

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



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An American National Standard

Approved by the
American National Standards Institute
October 27, 2017

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

11th Edition

Supersedes AWS A5.11/A5.11M:2010

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

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification prescribes the composition, dimensions, soundness, and properties of weld metal for more than 40 classifications of nickel and nickel-alloy covered electrodes. Major topics include general requirements, testing, manufacturing, identification, and packaging. A guide to using the specification is included in Annex A.

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



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ISBN: 978-0-87171-928-7

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Printed in the United States of America

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Foreword

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

This document is the fourth revision to A5.11 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, AWS A1.1, *Metric Practice Guide for the Welding Industry*, and International Standard ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials and fluxes — Type of product, dimensions, tolerances and markings*, 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. This document also relates its classifications to ISO 14172, *Welding consumables — Covered electrodes for manual metal arc welding of nickel and nickel alloys — Classification*.

The first specification for nickel and nickel-alloy covered electrodes was issued in 1954 by a joint committee of the American Society for Testing and Materials and the American Welding Society. The first revision in 1964 was also the result of the cooperative effort. This revision is the eighth prepared entirely by the AWS A5 Committee on Filler Metals and Allied Materials.

Substantive changes, such as addition of new filler metal classifications ENiCrFe-15 and ENiMoCr-1 along with chemical composition change in ENiCrMo-19 are shown in Italic font.

The requester of the chemical composition change for ENiCrMo-19 classification stated that this alloy is not patented in USA, but patented in Germany (patent DE 59801333), France (patent FR 991788), and the UK (GB 991788). All of these were generated out of the European patent EP991788 and will expire on May 27, 2018.

Requirements for diameter and length, core wire and covering, exposed core, electrode identification, packaging, and marking of packages now refer to AWS A5.02/A5.02M.

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

Document Development

ASTM B295-54T	<i>Tentative Specification for Nickel-Base Alloy Covered Welding Electrodes</i>
AWS A5.11-54T	
AWS A5.11-64T	<i>Tentative Specification for Nickel and Nickel-Alloy Covered Welding Electrodes</i>
ASTM B295-64T	
AWS A5.11-69	<i>Specification for Nickel and Nickel-Alloy Covered Welding Electrodes</i>
AWS A5.11-Add 1-75	<i>Addenda to Specification for Nickel and Nickel Alloy Covered Welding Electrodes</i>
AWS A5.11-76	<i>Specification for Nickel and Nickel Alloy Covered Welding Electrodes</i>
ANSI/AWS A5.11-83	<i>Specification for Nickel and Nickel Alloy Covered Welding Electrodes</i>
ANSI/AWS A5.11-90	<i>Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding</i>

Document Development (Continued)

ANSI/AWS A5.11/A5.11M-97	<i>Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding</i>
AWS A5.11/A5.11M:2005	<i>Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding</i>
AWS A5.11/A5.11M:2010	<i>Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding</i>

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

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

1. Scope

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

1.2 This specification makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore, each system must be used independently of the other without combining in any way when referring to material properties. The specification with the designation A5.11 uses U.S. Customary Units. The specification A5.11M 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 A5.11 or A5.11M specifications.

1.3 Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein. Some safety and health information can be found in Annex Clauses A5 and A10.

Safety and Health information is available from the following sources:

American Welding Society:

- (1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- (2) AWS Safety and Health Fact Sheets
- (3) Other safety and health information on AWS website

Material or Equipment Manufacturers:

- (1) Safety Data Sheets supplied by materials manufacturers
- (2) Operating Manuals supplied by equipment manufacturers
- (3) Applicable federal and state regulations

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

2. Normative References

2.1 The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreement based on this AWS standard are encouraged to investigate the possibility of applying the most recent edition of the documents shown below. For undated references, the latest edition of the standard referred to applies.

¹ Nickel-base covered electrodes for welding cast iron are treated separately in AWS A5.15, *Specification for Welding Electrodes and Rods for Cast Iron*.

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

- (1) AWS A1.1, *Metric Practice Guide for the Welding Industry*
- (2) AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*
- (3) AWS A5.01M/A5.01 (ISO 14344 MOD), *Welding Consumables—Procurement of Filler Metals and Fluxes*
- (4) AWS A5.02/A5.02M:2007, *Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*
- (5) AWS B4.0, *Standard Methods for Mechanical Testing of Welds*
- (6) AWS B4.0M, *Standard Methods for Mechanical Testing of Welds*

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

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

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

- (1) ASTM A131/A131M, *Standard Specification for Structural Steel for Ships*
- (2) ASTM A240/A240M, *Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*
- (3) ASTM A285/A285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*
- (4) ASTM A515/A515M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*
- (5) ASTM A560/A560M, *Standard Specification for Castings, Chromium-Nickel Alloy*
- (6) ASTM B127, *Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip*
- (7) ASTM B160, *Standard Specification for Nickel Rod and Bar*
- (8) ASTM B162, *Standard Specification for Nickel Plate, Sheet, and Strip*
- (9) ASTM B164, *Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire*
- (10) ASTM B166, *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06025, N06045, and N06696) Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Rod, Bar, and Wire*
- (11) ASTM B167, *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696) Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Seamless Pipe and Tube*
- (12) ASTM B168, *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696) Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Plate, Sheet, and Strip*
- (13) ASTM B333, *Standard Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip*
- (14) ASTM B435, *Standard Specification for UNS N06002, UNS N06230, UNS N12160, and UNS R30556 Plate, Sheet, and Strip*
- (15) ASTM B443, *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Plate, Sheet, and Strip*
- (16) ASTM B446, *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650), Rod and Bar*

(17) ASTM B575, *Standard Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Tungsten, and Low-Carbon Nickel-Molybdenum-Chromium Alloy Plate, Sheet, and Strip*

(18) ASTM B582, *Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip*

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

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

(21) ASTM E354, *Standard Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic and Other Similar Iron, Nickel, and Cobalt Alloys*

(22) ASTM E1019, *Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel and Cobalt Alloys by Various Combustion and Fusion Techniques*

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

(24) ASTM E1473, *Standard Test Methods for Chemical Analysis of Nickel, Cobalt, and High Temperature Alloys*

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

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

(2) ISO 14172, *Welding consumables — Covered electrodes for manual metal arc welding of nickel and nickel alloys — Classification*

(3) ISO 80000-1, *Quantities and units — Part 1: General*

3. Classification

3.1 The welding electrodes covered by the A5.11/A5.11M 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 their undiluted weld metal, as specified in Table 1.

3.2 Electrodes classified under one classification shall not be classified under any other classification in this specification. However, material may be classified under both A5.11 and A5.11M specifications.

4. Acceptance

Acceptance² of the electrodes shall be in accordance with the provisions of AWS A5.01M/A5.01 (ISO 14344 MOD).

5. Certification

By affixing the AWS specification and classification designation to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.³

² See Annex Clause A3 for further information concerning acceptance and testing of the material shipped, as well as AWS A5.01M/A5.01 (ISO 14344 MOD).

³ See Annex Clause A4 for further information concerning certification and the testing called for to meet this requirement.

Table 1
Chemical Composition Requirements for Undiluted Weld Metal

Weight-Percent ^{a, b}																		
AWS Classification	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
ENi-1	W82141	0.10	0.75	0.75	0.03	0.02	1.25	0.25	92.0 min.	—	1.0	1.0 to 4.0	—	—	—	—	—	0.50
ENiCr-4	W86172	0.10	1.5	1.0	0.02	0.02	1.0	0.25	Rem	—	—	—	48.0 to 52.0	1.0 to 2.5	—	—	—	0.50
ENiCu-7	W84190	0.15	4.0	2.5	0.02	0.015	1.5	Rem	62.0 to 69.0	—	0.75	1.0	—	—	—	—	—	0.50
ENiCrFe-1	W86132	0.08	3.5	11.0	0.03	0.015	0.75	0.50	62.0 min.	—	—	—	13.0 to 17.0	1.5 to 4.0 ^f	—	—	—	0.50
ENiCrFe-2	W86133	0.10	1.0 to 3.5	12.0	0.03	0.02	0.75	0.50	62.0 min.	(e)	—	—	13.0 to 17.0	0.5 to 3.0 ^f	0.5 to 2.5	—	—	0.50
ENiCrFe-3	W86182	0.10	5.0 to 9.5	10.0	0.03	0.015	1.0	0.50	59.0 min.	(e)	—	1.0	13.0 to 17.0	1.0 to 2.5 ^f	—	—	—	0.50
ENiCrFe-4	W86134	0.20	1.0 to 3.5	12.0	0.03	0.02	1.0	0.50	60.0 min.	—	—	—	13.0 to 17.0	1.0 to 3.5	1.0 to 3.5	—	—	0.50
ENiCrFe-7 ^g	W86152	0.05	5.0	7.0 to 12.0	0.03	0.015	0.75	0.50	Rem	(e)	0.50	0.50	28.0 to 31.5	1.0 to 2.5	0.5	—	—	0.50
ENiCrFe-9	W86094	0.15	1.0 to 4.5	12.0	0.02	0.015	0.75	0.50	55.0 min.	—	—	—	12.0 to 17.0	0.5 to 3.0	2.5 to 5.5	—	1.5	0.50

(Continued)

Table 1 (Continued)
Chemical Composition Requirements for Undiluted Weld Metal

Weight-Percent ^{a, b}																		
AWS Classification	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
ENiCrFe-10	W86095	0.20	1.0 to 3.5	12.0	0.02	0.015	0.75	0.50	55.0 min.	—	—	—	13.0 to 17.0	1.0 to 3.5	1.0 to 3.5	—	1.5 to 3.5	0.50
ENiCrFe-12	W86025	0.10 to 0.25	1.0	8.0 to 11.0	0.04	0.02	1.0	0.20	Rem	1.0	1.5 to 2.2	0.10 to 0.40	24.0 to 26.0	—	—	—	—	0.50
ENiCrFe-13 ^h	W86155	0.05	1.0	Rem	0.020	0.015	0.75	0.30	52.0 to 62.0	0.10	0.50	0.50	28.5 to 31.0	2.1 to 4.0	3.0 to 5.0	—	—	0.50
<i>ENiCrFe-15</i>	<i>W86056</i>	<i>0.05</i>	<i>2.5 to 4.5</i>	<i>2.0 to 3.0</i>	<i>0.02</i>	<i>0.015</i>	<i>0.50</i>	<i>0.3</i>	<i>Rem</i>	<i>0.10</i>	<i>0.6</i>	<i>0.40</i>	<i>26.0 to 28.0</i>	<i>2.0 to 3.6</i>	—	—	—	<i>0.50</i>
ENiCrFeSi-1	W86045	0.05 to 0.20	2.5	21.0 to 25.0	0.04	0.03	2.5 to 3.0	0.30	Rem	1.0	0.30	—	26.0 to 29.0	—	—	—	—	0.50
ENiMo-1	W80001	0.07	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	1.0	—	26.0 to 30.0	0.60	1.0	0.50
ENiMo-3	W80004	0.12	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	2.5 to 5.5	—	23.0 to 27.0	0.60	1.0	0.50
ENiMo-7	W80665	0.02	1.75	2.25	0.04	0.03	0.2	0.50	Rem	1.0	—	—	1.0	—	26.0 to 30.0	—	1.0	0.50
ENiMo-8	W80008	0.10	1.5	10.0	0.02	0.015	0.75	0.50	60.0 min.	—	—	—	0.5 to 3.5	—	17.0 to 20.0	—	2.0 to 4.0	0.50

(Continued)