

Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding



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An American National Standard

Approved by the
American National Standards Institute
April 10, 2012

Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

14th 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 establishes the requirements for classification of carbon steel electrodes for shielded metal arc welding. The requirements include mechanical properties of weld metal, weld metal soundness, and usability of electrode. Requirements for composition of the weld metal, moisture content of low-hydrogen electrode coverings, standard sizes and lengths, marking, manufacturing, and packaging are also included. A guide to the use of the standard is included in an annex.

Optional supplemental requirements include improved toughness and ductility, lower moisture contents, and diffusible hydrogen limits.

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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This standard is subject to revision at any time by the AWS A5 Committee on Filler Metals and Allied Materials. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are required and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS A5 Committee on Filler Metals and Allied Materials and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS A5 Committee on Filler Metals and Allied Materials to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 Doral Blvd., Doral, FL 33166.

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M. P. Parekh	<i>Consultant</i>
M. A. Quintana	<i>The Lincoln Electric Company</i>
E. S. Surian	<i>National University of Lomas de Zamora</i>

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K. Sampath	<i>Consultant</i>
M. S. Sierdzinski	<i>ESAB Welding & Cutting Products</i>

Advisors to the AWS A5A Subcommittee on Carbon and Low Alloy Steel Electrodes

S. Imaoka	<i>Kobe Steel, Limited</i>
D. J. Kotecki	<i>Damian Kotecki Welding Consultants</i>
D. R. Miller	<i>ABS Americas Materials Department</i>
M. D. Tumuluru	<i>U.S. Steel Corporation</i>

Foreword

This foreword is not part of [AWS A5.1/A5.1M:2012](#), *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*, but is included for informational purposes only.

This specification is the latest revision of the first filler metal specification issued over 70 years ago. The initial 1940 document and the three revisions within the next five years were prepared by a joint committee of the American Society for Testing and Materials and the American Welding Society. However, they were issued with only an ASTM specification designation. The 1948 revision was the first specification issued with the AWS designation appearing on the document. The 1969 revision was the first time that the document was issued without the ASTM designation.

This document is the second of the A5.1 specifications which makes use of both U.S. Customary Units and the International System of Units (SI). The dimensions are not exact equivalents in the two systems. Previous A5.1 specifications showed an approximate conversion to SI units for informational purposes only. This practice is discontinued. Instead SI units used are hard conversions to rational units. In selecting rational metric units, [AWS A1.1](#), *Metric Practice Guide for the Welding Industry*, and International Standard ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials — 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.

Substantive changes in this revision include adding of boron reporting requirement in Table 7, and updating Clause 6, Rounding-Off Procedure. These changes are shown in *italic* font.

Document Development:

ASTM A 233-40T	<i>Tentative Specifications for Iron and Steel Arc-Welding Electrodes</i>
ASTM A 233-42T	<i>Tentative Specifications for Iron and Steel Arc-Welding Electrodes</i>
ASTM A 233-43T	<i>Tentative Specifications for Iron and Steel Arc-Welding Electrodes</i>
ASTM A 233-45T	<i>Tentative Specifications for Iron and Steel Arc-Welding Electrodes</i>
ASTM A 233-48T	<i>Tentative Specifications for Mild Steel Arc Welding Electrodes</i>
AWS A5.1-48T	
ASTM A 233-55T	<i>Tentative Specifications for Mild Steel Arc Welding Electrodes</i>
AWS A5.1-55T	
ASTM A 233-58T	<i>Tentative Specification for Mild Steel Arc Welding Electrodes</i>
AWS A5.1-58T	
AWS A5.1-64T	<i>Tentative Specification for Mild Steel Covered Arc Welding Electrodes</i>
ASTM A 233-64T	
AWS A5.1-69	<i>Specification for Mild Steel Covered Arc Welding Electrodes</i>
ANSI W3.1-1973	
ANSI/AWS A5.1-78	<i>Specification for Carbon Steel Covered Arc-Welding Electrodes</i>
ANSI/AWS A5.1-81	<i>Specification for Carbon Steel Covered Arc-Welding Electrodes</i>
ANSI/AWS A5.1-91	<i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i>
AWS A5.1/A5.1M:2004	<i>Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding</i>

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

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Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	x
<i>List of Figures</i>	x
1. Scope	1
Part A—General Requirements	1
2. Normative References	1
3. Classification	2
4. Acceptance	2
5. Certification	2
6. Rounding-Off Procedure	3
Part B—Tests, Procedures, and Requirements	4
7. Summary of Tests	4
8. Retest	4
9. Weld Test Assemblies	5
10. Chemical Analysis	13
11. Radiographic Test	13
12. Tension Test	19
13. Bend Test	20
14. Impact Test	20
15. Fillet Weld Test	20
16. Moisture Test	22
17. Absorbed Moisture Test	22
18. Diffusible Hydrogen Test	24
Part C—Manufacture, Identification, and Packaging	25
19. Method of Manufacture	25
20. Standard Sizes and Lengths	25
21. Core Wire and Covering	26
22. Exposed Core	26
23. Electrode Identification	26
24. Packaging	26
25. Marking of Packages	27
Annex A (Informative)—Guide to AWS Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding	29
Annex B (Informative)—Guidelines for the Preparation of Technical Inquiries	45
AWS Filler Metal Specifications by Material and Welding Process	47
AWS Filler Metal Specifications and Related Documents	49

List of Tables

Table	Page No.
1 Electrode Classification	3
2 Tension Test Requirements	4
3 Charpy V-Notch Impact Requirements	5
4 Required Tests	6
5 Base Metal for Test Assemblies	14
6 Requirements for Preparation of Fillet Weld Test Assemblies	14
7 Chemical Composition Requirements for Weld Metal	16
8 Radiographic Soundness Requirements	19
9 Dimensional Requirements for Fillet Weld Usability Test Specimens	21
10 Moisture Content Limits for Electrode Coverings	23
11 Diffusible Hydrogen Limits for Weld Metal	24
12 Standard Sizes and Lengths	25
A.1 Canadian Electrode Classifications Similar to AWS Classifications	30
A.2 Comparison of Equivalent Classifications	32
A.3 Typical Storage and Drying Conditions for Covered Arc Welding Electrodes	35
A.4 Typical Amperage Ranges	37
A.5 Discontinued Electrode Classifications	43

List of Figures

Figure	Page No.
1 Pad for Chemical Analysis of Undiluted Weld Metal	8
2 Groove Weld Test Assembly for Mechanical Properties and Soundness of Weld Metal Produced by Using All Electrode Classifications Except E6022 [E4322] and E7018M [E4918M] Electrodes	9
3 Fillet Weld Test Assembly	10
4 Test Assembly for Transverse Tension and Longitudinal Guided Bend Tests for Welds Made with E6022 [E4322] Electrodes	11
5 Groove Weld Test Assembly for Mechanical Properties and Soundness of Weld Metal Produced by Using E7018M [E4918M] Electrodes	12
6 Welding Positions for Fillet Weld Test Assemblies	15
7 Radiographic Acceptance Standards for Rounded Indications (Grades 1 and 2)	17
8 Dimensions of Fillet Welds	21
9 Alternative Methods for Facilitating Fracture of the Fillet Weld	22
10 Order of Mandatory and Optional Supplemental Designators	27

Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of carbon steel electrodes for shielded metal arc welding.

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 Informative Annex Clauses A5 and A10. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*,¹ 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 A5.1 uses U.S. Customary Units. The specification A5.1M 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 A5.1 or A5.1M specifications.

Part A *General Requirements*

2. Normative References

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 editions of the documents shown below. For undated references, the latest edition of the standard referenced applies.

The following documents are referenced in the mandatory sections of this document:

- (1) [ASTM E29](#), *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*²
- (2) [ASTM E350](#), *Standard Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron*
- (3) [ASTM E1032](#), *Standard Test Method for Radiographic Examination of Weldments*

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

² ASTM standards are published by ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

- (4) [AWS A1.1](#), *Metric Practice Guide for the Welding Industry*³
- (5) [AWS A4.3](#), *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
- (6) [AWS A4.4M](#), *Standard Procedure for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings*
- (7) [AWS A5.01M/A5.01](#) (ISO 14344 MOD), *Procurement Guidelines for Consumables—Welding and Allied Processes—Flux and Gas Shielded Electrical Welding Processes*
- (8) [AWS B4.0](#) or [B4.0M](#), *Standard Methods for Mechanical Testing of Welds*
- (9) ANSI Z49.1 *Safety in Welding, Cutting, and Allied Processes*
- (10) ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials — Type of product, dimensions, tolerances and markings*.⁴

3. Classification

3.1 The welding electrodes covered by the A5.1 specification utilize a system based on U.S. Customary Units to classify the welding electrodes covered according to:

- (1) Type of current (see Table 1)
- (2) Type of covering (see Table 1)
- (3) Welding position (see Table 1)
- (4) Mechanical properties of the weld metal in the as-welded or aged condition (see Tables 2 and 3).

3.1M The welding electrodes covered by the A5.1M specification utilize a system based on International System of Units to classify the welding electrodes covered according to:

- (1) Type of current (see Table 1)
- (2) Type of covering (see Table 1)
- (3) Welding position (see Table 1)
- (4) Mechanical properties of the weld metal in the as-welded or aged condition (see Tables 2 and 3).

3.2 Material classified under one classification shall not be classified under any other classification in one specification, although it may be classified under both specifications, except that E7018M [E4918M] may also be classified as E7018 [E4918] provided the electrode meets all of the requirements of both classifications.

4. Acceptance

Acceptance of the welding electrodes shall be in accordance with the provisions of [AWS A5.01M/A5.01](#) (ISO 14344 MOD).

5. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.⁵

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

⁴ ISO standards are published by the American National Standards Institute, 11 West 42nd Street, New York, NY 10036-8002.

⁵ See Clause A4 for further information concerning certification and the testing called for to meet this requirement.

Table 1
Electrode Classification

AWS Classification		Type of Covering	Welding Position ^a	Type of Current ^b
A5.1	A5.1M			
E6010	E4310	High cellulose sodium	F, V, OH, H	dcep
E6011	E4311	High cellulose potassium	F, V, OH, H	ac or dcep
E6012	E4312	High titania sodium	F, V, OH, H	ac or dcen
E6013	E4313	High titania potassium	F, V, OH, H	ac, dcep, or dcen
E6018 ^c	E4318 ^c	Low-hydrogen potassium, iron powder	F, V, OH, H	ac or dcep
E6019	E4319	Iron oxide titania potassium	F, V, OH, H	ac, dcep, or dcen
E6020	E4320	High iron oxide	H-fillet F	ac or dcen ac, dcep, or dcen
E6022 ^d	E4322 ^d	High iron oxide	F, H-fillet	ac or dcen
E6027	E4327	High iron oxide, iron powder	H-fillet F	ac or dcen ac, dcep, or dcen
E7014	E4914	Iron powder, titania	F, V, OH, H	ac, dcep, or dcen
E7015	E4915	Low-hydrogen sodium	F, V, OH, H	dcep
E7016 ^c	E4916 ^c	Low-hydrogen potassium	F, V, OH, H	ac or dcep
E7018 ^c	E4918 ^c	Low-hydrogen potassium, iron powder	F, V, OH, H	ac or dcep
E7018M	E4918M	Low-hydrogen iron powder	F, V, OH, H	dcep
E7024 ^c	E4924 ^c	Iron power, titania	H-fillet, F	ac, dcep, or dcen
E7027	E4927	High iron oxide, iron powder	H-fillet F	ac or dcen ac, dcep, or dcen
E7028 ^c	E4928 ^c	Low-hydrogen potassium, iron powder	H-fillet, F	ac or dcep
E7048	E4948	Low-hydrogen potassium, iron powder	F, OH, H, V-down	ac or dcep

^a The abbreviations, F, H, H-fillet, V, V-down, and OH indicate the welding positions as follows: F = Flat, H = Horizontal, H-fillet = Horizontal fillet, V = Vertical, progression upwards (for electrodes 3/16 in [5.0 mm] and under, except 5/32 in [4.0 mm] and under for classifications E6018 [E4318], E7014 [E4914], E7015 [E4915], E7016 [E4916], E7018 [E4918], E7018M [E4918M], E7048 [E4948]). V-down = Vertical, progression downwards (for electrodes 3/16 in [5.0 mm] and under, except 5/32 in [4.0 mm] and under for classifications E6018 [E4318], E7014 [E4914], E7015 [E4915], E7016 [E4916], E7018 [E4918], E7018M [E4918M], E7048 [E4948]), OH = Overhead (for electrodes 3/16 in [5.0 mm] and under, except 5/32 in [4.0 mm] and under for classifications E6018 [E4318], E7014 [E4914], E7015 [E4915], E7016 [E4916], E7018 [E4918], E7018M [E4918M], E7048 [E4948]).

^b The term “dcep” refers to direct current electrode positive (dc, reverse polarity). The term “dcen” refers to direct current electrode negative (dc, straight polarity).

^c Electrodes with supplemental elongation, notch toughness, absorbed moisture, and diffusible hydrogen requirements may be further identified as shown in Tables 2, 3, 10, and 11.

^d Electrodes of the E6022 [E4322] classification are intended for single-pass welds only.

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 1000 psi (1 ksi) for tensile and yield strength for A5.1, or to the nearest 10 MPa for tensile and yield strength for A5.1M, 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.

Table 2
Tension Test Requirements^{a, b, c}

AWS Classification		Tensile Strength		Yield Strength at 0.2% Offset		Elongation
A5.1	A5.1M	A5.1 (ksi)	A5.1M (MPa)	A5.1 (ksi)	A5.1M (MPa)	Percentage in 4x Diameter Length
E6010	E4310	60	430	48	330	22
E6011	E4311	60	430	48	330	22
E6012	E4312	60	430	48	330	17
E6013	E4313	60	430	48	330	17
E6018	E4318	60	430	48	330	22
E6019	E4319	60	430	48	330	22
E6020	E4320	60	430	48	330	22
E6022 ^d	E4322 ^d	60	430	Not Specified		Not Specified
E6027	E4327	60	430	48	330	22
E7014	E4914	70	490	58	400	17
E7015	E4915	70	490	58	400	22
E7016	E4916	70	490	58	400	22
E7018	E4918	70	490	58	400	22
E7024	E4924	70	490	58	400	17 ^e
E7027	E4927	70	490	58	400	22
E7028	E4928	70	490	58	400	22
E7048	E4948	70	490	58	400	22
E7018M	E4918M	Note f	Note f	53–72 ^g	370–500 ^g	24

^a See Table 4 for sizes to be tested.

^b Requirements are in the as-welded condition with aging as specified in 12.2.

^c Single values are minimum.

^d A transverse tension test, as specified in 12.5 and a longitudinal guided bend test, as specified in Clause 13 are required.

^e Weld metal from electrodes identified as E7024-1 [E4924-1] shall have elongation of 22% minimum.

^f Tensile strength of this weld metal is a nominal 70 ksi [490 MPa].

^g For 3/32 in [2.4 mm] electrodes, the maximum yield strength shall be 77 ksi [530 MPa].

Part B

Tests, Procedures, and Requirements

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, moisture content of the low-hydrogen electrode covering, 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 Clauses 9 through 18. The supplemental tests for absorbed moisture, in Clause 17, and diffusible hydrogen, in Clause 18, are not required for classification of the low-hydrogen electrodes, except for E7018M [E4918M], where these are required (see notes i and m of Table 4).

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. Specimens for retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

Table 3
Charpy V-Notch Impact Requirements

AWS Classification		Limits for 3 out of 5 Specimens ^a	
A5.1	A5.1M	Average, Min.	Single Value, Min.
E6010, E6011, E6018 E6027, E7015, E7016 ^b , E7018 ^b , E7027, E7048	E4310, E4311, E4318 E4327, E4915, E4916 ^b , E4918 ^b , E4927, E4948	20 ft-lbf at –20°F [27 J at –30°C]	15 ft-lbf at –20°F [20 J at –30°C]
E6019 E7028	E4319 E4928	20 ft-lbf at 0°F [27 J at –20°C]	15 ft-lbf at 0°F [20 J at –20°C]
E6012, E6013, E6020, E6022, E7014, E7024 ^b	E4312, E4313 E4320, E4322 E4914, E4924 ^b	Not Specified	Not Specified

AWS Classification		Limits for 5 out of 5 Specimens ^c	
A5.1	A5.1M	Average, Min.	Single Value, Min.
E7018M	E4918M	50 ft-lbf at –20°F [67 J at –30°C]	40 ft-lbf at –20°F [54 J at –30°C]

^a Both the highest and lowest test values obtained shall be disregarded in computing the average. Two of these remaining three values shall equal or exceed 20 ft-lbf [27 J].

^b Electrodes with the following optional supplemental designations shall meet the lower temperature impact requirements specified below:

AWS Classification		Electrode Designation		Charpy V-Notch Impact Requirements, Limits for 3 out of 5 specimens (Refer to Note a above)	
A5.1	A5.1M	A5.1	A5.1M	Average, Min.	Single Value, Min.
E7016 E7018	E4916 E4918	E7016-1 E7018-1	E4916-1 E4918-1	20 ft-lbf at –50°F [27 J at –45°C]	15 ft-lbf at –50°F [20 J at –45°C]
E7024	E4924	E7024-1	E4924-1	20 ft-lbf at 0°F [27 J at –20°C]	15 ft-lbf at 0°F [20 J at –20°C]

^c All five values obtained shall be used in computing the average. Four of the five values shall equal, or exceed, 50 ft-lbf [67 J].

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 the number of test specimens does not apply.

9. Weld Test Assemblies

9.1 One or more of the following five weld test assemblies are required:

- (1) The weld pad in Figure 1 for chemical analysis of the weld metal
- (2) The groove weld in Figure 2 for mechanical properties and soundness of weld metal made with all electrode classifications except E6022 [E4322] and E7018M [E4918M]
- (3) The fillet weld in Figure 3 for the usability of the electrode

Table 4
Required Tests^a

AWS Classification			Electrode Size		Welding Position for Test Assembly ^b				
A5.1	A5.1M	Current and Polarity ^a	A5.1 (in)	A5.1M (mm)	Chemical ^c Analysis	Radiographic Test ^d All-Weld-Metal Tension Test ^e	Impact Test ^f	Fillet Weld Test ^g	Moisture Test ⁱ
E6010	E4310	dcep	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F	F	V & OH	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F	F	H-fillet	NR
			5/16	8.0	NR	F	NR	NR	NR
E6011	E4311	ac and dcep	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F	F	V & OH	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F	F	H-fillet	NR
			5/16	8.0	NR	F	NR	NR	NR
E6012	E4312	ac and dcen	1/16 to 1/8 inc.	1.6 to 3.2 inc.	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F ^h	NR	V & OH	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4, 5/16	6.0, 6.4, 8.0	F	F ^h	NR	H-fillet	NR
E6013	E4313	ac, dcep, and dcen	1/16 to 1/8 inc.	1.6 to 3.2 inc.	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F ^k	NR	V & OH	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4, 5/16	6.0, 6.4, 8.0	F	F ^k	NR	H-fillet	NR
E6018	E4318	ac and dcep	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32	4.0	F	F	F	V & OH	Reqd.
			3/16	4.8, 5.0	NR	F	F	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F	F	H-fillet	Reqd.
E6019	E4319	ac, dcep, and dcen	5/64 to 1/8 inc.	2.0 to 3.2 inc.	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F ^k	F ^l	V & OH	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4, 5/16	6.0, 6.4, 8.0	F	F ^k	F ^l	H-fillet	NR
E6020	E4320	For H-fillet, ac and dcen; For flat position, ac, dcep, and dcen	1/8	3.2	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F ^k	NR	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F ^k	NR	H-fillet	NR
E6022	E4322	ac and dcen	5/16	8.0	NR	F ^k	NR	NR	NR
			1/8	3.2	NR	F ^{h,j}	NR	NR	NR
			5/32 to 7/32 inc.	4.0 to 5.6 inc.	NR	F ^{h,j}	NR	NR	NR
			7/32	5.6	NR	F ^{k,1}	NR	NR	NR
E6027	E4327	For H-fillet, ac and dcen; For flat position, ac, dcep, and dcen	1/8	3.2	NR	NR	NR	NR	NR
			5/32, 3/16	4.0, 4.8, 5.0	F	F ^{k,1}	F ^k	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F ^{k,1}	F ^k	H-fillet	NR
			5/16	8.0	NR	F ^{k,1}	NR	NR	NR
E7014	E4914	ac, dcep, and dcen	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32	4.0	F ^k	F ^k	NR	V & OH	NR
			3/16	4.8, 5.0	NR	F ^k	NR	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F ^k	F ^k	NR	H-fillet	NR
E7014	E4914	ac, dcep, and dcen	5/16	8.0	NR	F ^k	NR	H-fillet	NR

(Continued)

Table 4 (Continued)
Required Tests^a

AWS Classification		Current and Polarity ^a	Electrode Size		Welding Position for Test Assembly ^b				
A5.1	A5.1M		A5.1 (in)	A5.1M (mm)	Chemical ^c Analysis	Radiographic Test ^d All-Weld-Metal Tension Test ^e	Impact Test ^f	Fillet Weld Test ^g	Moisture Test ⁱ
E7015	E4915	dcep	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32	4.0	F	F	F	V & OH	Reqd.
			3/16	4.8, 5.0	NR	F	F	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F	F	H-fillet	Reqd.
			5/16	8.0	NR	F	NR	NR	NR
E7016	E4916	ac and dcep	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32	4.0	F	F	F	V & OH	Reqd.
			3/16	4.8, 5.0	NR	F	F	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F	F	H-fillet	Reqd.
			5/16	8.0	NR	F	NR	NR	NR
E7018	E4918	ac and dcep	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR	NR	NR
			5/32	4.0	F	F	F	V & OH	Reqd.
			3/16	4.8, 5.0	NR	F	F	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F	F	H-fillet	Reqd.
			5/16	8.0	NR	F	NR	NR	NR
E7018M ^m	E4918M ^m	dcep	3/32 to 5/32 inc.	2.4 to 4.0 inc.	F	V	V	NR	Reqd.
			3/16 to 5/16 inc.	4.8 to 8.0 inc.	F	F	F	NR	Reqd.
E7024	E4924	ac, dcep, and dcen	3/32, 1/8	2.4, 2.5, 3.2	NR	NR	NR ⁿ	NR	NR
			5/32	4.0	F ^l	F ^{k,1}	F ⁿ	H-fillet	NR
			3/16	4.8, 5.0	NR	F ^{k,1}	F ⁿ	H-fillet	NR
			7/32	5.6	NR	NR	NR ⁿ	NR	NR
			1 / 4	6.0, 6.4	F ^l	F ^{k,1}	F ⁿ	H-fillet	NR
			5/16	8.0	NR	F ^{k,1}	NR ⁿ	NR	NR
E7027	E4927	For H-fillet, ac and dcen For flat position, ac, dcep, and dcen	1/8	3.2	NR	NR	NR	NR	NR
			5/32	4.0	F ^l	F ^{k,1}	F ^l	H-fillet	NR
			3/16	4.8, 5.0	NR	F ^{k,1}	F ^l	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F ^l	F ^{k,1}	F ^l	H-fillet	NR
			5/16	8.0	NR	F ^{k,1}	NR	NR	NR
E7028	E4928	ac and dcep	1/8	3.2	NR	NR	NR	NR	NR
			5/32	4.0	F	F ^l	F	H-fillet	Reqd.
			3/16	4.8, 5.0	NR	F ^l	F	H-fillet	NR
			7/32	5.6	NR	NR	NR	NR	NR
			1/4	6.0, 6.4	F	F ^l	F	H-fillet	Reqd.
			5/16	8.0	NR	F ^l	NR	NR	NR
E7048	E4948	ac and dcep	1/8	3.2	NR	NR	NR	NR	NR
			5/32	4.0	F	F	F	V-down & OH	Reqd.
			3/16	4.8, 5.0	NR	F	F	V-down & H-fillet	NR

(Continued)

Table 4 (Continued)
Required Tests^a

^a NR means “not required.” The abbreviations, F, H-fillet, V-down, V, and OH are defined in Note a of Table 1. The terms “dcep” and “dcen,” are defined in Note b of Table 1.

^b Standard electrode sizes not requiring this specific test can be classified provided at least two other sizes of that classification have passed the tests required for them, or the size to be classified meets specification requirements by having been tested in accordance with Figures 1, 2, and 3 and Table 6.

^c See Clause 10.

^d See Clause 11.

^e See Clause 12.

^f See Clause 14.

^g See Clause 15.

^h A radiographic test is not required for this classification.

ⁱ The moisture test given in Clause 16 is the required test for moisture content of the covering. In Clauses 17 and 18 are supplemental tests required only when their corresponding optional supplemental designators are to be used with the classification designators.

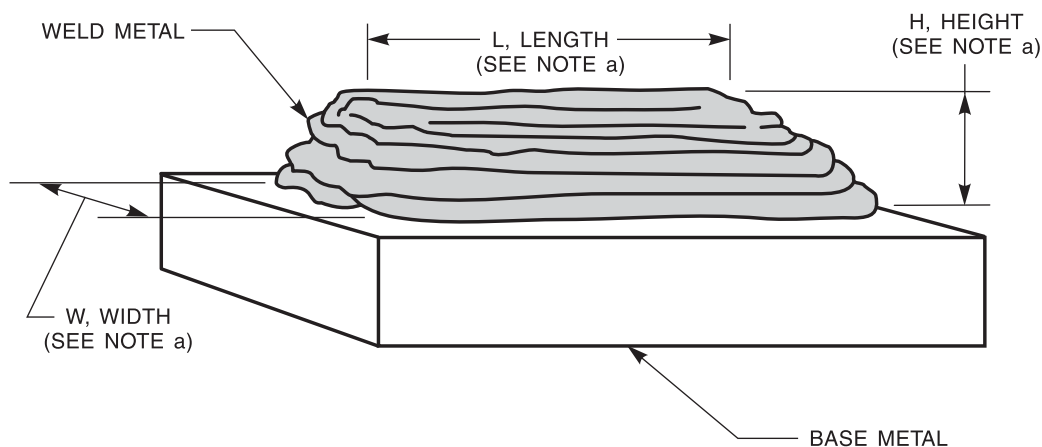
^j An all-weld-metal tension test is not required for E6022 [E4322] electrodes. Instead, a transverse tension test (see 12.5) and a longitudinal guided bend test (see Clause 13) are required for classification of 5/32 in, 3/16 in, and 7/32 in [4.0 mm, 5.0 mm, and 6.0 mm] E6022 [E4322] electrodes.

^k When dcep and dcen are shown, only dcen need be tested.

^l Electrodes longer than 18 in [450 mm] will require a double length test assembly in accordance with Note 1 of Figure 2, to ensure uniformity of the entire electrode.

^m Tests in Clause 17, and in Clause 18, are required for all sizes of E7018M [E4918M].

ⁿ Electrodes identified as E7024-1 [E4924-1] shall be impact tested (see Note b of Table 3).



^a The minimum completed pad size shall be at least four layers in height (H) with length (L) and width (W) sufficient to perform analysis. The sample for analysis shall be taken at least 1/4 in [6.0 mm] above the original base metal surface.

Notes:

1. Base metal of any convenient size, of any type specified in Table 5, shall be used as the base for the weld pad.
2. The surface of the base metal on which the filler metal is to be deposited shall be clean.
3. The pad shall be welded in the flat position with successive layers to obtain undiluted weld metal.
4. One pad shall be welded for each type of current shown in Table 4 except for those classifications identified by note k in Table 4.
5. 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. The width of each weld pass in each weld layer shall be no more than 2-1/2 times the diameter of the core wire.
6. The preheat temperature shall not be less than 60°F [15°C] and the interpass temperature shall not exceed 300°F [150°C].
7. The slag shall be removed after each pass.
8. The test assembly may be quenched in water between passes to control interpass temperature.

Figure 1—Pad for Chemical Analysis of Undiluted Weld Metal