Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
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.
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 Arcos Industries, LLC
J. J. DeLoach, Jr., 1st Vice Chair Naval Surface Warfare Center
R. D. Fuchs, 2nd Vice Chair Böhler Welding Group USA, Incorporated
R. K. Gupta, Secretary American Welding Society
T. Anderson Miller Electric Manufacturing Company
J. M. Blackburn Naval Sea Systems Command
J. C. Bundy Hobart Brothers Company
D. D. Crockett Consultant
R. V. Decker Weldstar
D. A. DelSignore Consultant
J. DeVito ESAB Welding and Cutting Products
H. W. Ebert Consultant
D. M. Fedor The Lincoln Electric Company
J. G. Feldstein Foster Wheeler North America
S. E. Ferree ESAB Welding and Cutting Products
D. A. Fink The Lincoln Electric Company
G. L. Franke Naval Surface Warfare Center
R. M. Henson J. W. Harris Company, Incorporated
S. D. Kiser Special Metals
P. J. Konkol Concurrent Technologies Corporation
D. J. Kotecki Damian Kotecki Welding Consultants
L. G. Kvidahl Ingalls Shipbuilding
A. Y. Lau Canadian Welding Bureau
J. S. Lee Chevron
T. Melfi The Lincoln Electric Company
R. Menon Stoody Company
K. M. Merlo EWI
M. T. Merlo RevWires LLC
B. Mosier Polymet Corporation
A. K. Mukherjee Siemens Energy, Incorporated
T. C. Myers Oceaneering Intervention Engineering
C. L. Null Consultant
B. A. Pletcher CB&I, Incorporated
K. C. Pruden Hydrii Company
K. Roossinck Ingalls Shipbuilding
P. K. Salvesen Det Norske Veritas (DNV)
K. Sampath Consultant
W. S. Severance ESAB Welding and Cutting Products
M. F. Sinfield Naval Surface Warfare Center
M. J. Sullivan NASSCO–National Steel and Shipbuilding
R. C. Sutherlin ATI Wah Chang
R. A. Swain Euroweld, Limited
K. P. Thornberry Care Medical, Incorporated
M. D. Tumuluru U.S. Steel Corporation
H. J. White HAYNES International
Advisors to the AWS A5 Committee on Filler Metal and Allied Material

R. L. Bateman  
Soldaduras West Arco Limitada

J. E. Beckham  
Chrysler LLC

R. A. Daemen  
Consultant

C. E. Fuerstenau  
Lucas-Milhaupt, Incorporated

J. P. Hunt  
Special Metals

S. Imaoka  
Kobe Steel, Limited

W. A. Marttila  
WAMcom Consulting LLC

D. R. Miller  
ABS Americas Materials Department

M. P. Parekh  
Consultant

M. A. Quintana  
The Lincoln Electric Company

E. S. Surian  
National University of Lomas de Zamora

AWS A5A Subcommittee on Carbon and Low Alloy Steel Electrodes

G. L. Franke, Chair  
Naval Surface Warfare Center

R. A. Swain, Vice Chair  
Euroweld, Limited

R. K. Gupta, Secretary  
American Welding Society

R. V. Decker  
Weldstar Company

J. J. DeLoach, Jr.  
Naval Surface Warfare Center

H. W. Ebert  
Consultant

K. K. Gupta  
Westinghouse Electric Corporation

M. James  
The Lincoln Electric Company

S. J. Knostman  
Hobart Brothers

A. Y. Lau  
Canadian Welding Bureau

T. C. Myers  
Oceaneering Intervention Engineering

M. P. Parekh  
Consultant

M. A. Quintana  
The Lincoln Electric Company

P. K. Salvesen  
Det Norske Veritas (DNV)

K. Sampath  
Consultant

M. S. Sierdzinski  
ESAB Welding & Cutting Products

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

S. Imaoka  
Kobe Steel, Limited

D. J. Kotecki  
Damian Kotecki Welding Consultants

D. R. Miller  
ABS Americas Materials Department

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

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

**Personnel** ................................................................................................................................. v  
**Foreword** .................................................................................................................................. vii  
**List of Tables** ................................................................................................................................. x  
**List of Figures** ................................................................................................................................. 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>
<thead>
<tr>
<th>Table</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electrode Classification ........................................</td>
</tr>
<tr>
<td>2</td>
<td>Tension Test Requirements .........................................</td>
</tr>
<tr>
<td>3</td>
<td>Charpy V-Notch Impact Requirements ...............................</td>
</tr>
<tr>
<td>4</td>
<td>Required Tests ..................................................................</td>
</tr>
<tr>
<td>5</td>
<td>Base Metal for Test Assemblies .......................................</td>
</tr>
<tr>
<td>6</td>
<td>Requirements for Preparation of Fillet Weld Test Assemblies</td>
</tr>
<tr>
<td>7</td>
<td>Chemical Composition Requirements for Weld Metal ...............</td>
</tr>
<tr>
<td>8</td>
<td>Radiographic Soundness Requirements ..............................</td>
</tr>
<tr>
<td>9</td>
<td>Dimensional Requirements for Fillet Weld Usability Test Specimens</td>
</tr>
<tr>
<td>10</td>
<td>Moisture Content Limits for Electrode Coverings ................</td>
</tr>
<tr>
<td>11</td>
<td>Diffusible Hydrogen Limits for Weld Metal ........................</td>
</tr>
<tr>
<td>12</td>
<td>Standard Sizes and Lengths ............................................</td>
</tr>
<tr>
<td>A.1</td>
<td>Canadian Electrode Classifications Similar to AWS Classifications</td>
</tr>
<tr>
<td>A.2</td>
<td>Comparison of Equivalent Classifications ........................</td>
</tr>
<tr>
<td>A.3</td>
<td>Typical Storage and Drying Conditions for Covered Arc Welding Electrodes</td>
</tr>
<tr>
<td>A.4</td>
<td>Typical Amperage Ranges ..............................................</td>
</tr>
<tr>
<td>A.5</td>
<td>Discontinued Electrode Classifications ............................</td>
</tr>
</tbody>
</table>

List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pad for Chemical Analysis of Undiluted Weld Metal ................</td>
</tr>
<tr>
<td>2</td>
<td>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</td>
</tr>
<tr>
<td>3</td>
<td>Fillet Weld Test Assembly ............................................</td>
</tr>
<tr>
<td>4</td>
<td>Test Assembly for Transverse Tension and Longitudinal Guided Bend Tests for Welds Made with E6022 [E4322] Electrodes ..................................................</td>
</tr>
<tr>
<td>5</td>
<td>Groove Weld Test Assembly for Mechanical Properties and Soundness of Weld Metal Produced by Using E7018M [E4918M] Electrodes ..................................................</td>
</tr>
<tr>
<td>6</td>
<td>Welding Positions for Fillet Weld Test Assemblies ................</td>
</tr>
<tr>
<td>7</td>
<td>Radiographic Acceptance Standards for Rounded Indications (Grades 1 and 2) .................................</td>
</tr>
<tr>
<td>8</td>
<td>Dimensions of Fillet Welds .............................................</td>
</tr>
<tr>
<td>9</td>
<td>Alternative Methods for Facilitating Fracture of the Fillet Weld ..................................................</td>
</tr>
<tr>
<td>10</td>
<td>Order of Mandatory and Optional Supplemental Designators .........................................................</td>
</tr>
</tbody>
</table>
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


(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.