

Specification for Bare Electrodes and Rods for Surfacing



Documents

Document Sharing Hub

AWS A5.21/A5.21M:2024
An American National Standard

Approved by the
American National Standards Institute
February 26, 2024

Specification for Bare Electrodes and Rods for Surfacing

6th Edition

Revises AWS A5.21/A5.21M: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 prescribes the requirements for classification of bare (*uncoated*) *solid wire as well as tubular electrodes and rods for weld surfacing*. Solid surfacing electrodes and rods are classified on the basis of the composition of the material as manufactured. Metal cored and flux cored composite (tubular) surfacing electrodes and rods are classified on the basis of the chemical composition of the deposited weld metal. Tubular tungsten carbide bare rods are classified on the basis of the mesh range, quantity, and composition of the tungsten carbide granules. A guide is appended to the specification as a source of information concerning the characteristics and applications of the classified electrodes *and rods*.



ISBN Print: 978-1-64322-305-6
ISBN PDF: 978-1-64322-306-3
© 2024 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

R. V. Decker, Chair	<i>Weldstar</i>
M. F. Sinfield, Vice Chair	<i>Naval Surface Warfare Center</i>
B. A. Pletcher, 2nd Vice Chair	<i>Bechtel Global Corporation</i>
K. R. Bulger, 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 Company</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>Hobart Brothers LLC</i>
M. James	<i>The Lincoln Electric Company</i>
S. D. Kiser	<i>Consultant</i>
S. J. Knostman	<i>Hobart Brothers Company</i>
L. G. Kvidahl	<i>Consultant</i>
J. S. Lee	<i>Consultant</i>
C. McEvoy	<i>Naval Nuclear Laboratories—Knolls Atomic Power Laboratory</i>
T. Melfi	<i>The Lincoln Electric Company</i>
W. C. Mosier	<i>Polymet Corporation</i>
T. C. Myers	<i>Westec</i>
K. J. Roossinck	<i>Ingalls Shipbuilding</i>
K. Sampath	<i>Consultant</i>
J. D. Schaefer	<i>Y12 National Security Complex</i>
J. B. Schaeffer	<i>The Lincoln Electric Company</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>

AWS A5G Subcommittee on Hardfacing Filler Metals

G. L. Chouinard, Chair	<i>Stoody Company (a division of ESAB)</i>
K. R. Bulger, Secretary	<i>American Welding Society</i>
T. A. Barnhart	<i>The Lincoln Electric Company</i>
F. B. Lake	<i>Stoody Company (a division of ESAB)</i>
P. F. Mendez	<i>University of Alberta, CCWJ</i>
K. A. Meszaros	<i>InnoTech Alberta</i>
R. A. Miller	<i>Consultant</i>
J-M. D. Tetevuide	<i>Har-Bach Marketing, Inc.</i>
J. G. Postle	<i>Postle Industries Inc.</i>
V. B. Rajan	<i>The Lincoln Electric Company</i>

AWS A5G Advisors to the Subcommittee on Hardfacing Filler Metals

F. G. Broshjeit	<i>Consultant</i>
W. E. Layo	<i>Midalloy</i>
B. Malinowski	<i>Select-Arc Inc.</i>
R. Menon	<i>Stoody Company (a division of ESAB)</i>

Foreword

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

This document 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, provide for interchangeability of products in both the U.S. Customary and SI Units.

The current document is the 5th revision of the initial joint ASTM/AWS document issued in 1970, *Specification for Composite Surfacing Welding Rods and Electrodes*. The evolution took place as follows:

The method of manufacture of the core wire was the prime consideration for earlier revisions of AWS A5.21. All electrodes and rods included composite (tubular) cores. Both bare and covered electrodes were thus included in the same specification.

The revision of A5.21:2001, just like that of A5.13:2000, departed from the earlier format by eliminating the method of manufacture of the core wire as a factor for classification. All electrodes and rods classified in accordance with A5.21:2001 have since been uncoated. Covered electrodes previously included were then classified in accordance with the revision of A5.13:2000. Some solid bare electrodes and rods previously classified in accordance with A5.13-80 had been incorporated into the previously revised A5.21:2001.

The historical background for the document itself is as follows:

ANSI/AWS A5.21-70, *Specification for Composite Surfacing Welding Rods and Electrodes*

ANSI W3.21-73, *Specification for Composite Surfacing Welding Rods and Electrodes*

ANSI/AWS A5.21-80, *Specification for Composite Surfacing Welding Rods and Electrodes*

AWS A5.21:2001, *Specification for Bare Electrodes and Rods for Surfacing*

AWS A5.21/A5.21M:2011, *Specification for Bare Electrodes and Rods for Surfacing*

Substantive changes in this revision include the addition of new classifications as well as modifications to many iron base existing composition ranges to better reflect current filler metal practice. These substantive changes are shown in *italic font* or a vertical line in the margin.

Modification of the chemical compositions for the following classifications: ERF_e-1, ERF_e-1A, ERF_e-2, ERF_e-3, ERF_e-6, ERF_e-8, ERF_eMn-F, ERF_eMn-G, ERF_eMnCr, ERF_eCr-A, ERF_eCr-A3A, ERF_eCr-A4, ERF_eCr-A5, ERF_eCr-A9, and ERF_eCr-A10.

Addition of new iron base bare rod and electrode classifications (see Table 1): ERF_e-9, ERF_e-10, ERF_e-RBU, ERF_eMn-D, ERF_eMn-RBU, ERF_eCr-E3, ERF_eCr-E4, ERF_eCr-E5, ERF_eV, and ERF_eB.

Addition of a new cobalt base bare rod and electrode classification (see Table 2): ERC_oCr-H.

Addition of new tungsten carbide bare rod and electrode classifications (see Table 5): ERF_eWCX-30/230 and ERNi-WCX-30/230.

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.

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

All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website.

Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Figures</i>	x
<i>List of Tables</i>	x
1. Scope	1
2. Normative References	1
3. Classification	2
4. Acceptance	2
5. Certification	2
6. Rounding Procedure	9
7. Summary of Tests	9
7.1 Solid Electrodes or Rods	9
7.2 Metal Cored and Flux Cored Composite (Tubular) Electrodes and Rods	9
7.3 Tungsten Carbide Rods	9
8. Retest	9
9. Chemical Composition Requirements	9
10. Method of Manufacture	11
11. Standard Sizes and Lengths	11
12. Finish and Uniformity	13
13. Standard Package Forms	13
14. Winding Requirements	13
15. Filler Metal Identification	13
16. Packaging	14
17. Marking of Packages	14
Annex A (Informative)—Guide to AWS Specification for Bare Electrodes and Rods for Surfacing	15
Annex B (Informative)—Requesting an Official Interpretation on an AWS Standard	29
AWS Filler Metal Specifications by Material and Welding Process	31
AWS Filler Metal Specifications and Related Documents	33

List of Tables

Table	Page No.
1 Solid and Cored Iron Base Electrodes and Rods—Chemical Requirements.....	3
2 Solid Cobalt and Nickel Base Bare Electrodes and Rods—Chemical Composition Requirements.....	5
3 Metal Cored and Flux Cored Composite Cobalt and Nickel-Base Bare Electrodes and Rods— Chemical Composition Requirements	6
4 Solid and Cored Copper Base Electrodes and Rods—Chemical Composition Requirements	7
5 Mesh Size and Quantity of Tungsten Carbide (WC) Granules in the Core of Tungsten Carbide Bare Rods and Electrodes	8
6 Chemical Composition Requirements for Tungsten Carbide Granules.....	8
7 Standard Sizes of Bare Electrodes and Rods Using Solid Drawn or Composite (Tubular) Wire.....	12
8 Standard Sizes for Cast Electrodes and Rods	12
9 Standard Sizes for Tungsten Carbide (WC) Rods	13
A.1 Discontinued and Transferred Electrode and Rod Classifications.....	27

List of Figures

Figure	Page No.
1 Pad for Chemical Analysis of Undiluted Weld Metal.....	10

Specification for Bare Electrodes and Rods for Surfacing

1. Scope

1.1 This specification prescribes the requirements for the classification of bare (*uncoated*) *solid* electrodes and rods *as well as tubular electrodes and rods* for *weld* surfacing. The specification does not provide for classification of electrode-flux combinations for submerged arc welding.

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 material. The specification with the designation A5.21 uses U.S. Customary Units. The specification A5.21M 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 A5.21 or A5.21M specifications.

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 the *non-mandatory* annex, Clauses A5 and A10.

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.

American Welding Society (AWS) documents:

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*

AWS A5.01M/A5.01 (ISO 14344 MOD), *Welding and Brazing Consumables—Procurement of Filler Metals and Fluxes*

AWS A5.02/A5.02M, *Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*

American National Standards Institute (ANSI) document:

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

ASTM International (ASTM) documents:

ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*

ASTM A285/A285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*

ASTM B214, *Standard Test Method for Sieve Analysis of Metal Powders*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E384, *Standard Test Method for Knoop and Vickers Hardness of Materials*

International Organization for Standardization (ISO) document:

ISO 80000-1, *Quantities and units — Part 1: General*

3. Classification

3.1 The surfacing electrodes and rods covered by this specification are classified according to the following:

3.1.1 Solid surfacing electrodes and rods are classified on the basis of the composition of the material as manufactured (or the stock from which it was made) (see Tables 1, 2, and 4).

3.1.2 Metal cored and flux cored composite (tubular) surfacing electrodes and rods, except for tungsten carbide rods, are classified on the basis of the composition of an undiluted weld deposit, as shown in Tables 1, 3, and 4.

3.1.3 Tubular tungsten carbide surfacing rods are classified on the basis of the mesh range, quantity, and composition of the tungsten carbide granules, as shown in Tables 5 and 6.

3.2 Material classified under one classification shall not be classified under any other classification in this specification, with the exception of the *ERFe-RBU* and *ERFeMn-RBU* classifications related to railway weld procedures described in the AWS D15.2 specification.

4. Acceptance

Acceptance of the welding electrodes and rods shall be in accordance with the provisions of AWS A5.01M/A5.01 and the tests and requirements of this specification. See A3 (in Annex A) for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01.

5. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification. See A4 (in Annex A) for further information concerning certification and the testing called for to meet this requirement.

Table 1
Solid and Cored Iron Base Electrodes and Rods—Chemical Composition Requirements^a

AWS Classification ^g	Annex A Reference	UNS Numbers ^b		Composition, Weight Percent ^{c, d, e, f}														Other Elements, Total ^h
		UNS (Solid)	UNS (Cored)	C	Mn	Si	Cr	Ni	Mo	V	W	Ti	Nb	Al	B	Fe		
ERFe-1	A7.1.1	T74000	W74030	0.03–0.20	0.2–3.0	1.5	4.0	3.0	1.5	—	—	1.5	—	2.0	—	Rem	1.0	
ERFe-1A	A7.1.1	T74001	W74031	0.04–0.25	1.5–3.5	1.0	0.5–3.5	—	—	—	—	—	—	2.0	—	Rem	1.0	
ERFe-2	A7.1.1	T74002	W74032	0.10–0.40	0.5–4.0	2.5	4.0	2.0	2.0	0.35	—	1.5	—	2.0	—	Rem	1.0	
ERFe-3	A7.1.2	T74003	W74033	0.40–0.80	0.5–2.0	1.0	4.0–9.0	—	1.5	—	—	—	—	2.0	—	Rem	1.0	
ERFe-5	A7.1.3	T74005	W74035	0.50–0.80	1.5–2.5	0.9	1.5–3.0	—	—	—	—	—	—	—	—	Rem	1.0	
ERFe-6	A7.1.4	T75006	W77530	0.6–1.3	0.4–1.0	1.5	3.0–5.0	—	7.0–9.5	0.5–2.5	0.5–2.5	—	—	—	—	Rem	1.0	
ERFe-8	A7.1.5	T75008	W77538	0.25–0.70	0.5–2.5	1.5	3.0–9.0	—	0.5–4.0	2.0	2.0	1.5	4.0	—	—	Rem	1.0	
ERFe-9	A7.1.6	—	—	1.0–2.5	1.0–2.5	2.0	5.0–10.0	—	2.0	1.5	2.0	7.0	9.0	—	—	Rem	1.0	
ERFe-10	A7.1.7	—	—	0.04–0.30	0.5–3.0	1.0	11.0–18.0	6.0	2.5	1.0	1.5	—	1.0	—	—	Rem	3.5	
ERFe-RBU	A7.1.8	—	—	0.03–0.40	0.2–4.0	2.5	4.0	4.0	2.0	0.35	—	1.5	—	2.0	—	Rem	1.0	
ERFeMn-C	A7.1.9	—	W79230	0.5–1.0	12–16	1.3	2.5–5.0	2.5–5.0	—	—	—	—	—	—	—	Rem	1.0	
ERFeMn-D	A7.1.9	—	—	0.5–1.0	15–20	1.5	7.5	—	1.5	1.2	—	—	—	2.0	—	Rem	1.0	
ERFeMn-F	A7.1.9	—	W79630	0.5–1.5	16–27	1.5	2.0–7.0	3.0	1.5	—	—	—	—	2.0	—	Rem	1.0	
ERFeMn-G	A7.1.9	—	W79231	0.5–1.5	12–18	1.5	2.0–7.0	1.0	1.5	—	—	—	—	2.0	—	Rem	1.0	
ERFeMn-H	A7.1.9	—	W79232	0.30–0.80	12–16	1.3	4.5–7.5	2.0	—	—	—	—	—	—	—	Rem	1.0	
ERFeMnCr	A7.1.10	—	W79730	0.25–0.75	12–18	1.5	11–18	2.0	2.0	1.0	—	—	—	2.0	—	Rem	1.0	
ERFeMn-RBU	A7.1.11	—	—	0.3–1.5	12–27	1.5	18.0	5.0	2.0	1.2	—	0.5	—	2.0	—	Rem	1.0	
ERFeCr-A	A7.1.12	—	W74531	1.5–3.5	0.5–1.5	2.0	8–15	—	3	—	—	—	—	—	—	Rem	1.0	

Continued)