

AWS A5.23/A5.23M:2021
An American National Standard

**Specification for
Low-Alloy *and*
High Manganese
Steel Electrodes
and Fluxes for
Submerged Arc
Welding**



AWS A5.23/A5.23M:2021
An American National Standard

Approved by the
American National Standards Institute
June 1, 2021

Specification for
Low-Alloy and High Manganese
Steel Electrodes and Fluxes
for Submerged Arc Welding

6th Edition

Revises AWS A5.23/A5.23M:2011

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 provides requirements for the classification of solid and composite carbon steel, low-alloy steel, and *high manganese steel* electrodes and fluxes for submerged arc welding. Electrode classification is based on chemical composition of the electrode for solid electrodes, and chemical composition of the weld metal for composite electrodes. Fluxes may be classified using a multiple-pass classification system or a two-run classification system, or both, under this specification. Multiple-pass classification is based on the mechanical properties and the deposit composition of weld metal produced with the flux and an electrode classified herein. Two-run classification is based upon mechanical properties only. Additional requirements are included for sizes, marking, manufacturing, and packaging. The form and usability of the flux are also included. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of submerged arc fluxes and 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.



ISBN Print: 978-1-64322-202-8
ISBN PDF: 978-1-64322-203-5
© 2021 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 revised, 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, Standards Development, 8669 NW 36 St, # 130, Miami, 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 requested 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 NW 36 St, # 130, Miami, FL 33166.

This page is intentionally blank.

Personnel

AWS A5 Committee on Filler Metals and Allied Materials

| | |
|--------------------------------|---|
| T. Melfi, Chair | <i>The Lincoln Electric Company</i> |
| R. V. Decker, Vice Chair | <i>Weldstar</i> |
| M. F. Sinfield, 2nd Vice Chair | <i>Naval Surface Warfare Center</i> |
| R. K. Gupta, Secretary | <i>American Welding Society</i> |
| T. Anderson | <i>ITW—Miller Electric Manufacturing Company</i> |
| A. Boulianne | <i>CWB Group</i> |
| J. C. Bundy | <i>Hobart Brothers LLC</i> |
| J. L. Caron | <i>Haynes International, Incorporated</i> |
| G. L. Chouinard | <i>Stoody Company (a division of ESAB)</i> |
| T. J. Eckardt | <i>Kiefner and Associates</i> |
| D. A. Fink | <i>The Lincoln Electric Company</i> |
| R. J. Fox | <i>Illinois Tools Works</i> |
| R. D. Fuchs | <i>Voestalpine Böhler Welding USA, Incorporated</i> |
| M. James | <i>The Lincoln Electric Company</i> |
| S. D. Kiser | <i>Consultant</i> |
| P. J. Konkol | <i>Concurrent Technologies Corporation</i> |
| D. J. Kotecki | <i>Damian Kotecki Welding Consultants</i> |
| L. G. Kvidahl | <i>Consultant</i> |
| J. S. Lee | <i>Chevron</i> |
| C. McEvoy | <i>Naval Nuclear Laboratories</i> |
| M. T. Merlo | <i>Consultant</i> |
| W. C. Mosier | <i>Polymet Corporation</i> |
| T. C. Myers | <i>Consultant</i> |
| B. A. Pletcher | <i>Bechtel Global Corporation</i> |
| K. Roossinck | <i>Huntington Ingalls Shipbuilding</i> |
| K. Sampath | <i>Consultant</i> |
| J. D. Schaefer | <i>Aqua-Chem</i> |
| F. A. Schweighardt | <i>Airgas</i> |
| W. S. Severance | <i>The Lincoln Electric Company</i> |
| D. Singh | <i>Baker Hughes</i> |
| R. C. Sutherlin | <i>Richard Sutherlin PE Consulting LLC</i> |
| H. D. Wehr | <i>Arcos Industries</i> |
| J. Zhang | <i>Ohmstede, Limited</i> |

Advisors to AWS A5 Committee on Filler Metals and Allied Materials

| | |
|-----------------|----------------------------|
| S. Ferree | <i>Consultant</i> |
| D. M. Fedor | <i>Consultant</i> |
| J. G. Feldstein | <i>Consultant</i> |
| G. Franke | <i>Consultant</i> |
| S. Imaoka | <i>Kobe Steel Limited</i> |
| S. J. Knostman | <i>Hobart Brothers LLC</i> |

**AWS A5B Subcommittee on Carbon and Low-Alloy Steel Electrodes
and Fluxes for Submerged Arc Welding**

| | |
|------------------------|---|
| T. Melfi, Chair | <i>The Lincoln Electric Company</i> |
| R. K. Gupta, Secretary | <i>American Welding Society</i> |
| H. Beck | <i>Harbert's Products, Incorporated</i> |
| R. J. Fox | <i>Illinois Tools Works</i> |
| R. D. Fuchs | <i>Voestalpine Böhler Welding USA, Incorporated</i> |
| B. D. Gaal | <i>Consultant</i> |
| D. J. Kotecki | <i>Damian Kotecki Welding Consultants</i> |
| M. T. Merlo | <i>Consultant</i> |
| D. W. Meyer | <i>ESAB Welding & Cutting Products</i> |
| J. Procario | <i>The Lincoln Electric Company</i> |
| A. K. Singh | <i>Welspun Pipes, Incorporated</i> |
| R. D. Strugar | <i>Bechtel Plant Machinery, Incorporated</i> |

**Advisor to the A5B Subcommittee on Carbon and Low-Alloy
Steel Electrodes and Fluxes for Submerged Arc Welding**

| | |
|-----------|---------------------------|
| S. Imaoka | <i>Kobe Steel Limited</i> |
|-----------|---------------------------|

Foreword

This foreword is not part of this standard but is included for informational purposes only.

This document is the fourth of the A5.23/A5.23M 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, AWS A1.1, *Metric Practice Guide for the Welding Industry*, is 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.

NOTE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

Substantive changes in this edition are shown in italic font and include:

- (1) A new classification (Mn2) for an austenitic high manganese (nominal 19% Mn) weld deposit.*
- (2) New classifications (EB115 and B115) for an electrode and corresponding weld deposit with 10.5% Cr and 0.5% Mo modified with niobium and vanadium.*
- (3) New designators for low Mn + Ni B91 weld deposit.*
- (4) Requirements for reporting base and weld metal chemical composition for two-run classifications.*

The welding terms used in this specification shall be interpreted in accordance with the definitions given in the latest edition of AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*.

The current document is the sixth revision of the initial joint ASTM/AWS document issued in 1976. The evolution of the AWS A5.23 specification took place as follows:

| | |
|----------------------------|---|
| ANSI/AWS A5.23-76 | <i>Specification for Bare Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i> |
| ANSI/AWS A5.23-80 | <i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i> |
| ANSI/AWS A5.23-90 | <i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i> |
| ANSI/AWS A5.23/A5.23M:1999 | <i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i> |
| AWS A5.23/A5.23M:2007 | <i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i> |
| AWS A5.23/A5.23M:2011 | <i>Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding</i> |

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS A5 Committee on Filler Metals and Allied Materials, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

This page is intentionally blank.

Table of Contents

| | Page No. |
|---|-----------------|
| <i>Personnel</i> | v |
| <i>Foreword</i> | vii |
| <i>List of Tables</i> | xi |
| <i>List of Figures</i> | xi |
| 1. Scope | 1 |
| 2. Normative References | 1 |
| 3. Classification | 3 |
| 4. Acceptance | 4 |
| 5. Certification | 4 |
| 6. Rounding Procedure | 4 |
| 7. Summary of Tests | 4 |
| 8. Retest | 4 |
| 9. Weld Test Assemblies | 5 |
| 9.1 Requirements for Classification | 5 |
| 9.2 Preparation | 5 |
| 9.3 Weld Pad..... | 5 |
| 9.4 Groove Weld for Multiple-Pass Classifications | 5 |
| 9.5 Butt Weld for Two-Run Classifications..... | 6 |
| 9.6 Diffusible Hydrogen..... | 6 |
| 10. Chemical Analysis | 6 |
| 11. Radiographic Test | 7 |
| 12. Tension Test | 8 |
| 13. Impact Test | 9 |
| 14. Diffusible Hydrogen Test | 9 |
| 15. Method of Manufacture | 9 |
| 15.1 Electrodes and Fluxes..... | 9 |
| 15.2 Crushed Slag | 10 |
| 16. Electrode Requirements | 10 |
| 16.1 Standard Sizes | 10 |
| 16.2 Finish and Uniformity | 10 |
| 16.3 Standard Package Forms | 10 |
| 16.4 Winding Requirements..... | 10 |
| 16.5 Electrode Identification | 10 |
| 16.6 Packaging | 10 |
| 16.7 Marking of Packages | 10 |

| | Page No. |
|---|-----------------|
| 17. Flux Requirements | 11 |
| 17.1 Form and Particle Size | 11 |
| 17.2 Usability | 11 |
| 17.3 Packaging | 11 |
| 17.4 Marking of Packages | 11 |
| Annex A (Informative)—Guide to AWS Specification for Low-Alloy <i>and High Manganese</i> Steel Electrodes and Fluxes for Submerged Arc Welding | 35 |
| Annex B (Informative)—Requesting an Official Interpretation on an AWS Standard | 47 |
| AWS Filler Metal Specifications by Material and Welding Process | 49 |
| AWS List of Filler Metal Specifications and Related Documents | 51 |

List of Tables

| Table | Page No. |
|--|----------|
| 1 A5.23 Tension Test Requirements | 12 |
| 1M A5.23M Tension Test Requirements | 13 |
| 2 Impact Test Requirements | 14 |
| 3 Chemical Composition Requirements for Weld Metal | 15 |
| 4 Chemical Composition Requirements for Solid Electrodes | 18 |
| 5 Tests Required for Classification | 21 |
| 6 Welding Parameters for Multiple-Pass Groove Weld Test Assembly | 22 |
| 7 Welding Parameters for Two-Run Weld Test Assembly | 23 |
| 8 Base Metals for Test Assemblies | 24 |
| 9 Preheat, Interpass, and Postweld Heat Treatment Temperatures for Multiple-Pass Classifications | 25 |
| 10 Diffusible Hydrogen Requirements | 25 |
| A.1 Comparison of Solid Electrode Designations | 45 |

List of Figures

| Figure | Page No. |
|--|----------|
| 1 A5.23 Multiple-Pass Classification System for U.S. Customary Units | 26 |
| 1M A5.23M Multiple-Pass Classification System for the International System of Units (SI) | 27 |
| 2 A5.23 Two-Run Classification System for U.S. Customary Units | 28 |
| 2M A5.23M Two-Run Classification System for the International System of Units (SI) | 29 |
| 3 Weld Pad for Chemical Analysis of Weld Metal | 30 |
| 4 Multiple-Pass Groove Weld Test Assembly | 31 |
| 5 Two-Run Weld Test Assembly | 32 |
| 6 Radiographic Standards for Rounded Indications | 33 |

This page is intentionally blank.

Specification for Low-Alloy and High Manganese Steel Electrodes and Fluxes for Submerged Arc Welding

1. Scope

1.1 This specification prescribes requirements for the classification of solid and composite carbon steel, low-alloy steel, and high manganese steel electrodes and flux-electrode combinations for submerged arc welding (SAW). This specification covers low-alloy and high manganese electrodes and low-alloy and high manganese multiple-pass flux-electrode classifications. This specification also addresses carbon steel, low-alloy steel, and high manganese steel two-run flux-electrode classifications. The multiple-pass classification of flux-electrode combinations for carbon steel SAW is not within the scope of this specification, but is covered in AWS A5.17/A5.17M.

1.2 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 weld metal properties. The specification with the designation A5.23 uses U.S. Customary Units. The specification A5.23M uses SI Units. The latter are shown within brackets [], in appropriate columns in tables and figures and in paragraphs numbered with an “M” suffix. Standard dimensions based on either system may be used for the sizing of electrodes, packaging, or both under specification A5.23 or A5.23M.

1.3 Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein. Some safety and health information can be found in Annex A Clauses A5 and A11. Safety and health information is available from the following sources:

American Welding Society:

- (1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- (2) AWS Safety and Health Fact Sheets
- (3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

- (1) Safety Data Sheets supplied by materials manufacturers
- (2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to or revisions of any of these publications do not apply.