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An American National Standard

Specification for Filler Metals for Brazing and Braze Welding

American Welding Society®

Approved American National Standard
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Specification for Filler Metals for Brazing and Braze Welding

10th Edition

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Prepared by the
American Welding Society (AWS) A5 Committee on Filler Metals and Allied Materials

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification prescribes the requirements for the classification of brazing filler metals for brazing and braze welding. The chemical composition, physical form, and packaging of more than 120 brazing filler metals are specified. The brazing filler metal groups described include aluminum, cobalt, copper, gold, magnesium, nickel, silver, titanium, 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 brazing 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 brazing filler metals for brazing and braze welding.

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

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Foreword

This foreword is not part of AWS A5.8M/A5.8:2011-AMD 1, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.

This document is the second of the AWS A5.8 specification revisions that makes use of both the International Systems of Units (SI) and the U.S. Customary Units. 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 SI Units and U.S. Customary Units, which with the application of the specified tolerances provides for interchangeability of products in both the SI Units and U.S. Customary Units.

The current document is the tenth revision of the initial joint ASTM/AWS document issued in 1952. The practice of issuing filler metal specifications as joint AWS/ASTM documents was discontinued shortly after the original version of this specification was issued. The 1969 revision and all subsequent versions, developed and published by AWS, have been certified by the American National Standards Institute (ANSI). The evolution of AWS A5.8M/A5.8, *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; and*
AWS A5.8/A5.8M:2004, *Specification for Filler Metals for Brazing and Braze Welding.*

The present edition, which supersedes AWS A5.8/A5.8M:2004, includes the following updates:

(1) *Seven new brazing filler metals: BTi-1, BTi-2, BTi-3, BTi-4, BTi-5, BCuP-10, and BNi-14*

(2) *The chemical composition range of zinc (Zn) for brazing filler metal BAg-33 is now 26.5–28.5*

(3) *The International System of Units (SI) is used as the primary unit of measurement*

(4) *All substantive updates within this document are italicized.*

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

Amendment

The following Amendment has been identified and is incorporated in this reprint.

AWS Standard: AWS A5.8M/A5/8:2011, *Specification for Filler Metals for Brazing and Braze Welding*

Amendment #: 1

Subject: Table 5 – Chemical Composition Requirements for Nickel and Cobalt Brazing Filler Metals

AWS classifications BNi-5a and BNi-5b; Boron weight percentage:

Replace:

AWS Classification	B
BNi-5a	1.3 – 1.6
BNi-5b	1.3 – 1.6

With previous information from AWS A5.8/A5.8M:2004:

AWS Classification	B
BNi-5a	1.0 – 1.5
BNi-5b	1.1 – 1.6

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Specification for Filler Metals for Brazing and Braze Welding

1. General Requirements

1.1 Scope. This specification prescribes requirements for the classification of brazing filler metals for brazing and braze welding. It includes brazing 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 brazing filler metal is suitable for use both as brazing rod for braze welding and as a brazing filler metal.

1.2 Units of Measurement. This specification makes use of both the International System of Units (SI) and U.S. Customary Units. 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 A5.8M uses the International System of Units. The specification A5.8 uses U.S. Customary 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 the sizing or packaging of brazing filler metal, or both, under A5.8M or A5.8 specifications.

1.3 Safety. Safety issues and concerns are addressed in this standard, although health issues and concerns are beyond the scope of this standard. Some safety and health information can be found in nonmandatory Annex Clauses B5 and B10.

Safety and health information is available from the following sources:

American Welding Society:

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

(2) AWS Safety and Health Fact Sheets (see Annex Clause B10)

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Material Safety Data Sheets supplied by the materials manufacturers

(2) Operating manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

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

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

2. Normative References

The standards listed below contain provisions that, through reference in this text, constitute mandatory provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

2.1 American Welding Society (AWS) standards:[2]

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

AWS A5.01M/A5.01 (ISO 14344:2002 MOD), *Procurement Guidelines for Consumables—Welding and Allied Processes—Flux and Gas Shielded Electrical Welding Processes*

2.2 American National Standards Institute (ANSI) standard:[3]

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

2.3 ASTM International standards:[4]

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

ASTM E11-01, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*

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

ASTM E1371-05, *Standard Test Method for Gravimetric Determination of Phosphorus in Phosphorus–Copper Alloys or Phosphorus–Copper–Silver Alloys*

Annual Book of ASTM Standards, Section 03—Metals Test Methods and Analytical Procedures, Volume 5—Analytical Chemistry for Metals, Ores, and Related Materials

2.4 International Organization for Standardization (ISO) standard:[5]

ISO 80000–1 *Quantities and units—Part 0: General Principles*

2.5 SAE International standard:[6]

SAE HS-1086, *Metals & Alloys in the Unified Numbering System*

3. Classification[7]

3.1 The brazing filler metals covered by the A5.8M/A5.8 specification are classified using a system that is independent of the International System of Units (SI) and U.S. Customary Units. Their classification is according to the chemical composition as specified in Tables 1 through 7.

3.2 Brazing filler metal classified under one classification shall not be classified under any other classification in this specification. However, material may be classified under both A5.8M and A5.8 specifications.

4. Acceptance

Acceptance[8] of the brazing filler metal shall be in accordance with the provisions of AWS A5.01M/A5.01 (ISO 14344 MOD).

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[2] AWS standards are published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166.
[3] This ANSI standard is published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, FL 33166.
[4] ASTM International standards are published by ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.
[5] ISO standards are published by the International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56 CH-1211 Geneva 20, Switzerland.
[6] SAE International standards are published by SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.
[7] An explanation of the method of classification of the filler metals is included in B2 (in Annex B).
[8] See B3 (in Annex B) for further information concerning acceptance, testing of the material shipped, and AWS A5.01M/A5.01 (ISO 14344 MOD).

5. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification. [9]

6. Rounding-Off Procedure

For purposes of determining compliance with the requirements of this standard, the actual test values shall be subjected to the rounding-off rules of ASTM E29 or Rule A in Clause B.3 of ISO 80000–1 (the results are the same). If the measured values are obtained by equipment calibrated in units other than those of the specified limit, the measured values shall be converted to the units of the specified limit before rounding off. If an average value is to be compared to the specified limit, rounding off shall be done only after calculating the average. An observed or calculated value shall be rounded to the nearest 10 MPa [1000 psi] for tensile and yield strength and to the nearest unit in the last right-hand place of figures used in expressing the limiting values for other quantities. The rounded-off results shall fulfill the requirements for the classification under test.

7. Summary of Tests

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

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

7.1.2 Brazing filler metals for vacuum service require a melt cleanliness test and a spatter test in addition to chemical analysis.

7.1.3 Sieve analysis is required for all powdered brazing filler metals.

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

7.2 The material for the preparation of test samples, the brazing and testing procedures to be employed, and the results required are specified in Clauses 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.

9. Chemical Analysis

9.1 Brazing filler metals shall conform to the chemical composition requirements of Tables 1 through 7 for the specific brazing filler metal being tested.

[9] See B4 (in Annex B) for further information concerning certification and the testing called for to meet this requirement.

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

		Chemical Composition, Weight Percent								
AWS Classification	UNS Number[c]	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	*26.5–28.5*	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

[a] See Table B.3 for discontinued brazing filler metal classifications.
[b] See Table 7 for the following Ag classifications intended for vacuum service not included here: BVAg-0, BVAg-6b, BVAg-8b, and BVAg-29 to BVAg-32.
[c] SAE HS-1086, *Metals & 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.

9.2 The sample shall be analyzed by accepted analytical methods.

9.3 In case of dispute, the referee methods for all elements except phosphorus shall be the appropriate analytical method in the latest edition of the *Annual Book of ASTM Standards, Section 03—Metals Test Methods and Analytical Procedures, Volume 5—Analytical Chemistry for Metals, Ores, and Related Materials*. For phosphorus, the referee method shall be that of ASTM E1371-05.

10. Sieve Analysis

10.1 Sieve analyses for standard sizes of powdered brazing filler metals shall be made in accordance with ASTM B214.

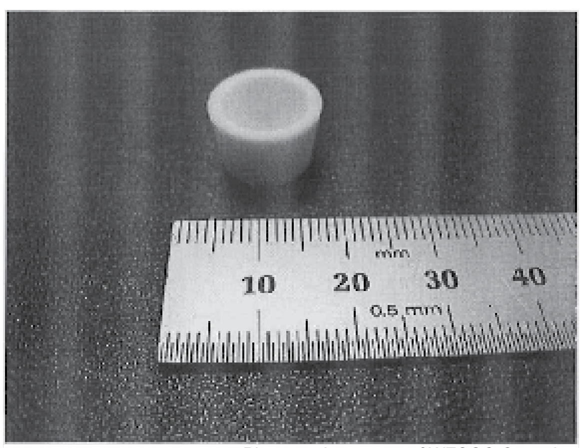
10.2 The results of the sieve analysis shall conform to the particle size distribution shown in Table 8. Sizes other than the standard sizes shall be as agreed upon between the purchaser and the supplier.

11. Melt Cleanliness Test

11.1 The melt cleanliness test shall be required for all BV class brazing filler metals produced for use in vacuum service applications only. The melt cleanliness test shall be performed on a sample of approximately 0.5 grams (g) [0.015 troy ounce (0.001 pound (lb))] of brazing 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 (greater than 94%) high purity alumina crucible. As an alternative, a fused silica crucible or boat that has been precleaned by air firing at a temperature of at least 1100°C [2000°F] and stored in a dust-free container may be used. Figure 1 illustrates a representative test crucible.

11.2 The container with the sample shall be placed in a combustion tube muffle made of dense polycrystalline alumina, fused silica, or an equivalent. The muffle shall be purged with a minimum of 30% dry hydrogen to keep the nitrogen level balanced (–40°C [–40°F] dew point or lower), and the sample shall be heated to a minimum of 20°C [68°F] above the liquidus temperature established for the material (see Table B.2). It shall be held at that temperature for ten minutes and then allowed to cool in the muffle to a temperature no higher than 65°C [150°F]. 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 5×. If it has melted completely and does not exhibit excessive black specks on the surface, it meets the requirements of the cleanliness test. The acceptance standard for black specks shall be established by the supplier or as agreed upon between the supplier and purchaser. Evidence of proper melting of the specimen is shown by the alloy forming into a spherical shape in the alumina crucible.



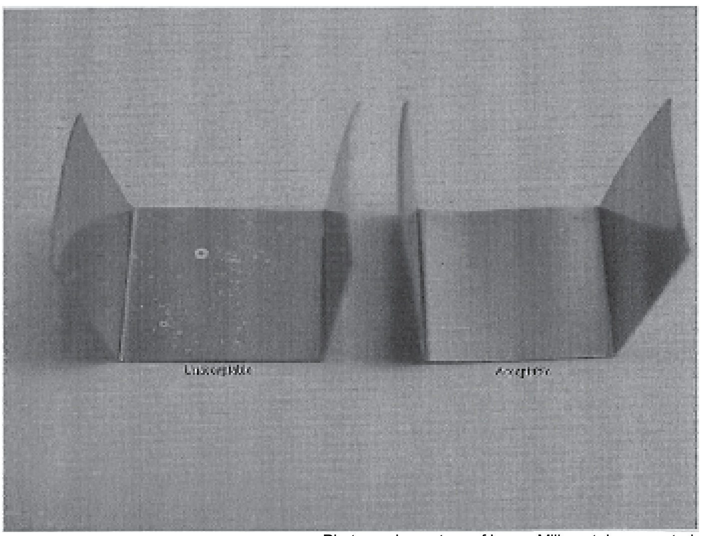
Photograph courtesy of WESGO Ceramics

Figure 1—Illustration of an Acceptable Crucible

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

AWS Classification	Chemical Composition, Weight Percent					
	UNS Number[c]	Au	Cu	Pd	Ni	Other Elements, 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

[a] See Table B.3 for discontinued brazing filler metal classifications.
[b] See Table 7 for the following Au classifications intended for vacuum service not included here: BVAu-2, BVAu-3, BVAu-4, BVAu-7, BVAu-8, BVAu-9, and BVAu-10.
[c] SAE HS-1086, *Metals & 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.



Photograph courtesy of Lucas-Milhaupt, Incorporated

Figure 2—Nickel Channel with Acceptable Test Results (right) and Unacceptable Spatter (left)

12. Spatter Test

12.1 The spatter test shall be required for all BV class brazing filler metals produced for use in vacuum service applications only. Brazing 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.

12.2 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, 1.5 mm [0.06 in] maximum, above the crucible. The bridge shall be no more than 10 mm [0.39 in] above the brazing filler metal. Figure 2 shows a suitable nickel channel and illustrates acceptable and unacceptable test results.

12.3 Upon completion of the test, the bottom side of the nickel channel shall be examined at a 5 × magnification for evidence of any spatter. If there is no evidence of spatter, the sample meets the requirements.

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

AWS	UNS	Chemical Composition, Weight Percent[b]												Other Elements[d]	
Classification	Number[c]	Si	Cu	Mg	Bi	Fe	Zn	Mn	Cr	N	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	0.15–1.50	—	0.005	—	0.0002–0.0008	8.3–9.7	—	0.30

[a] See Table B.3 for discontinued brazing filler metal classifications.
[b] Single values are maximum unless noted.
[c] SAE HS-1086, *Metals & 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 Brazing Filler Metals[a, b]

AWS Classification	UNS Number[d]	Chemical 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
BCu-1a	TBD	99.00[f] min.	—	—	—	—	—	—	—	—		—	0.30
BCu-1b	C11000	99.90 min.	—	—	—	—	—	—	—	—		—	0.10
BCu-2[g]	TBD	86.50[f] min.	—	—	—	—	—	—	—	—		—	0.50
BCu-3[h]	C10200	99.95 min.	—	—	—	—	—	—	—	—		—	0.05
RBCuZn-A	C47000	57.0–61.0	—	Remainder	0.25–1.00	*	*	—	—	0.05*	0.01*	*	0.50
RBCuZn-B	C68000	56.0–60.0[j]	—	Remainder	0.80–1.10	0.25–1.20	0.01–0.50	0.20–0.80[i]	—	0.05*	0.01*	0.04–0.20	0.50
RBCuZn-C	C68100	56.0–60.0[j]	—	Remainder	0.80–1.10	0.25–1.20	0.01–0.50	—	—	0.05*	0.01*	0.04–0.15	0.50
RBCuZn-D	C77300	46.0–50.0[j]	—	Remainder	—	—	—	9.0–11.0[i]	0.25	0.05*	0.01*	0.04–0.25	0.50
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	—	—	0.01–0.40	0.15
BCuP-10	*C55386*	*Remainder*	—	—	*5.5–6.5*	—	—	*3.0–5.0*	*6.8–7.2*	—	—	—	*0.15*

[a] See Table B.3 for discontinued brazing filler metal classifications.
[b] See Table 7 for the following Cu classifications intended for vacuum service not included here: BVCu-1x.
[c] Single values are maximum unless noted.
[d] SAE HS-1086, *Metals & Alloys in the Unified Numbering System*. Classifications BCu-1a and BCu-2 have had UNS Numbers applied for.
[e] The brazing 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 maximum allowable percentage of oxygen for this alloy is 0.001%.
[i] Includes residual cobalt.
[j] Includes residual silver.

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

AWS Classification	UNS Number[c]	Chemical 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
BNi-14	*N99660*	*Rem.*	*21.0–23.0*	*0.1*	*6.0–7.0*	*0.5*	*0.16*	*3.5–4.5*	*0.02*	*0.05*	*0.05*	—	—	*0.05*	—	*0.10*	—	—	*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

[a] See Table B.3 for discontinued brazing filler metal classifications.
[b] Single values are maximum.
[c] SAE HS-1086, *Metals & 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 6
Chemical Composition Requirements for Titanium and Titanium–Zirconium Brazing Filler Metals

AWS Classification	UNS Number[b]	Chemical Composition, Weight Percent[a]												
		Ti	Zr	Cu	Ni	Mo	Hf	Fe	Al	Si	O	N	C	Other Elements, Total[c]
BTi-1	TBD	Remainder	—	14.0–16.0	14.0–16.0	—	—	0.1	0.05	0.02	0.15	0.02	0.04	0.30
BTi-2	TBD	Remainder	—	14.0–16.0	24.0–26.0	—	—	0.1	0.05	0.02	0.15	0.02	0.04	0.30
BTi-3	TBD	Remainder	37.0–38.0	14.0–16.0	9.5–10.5	0.1	0.1	0.08	0.05	0.02	0.20	0.03	0.04	0.50
BTi-4	TBD	Remainder	23.5–24.5	15.0–17.0	15.0–17.0	1.5	0.1	0.08	0.05	0.02	0.20	0.03	0.04	0.50
BTi-5	TBD	Remainder	19.0–21.0	19.0–21.0	19.0–21.0	0.1	0.1	0.08	0.05	0.02	0.20	0.03	0.04	0.50

[a] Single values are maximum.
[b] UNS number has been applied for.
[c] 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 7
Chemical Composition Requirements for Brazing 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	0.020	0.005
BVAg-8	P07727	71.0–73.0	—	Remainder	—	—	—	—	—	0.002	0.002	0.002	0.020	0.005
BVAg-8b	P07728	70.5–72.5	—	Remainder	0.3–0.7	—	—	—	—	0.002	0.002	0.002	0.020	0.005
BVAg-18	P07607	59.0–61.0	—	Remainder	—	—	9.5–10.5	—	—	0.002	0.002	0.002	0.020	0.005
BVAg-29	P07627	60.5–62.5	—	Remainder	—	—	—	—	14.0–15.0	0.002	0.002	0.002	0.020	0.005
BVAg-30	P07687	67.0–69.0	—	Remainder	—	—	—	4.5–5.5	—	0.002	0.002	0.002	0.020	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	—

[a] 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. Elements detected that have a vapor pressure higher than 1.3×10^{-5} Pa [10^{-7} torr] at 500 °C [932 °F] are limited to 0.001% each for Grade 1 brazing filler metals and 0.002% each for Grade 2 brazing 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] SAE HS-1086, *Metals & Alloys in the Unified Numbering System.*

Table 8
Powder Mesh Designations and Particle Size Distribution[a]

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

[a] All of the above sieve sizes are standard ASTM sizes selected from Table 1 of ASTM E11-01, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*.
[b] 106 µm F [140 F mesh] shall be supplied unless otherwise specified by the customer.
[c] C = Coarse
[d] F = Fine

13. Binder Content of 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 0.8 mm × 13 mm × 50 mm [0.03 in × 0.5 in × 2 in] 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, applied to the strip, the plastic carrier removed, and the composite weighed. This weight shall be recorded as **Weight B**.

13.1.3 The composite strip and transfer tape shall be heated in a vacuum or other protective atmosphere furnace to a temperature of 550°C to 650°C [1022°F to 1200°F], 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:

$$\text{Percentage of binder} = \frac{\text{Weight B} - \text{Weight C}}{\text{Weight B} - \text{Weight A}} \times 100$$

13.1.5 The binder content of the transfer tape may also be determined by the alternative method described in 13.1.6 through 13.1.9.

13.1.6 A ceramic crucible shall be used. The crucible should be a clean, dense polycrystalline alumina. As an alternative, a fused silica crucible or boat that has been precleaned by air firing at a temperature of at least 1100°C [2000°F] and stored in a dust-free container may be used. The crucible shall be weighed, and the weight shall be recorded as “Weight A.”

13.1.7 A section of transfer tape approximately 0.8 mm × 13 mm × 50 mm [0.03 in × 0.5 in × 2 in], with the plastic carrier removed, shall be placed in the ceramic crucible. The crucible and transfer tape shall be weighed. This weight shall be recorded as “Weight B.”

13.1.8 The crucible and transfer tape shall be heated in a protective atmosphere furnace (including vacuum) to a temperature of 550°C to 650°C [1022°F to 1200°F], then cooled in the protective atmosphere, and reweighed. This weight shall be recorded as “Weight C.”

13.1.9 The percentage of binder shall be calculated as specified in 13.1.4.

13.2 To meet the requirements, the binder content of transfer tape shall be 6% maximum binder for transfer tape above 0.25 mm [0.010 in] and 10% maximum binder for transfer tape for 0.25 mm [0.010 in] and below; titanium transfer tape binder content shall not exceed 15% maximum.

14. Method of Manufacture

The brazing filler metals classified according to this specification may be manufactured by any method that will produce brazing 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 9.

15.2 Dimensional tolerances of wrought wire, rod, sheet, and strip shall be in accordance with Tables 10 and 11, 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. Brazing Filler Metal Identification

16.1 Brazing 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 listed in Clause 18.

16.2 When required by the purchase order or contract, special identification of individual pieces of brazing 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.

Table 9
Standard Forms and Sizes of Brazing Filler Metals[a, b, c]

AWS Classification	Standard Form	Standard Sizes: Dimensions Specified	Standard Sizes: Width, Length, or Powder Mesh Designation	Thickness or Diameter: mm	Thickness or Diameter: in
BAg All Classifications	Strip[d] (coiled or spooled)	Width and Thickness	6 mm to 150 mm in multiples of 1 mm or 0.25 in to 6.0 in in multiples of 2.25 in	0.05	0.002
				0.08	0.003
				0.10	
				0.13	0.005
				0.15	
				0.20	
				0.25	0.010
				0.50	0.020
	Round Wire (coiled or spooled); Rod (straight lengths)	Diameter for Wire and Rod	—	0.8	1/32 (0.031)
				1.0	
				1.2	3/64 (0.047)
				1.5	
				1.6	1/16 (0.062)
		Length for Rod	450 mm and 900 mm or 18 in and 36 in	2.0	
				2.4	3/32 (0.094)
				2.5	
				3.0	
				3.2	1/8 (0.125)
	Powder and Paste	Mesh Size (see Table 8)	150 µm [100 mesh] 106 µm C [140 C mesh] 106 µm F [140 F mesh] 45 µm [325 mesh]		
BVAg All Classifications	Strip, Wire (coiled or spooled), and Powder	Dimension shall be agreed by the purchaser and supplier			
BAu, BVAu, BVPd, BCu All Classifications	Strip, Wire (coiled or spooled), and Powder	Dimension shall be agreed by the purchaser and supplier			
BAlSi, BMg-1 All Classifications	Sheet (coiled)[e]	Thickness		0.25 0.38 0.50	0.010 0.015 0.020
BAlSi-3 BAlSi-4 BMg-1	Wire (coiled) or Rod (straight lengths)	Length and Diameter for Rod	900 mm or 36 in	1.6 2.4 3.2 4.0 4.8	1/16 (0.062) 3/32 (0.094) 1/8 (0.125) 5/32 (0.156) 3/16 (0.188)
BAlSi-4	Powder and Paste	Mesh Size (see Table 8)	150 µm [100 mesh]		
BCuP-5	Strip (coiled or spooled)	Width and Thickness	6.35 mm to 152.4 mm in multiples of 6.35 mm [0.25 in to 6.0 in in multiples of 0.25 in]	0.08 0.13 0.25 0.6	0.003 0.005 0.010 0.025

Table 9 (Continued)
Standard Forms and Sizes of Brazing Filler Metals

AWS Classification	Standard Form	Standard Sizes			
		Dimensions Specified	Width, Length, or Powder Mesh Designation	Thickness or Diameter mm	Thickness or Diameter in
BCuP: All Classifications	Round Wire (coiled or spooled)	Diameter	—		
	Round Rod (straight lengths)	Length and Diameter	450 mm and 900 mm or 18 in and 36 in		
	Rectangular Wire (coils or spools)	Width and Thicknesses	1.6 mm to 6.4 mm width in multiples of 0.8 mm or 1/16 in to 1/4 in width in multiples of 1/32 in	1.3 1.6 2.0 2.4	0.050 0.062 0.094
	Rectangular Rod (straight lengths)	Width, Length, and Thickness	1.6 mm, 2.4 mm, and 3.2 mm or 1/16 in, 3/32 in, and 18 in width 450 mm and 900 mm lengths or 18 in and 36 in length	2.8 3.2 4.0 6.4	0.109 0.125 0.250
	Powder and Paste	Mesh Size (see Table 8)	150 µm [100 mesh] 106 µm C [140 C mesh] 106 µm F [140 F mesh] 45 µm [325 mesh]		
BCu-1, BCu-1b, BCu-3 RBCuZn-A	Strip (coiled or spooled)	Dimensions shall be agreed upon between the purchaser and supplier			
BCu-1, BCu-1b, BCu-3 RBCuZn-A RBCuZn-B RBCuZn-C RBCuZn-D	Round Wire (coiled)	Diameter		0.8 1.6 2.4 3.2 4.0 4.8 6.4 8.0 9.5	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)
	Rod (straight lengths)	Length and Diameter	450 mm and 900 mm or 18 in and 36 in		
BCu-1a BCu-2	Powder and Paste	Mesh Size (see Table 8)	106 µm C [140 C mesh] 106 µm F [140 F mesh] 45 µm [325 mesh]		
BVCu-1x	Strip, Round Wire (coils or spools)	Dimensions shall be agreed upon between the purchaser and supplier			

Table 9 (Continued)
Standard Forms and Sizes of Brazing Filler Metals

AWS Classification	Standard Form	Standard Sizes: Dimensions Specified	Standard Sizes: Width, Length, or Powder Mesh Designation	Thickness or Diameter: mm	Thickness or Diameter: in
BNi: All Classifications except BNi-5a and BNi-5b BCo-1	Cast Round (straight lengths)[f] Foil	Diameter	—	1.6 3.2	1/16 (0.062) 1/8 (0.125)
	Cast and Wrought (borided) Foil	Width and Thickness	1/8 in to 4.0 in or 3.2 mm to 100 mm	0.025 0.037[g] 0.05 0.06	0.001 0.0015 0.002 0.0025
	Bonded Powder Rope, Sheet, and Transfer Tape[h]	Dimensions shall be agreed upon between the purchaser and supplier			
	Powder and Paste	Mesh Size (see Table 8)	106 µm C [140 C mesh] 106 µm F [140 F mesh] 45 µm [325 mesh]		
BNi-5a	Foil		1/8 in to 4.0 in or 3.2 mm to 100 mm	0.025 0.037 0.05 0.06	0.001 0.015 0.002 0.0025
BNi-5b	Foil		1/8 in to 8.0 in or 3.2 mm to 200 mm	0.025 0.037 0.05 0.06	0.001 0.0015 0.002 0.0025
BTi: All Classifications	*Powder and Paste*	*Mesh Size (see Table 8)*	*149 µm [100 mesh]* *106 µm C [140 C mesh]* *106 µm F [140 F mesh]* *74 µm [200 mesh]* *45 µm [325 mesh]*		
	Transfer Tape and Sheet	*Thickness*	*As Specified*		
	Amorphous or Partly Amorphous Foil	*Thickness*	*As Specified*		
	Clad Tape	*Thickness*	*As Specified*		

[a] Dimensions, sizes, and package forms other than those shown shall be as agreed upon between the purchaser and supplier.
[b] C = Coarse
[c] F = Fine
[d] 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.
[e] BAlSi-2, BAlSi-5, BAlSi-7, BAlSi-9, 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.
[f] Tolerances listed in Table 10 do not apply for cast rod forms.
[g] Available in widths up to 50 mm [2 in].
[h] Tolerances listed in Table 11 do not apply for these bonded powder forms.

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[10] as given in ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, (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 brazing 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) permanently affixed and prominently displayed in legible print.

[10] Typical examples of "warning labels" from ANSI Z49.1 for some common or specific consumables used with certain processes are shown in Figure B.1 and Figure B.2.

Table 10
Tolerances for Wrought Wire and Rod[a,b]

Form	Condition	Nominal Size[c]		Tolerances, ± Round		Rectangular Thickness		Rectangular Width	
		mm	in	mm	in	mm	in	mm	in
Wire	Cold-Drawn or Cold-Rolled	Over 0.25–0.51	Over 0.010–0.020	0.008	0.0003	0.020	0.0008	0.13	0.005
		Over 0.51–0.80	Over 0.020–0.031	0.013	0.0005	0.040	0.0016	0.13	0.005
		Over 0.80–1.00	Over 0.031–0.040	0.018	0.0007	0.045	0.0018	0.13	0.005
		Over 1.00–1.30	Over 0.040–0.051	0.020	0.0008	0.050	0.0020	0.13	0.005
		Over 1.30–1.50	Over 0.051–0.060	0.025	0.0010	0.064	0.0025	0.13	0.005
		Over 1.50–2.00	Over 0.060–0.080	0.038	0.0015	0.080	0.0031	0.13	0.005
		Over 2.00–6.40	Over 0.080–0.252	0.051	0.0020	0.100	0.0040	0.13	0.005
Rod	Cold-Drawn or Cold-Rolled	4.00 and under	5/32 and under	0.08	0.0031	0.23	0.0090	0.25	0.010
		4.80 and over	3/16 and over	0.10	0.0040	0.25	0.0100	0.25	0.010
Rod and Wire	Hot-Rolled or Extruded	Over 1.20–1.60	Over 3/64–1/16	0.13	0.0051	0.20	0.0080	0.25	0.010
		Over 1.60–3.20	Over 1/16–1/8	0.15	0.0060	0.23	0.0090	0.25	0.010
		Over 3.20–4.80	Over 1/8–3/16	0.18	0.0070	0.23	0.0090	0.25	0.010
		Over 4.80–6.40	Over 3/16–1/4	0.20	0.0080	0.25	0.0100	0.25	0.010

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

Table 11
Tolerances for Foil Strip and Sheet

Nominal Thickness		Thickness Tolerance, ±			
		Width 200 mm [8 in] and Under		Width over 200 mm [8 in]	
mm	in	mm	in	mm	in
0.15 and under	0.006 and under	0.015	0.0006	0.020	0.0008
Over 0.15–0.33 incl.	Over 0.006–0.013 incl.	0.025	0.0010	0.025	0.0010
Over 0.33–0.53 incl.	Over 0.013–0.021 incl.	0.038	0.0015	0.038	0.0015
Over 0.53–0.66 incl.	Over 0.021–0.026 incl.	0.050	0.0020	0.051	0.0020

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

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Annex A (Informative)
Informative References

This annex is not part of AWS A5.8M/A5.8:2011, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.

AWS, 2007, *Brazing Handbook*, 5th ed., Miami: American Welding Society.

AWS A1.1, *Metric Practice Guide for the Welding Industry*, American Welding Society.

AWS A5.31M/A5.31, *Specification for Fluxes for Brazing and Braze Welding*, American Welding Society.

AWS B2.2/B2.2M, *Specification for Brazing Procedure and Performance Qualification*, American Welding Society.

AWS C3.2M/C3.2, *Standard Method for Evaluating the Strength of Brazed Joints,* American Welding Society.

AWS C3.3, *Recommended Practices for the Design, Manufacture, and Examination of Critical Brazed Components*, American Welding Society.

AWS C3.4M/C3.4, *Specification for Torch Brazing*, American Welding Society.

AWS C3.5M/C3.5, *Specification for Induction Brazing*, American Welding Society.

AWS C3.6M/C3.6, *Specification for Furnace Brazing*, American Welding Society.

AWS C3.7M/C3.7, *Specification for Aluminum Brazing*, American Welding Society.

AWS C3.8M/C3.8, *Specification for the Ultrasonic Pulse-Echo Examination of Brazed Joints*, American Welding Society.

AWS C3.9M/C3.9, *Specification for Resistance Brazing*, American Welding Society.

AWS D10.13, *Recommended Practice for the Brazing of Copper Pipe and Tubing for Medical Gas Systems,* American Welding Society.

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Annex B (Informative)

Guide to AWS A5.8M/A5.8:2011, *Specification for Filler Metals for Brazing and Braze Welding*

This annex is not part of AWS A5.8M/A5.8:2011, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.

B1. Introduction

B1.1 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 brazing filler metal having a liquidus above 450 °C [840 °F] and below the solidus of the base metal. The brazing filler metal is distributed into or held in the closely fitted faying surfaces of the joint by capillary action.

B1.2 The purpose of this guide is to correlate the brazing filler metal classifications with their intended applications so that 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 should be followed.

B1.3 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 brazing 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.

B2. Method of Classification

B2.1 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 brazing filler metal, and the brazing conditions. Therefore, a classification method based on mechanical properties would be misleading as 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 brazing filler metal combination, tests should be conducted using the latest edition of AWS C3.2M/C3.2.

B2.2 Brazing filler metals are standardized into eight groups as follows: silver, gold, aluminum, copper, nickel, cobalt, magnesium, and titanium brazing filler metals. Many brazing 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.

B2.3 The basic classifications of brazing filler metal are identified by the principal element in their chemical composition, as shown in Tables 1 through 7 (see also Table B.2). 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 brazing 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 brazing 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 brazing 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 brazing filler metal for vacuum service is BVAg-6b, Grade l. Table 7 lists brazing filler metals for vacuum service.

B2.4 Request for Brazing 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 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 AWS A5 Committee on Filler Metals and Allied Materials or the AWS A5H Subcommittee on Filler Metals and Fluxes for Brazing 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 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 within that clause of the respective Annex; and

(d) For all A5 specifications, other than A5.10/A5.10M: actual test data for all tests required for classification according to the requirements of the specification for a minimum of two production heats/lots must be provided. In addition, if the filler metal specification is silent regarding mechanical properties, test data submitted shall include appropriate weld metal mechanical properties from a minimum of two production heats/lots.

(e) Patent policy: If the proposed new classification is patented, if a patent is pending for it, or if there is any intention to apply for a patent, the requester shall disclose this in the request. Prior to adoption of a standard that requires the use of any patented classification, the owner of the patent shall provide written assurance to AWS that:

i. No patent rights will be enforced against anyone using the patent to comply with the standard;

or

ii. The owner will make a license available to anyone wishing to use the patent to comply with the standard, without compensation or for reasonable rates, with reasonable terms and conditions demonstrably free of any unfair competition.

The Secretary will return the request to the requestor for further information.

(2) 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. 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 Subcommittee on Filler Metals and Fluxes for Brazing;

(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 still outstanding after 18 months shall be considered not to have been answered in a "timely manner," and the Secretary shall report these to the Chair of the AWS 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.

Table B.1
Comparison of Classifications with ISO/CD 17672

Aluminum (& Mg) Alloys	
A5.8M/A5.8	ISO 17672
BAlSi-2	Al 107
BAlSi-3	Al 210
BAlSi-4	Al 112
BAlSi-5	Al 110
BAlSi-7	Al 310
BAlSi-9	Al 317
BAlSi-11	Al 311
BMg-1	Mg 001

Silver (& Pd) Alloys	
A5.8M/A5.8	ISO 17672
BAg-1	Ag 345
BAg-1a	Ag 350
BAg-2	Ag 335
BAg-2a	Ag 330
BAg-3	Ag 351
BAg-4	Ag 440*
BAg-5	Ag 245
BAg-6	Ag 250
BAg-7	Ag 156
BAg-8	Ag 272
BAg-8a	
BAg-9	Ag 265
BAg-10	Ag 270
BAg-13	Ag 454
BAg-13a	Ag 456
BAg-18	Ag 160
BAg-19	–
BAg-20	Ag 230
BAg-21	Ag 463
BAg-22	Ag 449
BAg-23	Ag 485
BAg-24	Ag 450
BAg-26	Ag 425
BAg-27	–
BAg-28	Ag 140
BVAg 29	–
BVAg 30	Pd 305
BVAg 31	Pd 309
BVAg 32	Pd 325
BAg-33 (Ag 326*)	–
BAg-34	Ag 138
BAg-35	Ag 235
BAg-36 (Ag 145*)	–
BAg-37	Ag 125
BVPd-1	Pd 365

* Nearest equivalent

Copper Alloys	
A5.8M/A5.8	ISO 17672
BCu-1	Cu 141
BCu-1a	Cu 099
BCu-1b	Cu 100
BCu-2	Cu 087
BCu-3	Cu 103
RBCuZn-A	Cu 470*
RBCuZn-B	Cu 680
RBCuZn-C	Cu 681
RBCuZn-D	Cu 773
BCuP-2	Cu 181
BCuP-3	CuP 281
BCuP-4	CuP 283
BCuP-5	CuP 284
BCuP-6	CuP 280
BCuP-7	Cu 282
BCuP-8	CuP 285
BCuP-9	CuP 385
BCuP-10	–

* Nearest equivalent

Nickel (& Co) Alloys	
A5.8M/A5.8	ISO 17672
BNi-1	Ni 600
BNi-1a	Ni 610
BNi-2	Ni 620
BNi-3	Ni 630
BNi-4	Ni 631
BNi-5	Ni 650
BNi-5a	Ni 660
BNi-5b	Ni 661
BNi-6	Ni 700
BNi-7	Ni 710
BNi-8	Ni 800
BNi-9	Ni 612
BNi-10	Ni 670
BNi-11	Ni 671
BNi-12	Ni 720
BNi-13	Ni 810
BNi-14	–
BCo-1	Co 1

Gold Alloys	
A5.8M/A5.8	ISO 17672
BAu1*	Au 375
BVAu-2	Au 800
BVAu-3	Au 351
BVAu-4	Au 827
BAu-5*	Au 300
BAu-6*	Au 700
BVAu-7	Au 507
BVAu-8	Au 927
BVAu-9	Au 354
BVAu-10	Au 503

* Per A5.8/A5.8M:2004

B2.5 An international system for designating welding filler metals developed by the International Institute of Welding (IIW) is being adopted in many ISO specifications. Table B.1 shows those used in the ISO/CD 17672 specification for comparison with comparable classifications in this specification.

B3. Acceptance

Acceptance of all brazing filler metals classified under this specification is in accordance with AWS A5.01M/A5.01 (ISO 14344 MOD) as this specification states. Any sampling and testing a purchaser requires of the supplier for brazing filler metal shipped in accordance with this specification should be clearly stated in the purchase order, according to the provisions of AWS A5.01M/A5.01 (ISO 14344 MOD).

In the absence of any such statement in the purchase order, the supplier may ship the brazing filler metal with whatever testing the supplier normally conducts on brazing filler metal of that classification, as specified in Schedule F, Table 1, of AWS A5.01M/A5.01 (ISO 14344 MOD). Testing in accordance with any other schedule in Table 1 should be specifically required by the purchase order. In such cases, the acceptance of the brazing filler metal shipped should be in accordance with those requirements.

B4. 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 A5.01M/A5.01 (ISO 14344 MOD).

B5. Ventilation during Brazing

B5.1 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;

(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.

B5.2 American National Standard ANSI Z49.1 discusses the ventilation that is required during brazing and braze welding and should be referred to for details. Particular attention should be drawn to the clause on ventilation in that document. Further information concerning ventilation during brazing can be found in AWS F3.2, *Ventilation Guide for Weld Fume*.

B6. Brazing Terminology and Considerations

B6.1 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. [11]

liquidus. The lowest temperature at which a metal or alloy is completely liquid. [12]

B6.2 Table B.2 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 brazing 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 brazing filler metal with a wide temperature range will usually fill the capillary joint more easily.

B6.3 Brazing requires an understanding of several elements of procedures that are beyond the scope of this annex. The *AWS Brazing Handbook* should be referred to for particulars on such items as cleaning, brazing fluxes, brazing atmospheres, brazing safety, joint clearances, etc. Also, AWS C3.3 should be consulted for information on procedures for critical components.

B7. Brazing Characteristics and Applications

B7.1 BAg-XX Group of Classifications (Silver). Brazing filler metals in the BAg-XX group of classifications are used to join most ferrous and nonferrous metals, except aluminum and magnesium. These brazing 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 0.025 mm to 0.13 mm [0.001 in to 0.005 in] 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 brazing filler metals containing 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 brazing filler metals are recommended for furnace brazing in a protective atmosphere. Brazing filler metals containing cadmium and/or zinc should not be used in a vacuum furnace.

Brazing 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 B.2 shall be followed. The balance of the BAg classifications is cadmium free. [13]

B7.1.1 Brazing filler metal BAg-1 has the lowest brazing temperature range of the BAg brazing 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 brazing 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. [14]

B7.1.2 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 brazing filler metals are desired. **DANGER!** This brazing 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.

B7.1.3 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

[11] AWS A3.0M/A3.0:2010, *Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*, p. 39.

[12] AWS A3.0M/A3.0:2010, *Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*, p. 26.

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

[14] See Footnote 13.

Table B.2
Solidus, Liquidus, and Recommended Brazing Temperature Ranges

AWS Classification	Solidus[a] °C	Solidus[a] °F	Liquidus[a] °C	Liquidus[a] °F	Recommended Brazing Temperature Range °C	Recommended Brazing Temperature Range °F
SILVER						
BAg-1	607	1125	618	1145	620–760	1145–1400
BAg-1a	627	1160	635	1175	635–760	1175–1400
BAg-2	607	1125	702	1295	700–840	1295–1550
BAg-2a	607	1125	710	1310	710–840	1310–1550
BAg-3	632	1170	688	1270	690–815	1270–1500
BAg-4	671	1240	779	1435	780–900	1435–1650
BAg-5	663	1225	743	1370	740–845	1370–1550
BAg-6	688	1270	774	1425	775–870	1425–1600
BAg-7	618	1145	652	1205	650–760	1205–1400
BAg-8	779	1435	779	1435	780–900	1435–1650
BAg-8a	766	1410	766	1410	765–870	1410–1600
BAg-9	671	1240	718	1325	720–840	1325–1550
BAg-10	691	1275	738	1360	740–845	1360–1550
BAg-13	718	1325	857	1575	860–970	1575–1775
BAg-13a	771	1420	893	1640	870–980	1600–1800
BAg-18	602	1115	718	1325	720–840	1325–1550
BAg-19	760	1400	891	1635	880–980	1610–1800
BAg-20	677	1250	766	1410	765–870	1410–1600
BAg-21	691	1275	802	1475	800–900	1475–1650
BAg-22	680	1260	699	1290	700–830	1290–1525
BAg-23	960	1760	970	1780	970–1040	1780–1900
BAg-24	660	1220	707	1305	705–845	1305–1550
BAg-26	707	1305	800	1475	800–870	1475–1600
BAg-27	605	1125	745	1375	745–860	1375–1575
BAg-28	649	1200	710	1310	710–840	1310–1550
BAg-33	607	1125	682	1260	680–760	1260–1400
BAg-34	649	1200	721	1330	720–845	1330–1550
BAg-35	685	1265	754	1390	755–840	1390–1545
BAg-36	646	1195	677	1251	680–815	1251–1495
BAg-37	688	1270	779	1435	780–885	1435–1625
BVAg-0	961	1761	961	1761	960–1035	1761–1900
BVAg-6b	779	1435	872	1602	870–980	1600–1800
BVAg-8	779	1435	779	1435	780–900	1435–1650
BVAg-8b	779	1435	795	1463	800–900	1470–1650
BVAg-18	602	1115	718	1325	715–840	1325–1550
BVAg-29	624	1155	707	1305	705–790	1305–1450
BVAg-30	806	1485	809	1490	810–900	1490–1650
BVAg-31	824	1515	852	1565	850–885	1565–1625
BVAg-32	900	1650	950	1740	950–980	1740–1800
GOLD						
BAu-1	991	1815	1016	1860	1015–1090	1860–2000
BAu-2	891	1635	891	1635	890–1010	1635–1850
BAu-3	990	1814	1010	1850	1010–1070	1850–1950
BAu-4	949	1740	949	1740	950–1005	1740–1840
BAu-5	1135	2075	1166	2130	1165–1230	2130–2250
BAu-6	1007	1845	1046	1915	1045–1120	1915–2050
BVAu-2	891	1635	891	1935	890–1010	1635–1850
BVAu-3	990	1814	1010	1850	1010–1070	1850–1950

Table B.2 (Continued)
Solidus, Liquidus, and Recommended Brazing Temperature Ranges

AWS Classification	Solidus[a] °C	Solidus[a] °F	Liquidus[a] °C	Liquidus[a] °F	Recommended Brazing Temperature Range °C	Recommended Brazing Temperature Range °F
BVAu-4	949	1740	949	1740	950–1005	1740–1840
BVAu-7	1102	2015	1121	2050	1120–1155	2050–2110
BVAu-8	1200	2190	1240	2265	1240–1275	2265–2325
BVAu-9	990	1814	1010	1850	1010–1060	1850–1940
BVAu-10	955	1751	970	1778	970–1020	1778–1868
PALLADIUM						
BVPd-1	1230	2245	1235	2255	1235–1250	2255–2285
ALUMINUM						
BAlSi-2	577	1070	617	1142	600–620	1110–1150
BAlSi-3	521	970	585	1085	570–605	1060–1120
BAlSi-4	577	1070	582	1080	580–605	1080–1120
BAlSi-5	577	1070	599	1110	580–605	1090–1120
BAlSi-7	559	1038	596	1105	590–605	1090–1120
BAlSi-9	562	1044	582	1080	580–605	1080–1120
BAlSi-11	559	1038	596	1105	590–605	1090–1120
COPPER						
BCu-1	1083	1981	1083	1981	1095–1150	2000–2100
BCu-1a	1083	1981	1083	1981	1095–1150	2000–2100
BCu-1b	1083	1981	1083	1981	1095–1180	2000–2150
BVCu-1X	1083	1981	1083	1981	1095–1150	2000–2100
BCu-2	1083	1981	1083	1981	1095–1150	2000–2100
BCu-3	1083	1981	1083	1981	1095–1150	2000–2100
RBCuZn-A	888	1630	899	1650	910–955	1670–1750
RBCuZn-B	866	1590	882	1620	880–980	1620–1800
RBCuZn-C	866	1590	888	1630	910–955	1670–1750
RBCuZn-D	921	1690	935	1715	940–980	1720–1800
BCuP-2	710	1310	793	1460	730–845	1350–1550
BCuP-3	643	1190	813	1495	720–815	1325–1500
BCuP-4	643	1190	718	1325	690–790	1275–1450
BCuP-5	643	1190	802	1475	705–815	1300–1500
BCuP-6	643	1190	788	1450	730–815	1350–1500
BCuP-7	643	1190	771	1420	705–815	1300–1500
BCuP-8	643	1190	666	1230	665–685	1230–1270
BCuP-9	637	1178	675	1247	645–695	1190–1280
BCuP-10	*597*	*1107*	*683*	*1262*	*630–710*	*1170–1310*
NICKEL						
BNi-1	977	1790	1038	1900	1065–1205	1950–2200
BNi-1a	977	1790	1077	1970	1080–1205	1970–2200
BNi-2	971	1780	999	1830	1010–1180	1850–2150
BNi-3	982	1800	1038	1900	1010–1180	1850–2150
BNi-4	982	1800	1066	1950	1010–1180	1850–2150
BNi-5	1079	1975	1135	2075	1150–1205	2100–2200
BNi-5a	1065	1931	1150	2111	1150–1205	2100–2200
BNi-5b	1030	1886	1126	2053	1150–1205	2100–2200
BNi-6	877	1610	877	1610	930–1095	1700–2000
BNi-7	888	1630	888	1630	930–1095	1700–2000
BNi-8	982	1800	1010	1850	1010–1095	1850–2000
BNi-9	1055	1930	1055	1930	1065–1205	1950–2200

Table B.2 (Continued)
Solidus, Liquidus, and Recommended Brazing Temperature Ranges

AWS Classification	Solidus[a] °C	Solidus[a] °F	Liquidus[a] °C	Liquidus[a] °F	Recommended Brazing Temperature Range °C	Recommended Brazing Temperature Range °F
BNi-10	970	1780	1105	2020	1150–1205	2100–2200
BNi-11	970	1780	1095	2003	1150–1205	2100–2200
BNi-12	880	1620	950	1740	980–1095	1800–2000
BNi-13	970	1775	1080	1980	1095–1175	2000–2150
BNi-14	*960*	*1760*	*1015*	*1860*	*1065–1175*	*1950–2150*
COBALT						
BCo-1	1120	2050	1149	2100	1150–1230	2100–2250
MAGNESIUM						
BMg-1	443	830	599	1110	605–630	1120–1160
TITANIUM						
BTi-1[b]	*902*	*1655*	*950*	*1742*	*980–1050*	*1800–1920*
BTi-2[b]	*901*	*1653*	*915*	*1679*	*930–960*	*1705–1760*
BTi-3[b]	*825*	*1510*	*835*	*1535*	*850–880*	*1560–1620*
BTi-4[b]	*835*	*1535*	*850*	*1560*	*890–920*	*1630–1690*
BTi-5[b]	*848*	*1555*	*856*	*1572*	*870–900*	*1560–1620*

[a] The solidus and liquidus shown are for the nominal composition in each classification.
[b] The brazing temperature ranges presented in this table relate to the brazing of titanium and titanium alloys. Brazing temperatures can be increased over these ranges for the brazing of titanium aluminide alloys, graphite, and ceramics.

the lower melting constituents from separating out due to liquation. **DANGER!** This brazing 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.

B7.1.4 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 brazing 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.

B7.1.5 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 brazing 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.

B7.1.6 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 brazing filler metal is cadmium free.

B7.1.7 Brazing filler metals BAg-5 and BAg-6 are cadmium-free brazing 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 brazing filler metals is prohibited. BAg-5 is an excellent brazing 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 brazing filler metal for filling wide joint clearances or forming large fillets.

B7.1.8 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.

B7.1.9 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 brazing filler metal is cadmium free.

B7.1.10 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 760°C to 870°C [l400°F to l600°F] range. The lithium content serves to promote wetting and to increase the flow of the brazing filler metal on difficult-to-braze metals and alloys. Lithium is particularly helpful on base metals containing minor amounts of titanium or aluminum. This brazing filler metal is cadmium free.

B7.1.11 Brazing filler metals BAg-9 and BAg-10 are used particularly for joining sterling silver. These brazing filler metals have different brazing temperatures. Therefore, they can be used for the step brazing of successive joints. After brazing, the color of the brazing filler metal approximates the color of sterling silver. These brazing filler metals are cadmium free.

B7.1.12 Brazing filler metal BAg-13 is used for service temperatures up to 370°C [700°F]. 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 brazing filler metal is cadmium free.

B7.1.13 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 brazing filler metal is cadmium free.

B7.1.14 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 brazing filler metal is cadmium free.

B7.1.15 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 brazing filler metal is cadmium free.

B7.1.16 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 brazing filler metal are being developed. This brazing filler metal is cadmium free.

B7.1.17 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 1010°C [1850°F] 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 brazing 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 brazing filler metal is cadmium free.

B7.1.18 Brazing filler metal BAg-22 is a low-temperature brazing filler metal with improved wetting characteristics, particularly in the brazing of tungsten carbide tools. This brazing filler metal is cadmium free.

B7.1.19 Brazing filler metal BAg-23 is a high-temperature, free-flowing brazing filler metal usable for both torch brazing and furnace brazing in a protective atmosphere. This brazing filler metal is mainly used in the brazing of stainless steel, nickel-based, and cobalt-based alloys for high-temperature applications. If this brazing 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 produced by inert gas backfilling and a flow to provide a pressure of 67 Pa to 267 Pa [0.5 torr to 2 torr] is desirable when brazing with this brazing filler metal. This brazing filler metal is cadmium free.

B7.1.20 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 brazing filler metal is cadmium free.

B7.1.21 Brazing filler metal BAg-26 is a low-silver brazing filler metal suitable for carbide and stainless steel brazing. The brazing filler metal is characterized by its low brazing temperature, good wetting and flow, and moderate-strength joints when used with these base metals. This brazing filler metal is cadmium free.

B7.1.22 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 brazing 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.

B7.1.23 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 brazing filler metal is cadmium free.

B7.1.24 Brazing filler metal BAg-33 was developed to minimize brazing temperature for a brazing 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 brazing 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.

B7.1.25 Brazing filler metal BAg-34 is a brazing 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 brazing filler metals. This brazing filler metal is cadmium free.

B7.1.26 Brazing filler metal BAg-35 is a brazing filler metal used for brazing ferrous and nonferrous base metals. It is a moderate-temperature brazing filler metal frequently used for production brazing applications. This brazing filler metal is cadmium free.

B7.1.27 Brazing filler metal BAg-36 is a low-temperature brazing 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 brazing filler metal is cadmium free.

B7.1.28 Brazing filler metal BAg-37 is frequently used for the brazing of steel, copper, and brass. The low silver content makes it an economical brazing filler metal suitable for applications in which lower ductility is acceptable. This brazing filler metal is cadmium free.

B7.2 BAu-X Group of Classifications (Gold). Brazing filler metals in the BAu-X group of classifications 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 brazing 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 A5.31M/A5.31 or the AWS *Brazing Handbook* chapter on “Fluxes and Atmospheres.”

B7.2.1 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.

B7.2.2 Brazing filler metal BAu-4 is used to braze a wide range of high-temperature iron- and nickel-based alloys.

B7.2.3 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 brazing filler metal is well suited for furnace brazing under protective atmospheres (including vacuum).

B7.2.4 Brazing filler metal BAu-6 is primarily used for the joining of iron and nickel-based superalloys for service at elevated temperature. This brazing filler metal is well suited for furnace brazing under protective atmospheres (including vacuum).

B7.3 BAlSi-X Group of Classifications (Aluminum–Silicon). Brazing filler metals in the BAlSi-X group of classifications are used for joining the following grades of aluminum and aluminum alloys: 1060, 1350, 1100, 3003, 3004, 3005, 3105, 5005, 5050, 6053, 6061, 6951, 7005, and cast alloys 710.0 and 711.0. Joint clearances of 0.05 mm to 0.20 mm [0.002 in to 0.008 in] are common for members that overlap less than 6.4 mm [0.25 in]. Joint clearances up to 0.20 mm to 0.25 mm [0.008 in to 0.010 in] are used for members that overlap more than 6.4 mm [0.25 in].

Fluxing is essential for all processes, except when brazing aluminum in a vacuum when clearances of 0.00 mm to 0.05 mm [0.000 in to 0.002 in] 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.

B7.3.1 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.

B7.3.2 Brazing filler metal BAlSi-3 is used with all brazing processes, some casting alloys, and when limited flow is desired; it is a general purpose brazing filler metal.

B7.3.3 Brazing filler metal BAlSi-4 is used with all brazing processes requiring a free-flowing brazing filler metal and good corrosion resistance; it is a general purpose brazing filler metal.

B7.3.4 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 brazing filler metal cladding can be solution heat treated and aged.

B7.3.5 Brazing filler metal BAlSi-7 is 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 brazing filler metal contains additional magnesium, which is used as an oxygen getter to improve brazing.

B7.3.6 Brazing filler metal BAlSi-9 is 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 brazing filler metal contains additional magnesium, which is used as an oxygen getter to improve brazing.

B7.3.7 Brazing filler metal 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 multi-zone 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 595°C [1110°F]. BAlSi-11 contains additional magnesium, which is used as an oxygen getter to improve brazing.

B7.4 BCuP-XX Group of Classifications (Copper–Phosphorus). Brazing filler metals in the BCuP-XX group of classifications are used primarily for joining copper and copper alloys, although they have some limited use on silver, tungsten, and molybdenum. These brazing 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 brazing filler metal–base metal interface. They are suitable for all brazing processes. These brazing 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 B.2).

B7.4.1 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 0.03 mm to 0.08 mm [0.001 in to 0.003 in].

B7.4.2 Brazing filler metals BCuP-3 and BCuP-5 can be used when narrow joint clearances cannot be held. Joint clearances of 0.05 mm to 0.13 mm [0.002 in to 0.005 in] are recommended.

B7.4.3 Brazing filler metal BCuP-6 combines some of the properties of BCuP-2 and BCuP-3. It has the ability to fill wide joint clearances at the lower end of its brazing range. At the high end of the brazing range, it is more fluid. Joint clearances of 0.05 mm to 0.13 mm [0.002 in to 0.005 in] are recommended.

B7.4.4 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 0.05 mm to 0.13 mm [0.002 in to 0.005 in] are recommended.

B7.4.5 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, 0.03 mm to 0.08 mm [0.001 in to 0.003 in].

B7.4.6 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 brazing filler metal a self-fluxing property on copper. A flux is required when brazing brass or bronze. Joint clearances of 0.051 mm to 0.127 mm [0.002 in to 0.005 in] are recommended.

B7.4.7 *Brazing filler metal BCuP-10 is used for the brazing of copper, brass, and bronze. The addition of nickel improves corrosion resistance and produces a silver-colored braze that resists oxidation during cooling. The phosphorous inclusion gives the brazing filler metal a "self-fluxing" property on copper. A flux is required when brazing brass or bronze. Joint clearances of 0.05 mm to 0.13 mm [0.002 in to 0.005 in] are recommended.*

B7.5 BCu-X and RBCuZn-X Group of Classifications (Copper and Copper–Zinc). Brazing filler metals in the BCu-X and RBCuZn-X group of 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.

B7.5.1 Brazing filler metal BCu-1 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 a 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 may also 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.

B7.5.2 Brazing filler metal BCu-1a is a powder form similar to BCu-1. Its application and use are similar to those of BCu-1.

B7.5.3 Brazing filler metal BCu-1b is very free flowing. It is used most often in furnace brazing with a protective atmosphere of partially combusted natural gas, hydrogen, dissociated ammonia, or nitrogen-based atmosphere, usually without flux.

B7.5.4 Brazing filler metal BCu-2 is supplied as a copper-oxide suspension in an organic vehicle. Its applications are similar to those of BCu-1 and BCu-1a.

B7.5.5 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 may also 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.

B7.5.6 Brazing filler metal RBCuZn-A is used on steel, 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.[15] Joint clearances from 0.05 mm to 0.13 mm [0.002 in to 0.005 in] are suitable.

B7.5.7 Brazing filler metal RBCuZn-B is used for the brazing and braze welding of steel, cast iron, copper, copper alloys, nickel, nickel alloys, and stainless steel. It is also used for the surfacing of steel, as well as with torch, induction, and furnace processes. RBCuZn-B (low-fuming brass–nickel) braze welding rods are similar to RBCuZn-A rods but contain additions of iron and manganese that 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. Flux and joint clearances are the same as those specified for RBCuZn-A.[16]

[15] For additional information, see AWS A5.31M/A5.31, or the AWS *Brazing Handbook* chapter entitled "Fluxes and Atmospheres."
[16] See Footnote 15.

B7.5.8 Brazing filler metal RBCuZn-C is used on steel, 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.[17] Joint clearances from 0.05 mm to 0.13 mm [0.002 in to 0.005 in] are suitable.

B7.5.9 Brazing filler metal RBCuZn-D (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 brazing filler metal is unsuitable for furnace brazing in a protective atmosphere. [18]

B7.6 BNi-X Group of Classifications (Nickel). Brazing filler metals in the BNi-X group of classifications are generally used for their corrosion-resistant and heat-resistant properties. The BNi brazing 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 intermetallic compounds, increase joint ductility, and raise the remelt temperature. With complete diffusion, the remelt temperature can be increased to above 1370°C [2500°F].

When BNi brazing filler metals are used with the torch, air-atmosphere furnace, and induction brazing processes, a suitable flux must be used. BNi brazing 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 0.13 Pa [1×10^{-3} torr] at 1066°C [1950°F] without removal of the phosphorus. Greater strength and ductility in this group of brazing filler metals is obtainable by diffusion brazing.

B7.6.1 Brazing filler metal BNi-1 was the first of the nickel brazing filler metals to be developed. The nickel, chromium, and iron contents render it suitable for the brazing of nickel, chromium, or iron base metals. Since 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 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 brazing filler metal.

B7.6.2 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 brazing filler metal produces stronger joints but is less fluid than brazing filler metal BNi-1.

B7.6.3 Brazing filler metal BNi-2 has a lower and narrower melting range and better flow characteristics than BNi-1. These characteristics have made this brazing filler metal the most widely used of the nickel brazing filler metals.

B7.6.4 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 brazing filler metal that does not contain chromium.

B7.6.5 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.

B7.6.6 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.

B7.6.7 Brazing filler metal BNi-5a is a modified BNi-5 composition with 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.

B7.6.8 Brazing filler metal 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.

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[17] See Footnote 15.
[18] See Footnote 15.

B7.6.9 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.

B7.6.10 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.

B7.6.11 Brazing filler metal BNi-8 is used in honeycomb brazements and on stainless steels and other corrosion-resistant base metals. Since this brazing 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 –57°C [–70°F] 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 brazing 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.

B7.6.12 Brazing filler metal BNi-9 is a eutectic nickel–chromium–boron brazing 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 1370°C [2500°F], 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.

B7.6.13 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 brazing filler metal has a wide melting range. It has been used for brazing cracks in 0.5 mm [0.02 in] thick combustion chambers. It results in a layer of brazing 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.

B7.6.14 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.

B7.6.15 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 brazing filler metals cannot be used. This brazing filler metal is also used to coat base metals, such as copper to protect against oxidation at temperatures such as 816°C [1500°F]. 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.

B7.6.16 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.

B7.6.17 *Brazing filler metal BNi-14 is formulated to provide a lower brazing temperature compared to BNi-5. It is recommended for applications where boron filler metals cannot be used. This filler metal is also used to braze assemblies made of thin sheet metal as the diffusion with the base metal is minimized. Microstructure, strength, and ductility of the brazed joint are improved by increasing the time and/or the temperature of brazing and reducing the joint clearance.*

B7.7 BCo Classification Group (Cobalt). Brazing filler metals in the BCo-1 classification group are generally used for their high-temperature properties and their compatibility with cobalt-alloy base metals.

B7.8 BMg Classification Group (Magnesium). Brazing filler metal BMg-1 is used for the joining of AZ10A, KlA, and M1A magnesium alloys.

B7.9 Brazing Filler Metals for Vacuum Service. The brazing filler metals listed in Table 7 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 brazing 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 Clause 12, "Spatter Test," for the vacuum grade classifications.

In addition to these brazing 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 Clause 12, "Spatter Test," and are not alternatively classified in this specification as BVxx-xx, Grade y.

B7.10 ***BTi-X Group of Classifications (Titanium)***. *Brazing filler metals of the BTi classification group are used primarily for the joining of titanium, titanium alloys, and titanium aluminide alloys, although they are successfully used for the joining of titanium matrix composites, ceramics, ceramic composites, graphite, and carbon–carbon composite materials.*

The brazing filler metals of the BTi group are considered the best choice for joining titanium-based materials, especially for brazed structures that should operate at high temperatures up to 550°C [1020°F] and in highly corrosive atmospheres such as marine environments. The hot strength of brazed joints at 500°C to 550°C [932°F to 1020°F] is about 40% to 50% of the strength of the same joints at room temperature. However, the strength of titanium brazed joints produced with BTi brazing filler metals is significantly higher than that of joints produced with Ag-Cu-based or Al-based brazing filler metals both at hot and room temperatures.

All BTi brazing filler metals provide the best joint formation and strength with a maximum joint clearance of <0.1 mm [<0.004 in]. It is preferable to use a joint clearance of <0.08 mm [<0.003 in].

Brazing filler metals in the clad strip form can be placed both at the brazing clearance edge and into the joint between the titanium parts to be brazed. Brazing filler metals in the form of amorphous foil should be placed only into the joint. It is recommended that brazing filler metals in the form of powder or paste be applied at the edge of the brazing clearance. In order to braze large surfaces such as honeycombs or fin-plate heat exchangers, the powdered BTi brazing filler metal can be applied by painting with a paste or seeding dry powders on the surface first covered with a liquid adhesive binder.

When setting up brazing technology using the BTi group, attention should be paid to the microstructure to prevent uncontrolled growth of a continuous intermetallic layer at the joint–base metal interface, which may cause low impact and fatigue resistance of the brazed joints.

B7.10.1 *Although brazing filler metal BTi-1 has a brazing temperature above 900°C [1652°F], it provides sufficiently high-strength brazed joints, usually above 50% of the strength of the base metals. Moreover, the increase of brazing temperature up to 1050°C [1920°F] for BTi-1 may result in increasing the tensile and shear strength of joints with titanium alloys.*

B7.10.2 *Although brazing filler metal BTi-2 has a brazing temperature above 900°C [1652°F], it provides sufficiently high-strength brazed joints, usually above 50% of the strength of the base metals. Moreover, the increase of brazing temperature up to 960°C [1760°F] for BTi-2 may result in increasing the tensile and shear strength of joints with titanium alloys.*

B7.10.3 *Brazing filler metal BTi-3 has a brazing temperature below 900°C [1652°F] and can be especially recommended for the joining of thin-wall structures. BTi-3 is suitable for brazing beta-titanium alloys with the proviso of a relatively short holding time at the brazing temperature.*

The particle size of –105 microns [–140 mesh] is optimal for powdered brazing filler metal BTi-3 used for the brazing of titanium alloys and titanium matrix composites. Coarse powder of –177 microns [–80 mesh] or –149 microns [–100 mesh] is recommended for brazing titanium aluminide alloys, graphite, or carbon–carbon composites.

B7.10.4 *Brazing filler metal BTi-4 has a brazing temperature above 920°C [1688°F] and can be especially recommended for the joining of thin-wall structures. The particle size of –105 microns [–140 mesh] is optimal for powdered brazing filler metal BTi-4 when used for the brazing of titanium alloys and titanium matrix composites. Coarse powders of –177 microns [–80 mesh] or –149 microns [–100 mesh] are recommended for brazing titanium aluminide alloys, graphite, or carbon–carbon composites.*

B7.10.5 *Brazing filler metal BTi-5 has a brazing temperature below 900°C [1652°F] and can be especially recommended for the joining of thin-wall structures. BTi-5 is suitable for brazing beta-titanium alloys with the proviso of a relatively short holding time at the brazing temperature.*

The particle size of –105 microns [–140 mesh] is optimal for powdered brazing filler metal BTi-5 used for the brazing of titanium alloys and titanium matrix composites. Coarse powder of –177 microns [–80 mesh] or –129 microns [–100 mesh] is recommended for brazing titanium aluminide alloys, graphite, or carbon–carbon composites.

B8. 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 B.3, along with the year in which they were last included in the specification.

B9. 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 itself. Powders may be identified on the interior container. Fade-proof ink shall be resistant to oils, solvents, 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.

Table B.3
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	The Committee has chosen not to use these numbers, as they were improperly placed in another publication.
BAg-14	
BAg-15	
BAg-16	
BAg-17	

B10. General Safety Considerations

B10.1 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; revisions and additional sheets are periodically posted.

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

B11. General Label Information

B11.1 An example of the minimum appropriate precautionary information as given in ANSI Z49.1:2005 is shown in Figure B.1.

B11.2 An example of the precautionary information used for brazing 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 B.2.

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES AND GASES can be hazardous to your health.

HEAT RAYS (INFRARED RADIATION) from flame or hot metal can injure eyes.

- 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 flame, or both, to keep fumes and gases from your breathing zone and the general area.
- Wear correct eye, ear, and body protection.
- See American National Standard ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes,* published by the American Welding Society, 8669 Doral Blvd., Suite 130, Doral, Florida 33166. OSHA *Safety and Health Standards* are published by the U.S. Government Printing Office, 732 North Capitol Street NW, Washington DC 20401.

DO NOT REMOVE THIS INFORMATION

Source: Reproduced from ANSI Z49.1:2005, *Safety in Welding, Cutting, and Allied Processes,* American Welding Society, Figure 2.

Figure B.1—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 or exhaust, 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, 8669 Doral Blvd., Suite 130, Doral, Florida 33166. 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 develops after use, obtain medical help immediately.

DO NOT REMOVE THIS INFORMATION

Source: Adapted from ANSI Z49.1:2005, *Safety in Welding, Cutting, and Allied Processes,* American Welding Society, Figure 3.

Figure B.2—Precautionary Information for Brazing Filler Metals Containing Cadmium

Annex C (Informative)
Analytical Methods

This annex is not part of AWS A5.8M/A5.8:2011, *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 *Annual Book of ASTM Standards, Section 03 — Metals Test Methods and Analytical Procedures, Volume 5 — Analytical Chemistry for Metals, Ores, and Related Materials*, or as indicated in this annex.

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

C1. Phosphorous in Silver or Copper Brazing Filler Metals

Phosphorous range: Less than 0.030%, the Vanadate Colorimetric method in accordance with ASTM E378-97, *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 E1371-05.

C2. Lithium in Silver Brazing Filler Metals

Lithium range: Less than 5%, atomic absorption in accordance with ASTM E663-86(1991)E01, *Practice for Flame Atomic Absorption Analysis*.

C3. Manganese in Silver or Copper Brazing Filler Metals

Manganese range: Less than 0.1%, optical emission spectroscopy in accordance with ASTM E378-97, *Standard Test Method for Spectrographic Analysis of Silver by the Powder Technique*.

Manganese range: Greater than 0.1%, atomic absorption in accordance with ASTM E663-86(1991)E01, *Practice for Flame Atomic Absorption Analysis*.

C4. Tin in Silver or Copper Brazing Filler Metals

Tin range: 1% or less, optical emission spectroscopy in accordance with ASTM E378-97, *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.[19]

[19] Scott, W. W., and N. H. Furman, eds., 1939, *Standard Methods of Chemical Analysis*, 5th ed., New York: D. Van Nostrand.

C5. Nickel in Silver or Palladium Brazing Filler Metals

Nickel range: 0% to 3.0%, atomic absorption in accordance with ASTM E663-86(1991)E01.

Nickel range: 3% to 20%, gravimetric method as Ni-dimethylglyoxime, ASTM E1473-03, *Standard Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys*.

C6. Palladium in Silver, Gold, or Palladium Brazing Filler Metals

Palladium range: Less than 0.1%, optical emission spectroscopy, ASTM E378-97.

Palladium range: 1% to 5%, atomic absorption in accordance with ASTM E663-86(1991)E01.

Palladium range: 5% to 90%, gravimetric method in accordance with *Standard Methods of Chemical Analysis*, 5th edition.[20]

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

[20] Scott, W. W., and N. H. Furman, eds., 1939, *Standard Methods of Chemical Analysis*, 5th ed., New York: D. Van Nostrand.

Annex D (Informative)
Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS A5.8M/A5.8:2011-AMD 1, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for informational purposes only.

D1. 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.

D2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
8669 Doral Blvd., Suite 130
Doral, FL 33166

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

D2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

D2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

D2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

D2.4 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.

D3. 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.

D4. Publication of Interpretations

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

D5. Telephone Inquiries

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

D6. AWS Technical Committees

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

AWS Filler Metal Specifications by Material and Welding Process

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

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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 (ISO 8249 MOD)	*Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of 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*
A5.01M/A5.01 (ISO 14344 MOD)	*Procurement Guidelines for Consumables–Welding and Allied Processes–Flux and Gas Shielded Electrical Welding Processes*
A5.02/A5.02M	*Specification for Filler Metal Standard Sizes, Packaging, and Physical Attributes*
A5.1/A5.1M	*Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
A5.2/A5.2M	*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/A5.4M	*Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding*
A5.5/A5.5M	*Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*
A5.6/A5.6M	*Specification for Copper and Copper-Alloy Electrodes for Shielded Metal Arc Welding*
A5.7/A5.7M	*Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes*
A5.8M/A5.8	*Specification for Filler Metals for Brazing and Braze Welding*
A5.9/A5.9M	*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*
A5.12M/A5.12 (ISO 6848 MOD)	*Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting*
A5.13/A5.13M	*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/A5.20M	*Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*
A5.21/A5.21M	*Specification for Bare Electrodes and Rods for Surfacing*
A5.22/A5.22M	*Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods*
A5.23/A5.23M	*Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*
A5.24/A5.24M	*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/A5.28M	*Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*
A5.29/A5.29M	*Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*
A5.30/A5.30M	*Specification for Consumable Inserts*
A5.31M/A5.31	*Specification for Fluxes for Brazing and Braze Welding*
A5.32/A5.32M (ISO 14175 MOD)	*Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*
A5.34/A5.34M	*Specification for Nickel-Alloy Electrodes for Flux Cored Arc Welding*

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List of AWS Documents on Brazing and Soldering

Designation	Title
A2.4	*Standard Symbols for Welding, Brazing, and Nondestructive Examination*
A3.0M/A3.0	*Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*
A5.8M/A5.8	*Specification for Filler Metals for Brazing and Braze Welding*
A5.31M/A5.31	*Specification for Fluxes for Brazing and Braze Welding*
B2.2/B2.2M	*Specification for Brazing Procedure and Performance Qualification*
B2.3/B2.3M	*Specification for Soldering 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*
C3.4M/C3.4	*Specification for Torch Brazing*
C3.5M/C3.5	*Specification for Induction Brazing*
C3.6M/C3.6	*Specification for Furnace Brazing*
C3.7M/C3.7	*Specification for Aluminum Brazing*
C3.8M/C3.8	*Specification for the Ultrasonic Pulse-Echo Examination of Brazed Joints*
C3.9M/C3.9	*Specification for Resistance Brazing*
C3.11M/C3.11	*Specification for Torch Soldering*
D10.13/D10.13M	*Recommended Practices for the Brazing of Copper Tubing and Fittings for Medical Gas Systems*
BRH	*Brazing Handbook*
SHB	*Soldering Handbook*

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