

AWS A5.1/A5.1M:2012
An American National Standard



Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding



American Welding Society®



AWS A5.1/A5.1M:2012
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

Supersedes AWS A5.1/A5.1M:2004

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.



American Welding Society®

8669 Doral Blvd., Doral, FL 33166

International Standard Book Number: 978-0-87171-810-5
American Welding Society
8669 Doral Blvd., Doral, FL 33166
© 2012 by American Welding Society
All rights reserved
Printed in the United States of America

Photocopy Rights. No portion of this standard may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner.

Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <www.copyright.com>.

Statement on the Use of American Welding Society Standards

All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that have been developed in accordance with the rules of the American National Standards Institute (ANSI). When AWS American National Standards are either incorporated in, or made part of, documents that are included in federal or state laws and regulations, or the regulations of other governmental bodies, their provisions carry the full legal authority of the statute. In such cases, any changes in those AWS standards must be approved by the governmental body having statutory jurisdiction before they can become a part of those laws and regulations. In all cases, these standards carry the full legal authority of the contract or other document that invokes the AWS standards. Where this contractual relationship exists, changes in or deviations from requirements of an AWS standard must be by agreement between the contracting parties.

AWS American National Standards are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While AWS administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards.

AWS disclaims liability for any injury to persons or to property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this standard. AWS also makes no guarantee or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is neither undertaking to render professional or other services for or on behalf of any person or entity, nor is AWS undertaking to perform any duty owed by any person or entity to someone else. Anyone using these documents should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. It is assumed that the use of this standard and its provisions is entrusted to appropriately qualified and competent personnel.

This standard may be superseded by new editions. This standard may also be corrected through publication of amendments or errata, or supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda is posted on the AWS web page (www.aws.org). Users should ensure that they have the latest edition, amendments, errata, and addenda.

Publication of this standard does not authorize infringement of any patent or trade name. Users of this standard accept any and all liabilities for infringement of any patent or trade name items. AWS disclaims liability for the infringement of any patent or product trade name resulting from the use of this standard.

AWS does not monitor, police, or enforce compliance with this standard, nor does it have the power to do so.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Technical Services Division, 8669 Doral Blvd., Doral, FL 33166 (see Annex B). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. These opinions are offered solely as a convenience to users of this standard, and they do not constitute professional advice. Such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

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.

Personnel

AWS A5 Committee on Filler Metals and Allied Materials

H. D. Wehr, Chair	<i>Arcos Industries, LLC</i>
J. J. DeLoach, Jr., 1st Vice Chair	<i>Naval Surface Warfare Center</i>
R. D. Fuchs, 2nd Vice Chair	<i>Böhler Welding Group USA, Incorporated</i>
R. K. Gupta, Secretary	<i>American Welding Society</i>
T. Anderson	<i>Miller Electric Manufacturing Company</i>
J. M. Blackburn	<i>Naval Sea Systems Command</i>
J. C. Bundy	<i>Hobart Brothers Company</i>
D. D. Crockett	<i>Consultant</i>
R. V. Decker	<i>Weldstar</i>
D. A. DelSignore	<i>Consultant</i>
J. DeVito	<i>ESAB Welding and Cutting Products</i>
H. W. Ebert	<i>Consultant</i>
D. M. Fedor	<i>The Lincoln Electric Company</i>
J. G. Feldstein	<i>Foster Wheeler North America</i>
S. E. Ferree	<i>ESAB Welding and Cutting Products</i>
D. A. Fink	<i>The Lincoln Electric Company</i>
G. L. Franke	<i>Naval Surface Warfare Center</i>
R. M. Henson	<i>J. W. Harris Company, Incorporated</i>
S. D. Kiser	<i>Special Metals</i>
P. J. Konkol	<i>Concurrent Technologies Corporation</i>
D. J. Kotecki	<i>Damian Kotecki Welding Consultants</i>
L. G. Kvidahl	<i>Ingalls Shipbuilding</i>
A. Y. Lau	<i>Canadian Welding Bureau</i>
J. S. Lee	<i>Chevron</i>
T. Melfi	<i>The Lincoln Electric Company</i>
R. Menon	<i>Stoody Company</i>
K. M. Merlo	<i>EWI</i>
M. T. Merlo	<i>RevWires LLC</i>
B. Mosier	<i>Polymet Corporation</i>
A. K. Mukherjee	<i>Siemens Energy, Incorporated</i>
T. C. Myers	<i>Oceaneering Intervention Engineering</i>
C. L. Null	<i>Consultant</i>
B. A. Pletcher	<i>CB&I, Incorporated</i>
K. C. Pruden	<i>Hydril Company</i>
K. Roossinck	<i>Ingalls Shipbuilding</i>
P. K. Salvesen	<i>Det Norske Veritas (DNV)</i>
K. Sampath	<i>Consultant</i>
W. S. Severance	<i>ESAB Welding and Cutting Products</i>
M. F. Sinfield	<i>Naval Surface Warfare Center</i>
M. J. Sullivan	<i>NASSCO–National Steel and Shipbuilding</i>
R. C. Sutherlin	<i>ATI Wah Chang</i>
R. A. Swain	<i>Euroweld, Limited</i>
K. P. Thornberry	<i>Care Medical, Incorporated</i>
M. D. Tumuluru	<i>U.S. Steel Corporation</i>
H. J. White	<i>HAYNES International</i>

Advisors to the AWS A5 Committee on Filler Metal and Allied Material

R. L. Bateman	<i>Soldaduras West Arco Limitada</i>
J. E. Beckham	<i>Chrysler LLC</i>
R. A. Daemen	<i>Consultant</i>
C. E. Fuerstenau	<i>Lucas-Milhaupt, Incorporated</i>
J. P. Hunt	<i>Special Metals</i>
S. Imaoka	<i>Kobe Steel, Limited</i>
W. A. Marttila	<i>WAMcom Consulting LLC</i>
D. R. Miller	<i>ABS Americas Materials Department</i>
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>

AWS A5A Subcommittee on Carbon and Low Alloy Steel Electrodes

G. L. Franke, Chair	<i>Naval Surface Warfare Center</i>
R. A. Swain, Vice Chair	<i>Euroweld, Limited</i>
R. K. Gupta, Secretary	<i>American Welding Society</i>
R. V. Decker	<i>Weldstar Company</i>
J. J. DeLoach, Jr.	<i>Naval Surface Warfare Center</i>
H. W. Ebert	<i>Consultant</i>
K. K. Gupta	<i>Westinghouse Electric Corporation</i>
M. James	<i>The Lincoln Electric Company</i>
S. J. Knostman	<i>Hobart Brothers</i>
A. Y. Lau	<i>Canadian Welding Bureau</i>
T. C. Myers	<i>Oceaneering Intervention Engineering</i>
M. P. Parekh	<i>Consultant</i>
M. A. Quintana	<i>The Lincoln Electric Company</i>
P. K. Salvesen	<i>Det Norske Veritas (DNV)</i>
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.

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.