

AWS A5.4/A5.4M:2012 (R2022)
An American National Standard

Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding



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An American National Standard

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American National Standards Institute
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Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding

11th Edition

Revises AWS A5.4/A5.4M:2006

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

Composition and other requirements are specified for more than forty classifications of covered stainless steel welding electrodes. The requirements include general requirements, testing, and packaging. Annex A provides application guidelines and other useful information about the electrodes.

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



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Foreword

This foreword is not part of AWS A5.4/A5.4M:2012, *Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*, but is included for informational purposes only.

This document is the second of the A5.4 specifications which makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore each system must be used independently of the other, without combining values in any way. In selecting rational metric units, the *Metric Practice Guide for the Welding Industry* (AWS A1.1) and International Standard ISO 544, *Welding consumables—Technical delivery conditions for welding filler materials—Type of product, dimensions, tolerances, and marking* are used where suitable. Tables and figures make use of both U.S. Customary and SI Units, which with the application of the specified tolerances provides for interchangeability of products in both the U.S. Customary and SI Units.

The Major Changes Incorporated in This Revision Include Updating Clause 6 (Rounding-off Procedure), Adding “Bi” Reporting Requirement, and New Filler Metal Classification E2307-XX. These changes are shown in italic font.

This AWS specification has evolved since the mid 1940s to its present form. The specification for covered stainless steel electrodes, issued in 1946, was prepared by a joint committee of the American Society for Testing and Materials and the American Welding Society. This cooperative effort continued for about 20 years and produced three revisions. The first revision, produced exclusively by the AWS Committee on Filler Metals, was published in 1969.

The current revision represents the tenth revision of the original 1946 document as shown below:

ASTM A298-46T	<i>Tentative Specification for Corrosion-Resisting Chromium and</i>
AWS A5.4-46T	<i>Chromium-Nickel Steel Welding Electrodes</i>
ASTM A298-48T	<i>Tentative Specifications for Corrosion-Resisting Chromium and</i>
AWS A5.4-48T	<i>Chromium-Nickel Steel Welding Electrodes</i>
ASTM A298-55T	<i>Tentative Specifications for Corrosion-Resisting Chromium and</i>
AWS A5.4-55T	<i>Chromium-Nickel Steel Covered Welding Electrodes</i>
AWS A5.4-62T	<i>Tentative Specification for Corrosion-Resisting Chromium and</i>
ASTM A298-62T	<i>Chromium-Nickel Steel Covered Welding Electrodes</i>
AWS A5.4-69	<i>Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes</i>
AWS A5.4-Add. 1-75	<i>1975 Addenda to Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes</i>
AWS A5.4-78	<i>Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes</i>
ANSI/AWS A5.4-81	<i>Specification for Covered Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Electrodes</i>
ANSI/AWS A5.4-92	<i>Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding</i>
AWS A5.4/A5.4M:2006	<i>Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding</i>

In this reaffirmation, the following editorial changes were made: the American Welding Society’s address was updated; Table A.1 in the List of Tables was modified to match the actual table; The title of Clause 6 was revised to read “Rounding Procedure”; In Figure 2, the “ $45^\circ \pm 5^\circ$ ” angle was revised to read $22.5^\circ \pm 2.5^\circ$ on both sides; The text “from Cb to Nb” was added to Table 6 note a.

In this reaffirmation, the following errata was incorporated: The “H” symbol in Figure A.1 was changed to the “x” symbol.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, A5 Committee on Filler Metals and Allied Materials, American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166.

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Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of covered stainless steel electrodes for shielded metal arc welding.^{1,2}

The chromium content of weld metal deposited by these electrodes is not less than 10.5 percent and the iron content exceeds that of any other element. For purposes of classification, the iron content shall be derived as the balance element when all other elements are considered to be at their minimum specified values.

NOTE: No attempt has been made to classify all grades of filler metals within the limits of the above scope; only the more commonly used grades have been included.

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 Annex Sections A5 and A11. 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 state and federal 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 A5.4 uses U.S. Customary Units. The specification A5.4M uses SI Units. The latter are shown in 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 A5.4 or A5.4M specifications.

2. Normative References

2.1 The following AWS standards³ are referenced in the mandatory section of this document.

1. AWS A5.01M/A5.01 (ISO 14344 MOD). *Procurement Guidelines for Consumables – Welding and Allied Processes – Flux and Gas Shielded Electrical Welding Processes*
2. AWS A5.5, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
3. AWS B4.0, *Standard Methods for Mechanical Testing of Welds*
4. AWS B4.0M, *Standard Methods for Mechanical Testing of Welds*

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

1. ANSI Z49.1⁴, *Safety in Welding, Cutting and Allied Processes*

¹ Due to possible differences in composition, core wire from covered electrodes should not be used as bare filler wire.

² Classifications E502, E505, and E7Cr are no longer specified by this document. They are specified in AWS A5.5/A5.5M:2006, designated as follows: E502 as E801X-B6 and E801X-B6L, E505 as E801X-B8 and E801X-B8L, and E7Cr as E801X-B7 and E801X-B7L.

³ AWS standards are published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166.

⁴ ANSI Z49.1 is published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166.

2.3 The following ASTM standards⁵ are referenced in the mandatory section of this document.

1. ASTM A36, *Specification for Structural Steel*
2. ASTM A240, *Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels*
3. ASTM A285, *Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*
4. ASTM A515, *Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service*
5. ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*
6. ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*
7. ASTM E353, *Standard Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys*

2.4 The following ISO standard⁶ is referenced in the mandatory section of this document.

ISO 80 000-1 Quantities and Units Part 1: General

3. Classification

3.1 The welding electrodes covered by this A5.4/A5.4M specification are classified using the system that is independent of US customary units and the International System of Units (SI), and are classified according to:

1. Chemical composition requirements for undiluted weld metal (Table 1).
2. Type of welding current and position of welding (Table 2).

3.2 Materials classified under one classification may be classified under any other classification of this specification, provided they meet all the requirements for those classifications, except that a material may not be classified under more than one of the following EXXX-15, EXXX-16, EXXX-17, or EXXX-26 designations. Table 3 lists a number of examples of such dual classification.

NOTE: The test requirements of this specification establish minimum quality levels which will assure suitability of the electrodes for the usual applications. The guide appended to this specification describes the more common applications and suggests testing procedures for those applications which warrant tests that are beyond those included in this specification.

4. Acceptance

Acceptance⁷ of the material shall be in accordance with the provisions of AWS A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.⁸

⁵ ASTM standards are published by ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

⁶ ISO standards are published by the International Organization of Standardization, 1, chemin de la voie-creuse Case Postale 56 CH-1211 Genève 20 Switzerland.

⁷ See A3, Acceptance (in Annex A) for further information on acceptance, testing of material shipped and AWS A5.01M/A5.01 (ISO 14344 MOD).

⁸ See A4, Certification (in Annex A) for further information concerning certification and the tests called for to meet this requirement.

Table 1
Chemical Composition Requirements for Undiluted Weld Metal

AWS Classification ^c	UNS Number ^d	Weight Percent ^{a,b}											
		C	Cr	Ni	Mo	Nb (Cb) Plus Ta	Mn	Si	P	S	N	Cu	Other ^e
E209-XX	W32210	0.06	20.5–24.0	9.5–12.0	1.5–3.0	—	4.0–7.0	1.00	0.04	0.03	0.10–0.30	0.75	V = 0.10–0.30
E219-XX	W32310	0.06	19.0–21.5	5.5–7.0	0.75	—	8.0–10.0	1.00	0.04	0.03	0.10–0.30	0.75	
E240-XX	W32410	0.06	17.0–19.0	4.0–6.0	0.75	—	10.5–13.5	1.00	0.04	0.03	0.10–0.30	0.75	
E307-XX	W30710	0.04–0.14	18.0–21.5	9.0–10.7	0.5–1.5	—	3.30–4.75	1.00	0.04	0.03	—	0.75	
E308-XX	W30810	0.08	18.0–21.0	9.0–11.0	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E308H-XX	W30810	0.04–0.08	18.0–21.0	9.0–11.0	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E308L-XX	W30813	0.04	18.0–21.0	9.0–11.0	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E308Mo-XX	W30820	0.08	18.0–21.0	9.0–12.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E308LMo-XX ^f	W30823	0.04	18.0–21.0	9.0–12.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E309-XX	W30910	0.15	22.0–25.0	12.0–14.0	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E309H-XX	W30910	0.04–0.15	22.0–25.0	12.0–14.0	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E309L-XX	W30913	0.04	22.0–25.0	12.0–14.0	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E309Nb-XX ^g	W30917	0.12	22.0–25.0	12.0–14.0	0.75	0.70–1.00	0.5–2.5	1.00	0.04	0.03	—	0.75	
E309Mo-XX	W30920	0.12	22.0–25.0	12.0–14.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E309LMo-XX ^f	W30923	0.04	22.0–25.0	12.0–14.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E310-XX	W31010	0.08–0.20	25.0–28.0	20.0–22.5	0.75	—	1.0–2.5	0.75	0.03	0.03	—	0.75	
E310H-XX	W31015	0.35–0.45	25.0–28.0	20.0–22.5	0.75	—	1.0–2.5	0.75	0.03	0.03	—	0.75	
E310Nb-XX ^g	W31017	0.12	25.0–28.0	20.0–22.0	0.75	0.70–1.00	1.0–2.5	0.75	0.03	0.03	—	0.75	
E310Mo-XX	W31020	0.12	25.0–28.0	20.0–22.0	2.0–3.0	—	1.0–2.5	0.75	0.03	0.03	—	0.75	
E312-XX	W31310	0.15	28.0–32.0	8.0–10.5	0.75	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E316-XX	W31610	0.08	17.0–20.0	11.0–14.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E316H-XX	W31610	0.04–0.08	17.0–20.0	11.0–14.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E316L-XX	W31613	0.04	17.0–20.0	11.0–14.0	2.0–3.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E316LMn-XX	W31622	0.04	18.0–21.0	15.0–18.0	2.5–3.5	—	5.0–8.0	0.90	0.04	0.03	0.10–0.25	0.75	
E317-XX	W31710	0.08	18.0–21.0	12.0–14.0	3.0–4.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E317L-XX	W31713	0.04	18.0–21.0	12.0–14.0	3.0–4.0	—	0.5–2.5	1.00	0.04	0.03	—	0.75	
E318-XX	W31910	0.08	17.0–20.0	11.0–14.0	2.0–3.0	6 × C, min to 1.00 max	0.5–2.5	1.00	0.04	0.03	—	0.75	
E320-XX	W88021	0.07	19.0–21.0	32.0–36.0	2.0–3.0	8 × C, min to 1.00 max	0.5–2.5	0.60	0.04	0.03	—	3.0–4.0	
E320LR-XX	W88022	0.03	19.0–21.0	32.0–36.0	2.0–3.0	8 × C, min to 0.40 max	1.50–2.50	0.30	0.020	0.015	—	3.0–4.0	
E330-XX	W88331	0.18–0.25	14.0–17.0	33.0–37.0	0.75	—	1.0–2.5	1.00	0.04	0.03	—	0.75	
E330H-XX	W88335	0.35–0.45	14.0–17.0	33.0–37.0	0.75	—	1.0–2.5	1.00	0.04	0.03	—	0.75	

(Continued)

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

AWS Classification ^c	UNS Number ^d	Weight Percent ^{a,b}											
		C	Cr	Ni	Mo	Nb (Cb) Plus Ta	Mn	Si	P	S	N	Cu	Other ^e
E347-XX	W34710	0.08	18.0–21.0	9.0–11.0	0.75	8 × C, min to 1.00 max	0.5–2.5	1.00	0.04	0.03	—	0.75	
E349-XX	W34910	0.13	18.0–21.0	8.0–10.0	0.35–0.65	0.75–1.20	0.5–2.5	1.00	0.04	0.03	—	0.75	V = 0.10–0.30 Ti = 0.15 max W = 1.25–1.75
E383-XX	W88028	0.03	26.5–29.0	30.0–33.0	3.2–4.2	—	0.5–2.5	0.90	0.02	0.02	—	0.6–1.5	
E385-XX	W88904	0.03	19.5–21.5	24.0–26.0	4.2–5.2	—	1.0–2.5	0.90	0.03	0.02	—	1.2–2.0	
E409Nb-XX	W40910	0.12	11.0–14.0	0.6	0.75	0.50–1.50	1.0	1.00	0.04	0.03	—	0.75	
E410-XX	W41010	0.12	11.0–13.5	0.7	0.75	—	1.0	0.90	0.04	0.03	—	0.75	
E410NiMo-XX	W41016	0.06	11.0–12.5	4.0–5.0	0.40–0.70	—	1.0	0.90	0.04	0.03	—	0.75	
E430-XX	W43010	0.10	15.0–18.0	0.6	0.75	—	1.0	0.90	0.04	0.03	—	0.75	
E430Nb-XX	W43011	0.10	15.0–18.0	0.6	0.75	0.50–1.50	1.0	1.00	0.04	0.03	—	0.75	
E630-XX	W37410	0.05	16.00–16.75	4.5–5.0	0.75	0.15–0.30	0.25–0.75	0.75	0.04	0.03	—	3.25–4.00	
E16-8-2-XX	W36810	0.10	14.5–16.5	7.5–9.5	1.0–2.0	—	0.5–2.5	0.60	0.03	0.03	—	0.75	
E2209-XX	W39209	0.04	21.5–23.5	8.5–10.5	2.5–3.5	—	0.5–2.0	1.00	0.04	0.03	0.08–0.20	0.75	
E2307-XX	S82371	0.04	22.5–25.5	6.5–10.0	0.8	—	0.4–1.5	1.0	0.030	0.020	0.10–0.20	0.50	
E2553-XX	W39553	0.06	24.0–27.0	6.5–8.5	2.9–3.9	—	0.5–1.5	1.00	0.04	0.03	0.10–0.25	1.5–2.5	
E2593-XX	W39593	0.04	24.0–27.0	8.5–10.5	2.9–3.9	—	0.5–1.5	1.00	0.04	0.03	0.08–0.25	1.5–3.0	
E2594-XX	W39594	0.04	24.0–27.0	8.0–10.5	3.5–4.5	—	0.5–2.0	1.00	0.04	0.03	0.20–0.30	0.75	
E2595-XX	W39595	0.04	24.0–27.0	8.0–10.5	2.5–4.5	—	2.5	1.2	0.03	0.025	0.20–0.30	0.4–1.5	W = 0.4–1.0
E3155-XX	W73155	0.10	20.0–22.5	19.0–21.0	2.5–3.5	0.75–1.25	1.0–2.5	1.00	0.04	0.03	—	0.75	Co = 18.5–21.0 W = 2.0–3.0
E33-31-XX	W33310	0.03	31.0–35.0	30.0–32.0	1.0–2.0	—	2.5–4.0	0.9	0.02	0.01	0.3–0.5	0.4–0.8	

^a Analysis shall be made for the elements for which specific values are shown in the table. If, however, the presence of other elements is indicated in the course of analysis, further analysis shall be made to determine that the total of these other elements, except iron, is not present in excess of 0.50 percent.

^b Single values are maximum percentages.

^c Classification suffix -XX may be -15, -16, -17, or -26. See Clause A8 of Annex A for an explanation.

^d ASTM D5-56H/SAE HS-1086, *Metal & Alloys in the Unified Numbering System*.

^e Analysis for Bi is required to be reported if intentionally added, or if it is known to be present at levels greater than 0.002%.

^f E308LMo-XX and E309LMo-XX were formerly named E308MoL-XX and E309MoL-XX, respectively.

^g E309Nb-XX and E310Nb-XX were formerly named E309Cb-XX and E310Cb-XX. The change was made to conform to the worldwide uniform designation of the element niobium.

Table 2
Type of Welding Current and Position of Welding

AWS Classification ^a	Welding Current ^b	Welding Position ^c
EXXX(X)-15	dcep	All ^d
EXXX(X)-16	dcep and ac	All ^d
EXXX(X)-17	dcep and ac	All ^d
EXXX(X)-26	dcep and ac	F, H-fillet

^a See Clause A8, Classification as to Usability, for explanation of positions.

^b dcep = direct current electrode positive (reverse polarity)

ac = alternating current

^c The abbreviations F and H-fillet indicate welding positions as follows:

F = Flat

H-fillet = Horizontal fillet

^d Electrodes 3/16 in [4.8 mm] and larger are not recommended for welding in all positions.

Table 3
Examples of Potentially Occurring Dual Classified Electrodes and Suggested Marking

Primary Classification	Alternate Classification	Suggested Electrode Marking ^a
E308L-XX	E308-XX	E308/E308L-XX
E308H-XX	E308-XX	E308/E308H-XX
E316L-XX	E316-XX	E316/E316L-XX

^a This abbreviated, suggested marking is permitted only on the electrode (the E may be omitted). All packaging and packing labels and certifications must list the complete classification designation for all classifications intended.

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 E29 or ISO 80000-1, Annex B, Rule A (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 1 000 psi (1 ksi) for tensile strength for A5.4, or to the nearest 10 MPa for tensile strength for A5.4M, 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 fulfill the requirements for the classification under test.

7. Summary of Tests

The tests required for each classification are specified in Table 4. The purpose of these tests is to determine the chemical composition, mechanical properties and soundness of the weld metal and the usability of the electrodes. 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; Clause 10, Chemical Analysis; Clause 11, Radiographic Test; Clause 12, Tension Test; and Clause 13, Fillet Weld Test.

8. Retest

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. For chemical analysis, retest material may be taken from the original test sample or from a new sample. Retest for chemical analysis need be only for those specific elements that failed to meet the test requirement.