 having UNS number N06686) to itself, to steel, to other nickel-base alloys, and for cladding steel using the GTAW, GMAW, and SAW processes.

A7.7.12 ERNiCrMo-15. The nominal composition (wt.-%) of weld metal of this classification is 57 Ni, 21 Cr, 8 Mo, 7 Fe, 3 Nb plus Ta, 1.4 Ti. Filler metal of this classification is used for welding nickel-chromium-molybdenum alloy (ASTM B805, UNS number N07725) to itself, and for cladding steel using the GMAW and GTAW processes. The weld metal age hardens on heat treatment. For specific information concerning age hardening, consult the supplier or the supplier's technical literature.

A7.8 ERNiCrCoMo-X Classification (ERNiCrCoMo-1). The nominal composition (wt.-%) of weld metal of this classification is 53Ni, 23 Cr, 12 Co, 9 Mo, 1 Fe. Filler metal of this classification is used for welding nickel-chromium-cobalt-molybdenum alloy (UNS N06617) to itself using the GTAW and GMAW processes.

A7.9 ERNiCrWMo-X Classification (ERNiCrWMo-1). The nominal composition (wt.-%) of weld metal of this classification is 57 Ni, 22 Cr, 14 W, 2 Co, 2 Fe, 2 Mo. Filler metal of this classification is used for welding

nickel-chromium-tungsten-molybdenum-lanthanum alloy (ASTM B366, B435, B564, and B572 having UNS number N06230) to itself using the GTAW and GMAW processes.

A8. Special Tests

It is recognized that supplementary tests may be required for certain applications. In such cases, tests to determine specific properties such as corrosion resistance, scaling resistance, or strength at elevated or cryogenic temperatures may be required. ANSI/AWS A5.01 contains provisions for ordering such tests. This section is included to give guidance to those who desire to specify such special tests. Those tests shall be conducted as agreed upon between supplier and purchaser.

A8.1 Corrosion or Scaling Tests. Although welds made with electrodes and rods classified in this specification are commonly used in corrosion and heat-resisting applications, tests for those properties are not included in the specification. When required for a particular application, testing can be conducted on specimens taken from either a weld pad or a welded joint.

A8.1.1 Specimens from a joint are suitable for qualifying the welding procedure (for a specific application involving corrosion or oxidation resistance) but not for qualifying the filler metal. Tests on specimens from a joint have the disadvantage of being a combined test of the properties of the weld metal, the heat-affected zone, and the unaffected base metal. With such specimens, it is more difficult to obtain reproducible data (when a difference exists in the properties of the metal in the various parts of the specimen). Specimens taken from a joint do have the advantage of being able to duplicate the joint design and the welding sequence planned for fabrication.

A8.1.2 Specimens for testing corrosion or oxidation resistance of the weld metal alone are prepared by following the procedure normally used for the preparation of pads for chemical analysis (see 9.3 in ANSI/AWS A5.11/A5.11M). The pad size should be at least 3/4 in. [19 mm] in height by 2-1/2 in. [65 mm] in width by $(1 + 0.625n)$ in. $[25 + 16n \text{ mm}]$ where n represents the number of specimens required from the pad. Specimens measuring 1/2 by 2 by 1/4 in. [13 by 50 by 6.5 mm] are machined from the top of the pad, in a manner such that the 2 in. [50 mm] dimension of the specimen is parallel to the 2-1/2 in. [65 mm] dimension of the pad and the 1/2 in. [13 mm] dimension is parallel with the length of the pad. The heat treatment, surface finish, and marking of the specimens prior to testing should be in accordance with standard practices for tests of similar alloys in the wrought or cast forms. The testing procedures should

correspond to ASTM G4, *Recommended Practice for Conducting Plant Corrosion Tests*.

A8.2 Test for Mechanical Properties

The filler metals in this specification are used with a variety of welding processes and procedures. For this reason, weld metal tests have not been included in the specification. The tensile properties, bend ductility, and soundness of welds produced with these filler metals are determined during qualification of the procedure.

Variables in the procedure (current, voltage, and welding speed), in the shielding medium (the specific gas mixture or the flux), in the manual dexterity of the welder, and in the composition of the base metal and the filler metal all influence the results that can be obtained. Typical tensile values for weld metals are shown in Table A2. When supplementary tests for mechanical properties are specified, the testing procedures should be in accordance with ANSI/AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

A9. Discontinued Classifications

Some classifications have been discontinued from one revision of this specification to another. This resulted from either changes in commercial practice or changes in the classification system used in the specification. The discontinued classifications are listed in Table A3, along with the year last included in the specification.

A10. Safety Considerations

A10.1 Burn Protection. Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause burns if precautionary measures are not used. Workers should wear protective clothing made of fire-resistant material. Pant cuffs, open pockets, or other places on clothing that can catch and retain molten metal or sparks should not be worn. High-top shoes or leather leggings and fire-resistant gloves should be worn. Pant legs should be worn over the outside of high-top shoes. Helmets or hand shields that provide protection for the face, neck, and ears, and a head covering to protect the head should be used. In addition, appropriate eye protection should be used.

When welding overhead or in confined spaces, ear plugs to prevent weld spatter from entering the ear canals should be worn in combination with goggles, or the equivalent, to give added eye protection. Clothing should be kept free of grease and oil. Combustible materials should not be carried in pockets. If any combustible substance has been spilled on clothing, a change to clean, fire-resistant clothing should be made before working

Table A2
Typical Weld Metal
Tensile Strengths^a

AWS Classification	Tensile Strength (typical)	
	ksi	MPa
ERNi-1	55	380
ERNiCu-7	70	480
ERNiCu-8	100 ^b	690 ^b
ERNiCr-3	80	550
ERNiCr-4	100	690
ERNiCr-6	80	550
ERNiCrFe-5	80	550
ERNiCrFe-6	80	550
ERNiCrFe-7	80	550
ERNiCrFe-8	125 ^c	860 ^c
ERNiCrFe-11	94	650
ERNiFeCr-1	80	550
ERNiFeCr-2	165 ^d	1140 ^d
ERNiMo-1	100	690
ERNiMo-2	100	690
ERNiMo-3	100	690
ERNiMo-7	110	760
ERNiMo-8	95	660
ERNiMo-9	95	660
ERNiMo-10	110	760
ERNiCrMo-1	85	590
ERNiCrMo-2	95	660
ERNiCrMo-3	110	760
ERNiCrMo-4	100	690
ERNiCrMo-7	100	690
ERNiCrMo-8	85	590
ERNiCrMo-9	85	590
ERNiCrMo-10	100	690
ERNiCrMo-11	85	590
ERNiCrMo-13	110	760
ERNiCrMo-14	110	760
ERNiCrMo-15	174 ^e	1200 ^e
ERNiCrCoMo-1	90	620
ERNiCrWMo-1	110	760

Notes:

- Tensile strength in the as-welded condition, unless otherwise specified.
- Age-hardened condition: Heat treated at 1475°F [802°C] for 2 hours plus 1100°F [593°C] for 16 hours, then furnace cooled at 25°F [14°C] per hour to 900°F [482°C], then air cooled.
- Age-hardened condition: Heat treated at 1950°F [1066°C] for 2 hours plus 1300°F [704°C] for 20 hours, then air cooled.
- Age-hardened condition: Heat treated at 1325°F [718°C] for 8 hours, then furnace cooled to 1150°F [620°C] at 100°F [56°C] per hour, held for 8 hours, then air cooled.
- Age-hardened condition: Heat treated at 1900°F [1038°C] for 1 hour plus 1350°F [732°C] for 8 hours, then furnace cooled at 100°F [56°C] per hour to 1150°F [621°C] and held for 8 hours, then air cooled.

Table A3
Discontinued Classifications

Discontinued Classification	Last Year Published
RNi-2	1969
ERNi-3	1969
RNiCu-5	1969
RNiCu-6	1969
RNiCrFe-4	1969
ERNiMo-4 ^a	1969
ERNiMo-5	1969
ERNiMo-6 ^b	1969

Notes:

a. Reclassified as ERNiMo-1 in 1976

b. Reclassified as ERNiMo-3 in 1976

with open arcs or flames. Aprons, cape sleeves, leggings, and shoulder covers with bibs designed for welding service should be used. Where welding or cutting of unusually thick base metal is involved, sheet metal shields should be used for extra protection.

Mechanization of highly hazardous processes or jobs should be considered. Other personnel in the work area should be protected by the use of noncombustible screens or by the use of appropriate protection as described in the previous paragraph. Before leaving a work area, hot workpieces should be marked to alert other persons of this hazard. No attempt should be made to repair or disconnect electrical equipment when it is under load; disconnection under load produces arcing of the contacts and may cause burns or shock, or both. (*Note: Burns can be caused by touching hot equipment such as electrode holders, tips, and nozzles. Therefore, insulated gloves should be worn when these items are handled, unless an adequate cooling period has been allowed before touching.*)

The following references are for more detailed information on personal protection:

(1) American National Standards Institute. ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*. New York: American National Standards Institute.⁵

(2) American National Standards Institute. ANSI/ASC Z41.1, *Safety-Toe Footwear*. New York, N.Y.: American National Standards Institute.

5. ANSI standards may be obtained from the American National Standards Institute, 11 West 42 Street, 13th Floor, New York, NY 10036.

(3) American Welding Society. ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*. Miami, Fla.: American Welding Society.

(4) OSHA. *Code of Federal Regulations*, Title 29—Labor, Chapter XVII, Part 1910. Washington, D.C.: U.S. Government Printing Office.⁶

A10.2 Electrical Hazards. Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. The manufacturer's instructions and recommended safe practices should be read and understood. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger.

All electrical equipment and the workpieces should be grounded. The workpiece lead is not a ground lead; it is used only to complete the welding circuit. A separate connection is required to ground the workpiece.

The correct cable size should be used since sustained overloading will cause cable failure and can result in possible electrical shock or fire hazard. All electrical connections should be tight, clean, and dry. Poor connections can overheat and even melt. Further, they can produce dangerous arcs and sparks. Water, grease, or dirt should not be allowed to accumulate on plugs, sockets, or electrical units. Moisture can conduct electricity. To prevent shock, the work area, equipment, and clothing should be kept dry at all times. Welders should wear dry gloves and rubber-soled shoes, or stand on a dry board or insulated platform.

Cables and connections should be kept in good condition. Improper or worn electrical connections may create conditions that could cause electrical shock or short circuits. Worn, damaged, or bare cables should not be used. Open-circuit voltage should be avoided. When several welders are working with arcs of different polarities, or when a number of alternating current machines are being used, the open-circuit voltages can be additive. The added voltages increase the severity of the shock hazard.

In case of electric shock, the power should be turned off. If the rescuer must resort to pulling the victim from the live contact, nonconducting materials should be used. If the victim is not breathing, cardiopulmonary resuscitation (CPR) should be administered as soon as contact with the electrical source is broken. A physician should be called and CPR continued until breathing has been restored, or until a physician has arrived. Electrical burns are treated as thermal burns; that is, clean, cold (iced) compresses should be applied. Contamination should be avoided; the area should be covered with a clean, dry

6. OSHA standards may be obtained from the U.S. Government Printing Office, Washington, DC 20402.

dressings; and the patient should be transported to medical assistance.

Recognized safety standards such as ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and NFPA No. 70, *The National Electrical Code* should be followed.⁷

A10.3 Fumes and Gases. Many welding, cutting, and allied processes produce fumes and gases, which may be harmful to health. Fumes are solid particles which originate from welding filler metals and fluxes, the base metal, and any coatings present on the base metal. Gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment. Management, welders, and other personnel should be aware of the effects of these fumes and gases. The amount and composition of these fumes and gases depend upon the composition of the filler metal and base metal, welding process, current level, arc length, and other factors.

The possible effects of overexposure range from irritation of eyes, skin, and respiratory system to more severe complications. Effects may occur immediately or at some later time. Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fume fever. The possibility of more serious health effects exists when especially toxic materials are involved. In confined spaces, the shielding gases and fumes might displace breathing air and cause asphyxiation. One's head should always be kept out of the fumes. Sufficient ventilation, exhaust at the arc, or both, should be used to keep fumes and gases from your breathing zone and the general area.

In some cases, natural air movement will provide enough ventilation. Where ventilation may be questionable, air sampling should be used to determine if corrective measures should be applied.

More detailed information on fumes and gases produced by the various welding processes may be found in the following:

(1) The permissible exposure limits required by OSHA can be found in *Code of Federal Regulations*, Title 29—Labor, Chapter XVII, Part 1910.

(2) The recommended threshold limit values for these fumes and gases may be found in *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment* published by the American Conference of Governmental Industrial Hygienists (ACGIH).⁸

7. NFPA documents are available from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

8. ACGIH documents are available from the American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Suite 600, Cincinnati, OH 45240-1634.

(3) The results of an AWS-funded study are available in a report entitled, *Fumes and Gases in the Welding Environment*.

A10.4 Radiation. Welding, cutting, and allied operations may produce radiant energy (radiation) harmful to health. One should become acquainted with the effects of this radiant energy.

Radiant energy may be ionizing (such as x-rays), or nonionizing (such as ultraviolet, visible light, or infrared). Radiation can produce a variety of effects such as skin burns and eye damage, depending on the radiant energy's wavelength and intensity, if excessive exposure occurs.

A10.4.1 Ionizing Radiation. Ionizing radiation is produced by the electron beam welding process. It is ordinarily controlled within acceptance limits by use of suitable shielding enclosing the welding area.

A10.4.2 Nonionizing Radiation. The intensity and wavelengths of nonionizing radiant energy produced depend on many factors, such as the process, welding parameters, electrode and base-metal composition, fluxes, and any coating or plating on the base metal. Some processes such as resistance welding and cold pressure welding ordinarily produce negligible quantities of radiant energy. However, most arc welding and cutting processes (except submerged arc welding when used properly), laser beam welding and torch welding, cutting, brazing, or soldering can produce quantities of nonionizing radiation such that precautionary measures are necessary.

Protection from possible harmful effects caused by nonionizing radiant energy from welding include the following measures:

(1) One should not look at welding arcs except through welding filter plates which meet the requirements of ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*. It should be noted that transparent welding curtains are not intended as welding filter plates, but rather are intended to protect passersby from incidental exposure.

(2) Exposed skin should be protected with adequate gloves and clothing as specified in ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*.

(3) Reflections from welding arcs should be avoided, and all personnel should be protected from intense reflections. (Note: Paints using pigments of substantially zinc oxide or titanium dioxide have a lower reflectance for ultraviolet radiation.)

(4) Screens, curtains, or adequate distance from aisles, walkways, etc., should be used to avoid exposing passersby to welding operations.

(5) Safety glasses with UV-protective side shields have been shown to provide some beneficial protection from ultraviolet radiation produced by welding arcs.

A10.4.3 Ionizing radiation information sources include the following:

(1) American Welding Society. AWS F2.1-78, *Recommended Safe Practices for Electron Beam Welding and Cutting*. Miami, Fla.: American Welding Society.

(2) Manufacturer's product information literature.

A10.4.4 Nonionizing radiation information sources include:

(1) American National Standards Institute. ANSI/ASC Z136.1, *Safe Use of Lasers*. New York: American National Standards Institute.

(2) —. ANSI/ASC Z87.1, *Practice for Occupational and Educational Eye and Face Protection*. New York: American National Standards Institute.

(3) American Welding Society. ANSI/ASC Z49.1, *Safety in Welding, Cutting, and Allied Processes*. Miami, Fla.: American Welding Society.

(4) Hinrichs, J. F. "Project Committee on Radiation-Summary Report." *Welding Journal* 57(1):62-65, 1978.

(5) Marshall, W. J., Sliney, D. H., *et al.* "Optical radiation levels produced by air-carbon arc cutting processes." *Welding Journal* 59(3):43-46, 1980.

(6) Moss, C. E., and Murray, W. E. "Optical radiation levels produced in gas welding, torch brazing, and oxygen cutting." *Welding Journal* 58(9):37-46, 1979.

(7) Moss, C. E. "Optical radiation transmission levels through transparent welding curtains." *Welding Journal* 58(3):69-s to 75-s, 1979.

(8) National Technical Information Service. Nonionizing Radiation Protection Special Study No. 42-0053-77, *Evaluation of the Potential Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs*. Springfield, Va.: National Technical Information Service.⁹

(9) National Technical Information Service. Nonionizing Radiation Protection Special Study No. 42-0312-77, *Evaluation of the Potential Retina Hazards from Optical Radiation Generated by Electrical Welding and Cutting Arcs*. Springfield, Va.: National Technical Information Service.

9. National Technical Information documents are available from the National Technical Information Service, Springfield, VA 22161.

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		A5.14			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	A5.13, A5.21	A5.13, A5.21	A5.13, A5.21					
Consumable Inserts			A5.30					
Shielding Gases			A5.32	A5.32			A5.32	

AWS Filler Metal Specifications and Related Documents

AWS Designation	Title
FMC	Filler Metal Comparison Charts
UGFM	Users Guide for Filler Metals
A4.2	Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic 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
A5.01	Filler Metal Procurement Guidelines
A5.1	Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
A5.2	Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding
A5.3	Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding
A5.4	Specification for Stainless Steel Welding Electrodes for Shielded Metal Arc Welding
A5.5	Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding
A5.6	Specification for Covered Copper and Copper Alloy Arc Welding Electrodes
A5.7	Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes
A5.8	Specification for Filler Metals for Brazing and Braze Welding
A5.9	Specification for Bare Stainless Steel Welding Electrodes and Rods
A5.10	Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods
A5.11	Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding
A5.12	Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting
A5.13	Specification for Solid Surfacing Welding Rods and Electrodes
A5.14	Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods
A5.15	Specification for Welding Electrodes and Rods for Cast Iron
A5.16	Specification for Titanium and Titanium Alloy Welding Electrodes and Rods
A5.17	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
A5.18	Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
A5.19	Specification for Magnesium Alloy Welding Electrodes and Rods
A5.20	Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
A5.21	Specification for Composite Surfacing Welding Rods and Electrodes
A5.22	Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding
A5.23	Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
A5.24	Specification for Zirconium and Zirconium Alloy Welding Electrodes and Rods
A5.25	Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag
A5.26	Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding
A5.28	Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding
A5.29	Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding
A5.30	Specification for Consumable Inserts
A5.31	Specification for Fluxes for Brazing and Braze Welding
A5.32	Specification for Welding Shielding Gases

For ordering information, contact the AWS Order Department, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126. Telephones: (800) 334-9353, (305) 443-9353, ext. 280; FAX (305) 443-7559.