AWS A5.8/A5.8M:2004
An American National Standard

Specification for Filler Metals for Brazing and Braze Welding

American Welding Society

Approved American National Standard
ANSI

Key Words—Brazing, brazing filler metals, braze welding filler metals, aluminum filler metals, cobalt filler metals, copper filler metals, gold filler metals, magnesium filler metals, nickel filler metals, silver filler metals

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Approved by
American National Standards Institute
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Specification for Filler Metals for Brazing and Braze Welding

Supersedes ANSI/AWS A5.8-92

Prepared by
AWS A5 Committee on Filler Metals and Allied Materials

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification prescribes the requirements for the classification of filler metals for brazing and braze welding. The chemical composition, physical form, and packaging of more than 75 brazing filler metals are specified. The filler metal groups described include aluminum, cobalt, copper, gold, magnesium, nickel, silver, and brazing filler metals for vacuum service. Information is provided concerning the liquidus, the solidus, the brazing temperature range, and general areas of application recommended for each filler metal. Additional requirements are included for manufacture, sizes, lengths, and packaging. A guide is appended to the specification as a source of information concerning the classification system employed and the intended use of the filler metals for brazing and braze welding.

This specification makes use of both U.S. Customary Units and the International System of Units (SI). Since these are not equivalent, each must be used independently of the other.

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Foreword

(This Foreword is not a part of AWS A5.8/A5.8M:2004, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.)

This document is the first of the AWS A5.8 specification revisions that makes use of both the 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 International Standard ISO 544, *Welding Consumables—Technical Delivery Conditions for Welding Filler Materials—Type of Product, Dimensions, Tolerances, and Markings,* are used where suitable. Tables and figures make use of both U.S. Customary Units and SI units, which with the application of the specified tolerances provides for interchangeability of products in both U.S. Customary Units and SI units.

The current document is the ninth revision of the initial joint filler metal specification for brazing issued by the American Welding Society (AWS). The original specification was prepared by a joint committee of the American Welding Society and the American Society for Testing and Materials (ASTM). This joint activity continued for 17 years until 1969, when AWS became solely responsible for the development and publishing of the specification

The evolution of AWS A5.8/A5.8M, *Specification for Filler Metals for Brazing and Braze Welding*, is shown below:

ASTM B260-52T, AWS A5.8-52T	*Tentative Specification for Brazing Filler Metal*
ASTM B260-56T, AWS A5.8-56T	*Tentative Specification for Brazing Filler Metal*
AWS A5.8-62T, ASTM B260-62T	*Tentative Specification for Brazing Filler Metal*
AWS A5.8-69	*Specification for Brazing Filler Metal*
ANSI/AWS A5.8-76	*Specification for Brazing Filler Metal*
ANSI/AWS A5.8-81	*Specification for Brazing Filler Metal*
ANSI/AWS A5.8-89	*Specification for Filler Metals for Brazing*
ANSI/AWS A5.8-92	*Specification for Filler Metals for Brazing and Braze Welding*

The present edition, which supercedes ANSI/AWS A5.8-92, includes new filler metals. These are AWS BCu-1b; AWS BCu-3; AWS BCuP-8; AWS BCuP-9; AWS BNi-5b; AWS BNi-12; AWS BNi-13; AWS BVAu-3, Grades 1 and 2; BVAu-9, Grades 1 and 2; and BVAu-10, Grades 1 and 2.

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.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel, following established procedures (see Annex C).

Errata

(The following Errata have been identified and incorporated into the current reprint of this document.)

Page 6, in Table 4, Titled "Chemical Composition Requirements for Copper, Copper-Zinc, and Copper-Phosphorous Filler Metals," change the UNS number for BCuP-9 to C55385.

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Specification for Filler Metals for Brazing and Braze Welding

1. Scope

1.1 This specification prescribes requirements for the classification of filler metals for brazing and braze welding. It includes filler metals for brazing with or without a flux and in all protective atmospheres for various applications, including those for vacuum service.[1] The prefix "RB" indicates that the filler metal is suitable for use both as brazing rod for braze welding and as a brazing filler metal.

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 sections 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*, and applicable federal and state regulations.

1.3 This specification makes use of both U.S. Customary Units and the International System of Units (SI). The measurements are not exact equivalents; therefore, each system must be used independently of the other without combining in any way when referring to material properties. The specification with the designation A5.8 uses U.S. Customary Units. The specification A5.8M 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 A5.8 or A5.8M specifications.

Part A
General Requirements

2. Normative References

2.1 The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this AWS standard are encouraged to investigate the possibility of applying the most recent editions of the documents shown below. For undated references, the latest edition of the standard referred to applies.

2.2 The following AWS standards[2] are referenced in the mandatory sections of this document:

(1) AWS A5.01, *Filler Metal Procurement Guidelines*.

2.3 The following ANSI standards[3] are referenced in the mandatory sections of this document:

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

2.4 The following ASTM standards[4] are referenced in the mandatory sections of this document:

(1) *Analytical Chemistry for Metals, Ores, and Related Materials (I): C 571–E 354, Annual Book of ASTM Standards, Analytical Chemistry of Metals, Ores, and Related Materials*;

(2) *Analytical Chemistry for Metals, Ores, and Related Materials (II): E 356 to last; Molecular Spectroscopy; Surface Analysis, Annual Book of ASTM Standards, Analytical Chemistry of Metals, Ores, and Related Materials*;

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1. Filler metals for vacuum service are for devices operating in vacuum service, regardless of the atmosphere used in making the joint.

2. AWS standards can be obtained from Global Engineering Documents, an Information Handling Services Group company, 15 Inverness Way East, Englewood, Colorado 80112-5776; telephones: (800) 854-7179, (303) 397-7956; fax (303) 397-2740; Internet: www.global.ihs.com.

3. ANSI standards can be obtained from American National Standards Institute, 25 West 43 Street, Fourth Floor, New York, New York 10036 and Global Engineering Documents, an Information Handling Services Group company, 15 Inverness Way East, Englewood, Colorado 80112-5776; telephones: (800) 854-7179, (303) 397-7956; fax (303) 397-2740; Internet: www.global.ihs.com.

4. ASTM standards can be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(3) ASTM B 214, *Standard Method for Sieve Analysis of Granular Metal Powders*;

(4) ASTM DS-56, *Metals and Alloys in the Unified Numbering System*;

(5) ASTM E 11-01, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*; and

(6) ASTM E 29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.

3. Classification [5]

3.1 The brazing filler metals covered by the A5.8/A5.8M specification are classified using a system that is independent of U.S. Customary Units and the International System of Units (SI). Classification is according to the chemical composition of the brazing filler metal as specified in Tables 1 through 6.

3.2 Filler metal classified under one classification shall not be classified under any other classification of this specification.

4. Acceptance [6]

Acceptance of the brazing filler metal shall be in accordance with the provisions of AWS A5.01, *Filler Metal Procurement Guidelines*.

5. Certification [7]

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 the purpose of determining conformance with this specification, 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 value in accordance with the rounding-off method given in ASTM E 29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.

Part B
Tests, Procedures, and Requirements

7. Summary of Tests

The tests required for each classification or product form are as follows:

7.1 Chemical analysis of the filler metal is required for all classifications.

7.2 Filler metals for vacuum service require a melt cleanliness test and a spatter test in addition to chemical analysis.

7.3 Sieve analysis is required for all powdered brazing filler metal.

7.4 A binder content test for transfer tape used in conjunction with powdered brazing filler metals is required.

The material for the preparation of test samples, the brazing and testing procedures to be employed, and the results required are specified in Sections 9 through 13.

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. Samples for retest may be taken from the original sample or from one or two new samples. For chemical analysis, retest need be only for the specific elements that failed to meet the requirement. If the results of one or both retests 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 the preparation or after the completion of any test it is clearly determined that prescribed or proper procedures were not followed in preparing the test sample(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.

5. An explanation of the method of classification of the filler metals is included in A2.
6. See A3, "Acceptance," for further information concerning acceptance and the testing of the material shipped, as well as AWS A5.01, *Filler Metal Procurement Guidelines*.
7. See A4, "Certification," for further information concerning certification and the testing called for to meet this requirement.

Table 1[a, b]
Chemical Composition Requirements for Silver Filler Metals

AWS Classification	UNS Number[c]	Composition, Weight Percent								
		Ag	Cu	Zn	Cd	Ni	Sn	Li	Mn	Other Elements, Total[d]
BAg-1	P07450	44.0–46.0	14.0–16.0	14.0–18.0	23.0–25.0	—	—	—	—	0.15
BAg-1a	P07500	49.0–51.0	14.5–16.5	14.5–18.5	17.0–19.0	—	—	—	—	0.15
BAg-2	P07350	34.0–36.0	25.0–27.0	19.0–23.0	17.0–19.0	—	—	—	—	0.15
BAg-2a	P07300	29.0–31.0	26.0–28.0	21.0–25.0	19.0–21.0	—	—	—	—	0.15
BAg-3	P07501	49.0–51.0	14.5–16.5	13.5–17.5	15.0–17.0	2.5–3.5	—	—	—	0.15
BAg-4	P07400	39.0–41.0	29.0–31.0	26.0–30.0	—	1.5–2.5	—	—	—	0.15
BAg-5	P07453	44.0–46.0	29.0–31.0	23.0–27.0	—	—	—	—	—	0.15
BAg-6	P07503	49.0–51.0	33.0–35.0	14.0–18.0	—	—	—	—	—	0.15
BAg-7	P07563	55.0–57.0	21.0–23.0	15.0–19.0	—	—	4.5–5.5	—	—	0.15
BAg-8	P07720	71.0–73.0	Remainder	—	—	—	—	—	—	0.15
BAg-8a	P07723	71.0–73.0	Remainder	—	—	—	—	0.25–0.50	—	0.15
BAg-9	P07650	64.0–66.0	19.0–21.0	13.0–17.0	—	—	—	—	—	0.15
BAg-10	P07700	69.0–71.0	19.0–21.0	8.0–12.0	—	—	—	—	—	0.15
BAg-13	P07540	53.0–55.0	Remainder	4.0–6.0	—	0.5–1.5	—	—	—	0.15
BAg-13a	P07560	55.0–57.0	Remainder	—	—	1.5–2.5	—	—	—	0.15
BAg-18	P07600	59.0–61.0	Remainder	—	—	—	9.5–10.5	—	—	0.15
BAg-19	P07925	92.0–93.0	Remainder	—	—	—	—	0.15–0.30	—	0.15
BAg-20	P07301	29.0–31.0	37.0–39.0	30.0–34.0	—	—	—	—	—	0.15
BAg-21	P07630	62.0–64.0	27.5–29.5	—	—	2.0–3.0	5.0–7.0	—	—	0.15
BAg-22	P07490	48.0–50.0	15.0–17.0	21.0–25.0	—	4.0–5.0	—	—	7.0–8.0	0.15
BAg-23	P07850	84.0–86.0	—	—	—	—	—	—	Remainder	0.15
BAg-24	P07505	49.0–51.0	19.0–21.0	26.0–30.0	—	1.5–2.5	—	—	—	0.15
BAg-26	P07250	24.0–26.0	37.0–39.0	31.0–35.0	—	1.5–2.5	—	—	1.5–2.5	0.15
BAg-27	P07251	24.0–26.0	34.0–36.0	24.5–28.5	12.5–14.5	—	—	—	—	0.15
BAg-28	P07401	39.0–41.0	29.0–31.0	26.0–30.0	—	—	1.5–2.5	—	—	0.15
BAg-33	P07252	24.0–26.0	29.0–31.0	25.5–29.5	16.5–18.5	—	—	—	—	0.15
BAg-34	P07380	37.0–39.0	31.0–33.0	26.0–30.0	—	—	1.5–2.5	—	—	0.15
BAg-35	P07351	34.0–36.0	31.0–33.0	31.0–35.0	—	—	—	—	—	0.15
BAg-36	P07454	44.0–46.0	26.0–28.0	23.0–27.0	—	—	2.5–3.5	—	—	0.15
BAg-37	P07253	24.0–26.0	39.0–41.0	31.0–35.0	—	—	1.5–2.5	—	—	0.15

Notes:
a. See Table A2 for discontinued brazing filler metal classifications.
b. See Table 6 for the following Ag classification not included here: BVAg-0, BVAg-6b, BVAg-8b, and BVAg-29 to BVAg-32.
c. ASTM DS-56, *Metals and Alloys in the Unified Numbering System.*
d. The brazing filler metal shall be analyzed for those 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.

Table 2[a, b]
Chemical Composition Requirements for Gold Filler Metals

		Composition, Weight Percent				
AWS Classification	UNS Number[c]	Au	Cu	Pd	Ni	Other Element, Total[d]
BAu-1	P00375	37.0–38.0	Remainder	—	—	0.15
BAu-2	P00800	79.5–80.5	Remainder	—	—	0.15
BAu-3	P00350	34.5–35.5	Remainder	—	2.5–3.5	0.15
BAu-4	P00820	81.5–82.5	—	—	Remainder	0.15
BAu-5	P00300	29.5–30.5	—	33.5–34.5	35.5–36.5	0.15
BAu-6	P00700	69.5–70.5	—	7.5–8.5	21.5–22.5	0.15

Notes:
a. See Table A2 for discontinued brazing filler metal classifications.
b. See Table 6 for the following Au classifications not included here: BVAu-2, BVAu-3, BVAu-4, BVAu-7, BVAu-8, BVAu-9, and BVAu-10.
c. ASTM DS-56, *Metals and Alloys in the Unified Numbering System.*
d. The brazing filler metal shall be analyzed for those 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.

9. Chemical Analysis

9.1 Brazing filler metals and the filler metal portion of the clad product shall conform to the chemical composition requirements of Tables 1 through 6 for the specific filler metal being tested.

9.2 The sample shall be analyzed by accepted analytical methods.

9.3 In case of dispute, the referee methods for all elements shall be the appropriate analytical method in (1) *Analytical Chemistry for Metals, Ores, and Related Materials (I): C 571–E 354,* in the *Annual Book of ASTM Standards, Analytical Chemistry of Metals, Ores, and Related Materials*; (2) *Analytical Chemistry for Metals, Ores, and Related Materials (II): E 356 to last; Molecular Spectroscopy; Surface Analysis,* in the *Annual Book of ASTM Standards, Analytical Chemistry of Metals, Ores, and Related Materials*; or (3) as shown in Annex B.

10. Sieve Analysis

10.1 Sieve analyses for powdered brazing filler metals shall be performed in accordance with ASTM B 214, *Standard Method for Sieve Analysis of Granular Metal Powders.*

10.2 The results of the sieve analysis shall conform to the particle size distribution shown in Table 7. Sizes other than the standard sizes shall be as agreed between the purchaser and the supplier.

11. Melt Cleanliness Test

11.1 The melt cleanliness test shall be required for all BV class filler metals produced for use in vacuum service applications only. The melt cleanliness test shall be performed on a sample of approximately 0.015 troy ounce (0.001 pound (lb)) [0.5 grams (g)] of filler metal. Clean, dry tools shall be used to extract the sample from the stock, and the sample shall be placed in a clean, dense polycrystalline (99.6%) alumina crucible. As an alternative, a fused silica crucible or boat that has been precleaned by air firing at a temperature of at least 2000°F [1100°C] and stored in a dust-free container may be used.

11.2 The container with the sample shall be placed in a combustion tube muffle made of dense polycrystalline alumina, fused silica, or the equivalent. The muffle shall be purged with dry hydrogen (–40°F [–40°C] dew point or lower), and the sample shall be heated to a minimum of 36°F [20°C] above the liquidus temperature established for the material (see Table A1). It shall be held at that

Table 3[a]
Chemical Composition Requirements for Aluminum and Magnesium Filler Metals

AWS Classification	UNS Number[c]	Chemical Composition, Weight Percent[b]												Other Elements[d]	
		Si	Cu	Mg	Bi	Fe	Zn	Mn	Cr	Ni	Ti	Be	Al	Each	Total
BAlSi-2	A94343	6.8–8.2	0.25	—	—	0.8	0.20	0.10	—	—	—	—	Remainder	0.05	0.15
BAlSi-3	A94145	9.3–10.7	3.3–4.7	0.15	—	0.8	0.20	0.15	0.15	—	—	—	Remainder	0.05	0.15
BAlSi-4	A94047	11.0–13.0	0.30	0.10	—	0.8	0.20	0.15	—	—	—	—	Remainder	0.05	0.15
BAlSi-5	A94045	9.0–11.0	0.30	0.05	—	0.8	0.10	0.05	—	—	0.20	—	Remainder	0.05	0.15
BAlSi-7	A94004	9.0–10.5	0.25	1.0–2.0	—	0.8	0.20	0.10	—	—	—	—	Remainder	0.05	0.15
BAlSi-9	A94147	11.0–13.0	0.25	0.10–0.50	—	0.8	0.20	0.10	—	—	—	—	Remainder	0.05	0.15
BAlSi-11	A94104	9.0–10.5	0.25	1.0–2.0	0.02–0.20	0.8	0.20	0.10	—	—	—	—	Remainder	0.05	0.15
BMg-1	M19001	0.05	0.05	Remainder	—	0.005	1.7–2.3	0.15–1.5	—	0.005	—	0.0002–0.0008	8.3–9.7	—	0.30

Notes:
a. See Table A2 for discontinued brazing filler metal classifications.
b. Single values are maximum unless noted.
c. ASTM DS-56, *Metals and Alloys in the Unified Numbering System.*
d. The brazing filler metal shall be analyzed for those 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.

Table 4
Chemical Composition Requirements for Copper, Copper-Zinc, and Copper-Phosphorus Filler Metals[a, b]

AWS Classification	UNS Number[d]	Composition, Weight Percent[c]											
		Cu	Ag	Zn	Sn	Fe	Mn	Ni	P	Pb	Al	Si	Other Elements Total[e]
BCu-1	C14180	99.90 min.	—	—	—	—	—	—	0.075	0.02	0.01*	—	0.10[h]
BCu-1a	—	99.00 min.[f]	—	—	—	—	—	—	—	—	—	—	0.30
BCu-1b	C11000	99.90 min.	—	—	—	—	—	—	—	—	—	—	0.10
BCu-2[g]	—	86.50 min.[f]	—	—	—	—	—	—	—	—	—	—	0.50
BCu-3[k]	C10200	99.95 min.	—	—	—	—	—	—	—	—	—	—	0.05
RBCuZn-A	C47000	57.0–61.0[i]	—	Remainder	0.25–1.00	*	*	—	—	0.05*	0.01*	*	0.50[h]
RBCuZn-B	C68000	56.0–60.0[i]	—	Remainder	0.80–1.10	0.25–1.20	0.01–0.50	0.20–0.80[j]	—	0.05*	0.01*	0.04–0.20	0.50[h]
RBCuZn-C	C68100	56.0–60.0[i]	—	Remainder	0.80–1.10	0.25–1.20	0.01–0.50	—	—	0.05*	0.01*	0.04–0.15	0.50[h]
RBCuZn-D	C77300	46.0–50.0[i]	—	Remainder	—	—	—	9.0–11.0[j]	0.25	0.05*	0.01*	0.04–0.25	0.50[h]
BCuP-2	C55181	Remainder	—	—	—	—	—	—	7.0–7.5	—	—	—	0.15
BCuP-3	C55281	Remainder	4.8–5.2	—	—	—	—	—	5.8–6.2	—	—	—	0.15
BCuP-4	C55283	Remainder	5.8–6.2	—	—	—	—	—	7.0–7.5	—	—	—	0.15
BCuP-5	C55284	Remainder	14.5–15.5	—	—	—	—	—	4.8–5.2	—	—	—	0.15
BCuP-6	C55280	Remainder	1.8–2.2	—	—	—	—	—	6.8–7.2	—	—	—	0.15
BCuP-7	C55282	Remainder	4.8–5.2	—	—	—	—	—	6.5–7.0	—	—	—	0.15
BCuP-8	C55285	Remainder	17.2–18.0	—	—	—	—	—	6.0–6.7	—	—	—	0.15
BCuP-9	C55385	Remainder	—	—	6.0–7.0	—	—	—	6.0–7.0	—	—	0.01–0.4	0.15

Notes:
a. See Table A2 for discontinued brazing filler metal classifications.
b. See Table 6 for the following Cu classification not included here: BVCu-1x.
c. Single values are maximum unless noted.
d. ASTM DS-56, *Metals and Alloys in the Unified Numbering System.*
e. The filler metal shall be analyzed for those specific elements for which values or asterisks (*) 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 in "Other Elements, Total."
f. The balance is oxygen, which is present as cuprous oxide. Oxygen is not to be included in "Other Elements."
g. These chemical composition requirements pertain only to the cuprous oxide powder and do not include requirements for the organic vehicle in which the cuprous oxide is suspended, when supplied in paste form.
h. The total of all other elements, including those for which a maximum value or an asterisk (*) is shown, shall not exceed the value specified in "Other Elements, Total."
i. Includes residual silver.
j. Includes residual cobalt.
k. The maximum allowable percentage of oxygen for this alloy is 0.001%.

Table 5[a]
Chemical Composition Requirements for Nickel and Cobalt Filler Metals

AWS Classification	UNS Number[c]	Composition, Weight Percent[b]																		
		Ni	Cr	B	Si	Fe	C	P	S	Al	Ti	Mn	Cu	Zr	W	Co	Mo	Nb	Se	Other Elements, Total[d]
BNi-1	N99600	Rem.	13.0–15.0	2.75–3.50	4.0–5.0	4.0–5.0	0.60–0.90	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-1a	N99610	Rem.	13.0–15.0	2.75–3.50	4.0–5.0	4.0–5.0	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-2	N99620	Rem.	6.0–8.0	2.75–3.50	4.0–5.0	2.5–3.5	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-3	N99630	Rem.	—	2.75–3.50	4.0–5.0	0.5	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-4	N99640	Rem.	—	1.50–2.20	3.0–4.0	1.5	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-5	N99650	Rem.	18.5–19.5	0.03	9.75–10.50	—	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-5a	N99651	Rem.	18.5–19.5	1.0–1.5	7.0–7.5	0.5	0.10	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-5b	N99652	Rem.	14.5–15.5	1.1–1.6	7.0–7.5	1.0	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	1.0	—	—	0.005	0.50
BNi-6	N99700	Rem.	—	—	—	—	0.06	10.0–12.0	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-7	N99710	Rem.	13.0–15.0	0.02	0.10	0.2	0.06	9.7–10.5	0.02	0.05	0.05	0.04	—	0.05	—	0.10	—	—	0.005	0.50
BNi-8	N99800	Rem.	—	—	6.0–8.0	—	0.06	0.02	0.02	0.05	0.05	21.5–24.5	4.0–5.0	0.05	—	0.10	—	—	0.005	0.50
BNi-9	N99612	Rem.	13.5–16.5	3.25–4.00	—	1.5	0.06	0.02	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-10	N99622	Rem.	10.0–13.0	2.0–3.0	3.0–4.0	2.5–4.5	0.40–0.55	0.02	0.02	0.05	0.05	—	—	0.05	15.0–17.0	0.10	—	—	0.005	0.50
BNi-11	N99624	Rem.	9.00–11.75	2.2–3.1	3.35–4.25	2.5–4.0	0.30–0.50	0.02	0.02	0.05	0.05	—	—	0.05	11.00–12.75	0.10	—	—	0.005	0.50
BNi-12	N99720	Rem.	24.0–26.0	0.02	0.1	0.2	0.06	9.0–11.0	0.02	0.05	0.05	—	—	0.05	—	0.10	—	—	0.005	0.50
BNi-13	N99810	Rem.	7.0–9.0	2.75–3.50	3.8–4.8	0.4	0.06	0.02	0.02	0.05	0.05	—	2.0–3.0	0.05	—	0.10	1.5–2.5	1.5–2.5	0.005	0.50
BCo-1	R39001	16.0–18.0	18.0–20.0	0.70–0.90	7.5–8.5	1.0	0.35–0.45	0.02	0.02	0.05	0.05	—	—	0.05	3.5–4.5	Rem.	—	—	0.005	0.50

Notes:
a. See Table A2 for discontinued brazing filler metal classifications.
b. Single values are maximum.
c. ASTM DS-56, *Metals and Alloys in the Unified Numbering System.*
d. The filler metal shall be analyzed for those 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.

Table 6
Chemical Composition Requirements for Filler Metals for Vacuum Service

AWS Classification	UNS Number[c]	Chemical Composition, Weight Percent[a, b]												
		Ag	Au	Cu	Ni	Co	Sn	Pd	In	Zn	Cd	Pb	P	C
Grade 1														
BVAg-0	P07017	99.95 min.	—	0.05	—	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAg-6b	P07507	49.0–51.0	—	Remainder	—	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAg-8	P07727	71.0–73.0	—	Remainder	—	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAg-8b	P07728	70.5–72.5	—	Remainder	0.3–0.7	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAg-18	P07607	59.0–61.0	—	Remainder	—	—	9.5–10.5	—	—	0.001	0.001	0.002	0.002	0.005
BVAg-29	P07627	60.5–62.5	—	Remainder	—	—	—	—	14.0–15.0	0.001	0.001	0.002	0.002	0.005
BVAg-30	P07687	67.0–69.0	—	Remainder	—	—	—	4.5–5.5	—	0.001	0.001	0.002	0.002	0.005
BVAg-31	P07587	57.0–59.0	—	31.0–33.0	—	—	—	Remainder	—	0.001	0.001	0.002	0.002	0.005
BVAg-32	P07547	53.0–55.0	—	20.0–22.0	—	—	—	Remainder	—	0.001	0.001	0.002	0.002	0.005
BVAu-2	P00807	—	79.5–80.5	Remainder		—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAu-3	P00351	—	34.5–35.5	Remainder	2.5–3.5	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAu-4	P00827	—	81.5–82.5	—	Remainder	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAu-7	P00507	—	49.5–50.5	—	24.5–25.5	0.06	—	Remainder	—	0.001	0.001	0.002	0.002	0.005
BVAu-8	P00927	—	91.0–93.0	—	—	—	—	Remainder	—	0.001	0.001	0.002	0.002	0.005
BVAu-9	P00354	—	34.5–35.5	Remainder	—	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVAu-10	P00503	—	49.5–50.5	Remainder	—	—	—	—	—	0.001	0.001	0.002	0.002	0.005
BVPd-1	P03657	—	—	—	0.06	Remainder	—	64.0–66.0	—	0.001	0.001	0.002	0.002	0.005
Grade 2														
BVAg-0	P07017	99.95 min.	—	0.05	—	—	—	—	—	0.002	0.002	0.002	0.002	0.005
BVAg-6b	P07507	49.0–51.0	—	Remainder	—	—	—	—	—	0.002	0.002	0.002	0.02	0.005
BVAg-8	P07727	71.0–73.0	—	Remainder	—	—	—	—	—	0.002	0.002	0.002	0.02	0.005
BVAg-8b	P07728	70.5–72.5	—	Remainder	0.3–0.7	—	—	—	—	0.002	0.002	0.002	0.02	0.005
BVAg-18	P07607	59.0–61.0	—	Remainder	—	—	9.5–10.5	—	—	0.002	0.002	0.002	0.02	0.005
BVAg-29	P07627	60.5–62.5	—	Remainder	—	—	—	—	14.0–15.0	0.002	0.002	0.002	0.02	0.005
BVAg-30	P07687	67.0–69.0	—	Remainder	—	—	—	4.5–5.5	—	0.002	0.002	0.002	0.002	0.005
BVAg-31	P07587	57.0–59.0	—	31.0–33.0	—	—	—	Remainder	—	0.002	0.002	0.002	0.002	0.005
BVAg-32	P07547	53.0–55.0	—	20.0–22.0	—	—	—	Remainder	—	0.002	0.002	0.002	0.002	0.005
BVAu-2	P00807	—	79.5–80.5	Remainder	—	—	—	—	—	0.002	0.002	0.002	0.002	0.005
BVAu-3	P00351	—	34.5–35.5	Remainder	2.5–3.5	—	—	—	—	0.002	0.002	0.002	0.002	0.005
BVAu-4	P00827	—	81.5–82.5	—	Remainder	—	—	—	—	0.002	0.002	0.002	0.002	0.005
BVAu-7	P99507	—	49.5–50.5	—	24.5–25.5	0.06	—	Remainder	—	0.002	0.002	0.002	0.002	0.005
BVAu-8	P00927	—	91.0–93.0	—	—	—	—	Remainder	—	0.002	0.002	0.002	0.002	0.005
BVAu-9	P00354	—	34.5–35.5	Remainder	—	—	—	—	—	0.002	0.002	0.002	0.002	0.005
BVAu-10	P00503	—	49.5–50.5	Remainder	—	—	—	—	—	0.002	0.002	0.002	0.002	0.005
BVPd-1	P03657	—	—	—	0.06	Remainder	—	64.0–66.0	—	0.002	0.002	0.002	0.002	0.005
BVCu-1x	C14181	—	—	99.99 min.	—	—	—	—	—	0.002	0.002	0.002	0.002	—

Notes:

a. The filler metal shall be analyzed for those 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. Elements detected that have a vapor pressure higher than 10^{-7} torr [1.3×10^{-5} Pa] at 932°F [500°C] are limited to 0.001% each for Grade1 filler metals and 0.002% each for Grade 2 filler metals. The total of all high vapor pressure elements (including zinc, cadmium, and lead) is limited to 0.010%. The total of all other impurity elements is 0.01% maximum for Grade 1 and 0.05% maximum for Grade 2.

b. Single values are maximum unless noted.

c. ASTM DS-56, *Metals and Alloys in the Unified Numbering System.*

Table 7
Powder Mesh Designations and Particle Size Distribution[a]

Powder Mesh[b] Designation		Particle Size Distribution		
		Sieve Size		Distribution
U.S. Number	µm	U.S. Number	µm	%
100 mesh	150	Through 60 Through 100	Through 250 Through 150	100 95 min.
140 C[c] mesh	106 C	On 100 On 140 Through 325	On 150 On 106 Through 45	0.5 max. 10 max. 20 max.
140 F[d] mesh	106 F	On 100 On 140 Through 325	On 150 On 106 Through 45	0.5 max. 10 max. 55 max.
325 mesh	45	On 200 On 325 Through 325	On 75 On 45 Through 45	0.5 max. 10 max. 90 min.

Notes:
a. All of the above sieve sizes are standard ASTM sizes selected from Table 1 of ASTM E 11-01, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*.
b. 140 F (106 µm F) mesh shall be supplied unless otherwise specified by the customer.
c. C = Coarse.
d. F = Fine.

temperature for ten minutes and then allowed to cool in the muffle to a temperature no higher than 150°F [65°C]. At that time, the flow of hydrogen shall be stopped, and the sample shall be removed for examination.

11.3 The fused sample shall be examined at a magnification of 5X. If it has melted completely and has no more than a light smokiness on the surface and no discrete black specks, it meets the requirements of the cleanliness test.

12. Spatter Test

The spatter test shall be required for all BV class filler metals produced for use in vacuum service applications only. Filler metal in the form of powder is exempt from the spatter test due to its high ratio of surface area to volume and the oxides usually present on these surfaces.

12.1 The spatter test shall be performed at the same time as the melt cleanliness test by bridging the crucible or boat with a nickel channel, the legs of which are designed to allow a small clearance, 0.06 inch (in) [1.5 millimeter (mm)] maximum, above the crucible. The bridge shall be no more than 0.38 in [9.6 mm] above the filler metal.

12.2 Upon completion of the test, the bottom side of the nickel channel shall be examined at a 5X magnification for evidence of any spatter. If no evidence of spatter exists, the sample meets the requirements.

13. Binder Content of the Transfer Tape

13.1 The binder content of the transfer tape shall be determined by the following method:

13.1.1 A strip of Type 304 stainless steel approximately 0.031 in × 0.5 in × 2 in [0.8 mm × 13 mm × 50 mm] shall be weighed, and the weight shall be recorded as “Weight A.”

13.1.2 The transfer tape shall be shaped to the dimensions of the stainless steel strip and applied to the strip. The plastic carrier shall be removed, and the composite shall be weighed. This weight shall be recorded as “Weight B.”

13.1.3 The composite strip and transfer tape shall be heated in a protective atmosphere furnace (including vacuum) to a temperature above 1000°F [538°C], then cooled in the protective atmosphere, and reweighed. This weight shall be recorded as "Weight C."

13.1.4 The percentage of binder shall be calculated as follows:

Percentage of binder =

$$\frac{\text{Weight B} - \text{Weight C}}{\text{Weight B} - \text{Weight A}} \times 100 \quad (1)$$

13.2 To meet the requirements, the binder content of transfer tape shall be 6.0% maximum, except when otherwise agreed by the purchaser and the supplier.

Part C
Manufacture, Identification, and Packaging

14. Method of Manufacture

The brazing filler metals classified according to this specification may be manufactured by any method that will produce filler metals that meet the requirements of this specification.

15. Standard Forms, Sizes, and Tolerances

15.1 Standard forms and sizes of brazing filler metals shall be as shown in Table 8.

15.2 Dimensional tolerances of wrought wire, rod, sheet, and strip shall be in accordance with Tables 9 and 10, as applicable.

15.3 Size and tolerances of cast rod, transfer tape, bonded sheet and bonded rope shall be as agreed upon between the purchaser and supplier.

16. Filler Metal Identification

16.1 Filler metal identification is to be accomplished by tags, labels, or appropriate marking on the unit package. Unit packages include coils, spools, bundles, mandrels, and containers. Specific marking requirements are contained in Section 18.

16.2 When required by the purchase order or contract, special identification of individual pieces of filler metals shall be provided in addition to the identification of the unit package. When so prescribed, the use of pressure-sensitive labels or imprint marking shall become a requirement for conformance to this specification.

17. Packaging

Brazing filler metals shall be suitably packaged to ensure against damage during shipment or storage under normal conditions.

18. Marking of Packages

18.1 The following product information (as a minimum) shall be legibly marked on the outside of each unit package:

(1) AWS specification and classification designations (year of issue may be excluded);

(2) Supplier's name and trade designation;

(3) Size and net weight;

(4) Lot, control, or heat number; and

(5) Date of manufacture for tape and paste.

18.2 Marking of any overpacking of unit packages only requires conformance with regulations of DOT or other shipping agencies. Items listed in 18.1 are not required in any overpacking.

18.3 The appropriate precautionary information[8] as given in ANSI Z49.1, *Safety in Welding, Cutting, and Allied Practices,* (as a minimum) or its equivalent shall be prominently displayed in legible print on all packages of brazing filler metal, including individual unit packages enclosed within a larger package.

18.4 In addition to the precautionary information required in 18.3, all packages (including individual unit packages enclosed within a larger package and special containers such as spools and mandrels) of filler metals BAg-1, BAg-1a, BAg-2, BAg-2a, BAg-3, BAg-27, and BAg-33 shall have the appropriate precautionary information for cadmium as given in ANSI Z49.1 or its equivalent permanently affixed and prominently displayed in legible print.

8. Typical examples of "warning labels" from ANSI Z49.1:1999 are shown in Figure A1 and Figure A2 for some common or specific consumables used with certain processes.

Table 8
Standard Forms and Sizes of Filler Metals[a]

AWS Classification	Standard Form	Standard Sizes: Dimensions Specified	Standard Sizes: Width, Length, or Mesh Size	Thickness or Diameter: in	Thickness or Diameter: mm
BAg All classifications	Strip[b] (coiled or spooled)	Width and thickness	0.25 in to 6.0 in in multiples of 0.25 in or 6 mm to 150 mm in multiples of 1 mm	0.002 0.003 0.005 0.010 0.020	0.05 0.08 0.10 0.13 0.15 0.20 0.25 0.50
	Round wire (coiled or spooled); rod (straight lengths)	Diameter for wire and rod	—	1/32 (0.031) 3/64 (0.047) 1/16 (0.062) 3/32 (0.094) 1/8 (0.125)	0.8 1.0 1.2 1.5 1.6 2.0 2.4 2.5 3.0 3.2
		Length for rod	18 in and 36 in or 450 mm and 900 mm		
	Powder and paste	Mesh size (See Table 7)	100 [150 µm] 140 C [106 µm coarse] 140 F [106 µm fine] 325 [45 µm]		
BVAg All classifications	Strip, wire (coiled or spooled), and powder	Dimensions shall be agreed upon by purchaser and supplier			
BAu, BVAu, BVPd, BCu All classifications	Strip, wire (coiled or spooled), and powder	Dimensions shall be agreed upon by purchaser and supplier			
BAlSi, BMg All classifications	Sheet (coiled)[c]	Thickness		0.010 0.015 0.020	0.25 0.38 0.50
BAlSi-3 BAlSi-4 BMg-1	Wire (coiled) or rod (straight lengths)	Length and diameter for rod	36 in or 900 mm	1/16 (0.062) 3/32 (0.094) 1/8 (0.125) 5/32 (0.156) 3/16 (0.188)	1.6 2.4 3.2 4.0 4.8
BAlSi-4	Powder and paste	Mesh size (See Table 7)	100 [150 µm]		
BCuP-5	Strip (coiled or spooled)	Width and thickness	0.25 in to 6.0 in in multiples of 0.25 in	0.003 0.005 0.010 0.025	0.08 0.13 0.25 0.6

(Continued)

Table 8 (Continued)

AWS Classification	Standard Form	Dimensions Specified	Standard Sizes: Width, Length, or Mesh Size	Thickness or Diameter: in	Thickness or Diameter: mm
BCuP All classifications	Round wire (coiled or spooled)	Diameter	—		
	Round rod (straight lengths)	Length and diameter	18 in and 36 in or 450 mm and 900 mm		
	Rectangular wire (coils or spools)	Width and thicknesses	1/16 in to 1/4 in width in multiples of 1/32 in or 1.6 mm to 6.4 mm width in multiples of 0.8 mm	0.050 0.062 0.094	1.3 1.6 2.0 2.4
	Rectangular rod (straight lengths)	Width, length, and thickness	1/16 in, 3/32 in, and 18 in width or 1.6 mm, 2.4 mm, and 3.2 mm 18 in and 36 in lengths or 450 mm and 900 mm lengths	0.109 0.125 0.250	2.8 3.2 4.0 6.4
	Powder and paste	Mesh size (See Table 7)	100 mesh [150 µm] 140 C mesh [106 µm coarse] 140 F mesh [106 µm fine] 325 mesh [45 µm]		
BCu-1, BCu-1b, BCu-3 RBCuZn-A	Strip (coiled or spooled	Dimensions shall be agreed upon by purchaser and supplier			
BCu-1, BCu-1b, BCu-3 RBCuZn-A RBCuZn-B RBCuZn-C RBCuZn-D	Round wire (coiled)	Diameter		1/32 (0.031) 1/16 (0.062) 3/32 (0.094) 1/8 (0.125) 5/32 (0.156) 3/16 (0.188) 1/4 (0.250) 5/16 (0.312) 3/8 (0.375)	0.8 1.6 2.4 3.2 4.0 4.8 6.4 8.0 9.5
	Rod (straight lengths)	Length and diameter	18 in and 36 in or 450 mm and 900 mm		
BCu-1a BCu-2	Powder and paste	Mesh size (See Table 7)	140 C mesh [106 µm coarse] 140 F mesh [106 µm fine] 325 mesh [45 µm]		
BVCu-1x	Strip, round wire (coils or spools)	Dimensions shall be agreed upon by purchaser and supplier			

(Continued)

Table 8 (Continued)

AWS Classification	Standard Form	Standard Sizes: Dimensions Specified	Standard Sizes: Width, Length, or Mesh Size	Thickness or Diameter: in	Thickness or Diameter: mm
BNi: All classifications except BNi-5a and BNi-5b; BCo-1	Cast round rod (straight lengths)[d] foil	Diameter	—	1/16 (0.062) 1/8 (0.125)	1.6 3.2
	Cast and wrought (borided) foil	Width and thickness	1/8 in to 4.0 in or 3.2 mm to 100 mm	0.001 0.0015[e] 0.002 0.0025	0.025 0.037 0.05 0.06
	Bonded Powder rope, sheet, and transfer tape[f]	Dimensions shall be agreed upon by purchaser and supplier			
	Powder and paste	Mesh size (See Table 7)	140 C mesh [106 µm coarse] 140 F mesh [106 µm fine] 325 mesh [45 µm]		
BNi-5a	Foil		1/8 in to 4.0 in or 3.2 mm to 100 mm	0.001 0.0015 0.002 0.0025	0.025 0.037 0.05 0.06
BNi-5b	Foil		1/8 in to 8.0 in or 3.2 mm to 200 mm	0.001 0.0015 0.002 0.0025	0.025 0.037 0.05 0.06

Notes:
a. Dimensions, sizes, and package forms other than those shown shall be as agreed between purchaser and supplier.
b. BAg-2, BAg-3, BAg-4 BAg-22, BAg-24, and BAg-26 as filler metal clad or bonded to each side of a copper core is also a standard form. The standard thickness ratios of filler metal to copper core to filler metal cladding are 1:2:1 or 1:4:1.
c. BAlSi-2, BAlSi-5, BAlSi-7, BAlSi-9, and BAlSi-11 filler metal clad or bonded to one or both sides of an aluminum alloy is also a standard form. The standard thickness of the filler metal cladding is 5% to 10% of the thickness of the aluminum alloy core.
d. Tolerances listen in Table 9 do not apply for cast rod forms.
e. Available in widths up to 2 in [20 mm].
f. Tolerances listed in Table 10 do not apply for these bonded powder forms.

Table 9
Tolerances for Wrought Wire and Rod[a, b]

				Tolerances, ±					
						Rectangular			
		Nominal Size[c]		Round		Thickness		Width	
Form	Condition	in	mm	in	mm	in	mm	in	mm
Wire	Cold-drawn or cold-rolled	0.010–0.020	0.25–0.51	0.0003	0.008	0.0008	0.02	0.005	0.13
		Over 0.020–0.030	Over 0.51–0.8	0.0005	0.013	0.0016	0.04	0.005	0.13
		Over 0.030–0.040	Over 0.8–1.0	0.0007	0.018	0.0018	0.045	0.005	0.13
		Over 0.040–0.050	Over 1.0–1.3	0.0008	0.020	0.0020	0.05	0.005	0.13
		Over 0.050–0.060	Over 1.3–1.5	0.0010	0.025	0.0025	0.064	0.005	0.13
		Over 0.060–0.080	Over 1.5–2.0	0.0015	0.038	0.003	0.08	0.005	0.13
		Over 0.080–0.250	Over 2.0–6.4	0.0020	0.051	0.004	0.10	0.005	0.13
Rod	Cold-drawn or cold-rolled	5/32 and under	4.0 and under	0.003	0.08	0.009	0.23	0.010	0.25
		3/16 and over	4.8 and over	0.004	0.10	0.010	0.25	0.010	0.25
Rod and wire	Hot-rolled or extruded	3/64–1/16	1.2–1.6	0.005	0.13	0.008	0.20	0.010	0.25
		Over 1/16–1/8	Over 1.6–3.2	0.006	0.15	0.009	0.23	0.010	0.25
		Over 1/8–3/16	Over 3.2–4.8	0.007	0.18	0.009	0.23	0.010	0.25
		Over 3/16–1/4	Over 4.8–6.4	0.008	0.20	0.010	0.25	0.010	0.25

Notes:
a. Tolerances for cast rod shall be as agreed upon by the purchaser and the supplier.
b. Length tolerance shall be ± 1/2 in [± 12 mm] for rod.
c. Diameter for round; thickness or width for rectangular.

Table 10
Tolerances for Foil Strip and Sheet[a]

		Thickness Tolerance, ±			
Nominal Thickness		Width 8 in [200 mm] and Under		Width over 8 in [200 mm]	
in	mm	in	mm	in	mm
0.006 and under	0.15 and under	0.0006	0.015	0.0008	0.020
Over 0.006–0.013 incl.	Over 0.15–0.33 incl.	0.0010	0.025	0.0010	0.025
Over 0.013–0.021 incl.	Over 0.33–0.53 incl.	0.0015	0.038	0.0015	0.038
Over 0.021–0.026 incl.	Over 0.53–0.66 incl.	0.0020	0.05	0.0020	0.051

		Width Tolerance, ±			
Nominal Width		Thickness of 0.062 in [1.59 mm] and Under		Thickness of 0.063 in [1.6 mm] to 0.125 in [3.18 mm] incl.	
in	mm	in	mm	in	mm
0.062–1.0	1.6 to 25 incl.	0.005	0.13	0.007	0.18
Over 1.0–2.0 incl.	Over 25–50 incl.	0.005	0.13	0.009	0.23
Over 2.0–6.0 incl.	Over 50–150 incl.	0.005	0.13	0.012	0.30
Over 6.0–15.0 incl.	Over 150–380 incl.	0.007	0.18	0.017	0.43
Over 15.0	Over 380–500 incl.	0.007	0.18	0.017	0.43

Note:
a. Length tolerance shall be 60% of as-ordered length and 10% of pieces in the order may be shorts.

Nonmandatory Annexes

Annex A

Guide to AWS A5.8/A5.8M:2004, Specification for Filler Metals for Brazing and Braze Welding

(This Annex is not a part of AWS A5.8/A5.8M:2003, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.)

A1. Introduction

A1.1 The purpose of this guide is to correlate the brazing filler metal classifications with their intended applications so the specification can be used effectively. The AWS *Brazing Handbook* should be consulted for detailed information. If the component has critical applications, AWS C3.3, *Recommended Practices for the Design, Manufacture, and Inspection of Critical Brazed Components*, should be followed.

A1.2 This specification is intended to provide both the supplier and the user of brazing filler metals with a guide for production control and a basis of acceptance through mutually acceptable standard requirements. This specification classifies only those filler metals that were commercially significant at the time it was issued. As other brazing filler metals become commercially significant, they may be added to the specification. Those that lose their commercial significance may be discontinued.

A1.3 Brazing is a group of joining processes that produces the coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having a liquidus above 840°F [450°C] and below the solidus of the base metal. The filler metal is distributed into or held in the closely fitted faying surfaces of the joint by capillary action.

A2. Method of Classification

A2.1 The classification of brazing filler metals is based on chemical composition rather than on mechanical property requirements. The mechanical properties of a brazed joint depend, among other things, on the base metal, the filler metal, and the brazing conditions. Therefore, a classification method based on mechanical properties would be misleading since it would only apply if the brazing filler metal were used on a given base metal using specific brazing conditions. If the user of a brazing filler metal desires to determine the mechanical properties of a given base metal and filler metal combination, tests should be conducted using the latest edition of AWS C3.2/C3.2M, *Standard Method for Evaluating the Strength of Brazed Joints*.

A2.2 Brazing filler metals are standardized into seven classifications as follows: silver, gold, aluminum, copper, nickel, cobalt, and magnesium filler metals. Many filler metals in these classifications are used for joining assemblies for vacuum service applications, such as vacuum tubes and other electronic devices. For these critical applications, it is desirable to hold the high vapor pressure elements to a minimum, as they usually contaminate the vacuum with vaporized elements during the operation of the device. Filler metals for electronic devices have been incorporated as additional "vacuum grade" classifications within this specification.

A2.3 The basic classifications of brazing filler metal are identified by the principal element in their chemical composition, as shown in Tables 1 through 6 (see also Table A1). For example, in the designation BCuP-2, the "B" denotes *brazing filler metal* (as the "E" denotes *electrodes* and the "R" denotes *welding rods* in other AWS specifications). The "RB" in RBCuZn-A, RBCuZn-B, RBCuZn-C, and RBCuZn-D indicates that the filler metal is suitable as a braze welding rod and as a brazing filler metal. The term "CuP" denotes *copper-phosphorus*, the two principal elements in this particular brazing filler metal (similarly, in other brazing filler metals, "Si" denotes *silicon*, “Ag” denotes *silver*, and so forth, using standard chemical symbols). The designation following the chemical symbol indicates the chemical composition within a group.

The nomenclature for the vacuum-grade filler metals follows the examples above, with two exceptions. The first exception is the addition of the letter “V,” yielding the generic letters “BV,” denoting brazing filler metals for vacuum service. The second exception is the use of the grade suffix number; Grade 1 is used to indicate the more stringent requirements for high vapor pressure impurities, and Grade 2 is used to indicate less stringent requirements for high vapor pressure impurities. Vacuum-grade filler metals are considered to be spatter free. Therefore, this specification no longer lists spatter-free and nonspatter-free vacuum grades. An example of a filler metal for vacuum service is BVAg-6b, Grade 1. Table 6 lists filler metals for vacuum service.

A2.4 Request for Filler Metal Classification. When a brazing filler metal cannot be classified according to a classification given in this specification, the manufacturer may request that a classification be established for that brazing filler metal. The manufacturer can do this using the following the procedure:

(1) A request to establish a new brazing filler metal classification must be a written request and it needs to provide sufficient detail to permit the 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.

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 the brazing conditions are the same as for other classifications);

(c) Information on descriptions and intended use paralleling that for existing classifications for incorporation in the Annex; and

(d) Proposed ASME “F” Number, if appropriate. 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.

A request for a new classification that fails to include the above information will be considered incomplete. The Secretary will return the request to the requestor for further information.

(2) The request should be sent to the Secretary of the 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 Committee on Filler Metals and Allied Materials and the Chair of the particular Subcommittee involved;

(d) File the original request; and

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

(3) 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 that remain 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 Committee on Filler metals and Allied Materials for action.

(4) 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 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 brazing filler metals classified under this specification is in accordance with AWS A5.01, *Filler Metal Procurement Guidelines*, as this specification states. Any sampling and testing a purchaser requires of the supplier for filler metal shipped in accordance with this specification should be clearly stated in the purchase order, according to the provisions of AWS A5.01.

In the absence of any such statement in the purchase order, the supplier may ship the filler metal with whatever testing the supplier normally conducts on filler metal of that classification, as specified in Schedule F, Table 1, of AWS A5.01, *Filler Metal Procurement Guidelines.* Testing in accordance with any other schedule in Table 1 should be specifically required by the purchase order. In such cases, the acceptance of the filler metal shipped should 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 or the 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 has met the requirements of this specification. Representative material, in this case, is any production run of that classification from 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 conducted. The basis for the certification required by the specification is the classification test of "representative material" cited above, and the "Manufacturer's Quality Assurance Program" in AWS A5.01, *Filler Metal Procurement Guidelines*.

A5. Ventilation during Brazing

A5.1 Five major factors govern the quantity of fumes to which brazers and brazing operators can be exposed during brazing. They are:

(1) Dimensions of the space in which brazing is performed (with special regard to the height of the ceiling);

(2) Number of brazers and brazing operators working in that space;

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

(4) The proximity of the brazer or brazing operators to the fumes as these fumes issue from the brazing zone and to the gases and dusts in the space in which they are working; and

(5) The ventilation provided to the space in which the brazing is performed.

A5.2 American National Standard ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes,* discusses the ventilation that is required during brazing and braze welding, and should be referred to for details. Particular attention should be paid to the section titled "Ventilation" in this document.

A6. Brazing Considerations

A6.1 To avoid confusion, solidus and liquidus are specified instead of melting and flow points. The terms *solidus* and *liquidus* are defined as follows:

solidus. The highest temperature at which a metal or alloy is completely solid.[9]

liquidus. The lowest temperature at which a metal or alloy is completely liquid.[10]

A6.2 Table A1 lists the nominal solidus, liquidus, and the recommended brazing temperature range for the various brazing filler metals. When brazing with some brazing filler metals (particularly those with a wide temperature range between solidus and liquidus), the several constituents of the filler metals tend to separate during the melting process. The lower melting constituent will flow, leaving behind an unmelted residue or skull of the high-melting constituent. This occurrence, termed *liquation*, is usually undesirable in that the unmelted skull does not readily flow into the joint. However, when wide joint clearance occurs, a filler metal with a wide temperature range will usually fill the capillary joint more easily.

A6.3 Brazing requires an understanding of several elements of procedures that are beyond the scope of this Annex. The *Brazing Handbook* should be referred to for particulars on such items as cleaning, brazing fluxes, brazing atmospheres, joint clearances, and so forth. Also, AWS C3.3, *Recommended Practices for the Design, Manufacture, and Inspection of Critical Brazed Components*, should be consulted for information on procedures for critical components.

A7. Brazing Characteristics and Applications

A7.1 BAg Classification (Silver). Brazing filler metals in the BAg classification are used to join most ferrous and nonferrous metals, except aluminum and magnesium. These filler metals have good brazing properties and are suitable for preplacement in the joint or for manual feeding into the joint. Although lap joints are generally used, butt joints may be used if requirements are less stringent. Joint clearances of 0.001 to 0.005 in [0.025 to 0.13 mm] are recommended for the proper capillary action. Flux is generally required on most metals.

When furnace brazing in a protective atmosphere, flux is generally not required. If filler metals containing

9. American Welding Society (AWS) A2 Committee on Definitions and Symbols, 2001, *Standard Welding Terms and Definitions,* AWS A3.0:2001, Miami, American Welding Society, p. 36.

10. American Welding Society (AWS) A2 Committee on Definitions and Symbols, 2001, *Standard Welding Terms and Definitions,* AWS A3.0:2001, Miami, American Welding Society, p. 23.

Table A1
Solidus, Liquidus, and Brazing Temperature Ranges*

AWS Classification	Solidus		Liquidus		Brazing Temperature Range	
	°F	°C	°F	°C	°F	°C
SILVER						
BAg-1	1125	607	1145	618	1145–1400	618–760
BAg-1a	1160	627	1175	635	1175–1400	635–760
BAg-2	1125	607	1295	702	1295–1550	702–843
BAg-2a	1125	607	1310	710	1310–1550	710–843
BAg-3	1170	632	1270	688	1270–1500	688–816
BAg-4	1240	671	1435	779	1435–1650	779–899
BAg-5	1225	663	1370	743	1370–1550	743–843
BAg-6	1270	688	1425	774	1425–1600	774–871
BAg-7	1145	618	1205	652	1205–1400	652–760
BAg-8	1435	779	1435	779	1435–1650	779–899
BAg-8a	1410	766	1410	766	1410–1600	766–871
BAg-9	1240	671	1325	718	1325–1550	718–843
BAg-10	1275	691	1360	738	1360–1550	738–843
BAg-13	1325	718	1575	857	1575–1775	857–968
BAg-13a	1420	771	1640	893	1600–1800	871–982
BAg-18	1115	602	1325	718	1325–1550	718–843
BAg-19	1400	760	1635	891	1610–1800	877–982
BAg-20	1250	677	1410	766	1410–1600	766–871
BAg-21	1275	691	1475	802	1475–1650	802–899
BAg-22	1260	680	1290	699	1290–1525	699–830
BAg-23	1760	960	1780	970	1780–1900	970–1038
BAg-24	1220	660	1305	707	1305–1550	707–843
BAg-26	1305	707	1475	800	1475–1600	800–870
BAg-27	1125	605	1375	745	1375–1575	745–860
BAg-28	1200	649	1310	710	1310–1550	710–843
BAg-33	1125	607	1260	682	1260–1400	681–760
BAg-34	1200	649	1330	721	1330–1550	721–843
BAg-35	1265	685	1390	754	1390–1545	754–841
BAg-36	1195	646	1251	677	1251–1495	677–813
BAg-37	1270	688	1435	779	1435–1625	779–885
BVAg-0	1761	961	1761	961	1761–1900	961–1038
BVAg-6b	1435	779	1602	872	1600–1800	871–982
BVAg-8	1435	779	1435	779	1435–1650	779–899
BVAg-8b	1435	779	1463	795	1470–1650	799–899
BVAg-18	1115	602	1325	718	1325–1550	718–843
BVAg-29	1155	624	1305	707	1305–1450	707–788
BVAg-30	1485	806	1490	809	1490–1650	809–899
BVAg-31	1515	824	1565	852	1565–1625	852–885
BVAg-32	1650	900	1740	950	1740–1800	950–982
GOLD						
BAu-1	1815	991	1860	1016	1860–2000	1016–1093
BAu-2	1635	891	1635	891	1635–1850	891–1010
BAu-3	1814	990	1850	1010	1850–1950	1010–1072
BAu-4	1740	949	1740	949	1740–1840	949–1004
BAu-5	2075	1135	2130	1166	2130–2250	1166–1232
BAu-6	1845	1007	1915	1046	1915–2050	1046–1121
BVAu-2	1635	891	1935	891	1635–1850	891–1010
BVAu-3	1814	990	1850	1010	1850–1950	1010–1072
BVAu-4	1740	949	1740	949	1740–1840	949–1004
BVAu-7	2015	1102	2050	1121	2050–2110	1121–1154
BVAu-8	2190	1200	2265	1240	2265–2325	1240–1274
BVAu-9	1814	990	1850	1010	1850–1940	1010–1060
BVAu-10	1751	955	1778	970	1778–1868	970–1020

(Continued)

Table A1 (Continued)

AWS Classification	Solidus		Liquidus		Brazing Temperature Range	
	°F	°C	°F	°C	°F	°C
			PALLADIUM			
BVPd-1	2245	1230	2255	1235	2255–2285	1235–1252
			ALUMINUM			
BAlSi-2	1070	577	1142	617	1110–1150	599–621
BAlSi-3	970	521	1085	585	1060–1120	571–604
BAlSi-4	1070	577	1080	582	1080–1120	582–604
BAlSi-5	1070	577	1110	599	1090–1120	588–604
BAlSi-7	1038	559	1105	596	1090–1120	588–604
BAlSi-9	1044	562	1080	582	1080–1120	582–604
BAlSi-11	1038	559	1105	596	1090–1120	588–604
			COPPER			
BCu-1	1981	1083	1981	1083	2000–2100	1093–1149
BCu-1a	1981	1083	1981	1083	2000–2100	1093–1149
BCu-1b	1981	1083	1981	1083	2000–2150	1093–1177
BVCu-1X	1981	1083	1981	1083	2000–2100	1093–1149
BCu-2	1981	1083	1981	1083	2000–2100	1093–1149
BCu-3	1981	1083	1981	1083	2000–2100	1093–1149
RBCuZn-A	1630	888	1650	899	1670–1750	910–954
RBCuZn-B	1590	866	1620	882	1620–1800	882–982
RBCuZn-C	1590	866	1630	888	1670–1750	910–954
RBCuZn-D	1690	921	1715	935	1720–1800	938–982
BCuP-2	1310	710	1460	793	1350–1550	732–843
BCuP-3	1190	643	1495	813	1325–1500	718–816
BCuP-4	1190	643	1325	718	1275–1450	691–788
BCuP-5	1190	643	1475	802	1300–1500	704–816
BCuP-6	1190	643	1450	788	1350–1500	732–816
BCuP-7	1190	643	1420	771	1300–1500	704–816
BCuP-8	1190	643	1230	666	1230–1270	664–686
BCuP-9	1178	637	1247	675	1190–1280	643–693
			NICKEL			
BNi-1	1790	977	1900	1038	1950–2200	1066–1204
BNi-1a	1790	977	1970	1077	1970–2200	1077–1204
BNi-2	1780	971	1830	999	1850–2150	1010–1177
BNi-3	1800	982	1900	1038	1850–2150	1010–1177
BNi-4	1800	982	1950	1066	1850–2150	1010–1177
BNi-5	1975	1079	2075	1135	2100–2200	1149–1204
BNi-5a	1931	1065	2111	1150	2100–2200	1149–1204
BNi-5b	1886	1030	2053	1126	2100–2200	1149–1204
BNi-6	1610	877	1610	877	1700–2000	927–1093
BNi-7	1630	888	1630	888	1700–2000	927–1093
BNi-8	1800	982	1850	1010	1850–2000	1010–1093
BNi-9	1930	1055	1930	1055	1950–2200	1066–1204
BNi-10	1780	970	2020	1105	2100–2200	1149–1204
BNi-11	1780	970	2003	1095	2100–2200	1149–1204
BNi-12	1620	880	1740	950	1800–2000	980–1095
BNi-13	1775	970	1980	1080	2000–2150	1095–1175
			COBALT			
BCo-1	2050	1120	2100	1149	2100–2250	1149–1232
			MAGNESIUM			
BMg-1	830	443	1110	599	1120–1160	604–627

*The solidus and liquidus shown are for the nominal composition in each classification.

zinc or cadmium are used in a protective atmosphere furnace, the zinc or cadmium is vaporized, changing the chemical composition as well as the solidus and liquidus. Therefore, cadmium- and zinc-free filler metals are recommended for furnace brazing in a protective atmosphere. Filler metals containing cadmium and/or zinc should not be used in a vacuum furnace.

Filler metals conforming to BAg-1, BAg-1a, BAg-2, BAg-2a, BAg-3, BAg-27, and BAg-33 contain cadmium. The special precautions in Figure A2 shall be followed. The balance of the BAg classifications are cadmium free.[11]

A7.1.1 Brazing filler metal BAg-1 has the lowest brazing temperature range of the BAg filler metals. It also flows most freely into narrow clearance capillary joints. Its narrow melting range is suitable for rapid or slow methods of heating. BAg-1 is more economical (less silver) than BAg-1a. **DANGER!** This filler metal contains cadmium, and the fumes formed on heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.2 Brazing filler metal BAg-1a has properties similar to those of BAg-1. BAg-1a has a narrower melting range than BAg-1, making it slightly more free flowing. It also has a higher silver-plus-copper to zinc-plus-cadmium ratio, resulting in a slight increase in its resistance to corrosion in chlorine, sulfur, and steam environments. Either composition may be used when low-temperature, free-flowing filler metals are desired. **DANGER!** This filler metal contains cadmium, and the fumes formed upon heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.3 Brazing filler metal BAg-2, like BAg-1, is free flowing and suited for general-purpose work. Its broader melting range is helpful when clearances are wide or not uniform. Unless heating is rapid, care must be taken to prevent the lower melting constituents from separating out due to liquation. **DANGER!** This filler metal contains cadmium, and the fumes formed upon heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.4 Brazing filler metal BAg-2a is similar to BAg-2, but it is more economical than BAg-2 because it contains 5% less silver. **DANGER!** This filler metal contains cadmium, and the fumes formed upon heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.5 Brazing filler metal BAg-3 is a modification of BAg-1a in that nickel is added. It has good corrosion resistance in marine environment and caustic media. When used on stainless steel, it inhibits crevice (interface) corrosion. Because its nickel content improves wettability on tungsten carbide tool tips, the largest use is in the brazing of carbide tool assemblies. Its melting range and low fluidity make BAg-3 suitable for forming larger fillets or filling wide joint clearances. **DANGER!** This filler metal contains cadmium, and the fumes formed upon heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.6 Brazing filler metal BAg-4, like BAg-3, is used extensively for the brazing of carbide tips, but it flows less freely than BAg-3. This filler metal is cadmium free.

A7.1.7 Brazing filler metals BAg-5 and BAg-6 are cadmium-free filler metals used especially for brazing in the electrical industry. They are used, along with BAg-7 and BAg-24, in the dairy and food industries, in which the use of cadmium-containing filler metals is prohibited. BAg-5 is an excellent filler metal for the brazing of brass components (e.g., ship piping, band instruments, lamps, and so forth). Since BAg-6 has a broad melting range and is not as free flowing as BAg-1 and BAg-2, it is a better filler metal for filling wide joint clearances or forming large fillets.

A7.1.8 Brazing filler metal BAg-7, a cadmium-free substitute for BAg-1, is low-melting with good flow and wetting properties. BAg-7 is typically used for food equipment when cadmium must be avoided, when the white color will improve the color match with the base metal, and to minimize the stress corrosion cracking of nickel or nickel-based alloys at low brazing temperatures.

A7.1.9 Brazing filler metal BAg-8 is suitable for furnace brazing in a protective atmosphere without the use of a flux, as well as for brazing procedures requiring a flux. It is usually used on copper or copper alloys. When molten, BAg-8 is very fluid and may flow out over the workpiece surfaces during some furnace brazing applications. It can also be used on stainless steel, nickel-based alloys, and carbon steel, although its wetting action on these metals is slow. Higher brazing temperatures improve flow and wetting. This filler metal is cadmium free.

11. Cadmium-free filler metal contains no intentionally added cadmium and meets AWS specifications of 0.15% maximum for all other elements including cadmium.

A7.1.10 Brazing filler metal BAg-8a is used for brazing in a protective atmosphere and is advantageous when brazing precipitation-hardening and other stainless steels in the 1400°F to 1600°F [760°C to 870°C] range. The lithium content serves to promote wetting and to increase the flow of the filler metal on difficult-to-braze metals and alloys. Lithium is particularly helpful on base metals containing minor amounts of titanium or aluminum. This filler metal is cadmium free.

A7.1.11 Brazing filler metals BAg-9 and BAg-10 are used particularly for joining sterling silver. These filler metals have different brazing temperatures. Therefore, they can be used for the step brazing of successive joints. After brazing, the color of the filler metal approximates the color of sterling silver. These filler metals are cadmium free.

A7.1.12 Brazing filler metal BAg-13 is used for service temperatures up to 700°F [370°C]. Its low zinc content makes it suitable for furnace brazing when used at the low end of the temperature range and with flux. Without flux in a gaseous protective atmosphere or vacuum, the zinc vaporizes. This filler metal is cadmium free.

A7.1.13 Brazing filler metal BAg-13a is similar to BAg-13, except that it contains no zinc, which is advantageous when volatilization is objectionable in furnace brazing. This filler metal is cadmium free.

A7.1.14 Brazing filler metal BAg-18 is similar to BAg-8 in its applications. Its tin content helps promote wetting on stainless steel, nickel-base alloys, and carbon steel. BAg-18 has a lower liquidus than BAg-8 and is used in step brazing applications in which fluxless brazing is important. This filler metal is cadmium free.

A7.1.15 Brazing filler metal BAg-19 is used for the same applications as BAg-8a. BAg-19 is often used in higher brazing temperature applications in which precipitation-hardening heat treatment and brazing are combined. This filler metal is cadmium free.

A7.1.16 Brazing filler metal BAg-20 possesses good wetting and flow characteristics and has a brazing temperature range higher than the popular Ag-Cu-Zn-Cd compositions. Due to its good brazing properties and economical silver content, new uses for this filler metal are being developed. This filler metal is cadmium free.

A7.1.17 Brazing filler metal BAg-21 is used in brazing AISI 300- and 400-series stainless steels, as well as the precipitation-hardening nickel and steel alloys. BAg-21 is particularly suited to furnace brazing in a protective atmosphere because of the absence of zinc and cadmium. It does not require a flux for proper brazing when the temperature is 1850°F [1010°C] or above. It requires a high brazing temperature, and it flows in a sluggish manner. The nickel-rich layer (halo) formed along the fillet edges during melting and flow of the filler metal prevents crevice (interface) corrosion of stainless steels. This is particularly important for the 400-series steels that do not contain nickel and are, therefore, more susceptible to crevice (interface) corrosion. BAg-21 has been used for brazing stainless steel vanes of aircraft gas turbine engines. This filler metal is cadmium free.

A7.1.18 Brazing filler metal BAg-22 is a low-temperature filler metal with improved wetting characteristics, particularly in the brazing of tungsten carbide tools. This filler metal is cadmium free.

A7.1.19 Brazing filler metal BAg-23 is a high-temperature, free-flowing filler metal usable both for torch brazing and furnace brazing in a protective atmosphere. This filler metal is mainly used in the brazing of stainless steel, nickel-based, and cobalt-based alloys for high-temperature applications. If this filler metal is used in a high vacuum atmosphere, a loss of manganese will occur due to its high vapor pressure. Thus, a partial-pressure vacuum produced by inert gas backfilling and a flow to provide a vacuum of 500 to 2000 microns is desirable when brazing with this filler metal. This filler metal is cadmium free.

A7.1.20 Brazing filler metal BAg-24 is a low-melting, free-flowing brazing filler metal suitable for use in joining 300-series stainless steels (particularly food-handling equipment and hospital utensils) and small tungsten carbide inserts in cutting tools. This filler metal is cadmium free.

A7.1.21 Brazing filler metal BAg-26 is a low-silver filler metal suitable for carbide and stainless steel brazing. The filler metal is characterized by its low brazing temperature, good wetting and flow, and moderate-strength joints when used with these base metals. This filler metal is cadmium free.

A7.1.22 Brazing filler metal BAg-27 is similar to BAg-2 but has a lower silver content and is somewhat more subject to liquation due to a wider melting range. **DANGER!** This filler metal contains cadmium, and the fumes formed upon heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.23 Brazing filler metal BAg-28 has a lower brazing temperature with a narrower melting range than other cadmium-free classifications with similar silver content. BAg-28 also has free-flowing characteristics. This filler metal is cadmium free.

A7.1.24 Brazing filler metal BAg-33 was developed to minimize brazing temperature for a filler metal containing 25% silver. It has a lower liquidus and therefore a narrower melting range than BAg-27. Its higher total zinc plus cadmium content may require more care during brazing. **DANGER!** This filler metal contains cadmium, and the fumes formed upon heating are toxic. Special precautions as shown in the required precautionary information, as specified in 18.4 of this specification, shall be followed.

A7.1.25 Brazing filler metal BAg-34 is a filler metal with free-flowing characteristics. Its brazing temperature range is similar to that of BAg-2 and BAg-2a, making it an ideal substitute for these filler metals. This filler metal is cadmium free.

A7.1.26 BAg-35 is a filler metal used for brazing ferrous and nonferrous base metals. It is a moderate-temperature filler metal frequently used for production brazing applications. This filler metal is cadmium free.

A7.1.27 BAg-36 is a low-temperature filler metal suitable for the brazing of ferrous and nonferrous base metals. Its lower brazing temperature makes it a useful replacement for several of the cadmium-bearing classifications. This filler metal is cadmium free.

A7.1.28 Brazing filler metal BAg-37 is frequently used for the brazing of steel, copper, and brass. The low silver content makes it an economical filler metal suitable for applications in which lower ductility is acceptable. This filler metal is cadmium free.

A7.2 BAu Classification (Gold). Brazing filler metals in the BAu classification are used for the brazing of iron, nickel, and cobalt base metals when better ductility or a greater resistance to oxidation and corrosion is required. Because of their low rate of interaction with the base metal, they are commonly used on thin base metals. These filler metals are usually used with induction, furnace, or resistance brazing in a protective atmosphere. In these cases, no flux is used. Additional information is provided in AWS A5.31, *Specification for Fluxes for Brazing and Braze Welding,* or the AWS *Brazing Handbook*, Chapter 4, "Fluxes and Atmospheres."

A7.2.1 Brazing filler metals BAu-1, BAu-2, and BAu-3, when used for different joints in the same assembly, permit variation in brazing temperature so that step brazing can be used.

A7.2.2 Brazing filler metal BAu-4 is used to braze a wide range of high-temperature iron- and nickel-based alloys.

A7.2.3 Brazing filler metal BAu-5 is primarily used to join heat- and corrosion-resistant base metals when corrosion-resistant joints with good strength at high temperatures are required. This filler metal is well suited for furnace brazing under protective atmospheres (including vacuum).

A7.2.4 Brazing filler metal BAu-6 is primarily used for the joining of iron and nickel-based superalloys for service at elevated temperature. This filler metal is well suited for furnace brazing under protective atmospheres (including vacuum).

A7.3 BAlSi Classification (Aluminum-Silicon). Brazing filler metals in the BAlSi classification are used for joining the following grades of aluminum and aluminum alloys; 1060,1350, 1100, 3003, 3004, 3005, 5005, 5050, 6053, 6061, 6951, 7005, and cast alloys 710.0 and 711.0. Joint clearances of 0.002 in to 0.008 in [0.05 mm to 0.20 mm] are common for members that overlap less than 0.25 in [6.4 mm]. Joint clearances up to 0.008 in to 0.010 in [0.20 mm to 0.25 mm] are used for members that overlap more than 0.25 in [6.4 mm].

Fluxing is essential for all processes, except when brazing aluminum in a vacuum when clearances of 0.000 in to 0.002 in [0.00 mm to 0.05 mm] are recommended. After brazing with flux, the brazed parts should be cleaned thoroughly. Immersion in boiling water generally removes the residue. If this is not adequate, the parts are usually immersed in a concentrated commercial nitric acid or other suitable acid solution and then rinsed thoroughly.

A7.3.1 Brazing filler metal BAlSi-2 is available as sheet and as a cladding on one or both sides of a brazing sheet having a core of either 3003 or 6951 aluminum alloy. It is used for furnace and dip brazing only.

A7.3.2 BAlSi-3 is a general purpose brazing filler metal. It is used with all brazing processes, with some casting alloys, and when limited flow is desired.

A7.3.3 BAlSi-4 is a general purpose brazing filler metal. It is used with all brazing processes requiring a free-flowing filler metal and good corrosion resistance.

A7.3.4 Brazing filler metal BAlSi-5 is available as sheet and as a cladding on one side or both sides of a brazing sheet having a core of 6951 aluminum alloy. BAlSi-5 is used for furnace and dip brazing at a lower temperature than BAlSi-2 is. The core alloy employed in brazing sheet with this filler metal cladding can be solution heat treated and aged.

A7.3.5 BAlSi-7 is a filler metal suitable for brazing in a vacuum. It is available as a cladding on one or both sides of a brazing sheet having a core of 3003 or 6951 aluminum alloy. The 6951 alloy core can be solution heat treated and aged after brazing. This filler metal contains additional magnesium, which is used as an oxygen getter to improve brazing.

A7.3.6 BAlSi-9 is a filler metal suitable for brazing in a vacuum. It is available as a cladding on one side or both sides of a brazing sheet having a core of 3003 aluminum alloy and is typically used in heat-exchanger applications to join fins made from 5000- or 6000-series aluminum alloys. This filler metal contains additional magnesium, which is used as an oxygen getter to improve brazing.

A7.3.7 BAlSi-11 is a brazing sheet clad on one or two sides of alloy 3105 to form a composite sheet suitable for brazing in a vacuum. It is designed for brazing in a multizone furnace in which the vacuum level is interrupted one or more times during the brazing cycle. The composite can be used in batch-type vacuum furnaces; however, vacuum sheet suitable for brazing with a 3003 core is more resistant to erosion. The maximum brazing temperature for the BAlSi-11/3105 composite is 1110°F [595°C]. This filler metal contains additional magnesium, which is used as an oxygen getter to improve brazing.

A7.4 BCuP Classification (Copper-Phosphorus). Brazing filler metals in the BCuP classification are used primarily for joining copper and copper alloys, although they have some limited use on silver, tungsten, and molybdenum. These filler metals should not be used on ferrous or nickel-based alloys or on copper-nickel alloys containing a nickel content in excess of 10%, as brittle intermetallic compounds are formed at the filler metal-base metal interface. They are suitable for all brazing processes. These filler metals have self-fluxing properties when used on copper; however, a flux is recommended when used on all other base metals, including alloys of copper. Corrosion resistance is satisfactory except when the joint is in contact with sulfurous atmospheres. It should be noted that the brazing temperature ranges begin below the liquidus (see Table A1).

A7.4.1 Brazing filler metals BCuP-2 and BCuP-4 are very fluid at brazing temperatures and penetrate joints with small clearances. Best results are obtained with clearances of 0.001 in to 0.003 in [0.03 mm to 0.08 mm].

A7.4.2 Brazing filler metals BCuP-3 and BCuP-5 can be used when narrow joint clearances cannot be held. Joint clearances of 0.002 in to 0.005 in [0.05 mm to 0.13 mm] are recommended.

A7.4.3 Brazing filler metal BCuP-6 combines some of the properties of BCuP-2 and BCuP-3. It has the ability to fill wide joints clearances at the lower end of its brazing range. At the high end of the brazing range, it is more fluid. Joint clearances of 0.002 in to 0.005 in [0.05 mm to 0.13 mm] are recommended.

A7.4.4 Brazing filler metal BCuP-7 is slightly more fluid than BCuP-3 or BCuP-5 and has a lower liquidus temperature. It is used extensively in the form of preplaced rings in heat exchanger and tubing joints. Joint clearances of 0.002 in to 0.005 in [0.05 mm to 0.13 mm] are recommended.

A7.4.5 Brazing filler metal BCuP-8 is the most fluid and has the lowest brazing temperature of the BCuP series filler metals. It is used primarily for tight clearances, 0.001 in to 0.003 in [0.025 mm to 0.075 mm].

A7.4.6 Brazing filler metal BCuP-9 is used for the brazing of copper, brass, and bronze. The addition of silicon lowers the melting temperature and produces a silver-colored braze that resists oxidation darkening during cooling. It also provides the ability to produce a large shoulder or cap around the assembly. The phosphorous inclusion gives the filler metal a self-fluxing property on copper. A flux is required when brazing brass or bronze. Joint clearances of 0.002 in to 0.005 in [0.051 mm to 0.127 mm] are recommended.

A7.5 BCu and RBCuZn Classifications (Copper and Copper-Zinc). Brazing filler metals in the BCu and RBCuZn classifications are used for joining various ferrous and nonferrous metals. They can also be used with various brazing processes. However, with the RBCuZn filler metals, overheating should be avoided. Voids may be formed in the joint by entrapped zinc vapors.

A7.5.1 BCu-1 brazing filler metal is used for the joining of ferrous metals, nickel-based alloys and copper-nickel alloys. It is very free flowing and is often used in furnace brazing, with a protective atmosphere of partially combusted natural gas, hydrogen, dissociated ammonia or nitrogen-based atmosphere, generally without flux. On metals that have constituents with difficult-to-reduce oxides (chromium, manganese, silicon, titanium, vanadium, and aluminum) a flux may be required. However, pure dry hydrogen, argon, dissociated ammonia, and vacuum atmospheres are suitable for base metals containing chromium, manganese, or silicon. Flux also may be used with zinc-containing base metals to retard vaporization. Vacuum atmospheres, electrolytic nickel plating, or both, are used for base metals containing titanium and aluminum. Mineral fluxes should not be used in vacuum atmospheres.

A7.5.2 Brazing filler metal BCu-1a is a powder form similar to BCu-1. Its application and use are similar to those of BCu-1.

A7.5.3 Brazing filler metal BCu-1b is very free flowing. It is used most often in furnace brazing with a protective atmosphere of partially combusted gas, hydrogen, dissociated ammonia, or nitrogen-based atmosphere, usually without flux.

A7.5.4 BCu-2 brazing filler metal is supplied as a copper-oxide suspension in an organic vehicle. Its applications are similar to those of BCu-1 and BCu-1a.

A7.5.5 Brazing filler metal BCu-3 is similar to BCu-1 and may be used for the joining of ferrous metals, nickel-based alloys, and copper-nickel alloys. It is very free flowing and is often used in furnace brazing, with a protective atmosphere of partially combusted natural gas, hydrogen, dissociated ammonia or nitrogen-base atmosphere, generally without flux. On metals that have constituents with difficult-to-reduce oxides (chromium, manganese, silicon, titanium, vanadium, and aluminum), a flux may be required. However, pure dry hydrogen, argon, dissociated ammonia, and vacuum atmospheres are suitable for base metals containing chromium, manganese, or silicon. Flux also may be used with zinc-containing base metals to retard vaporization. Vacuum atmospheres, electrolytic nickel plating, or both, are used for base metals containing titanium and aluminum. Mineral fluxes should not be used in vacuum atmospheres.

A7.5.6 Brazing filler metal RBCuZn-A[12] is used on steels, copper, copper alloys, nickel, nickel alloys, and stainless steel when corrosion resistance is not of importance. It is used with torch, furnace, and induction brazing processes. Fluxing is generally required, and a borax-boric acid type flux is commonly used. Joint clearances from 0.002 in to 0.005 in [0.05 mm to 0.13 mm] are suitable.

A7.5.7 RBCuZn-B[13] (low-fuming brass-nickel) braze welding rods are similar to RBCuZn-A rods but contain additions of iron and manganese which serve to increase the hardness and strength. In addition, a small amount of silicon [0.04% to 0.20%] serves to control the vaporization of the zinc, yielding the “low-fuming” property. The nickel addition [0.2% to 0.8%] assures uniform distribution of the iron in the deposit.

This filler metal is used for brazing and braze welding of steel, cast iron, copper, copper alloys, nickel, nickel alloys, and stainless steel. RBCuZn-B filler metal also is used for the surfacing of steel. It is used with torch, induction, and furnace processes. Flux and joint clearances are the same as those specified for RBCuZn-A.

12. For additional information, see AWS A5.31, *Specification for Fluxes for Brazing and Braze Welding,* or the AWS *Brazing Handbook*, Chapter 4, “Fluxes and Atmospheres.”
13. See Footnote 12.

A7.5.8 Brazing filler metal RBCuZn-C[14] is used on steels, copper, copper alloys, nickel, nickel alloys, and stainless steel. It is used with the torch, furnace, and induction brazing processes. Fluxing is required, and a borax-boric acid flux is commonly used. Joint clearances from 0.002 in to 0.005 in [0.05 mm to 0.13 mm] are suitable.

A7.5.9 Brazing filler metal RBCuZn-D[15] (referred to as *nickel silver*) is primarily used for brazing tungsten carbide. It is also used with steel, nickel, and nickel alloys. It can be used with all brazing processes. This filler metal is unsuitable for furnace brazing in a protective atmosphere.

A7.6 BNi Classification (Nickel). Brazing filler metals in the BNi classification are generally used for their corrosion-resistant and heat-resistant properties. The BNi filler metals have excellent properties at high-service temperatures. They are also satisfactorily used for room-temperature applications and when the service temperatures are equal to the temperature of liquid oxygen, helium, or nitrogen. Best quality can be obtained by brazing in an atmosphere that is reducing to both the base metal and the brazing filler metal. Narrow joint clearances and postbraze thermal diffusion cycles are often employed to minimize the presence of inermetallic compounds, increase joint ductility, and raise the remelt temperature. With complete diffusion, the remelt temperature can be increased to above 2500°F [1370°C].

When BNi filler metals are used with the torch, air-atmosphere furnace, and induction brazing processes, a suitable flux must be used. BNi filler metals are particularly suited to vacuum systems and vacuum tube applications because of their low vapor pressure. Chromium is the limiting element in metals to be used in vacuum applications. It should be noted that when phosphorus is combined with some other elements, these compounds have very low vapor pressures and can be readily used in a vacuum brazing atmosphere of 1×10^{-3} torr [0.13 Pa] at 1950°F [1066°C] without removal of the phosphorus. Greater strength and ductility in this group of filler metals is obtainable by diffusion brazing.

A7.6.1 Brazing filler metal BNi-1 was the first of the nickel filler metals to be developed. The nickel, chromium, and iron contents render it suitable for the brazing of nickel, chromium, or iron base metals. While high carbon content in 300-series stainless steels is usually metallurgically undesirable from a corrosion standpoint, the high carbon in BNi-1 would appear to make it undesirable for brazing stainless steels. However, Strauss test

14. See Footnote 12.
15. See Footnote 12.

results have not shown any adverse affects when used on base metals such as AISI 347 stainless steel since the carbon is already tied up with the chromium in the filler metal.

A7.6.2 Brazing filler metal BNi-1a is a low-carbon grade of BNi-1 with an identical chemical composition, except that while the specified carbon content is 0.06% maximum, the carbon content is usually 0.03% or lower. While the carbon content is lower, corrosion testing results with the Strauss and Huey tests are no better than for joints made with BNi-1. This filler metal produces stronger joints but is less fluid than the BNi-1 filler metal.

A7.6.3 Brazing filler metal BNi-2 has a lower and narrower melting range and better flow characteristics than BNi-1. These characteristics have made this filler metal the most widely used of the nickel filler metals.

A7.6.4 Brazing filler metal BNi-3 is used for applications similar to BNi-1 and BNi-2 and is less sensitive to marginally protective atmospheres (includes vacuum). BNi-3 is a Ni-Si-B filler metal that does not contain chromium.

A7.6.5 Brazing filler metal BNi-4 is similar to but more ductile than BNi-3. It is used to form large fillets or joints when large joint clearances are present.

A7.6.6 Brazing filler metal BNi-5 is used for applications similar to those for BNi-1, except that it can be used in certain nuclear applications in which boron cannot be tolerated.

A7.6.7 BNi-5a is a modified BNi-5 composition with a reduced silicon content plus a small addition of boron. The presence of boron excludes this alloy from nuclear applications. Otherwise, the applications are similar to those of BNi-5. High-strength joints can be produced. BNi-5a material can be used in place of BNi-1 when a reduced level of boron is desired. The brazing of thin-gauge honeycomb to sheet metal base parts is a typical application.

A7.6.8 BNi-5b is a modified BNi-5 composition with reduced chromium. The presence of boron excludes this alloy from nuclear applications. Otherwise, the applications are similar to those of BNi-5. High-strength joints can be produced. BNi-5b material can be used in place of BNi-1 when a reduced level of boron is desired.

A7.6.9 Brazing filler metal BNi-6 is free flowing. It is used in marginally protective atmospheres and for the brazing of low-carbon steels in exothermic atmospheres.

A7.6.10 Brazing filler metal BNi-7 is used for the brazing of honeycomb structures, thin-walled tube assemblies, and other structures that are used at high temperatures. It is recommended for nuclear applications when boron cannot be used. The best results are obtained when it is used in the furnace brazing process. The microstructure and ductility of the joint are improved by increasing the time at the brazing temperature.

A7.6.11 Brazing filler metal BNi-8 is used in honeycomb brazements and on stainless steels and other corrosion-resistant base metals. Since this filler metal contains a high percentage of manganese, special brazing procedures should be observed. As manganese oxidizes more readily than chromium, the hydrogen, argon, and helium brazing atmospheres must be pure and very dry, with a dew point of –70°F [–57°C] or below. The vacuum atmosphere must employ a partial pressure using dry argon or nitrogen, and the furnace must have a low leak rate to ensure a very low partial pressure of oxygen. It should be noted that the chemical composition and the melting characteristics of this filler metal change when the manganese is oxidized or vaporized during brazing in gas or vacuum atmospheres. However, the effect of manganese is not a concern in an atmosphere of proper quality.

A7.6.12 Brazing filler metal BNi-9 is a eutectic nickel-chromium-boron filler metal that is particularly well suited for diffusion brazing applications. As boron has a small molecular diameter, it diffuses rapidly out of the brazed joint, leaving the more ductile nickel-chromium alloy in the joint along with elements that diffuse from the base metal into the joint, such as aluminum, titanium, and so forth. Depending on the diffusion time and temperature, the joint remelt temperature can be above 2500°F [1370°C], and, depending on the base metal, the hardness can be as low as HRB70. With further diffusion time, the grains can grow across the joint, and it may appear as all base metal. The single solidus and liquidus temperature (eutectic) eliminates the possibility of liquation and thus helps in brazing thick sections that require slower heating.

A7.6.13 Brazing filler metal BNi-10 is a high-strength material for high-temperature applications. The tungsten is a matrix strengthener that makes it useful for brazing base metals containing cobalt, molybdenum, and tungsten. This filler metal has a wide melting range. It has been used for brazing cracks in 0.020 in [0.5 mm] thick combustion chambers. It results in a layer of filler metal across the joint that acts as a doubler, while the lower melting constituent is fluid enough to flow through the thin crack and produce a suitable brazement.

A7.6.14 Brazing filler metal BNi-11 is a strong material for high-temperature brazement applications. The tungsten matrix hardener makes it suitable for brazing base metals containing cobalt, molybdenum, and tungsten. With its wider melting range, it is suitable for slightly higher than normal brazing clearances.

A7.6.15 Brazing filler metal BNi-12 is formulated to improve the oxidation resistance and corrosion resistance of the brazed joint. It is recommended for nuclear applications in which boron-containing filler metals cannot be used. This filler metal is also used to coat base metals, such as copper to protect against oxidation at temperatures such as 1500°F [816°C]. Best results are obtained when using the furnace brazing process. The microstructure, strength, and ductility of the joint are improved by increasing the time and/or the temperature of brazing.

A7.6.16 Brazing filler metal BNi-13 is formulated to improve the corrosion resistance of the brazed joint. It is especially used for brazing 300-series stainless steels when interfacial corrosion has occurred under some conditions. For best results, the brazing cycle should be as short as possible with the brazing temperature as low as practical. Alternatively, the diffusion brazing process is used, and the brazement is held at the highest practical brazing temperature for up to two hours.

A7.7 BCo Classification (Cobalt). Brazing filler metals in the BCo-1 classification are generally used for their high-temperature properties and their compatibility with cobalt-alloy base metals.

A7.8 BMg Classification (Magnesium). Brazing filler metal BMg-1 is used for the joining of AZ10A, KlA, and M1A magnesium alloys.

A7.9 Filler Metals for Vacuum Service. The brazing filler metals listed in Table 6 are specially controlled to fabricate high-quality electronic devices when the service life and operating characteristics are of prime importance. Brazing filler metals for vacuum service should be brazed in a high-purity protective atmosphere in order to maintain the purity of the filler metal and to assure proper brazing and final brazement quality. In some applications, it is very important that the brazing filler metal not spatter onto areas near the joint area. For this reason, this specification includes the spatter test requirements described in Section 12, "Spatter Test," for the vacuum grade classifications.

In addition to these filler metals tested and classified for vacuum service, BCo-1 and all BNi-xx brazing filler metals except BNi-8 may also be suitable for vacuum service although they are not required to be tested per Section 12, "Spatter Test," and are not alternatively classified in this specification as BVxx-xx, Grade y.

Table A2
Discontinued Brazing Filler Metal Classifications

AWS Classification	Last AWS A5.8 Publication Date
RBCuZn-1	1952
RBCuZn-2	1952
RBCuZn-3	1952
RBCuZn-4	1952
RBCuZn-5	1952
RBCuZn-6	1952
RBCuZn-7	1952
BAgMn	1956
BAlSi-1	1956
BNiCr	1956
BCuAu-1	1956
BCuAu-2	1956
BAg-11	1962
BMg-2	1962
BMg-2a	1976
BAlSi-6	1981
BAlSi-8	1981
BAlSi-10	1981
BAg-25	1981
RBCuZn-E	1981
RBCuZn-F	1981
RBCuZn-G	1981
RBCuZn-H	1981
BCuP-1	1992
BAg-12 BAg-14 BAg-15 BAg-16 BAg-17	The Committee has chosen not to use these numbers, as they improperly appeared in another publication.

A8. 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 system used in the specification. The classifications that have been discontinued are listed in Table A2, along with the year in which they were last included in the specification.

A9. Special Marking

Strip, wire, and rods may be identified by either indenting or imprinting on the surface of the brazing filler metal. Spooled wire that is too small to be marked with imprinting or indenting may be identified with fade-proof ink on the flange of the spools and on the interior and exterior of shipping containers. Preformed rings may be identified with fade-proof ink on metal surfaces or, when in individual envelopes, on the envelope. Powders may be identified on the interior container. Fade-proof ink shall be resistant to oils, solvents, and all atmospheric conditions and to the normal wear and tear encountered during shipping and handling. Marking by the use of a group of impressed dots is not permitted.

A10. General Safety Considerations

Note: 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 Section A5. Safety and health information is available from other sources, including, but not limited to the Safety and Health Fact Sheets listed in A10.1; ANSI Z49.1, Safety in Welding, Cutting, and Allied Processes, *and applicable federal and state regulations.*

A10.1 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.

No.	Title
1	*Fumes and Gases*
2	*Radiation*
3	*Noise*
4	*Chromium and Nickel in Welding Fume*
5	*Electric Hazards*
6	*Fire and Explosion Prevention*
7	*Burn Protection*
8	*Mechanical Hazards*
9	*Tripping and Falling*
10	*Falling Objects*
11	*Confined Space*
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 and Allied Processes*
23	*California Proposition 65*
24	*Fluxes for Arc Welding and Brazing: Safe Handling and Use*
25	*Metal Fume Fever*

A11. General Label Information

A11.1 An example of the minimum appropriate precautionary information as given in ANSI Z49.1:1999 is shown in Figure A1.

A11.2 An example of the precautionary information used for filler metals containing cadmium (e.g., BAg-1, BAg-1a, BAg-2, BAg-2a, BAg-3, BAg-27, and BAg-33) is shown in Figure A2.

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES AND GASES can be hazardous to your health.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can KILL.

- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
- Wear correct eye, ear, and body protection.
- Do not touch live electrical parts.
- See American National Standard ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes,* published by the American Welding Society, 550 N.W. LeJeune Rd., Miami, Florida 33126; OSHA *Safety and Health Standards*, available from the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954.

DO NOT REMOVE THIS INFORMATION

Source: American National Standards Institute Accredited Standards Committee Z49, 1999, *Safety in Welding, Cutting, and Allied Processes*, ANSI Z49.1:1999, Miami: American Welding Society, Figure 1.

Figure A1—Precautionary Information for Brazing Processes and Equipment

DANGER: CONTAINS CADMIUM

PROTECT yourself and others. Read and understand this information.

FUMES ARE POISONOUS AND CAN KILL.

- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Do not breathe fumes. Even brief exposure to high concentrations should be avoided.
- Use enough ventilation, exhaust at the work or both, to keep fumes and gases from your breathing zone and the general area. If this cannot be done, use air supplied respirators
- Keep children away when using.
- See American National Standard ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes,* published by the American Welding Society, 550 N.W. LeJeune Rd., Miami, Florida 33126; OSHA *Safety and Health Standards*, available from the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954.

First Aid: If chest pain, shortness of breath, cough, or fever develop after use, obtain medical help immediately.

DO NOT REMOVE THIS INFORMATION

Source: American National Standards Institute Accredited Standards Committee Z49, 1999, *Safety in Welding, Cutting, and Allied Processes*, ANSI Z49.1:1999, Miami: American Welding Society, Figure 3.

Figure A2—Precautionary Information for Brazing Filler Metals Containing Cadmium

Annex B
Analytical Methods

(This Annex is not a part of AWS A5.8/A5.8M:2004, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.)

In case of dispute, the referee methods for all elements shall be the appropriate analytical method in *Analytical Chemistry for Metals, Ores, and Related Materials (I): C 571–E 354,* in the *Annual Book of ASTM Standards,* and *Analytical Chemistry for Metals, Ores, and Related Materials (II): E 356 to last; Molecular Spectroscopy; Surface Analysis,* in the *Annual Book of ASTM Standards*, or as indicated in this annex.

The following methods are suggested for the analysis of various elements in silver brazing filler metals:

Phosphorous in Silver or Copper Filler Metals

Phosphorous range: Less than 0.030%, the Vanadate Colormetric method in accordance with ASTM E 78, *Standard Test Method for Spectrographic Analysis of Silver by the Powder Technique.*

Phosphorous range: 4.0% to 8.0%, gravimetric as magnesium pyrophosphate in accordance with ASTM E 1371-90, *Gravimetric Determination of Phosphorus in Phosphorus-Copper Alloys or Phosphorus-Copper-Silver Alloys*.

Lithium in Silver Filler Metals

Lithium range: Less than 5%, atomic absorption in accordance with ASTM E 663, *Practice for Flame Atomic Absorption Analysis.*

Manganese in Silver or Copper Filler Metals

Manganese range: Less than 0.1%, optical emission spectroscopy in accordance with ASTM E 378, *Standard Test Method for Spectrographic Analysis of Silver by the Powder Technique.*

Manganese range: Greater than 0.1%, atomic absorption in accordance with ASTM E 663, *Practice for Flame Atomic Absorption Analysis.*

Tin in Silver or Copper Filler Metals

Tin range: 1% or less, optical emission spectroscopy in accordance with ASTM E 378, *Standard Test Method for Spectrographic Analysis of Silver by the Powder Technique.*

Tin range: Greater than 0.1%, gravimetric method in accordance with *Standard Methods of Chemical Analysis,* 5th edition.[16]

Nickel in Silver or Palladium Filler Metals

Nickel range: 0% to 3.0%, atomic absorption in accordance with ASTM E 663, *Practice for Flame Atomic Absorption Analysis*.

Nickel range: 3% to 20%, gravimetric method as Nidimetheylglyoxine, ASTM E 1473, *Standard Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys.*

Palladium in Silver, Gold, or Palladium Filler Metals

Palladium range: Less than 0.1%, optical emission spectroscopy, ASTM E 378, *Standard Test Method for Spectrographic Analysis of Silver by the Powder Technique.*

Palladium range: 1% to 5%, atomic absorption in accordance with ASTM E 663, *Practice for Flame Atomic Absorption Analysis*.

Palladium range: 5% to 90%, gravimetric method in accordance with *Standard Methods of Chemical Analysis*, 5th edition.[17]

NOTE: Although several of the above-referenced specifications have been discontinued, the bases for analysis are still derived from these standards.

16. Scott, W. W., and N. H. Furman, eds., 1939, *Standard Methods of Chemical Analysis*, 5th ed., New York: D. Van Nostrand.
17. See Footnote 16.

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Annex C

Guidelines for the Preparation of Technical Inquiries for American Welding Society (AWS) Technical Committees

(This Annex is not a part of AWS A5.8/A5.8M:2004, *Specification for Filler Metals for Brazing and Braze Welding,* but is included for informational purposes only.)

C1. 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.

C2. Procedure

All inquiries must be directed to:

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

All inquiries must contain the name, address, and affiliation of the inquirer, and they must 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.

C2.1 Scope. Each inquiry must address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. That provision must be identified in the scope of the inquiry, along with the edition of the standard that contains the provisions that the inquirer is addressing.

C2.2 Purpose of the Inquiry. The purpose of the inquiry must be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard requirement or to request the revision of a particular provision in the standard.

C2.3 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 must be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry must provide technical justification for that revision.

C2.4 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.

C3. 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.

C4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal*.

C5. 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 of Directors' policy 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.

C6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committee or to consideration of revisions to existing provisions on the basis of new data or technology. Neither the committee nor the staff is 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.

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		A5.14			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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American Welding Society (AWS) Filler Metal Specifications and Related Documents

Designation	Title
FMC	*Filler Metal Comparison Charts*
IFS	*International Index of Welding Filler Metal Classifications*
UGFM	*User's Guide to Filler Metals*
A4.2M/A4.2	*Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal*
A4.3	*Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
A4.4M	*Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings*
A5.01	*Filler Metal Procurement Guidelines*
A5.1	*Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
A5.2	*Specification for Carbon and Low Alloy Steel Rods for Oxyfuel Gas Welding*
A5.3/A5.3M	*Specification for Aluminum and Aluminum-Alloy Electrodes for Shielded Metal Arc Welding*
A5.4	*Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*
A5.5	*Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
A5.6	*Specification for Covered Copper and Copper Alloy Arc Welding Electrodes*
A5.7	*Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes*
A5.8	*Specification for Filler Metals for Brazing and Braze Welding*
A5.9	*Specification for Bare Stainless Steel Welding Electrodes and Rods*
A5.10/A5.10M	*Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*
A5.11/A5.11M	*Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding*
A5.12/A5.12M	*Specification for Tungsten and Tungsten-Alloy Electrodes for Arc Welding and Cutting*
A5.13	*Specification for Surfacing Electrodes for Shielded Metal Arc Welding*
A5.14/A5.14M	*Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*
A5.15	*Specification for Welding Electrodes and Rods for Cast Iron*
A5.16/A5.16M	*Specification for Titanium and Titanium Alloy Welding Electrodes and Rods*
A5.17/A5.17M	*Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.18/A5.18M	*Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.19	*Specification for Magnesium Alloy Welding Electrodes and Rods*
A5.20	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
A5.21	*Specification for Bare Electrodes and Rods for Surfacing*
A5.22	*Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding*
A5.23/A5.23M	*Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.24	*Specification for Zirconium and Zirconium Alloy Welding Electrodes and Rods*
A5.25/A5.25M	*Specification for Carbon and Low-Alloy Steel Electrodes and Fluxes for Electroslag Welding*
A5.26/A5.26M	*Specification for Carbon and Low-Alloy Steel Electrodes for Electrogas Welding*
A5.28	*Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.29	*Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
A5.30	*Specification for Consumable Inserts*
A5.31	*Specification for Fluxes for Brazing and Braze Welding*
A5.32/A5.32M	*Specification for Welding Shielding Gases*

For ordering information, contact Global Engineering Documents, an Information Handling Services (IFS) Group company, 15 Inverness Way East, Englewood, Colorado 80112-5776; telephones (800) 854-7179, (303) 397-7956; fax (303) 397-2740; Internet: www.global.ihs.com.

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List of AWS Documents on Brazing and Soldering

Designation	Title
A2.4	*Standard Symbols for Welding, Brazing, and Nondestructive Examination*
A3.0	*Standard Welding Terms and Definitions, Including Terms for Brazing, Soldering, Thermal Spraying, and Thermal Cutting*
A5.8	*Specification for Filler Metals for Brazing and Braze Welding*
A5.31	*Specification for Fluxes for Brazing and Braze Welding*
B2.2	*Standard for Brazing Procedure and Performance Qualification*
C3.2M/C3.2	*Standard Method for Evaluating the Strength of Brazed Joints*
C3.3	*Recommended Practices for the Design, Manufacture, and Examination of Critical Brazed Components*
C3.4	*Specification for Torch Brazing*
C3.5	*Specification for Induction Brazing*
C3.6	*Specification for Furnace Brazing*
C3.7	*Specification for Aluminum Brazing*
C3.8	*Recommended Practices for Ultrasonic Inspection of Brazed Joints*
BRH	*Brazing Handbook*
SHB	*Soldering Handbook*

For ordering information, contact Global Engineering Documents, an Information Handling Services (IHS) Group company, 15 Inverness Way East, Englewood, Colorado 80112-5776; telephones: (800) 854-7179, (303) 397-7956; fax (303) 397-2740; Internet: www.global.ihs.com.

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