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An American National Standard

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American National Standards Institute
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Specification for Bare Electrodes and Rods for Surfacing

5th Edition

Supersedes AWS A5.21:2001

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 electrodes and rods for 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.

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Foreword

This foreword is not part of AWS A5.21/A5.21M:2011, *Specification for Bare Electrodes and Rods for Surfacing*, but is included for informational purposes only.

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 included in the same specification.

The previous revision of A5.21:2001, 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 now classified in accordance with A5.21:2001 are 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.

This document is the first of the A5.21 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*, and ISO 544 *Welding consumables — Technical delivery conditions for welding filler materials — Type of product, dimensions, tolerances and marking*, 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.

This newly metricated edition has a new "Rounding-off Procedure."AWS F3.2, Ventilation Guide for Weld Fume, has been referenced in A5.2. Detailed safety information in the annex has been replaced by reference to the AWS Safety and Health Fact Sheets. Detailed information about standard sizes and packaging has been replaced with reference to AWS A5.02/A5.02M. Added subclause 2(d) in A2.5 regarding requesting of new classifications. Significant changes such as these are shown in Italic font.

Historical background for the document is as follows:

ANSI/AWS A5.21-70 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*

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, 550 N.W. LeJeune Road, Miami, FL 33126.

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Specification for Bare Electrodes and Rods for Surfacing

1. Scope

1.1 This specification prescribes the requirements for the classification of bare electrodes and rods for surfacing. The specification does not provide for classification of electrode-flux combinations for submerged 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 the nonmandatory 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. 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.*

2. Referenced Documents

The following documents are referenced within this publication. 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.

2.1 AWS Standards[2]

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*

AWS A5.01M/A5.01 (ISO 14344), *Procurement Guidelines for Consumables—Welding and Allied Processes—Flux and Gas Shielded Electrical Welding Processes*

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

AWS F3.2, *Ventilation Guide for Weld Fume*

2.2 ANSI Standards

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

2.3 ASTM Standards[3]

ASTM E 29, *Standard Practice of Using Significant Digits in Test Data to Determine Conformance with Specifications*

[1] ANSI Z49.1 is published by American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
[2] AWS standards are published by American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
[3] ASTM standards are published by ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 36/A 36M, *Standard Specification for Carbon Structural Steel*

ASTM B 214, *Standard Test Method for Sieve Analysis of Metal Powders*

ASTM A 285/A 285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*

2.4 ISO Standards[4]

ISO 544, *Welding Consumables — Technical delivery conditions for welding filler materials — Type of product, dimensions, tolerances and marking*

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.

4. Acceptance

Acceptance[5] of the welding electrodes and rods shall be in accordance with the provisions of AWS A5.01M/A5.01 (ISO 14344).

5. Certification[6]

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.

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 E 29 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 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.

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[4] ISO standards are published by the *International Organization for Standardization, 1, rue de Varembé*, Case postale 56, CH-1211 Geneva 20, Switzerland.

[5] See Clause A3, Acceptance, for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01 (ISO 14344).

[6] See Clause A4, Certification, for further information concerning certification and the testing specified 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]									
		Solid	Cored	C	Mn	Si	Cr	Ni	Mo	V	W	Fe	Other Elements, Total[b]
ERFe-1	A7.1.1	T74000	W74030	0.04–0.20	0.5–2.0	1.0	0.5–3.5	—	1.5	—	—	Rem	1.0
ERFe-1A	A7.1.1	T74001	W74031	0.05–0.25	1.7–3.5	1.0	0.5–3.5	—	—	—	—	Rem	1.0
ERFe-2	A7.1.1	T74002	W74032	0.10–0.30	0.5–2.0	1.0	1.8–3.8	1.0	1.0	0.35	—	Rem	1.0
ERFe-3	A7.1.2	T74003	W74033	0.50–0.80	0.5–1.5	1.0	4.0–8.0	—	1.0	—	—	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	0.6–1.0	0.4–1.0	1.0	3.0–5.0	—	7.0–9.5	0.5–1.5	0.5–1.5	Rem	1.0
ERFe-8	A7.1.5	T75008	W77538	0.30–0.60	1.0–2.0	1.0	4.0–8.0	—	1.0–2.0	0.50	1.0–2.0	Rem	1.0
ERFeMn-C	A7.1.6	—	W79230	0.5–1.0	12–16	1.3	2.5–5.0	2.5–5.0	—	—	—	Rem	1.0
ERFeMn-F	A7.1.6	—	W79630	0.7–1.1	16–22	1.3	2.5–5.0	1.0	—	—	—	Rem	1.0
ERFeMn-G	A7.1.6	—	W79231	0.5–1.0	12–16	1.3	2.5–5.0	1.0	—	—	—	Rem	1.0
ERFeMn-H	A7.1.6	—	W79232	0.30–0.80	12–16	1.3	4.5–7.5	2.0	—	—	—	Rem	1.0
ERFeMnCr	A7.1.7	—	W79730	0.25–0.75	12–18	1.3	11–16	2.0	2.0	—	—	Rem	1.0
ERFeCr-A	A7.1.8	—	W74531	1.5–3.5	0.5–1.5	2.0	8.0–14.0	—	1.0	—	—	Rem	1.0
ERFeCr-A1A	A7.1.9	—	W74530	3.5–5.5	4.0–6.0	0.5–2.0	20–25	—	0.50	—	—	Rem	1.0
ERFeCr-A3A	A7.1.10	—	W74533	2.5–3.5	1.5–3.5	0.5–2.0	14–20	—	—	—	—	Rem	1.0
ERFeCr-A4	A7.1.9	—	W74534	3.5–4.5	1.5–3.5	1.5	23–29	—	1.0–3.0	—	—	Rem	1.0
ERFeCr-A5	A7.1.11	—	W74535	1.5–2.5	0.5–1.5	2.0	24–32	4.0	4.0	—	—	Rem	1.0
ERFeCr-A9	A7.1.12	—	W74539	3.5–5.0	0.5–1.5	2.5	24–30	—	—	—	—	Rem	1.0
ERFeCr-A10	A7.1.13	—	W74540	5.0–7.0	0.5–2.5	1.5	20–25	—	—	—	—	Rem	1.0

[a] Covered composite iron base electrodes that were included in AWS A5.21-80, *Specification for Bare Surfacing Electrodes and Rods*, were deleted from A5.21:2001. They are now in AWS A5.13:2000, *Specification for Surfacing Electrodes for Shielded Metal Arc Welding*.
[b] ASTM DS-56/SAE HS-1086 *Metals & Alloys in the Unified Numbering System*.
[c] Single values are maximum. Rem = Remainder.
[d] Electrodes and rods shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "Other Elements, Total" in the last column of the table.
[e] Sulfur and phosphorus contents shall not exceed 0.035% each.
[f] For solid electrodes and rods, composition is that of the electrode itself or the stock from which it was made. For metal cored or flux cored electrodes, the composition is that of a weld deposit prepared in accordance with 9.3.
[g] For metal cored and flux cored composite (tubular) electrodes and rods, insert "C" in the classification designation immediately following the "R."
[h] Aluminum and magnesium contents of weld metal deposited by self-shielding electrodes shall not be included in the value of "Other Elements, Total."

Table 2
Solid Cobalt and Nickel Base Bare Electrodes and Rods—Chemical Composition Requirements

AWS Classification	Annex A Reference	UNS Number[d]	Composition, Weight Percent[a,b,c]											
			C	Mn	Si	Cr	Ni	Mo	Fe	W	Co	B	V	Other Elements, Total
ERCoCr-A	A7.2.1	R30006	0.9–1.4	1.0	2.0	26–32	3.0	1.0	3.0	3.0–6.0	Rem	—	—	0.50
ERCoCr-B	A7.2.2	R30012	1.2–1.7	1.0	2.0	26–32	3.0	1.0	3.0	7.0–9.5	Rem	—	—	0.50
ERCoCr-C	A7.2.3	R30001	2.0–3.0	1.0	2.0	26–33	3.0	1.0	3.0	11.0–14.0	Rem	—	—	0.50
ERCoCr-E	A7.2.4	R30021	0.15–0.45	1.5	1.5	25–30	1.5–4.0	4.5–7.0	3.0	0.50	Rem	—	—	0.50
ERCoCr-F	A7.2.5	R30002	1.5–2.0	1.0	1.5	24–27	21–24	1.0	3.0	11–13	Rem	—	—	0.50
ERCoCr-G	A7.2.6	R30014	3.0–4.0	1.0	2.0	24–30	4.0	1.0	3.0	12–16	Rem	—	—	0.50
ERNiCr-A	A7.3.1	N99644	0.20–0.60	—	1.2–4.0	6.5–14.0	Rem[e]	—	1.0–3.5	—	—	1.5–3.0	—	0.50
ERNiCr-B	A7.3.1	N99645	0.30–0.80	—	3.0–5.0	9.5–16.0	Rem[e]	—	2.0–5.0	—	—	2.0–4.0	—	0.50
ERNiCr-C	A7.3.1	N99646	0.50–1.00	—	3.5–5.5	12–18	Rem[e]	—	3.0–5.5	—	—	2.5–4.5	—	0.50
ERNiCr-D	A7.3.4	N99647	0.6–1.1	—	4.0–6.6	8.0–12.0	Rem[e]	—	1.0–5.0	1.0–3.0	0.10	0.35–0.60	—	0.50
ERNiCr-E	A7.3.4	N99648	0.1–0.5	—	5.5–8.0	15–20	Rem[e]	—	3.5–7.5	0.5–1.5	0.10	0.7–1.4	—	Sn = 0.5–0.9 Others = 0.50
ERNiCrMo-5A	A7.3.2	N10006	0.12	1.0	1.0	14–18	Rem[e]	14–18	4.0–7.0	3.0–5.0	—	—	0.40	0.50
ERNiCrFeCo	A7.3.3	F46100	2.5–3.0	1.0	0.6–1.5	25–30	10–33	7–10	20–25	2.0–4.0	10–15	—	—	0.50

[a] Single values are maximum. Rem = Remainder.
[b] Electrodes and rods shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "Other Elements, Total" in the last column of the table.
[c] Sulfur and phosphorus content shall not exceed 0.03% each.
[d] ASTM DS-56/SAE HS-1086 *Metals & Alloys in the Unified Numbering System*.
[e] Includes incidental cobalt.

Table 3
Metal Cored and Flux Cored Composite Cobalt and Nickel-Base Bare Electrodes and Rods—Chemical Composition Requirements

AWS Classification[d]	Annex A Reference	UNS Number[e]	Composition, Weight Percent[a,b,c]											
			C	Mn	Si	Cr	Ni	Mo	Fe	W	Co	B	V	Other Elements, Total
ERCCoCr-A	A7.2.1	W73036	0.7–1.4	2.0	2.0	25–32	3.0	1.0	5.0	3.0–6.0	Rem	—	—	1.0
ERCCoCr-B	A7.2.2	W73042	1.2–2.0	2.0	2.0	25–32	3.0	1.0	5.0	7–10	Rem	—	—	1.0
ERCCoCr-C	A7.2.3	W73031	2.0–3.0	2.0	2.0	25–33	3.0	1.0	5.0	11–14	Rem	—	—	1.0
ERCCoCr-E	A7.2.4	W73041	0.15–0.40	2.0	1.5	25–30	1.5–4.0	4.5–7.0	5.0	0.50	Rem	—	—	1.0
ERCCoCr-G	A7.2.6	W73032	3.0–4.0	1.0	2.0	24–30	4.0	1.0	5.0	12–16	Rem	—	—	1.0
ERCNiCr-A	A7.3.1	W89634	0.20–0.60	—	1.2–4.0	6.5–14.0	Rem[f]	—	1.0–3.5	—	—	1.5–3.0	—	1.0
ERCNiCr-B	A7.3.1	W89635	0.30–0.80	—	3.0–5.0	9.5–16.0	Rem[f]	—	2.0–5.0	—	—	2.0–4.0	—	1.0
ERCNiCr-C	A7.3.1	W89636	0.50–1.00	—	3.0–5.5	12–18	Rem[f]	—	3.0–5.5	—	—	2.5–4.5	—	1.0
ERCNiCrMo-5A	A7.3.2	W80036	0.12	1.0	2.0	14–18	Rem[f]	14–18	4.0–7.0	3.0–5.0	—	—	0.40	1.0
ERCNiCrFeCo	A7.3.3	W83032	2.2–3.0	1.0	2.0	25–30	10–33	7–10	20–25	2.0–4.0	10–15	—	—	1.0

[a] Single values are maximum. Rem = Remainder.
[b] Electrodes and rods shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "Other Elements, Total" in the last column of the table.
[c] Sulphur and phosphorus contents shall not exceed 0.03% each.
[d] The designator "C" following ER indicates that the electrode or rod is a metal cored or flux cored composite (tubular) product.
[e] ASTM DS-56/SAE HS-1086 *Metals & Alloys in the Unified Numbering System*.
[f] Includes incidental cobalt.

Table 4
Solid and Cored Copper Base Electrodes and Rods—Chemical Composition Requirements

		UNS Numbers[a]		Composition, Weight Percent[b,c,d]									
AWS Classification[e]	Annex A Reference	Solid	Cored	Fe	Cu	Al	Zn	Si	Pb	Sn	P	Mn	Other Elements, Total[f]
ERCuAl-A2[g]	A7.4.1.1	C61800	W60618	0.5–1.5	Rem	8.5–11.0	0.02	0.10	0.02	—	—	—	0.50
ERCuAl-A3[g]	A7.4.1.2	C62400	W60624	2.0–4.5	Rem	10.0–11.5	0.10	0.10	0.02	—	—	—	0.50
ERCuAl-C	A7.4.1.3	C62580	W60626	3.0–5.0	Rem	12–13	0.02	0.04	0.02	—	—	—	0.50
ERCuAl-D	A7.4.1.3	C62581	W61626	3.0–5.0	Rem	13–14	0.02	0.04	0.02	—	—	—	0.50
ERCuAl-E	A7.4.1.3	C62582	W62626	3.0–5.0	Rem	14–15	0.02	0.04	0.02	—	—	—	0.50
ERCuSi-A[g]	A7.4.1.4	C65600	W60657	0.50	Rem	0.01	1.0	2.8–4.0	0.02	1.0	—	1.5	0.50
ERCuSn-A[g]	A7.4.1.5	C51800	W60518	—	Rem	0.01	—	—	0.02	4.0–6.0	0.10–0.35	—	0.50
ERCuSn-D	A7.4.1.5	C52400	W60524	—	88.5 min.	0.01	—	—	0.05	9.0–11.0	0.10–0.35	—	0.50

[a] ASTM DS-56/SAE HS-1086 *Metals & Alloys in the Unified Numbering System*.
[b] Single values are maximum, except where otherwise specified. Rem = Remainder.
[c] Electrodes and rods shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for “Other Elements, Total” in the last column of the table.
[d] For solid electrodes and rods, composition is that of the electrode itself or the stock from which it was made. For metal cored or flux cored electrodes, the composition is that of a weld deposit prepared in accordance with 9.3 or 9.4.
[e] For metal cored and flux cored composite (tubular) electrodes and wires, insert “C” in the classification designation immediately following the “R.”
[f] Sulfur content shall not exceed 0.015%.
[g] These AWS classifications are intended to correspond to the same classification that appears in AWS A5.7/A5.7M, *Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes*. Due to possible ongoing revisions, the composition ranges may not be identical.

Table 5
Mesh Size and Quantity of Tungsten Carbide (WC) Granules in the Core of Tungsten Carbide Bare Rods and Electrodes

AWS Classification[a,b,c]	U.S. Standard Mesh Size of Tungsten Carbide Granules[d]	Quantity of Tungsten Carbide (WC1 + WC2) Granules, Weight Percent[e]	SI Equivalents	
			U.S. Standard Mesh Size	Opening, mm
(ER/R)WCX-12/30	thru 12–on 30	60	12	1.70
(ER/R)WCX-20/30	thru 20–on 30	60	20	0.85
(ER/R)WCX-30/40	thru 30–on 40	60	30	0.6
(ER/R)WCX-40	thru 40	60	40	0.43
(ER/R)WCX-40/120	thru 40–on 120	60	120	0.13

[a] "X" designates the type of tungsten carbide granules; X = 1 for WC1 granules, X = 2 for WC2 granules, X = 3 for a blend of WC1 and WC2 granules.
[b] The C normally present in composite designations can be deleted in these classifications, as tungsten carbide electrodes and rods are only composite.
[c] See A7.5 in Annex A.
[d] The mesh size of the tungsten carbide granules may vary from that specified above, provided that no more than 5.0% of the granules is retained on the "thru" sieve and that no more than 20.0% passes the "on" sieve.
[e] The tolerance +2.0%, –1.5% of the amount specified.

Table 6
Chemical Composition Requirements for Tungsten Carbide Granules

	Composition, Weight Percent[a]		
Element	WC1	WC2	WC3
C	3.6–4.2	6.0–6.2	As agreed upon between the purchaser and supplier
Si	0.3	0.3	
Ni	0.3	0.3	
Mo	0.6	0.6	
Co	0.3	0.3	
W	94.0 min.	91.5 min.	
Fe	1.0	1.0	
Th	0.01	0.01	

[a] Single values are maximum, unless noted otherwise.

7. Summary of Tests

7.1 Solid Electrodes or Rods. Chemical analysis of the filler metal itself (or the stock from which it is made) is the only test required for classification of a product under this specification.

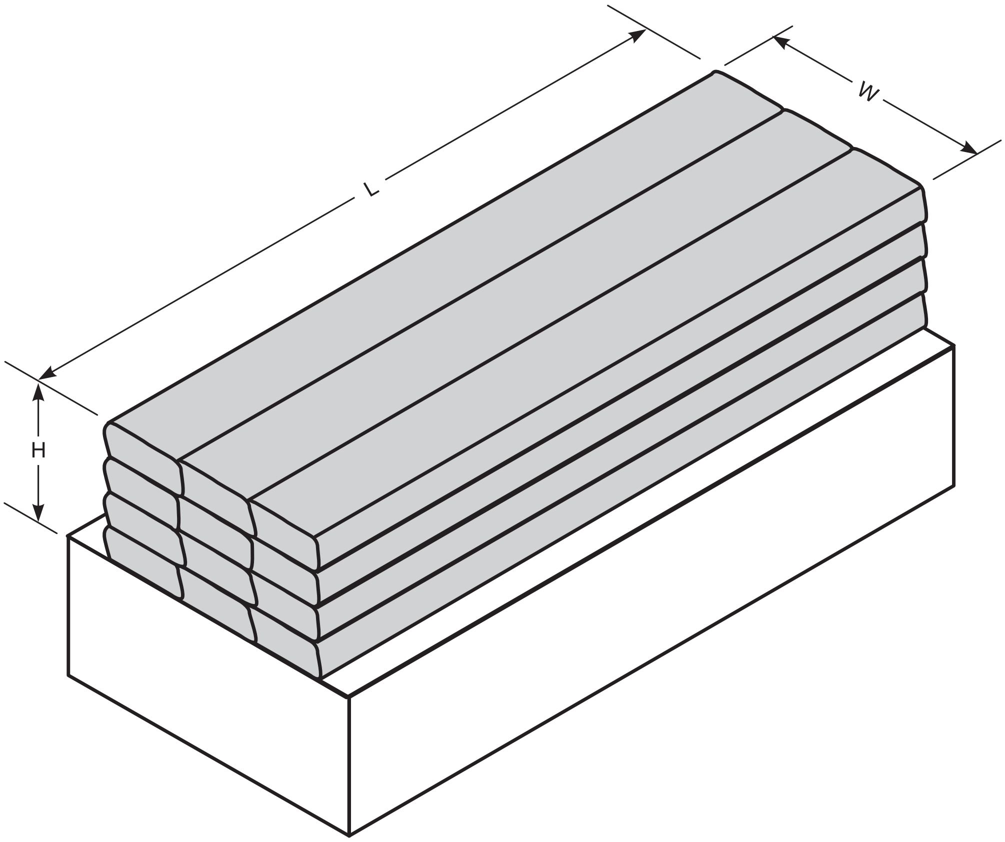
7.2 Metal Cored and Flux Cored Composite (Tubular) Electrodes and Rods

7.2.1 Chemical analysis of a pad of undiluted weld metal, as shown in Figure 1, or a fused sample as agreed upon by the supplier and purchaser, is the only test required for classification. In case of dispute, the weld pad described in 9.3 shall be the referee method.

7.3 Tungsten Carbide Rods

7.3.1 The amount and mesh size distribution of the tungsten carbide granules shall be determined (see Table 5). Sieve analysis shall be in accordance with ASTM B 214.

7.3.2 Chemical analysis of the tungsten carbide granules shall be determined (see Table 6).



Electrode Size		Weld Pad Size, minimum	
in	mm	in	mm
0.045	1.2	L = 2	50
0.052	1.3	W = 1/2	13
1/16 (0.062)	1.6	H = 1/2	13
5/64 (0.078)	2.0		
3/32 (0.094)	2.4	L = 3	75
—	2.5	W = 1/2	13
7/64 (0.109)	2.8	H = 5/8	16
0.120	3.0		
1/8 (0.125)	3.2		
5/32 (0.156)	4.0		
3/16 (0.187)	4.8	L = 3	75
0.197	5.0	W = 1/2	13
0.238	6.0	H = 3/4	19
1/4 (0.250)	6.4		
5/16 (0.312)	8.0		

Source: AWS A5.21:2001, Figure 1.

Figure 1—Pad for Chemical Analysis of Undiluted Weld Metal

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. Material, specimens, or samples for retest may be taken from the original test assembly or sample, or from one or two new test assemblies or samples. 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 retest fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

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. Chemical Composition Requirements

9.1 For solid drawn bare surfacing electrodes or rods, a sample of the filler metal or the stock from which it is made, shall be prepared for chemical analysis. Solid filler metal, when analyzed for elements that are present in a coating (copper flashing for example), shall be analyzed without removing the coating. When the filler metal is analyzed for elements other than those in the coating, the coating shall be removed if its presence affects the results of the analysis for other elements. Rod stock may be analyzed prior to coating for those elements not added in the coating.

9.2 *For cast bare surfacing electrodes or rods, the chemical analysis sample shall be prepared from the as-manufactured material only.*

9.3 For composite metal cored electrodes or rods other than tungsten carbide rods (see 9.5), samples for chemical analysis may be obtained by any method producing undiluted weld metal *or ingot* as agreed upon between the purchaser and supplier. A weld pad *may be prepared using* the welding process for which it was designed to operate (Figure 1). In case of a dispute, the weld pad shall be the referee method.

9.3.1 For flux cored composite electrodes and rods, including self-shielded electrodes, the sample for chemical analysis shall be obtained from an undiluted weld pad (see Figure 1) deposited with the welding process for which it was designed.

9.3.2 The dimensions of the completed pad shall be as shown in Figure 1 for each size of electrode. Testing shall be as specified in 9.3.5.

9.3.3 The weld pad test assembly shall be welded in the flat position using welding conditions specified by the manufacturer.

9.3.4 The base metal shall conform to one of the following specifications or its equivalent:

9.3.4.1 ASTM A 285/A 285M

9.3.4.2 ASTM A 36/A 36M

9.3.5 *The top surface of the pad or ingot shall be removed and discarded, and a sample for analysis shall be obtained from the underlying metal by any appropriate means. Postweld heat treatment may be used to facilitate this removal procedure. Chemical analysis may be made by any suitable method as agreed upon between the purchaser and supplier. The referee method shall be the appropriate ASTM method for the element being determined.*

9.4 The results of the analysis shall meet the requirements in either Table 1, 2, 3, or 4, for the classification of bare surfacing electrode or rod under test.

9.5 Tungsten Carbide Electrodes and Rods

9.5.1 Weight-percentage of the tungsten carbide particles, as specified in Table 5, shall be determined by the following steps:

(1) Record the weight of the tungsten carbide welding electrode or rod sample to the nearest tenth of a gram.

(2) Remove the tungsten carbide from the tube and clean it by washing with water and treating with 1-1 hydrochloric acid, as required, to remove any flux, powdered iron, graphite, etc. Heating of the acid may be required. Hot or cold 1-1 hydrochloric acid will not appreciably attack cast tungsten carbide in less than an hour. When handling any acids, appropriate safety precautions should be followed.

(3) Wash and rinse the tungsten carbide particles thoroughly with tap water.

(4) Dry the tungsten carbide particles by holding in an oven at 250°F ± 25°F [120°C ± 15°C] for a minimum period of one hour.

(5) Weigh the cleaned and dried tungsten carbide particles, and calculate the percentage of tungsten carbide from the initial weight of the tube, using the formula:

$$\text{\% of tungsten carbide particles} = \frac{\text{weight of clean and dried tungsten carbide particles}}{\text{weight of bare electrode or rod sample}} \times 100$$

9.5.2 Chemical composition of tungsten carbide particles shall conform to the requirements of Table 6. Chemical analysis may be made by any suitable method as agreed upon between the purchaser and supplier. Tungsten carbide particles for chemical analysis shall be free of any surface contaminants.

10. Method of Manufacture

The electrodes and rods classified according to this specification may be manufactured by any method that will produce material that meets the requirements of this specification. For tungsten carbide rods, any carbon steel sheath material that will not significantly alter the matrix of the deposit may be used.

11. Standard Sizes and Lengths

Standard sizes and lengths of electrodes and rods shall be as shown in Tables 7, 8, and 9.

12. Finish and Uniformity

Finish and uniformity shall be as specified in 4.2 of AWS A5.02/A5.02M.

13. Standard Package Forms

Standard package dimensions and weights and other requirements for each form shall be as specified in 4.3 of AWS A5.02/A5.02M.

14. Winding Requirements

14.1 Winding requirements shall be as specified in 4.4.1 of AWS A5.02/A5.02M.

14.2 The cast and helix of filler metal shall be as specified in 4.4.2 of AWS A5.02/A5.02M.

15. Filler Metal Identification

15.1 Filler metal identification, product information and the precautionary information shall be as specified in 4.5.2 through 4.5.6 of AWS A5.02/A5.02M.

15.2 Coils without support shall have a tag containing this information securely attached to the filler metal at the inside end of the coil.

Table 7
Standard Sizes for
Bare Electrodes and Rods Using
Solid Drawn or Composite (Tubular) Wire[a,b]

Diameter		Tolerance	
in	mm	in	mm
0.045	—	±0.002	—
—	1.2	—	+0.02, −0.05
0.052	1.3[c]	±0.002	—
—	1.4	—	+0.02, −0.05
1/16 (0.062)	1.6	±0.002	+0.02, −0.06
5/64 (0.078)	2.0	±0.003	+0.02, −0.06
3/32 (0.094)	2.4	±0.003	+0.02, −0.06
—	2.5	—	+0.02, −0.06
7/64 (0.109)	2.8	±0.003	+0.02, −0.06
0.120	3.0	±0.003	+0.02, −0.06
1/8 (0.125)	3.2	±0.005	+0.02, −0.07
5/32 (0.156)	4.0	±0.005	+0.02, −0.07
3/16 (0.188)	4.8[c]	±0.005	—
—	5.0	—	+0.02, −0.08
—	6.0	—	+0.02, −0.08
1/4 (0.250)	6.4[c]	±0.005	—
5/16 (0.312)	8.0	±0.005	+0.02, −0.08

[a] Other diameter electrodes may be supplied as agreed upon between the manufacturer and purchaser.
[b] Electrode and rod length may be supplied as agreed upon between the manufacturer and purchaser.
[c] Nonstandard size in ISO 544.

Table 8
Standard Sizes for
Cast Electrodes and Rods[a,b]

Nominal Diameter		Tolerance	
in	mm	in	mm
3/32 (0.094)	2.4	±0.02	±0.5
1/8 (0.125)	3.2	±0.02	±0.5
5/32 (0.156)	4.0	±0.02	±0.5
3/16 (0.188)	—	±0.02	—
—	5.0	—	±0.5
1/4 (0.250)	6.4	±0.03	±0.8
5/16 (0.312)	8.0	±0.03	±0.8

[a] Other diameter electrodes or rods may be supplied as agreed upon between the manufacturer and purchaser.
[b] Electrode and rod length may be supplied as agreed upon between the manufacturer and purchaser.

Table 9
Standard Sizes for
Tungsten Carbide (WC) Rods

Nominal Diameter[a]		
in	mm	Length
1/8 (0.125)	3.2	See Note b
5/32 (0.156)	4.0	
3/16 (0.188)	—	
—	5.0	
1/4 (0.250)	6.4	
5/16 (0.312)	8.0	
3/8 (0.375)	9.5	

[a] Diameter tolerance is ±1/16 (0.063) in [±1.6 mm] from the nominal diameter.
[b] Rod length may be supplied as agreed upon between the purchaser and supplier.

15.3 Coils with support shall have the information securely affixed in a prominent location on the support.

15.4 Spools shall have the information securely affixed in a prominent location on the outside of at least one flange of the spool.

15.5 Drums shall have the information securely affixed in a prominent location on the side of the drum.

16. Packaging

16.1 *Filler metal in all product forms, excepting welding rods in straight lengths, shall be packaged in accordance with 4.3 of AWS A5.02/A5.02M.*

16.2 Packaging of straight lengths of bare welding rods shall be as agreed upon between the purchaser and supplier.

17. Marking of Packages

17.1 *The product information (as a minimum) shall be legibly marked so as to be visible from the outside of each unit package as specified in AWS A5.02/A5.02M.*

17.2 The appropriate precautionary information[7] given in ANSI Z49.1, latest edition (as a minimum) or its equivalent shall be prominently displayed in legible print on all packages of electrodes and rods, including individual unit packages within a larger package.

[7] Typical examples of "warning labels" and precautionary information are shown in figures in ANSI Z49.1 for some common or specific consumables used with certain processes.

Annex A (Informative)

Guide to AWS Specification for Bare Electrodes and Rods for Surfacing

This annex is not part of AWS A5.21/A5.21M: 2011, *Specification for Bare Electrodes and Rods for Surfacing*, but is included for informational purposes only.

A1. Introduction

This guide has been prepared as an aid to prospective users of the electrodes and rods covered by the specification in determining the classification of filler metal best suited for a particular application, with due consideration to the particular requirements for that application.

A2. Classification System

A2.1 The system for identifying the electrode classifications in this specification follows the standard pattern used in other AWS filler metal specifications. The letters ER at the beginning of each classification designation stand for electrode and rod, indicating that the filler metal may be used either way. The letter R alone means the electrode may be used only as a welding rod. The designator C, when it appears after ER or R, indicates that the electrode or rod is either a metal cored or flux cored composite (tubular) electrode or rod.

A2.2 The letters immediately after the R, RC, ER, or ERC are the chemical symbols for the principal elements in the classification. Thus, CoCr is a cobalt-chromium alloy; CuAl is a copper-aluminum alloy, etc. Where more than one classification is included in a basic group, the individual classifications in the group are identified by the letters, A, B, C, etc., as in ERCuSn-A. Further subdivision is done by using a 1, 2, etc., after the last letter, as the "2" in ERCuAl-A2. An additional letter or number has been added to some designations if the composition requirements in this specification differ somewhat from those of the earlier versions for electrodes of the same basic classification.

A2.3 For SMAW applications, many classifications in this specification have a corresponding classification in A5.13/A5.13M, *Specification for Surfacing Electrodes for Shielded Metal Arc Welding*.

A2.4 Request for Filler Metal Classification

(1) When a surfacing electrode or rod cannot be classified as given in this specification, the manufacturer may request that a classification be established for that welding electrode. The manufacturer may do this by following the procedure given here.

(2) A request to establish a new electrode or rod classification must be a written request, and must provide sufficient detail to permit the AWS A5 Committee on Filler Metals and Allied Materials or the subcommittee to determine whether the new classification or the modification of an existing classification is more appropriate, and whether either is necessary to satisfy the need. The request needs to state the variables and their limits, for such a classification or modification. The request should contain some indication of the time by which completion of the new classification or modification is needed. In particular, the request needs to include:

(a) All classification requirements as given for existing classifications, such as chemical composition ranges and usability test requirements.

(b) Any testing conditions for conducting the tests used to demonstrate that the product meets the classification requirements. (It would be sufficient, for example, to state that welding conditions are the same as for other classifications.)

(c) Information on Descriptions and Intended Use, which parallels that for existing classifications, for that clause of the annex.

(d) Actual test data for all tests required for classification according to the requirements of the specification for a minimum of two production heats/lots must be provided. In addition, if the filler metal specification is silent regarding mechanical properties, test data submitted shall include appropriate weld metal mechanical properties from a minimum of two production heats/lots."

(e) A request for a new classification without the above information will be considered incomplete. The Secretary will return the request to the requestor for further information.

(3) The request should be sent to the Secretary of the A5 Committee on Filler Metals and Allied Materials at AWS Headquarters. Upon receipt of the request, the Secretary will:

(a) Assign an identifying number to the request. This number will include the date the request was received.

(b) Confirm receipt of the request and give the identification number to the person who made the request.

(c) Send a copy of the request to the Chair of the A5 Committee on Filler Metals and Allied Materials, and the Chair of the particular subcommittee involved.

(d) File the original request.

(e) Add the request to the log of outstanding requests.

(4) All necessary action on each request will be completed as soon as possible. If more than 12 months lapse, the Secretary shall inform the requestor of the status of the request, with copies to the Chairs of the Committee and of the Subcommittee. Requests still outstanding after 18 months shall be considered not to have been answered in a "timely manner" and the Secretary shall report these to the Chair of the A5 Committee on Filler Metals and Allied Materials, for action.

(5) The Secretary shall include a copy of the log of all requests pending and those completed during the preceding year with the agenda for each A5 Committee on Filler Metals and Allied Materials meeting. Any other publication of requests that have been completed will be at the option of the American Welding Society, as deemed appropriate.

A3. Acceptance

Acceptance of all welding materials classified under this specification is in accordance with AWS A5.01M/A5.01 (ISO 14344 MOD) as the specification states. Any testing a purchaser requires of the supplier, for material shipped in accordance with this specification, needs to be clearly stated in the purchase order, according to the provisions of AWS A5.01M/A5.01(ISO 14344 MOD). In the absence of any such statement in the purchase order, the supplier may ship the material with whatever testing he normally conducts on material of that classification, as specified in Schedule F, Table 1, of AWS A5.01M/A5.01(ISO 14344 MOD). Testing in accordance with any other Schedule in that table must be specifically required by the purchase order. In such cases, acceptance of the material shipped will be in accordance with those requirements.

A4. Certification

The act of placing the AWS specification and classification designations on the packaging enclosing the product, or the classification on the product itself, constitutes the supplier's (manufacturer's) certification that the product meets all of the requirements of the specification.

The only testing requirement implicit in this "certification" is that the manufacturer has actually conducted the tests required by the specification on material that is representative of that being shipped and that the material met the requirements of the specification. Representative material, in this case, is any production run of that classification using the same formulation. "Certification" is not to be construed to mean that tests of any kind were necessarily conducted on samples of the specific material shipped. Tests on such material may or may not have been made. The basis for the "certification" required by the specification is the classification test of "*representative material*" cited above, and the "Manufacturer's Quality Assurance System" in AWS A5.01M/A5.01 (ISO 14344).

A5. Ventilation During Welding

A5.1 Five major factors govern the quantity of fume to which welders and welding operators are exposed during welding. These are as follows:

(1) Dimensions of the space in which welding is done (with special regard to the height of the ceiling)

(2) Number of welders and welding operators working in that space

(3) Rate of evolution of fumes, gases, or dust, according to the materials and processes involved

(4) The proximity of the welder or welding operator to the fumes as they issue from the welding zone, and to the gases and dusts in the space in which he is working

(5) The ventilation provided to the space in which the welding is done

A5.2 American National Standard ANSI Z49.1 discusses the ventilation that is required during welding and should be referred to for details. Attention is particularly drawn to the section entitled "Ventilation." *See also AWS F3.2,* Ventilation Guide for Weld Fumes*, for more detailed description of ventilation options.*

A6. Surfacing Considerations

A6.1 Role of Hydrogen in Surfacing. Hydrogen can be detrimental to surfacing deposits. The effect varies widely from one alloy type to another. In general, hydrogen's detrimental effect on microstructure is most pronounced for martensitic types, with austenitic types being the least affected. Other factors influencing hydrogen's effect include carbon and alloy contents plus in-service welding variables.

In welding there are many sources for hydrogen contamination with moisture being one of the most important. Most electrodes and welding rods are manufactured and packaged to control moisture. When received, consideration must be given to proper storage to prevent moisture pick-up. During use, improper regard to welding procedure and environment variables can result in spalling or "hydrogen-induced" (underbead) cracking. In austenitic materials, excessive hydrogen can manifest itself as porosity in the deposit.

A6.2 For additional surfacing considerations refer to the appropriate volume of the AWS *Welding Handbook*.

A7. Description and Intended Use of Electrodes and Rods for Surfacing

A7.1 Iron Base Electrodes and Rods

A7.1.1 ERFe-1, ERFe-1A, and ERFe-2 Electrodes

A7.1.1.1 Characteristics. Deposits made with these electrodes and rods are a machinery-grade steel suitable for application on carbon and alloy steels. With care, they can be applied crack-free. Deposits are machinable with carbide tipped tools. Deposit hardness generally is in the range of 25–50 HRC with ERFe-2 filler metal providing weld metal with the higher hardness. These deposits contain sufficient alloy to attain full hardness without the need of heat treatment. Abrasion resistance is comparable to heat treated steels of equal hardness.

A7.1.1.2 Applications. These electrodes and rods are used to restore worn machinery parts to their original dimensions. Deposit surfaces are suitable for metal-to-metal rolling and sliding contact such as occurs on large low speed gear teeth, shafts, etc. High compressive strength makes these materials suitable as a base for more abrasion resistant materials.

A7.1.2 ERFe-3 Electrodes and Rods

A7.1.2.1 Characteristics. Weld metal deposited by these electrodes and rods is an air-hardening tool steel type with high room-temperature hardness (55–60 HRC). Deposits can be applied crack-free with careful procedures. The deposits cannot be machined and generally are ground when finishing is required.

A7.1.2.2 Applications. ERFe-3 electrodes and rods are used to overlay surfaces and edges requiring high hardness and crack-free deposits such as the edges of tools and dies. Deposits are suitable for subsequent surfacing with high-nickel alloys and many tool steels. Although generally used for metal-to-metal applications, the weld metal performs well in earth-abrasion applications where high impact is encountered.

A7.1.3 ERFe-5 Electrodes and Rods

A7.1.3.1 Characteristics. These electrodes and rods deposit a cold work tool steel weld metal. Hardness as deposited should be in the range of 50–55 HRC. Weld metal deposited by ERFe-5 electrodes is air hardening and machinable only after annealing. Typical deposit characteristics include high compressive strength with moderate abrasion resistance.

A7.1.3.2 Applications. These electrodes are used for metal-to-metal wear applications such as machine components, shafts, brake drums, and knife edges.

A7.1.4 ERFe-6 Electrodes and Rods

A7.1.4.1 Characteristics. Weld metal deposited by ERFe-6 electrodes and rods is a high-speed tool steel with a hardness in the range of 60 HRC or higher. The deposit maintains a high degree of hardness to 1100°F [600°C]. Weld metal deposited by ERFe-6 electrodes is air hardening and is machinable only after annealing.

A7.1.4.2 Applications. Weld deposits may be used for metal-to-metal wear applications at temperatures to 1100°F [600°C]. Typical applications combine high-temperature service with moderate abrasion and severe metal-to-metal wear.

A7.1.5 ERFe-8 Electrodes and Rods

A7.1.5.1 Characteristics. Weld metal deposited by ERFe-8 electrodes and rods is similar to an H12 hot work tool steel with an as-deposited hardness of 54–60 HRC. The microstructure consists of martensite plus alloy carbides to produce a tough, hard deposit on either carbon or low-alloy steel base metal. Proper preheating (consult the manufacturer) is essential to ensure crack-free deposits. The deposit may be finished by grinding.

A7.1.5.2 Applications. This composition is used for overlaying surfaces subjected to moderate abrasive wear with high impact. Applications typically include machine tools and components subject to sliding metal-to-metal wear.

A7.1.6 ERFeMn Series Electrodes and Rods (except ERFeMnCr)

A7.1.6.1 Characteristics. Deposits made with these electrodes and rods nominally contain 14% manganese, although they may vary from 12% to 22%. This is an amount sufficient to yield austenitic weld deposits. Austenite is a nonmagnetic, tough form of steel. To preserve the toughness, excessive heat must be avoided during welding. Stringer beads and skip welding are recommended. The additions of other alloys, such as 4% nickel, are made to give more stability to the austenite. Chromium and molybdenum can also be added to increase the yield strength. Abrasion resistance is only a little better than that of low-carbon steel unless there has been sufficient impact to cause work hardening. As deposited, surfaces generally are no harder than 20 HRC, but can work harden to 55 HRC. Deposits are difficult to machine; grinding is preferred for finishing.

Weld metal deposited by ERFeMn-F electrodes differ from the other austenitic manganese classifications in that a one layer deposit will be fully austenitic when deposited on carbon steel or low-alloy steel base metal. This is the direct result of the higher carbon and manganese contents of the filler metal.

A7.1.6.2 Applications. These electrodes are used for the rebuilding, repair, and joining of austenitic manganese steels. Ability to absorb high impact makes such deposits ideal for rebuilding of worn rock-crushing equipment and parts subject to impact loading such as railroad frogs.

A7.1.7 ERFeMnCr Electrodes and Rods

A7.1.7.1 Characteristics. Weld metal deposited by ERFeMnCr electrodes have similar characteristics to those of the austenitic manganese deposits. The high-chromium content improves the stability of austenite when compared to ERFeMn deposits. These deposits cannot be flame cut, and care must be taken in application to avoid heat build-up.

A7.1.7.2 Applications. Like ERFeMn-type electrodes and rods, ERFeMnCr electrodes and rods are used for rebuilding, repair, and joining of equipment made from austenitic manganese steels. ERFeMnCr electrodes and rods offer the added advantage of being usable for joining austenitic manganese steel both to itself and to carbon steel. ERFeMnCr weld metals often are used as a base for surfacing with ERFeCr-AX(X) types for parts subject to both abrasion and impact.

A7.1.8 ERFeCr-A Electrodes and Rods

A7.1.8.1 Characteristics. Weld metal deposited by these electrodes and rods will contain moderate amounts of chromium carbides in a high-carbon austenitic matrix. Two layers are recommended to maintain uniform hardness and deposit composition. Additional layers may be prone to spalling and should be applied with caution. The deposit provides greater impact resistance but decreased abrasion resistance as compared to other ERFeCr-X(X) classifications. The deposits should be ground if finishing is required as they are not readily machined or flame cut. Weld metal deposited by ERFeCr-A electrodes may be applied to carbon, low-alloy, austenitic manganese steel, and austenitic stainless steel base metals.

A7.1.8.2 Applications. A general purpose hardfacing alloy which can be used where limited stress-relief cracks (checks) are acceptable but severe abrasion is not encountered.

A7.1.9 ERFeCr-A1A and ERFeCr-A4 Electrodes and Rods

A7.1.9.1 Characteristics. Weld metal deposited by these electrodes and rods will contain massive chromium carbides in an austenitic matrix providing excellent wear resistance and fair toughness. Surface checks are normal and give a degree of stress relief. Deposits cannot be machined and must be ground when finishing is required. To achieve the desired composition, a minimum of two layers is usually recommended. Additional layers may be prone to spalling and must be applied with caution. These electrodes are suitable for welding on carbon, low-alloy, and austenitic steels and cast irons. The weld metal deposited by ERFeCr-AlA electrodes generally provides greater impact resistance than ERFeCr-A4.

A7.1.9.2 Applications. Typical applications include bucket lips and teeth, impact hammers, and conveyors used for crushing and transporting rock, ore, etc. Very low coefficients of friction develop as a result of scouring by earth products.

A7.1.10 ERFeCr-A3A Electrodes and Rods

A7.1.10.1 Characteristics. The microstructure of weld metal deposited by ERFeCr-A3A electrodes and rods resembles that of white cast iron. The deposit has higher toughness than weld metal deposited by ERFeCr-A1A, ERFeCr-A4, ERFeCr-A9, or ERFeCr-A10 electrodes, but is accompanied by a reduction in abrasion resistance.

A7.1.10.2 Applications. This weld metal is a general-purpose hardfacing alloy typically used as a final overlay on roll crushers, hammer mill hammers, and cone crushers over a build-up of austenitic manganese steel material.

A7.1.11 ERFeCr-A5 Electrodes and Rods

A7.1.11.1 Characteristics. The weld deposit contains chromium carbide in an austenitic matrix. The nonmagnetic weld metal has fair machinability. Build-up should be restricted to three layers to minimize relief checking.

A7.1.11.2 Applications. Components surfaced with these electrodes and rods are frequently used for applications involving metal-to-metal friction wear or earth scouring under low-stress abrasive conditions.

A7.1.12 ERFeCr-A9 Electrodes and Rods

A7.1.12.1 Characteristics. The deposit contains hexagonal chromium carbides in an austenitic matrix with a hardness of 50–60 HRC. Deposits develop relief checks. The weld metal may be applied on carbon or low-alloy steel, austenitic manganese steel, or austenitic stainless steel base metal.

A7.1.12.2 Applications. These electrodes are frequently used for applications involving abrasive wear combined with moderate impact.

A7.1.13 ERFeCr-A10 Electrodes and Rods

A7.1.13.1 Characteristics. Weld metal deposited by these electrodes and rods contains massive hexagonal carbides in an austenite-carbide matrix. The deposit has a hardness of 58–63 HRC which is maintained to a temperature of 1400°F [760°C]. The deposit cannot be flame cut. Finishing is by grinding only.

The composition provides the ultimate in low stress abrasion resistance, but with reduced impact resistance. Deposit thickness should not exceed two layers.

A7.1.13.2 Applications. Deposits of this type may be used in the most severe abrasive applications that involve minimal impact. Typical applications include coal pulverizing and handling equipment, glass sand handling equipment, and certain high-temperature applications.

A7.2 Cobalt Base Electrodes and Rods

A7.2.1 ERCoCr-A Electrodes and Rods

A7.2.1.1 Characteristics. Weld metals deposited by ERCoCr-A electrodes and rods are characterized by a hypoeutectic structure, consisting of a network of about 13% eutectic chromium carbides distributed in a cobalt-chromium-tungsten solid solution matrix. The result is a material with a combination of overall resistance to low stress abrasive wear, with the necessary toughness to resist some degree of impact. Cobalt alloys also are inherently good for resisting metal-to-metal wear, particularly in high load situations that are prone to galling. The high-alloy content of the matrix also affords excellent resistance to corrosion, oxidation, and elevated temperature retention of hot hardness up to a maximum of 1200°F [650°C]. These alloys are not subject to allotropic transformation and therefore do not lose their properties if the base metal is subsequently heat treated.

A7.2.1.2 Applications. The alloy is recommended for cases where wear is accompanied by elevated temperatures and where corrosion is involved, or both. Some typical applications are automotive and fluid flow valves, chain saw guides, hot punches, shear blades, and extruder screws.

A7.2.2 ERCoCr-B Electrodes and Rods

A7.2.2.1 Characteristics. Weld metal deposited by ERCoCr-B electrodes and rods is similar in composition to deposits made using ERCoCr-A electrodes and rods except for a slightly higher percentage (approximately 16%) of carbides. The alloy also has a slightly higher hardness and better abrasive and metal-to-metal wear resistance. Impact and corrosion resistance are lowered slightly. Deposits can be machined with carbide tools.

A7.2.2.2 Applications. ERCoCr-B electrodes and rods are used interchangeably with ERCoCr-A electrodes and rods. Choice will depend on the specific application.

A7.2.3 ERCoCr-C Electrodes and Rods

A7.2.3.1 Characteristics. This alloy has a higher percentage (approximately 19%) of carbides than deposits made using either ERCoCr-A or ERCoCr-B class. In fact, the composition is such that primary hypereutectic carbides are found in the microstructure. This characteristic gives the alloy higher wear resistance accompanied by reductions in the impact and corrosion resistance. The higher hardness also means a greater tendency to check during cooling. The checking tendency may be minimized by closely monitoring preheating, interpass temperature, and postheating techniques.

While the cobalt-chromium deposits soften somewhat at elevated temperatures, they normally are considered immune to tempering.

A7.2.3.2 Applications. Weld metal deposited by ERCoCr-C electrodes and rods is used to build-up items such as mixers, rotors, or wherever harsh abrasion and low impact are encountered.

A7.2.4 ERCoCr-E Electrodes and Rods

A7.2.4.1 Characteristics. Welds made using ERCoCr-E electrodes and rods have very good strength and ductility in temperatures up to 2100°F [1150°C]. Deposits are resistant to thermal shock and oxidizing and reducing atmospheres. Early applications of these types of alloys were found in jet engine components such as turbine blades and vanes.

The deposit is a solid solution strengthened alloy with a relatively low weight-percent carbide phase in the microstructure. Hence, the alloy is very tough and will work harden. Deposits possess excellent self-mated galling resistance and also are very resistant to cavitation erosion.

A7.2.4.2 Applications. Welds made using ERCoCr-E electrodes and rods are used where the resistance to thermal shock is important. Typical applications, similar to those of deposits made using ERCoCr-A electrodes and rods, include guide rolls, hot extrusion and forging dies, hot shear blades, tong bits, valve trim, etc.

A7.2.5 ERCoCr-F Electrodes and Rods

A7.2.5.1 Characteristics. ERCoCr-F differs from the other cobalt chrome tungsten alloys due to the addition of over 20% nickel. This alloy was developed to impart additional oxidation and corrosion resistance, especially where lead additives are made to automotive engine fuels. Other properties, such as hot hardness, metal-to-metal wear resistance, and thermal fatigue, are similar to type ERCoCr-A type deposits.

A7.2.5.2 Applications. ERCoCr-F is used almost exclusively on automotive (gasoline) exhaust valves, especially on air-cooled (higher operating temperature) engines. Most surfacing is done with automatic equipment by the original equipment manufacturer, and very little by the maintenance market. Both oxyfuel gas welding (OFW) and gas tungsten arc welding (GTAW) are used.

A7.2.6 ERCoCr-G Electrodes and Rods

A7.2.6.1 Characteristics. ERCoCr-G is a higher carbon and tungsten version of ERCoCr-C that imparts excellent abrasion resistance under high loads. The increase in the volume fraction of primary carbides also increases the average hardness and adhesive wear resistance. This type of material is sensitive to cracking in the weld deposits and therefore, preheat and interpass temperatures as well as cooling rate must be closely controlled.

A7.2.6.2 Applications. ERCoCr-G is used extensively on bearing areas of tri-cone type drilling tools. Application is typically by manual or automated gas tungsten arc welding (GTAW) and oxyfuel gas welding (OFW).

A7.2.7 Typical hardness values for multilayer welds made using cobalt base electrodes and rods are as follows:

CoCr-A	23–47 HRC
CoCr-B	34–47 HRC
CoCr-C	43–58 HRC
CoCr-E	20–35 HRC
CoCr-F	32–46 HRC
CoCr-G	52–60 HRC

A7.3 Nickel Base Electrodes and Rods

A7.3.1 ERNiCr-A, -B, and -C Electrodes and Rods

A7.3.1.1 Characteristics. Undiluted weld metals of these compositions exhibit a structure consisting of borides and chromium carbides in a nickel-rich matrix. The nickel-base and high-chromium content gives these deposits good heat and corrosion resistance. Care should be taken when cooling these deposits because of a tendency to stress crack. These alloys possess excellent resistance to low-stress abrasion which increases with increasing boron content in the deposit.

Weld metal deposited by these electrodes and rods flows very easily, has very high abrasion resistance, and normally takes on a high polish.

The deposits have high corrosion resistance and normally require grinding for finishing. Single-layer deposits typically have hardness between 35 and 45 HRC. Multilayer deposits typically have hardness between 49 and 56 HRC.

A7.3.1.2 Applications. Typical applications include cultivator sweeps, plow shares, extrusion screws, pump sleeves, pistons, impellers, capstan rings, glass mold faces, centrifuge filters, and sucker pump rods.

A7.3.2 ERNiCrMo-5A Electrodes and Rods

A7.3.2.1 Characteristics. Weld metal of this composition is a solid solution strengthened alloy with a relatively low weight-percent carbide phase. The resultant deposit is tough and work hardening.

Deposits have the ability to retain hardness to 1400°F [760°C]. Deposits are machinable with high-speed tool bits and have excellent resistance to high-temperature wear and impact.

A7.3.2.2 Applications. These electrodes are used to rebuild and repair hot extrusion and forging dies, sizing punches, hot shear blades, guide rolls, tong bits, blast furnace bells, etc.

A7.3.3 ERNiCrFeCo Electrodes and Rods

A7.3.3.1 Characteristics. Filler metal deposited by these electrodes is a nickel-chromium-iron-cobalt base alloy containing a fairly large volume fraction of hypereutectic chromium carbides distributed throughout the microstructure. The alloy offers many of the same high performance characteristics of deposits made using ERCoCr-C or ERNiCr-C electrodes or rods in terms of abrasive wear resistance. The reduced content of nickel or cobalt, or both, lowers corrosion properties and galling resistance. The high volume fraction of carbides makes this alloy sensitive to cracking during cooling.

Hardness values for single layer deposits will be lower because of dilution from the base metal.

A7.3.3.2 Applications. Welds made using ERNiCrFeCo electrodes or rods are preferred where high abrasion with low impact is a major factor. Typical applications are feed screws, slurry pumps, and mixer components.

A7.3.4 ERNiCr-D and E Electrodes and Rods

A7.3.4.1 Characteristics. Undiluted weld metals of these compositions with Si/B greater than 3.3 exhibit a structure consisting of a nickel solid solution, a binary eutectic of nickel solid solution and nickel silicide; and a ternary eutectic of nickel solid solution, nickel silicide, and nickel boride. There are also carbide and boride particles dispersed in the matrix. The microstructures differ from those of ERNiCr-A, B, and C in that the brittle binary eutectic of nickel solid solution and nickel boride does not form, thus improving the cracking resistance during welding.

A7.3.4.2 Applications. Welds of these compositions are used for hardfacing the trims of fluid control valves. In the nuclear industry, they are used to replace cobalt-containing weld overlays in order to reduce the cobalt content in the process stream.

A7.4 Copper Base Electrodes and Rods

A7.4.1 Introduction. The copper base solid welding materials classified by this specification are used to deposit overlays for bearings and wear-resistant surfaces and to resist corrosion.

A7.4.1.1 ERCuAl-A2 filler metal is used for building up bearing surfaces between the hardness range of 130–150 HB. It is also used for wear-resistant surfaces as well as for corrosion-resistant surfaces subject to saltwater and many commonly used acids.

A7.4.1.2 ERCuAl-A3 filler metal deposits produce a deposit of high strength and good ductility with a nominal hardness of 166 HB. This alloy is ideal for bearing surfaces requiring high strength and good ductility such as for a forge press piston.

A7.4.1.3 ERCuAl-C, ERCuAl-D, ERCuAl-E, filler metals have excellent wear-resisting characteristics and are used where extreme wear and high pressure are encountered in service. ERCuAl-D and ERCuAl-E are also used for fabricating new or rebuilding worn ferrous dies used for forming or drawing titanium, and low-carbon and stainless steel. These alloys are not recommended for corrosion. Typical hardness levels for ERCuAl-C, ERCuAl-D and ERCuAl-E are 250–290 HB, 310–350 HB, and 340–380 HB, respectively.

A7.4.1.4 ERCuSi-A (copper-silicon) filler metal is used primarily for corrosion-resistant surfaces. Copper silicon deposits are generally not suited for bearing service applications.

A7.4.1.5 ERCuSn-A, ERCuSn-D (copper-tin) filler metal is primarily used to build-up bearing surfaces where lower hardness is required. This alloy is used for corrosion-resistant surfaces, and occasionally, for wear-resistance applications. The higher tin content of ERCuSn-D weld deposits has improved wear resistance but also has increased hot shortness of the alloys.

A7.4.2 Applications

A7.4.2.1 Hot Hardness. The copper base filler metals are not recommended for use at elevated temperatures. Mechanical properties will generally degrade as the temperature increases above 400°F [200°C]

A7.4.2.2 Abrasion. Copper-base weld deposits are not recommended for use where severe abrasion is encountered in service.

A7.4.2.3 Metal to Metal Wear. Bearing surface overlays are often designed with preferential wear requirements. To do this with copper-base alloys, select a material that will result in a weld deposit of 50–75 points Brinell softer than the mating surface. This will assure a preferential wear system.

A7.4.2.4 Machinability. All of the copper-base weld deposits are machinable.

A7.4.2.5 Preparation and Welding Characteristics. The base metal should be machined or ground prior to application of the first pass. The weld deposits should be wire brushed or ground between passes. The first pass should be applied at the low end of amperage to minimize dilution. Excessive base metal dilution can result in reduced machinability and service performance. The manufacturer should be consulted for specific welding parameters.

A7.4.2.6 Preheat. Preheating may be desirable depending on the base metal to be overlaid. Generally, no preheat is necessary on low carbon steel. Medium-to-high carbon steel may require 300°F–600°F [150°C–315°C] preheat, depending on the carbon content. On subsequent layers, an interpass temperature of 500°F [260°C] should not be exceeded. The manufacturer should be consulted for complicated overlays.

A7.5 Tungsten Carbide Electrodes and Rods

A7.5.1 Characteristics. Tungsten carbide electrodes and rods classified in this specification contain 60% by weight of tungsten carbide particles. The WC1 carbide is a mixture of WC and W_2C. The WC2 carbide is macrocrystalline WC. Hardness of the matrix of the deposit can be varied from 30–60 HRC depending on welding technique. Hardness of individual carbide particles typically is about 2400 HV20.

Abrasion resistance of tungsten carbide deposits is outstanding.

A7.5.2 Applications. Tungsten carbide deposits are applied on surfaces subject to sliding abrasion combined with a limited amount of impact. Such applications are encountered in earth drilling, digging, and farming. Specific tools that may require this type of a surfacing overlay include oil drill bits and tool joints, earth handling augers, excavator teeth, farm fertilizer applicator knives, and cultivator shares.

A8. Suggested Methods for Preparation of Fused Samples for Analysis

A8.1 The determination of the chemical composition of the as-manufactured solid bare electrodes and rods presents no technical difficulties. The filler metal, in the form of a solid wire, may be subdivided for analysis by any convenient method, and all samples or chips will be representative of the lot of filler metal. Difficulties are encountered in obtaining a representative sample of metal cored and flux cored composite (tubular) electrodes and rods. Some filler metal of the composite type is in the form of a tubular wire, the core of which is filled with a mixture of particles, often unbonded. Samples obtained by merely cutting or subdividing the composite type of filler metal may not prove representative of the filler metal due to the possible loss of some of the core material at the ends of the sample. Therefore, the sheath and core of composite-type welding electrodes and welding rods must be combined before a sample representative of the filler metal can be obtained. To accomplish this, the specification requires the preparation of an essentially homogeneous fused sample of the metal cored electrode or rod and a weld metal pad of the flux cored composite (tubular) electrode or rod. These samples can then be subdivided by routine methods.

A8.2 Preparation of a fused sample by gas tungsten arc welding using argon or helium shielding gas will transfer essentially all of the components of the composite-type welding rods through the arc. Some slight loss in carbon will occur, but such loss will never be greater than would be encountered in an actual welding operation, regardless of process. Nonmetallic ingredients, if present in the core, will form a slag on the top of the deposit which must be removed and discarded. The specification classifies the filler metals only on the basis of metallic chemical composition. Gas tungsten arc welded fused samples should not be prepared using composite tubular electrodes of the self-shielded type as the formation of reactive gases will cause instabilities in the arc.

A8.3 The sample of fused filler metal must be large enough to provide the amount of undiluted material required by the chemist for analysis. No size or shape of deposited pads has been specified because these are immaterial if the deposit is truly undiluted.

A8.4 A sample made using the composite type filler metal which has been fused in a copper mold will be undiluted since there will be essentially no admixture with base metal.

A8.5 A sample made using the composite type filler metal deposited on a steel base plate, Figure 1, will become diluted and contaminated by admixture with the base metal. Such a deposit will have to be multilayered to overcome this dilution. To ensure an undiluted sample, the pad will need to be 1/2 in [13 mm] minimum height for electrode diameters 0.045 in–1/16 in [1.2 mm–1.6 mm], 5/8 in [16 mm] minimum height for electrode diameters 5/64 in–0.120 in [2.0 mm–3.0 mm], and 3/4 in [19 mm] minimum height for larger electrode sizes.

A8.6 Assurance that an undiluted sample is being obtained from the chosen size of pad at the selected distance above the base can be obtained by analyzing chips removed from successively lower layers of the pad. Layers which are undiluted will all have the same chemical composition. Therefore, the determination of identical compositions for two successive layers of deposited filler metal will provide evidence that the last layer is undiluted.

A9. Discontinued Classifications

Some classifications have been discontinued from one revision of this specification to another. This results either from changes in commercial practice or changes in the classification used in the specification. The classifications that have been discontinued are listed in Table A.1, along with the year they were last included in the specification.

A10. General Safety Considerations

A10.1 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 annex Clause A5 and below. Safety and health information is available from other sources, including but not limited to ANSI Z49.1, and applicable federal and state regulations.

Table A.1
Discontinued and Transferred
Electrode and Rod Classifications[a]

AWS Classification	Last A5.21 Publication Date
RFe5-A	1980
RFe5-B	1980
RFeCr-A1	1980
EFe5-A	1980
EFe5-B	1980
EFe5-C	1980
EFeMn-A[b]	1980
EFeMn-B[b]	1980
EFeCr-A1	1980
RWC-5/8	1980
RWC-8/12	1980
RWC-12/20	1980
RWC-30	1980
EWC-12/30[c]	1980
EWC-20/30[c]	1980
EWC-30/40[c]	1980
EWC-40[c]	1980
EWC-40/120[c]	1980

[a] See Clause A9, Discontinued Classifications (in Annex A), for information on discontinued classifications.
[b] These AWS classifications have been transferred to AWS A5.13 without a change in classification designation.
[c] These AWS classifications have been transferred to AWS A5.13 with a change in classification to EWCX-X/X.

A10.2 ***Safety and Health Fact Sheets.*** *The Safety and Health Fact Sheets listed below are published by the American Welding Society (AWS). They may be downloaded and printed directly from the AWS website at http://www.aws.org. The Safety and Health Fact Sheets are revised and additional sheets added periodically.*

A10.3 ***AWS Safety and Health Fact Sheet Index (SHF)***[8]

No.	*Title*
1	Fumes and Gases
2	Radiation
3	Noise
4	Chromium and Nickel Welding Fume
5	Electrical Hazards
6	Fire and Explosion Prevention
7	Burn Protection
8	Mechanical Hazards
9	Tripping and Falling
10	Falling Objects
11	Confined Spaces
12	Contact Lens Wear
13	Ergonomics in the Welding Environment
14	Graphic Symbols for Precautionary Labels
15	Style Guidelines for Safety and Health Documents
16	Pacemakers and Welding
17	Electric and Magnetic Fields (EMF)
18	Lockout/Tagout
19	Laser Welding and Cutting Safety
20	Thermal Spraying Safety
21	Resistance Spot Welding
22	Cadmium Exposure from Welding & Allied Processes
23	California Proposition 65
24	Fluxes for Arc Welding and Brazing: Safe Handling and Use
25	Metal Fume Fever
26	Arc Viewing Distance
27	Thoriated Tungsten Electrodes
28	Oxyfuel Safety: Check Valves and Flashback Arrestors
29	Grounding of Portable and Vehicle Mounted Welding Generators
30	Cylinders: Safe Storage, Handling, and Use
31	Eye and Face Protection for Welding and Cutting Operations
33	Personal Protective Equipment (PPE) for Welding & Cutting
34	Coated Steels: Welding and Cutting Safety Concerns
36	Ventilation for Welding & Cutting
37	Selecting Gloves for Welding & Cutting

[8] AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Annex B

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS A5.21/A5.21M: 2011, *Specification for Bare Electrodes and Rods for Surfacing*, but is included for informational purposes only.

B1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

B2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

B2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

B2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

B2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

B2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

B3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS technical committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon approval by the committee, the interpretation is an official interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

B4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

B5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The AWS *Board Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

B6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

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AWS Filler Metal Specifications by Material and Welding Process

	OFW	SMAW	GTAW GMAW PAW	FCAW	SAW	ESW	EGW	Brazing
Carbon Steel	A5.2	A5.1	A5.18	A5.20	A5.17	A5.25	A5.26	A5.8, A5.31
Low-Alloy Steel	A5.2	A5.5	A5.28	A5.29	A5.23	A5.25	A5.26	A5.8, A5.31
Stainless Steel		A5.4	A5.9, A5.22	A5.22	A5.9	A5.9	A5.9	A5.8, A5.31
Cast Iron	A5.15	A5.15	A5.15	A5.15				A5.8, A5.31
Nickel Alloys		A5.11	A5.14	A5.34	A5.14	A5.14		A5.8, A5.31
Aluminum Alloys		A5.3	A5.10					A5.8, A5.31
Copper Alloys		A5.6	A5.7					A5.8, A5.31
Titanium Alloys			A5.16					A5.8, A5.31
Zirconium Alloys			A5.24					A5.8, A5.31
Magnesium Alloys			A5.19					A5.8, A5.31
Tungsten Electrodes			A5.12					
Brazing Alloys and Fluxes								A5.8, A5.31
Surfacing Alloys	A5.21	A5.13	A5.21	A5.21	A5.21			
Consumable Inserts			A5.30					
Shielding Gases			A5.32	A5.32			A5.32	

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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.

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On occasion, text, tables, or figures are printed incorrectly, constituting errata. Such errata, when discovered, are posted on the AWS web page (www.aws.org).

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, 550 N.W. LeJeune Road, Miami, FL 33126 (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, 550 N.W. LeJeune Road, Miami, FL 33126.