

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



American Welding Society



AWS A5.11/A5.11M:2010
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American National Standards Institute
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Specification for

Nickel and Nickel-Alloy Welding Electrodes

for Shielded Metal Arc Welding

10th Edition

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

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification prescribes the composition, dimensions, soundness, and properties of weld metal from more than 30 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.



American Welding Society

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Foreword

This foreword is not part of AWS A5.11/A5.11M:2010, *Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding*, but is included for informational purposes only.

This document is the third 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, ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry*, and International Standard ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials — 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 seventh prepared entirely by the AWS A5 Committee on Filler Metals and Allied Materials. *This revision contains new classifications ENiCrFe-13 and ENiCrMo-22. The Rounding-Off Procedure has been revised. Based on new Rounding-Off Procedure, tensile strength of ENiCrMo-11 in Table 4 has been rounded up from 585 MPa to 590 MPa, because new rounding off procedure requires rounding to the nearest 10 MPa. Substantive changes are shown in the Italic font.*

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>
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>

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 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 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 nonmandatory 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.

1.3 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.

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.

2.2 The following AWS standards² are referenced in the mandatory Clauses of this document:

- (1) AWS A1.1, *Metric Practice Guide for the Welding Industry*
- (2) AWS A5.01M/A5.01 (ISO 14344), *Procurement Guidelines for Consumables — Welding and Allied Processes — Flux and Gas Shielded Electrical Welding Processes*
- (3) AWS B4.0, *Standard Methods for Mechanical Testing of Welds*
- (4) AWS B4.0M, *Standard Methods for Mechanical Testing of Welds*

2.3 The following ANSI standard³ is referenced in the mandatory Clauses of this document:

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

³ ANSI Z49.1 is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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

2.4 The following ASTM standards⁴ are referenced in the mandatory clauses of this document:

- (1) ASTM A 131/A 131M, *Standard Specification for Structural Steel for Ships*
- (2) ASTM A 240/A 240M, *Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels*
- (3) ASTM A 285/A 285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*
- (4) ASTM A 515/A 515M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*
- (5) ASTM A 560/A 560M, *Standard Specification for Castings, Chromium-Nickel Alloy*
- (6) ASTM B 127, *Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip*
- (7) ASTM B 160, *Standard Specification for Nickel Rod and Bar*
- (8) ASTM B 162, *Standard Specification for Nickel Plate, Sheet, and Strip*
- (9) ASTM B 164, *Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire*
- (10) ASTM B 166, *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Rod, Bar, and Wire*
- (11) ASTM B 167, *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Seamless Pipe and Tube*
- (12) ASTM B 168, *Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Plate, Sheet, and Strip*
- (13) ASTM B 333, *Standard Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip*
- (14) ASTM B 435, *Standard Specification for UNS N06002, UNS N06230, UNS N12160, and UNS R30556 and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Plate, Sheet, and Strip*
- (15) ASTM B 443, *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Plate, Sheet, and Strip*
- (16) ASTM B 446, *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), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650) Rod and Bar*
- (17) ASTM B 575, *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip*
- (18) ASTM B 582, *Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip*
- (19) ASTM E 29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*
- (20) ASTM E 76, *Standard Methods for Chemical Analysis of Nickel-Copper Alloys*

⁴ ASTM standards are published by the ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(21) ASTM E 354, *Test Methods for Chemical Analysis of High-temperature, Electrical, Magnetic and Other Similar Iron, Nickel, and Cobalt Alloys*

(22) ASTM E 1019, *Methods for Determination of Carbon, Sulfur, Nitrogen, Oxygen, and Hydrogen in Steel and in Iron, Nickel and Cobalt Alloys*

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

(24) ASTM E 1473, *Test Methods for Chemical Analysis of Nickel, Cobalt and High Temperature Alloys*

2.4 The following ISO standards⁵ are referenced in the mandatory Clauses of this document:

(1) ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials — 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. 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. However, material may be classified under both A5.11 and A5.11M specifications.

4. Acceptance

Acceptance⁶ of the electrodes shall be in accordance with the provisions of AWS A5.01M/A5.01 (ISO 14344).

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.⁷

6. Rounding-Off Procedure

For purposes of determining compliance with the requirements of this standard, the actual test values obtained shall be subjected to the rounding-off rules of ASTM E 29 or Rule A in Clause B.3 of ISO 80000-1 (the results are the same). If the measured values are obtained by equipment calibrated in units other than those of the specified limit, the measured values shall be converted to the units of the specified limit before rounding off. If an average value is to be compared to the specified limit, rounding off shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 1000 psi (1 ksi) for tensile and yield strength for A5.11 or to the nearest 10 MPa for tensile and yield strength for A5.11M; and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities. The rounded-off results shall fulfil the requirements for the classification under test.

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

⁶ See Clause A3, Acceptance (in Annex A), for further information concerning acceptance and testing of the material shipped, as well as AWS A5.01M/A5.01 (ISO 14344).

⁷ See Clause A4, Certification (in Annex A), 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(Cb) 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	10.00	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	12.00	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	12.00	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
ENiCrFe-10	W86095	0.20	1.0 to 3.5	12.00	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

(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(Cb) plus Ta	Mo	V	W	Other Elements Total
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
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
ENiMo-9	W80009	0.10	1.5	7.0	0.02	0.015	0.75	0.3 to 1.3	62.0 min.	—	—	—	—	—	18.0 to 22.0	—	2.0 to 4.0	0.50
ENiMo-10	W80675	0.02	2.0	1.0 to 3.0	0.04	0.03	0.2	0.50	Rem	3.0	—	—	1.0 to 3.0	—	27.0 to 32.0	—	3.0	0.50
ENiMo-11	W80629	0.02	2.5	2.0 to 5.0	0.04	0.03	0.2	0.5	Rem	1.0	0.1 to 0.5	0.3	0.5 to 1.5	0.5	26.0 to 30.0	—	—	0.50
ENiCrMo-1	W86007	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
ENiCrMo-2	W86002	0.05 to 0.15	1.0	17.0 to 20.0	0.04	0.03	1.0	0.50	Rem	0.50 to 2.50	—	—	20.5 to 23.0	—	8.0 to 10.0	—	0.2 to 1.0	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	Nb(Cb) plus Ta			Mo	V	W	Other Elements Total
													Cr	Ta					
ENiCrMo-3	W86112	0.10	1.0	7.0	0.03	0.02	0.75	0.50	55.0 min.	(e)	—	—	20.0 to 23.0	3.15 to 4.15	8.0 to 10.0	—	—	—	0.50
ENiCrMo-4	W80276	0.02	1.0	4.0 to 7.0	0.04	0.03	0.2	0.50	Rem	2.5	—	—	14.5 to 16.5	—	15.0 to 17.0	0.35	3.0 to 4.5	0.50	
ENiCrMo-5	W80002	0.10	1.0	4.0 to 7.0	0.04	0.03	1.0	0.50	Rem	2.5	—	—	14.5 to 16.5	—	15.0 to 17.0	0.35	3.0 to 4.5	0.50	
ENiCrMo-6	W86620	0.10	2.0 to 4.0	10.0	0.03	0.02	1.0	0.50	55.0 min.	—	—	—	12.0 to 17.0	0.5 to 2.0	5.0 to 9.0	—	1.0 to 2.0	0.50	
ENiCrMo-7	W86455	0.015	1.5	3.0	0.04	0.03	0.2	0.50	Rem	2.0	—	0.70	14.0 to 18.0	—	14.0 to 17.0	—	0.5	0.50	
ENiCrMo-9	W86985	0.02	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	0.5	6.0 to 8.0	—	1.5	0.50	
ENiCrMo-10	W86022	0.02	1.0	2.0 to 6.0	0.03	0.015	0.2	0.50	Rem	2.5	—	—	20.0 to 22.5	—	12.5 to 14.5	0.35	2.5 to 3.5	0.50	
ENiCrMo-11	W86030	0.03	1.5	13.0 to 17.0	0.04	0.02	1.0	1.0 to 2.4	Rem	5.0	—	—	28.0 to 31.5	0.3 to 1.5	4.0 to 6.0	—	1.5 to 4.0	0.50	
ENiCrMo-12	W86032 ^h	0.03	2.2	5.0	0.03	0.02	0.7	0.50	Rem	—	—	—	20.5 to 22.5	1.0 to 2.8	8.8 to 10.0	—	—	0.50	
ENiCrMo-13	W86059	0.02	1.0	1.5	0.015	0.01	0.2	0.50	Rem	—	—	—	22.0 to 24.0	—	15.0 to 16.5	—	—	0.50	
ENiCrMo-14	W86686	0.02	1.0	5.0	0.02	0.02	0.25	0.50	Rem	—	—	0.25	19.0 to 23.0	—	15.0 to 17.0	—	3.0 to 4.4	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(Cb) plus Ta	Mo	V	W	Other Elements Total
ENiCrMo-17	W86200	0.020	0.5	3.0	0.030	0.015	0.2	1.3 to 1.9	Rem	2.0	—	—	22.0 to 24.0	—	15.0 to 17.0	—	—	0.50
ENiCrMo-18	W86650	0.03	0.7	12.0 to 15.0	0.03	0.02	0.6	0.3	Rem	1.0	0.5	—	19.0 to 22.0	0.3	10.0 to 13.0	0.15	1.0 to 2.0	0.50
ENiCrMo-19 ⁱ	W86058	0.02	1.5	1.5	0.03	0.02	0.2	0.5	Rem	0.3	0.4	—	20.0 to 23.0	—	19.0 to 21.0	—	0.3	0.50
ENiCrMo-22	W86035	0.05	0.50	2.00	0.030	0.015	0.60	0.30	Rem	1.00	0.40	0.20	32.25 to 34.25	0.50	7.6 to 9.0	0.20	0.60	0.50
ENiCrCoMo-1	W86117	0.05 to 0.15	0.3 to 2.5	5.0	0.03	0.015	0.75	0.50	Rem	9.0 to 15.0	—	—	21.0 to 26.0	1.0	8.0 to 10.0	—	—	0.50
ENiCrWMo-1	W86231	0.05 to 0.10	0.3 to 1.0	3.0	0.02	0.015	0.25 to 0.75	0.50	Rem	5.0	0.50	0.10	20.0 to 24.0	—	1.0 to 3.0	—	13.0 to 15.0	0.50

^a 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.

^b Single values are maximum, except where otherwise specified. Rem = remainder.

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

^d Includes incidental cobalt. Rem = remainder.

^e Cobalt—0.12 maximum, when specified by the purchaser.

^f Tantalum—0.30 maximum, when specified by the purchaser.

^g Boron is 0.005% maximum and Zr is 0.020% maximum when specified by purchaser.

^h B is 0.003% max. and Zr is 0.020% max.

ⁱ UNS number formerly was W86040.

^j N = 0.02 to 0.15.

7. Summary of Tests

The tests required for classification are specified in Table 2. The purpose of these tests is to determine the chemical composition, the mechanical properties and soundness of the weld metal, and the usability of the electrode. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required are given in Clause 9, Weld Test Assemblies, through Clause 13, Bend Test.

8. Retest

8.1 If the results of any test fail 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 one or two new test assemblies. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement.

8.2 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.

8.3 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 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. Weld Test Assemblies

9.1 To perform all required tests as specified in Table 2, a minimum of one weld test assembly is required. Two, or even three, may be necessary (according to the classification, size, and manner in which the testing is conducted, i.e., with respect to alternative options).

The weld test assemblies are identified as follows:

- (1) The weld pad in Figure 1 for chemical analysis of the undiluted weld metal
- (2) The groove weld in Figure 2 for mechanical properties and soundness
- (3) The groove weld in Figure 3 for radiographic soundness

The sample for chemical analysis may be taken from a low dilution area in the groove weld in Figure 2, or from the reduced section of the fractured tension test specimen, 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, 9.4.1, and 9.4.2. The base metal for each assembly shall meet the requirements of the appropriate ASTM specification shown in Table 3 or an equivalent specification. Testing of assemblies shall be as prescribed in Clauses 10 through 13.

9.3 Weld Pad. A weld pad shall be prepared as specified in Table 2 and shown in Figure 1, except when one of the alternatives in 9.1 (taking the sample from the weld metal in the groove or from the tension test specimen) is selected. Base metal of any convenient size, of the type specified in Table 3, 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 and layers to obtain undiluted weld metal. The type of current and range of amperage used for welding shall be as recommended by the manufacturer. The preheat temperature shall be not less than 60°F [16°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 (temperature above 60°F [16°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.

Table 2
Required Tests and Positions^a

AWS Classification	Electrode Diameter		Required Tests				Position Radiographic Test ^d
	in	mm	Chemical Analysis	Tension Test	Bend Test ^b	Radiographic Test ^c	
ENi-1							
ENiCr-4 ^g							
ENiCu-7							
ENiCrFe-1	5/64	2.0	Required	Required	Required	Required	V
ENiCrFe-2	3/32	2.4 ^e					
ENiCrFe-3	—	2.5					
ENiCrFe-4	1/8	3.2					
ENiCrFe-7							
ENiCrFe-9							
ENiCrFe-10							
ENiCrFe-13							
ENiMo-11	5/32	4.0	Required	Required	Required	Required	F
ENiCrMo-3	3/16	4.8 ^e					
ENiCrMo-6	—	5.0					
ENiCrMo-10	1/4 ^f	6.4 ^{e, f}					
ENiCrMo-12							
ENiCrMo-14							
ENiCrMo-17							
ENiCrCoMo-1							
ENiCrFe-12							
ENiCrFeSi-1							
ENiMo-1							
ENiMo-3							
ENiMo-7							
ENiMo-8							
ENiMo-9	5/64	2.0	Required	Required	Required	Required	F
ENiMo-10	3/32	2.4 ^e					
ENiCrMo-1	—	2.5					
ENiCrMo-2	1/8	3.2					
ENiCrMo-4	5/32	4.0					
ENiCrMo-5	3/16	4.8 ^e					
ENiCrMo-7	—	5.0					
ENiCrMo-9							
ENiCrMo-11							
ENiCrMo-13							
ENiCrMo-18							
ENiCrMo-19							
ENiCrMo-22							
ENiCrWMo-1							

^a See Table 3 for base metals to be used in these tests.

^b Three transverse side-bend test specimens are required except for 5/64 in [2.0 mm] electrodes. For that size, two transverse face-bend specimens are required.

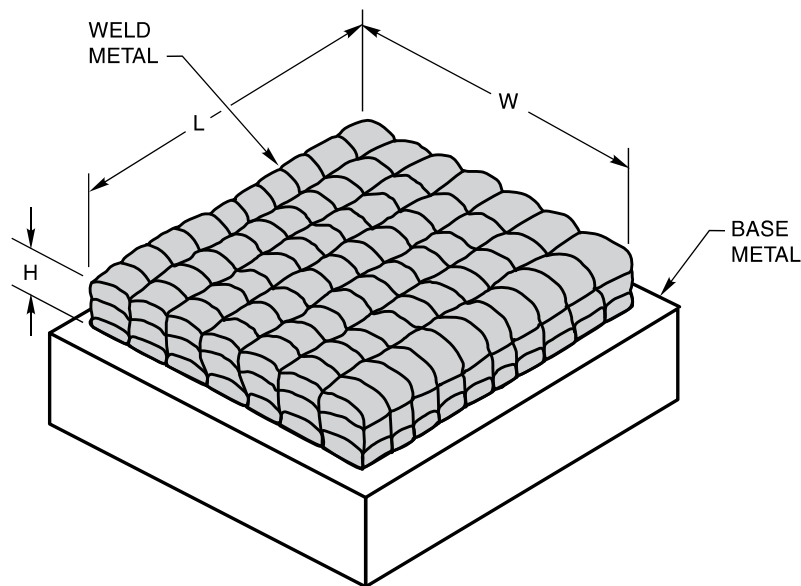
^c The groove weld for mechanical properties (Figure 2) may also be used for the radiographic soundness test conducted in the flat position. In that case, the test assembly is radiographed before the coupons for the tensile and bend test specimens are removed.

^d The position of welding shown in this column is only for the radiographic soundness test (V = vertical with uphill progression, F = flat). All other test assemblies are welded in the flat position.

^e Metric sizes not shown in ISO 544.

^f Applies only to ENiCu-7 classification.

^g No bend test required for this classification.



Electrode Size		Weld Pad Size	
in	mm	in, min.	mm, min.
5/64	2.0	L = 1-1/2 W = 1-1/2 H = 1/2	38
3/32	2.4 ^a		38
—	2.5		13
1/8	3.2		
5/32	4.0	L = 2	50
3/16	4.8 ^a	W = 2	50
—	5.0	H = 7/8	22
1/4	6.4 ^a		

^a Metric sizes not shown in ISO 544.

Notes:

1. The number and size of the beads will vary according to the size of the electrode and the width of the weave, as well as the amperage employed.
2. If carbon steel base metal is used for the chemical analysis pad, the height of the pad (dimension H) shall be increased as required in note "a" of Table 3.

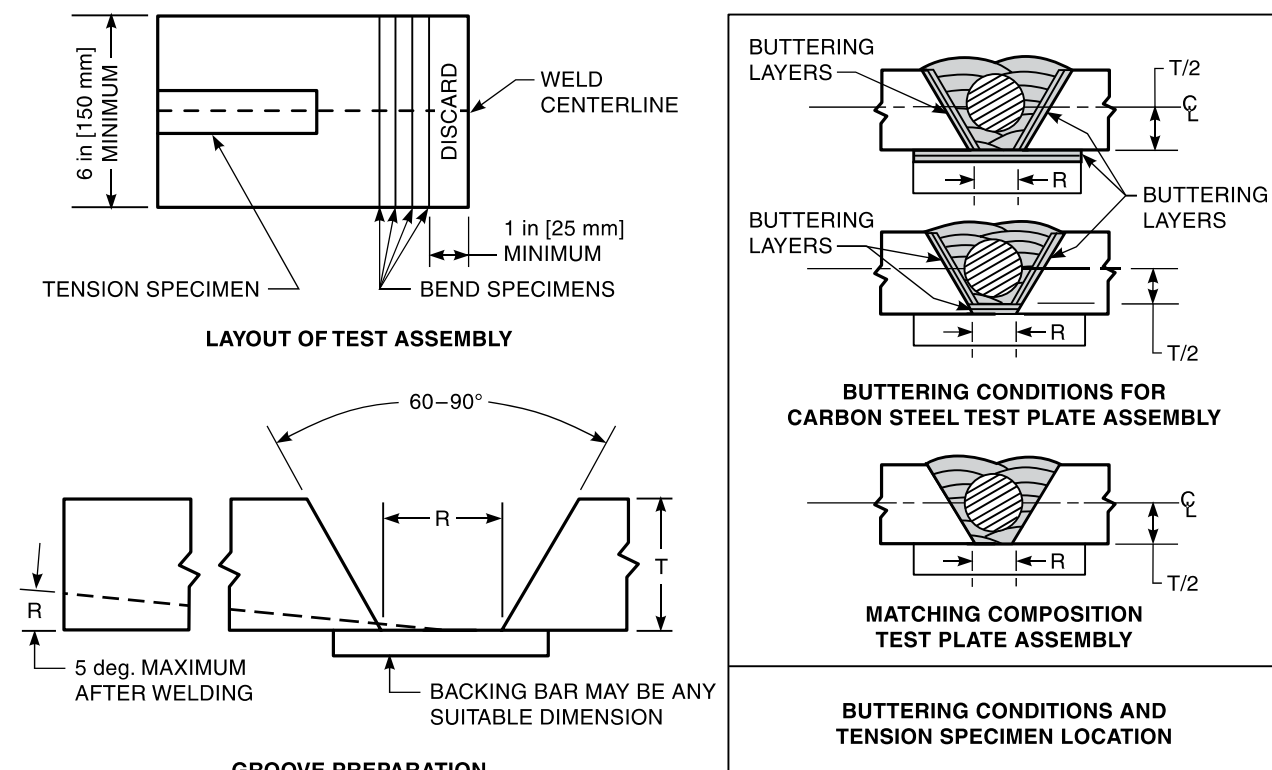
Source: Figure 1 of AWS A5.11/A5.11M:2005.

Figure 1—Pad for Chemical Analysis of Undiluted Weld Metal

9.4 Groove Weld

9.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Figure 2 and Table 2 using base metal of an appropriate type in Table 3. Testing of this assembly shall be as specified in Clause 12, Tension Test, and Clause 13, Bend Test. Additionally, this assembly may be used to satisfy the requirements of the flat position radiographic test (note c to Table 2). In that case, the assembly shall be radiographed as required in Clause 11, Radiographic Test. The assembly shall be tested in the as-welded condition.

9.4.2 Radiographic Soundness. A test assembly shall be prepared for electrodes of all classifications and welded as shown in Figure 3, using base metal of the appropriate type specified in Table 3. The welding position shall be as specified in Table 2 for the different electrode sizes and classifications. Testing of the assembly shall be as specified in Clause 11, Radiographic Test. The groove weld in Figure 2 may be radiographed (for those classifications for which the radiographic test is welded in the flat position), thus eliminating the need to make the groove weld in Figure 3, in those cases.



Electrode Size		T (Thickness), min.		R (Root Opening) ^a		Number of Layers
in	mm	in	mm	in	mm	min.
5/64	2.0	3/8	10	3/16	5	(b)
3/32	2.4 ^c	1/2	13	1/4	7	(b)
—	2.5	1/2	13	1/4	7	(b)
1/8	3.2	1/2	13	1/4	7	(b)
5/32	4.0	3/4	19	1/2	13	6
3/16	4.8 ^c	3/4	19	1/2	13	6
—	5.0	3/4	19	1/2	13	6
1/4	6.4 ^c	3/4	19	1/2	13	6

^a Tolerance: $\pm 1/16$ in [2 mm].

^b Number of layers not specified, but pass and layer sequence shall be recorded and reported.

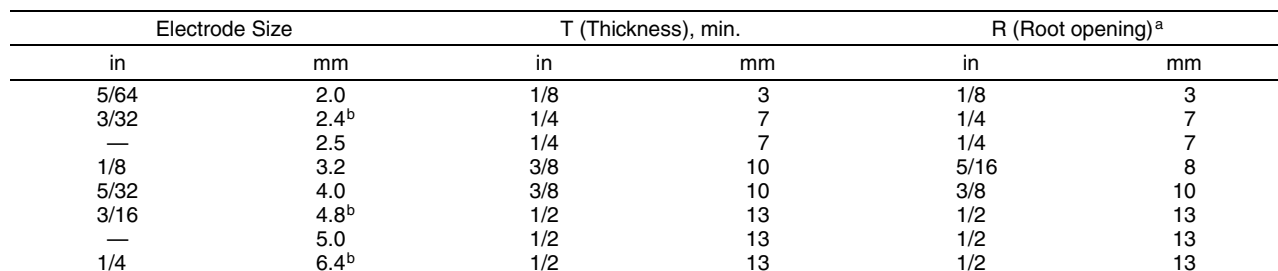
^c Metric sizes not shown in ISO 544.

Notes:

1. Base metal shall be as specified in Table 3.
2. The surfaces to be welded shall be clean.
3. The minimum length of the test assembly is 6 in [150 mm] but the assembly shall be as long as necessary to provide the specimens for the number and type of tests required. Minimum width is 6 in [150 mm].
4. Prior to welding, the assembly may be preset so that the welded joint will be within 5 degrees of plane after welding. As an alternate, restraint or a combination of restraint and presetting may be used. A test assembly that is more than 5 degrees out of plane shall be discarded. Straightening of the test assembly is prohibited.
5. Welding shall be performed in the flat position, using the type and range of current and welding technique recommended by the electrode manufacturer.
6. The preheat temperature shall be 60°F [16°C]. The interpass temperature shall not exceed 300°F [150°C].
7. The welds shall be made with stringer beads or weave beads no wider than four times the diameter of the core wire. The completed weld shall be at least flush with the surface of the test plate. For electrodes larger than 1/8 in [3.2 mm], the root beads may be deposited with 3/32 or 1/8 in [2.4, 2.5, or 3.2 mm] electrodes.
8. The tests shall be conducted without a postweld heat treatment.

Source: Figure 2 of AWS A5.11/A5.11M:2005.

Figure 2—Groove Weld Test Assembly for Mechanical Properties and Soundness



^b Metric sizes not shown in ISO 544.

1. Base metal shall be as specified in Table 3.
2. The surfaces to be welded shall be clean.
3. Welding shall be conducted in the vertical-up or flat position, as required in Table 2 (also see note c in Table 2) using the type and range of current, and technique recommended by the electrode manufacturer.
4. The preheat temperature shall be 60°F [16°C]. The interpass temperature shall not exceed 300°F [150°C].
5. The welds shall be made with a stringer bead technique or a weave to produce a bead no wider than four times the diameter of the core wire. The root layer in tests of electrodes larger than 1/8 in [3.2 mm] diameter may be deposited with 3/32 or 1/8 in [2.4, 2.5, or 3.2 mm] electrodes of that same classification. In addition to the start and stop at the ends of the weld, each bead shall also contain a start and a stop somewhere in between.
6. A small amount of grinding between beads is permissible for welds in the vertical position, but an inordinate amount should not be required to produce a satisfactory weld.
7. The completed weld shall be at least flush with the surface of the test plate.
8. The backing strip shall be removed, and the weld on both sides of the assembly shall be machined or ground smooth and flush with the original surfaces of the base plate (see 11.1).
9. The assembly shall be radiographed as specified in Clause 11, Radiographic Test.

Figure 3—Groove Weld Test Assembly for Radiographic Soundness Test

Table 3
Base Metals for Test Assemblies

AWS Classification	Materials ^{a,b}	ASTM Specifications ^c	UNS Number
ENi-1	Nickel	B 160, B 162	N02200, N02201
ENiCr-4	Nickel-Chromium	A 560	R20500
ENiCu-7	Nickel-Copper Alloy	B 127, B 164	N04400
ENiCrFe-1, 2, 3, 4, 9, 10	Nickel-Chromium-Iron Alloy	B 166, B 168	N06600
ENiCrFe-7, 13	Nickel-Chromium-Iron Alloy	B 166, B 167, B 168	N06690
ENiCrFe-12	Nickel-Chromium-Iron Alloy	B 168	N06025
ENiCrFeSi-1	Nickel-Chromium-Iron-Silicon Alloy	B 168	N06045
ENiMo-1, 3, 7, 8, 9, 10	Nickel-Molybdenum Alloy	B 333	N10001, N10665, N10675
ENiMo-11	Nickel-Molybdenum Alloy	B 333	N10629
ENiCrMo-1, 9, 11	Nickel-Chromium-Molybdenum Alloy	B 582	N06007, N06985, N06030
ENiCrMo-2	Nickel-Chromium-Molybdenum Alloy	B 435	N06002
ENiCrMo-3	Nickel-Chromium-Molybdenum Alloy	B 443, B 446	N06625
ENiCrMo-4, 5, 7, 10, 13, 14, 19, 22	Low Carbon Nickel-Chromium-Molybdenum Alloy	B 575	N10276, N06455, N06022, N06059, N06686, N06058, N06035
ENiCrMo-6	Nickel-Chromium-Molybdenum Alloy	B 166, B 168	N06600
ENiCrMo-12	Chromium-Nickel-Molybdenum Alloy (Austenitic Stainless Steel)	A 240	S31254
ENiCrMo-17	Low Carbon Nickel-Chromium-Molybdenum Alloy	B 575	N06200
ENiCrMo-18	Nickel-Chromium-Iron-Molybdenum-Tungsten Alloy	B 446	N06650
ENiCrCoMo-1	Nickel-Chromium-Cobalt-Molybdenum Alloy	B 166, B 168	N06617
ENiCrWMo-1	Nickel-Chromium-Tungsten-Molybdenum Alloy	B 435	N06230

^a Either the base metals specified or carbon steel (A 131, A 285, A 515) may be used. If carbon steel is used, two layers of buttering shall be applied to the surface and the backing strip if appropriate. For chemical analysis, base metals other than those specified may be used as the base for the undiluted weld pad provided that, for electrodes of the 1/8 in [3.2 mm] size and smaller, the minimum height shown in Figure 1 is 3/4 in [19 mm] and the sample for analysis is taken at least 5/8 in [16 mm] from the nearest surface of the base metal. For electrode sizes 5/32 in [4 mm] through 1/4 in [6.4 mm], the dimensions are 1 in [25 mm] and 7/8 in [22 mm], respectively.

^b All specified base metals shall be in the annealed condition prior to welding.

^c Equivalent material specifications may be used.

10. Chemical Analysis

10.1 The sample for analysis shall be taken from weld metal obtained from the weld pad, the reduced section of the fractured tension test specimen, or a low-dilution area of the groove weld in Figure 2. The top surface of the pad described in 9.3 and shown in Figure 1 (when the pad is used), shall be removed and discarded. A sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag.

For electrodes smaller than 5/32 in [4.0 mm], the sample shall be taken at least 3/8 in [9.5 mm] from the nearest surface of the base metal. For electrodes 5/32 in [4.0 mm] and larger, the sample shall be taken at least 3/4 in [19 mm] from that surface. If carbon-steel base metal is used in the chemical analysis test pad, see Note “a” in Table 3. The sample from the reduced section of the fractured tension test specimen and the sample from a low-dilution area of the groove weld shall be prepared for analysis by any suitable mechanical means.

10.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM E 1473, supplemented by ASTM E 1019 and ASTM E 354 for nickel base alloys, and ASTM E 76 for nickel copper alloys, as appropriate.

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

11. Radiographic Test

11.1 The radiographic soundness test weld described in 9.4.2 and shown in Figure 3 (or the groove weld described in 9.4.1 and shown in Figure 2, when that is desired and is permitted by note c of Table 2), shall be radiographed to evaluate 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 (except as noted) 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. Thickness of the weld metal shall not be reduced by more than 1/16 in [1.5 mm] less than the nominal base metal thickness. 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. The quality level of inspection shall be 2-2T.

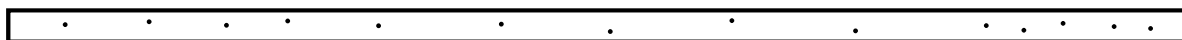
11.3 The electrode meets the requirements of this specification if the radiograph shows the following:

- (1) No cracks, no incomplete fusion, and no incomplete penetration
- (2) No slag inclusions in excess of those permitted by Note 4 to the radiographic standards in Figures 4 through 8, according to the size of the electrode
- (3) No rounded indications in excess of those permitted by the radiographic standards in Figures 4 through 8, according to the thickness of the test assembly, or the alternative method of evaluation in 11.3.1

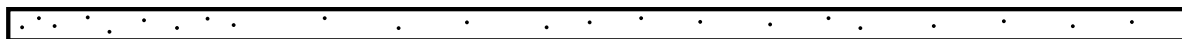
In evaluating the radiograph, 1 in [25 mm] of the weld on each end of the test assembly shall be disregarded.

11.3.1 The alternative method of evaluation involves calculation of the total area of the rounded indications as they appear on the radiograph. This total area shall not exceed 1 percent of the thickness of the test assembly multiplied by the length of the weld used in the evaluation (length of the weld in the test assembly minus 1 in [25 mm] on each end). The value given in Note 3 to each of the Figures (4 through 8) has been calculated for 6 in [150 mm] of weld (an 8 in [200 mm] long test assembly). The value for weld lengths other than this will differ on a linearly proportional basis.

11.3.2 A rounded indication is an indication (on the radiograph) whose length is no more than three times its width. Rounded indications may be circular, elliptical, conical, or irregular in shape, and they may have tails. The size of a rounded indication is the largest dimension of the indication including any tail that may be present. The indications may be of porosity or slag. The total area of the rounded indications for the alternative method shall not exceed the values given in Note 3 to the radiographic standards (Figures 4 through 8). Indications whose largest dimension does not exceed 1/64 in [0.4 mm] shall be disregarded. Test assemblies with rounded indications larger than the largest indications permitted in the radiographic standards do not meet the requirements of this specification.

**(A) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.025 in [0.6 mm] MAXIMUM.
 NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 14.

**(B) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.020 in [0.5 mm] MAXIMUM.
 NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 23.

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 0.008 in² [5.2 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: 1/16 in [1.6 mm] maximum
 - (b) Total length of all slag indications: 1/8 in [3.2 mm] maximum

Source: Figure 4 of AWS A5.11/A5.11M:2005.

Figure 4—Radiographic Standards for 1/8 in [3 mm] Test Assembly**12. Tension Test**

12.1 One all-weld-metal tension test specimen, as specified in the Tension Test section of AWS B4.0 or AWS B4.0M shall be machined as described 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 [19 mm] thickness, a nominal diameter of 0.250 in [6.4 mm] for test assemblies 1/2 in [13 mm] thickness, and a nominal diameter of 0.160 in [4.0 mm] for test assemblies of 3/8 in [10 mm] thickness.

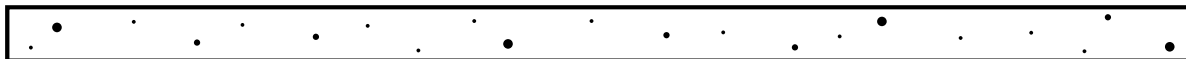
12.2 The specimen shall be tested in the manner described in the tension test section of the latest edition of AWS B4.0 or AWS B4.0M.

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

13. Bend Test

13.1 Three transverse side bend specimens (for electrodes larger than 5/64 in [2.0 mm]) or two transverse face bend specimens (for 5/64 in [2.0 mm] electrodes), as required in Table 2, shall be taken from the assembly described in 9.4.1 and shown in Figure 2. The dimensions of the specimens shall be as shown in Table 5.

13.2 The specimens shall be tested in the manner described in the Bend Test section of AWS B4.0 or B4.0M, by bending them uniformly through 180 degrees over a 3/4 in [19 mm] radius. Any suitable jig, as specified in the Bend Test section of AWS B4.0 or B4.0M may be used. Positioning of the side bend specimens shall be such that the side of the specimen with the greater discontinuities, if any, is in tension. Positioning of the face bend specimens shall be such that face of the weld is in tension. For both types of transverse bend specimen, the weld shall be at the center of the bend.

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.050 in [1.3 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 21, WITH THE FOLLOWING RESTRICTIONS:

LARGE: UP TO 0.050 in [1.3 mm] – 4 PERMITTED

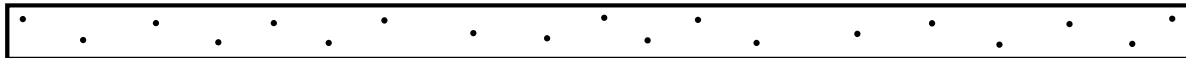
MEDIUM: UP TO 0.031 in [0.8 mm] – 5 PERMITTED

SMALL: UP TO 0.020 in [0.5 mm] – 12 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

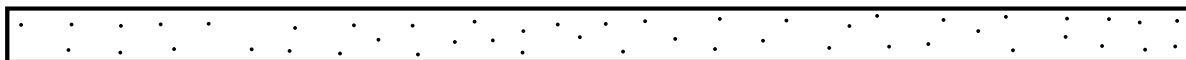
SIZE PERMITTED IS 0.050 in [1.3 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 8.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.031 in [0.8 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 19.

**(D) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.020 in [0.5 mm] MAXIMUM.

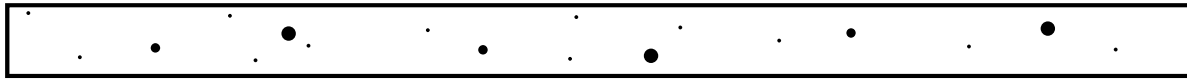
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 48.

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 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 0.015 in² [9.7 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

Source: Figure 5 of AWS A5.11/A5.11M:2005.

Figure 5—Radiographic Standards for 1/4 in [7 mm] Test Assembly

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.075 in [1.9 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 17, WITH THE FOLLOWING RESTRICTIONS:

LARGE: UP TO 0.075 in [1.9 mm] – 3 PERMITTED

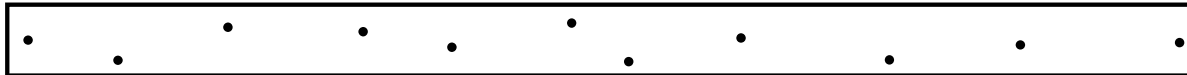
MEDIUM: UP TO 0.049 in [1.3 mm] – 3 PERMITTED

SMALL: UP TO 0.020 in [0.5 mm] – 11 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

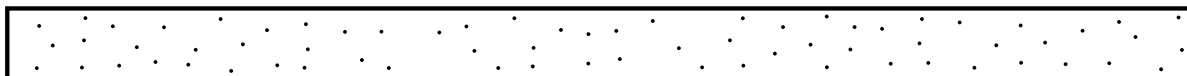
SIZE PERMITTED IS 0.075 in [1.9 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 5.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.049 in [1.3 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 11.

**(D) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.020 in [0.5 mm] MAXIMUM.

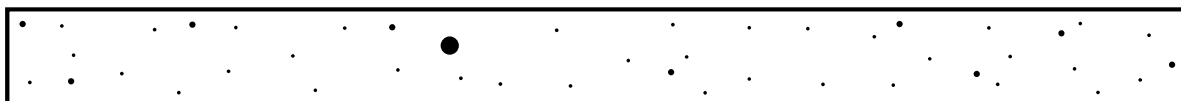
NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 72.

Notes:

1. 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 0.023 in² [14.8 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 [9.5 mm] maximum

Source: Figure 6 of AWS A5.11/A5.11M:2005.

Figure 6—Radiographic Standards for 3/8 in [10 mm] Test Assembly

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.10 in [2.5 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 45, WITH THE FOLLOWING RESTRICTIONS:

LARGE: UP TO 0.10 in [2.5 mm] – 1 PERMITTED

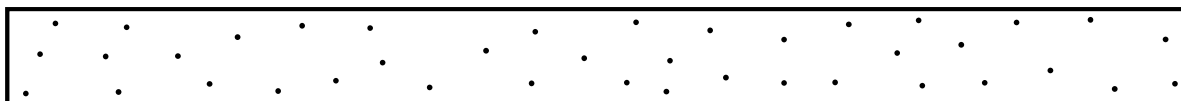
MEDIUM: UP TO 0.031 in [0.8 mm] – 9 PERMITTED

SMALL: UP TO 0.019 in [0.5 mm] – 35 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.10 in [2.5 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 4.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.031 in [0.8 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 40.

**(D) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.019 in [0.5 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 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 [19.4 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

Source: Figure 7 of AWS A5.11/A5.11M:2005.

Figure 7—Radiographic Standards for 1/2 in [13 mm] Test Assembly

**(A) ASSORTED ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.125 in [3.2 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 53, WITH THE FOLLOWING RESTRICTIONS:

LARGE: UP TO 0.125 in [3.2 mm] – 1 PERMITTED

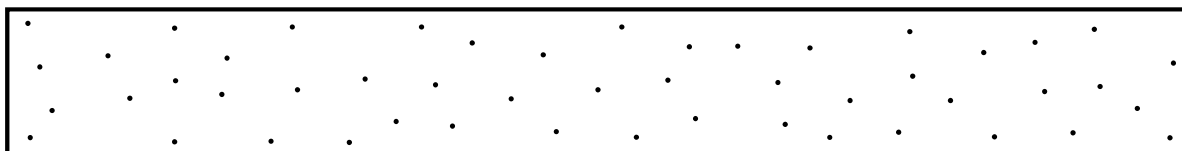
MEDIUM: UP TO 0.034 in [0.9 mm] – 17 PERMITTED

SMALL: UP TO 0.024 in [0.6 mm] – 35 PERMITTED

**(B) LARGE ROUNDED INDICATIONS**

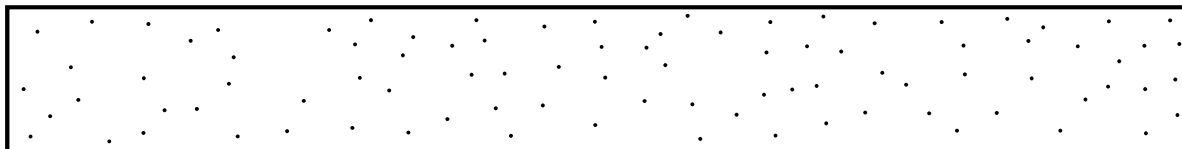
SIZE PERMITTED IS 0.125 in [3.2 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 4.

**(C) MEDIUM ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.034 in [0.9 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 50.

**(D) SMALL ROUNDED INDICATIONS**

SIZE PERMITTED IS 0.024 in [0.6 mm] MAXIMUM.

NUMBER PERMITTED IN ANY 6 in [150 mm] OF WELD IS 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 [29.0 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

Source: Figure 8 of AWS A5.11/A5.11M:2005.

Figure 8—Radiographic Standards for 3/4 in [19 mm] Test Assembly

Table 4
All-Weld-Metal Tension Test Requirements

AWS Classification	Tensile Strength, min.		Elongation ^a Percent, min.
	ksi	MPa	
Ni			
ENi-1	60	410	20
NiCr			
ENiCr-4	110	760	—
NiCu			
ENiCu-7	70	480	30
NiCrFe			
ENiCrFe-1	80	550	30
ENiCrFe-2			
ENiCrFe-3			
ENiCrFe-7			
<i>ENiCrFe-13</i>	95	650	20
ENiCrFe-4			
ENiCrFe-12	95	650	25
ENiCrFe-9			
ENiCrFe-10			
NiCrFeSi			
ENiCrFeSi-1	90	620	20
NiMo			
ENiMo-8	95	650	25
ENiMo-9			
ENiMo-1	100	690	25
ENiMo-3			
ENiMo-7			
ENiMo-10			
ENiMo-11			
NiCrMo			
ENiCrMo-11	85	590	25
<i>ENiCrMo-22</i>			
ENiCrMo-1	90	620	20
ENiCrMo-9	90	620	25
ENiCrMo-6	90	620	35
ENiCrMo-2	95	650	20
ENiCrMo-18	95	650	30
ENiCrMo-12	95	650	35
ENiCrMo-4	100	690	25
ENiCrMo-5			
ENiCrMo-7			
ENiCrMo-10			
ENiCrMo-13			
ENiCrMo-17	100	690	30
ENiCrMo-14			
ENiCrMo-3	110	760	30
ENiCrMo-19	120	830	20
NiCrCoMo			
ENiCrCoMo-1	90	620	25
NiCrWMo			
ENiCrWMo-1	90	620	20

^a The elongation shall be determined from the gage length equal to four times the gage diameter.

Table 5
Dimensions of Bend Test Specimens

	Length, min.		Width, min.		Thickness, min.	
	in	mm	in	mm	in	mm
Side ^a	6	150	(b)	(b)	3/8	9.5
Face ^a	6	150	1-1/2	38	3/8	9.5

^a The radius of the corners of the specimen shall be 1/8 in [3.2 mm] maximum.

^b The width of the specimen is the thickness of the test assembly from which the specimen is taken (see Figure 2).

13.3 Each specimen, after bending, shall conform to the 3/4 in [19 mm] radius, with an appropriate allowance for spring-back, and the weld metal shall not contain fissures in excess of those permitted in Table 6 when examined with the unaided eye.

14. Method of Manufacture

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

15. Standard Sizes and Lengths

15.1 Standard sizes (diameter of the core wire) and lengths of electrodes are as shown in Table 7.

15.2 The diameter of the core wire shall not vary more than ± 0.003 in [± 0.08 mm] from the diameter specified. The length shall not vary more than $\pm 3/8$ in [± 10 mm] from that specified.

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 dimension by more than the following:

- (1) Seven percent of the mean dimension in sizes 3/32 in [2.5 mm] and smaller
- (2) Five percent of the mean dimension in sizes 1/8 in [3.2 mm] and 5/32 in [4.0 mm]
- (3) Four percent of the mean dimension in sizes 3/16 in [4.8 mm] and larger

The 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 3/4 in [19 mm], nor more than 1-1/4 in [32 mm], to provide for electrical contact with the holder.

Table 6
Bend Test Requirements^a

AWS Classification	Fissures Permitted				
	Electrode Size		Maximum Number ^b	Maximum Length ^c	
	in	mm		in	mm
ENi-1	5/64	2.0	3	1/8	3
	3/32	2.4 ^d			
	—	2.5			
	1/8	3.2			
	5/32	4.0	4	1/8	3
	3/16	4.8 ^d			
	—	5.0			
ENiCu-7	5/64	2.0	3	3/32	2.5
	3/32	2.4 ^d			
	—	2.5			
	1/8	3.2			
	5/32	4.0	4	3/32	2.5
	3/16	4.8 ^d			
	—	5.0			
	1/4	6.4 ^d			
ENiCrFe-1	ENiCrFe-2	5/64 3/32 — 1/8 5/32 3/16 — 2.0 2.4^d 2.5 3.2 4.0 4.8^d 5.0	3	3/32	2.5
ENiCrFe-4	ENiCrFe-7				
ENiCrFe-9	ENiCrFe-10				
ENiCrFe-12	ENiCrFe-13				
ENiCrFeSi-1					
ENiMo-1	ENiMo-3				
ENiMo-7	ENiMo-8				
ENiMo-9	ENiMo-10				
ENiMo-11					
ENiCrMo-1	ENiCrMo-2				
ENiCrMo-3	ENiCrMo-4				
ENiCrMo-5	ENiCrMo-6				
ENiCrMo-7	ENiCrMo-9				
ENiCrMo-10	ENiCrMo-11				
ENiCrMo-12	ENiCrMo-13				
ENiCrMo-14	ENiCrMo-17				
ENiCrMo-18	ENiCrMo-19				
ENiCrMo-22	ENiCrCoMo-1				
ENiCrWMo-1					
ENiCrFe-3		5/64	2	3/32	2.5
		3/32			
		—			
		1/8			
		5/32			
		3/16			
		—			

^a These requirements apply to both side and face-bend specimens.

^b The value shown is the maximum number of fissures permitted in the weld metal on the tension side of each bend specimen. The sizes of the fissures are defined in Note c.

^c The number of fissures referred to in Note b, is for fissures between 1/64 in [0.4 mm] and the length shown in the last column of the table. Those less than 1/64 in [0.4 mm] in length and those on the corners of the specimens shall be disregarded. Bend specimens with fissures longer than the length shown do not meet the requirements of this specification.

^d Metric sizes not shown in ISO 544.

Table 7
Standard Sizes and Lengths

Standard Lengths ^a											
Electrode Size (Core Wire Diameter)			ENi-1		ENiCr-4		ENiCu-7		ENiCrFe-1 ENiCrFe-2 ENiCrFe-3 ENiCrFe-4 ENiCrFe-7 ENiCrFe-9 ENiCrFe-10 <i>ENiCrFe-13</i> ENiCrMo-3 ENiCrFe-12 ENiMo-1 ENiMo-7 ENiMo-9 ENiMo-11 ENiCrMo-2 ENiCrMo-5 ENiCrMo-7 ENiCrMo-10 ENiCrMo-12^c ENiCrMo-14 ENiCrMo-18 <i>ENiCrMo-22</i> ENiCrWMo-1		
			in	mm	in	mm	in	mm	in	mm	mm
5/64	2.0	230	9	230	12	300	9	230	9	230	230
3/32	2.4 ^b	230 or 300	9 or 12	230 or 300	12	300	9 or 12	230 or 300	9 or 12	230 or 300	230 or 300
—	2.5	250	—	250	14	350	—	250	—	250	250
1/8	3.2	350	14	350	14	350	14	350	14	350	350
5/32	4.0	350	14	350	14	350	14	350	14	350	350
3/16 ^c	4.8 ^{b,c}	350	14	350	18	450	14	350	14	350	350
—	5.0 ^c	350	—	350	—	—	—	350	—	—	—
1/4	6.4 ^b	—	—	—	—	—	14	350	—	—	—

^a Other sizes and lengths shall be as agreed upon by the purchaser and the supplier.

^b Metric sizes not shown in ISO 544.

^c The 3/16 in [4.8 or 5.0 mm] diameter is not standard for the ENiCrMo-12 classification.

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 to the point where the full cross section of the covering is obtained) shall not exceed 1/8 in [3 mm] or the diameter of the core wire, whichever is less. Electrodes with chipped coverings near the arc end, baring the core wire no more than the lesser of 1/4 in [6 mm] or twice the diameter of the core wire meet the requirements of this specification, provided no chip uncovers more than 50 percent of the circumference of the core.

18. Electrode Identification

All electrodes shall be identified as follows:

18.1 At least one legible imprint of the AWS electrode classification shall be applied to the electrode covering starting within 2-1/2 in [65 mm] of the grip end of the electrode. Additionally, the numerical classification number from ISO 14172 may be applied as a reference designation, provided the requirements of ISO 14172 are satisfied (see A2.4 and Table A.1).

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.

18.4 The prefix letter “E” in the electrode classification may be omitted from the imprint.

19. Packaging

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

19.2 Package weights shall be as agreed upon by supplier and purchaser.

20. Marking of Packages

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), 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 Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding

This annex is not part of AWS A5.11/A5.11M:2010, *Specification for Nickel and Nickel-Alloy Welding 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. Reference to appropriate base metal specifications is made whenever that can be done and when it would be helpful. Such references are intended only as examples rather than complete listings of the base metals for which each filler metal is suitable.

A2. Classification System

A2.1 The system for identifying the electrode classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The letter “E,” at the beginning of each classification designation stands for electrode.

A2.2 Since the electrodes are classified according to the chemical composition of the weld metal they deposit, the chemical symbol “Ni” appears right after the “E,” as a means of identifying the electrodes as nickel-base alloys. The other symbols (Cr, Cu, Fe, Mo, Si, W, and Co) in the designations are intended to group the electrodes according to their principal alloying elements. The individual designations are made up of these symbols and a number at the end of the designation (ENiMo-1 and ENiMo-3, 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, the electrode classifications in this specification have corresponding classifications in AWS A5.14/A5.14M, *Specification for Bare Nickel and Nickel-Alloy Welding Electrodes and Rods*, for those cases in which there is a corresponding application for a bare electrode or rod (ER). Table A.1 correlates the covered electrode classifications in this edition with the corresponding ER classification in AWS A5.14/A5.14M. It also lists the current designation for each classification as it is given in a prominent and pertinent military specification, when such a designation exists.

A2.4 An international system for designating welding filler metals developed by the International Institute of Welding (IIW) is being adopted in many ISO specifications. Table A.1 shows those used in ISO 14172 specification for comparison with comparable classifications in this specification. To understand the proposed international designation system, one is referred to Table 10A of the annex of the AWS document 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 A5.01M/A5.01 (ISO 14344), 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 A5.01M/

Table A.1
Comparison of Classifications^a

Present AWS Classification	UNS Number	Military Designation ^b	Corresponding A5.14/A5.14M ^c	ISO 14172 Designation
ENi-1	W82141	4N11	ERNi-1	ENi 2061
ENiCr-4	W86172	—	ERNiCr-4	—
ENiCu-7	W84190	9N10	ERNiCu-7	ENi 4060
ENiCrFe-1	W86132	3N12	ERNiCrFe-5	ENi 6062
ENiCrFe-2	W86133	4N1A	ERNiCrFe-6	ENi 6133
ENiCrFe-3	W86182	8N12	ERNiCr-3	ENi 6182
ENiCrFe-4	W86134	—	—	ENi 6093
ENiCrFe-7	W86152	—	ERNiCrFe-7	ENi 6152
ENiCrFe-9	W86094	—	—	ENi 6094
ENiCrFe-10	W86095	—	—	ENi 6095
ENiCrFe-12	W86025	—	ERNiCrFe-12	ENi 6025
<i>ENiCrFe-13</i>	<i>W86155</i>	—	<i>ERNiCrFe-13</i>	—
ENiCrFeSi-1	W86045	—	ERNiCrFeSi-1	—
ENiMo-1	W80001	3N1B	ERNiMo-1	ENi 1001
ENiMo-3	W80004	4N1W	ERNiMo-3	ENi 1004
ENiMo-7	W80665	—	ERNiMo-7	ENi 1066
ENiMo-8	W80008	—	ERNiMo-8	ENi 1008
ENiMo-9	W80009	—	ERNiMo-9	ENi 1009
ENiMo-10	W80675	—	ERNiMo-10	ENi 1067
ENiMo-11	W80629	—	ERNiMo-11	ENi 1069
ENiCrMo-1	W86007	—	ERNiCrMo-1	—
ENiCrMo-2	W86002	—	ERNiCrMo-2	ENi 6002
ENiCrMo-3	W86112	1N12	ERNiCrMo-3	ENi 6625
ENiCrMo-4	W80276	—	ERNiCrMo-4	ENi 6276
ENiCrMo-5	W80002	3N1C	—	ENi 6275
ENiCrMo-6	W86620	—	—	ENi 6620
ENiCrMo-7	W86455	—	ERNiCrMo-7	ENi 6455
ENiCrMo-9	W86985	—	ERNiCrMo-9	ENi 6985
ENiCrMo-10	W86022	—	ERNiCrMo-10	ENi 6022
ENiCrMo-11	W86030	—	ERNiCrMo-11	ENi 6030
ENiCrMo-12	W86032	—	—	ENi 6627
ENiCrMo-13	W86059	—	ERNiCrMo-13	ENi 6059
ENiCrMo-14	W86026	—	ERNiCrMo-14	ENi 6686
ENiCrMo-17	W86200	—	ERNiCrMo-17	ENi 6200
ENiCrMo-18	W86650	—	ERNiCrMo-18	ENi 6650
ENiCrMo-19	W86058	—	ERNiCrMo-19	—
<i>ENiCrMo-22</i>	<i>W86035</i>	—	<i>ERNiCrMo-22</i>	—
ENiCrCoMo-1	W86117	—	ERNiCrCoMo-1	ENi 6117
ENiCrWMo-1	W86231	—	ERNiCrWMo-1	ENi 6231

^a The requirements for equivalent classifications are not necessarily identical in every respect.

^b Designations are from MIL-E-22200/3, *Nickel Base Alloy and Cobalt Base Alloy Covered Welding Electrodes*.

^c AWS A5.14/A5.14M:2005, *Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*.

A5.01 (ISO 14344). 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 A5.01M/A5.01 (ISO 14344). Testing in accordance with any other Schedule in that Table must be specifically required in 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 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 A5.01M/A5.01 (ISO 14344).

A5. Ventilation During Welding

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

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

A5.2 American National Standard ANSI Z49.1 (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 Before welding or heating any nickel-base alloy, the material must be clean. Oil, grease, paint, lubricants, marking pencils, temperature-indicating materials, threading compounds, and other such materials frequently contain sulfur, lead, or silver, which 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 (steel, 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 nickel base metal, rather than the dissimilar metal member.

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

A7. Description and Intended Use of Electrodes

A7.1 ENi-1 Classification. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 95 Ni, and 2.5 Ti. Electrodes of this classification are used for welding wrought and cast forms of commercially pure nickel to themselves and to steel (i.e., joining nickel to steel and surfacing steel with nickel). Typical specifications for this nickel base metal are ASTM B 160, B 161, B 162, and B 163, all of which have UNS Number N02200 or N02201. Electrodes through the 1/8 in [3.2 mm] size can be used in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.2 ENiCr-4 Classification. Electrodes of this classification are primarily used to weld cast grade ASTM A 560. ENiCr-4 is resistant to carburizing furnace atmospheres and fuel ash corrosion which occurs when burning low grade heavy fuels. ENiCr-4 is scale resistant up to 2100°F [1150°C].

A7.3 ENiCu-7 Classification. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 66 Ni, 30 Cu, 3 Mn, and 1 Fe. Electrodes of this classification are used for welding nickel-copper alloys to themselves and to steel, for welding the clad side of joints in steel clad with a nickel-copper alloy, and for surfacing steel with nickel-copper alloy weld metal. Typical specifications for the nickel-copper base metal are ASTM B 127, B 163, B 164, and B 165, all of which have UNS Number N04400.

Electrodes through the 1/8 in [3.2 mm] size can be used in all positions. Electrodes larger than that are used only in the flat and horizontal positions. The weld metal is suitable for service both in the as-welded condition and after an appropriate postweld heat treatment. Qualification tests should be conducted beforehand to make certain the necessary properties can be obtained after the particular heat treatment is employed.

A7.4 ENiCrFe-X Classifications

A7.4.1 ENiCrFe-1. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 70 Ni, 15 Cr, 8 Fe, 3.5 Mn, and 2.5 Nb (Cb) plus Ta. Electrodes of this classification are used for welding nickel-chromium-iron alloys, for the clad side of joints in steel clad with nickel-chromium-iron alloy, and for surfacing steel with nickel-chromium-iron weld metal. The electrodes may be used for applications at temperatures ranging from cryogenic to around 1800°F [980°C]. However, for temperatures above 1500°F [820°C], weld metal produced by these electrodes does not exhibit optimum oxidation resistance and strength. These electrodes are also suitable for joining steel to nickel-base alloys. Typical specifications for the nickel-chromium-iron base metal are ASTM B 163, B 166, B 167, and B 168, all of which have UNS Number N06600. Electrodes through the 1/8 in [3.2 mm] size can be used in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.4.2 ENiCrFe-2. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 70 Ni, 15 Cr, 8 Fe, 2 Mn, 2 Nb plus Ta, and 1.5 Mo. Electrodes of this classification are used for welding nickel-chromium-iron alloys, 9 percent nickel steel, and a variety of dissimilar metal joints (involving carbon steel, stainless steel, nickel, and nickel-base alloys). The base metals can be wrought or cast (welding grade), or both. The electrodes may be used for applications at temperatures ranging from cryogenic to around 1800°F [980°C]. However, for temperatures above 1500°F [820°C], weld metal produced by ENiCrFe-2 does not exhibit optimum oxidation resistance and strength. Typical specifications for the nickel-chromium-iron base metal are ASTM B 163, B 166, B 167, and B 168, all of which have UNS Number N06600. Electrodes through the 1/8 in [3.2 mm] size can be used in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.4.3 ENiCrFe-3. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 65 Ni, 15 Cr, 8 Fe, 7.5 Mn, and 2 Nb plus Ta. Electrodes of this classification are used for welding nickel-chromium-iron alloys, for welding the clad side of joints on steel clad with nickel-chromium-iron alloy, and for surfacing steel with nickel-chromium-iron weld metal, when comparatively high manganese contents are not detrimental. The electrode may be used for applications at temperatures ranging from cryogenic to about 900°F [480°C]. Typical specifications for the nickel-chromium-iron base metal are ASTM B 163, B 166, B 167, and B 168, all of which have UNS Number N06600.

These electrodes can also be used for welding steel to other nickel-base alloys. Fewer fissures are permitted on the bend test for this weld metal than for weld metal of the ENiCrFe-1 and ENiCrFe-2 classifications. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the horizontal and flat positions.

A7.4.4 ENiCrFe-4. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 70 Ni, 15 Cr, 8 Fe, 2.5 Mn, 2.5 Nb plus Ta, and 2.5 Mo. Electrodes of this classification are used for welding 9 percent nickel steel. Typical specifications for the 9% nickel steel base metal are ASTM A 333, A 334, A 353, A 522, and A 553, all of which have UNS Number K81340. The strength of the weld metal is higher than that of the ENiCrFe-2 classification.

A7.4.5 ENiCrFe-7. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 55 Ni, 29 Cr, 9.5 Fe, 3 Mn, and 1.5 Nb plus Ta. Electrodes of this classification are used for welding the nickel-chromium-iron alloy of the UNS Number N06690. Typical specifications for the nickel-chromium-iron base metal are ASTM B 166, B 167, and B 168. The electrodes may also be used for the welding of nickel-chromium-iron alloys to

steels and stainless steels, and for corrosion-resistant overlays on steels. Specification of values for boron and zirconium are helpful in reducing the tendency for ductility dip cracking. Electrodes through the 1/8 in [3.2 mm] size can be used in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.4.6 ENiCrFe-9. The nominal composition (wt.-%) of electrodes of this classification is 70 Ni, 14 Cr, 9 Fe, 1.5 Nb plus Ta, and 4 Mo. Electrodes of this classification are used for welding 9 percent nickel steel. Typical specifications for the 9 percent nickel steel base metal are ASTM A 333, A 334, A 353, A 522, and A 553, all of which have UNS Number K81340. Electrodes through the 5/32 in [4.0 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.4.7 ENiCrFe-10. The nominal composition (wt.-%) of electrodes of this classification is 65 Ni, 15 Cr, 10 Fe, 1.5 Nb plus Ta, 3 Mo, and 2 W. Electrodes of this classification are used for welding 9 percent nickel steel. Typical specifications for the 9 percent nickel steel base metal are ASTM A 333, A 334, A 353, A 522, and A 553, all of which have UNS Number K81340. Electrodes through the 5/32 in [4.0 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.4.8 ENiCrFe-12. The nominal chemical composition (wt.-%) of weld metal produced by electrodes of this classification is 63 Ni, 25 Cr, 9.5 Fe, and 2.1 Al. Electrodes of this classification are used for welding UNS Number N06025, welding nickel-chromium-iron to steel and to other nickel base alloys. Typical specifications for the base metal are ASTM B 163, B 166, B 167, B 168, B 366, B 516, B 517, B 546, and B 564, all of which have UNS Number N06025.

A7.4.9 ENiCrFe-13. *The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 55.5 Ni, 29 Cr, 8.5 Fe, 3.5 Mo, 2.5 Nb. Electrodes of this composition are used for welding nickel-chromium-iron alloy themselves to steels, and to weld clad steels with the nickel-chromium-iron alloy using the SMAW process. This classification provides improved resistance to ductility dip cracking under conditions of high restraint when compared to products offered under ENiCrFe-7. Electrodes through the 1/8 in [3.2 mm] size can be used in all positions. Electrodes larger than that are used only in the flat and horizontal positions. Typical specifications for nickel-chromium-iron base metals are ASTM B 163, B 166, B 167, and B 168, all of which have UNS Number N06690.*

A7.5 ENiCrFeSi-1 Classification. The nominal chemical composition (wt.-%) of weld metal produced by electrodes of this classification is 46 Ni, 28 Cr, 23 Fe, and 2.75 Si. Electrodes of this classification are used for welding UNS Number N06045, welding nickel-chromium-iron to steel and to other nickel base alloys. Typical specifications for the base metal are ASTM B 163, B 166, B 167, B 168, B 366, B 516, B 517, B 546, and B 564, all of which have UNS Number N06045.

A7.6 ENiMo-X Classifications

A7.6.1 ENiMo-1. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 67 Ni, 28 Mo, and 5 Fe. Electrodes of the ENiMo-1 classification are used for welding nickel-molybdenum alloys as well as the clad side of joints in steel clad with a nickel-molybdenum alloy and for welding nickel-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-molybdenum base metal are ASTM B 333, B 335, B 619, B 622, and B 626, all of which have UNS Number N10001. ENiMo-1 electrodes normally are used only in the flat position.

A7.6.2 ENiMo-3. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 63 Ni, 25 Mo, 5.5 Fe, and 4 Cr. Electrodes of the ENiMo-3 classification are used for welding dissimilar metal combinations of nickel-, cobalt-, and iron-base alloys. These electrodes normally are used only in the flat position.

A7.6.3 ENiMo-7. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 69 Ni, 28 Mo, 1.5 Fe, and 1.5 Mn. Electrodes of the ENiMo-7 classification have controlled low levels of carbon, iron, and cobalt and are used for welding nickel-molybdenum alloys, for welding the clad side of joints in steel clad with a nickel-molybdenum alloy, and for welding nickel-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-molybdenum base metals are ASTM B 333, B 335, B 619, B 622, and B 626, all of which have UNS Number N10665. These electrodes normally are used only in the flat position.

A7.6.4 ENiMo-8. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 70 Ni, 18 Mo, 7 Fe, 3 W, and 2 Cr. Electrodes of this classification are used for welding 9 percent nickel steel, but they can be used in other applications as well. Typical specifications for the 9 percent nickel steel base metal are ASTM A 333, A 334, A 353, A 522, and A 553, all of which have UNS Number K81340. Electrodes through the 5/32 in

[4.0 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.6.5 ENiMo-9. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 70 Ni, 19 Mo, 3 Fe, 3 W, and 1 Cu. Electrodes of this classification are used for welding 9 percent nickel steel, but they can be used in other applications as well. Typical specifications for the 9 percent nickel steel base metal are ASTM A 333, A 334, A 353, A 522, and A 553, all of which have UNS Number K81340. Electrodes through the 5/32 in [4.0 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.6.6 ENiMo-10. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 69 Ni, 28 Mo, 1.5 Cr, 1.5 Fe, and low levels of carbon. The filler materials are used for welding nickel-molybdenum alloys (UNS numbers N10665 and N10675), for welding the clad side of joints in steel clad with a nickel-molybdenum alloy, and for welding nickel-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-molybdenum base metals are ASTM B 333, B 335, B 366, B 564, B 619, B 622, and B 626. These coated electrodes are normally used in the flat position.

A7.6.7 ENiMo-11. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 67Ni, 28 Mo, 3 Fe, 1.3 Cr, and low C. The filler materials are used for welding nickel-molybdenum alloys (UNS Numbers N10665 and N10629), for welding clad side of joints in steel clad with Ni-Mo alloy, and for welding Ni-Mo alloys to steel and to other nickel-base alloys. The ASTM specifications for the Ni-Mo alloys (base metal) are B 333, B 335, B 366, B 564, B 619, B 622, and B 629. These coated electrodes are generally used in flat position.

A7.7 ENiCrMo-X Classifications

A7.7.1 ENiCrMo-1. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 43 Ni, 22 Cr, 19.5 Fe, 6.5 Mo, 2 Nb plus Ta, 2 Cu, and 1.5 Mn. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for welding nickel-chromium-molybdenum alloy to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 581, B 582, B 619, and B 622, all of which have UNS Number N06007. These electrodes normally are used only in the flat position.

A7.7.2 ENiCrMo-2. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 47 Ni, 22 Cr, 18 Fe, 9 Mo, and 1.5 Co. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for welding nickel-chromium-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 435, B 572, B 619, B 622, and B 626, all of which have UNS Number N06002. These electrodes normally are used only in the flat position.

A7.7.3 ENiCrMo-3. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 60 Ni, 22 Cr, 9 Mo, 5 Fe, 3.5 Nb plus Ta. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys to themselves and to steel, and for surfacing steel with nickel-chromium-molybdenum weld metal. These electrodes also can be used for welding nickel-base alloys to steel. The electrodes are used in applications where the temperature ranges from cryogenic to 1000°F [540°C]. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 443, B 444, and B 446, all of which have UNS Number N06625. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.7.4 ENiCrMo-4. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 57 Ni, 16 Mo, 15.5 Cr, 5.5 Fe, 4 W, and low C. Electrodes of this classification are used for welding low-carbon nickel-chromium-molybdenum alloy, for welding the clad side of joints in steel clad with low-carbon nickel-chromium-molybdenum alloy, and for welding low-carbon nickel-chromium-molybdenum alloy to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 574, B 575, B 619, B 622, and B 626, all of which have UNS Number N10276. These electrodes normally are used only in the flat position.

A7.7.5 ENiCrMo-5. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 53 Ni, 16 Mo, 15.5 Cr, 5.5 Fe, and 4 W. Electrodes of this classification are used for surfacing steel clad with a nickel-chromium-molybdenum alloy. These electrodes normally are used only in the flat position.

A7.7.6 ENiCrMo-6. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 65 Ni, 14.5 Cr, 7 Fe, 7 Mo, 3 Mn, 1.5 W, and 1.5 Nb plus Ta. Electrodes of this classification are used for welding 9 percent nickel steel, but they can be used in other applications as well. Typical specifications for the 9 percent nickel steel base metal are ASTM A 333, A 334, A 353, A 522, and A 553, all of which have UNS Number K81340. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat and horizontal positions.

A7.7.7 ENiCrMo-7. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 65 Ni, 16 Cr, 15.5 Mo, and 1.5 Fe. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloy, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for joining nickel-chromium-molybdenum alloys to alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 574, B 575, B 619, B 622, and B 626, all of which have UNS Number N06455. These electrodes normally are used only in the flat position.

A7.7.8 ENiCrMo-9. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 44 Ni, 22 Cr, 19.5 Fe, 7 Mo, 2 Co, and 2 Cu. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloys, and for joining nickel-chromium-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metal are ASTM B 581, B 582, B 619, B 622, and B 626, all of which have UNS Number N06985. These electrodes normally are used only in the flat position.

A7.7.9 ENiCrMo-10. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 56 Ni, 22 Cr, 13 Mo, 4 Fe, and 3 W. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, to steel and to other nickel-base alloys; and for joining nickel-chromium-molybdenum alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 574, B 575, B 619, B 622, and B 626, all of which have UNS Number N06022. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat position.

A7.7.10 ENiCrMo-11. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 43 Ni, 30 Cr, 15 Fe, 5 Mo, 2 Co, 3 W, and 2 Cu. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloys, and for joining nickel-chromium-molybdenum alloys to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metal are ASTM B 581, B 582, B 619, B 622, and B 626, all of which have UNS Number N06030. These electrodes normally are used only in the flat position.

A7.7.11 ENiCrMo-12. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 58 Ni, 21.5 Cr, 9.5 Mo, 3 Fe, and 2 Nb plus Ta. Electrodes of this classification are used for welding chromium-nickel-molybdenum austenitic stainless steels to themselves, to duplex ferritic-austenitic stainless steels, to nickel-chromium-molybdenum alloys, and to steel. The ENiCrMo-12 composition is balanced to provide corrosion-resistant welds for use at temperatures below the creep range of highly alloyed austenitic stainless steels. Typical specifications for the chromium-nickel-molybdenum stainless steel base metals are ASTM A 240, A 167, A 182, A 249, A 276, A 312, A 358, A 473, and A 479, most particularly the grade UNS S31254 contained in those specifications. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that can be used only for welding in the flat and horizontal positions.

A7.7.12 ENiCrMo-13. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 59 Ni, 23 Cr, 16 Mo, 1 Fe, and low C. Electrodes of this classification are used to weld low-carbon nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with low-carbon nickel-chromium-molybdenum alloys, and for welding low carbon nickel-chromium-molybdenum alloy to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 574, B 575, B 619, B 622, and B 626, all of which have UNS Number N06059.

A7.7.13 ENiCrMo-14. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 57 Ni, 21 Cr, 16 Mo, and 4 W. Electrodes of this classification are used to weld nickel-chromium-molybdenum alloys (UNS Numbers N06686, N06625, N10276, and N06022) that are used in severe corrosion applications where resistance to reducing, oxidizing, crevice and pitting conditions is required. It is recommended for corrosion-resistant overlay cladding of iron-base metals for the same environments.

A7.7.14 ENiCrMo-17. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 59 Ni, 23 Cr, 16 Mo, and 1.6 Cu. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for the welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, to steel and to other nickel base alloys; and for joining nickel-chromium-molybdenum alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 574, B 575, B 619, B 622, and B 626, all of which have UNS Number N06200. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat position.

A7.7.15 ENiCrMo-18. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 50 Ni, 20 Cr, 13.5 Fe, 11.5 Mo, and 1.5 W. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys like UNS Number N06625, for welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, to steel and to other nickel base alloys; and for joining some other nickel-chromium-molybdenum alloys, such as UNS Numbers N06625, N08825, N06985, N08020, N08926 and N08031. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat position.

A7.7.16 ENiCrMo-19. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 58 Ni, 21 Cr, 20 Mo, and 1 Fe. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding of the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, to steel and to other nickel base alloys; and for joining nickel-chromium-molybdenum alloys. Typical specifications for the nickel-chromium-molybdenum base metals are B 574, B 575, B 366, B 564, B 619, B 622, and B 626 all of which are UNS Number N06058. Electrodes through the 1/8 in [3.2mm] size can be used for welding in all positions. Electrodes larger than that are used only in the flat position.

A7.7.17 ENiCrMo-22. *The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 58 Ni, 33 Cr, 8 Mo. Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy, and for welding nickel-chromium-molybdenum alloys to steel and other nickel base alloys. Typical specifications for the nickel-chromium-molybdenum base metals are ASTM B 574, B 575, B 619, B 622, and B 626, all of which have UNS Number N06035. These electrodes normally are used only in the flat position.*

A7.8 ENiCrCoMo-1 Classification. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 52 Ni, 23 Cr, 12 Co, 9 Mo, 2 Fe, and 1.5 Mn. Electrodes of this classification are used for welding nickel-chromium-cobalt-molybdenum alloys (UNS Number N06617) to themselves and to steel and for surfacing steel with nickel-chromium-cobalt-molybdenum weld metal. The electrodes are also used for applications where optimum strength and oxidation resistance are required above 1500°F [820°C] up to 2100°F [1150°C], especially when welding on base metals of nickel-iron-chromium alloys. Electrodes through the 1/8 in [3.2 mm] size can be used for welding in all positions. Larger electrodes are used for welding in the flat or horizontal positions.

A7.9 ENiCrWMo-1 Classification. The nominal composition (wt.-%) of weld metal produced by electrodes of this classification is 57 Ni, 22 Cr, 14 W, <5 Co, <3 Fe, and 2 Mo. Electrodes of this classification are used for welding nickel-chromium-tungsten-molybdenum-lanthanum alloy ASTM B 366, B 435, B 564, and B 572 having UNS Number N06230. Electrodes of this classification are generally used only in the flat position.

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.

AWS A5.01M/A5.01 (ISO 14344) contains provisions for ordering such tests. This section is included for the guidance of those who desire to specify such special tests. Those tests may be conducted as agreed upon between supplier and purchaser.

A8.1 Corrosion or Scaling Tests

A8.1.1 Although welds with electrodes 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, tests can be conducted on specimens taken from either a weld pad or a welded joint. 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 electrode.

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 (HAZ), and the unaffected base metal. With them, 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 have the advantage of being able to duplicate the joint design and the welding sequence planned for fabrication.

A8.1.2 Specimens for testing the corrosion or oxidation resistance of the weld metal alone are prepared by following the procedure outlined in 9.3 and Figure 1 of the specification. The pad size should be at least 3/4 in [19 mm] in height, 2-1/2 in [65 mm] in width, and $1 + 5/8 n$ (in) [$25 + 16 n$ {mm}] in length, where n represents the number of specimens required from the pad. Specimens measuring $1/2 \times 2 \times 1/4$ in [$13 \times 50 \times 6.4$ 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 with 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.

A8.1.3 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 *Recommended Practice G4 for Conducting Plant Corrosion Tests* (published by ASTM).

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.2, 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 information is available from other sources, including, but not limited to Safety and Health Fact Sheets listed in A10.2, ANSI Z49.1⁹, 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.

⁹ ANSI Z49.1 is published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Table A.2
Discontinued Classifications

Discontinued Classification	Year Last Published
ENiCu-1	1969
ENiCu-2	1969
ENiCu-3	1964
ENiCu-4	1969
ENiCr-1	1969
ENiMo-2 ^a	1964
ENiMoCr-1 ^b	1969
ENiCuAl-1	1969

^a Reclassified as ENiMoCr-1 in 1969.

^b Reclassified as ENiCrMo-5 in 1976.

A10.3 AWS Safety and Health Fact Sheets Index (SHF)¹⁰

No.	Title
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>
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 Welding 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>
33	<i>Personal Protective Equipment (PPE) for Welding & Cutting</i>
34	<i>Coated Steels: Welding and Cutting Safety Concerns</i>
36	<i>Ventilation for Welding & Cutting</i>
37	<i>Selecting Gloves for Welding & cutting</i>

¹⁰ AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Annex B (Informative)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS A5.11/A5.11M:2010, *Specification for Nickel and Nickel-Alloy Welding 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 Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

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	A5.14		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 of 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>
A5.01M/A5.01 (ISO 14344:2002 MOD)	<i>Procurement Guidelines for Consumables—Welding and Allied Processes—Flux and Gas Shielded Electrical Welding Processes</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 Electrode Gas 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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