

SPECIFICATION FOR FILLER METALS FOR BRAZING AND BRAZE WELDING



SFA-5.8



(Identical with AWS Specification A5.8-92)

1. Scope

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

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The brazing filler metals covered by this specification are classified according to their chemical composition, as specified in Tables 1 through 6.²

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

3. Acceptance

Acceptance of the brazing filler metal shall be in accordance with the provisions of the latest edition of ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.³

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

² An explanation of the method of classification of the filler metals is included in A2.

³ See A3, Acceptance (in the Appendix) for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*.

AWS documents may be obtained from the American Welding

4. Certification

By affixing the AWS specification and classification designations to the package, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.⁴

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. Customary Units are the standard units of measure in this specification. The SI Units are given as equivalent values to the U.S. Customary Units. The standard sizes and dimensions in the two systems are not identical, and for this reason conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions encompassing standard sizes of both can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the "nearest unit" in the last right-hand place of figures used in expressing the limiting value in accordance with the rounding-off method given in ASTM E29, *Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*.⁵

Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

⁴ See A4, Certification (in the Appendix) for further information concerning certification and the testing called for to meet this requirement.

⁵ ASTM standards can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

TABLE 1
CHEMICAL COMPOSITION REQUIREMENTS FOR SILVER FILLER METALS

Composition, Weight Percent										
AWS Classification	UNS Number ^a	Ag	Cu	Zn	Cd	Ni	Sn	Li	Mn	Other Elements, Total ^b
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

NOTES:

a. SAE/ASTM Unified Numbering System for Metals and Alloys.

b. 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.

See Table A2 for discontinued brazing filler metal classification.

See Table 6 for the following Ag classifications not included here: BVAg-0, BVAg-6b, BVAg-8b, BVAg-29 to BVAg-32.

TABLE 2
CHEMICAL COMPOSITION REQUIREMENTS FOR GOLD FILLER METALS

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

NOTES:

a. SAE/ASTM Unified Numbering System for Metals and Alloys.

b. 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.

PART B — TESTS, PROCEDURES, AND REQUIREMENTS

6. Summary of Tests

6.1 Chemical analysis is required for all classifications.

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

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

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

7. Retest

If the results of any test fail to meet the requirement, that test shall be repeated twice. The results of both tests 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.

8. Chemical Analysis

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

8.2 The sample shall be analyzed by accepted analytical methods.

8.3 In case of dispute, the referee method for all elements except phosphorous shall be the appropriate analytical method in the latest edition of the *Annual Book of ASTM Standards, Chemical Analysis of Metals; Sampling and Analysis of Metal Bearing Ores*. For phosphorus, the referee method shall be that of the latest edition of ASTM E1, *Standard Photometric Method for Determination of Phosphorus in High-Phosphorus Brazing Filler Metals*.

9. Sieve Analysis

9.1 Sieve analysis for powdered brazing filler metals shall be made in accordance with ASTM B214, *Standard Method for Sieve Analysis of Granular Metal Powders*.

9.2 The results of sieve analysis shall conform to the particle size distribution of the requirements of Table 7.

10. Melt Cleanliness Test

10.1 The melt cleanliness test shall be performed on a sample of approximately one gram of filler metal. Clean, dry tools shall be used to extract the sample from the stock, and the sample shall be placed in a clean, dense polycrystalline alumina crucible or boat of at least 99.6% alumina. As an alternative, a fused silica crucible or boat that has been precleaned by air

TABLE 3
CHEMICAL COMPOSITION REQUIREMENTS FOR ALUMINUM AND MAGNESIUM FILLER METALS

AWS Classification	UNS Number ^b	Chemical Composition, Weight Percent ^a											Other Elements ^c	
		Si	Cu	Mg	Bi	Fe	Zn	Mn	Cr	Ni	Ti	Be	Al	Total
BAISI-2	A94343	6.8-8.2	0.25	—	—	0.8	0.20	0.10	—	—	—	—	Remainder	0.05
BAISI-3	A94145	9.3-10.7	3.3-4.7	0.15	—	0.8	0.20	0.15	0.15	—	—	—	Remainder	0.05
BAISI-4	A94047	11.0-13.0	0.30	0.10	—	0.8	0.20	0.15	—	—	—	—	Remainder	0.05
BAISI-5	A94045	9.0-11.0	0.30	0.05	—	0.8	0.10	0.05	—	—	0.20	—	Remainder	0.05
BAISI-7	A94004	9.0-10.5	0.25	1.0-2.0	—	0.8	0.20	0.10	—	—	—	—	Remainder	0.05
BAISI-9	A94147	11.0-13.0	0.25	0.10-0.5	—	0.8	0.20	0.10	—	—	—	—	Remainder	0.05
BAISI-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
BMg-1	M19001	0.05	0.05	Remainder	—	0.005	1.7-2.3	0.15-1.5	—	0.005	—	0.0002- 0.0008	8.3-9.7	0.30

NOTES:

- a. Single values are maximum, unless otherwise noted.
- b. SAE/ASTM Unified Numbering System for Metals and Alloys.
- c. The filler metal shall be analyzed for those specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that they, or their total do not exceed the limits specified.

TABLE 4
CHEMICAL COMPOSITION REQUIREMENTS FOR COPPER, COPPER-ZINC, AND COPPER-PHOSPHORUS FILLER METALS

Chemical Composition, Weight Percent ^a													
AWS Classification	UNS Number ^b	Cu	Ag	Zn	Sn	Fe	Mn	Ni	P	Pb	Al	Si	Other Elements, Total ^c
BCu-1 ^f	C14180	99.90 min	—	—	—	—	—	—	0.075	0.02	0.01*	—	0.10 ^f
BCu-1a	—	99.00 min ^d	—	—	—	—	—	—	—	—	—	—	0.30 ^d
BCu-2 ^e	—	86.50 min	—	—	—	—	—	—	—	—	—	—	0.50
RBCuZn-A ^f	C47000	57.0–61.0	—	Remainder	0.25–1.00	*	*	—	—	0.05*	0.01*	*	0.50 ^f
RBCuZn-B ^f	C68000	56.0: NND: 60.0 ^g	—	Remainder	0.80–1.10	0.25–1.20	0.01–0.50	0.20–0.80 ^h	—	0.05*	0.01*	0.04–0.15	0.50 ^f
RBCuZn-C ^f	C68100	56.0–60.0	—	Remainder	0.80–1.10	0.25–1.20	0.01–0.50	—	—	0.05*	0.01*	0.04–0.15	0.50 ^f
RBCuZn-D ^f	C77300	46.0–50.0	—	Remainder	—	—	—	9.0–11.0	0.25	0.05*	0.01*	0.04–0.25	0.50 ^f
BCuP-1	C55180	Remainder	—	—	—	—	—	—	4.8–5.2	—	—	—	0.15
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

NOTES:

- Single values are maximum, unless noted.
- SAE/ASTM Unified Numbering System for Metals and Alloys.
- The filler metal shall be analyzed for those specific elements for which values or asterisks are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified.
- The balance is oxygen, present as cuprous oxide. Oxygen is not to be included in "Other Elements."
- 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.
- The total of all other elements including those for which a maximum value or asterisk is shown, shall not exceed the value specified in "Other Elements, Total."
- Silver residual is included in Cu analysis.
- Includes cobalt.

TABLE 5
CHEMICAL COMPOSITION REQUIREMENTS FOR NICKEL AND COBALT FILLER METALS

Chemical Composition, Weight Percent ^a																		
AWS Classification	UNS Number ^b	Ni	Cr	B	Si	Fe	C	P	S	Al	Ti	Mn	Cu	Zr	W	Co	Se	Other Elements, Total ^c
BNi-1	N99600	Remainder	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	Remainder	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	Remainder	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	Remainder	—	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	Remainder	—	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	Remainder	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	Remainder	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-6	N99700	Remainder	—	—	—	—	0.06	10.0–12.0	0.02	0.05	0.05	—	—	0.05	—	0.10	0.005	0.50
BNi-7	N99710	Remainder	13.0–15.0	0.01	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	Remainder	—	—	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	Remainder	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	Remainder	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	Remainder	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	11.50–12.75	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	Remainder	0.005	0.50

NOTES:

a. Single values are maximum.

b. SAE/ASTM Unified Numbering System for Metals and Alloys.

c. The filler metal shall be analyzed for those specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified.

PART C — SPECIFICATIONS FOR WELDING RODS,
ELECTRODES, AND FILLER METALS

SFA-5.8

TABLE 6
CHEMICAL COMPOSITION REQUIREMENTS FOR FILLER METALS FOR VACUUM SERVICE

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

NOTES:

- The filler metal shall be analyzed for those specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined.
- All other elements in addition to those listed in the table above, with a vapor pressure higher than 10^{-7} torr at 932°F (500°C) (such as Mg, Sb, K, Na, Li, Ti, S, Cs, Rb, Se, Te, Sr and Ca) are limited to 0.001 percent each for Grade 1 filler metals and 0.002 percent each for Grade 2 filler metals. The total of all these high vapor pressure elements (including zinc, cadmium, and lead) is limited to 0.010 percent. The total of other elements not designated as high vapor pressure elements is limited to 0.05 percent, except for BVCu-1x, for which the total shall be 0.015 percent, max.
- Single values are maximum, unless noted.

TABLE 7
POWDER MESH DESIGNATIONS AND PARTICLE
SIZE DISTRIBUTION*

Designations	Particle Size Distribution	
	Sieve Size	Distribution Percent
100 mesh	Through No. 60 (250 μ)	100
	Through No. 100 (149 μ)	95 min
140 C mesh	On No. 100 (149 μ)	0.5 max
	On No. 140 (105 μ)	10 max
	Through No. 325 (45 μ)	20 max
140 F mesh	On No. 100 (149 μ)	0.5 max
	On No. 140 (105 μ)	10 max
	Through No. 325 (45 μ)	55 max
325 mesh	On No. 200 (74 μ)	0.5 max
	On No. 325 (45 μ)	10 max
	Through No. 325 (45 μ)	90 min

* These are standard ASTM sieve sizes selected from Table 1 of ASTM E11, *Standard Specification for Wire Cloth Sieves for Testing Purposes*.

firing at a temperature of at least 2012°F (1100°C), and stored in a dust-free container, may be used.

10.2 The container with the sample shall be placed in a combustion tube muffle made of dense polycrystalline alumina, or fused silica. The muffle shall be purged with dry hydrogen [−40°F (−40°C) dew point or lower], and the sample shall be heated to a temperature of 36°F (20°C) above the liquidus temperature established for the material (See Table A1). It shall be held at that temperature for ten minutes, then allowed to cool in the muffle to a temperature no higher than 150°F (65°C). At that time the flow of hydrogen shall be stopped, and the sample shall be removed for examination.

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

11. Spatter Test

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

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

12. Binder Content of Transfer Tape

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

12.1.1 A strip of Type 304 stainless steel approximately 0.031 $\times$ 0.5 $\times$ 2 in. (0.8 $\times$ 13 $\times$ 51 mm), shall be weighed and the weight shall be recorded as Weight A.

12.1.2 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.

12.1.3 Heat the composite in a vacuum or other protective atmosphere furnace to a temperature above 1000°F (538°C), cool under the protective atmosphere, to less than 300°F (150°C) remove from the furnace and reweigh. This weight shall be recorded as Weight C.

12.1.4 The percentage of binder shall be calculated as follows:

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

12.2 To meet the requirements, the binder content of transfer tape shall be 6.0 percent maximum except when otherwise agreed between purchaser and supplier.

PART C — MANUFACTURE, IDENTIFICATION AND PACKAGING

13. Method of Manufacture

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

14. Standard Forms, Sizes and Tolerances

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

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

TABLE 8
STANDARD FORMS AND SIZES

Standard Sizes												
AWS Classification	Standard Form	Dimensions Specified	Width, Length, or Mesh Size	Thickness or Diameter								
				in.	mm							
BAg All Classifi- cations	Strip ^a (Coiled or Spooled)	Width and Thickness	0.25 (6.4 mm) to 6.0 in. (150 mm) in multiples of 0.25 in.	}	}	0.002	0.05					
						0.003	0.08					
						0.005	0.13					
						0.010	0.25					
						0.020	0.51					
	Round Wire (coiled or spooled), rod (straight lengths)	Diameter for wire	—	}	}	}	—	—				
							Length and Diameter for Rod	18 in. (455 mm) and 36 in. (910 mm)	}	}	1/32 (0.31)	0.8
											3/64 (0.047)	1.2
											1/16 (0.062)	1.6
											3/32 (0.094)	2.4
1/8 (0.125)	3.2											
Powder and Paste	Mesh Size	100 140C 140F 325										
BVAg All Classifica- tions	Strip, wire (coiled or spooled) and powder	Dimensions shall be as specified on purchase order or contract.										
BAu, BVAu, BVPd, All Classifi- cations		Strip, wire (coiled or spooled) and powder	Dimensions shall be as specified on purchase order or contract.									

(continued)

TABLE 8 (CONT'D)
STANDARD FORMS AND SIZES

AWS Classification	Standard Form	Dimensions Specified	Width, Length, or Mesh Size	Standard Sizes	
				Thickness or Diameter	
				in.	mm
BAISi, BMg, All Classifi- cations	Sheet (coiled) ^b	Thickness		0.010 0.015 0.020	0.25 0.38 0.51
BAISi-3 BAISi-4 BMg-1	Wire (coiled) or Rod (Straight lengths)	Length and diameter for rod	36 in. (455 mm)	$\frac{1}{16}$ (0.062) $\frac{3}{32}$ (0.094) $\frac{1}{8}$ (0.125) $\frac{5}{32}$ (0.156) $\frac{3}{16}$ (0.188)	1.6 2.4 3.2 4.0 4.8
BAISi-4	Powder and Paste	Mesh Size	100		
BCuP-1 BCuP-5	Strip (coiled or spooled)	Width and Thickness	0.25 in. (6.4 mm) to 6 in. (150 mm) in multiples of 0.25 in.	0.003 0.005 0.010 0.025	0.08 0.13 0.25 0.6
BCuP All Classifi- cations	Round wire (coiled or spooled)	Diameter	—		
	Round rod (straight lengths)	Length and Diameter	18 in. (455 mm) and 36 in. (910 mm)		
	Rectangular wire (coils or spools)	Width and Thickness	$\frac{1}{16}$ in. (1.6 mm) to $\frac{1}{4}$ in. (6.4 mm) width in multiples of $\frac{1}{32}$ in.	0.050 0.062 0.094	1.3 1.6 2.4
	Rectangular rod (straight lengths)	Width, Length and Thickness	$\frac{1}{16}$, $\frac{3}{32}$ and $\frac{1}{8}$ in. (1.6, 2.4, and 3.2 mm) wide 18 in. (455 mm) and 36 in. (910 mm) lengths	0.109 0.125 0.250	2.8 3.2 6.4
	Powder and Paste	Mesh Size	100 140C 140F 325		
BCu-1 RBCuZn-A	Strip (coiled or spooled)	Dimensions shall be as specified on purchase order or contract.			
BCu-1 RBCuZn-A RBCuZn-C RBCuZn-D	Round wire (coiled)	Diameter	—	$\frac{1}{32}$ (0.031) $\frac{1}{16}$ (0.062) $\frac{3}{32}$ (0.096)	0.8 1.6 2.4
	Rod (straight lengths)	Length and Diameter	18 in. (455 mm) and 36 in. (910 mm)	$\frac{1}{8}$ (0.125) $\frac{5}{32}$ (0.156) $\frac{3}{16}$ (0.188) $\frac{1}{4}$ (0.250) $\frac{5}{16}$ (0.312) $\frac{3}{8}$ (0.375)	3.2 4.0 4.8 6.4 8.0 9.5
BCu-1a BCu-2	Powder and Paste	Mesh Size	140C 140F 325		

(continued)

TABLE 8 (CONT'D)
STANDARD FORMS AND SIZES

AWS Classification	Standard Form	Dimensions Specified	Standard Sizes			
			Width, Length, or Mesh Size	Thickness or Diameter		
				in.	mm	
BVCu-1x	{ Strip, round wire (coils or spools)	Dimensions shall be as specified on purchase order or contract.				
BNi All Classifica- tions except BNi-5a		Diameter	{	$\frac{1}{16}$ (0.062)	1.6	
				$\frac{1}{8}$ (0.125)	3.2	
BCo	{ Cast and wrought (bored) foil	Width and Thickness	$\frac{1}{8}$ in. (3.2 mm) to 4 in. (102 mm)	{	0.001	0.025
					0.0015 ^d	0.037
					0.002	0.05
					0.0025	0.06
	{ Bonded powder rope, sheet and transfer tape ^e	Dimensions shall be as specified on purchase order or contract.				
		Powder and paste	Mesh Size	140C 140F 325		
BNi-5a	{ foil		$\frac{1}{8}$ in. (3.2 mm) to 4 in. (102 mm)	{	0.001	0.025
					0.002	0.05
					0.0025	0.05

NOTES:

- BAG-2, -3, -4, -22 and -26 as filler metal clad or bonded to each side of a copper core is also a standard form. The standard thickness ratio of filler metal:copper core:filler metal cladding is 1:2:1 or 1:4:1.
- BAISi-2, -5, -7, -9 and -11 filler metal clad or bonded to one or both sides of an aluminum alloy is also standard form. The standard thickness of the filler metal cladding is 5 to 10 percent of the thickness of the aluminum alloy core.
- Tolerances listed in Table 9 do not apply for cast rod forms.
- Available in widths up to 2 in. (50 mm).
- Tolerances listed in Table 10 do not apply for these bonded powder forms.

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

15. Special Identification Labels or Marking

15.1 Filler metal identification is to be accomplished by tags, labels or appropriate marking of the unit package. Unit packages include coils, spools, bundles, mandrels, and containers. Specific marking requirements are contained in Section 17.

15.2 When required by the purchase order or contract, special identification, of individual pieces of filler metal

shall be included beyond the identification of the unit package. When so prescribed, the use of pressure sensitive labels or imprint marking shall become a requirement for conformance of filler metals to this specification.

16. Packaging

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

TABLE 9
TOLERANCES FOR WROUGHT WIRE AND ROD^a

Form	Condition	Tolerances ±							
		Nominal Size ^b		Rectangular					
				Round		Thickness		Width	
		in.	mm	in.	mm	in.	mm	in.	mm
Wire	Cold Drawn or Cold Rolled	0.010–0.020 incl.	0.25–0.51	0.0003	0.008	0.0008	0.020	0.005	0.13
		over 0.020–0.030 incl.	0.51–0.8	0.0005	0.013	0.0016	0.041	0.005	0.13
		over 0.030–0.040 incl.	0.8–1.0	0.0007	0.018	0.0018	0.046	0.005	0.13
		over 0.040–0.050 incl.	1.0–1.3	0.0008	0.020	0.0020	0.051	0.005	0.13
		over 0.050–0.060 incl.	1.3–1.5	0.0010	0.025	0.0025	0.064	0.005	0.13
		over 0.060–0.080 incl.	1.5–2.0	0.0015	0.038	0.003	0.08	0.005	0.13
		over 0.080–0.250 incl.	2.0–6.4	0.0020	0.051	0.004	0.10	0.005	0.13
Rod	Cold Drawn or Cold Rolled (round, rectan- gular or square)	$\frac{5}{32}$ and under	4.0	0.003	0.08	0.009	0.23	0.010	0.25
		$\frac{3}{16}$ and over	4.8	0.004	0.10	0.010	0.25	0.010	0.25
Rod & Wire	Hot Rolled or Extruded	$\frac{3}{64}$ – $\frac{1}{16}$ incl.	1.2–1.6	0.005	0.13	0.008	0.20	0.010	0.25
		over $\frac{1}{16}$ – $\frac{1}{8}$ incl.	1.6–3.2	0.006	0.15	0.009	0.23	0.010	0.25
		over $\frac{1}{8}$ – $\frac{3}{16}$ incl.	3.2–4.8	0.007	0.18	0.009	0.23	0.010	0.25
		over $\frac{3}{16}$ – $\frac{1}{4}$ incl.	4.8–6.4	0.008	0.20	0.010	0.25	0.010	0.25

NOTES:

- a. Tolerances for cast rod shall be as agreed by purchaser and supplier.
b. Diameter for round; thickness or width for rectangular.

17. Marking of Packages

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

- (1) AWS classification and specification (including the year of issue)
- (2) Supplier's name and trade designation
- (3) Size and net weight
- (4) Lot, control, or heat number
- (5) Date of manufacture for tape and paste

17.2 Marking of any overpacking of unit packages only requires conformance with regulation of D.O.T. or other shipping agencies. Items listed in 17.1 are not required in any overpacking.

17.3 The following precautionary information (as a minimum) shall be prominently displayed in legible print on all packages of brazing filler metals including individual unit packages enclosed within a larger package.

WARNING:

Protect yourself and others.

Read and understand this information.

FUMES AND GASES can be dangerous to your health.

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

- Before use, read, understand, and follow 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 work, 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 Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135; *OSHA Safety*

TABLE 10
TOLERANCES FOR FOIL STRIP AND SHEET

Nominal Thickness		Thickness Tolerance $\pm$			
		Width 8 in. (200 mm) and under		Width over 8 in. (200 mm)	
		in.	mm	in.	mm
0.006 and under	0.15 and under	0.0006	0.015	0.0008	0.020
over 0.006–0.013 incl.	over 0.15–0.33 incl.	0.0010	0.025	0.0010	0.025
over 0.013–0.021 incl.	over 0.33–0.53 incl.	0.0015	0.038	0.0015	0.038
over 0.021–0.026 incl.	over 0.53–0.66 incl.	0.0020	0.05	0.0020	0.051

Nominal Width		Width Tolerance $\pm$			
		Thickness of 0.062 in. (1.59 mm) and under		Thickness of 0.063 in. (1.60 mm) to 0.125 in. (3.18 mm) incl.	
		in.	mm	in.	mm
0.062–1.0	1.59 to 25 incl.	0.005	0.13	0.007	0.18
over 1.0–2.0 incl.	over 25–51 incl.	0.005	0.13	0.009	0.23
over 2.0–6.0 incl.	over 51–152 incl.	0.005	0.13	0.012	0.30
over 6.0–15.0 incl.	over 152–381 incl.	0.007	0.18	0.017	0.43
over 15.0–20.0 incl.	over 381–508 incl.	0.007	0.18	0.017	0.43

and Health Standards, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, DC 20402.

DO NOT REMOVE THIS LABEL

17.4 In addition to the precautionary information in 17.3, all packages (including individual unit packages enclosed within a larger package) of BAg-1, BAg-1a, BAg-2, BAg-2a, BAg-3, BAg-27, and BAg-33 shall have as a minimum, the following cadmium warning, permanently affixed and prominently displayed in legible print.

DANGER:

CONTAINS CADMIUM. Protect yourself and others. Read and understand this label.

FUMES ARE POISONOUS AND CAN KILL

- Before use, read, understand, and follow 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 only with enough ventilation, exhaust at the work, or both to keep fumes from your breathing zone and the general area. If this cannot be done, use air supplied respirators.
- Keep children away when using.
- See American Standard Z49.1, *Safety in Welding and Cutting* available from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040 Miami, Florida 33135; *OSHA Safety and Health Standards*, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, DC 20402.

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

DO NOT REMOVE THIS LABEL

Appendix

Guide to AWS Specification for Filler Metals for Brazing and Braze Welding

(This Appendix is not a part of ANSI/AWS A5.8-92, *Specification for Filler Metals for Brazing and Braze Welding*, but is included for information only.)

A1. Introduction

A1.1 This guide has been prepared as an aid to users of brazing filler metals, to help them determine which classification of brazing filler metal is best for a particular job. The AWS *Brazing Handbook* should be consulted for more detailed information. If the component will have critical applications, the latest edition of ANSI/AWS C3.3, *Recommended Practices for Design, Manufacture, and Inspection of Critical Brazed Components*, should be followed.

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

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

A1.4 Brazing filler metals are metals that are added when making a braze. They have a liquidus below that of the materials being brazed and above 840°F (450°C), with properties suitable for making joints by capillary action between closely fitted surfaces.

A2. Method of Classification

A2.1 The classification method for 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 and filler metal used. Therefore, a classification method based on mechanical properties would be misleading since it would only apply if the brazing filler metal were used on a given base metal with a specific joint design. If a user of brazing filler metal desires to determine the mechanical properties of a given base metal and filler metal combination, tests should be conducted using the latest edition of ANSI/AWS C3.2, *Standard Method for Evaluating the Strength of Brazed Joints*.

A2.2 Brazing filler metals are standardized into seven groups of classifications as follows: silver, gold, aluminum, copper, nickel, cobalt, and magnesium filler metals. Many filler metals of these classifications are used for joining assemblies for vacuum 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 operation of the device. Filler metals for electronic devices have been incorporated as additional "vacuum grade" classifications within this specification.

A2.3 The basic groups of classifications of brazing filler metal are identified, as shown in Tables 1 through 6, by the principal element in their chemical composition. In a typical example, such as BCuP-2, the "B" is for brazing filler metal (as the "E" for electrodes

and the “R” for welding rods in other AWS specifications). The “RB” in RBCuZn-A, RBCuZn-C, and RBCuZn-D indicates that the filler metal is suitable as a welding rod and as a brazing filler metal. “CuP” is for copper-phosphorus, the two principal elements in this particular brazing filler metal. (Similarly, in other brazing filler metals, Si is for silicon, Ag for silver, etc., using standard chemical symbols.) The numeral or letter following the chemical symbol indicates chemical composition within a group.

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

A3. Acceptance

Acceptance of all brazing filler metals classified under this specification is in accordance with ANSI/AWS A5.01, *Filler Metal Procurement Guidelines*, as this specification states. Any testing a purchaser requires of the supplier, for filler metal shipped in accordance with this specification, should be clearly stated in the purchase order, according to the provisions of ANSI/AWS A5.01. In the absence of any such statement in the purchase order, the supplier may ship the filler metal with whatever testing the supplier normally conducts on filler metal of that classification, as specified in Schedule F, Table 1, of ANSI/AWS A5.01. Testing in accordance with any other Schedule in that Table should be specifically required by the purchase order. In such cases, acceptance of the filler metal shipped should be in accordance with those requirements.

A4. Certification

The act of placing the AWS specification and classification designations on the packaging enclosing the product, or the classification on the product itself, constitutes the supplier's or 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 filler metal that is representative of that being shipped and that the filler metal met the requirements of this specification. Representative filler metal, in this case, is any production run of that classification from the same heat or lot. The basis for the certification required by the specification is the classification test of “representative filler metal” cited above, and the Manufacturer's Quality Assurance Program in ANSI/AWS A5.01.

A5. Ventilation During Brazing

A5.1 The following five major factors govern the quantity of fumes to which brazers and brazing operators can be exposed during brazing:

- (1) Dimensions of the space in which brazing is done (with special regard to the height of the ceiling)
- (2) Number of brazers and brazing operators working in that space
- (3) Rate of evolution of fumes, gases, or dust, according to the materials and processes involved
- (4) The proximity of the brazer or brazing operators to the fumes as they issue from the brazing zone, and to the gases and dusts in the space in which they are working
- (5) The ventilation provided to the space in which the brazing is done

A5.2 American National Standard Z49.1-88 discusses the ventilation that is required during welding and should be referred to for details. Attention is particularly drawn to Section 5 of that document, “Ventilation.”

A6. Brazing Considerations

A6.1 To avoid confusion, solidus and liquidus are specified instead of melting and flow points. The terms solidus and liquidus are defined as follows:⁶

- (1) *Solidus*. The highest temperature under equilibrium conditions at which the metal is completely solid; that is, the temperature at which melting starts.
- (2) *Liquidus*. The lowest temperature under equilibrium conditions at which the metal is completely liquid; that is, the temperature at which freezing starts.

A6.2 Table A1 in the Appendix lists the solidus, liquidus, and also 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),

⁶ ASM Handbook, 8th Ed. Vol 1.

TABLE A1
SOLIDUS, LIQUIDUS, AND BRAZING TEMPERATURE RANGES*

AWS Classification	Solidus		Liquidus		Brazing Temperature Range	
	°F	°C	°F	°C	°F	°C
SILVER						
BAg-1	1125	607	1145	618	1145-1400	618-760
BAg-1a	1160	627	1175	635	1175-1400	635-760
BAg-2	1125	607	1295	702	1295-1550	702-843
BAg-2a	1125	607	1310	710	1310-1550	710-843
BAg-3	1170	632	1270	688	1270-1500	688-816
BAg-4	1240	671	1435	779	1435-1650	779-899
BAg-5	1225	663	1370	743	1370-1550	743-843
BAg-6	1270	688	1425	774	1425-1600	774-871
BAg-7	1145	618	1205	652	1205-1400	652-760
BAg-8	1435	779	1435	779	1435-1650	779-899
BAg-8a	1410	766	1410	766	1410-1600	766-871
BAg-9	1240	671	1325	718	1325-1550	718-843
BAg-10	1275	691	1360	738	1360-1550	738-843
BAg-13	1325	718	1575	857	1575-1775	857-968
BAg-13a	1420	771	1640	893	1600-1800	871-982
BAg-18	1115	602	1325	718	1325-1550	718-843
BAg-19	1400	760	1635	891	1610-1800	877-982
BAg-20	1250	677	1410	766	1410-1600	766-871
BAg-21	1275	691	1475	802	1475-1650	802-899
BAg-22	1260	680	1290	699	1290-1525	699-830
BAg-23	1760	960	1780	970	1780-1900	970-1038
BAg-24	1220	660	1305	750	1305-1550	750-843
BAg-26	1305	705	1475	800	1475-1600	800-870
BAg-27	1125	605	1375	745	1375-1575	745-860
BAg-28	1200	649	1310	710	1310-1550	710-843
BAg-33	1125	607	1260	682	1260-1400	681-760
BAg-34	1200	649	1330	721	1330-1550	721-843
BAg-35	1265	685	1390	754	1390-1545	754-841
BAg-36	1195	646	1251	677	1251-1495	677-813
BAg-37	1270	688	1435	779	1435-1625	779-885
BVAg-0	1761	961	1761	961	1761-1900	961-1038
BVAg-6b	1435	779	1602	872	1600-1800	871-982
BVAg-8	1435	779	1435	779	1435-1650	779-899
BVAg-8b	1435	779	1463	795	1470-1650	799-899
BVAg-18	1115	602	1325	718	1325-1550	718-843
BVAg-29	1155	624	1305	707	1305-1450	707-788
BVAg-30	1485	807	1490	810	1490-1700	810-927
BVAg-31	1515	824	1565	852	1565-1625	852-885
BVAg-32	1650	900	1740	950	1740-1800	950-982
GOLD						
BAu-1	1815	991	1860	1016	1860-2000	1016-1093
BAu-2	1635	891	1635	891	1635-1850	891-1010
BAu-3	1785	974	1885	1029	1885-1995	1029-1091
BAu-4	1740	949	1740	949	1740-1840	949-1004
BAu-5	2075	1135	2130	1166	2130-2250	1166-1232
BAu-6	1845	1007	1915	1046	1915-2050	1046-1121
BVAu-2	1635	891	1635	891	1635-1850	891-1010
BVAu-4	1740	949	1740	949	1740-1840	949-1004
BVAu-7	2015	1102	2050	1121	2050-2110	1121-1154
BVAu-8	2190	1200	2265	1240	2265-2325	1240-1274

TABLE A1 (CONT'D)
SOLIDUS, LIQUIDUS, AND BRAZING TEMPERATURE RANGES*

AWS Classification	Solidus		Liquidus		Brazing Temperature Range	
	°F	°C	°F	°C	°F	°C
PALLADIUM						
BVPd-1	2245	1230	2255	1235	2255-2285	1235-1252
ALUMINUM						
BAISi-2	1070	577	1142	617	1110-1150	599-621
BAISi-3	970	521	1085	585	1060-1120	571-604
BAISi-4	1070	577	1080	582	1080-1120	582-604
BAISi-5	1070	577	1095	591	1090-1120	588-604
BAISi-7	1038	559	1105	596	1090-1120	588-604
BAISi-9	1044	562	1080	582	1080-1120	582-604
BAISi-11	1038	559	1105	596	1090-1120	588-604
COPPER						
BCu-1	1981	1083	1981	1083	2000-2100	1093-1149
BCu-1a	1981	1083	1981	1083	2000-2100	1093-1149
BVCu-1X	1981	1083	1981	1083	2000-2100	1093-1149
BCu-2	1981	1083	1981	1083	2000-2100	1093-1149
RBCuZn-A	1630	888	1650	899	1670-1750	910-954
RBCuZn-B	1590	866	1620	882	1620-1800	882-982
RBCuZn-C	1590	866	1630	888	1670-1750	910-954
RBCuZn-D	1690	921	1715	935	1720-1800	938-982
BCuP-1	1310	710	1695	924	1450-1700	788-927
BCuP-2	1310	710	1460	793	1350-1550	732-843
BCuP-3	1190	643	1495	813	1325-1500	718-816
BCuP-4	1190	643	1325	718	1275-1450	691-788
BCuP-5	1190	643	1475	802	1300-1500	704-816
BCuP-6	1190	643	1450	788	1350-1500	732-816
BCuP-7	1190	643	1420	771	1300-1500	704-816
NICKEL						
BNi-1	1790	977	1900	1038	1950-2200	1066-1204
BNi-1a	1790	977	1970	1077	1970-2200	1077-1204
BNi-2	1780	971	1830	999	1850-2150	1010-1177
BNi-3	1800	982	1900	1038	1850-2150	1010-1177
BNi-4	1800	982	1950	1066	1850-2150	1010-1177
BNi-5	1975	1079	2075	1135	2100-2200	1149-1204
BNi-5a	1931	1065	2111	1150	2100-2200	1149-1204
BNi-6	1610	877	1610	877	1700-2000	927-1093
BNi-7	1630	888	1630	888	1700-2000	927-1093
BNi-8	1800	982	1850	1010	1850-2000	1010-1093
BNi-9	1930	1055	1930	1055	1950-2200	1066-1204
BNi-10	1780	970	2020	1105	2100-2200	1149-1204
BNi-11	1780	970	2003	1095	2100-2200	1149-1204
COBALT						
BCo-1	2050	1120	2100	1149	2100-2250	1149-1232
MAGNESIUM						
BMg-1	830	443	1110	599	1120-1160	604-627

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

the several constituents of the filler metals tend to separate during the melting process. The lower melting constituent will flow, leaving behind an unmelted residue or skull of the high-melting constituent. This occurrence, called liquation, is usually undesirable in that the unmelted skull does not readily flow into the joint. However, where wide joint clearance occurs, a filler metal with a wide temperature range will usually fill the capillary joint more easily.

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

A7. Brazing Characteristics and Applications

A7.1 BAg Classifications (Silver). Brazing filler metals of the BAg classifications are used for joining most ferrous and nonferrous metals, except aluminum and magnesium. These filler metals have good brazing properties and are suitable for preplacement in the joint, or for manual feeding into the joint. Although lap joints are generally used, butt joints may be used if requirements are less stringent. Joint clearances of 0.001 to 0.005 in. (0.025 to 0.13 mm) are recommended for proper capillary action. Flux is generally required, however, on most metals. When furnace brazing in a protective atmosphere, flux is generally not required. If filler metals containing zinc or cadmium are used in a protective atmosphere furnace, the zinc or cadmium is vaporized changing chemical composition as well as the solidus and liquidus. Therefore, filler metals free of cadmium or zinc are recommended for furnace brazing in a protective atmosphere.

A7.1.1 BAg-1 brazing filler metal has the lowest brazing temperature range of the BAg filler metals. It also flows most freely into narrow clearance capillary joints. Its narrow melting range is suitable for rapid or slow methods of heating. This filler metal contains cadmium. The special precautions of the warning label in 17.4 should be followed. BAg-1 is more economical (less silver) than BAg-1a.

A7.1.2 BAg-1a brazing filler metal has properties similar to 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 : 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 where low-temperature, free-flowing filler metals are desired. This filler metal contains cadmium. The special precautions of the warning label in 17.4 should be followed.

A7.1.3 BAg-2 brazing filler metal, like BAg-1, is free-flowing and suited for general-purpose work. Its broader melting range is helpful where clearances are wide or are not uniform. Unless heating is rapid, care must be taken that the lower melting constituents do not separate out by liquation. This filler metal contains cadmium, and the special precautions of the warning label in 17.4 should be followed.

A7.1.4 BAg-2a brazing filler metal is similar to BAg-2, but is more economical than BAg-2, since it contains five percent less silver. This filler metal contains cadmium. The special precautions of the warning label in 17.4 should be followed.

A7.1.5 BAg-3 brazing filler metal is a modification of BAg-1a, i.e., nickel is added. It has good corrosion resistance in marine environment and caustic media. When used on stainless steel, it will inhibit crevice (interface) corrosion. Because its nickel content improves wettability on tungsten carbide tool tips, the largest use is to braze carbide tool assemblies. Melting range and low fluidity make BAg-3 suitable for forming larger fillets or filling wide joint clearances. This filler metal contains cadmium. The special precautions of the warning label in 17.4 should be followed.

A7.1.6 BAg-4 brazing filler metal, like BAg-3, is used extensively for carbide tip brazing, but flows less freely than BAg-3. This filler metal does not contain cadmium.

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

A7.1.8 BAg-7 brazing filler metal, a cadmium-free substitute for BAg-1, is low-melting with good flow and wetting properties. Typical applications include the following:

(1) For food equipment where cadmium must be avoided

(2) To minimize stress corrosion cracking of nickel or nickel-base alloys at low brazing temperatures

(3) Where the white color will improve color match with the base metal

A7.1.9 BAg-8 brazing filler metal 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-base alloys and carbon steel, although its wetting action on these metals is slow. Higher brazing temperatures will improve flow and wetting.

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

A7.1.11 BAg-9 and -10 filler metals are used particularly for joining sterling silver. These filler metals have different brazing temperatures and so can be used for step brazing of successive joints. The color, after brazing, approximates the color of sterling silver.

A7.1.12 BAg-13 brazing filler metal is used for service temperatures up to 700°F (370°C). Its low zinc content makes it suitable for furnace brazing.

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

A7.1.14 BAg-18 brazing filler metal 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 where fluxless brazing is important.

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

A7.1.16 BAg-20 brazing filler metal 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, freedom from cadmium, and a more economical silver content, new uses for this filler metal are being developed.

A7.1.17 BAg-21 brazing filler metal is used in brazing AISI 300 and 400 series stainless steels, as well as the precipitation hardening nickel and steel alloys. BAg-21 is particularly suited to furnace brazing in a protective atmosphere because of the absence of zinc and cadmium. It does not require a flux for proper brazing when the temperature is 1850°F (1010°C) or above. It requires a high brazing temperature, and it flows in a sluggish manner. The nickel-rich layer (halo) formed along the fillet edges during melting and flow of the filler metal prevent 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.

A7.1.18 BAg-22 is a low-temperature, cadmium-free filler metal with improved brazing characteristics over BAg-3, particularly in brazing tungsten carbide tools.

A7.1.19 BAg-23 is a high-temperature, free-flowing filler metal usable both for torch brazing and furnace brazing in a protective atmosphere. This filler metal is mainly used in brazing stainless steel, nickel-base and cobalt-base alloys for high-temperature applications. If this filler metal is used in a hard vacuum atmosphere, a loss of manganese will occur due to its high vapor pressure. Thus, a soft vacuum, produced by inert gas back filling a hard vacuum, is desirable when brazing with this filler metal.

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

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

A7.1.22 BAg-27 brazing filler metal is similar to BAg-2 but has lower silver and is somewhat more

subject to liquation, due to a wider melting range. This filler metal contains cadmium. The special precautions of the warning label in 17.4 should be followed.

A7.1.23 BAg-28 brazing filler metal 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.

A7.1.24 BAg-33 brazing filler metal was developed to minimize brazing temperature for a filler metal containing 25 percent 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. The special precautions of the warning label in 17.4 should be followed.

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

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

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

A7.1.28 BAg-37 brazing filler metal is a cadmium-free material frequently used for brazing steel, copper and brass. The low silver content makes it an economical filler metal suitable for applications where lower ductility is acceptable.

A7.2 BAu Classifications (Gold). Brazing filler metals of the BAu classifications are used for the brazing of iron, nickel, and cobalt base metals where better ductility or a greater resistance to oxidation and corrosion is required. Because of their low rate of interaction with the base metal, they are commonly used on thin base metals. These filler metals are usually used with induction, furnace, or resistance brazing in a protective atmosphere. In these cases, no flux is used. For other applications, a borax-boric acid flux is used.

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

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

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

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

A7.3 BAISi Classifications (Aluminum-Silicon). Brazing filler metals of the BAISi classifications are used for joining the following grades of aluminum and aluminum alloys: 1060, 1350, 1100, 3003, 3004, 3005, 5005, 5050, 6053, 6061, 6951, 7005, and cast alloys 710.0 and 711.0. Joint clearances of 0.006 to 0.010 in. (0.15 to 0.25 mm) are common for members which overlap less than $\frac{1}{4}$ in. (6.4 mm). Joint clearances up to 0.025 in. (0.64 mm) are used for members which overlap more than $\frac{1}{4}$ in. Fluxing is essential for all processes, except when brazing aluminum in a vacuum. After brazing with flux, the brazed parts should be cleaned thoroughly. Immersion in boiling water generally will remove the residue. If this is not adequate, the parts are usually immersed in a concentrated commercial nitric acid, or other suitable acid solution and then rinsed thoroughly.

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

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

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

A7.3.4 BAISi-5 brazing filler metal 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. BAISi-5 is used for furnace and dip brazing at a lower temperature than BAISi-2. The core alloy employed in brazing sheet with this filler metal cladding can be solution heat-treated and aged.

A7.3.5 BAlSi-7 is a filler metal suitable for brazing in a vacuum, 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.

A7.3.6 BAlSi-9 is a filler metal suitable for brazing in a vacuum, 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.

A7.3.7 BAlSi-11 is a brazing sheet clad on one or two sides of alloy 3105 to form a composite sheet suitable for brazing in a vacuum, designed for brazing in a multizone furnace where the vacuum level is interrupted one or more times during a brazing cycle. The composite can be used in batch-type vacuum furnaces; however, vacuum sheet suitable for brazing with a 3003 core is more resistant to erosion. The maximum brazing temperature for the BAlSi-11/3105 composite is 1110°F (595°C).

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

A7.4.1 BCuP-1 brazing filler metal is particularly suited for resistance brazing applications. This filler metal is somewhat more ductile and less fluid at brazing temperature than other BCuP filler metals containing more phosphorus. Joint clearances of 0.003 to 0.005 in. (0.08 to 0.13 mm) are recommended.

A7.4.2 BCuP-2 and -4 brazing filler metals are very fluid at brazing temperatures and will penetrate joints with small clearances. Best results are obtained with clearances of 0.001 to 0.003 in. (0.03 to 0.08 mm).

A7.4.3 BCuP-3 and -5 brazing filler metals may be used where narrow joint clearances cannot be held.

Joint clearances of 0.002 to 0.005 in. (0.06 to 0.13 mm) are recommended.

A7.4.4 BCuP-6 brazing filler metal 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 0.002 to 0.005 in. (0.06 to 0.13 mm) are recommended.

A7.4.5 BCuP-7 brazing filler metal is slightly more fluid than BCuP-3 or -5 and has a lower liquidus temperature. It is used extensively in the form of preplaced rings in heat exchanger and tubing joints. Joint clearances of 0.002 to 0.005 in. (0.06 to 0.13 mm) are recommended.

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

A7.5.1 BCu-1 brazing filler metal is used for joining ferrous metals, nickel-base 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 and generally no flux. On metals that have constituents with difficult-to-reduce oxides (chromium, manganese, silicon, titanium, vanadium, and aluminum) a flux may be required. However, pure dry hydrogen, argon, dissociated ammonia, and vacuum atmospheres are suitable for base metals containing chromium, manganese, or silicon. Flux also may be used with zinc-containing base metals to retard vaporization. Vacuum atmospheres, electrolytic nickel plating, or both, are used for base metals containing titanium and aluminum.

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

A7.5.3 BCu-2 brazing filler metal is supplied as a copper-oxide suspension in an organic vehicle. Its applications are similar to BCu-1 and -1a.

A7.5.4 RBCuZn-A⁷ brazing filler metal is used on steels, copper, copper alloys, nickel, nickel alloys, and stainless steel where corrosion resistance is not of

⁷RBCuZn-X Filler metals are used for braze welding applications.

importance. It is used with torch, furnace, and induction brazing processes. Fluxing is generally required, and a borax-boric acid flux is commonly used. Joint clearances from 0.002 to 0.005 in. (0.05 to 0.13 mm) are suitable.

A7.5.5 RBCuZn-B (low-fuming brass-nickel) welding rods are similar to RBCuZn-A, but contain additions of iron and manganese which serve to increase the hardness and strength. In addition, a small amount of silicon (0.04-0.15 percent) serves to control the vaporization of the zinc; hence, the "low-fuming" property. The nickel addition (0.2 to 0.8 percent) assures uniform distribution of the iron in the deposit.

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

A7.5.6 RBCuZn-C brazing filler metal is used on steels, copper, copper alloys, nickel, nickel alloys, and stainless steel. It is used with the torch, furnace, and induction brazing processes. Fluxing is required, and a borax-boric acid flux is commonly used. Joint clearances from 0.002 to 0.005 in. (0.05 to 0.13 mm) are suitable.

A7.5.7 RBCuZn-D brazing filler metal (called nickel silver) is primarily used for brazing tungsten carbide. It is also used with steel, nickel, and nickel alloys. It can be used with all brazing processes. This filler metal is unsuitable for furnace brazing in a protective atmosphere.

A7.6 BNi Classification (Nickel). Brazing filler metals of the BNi classifications are generally used for their corrosion-resistant and heat-resistant properties. The BNi filler metals have excellent properties at high-service temperatures. They are also satisfactorily used for room-temperature applications and where the service temperatures are equal to the temperature of liquid oxygen, helium, or nitrogen. Best quality can be obtained by brazing in an atmosphere which is reducing to both the base metal and the brazing filler metal.

Narrow joint clearances and postbrazing thermal diffusion cycles are often employed to minimize the presence of intermetallic compounds and low-ductility joint conditions. When BNi filler metals are used with the torch, air-atmosphere furnace, and induction brazing processes, a suitable flux must be used. BNi filler metals are particularly suited to vacuum systems and vacuum tube applications because of their low vapor pressure. Chromium is the limiting element in metals to be used in vacuum applications. It should be noted that when

phosphorus is combined with some other elements, these compounds have very low vapor pressures and can be readily used in a vacuum brazing atmosphere of 1×10^{-3} Torr (0.13 Pa) at 1950°F (1066°C) without removal of the phosphorus.

Greater strength and ductility in this group of filler metals is obtainable by diffusion brazing.

A7.6.1 BNi-1 filler metal was the first of the nickel filler metals to be developed. The nickel, chromium, and iron contents render it suitable for brazing nickel, chromium or iron base metals. While high carbon content in 300 series stainless steels is usually metallurgically undesirable from a corrosion standpoint, the high carbon in BNi-1 would appear to make it undesirable for brazing stainless steels. The Strauss test for corrosion has been run by one aircraft engine company and did not show any adverse effect of the high-carbon content on the corrosion resistance of joints in base metals such as AISI 347 stainless steels. The reason given for this is that the carbon is already tied up with the chromium in the filler metal.

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

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

A7.6.4 BNi-3 brazing filler metal is used for applications similar to BNi-1 and BNi-2 and is less sensitive to marginally protective atmospheres.

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

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

A7.6.7 BNi-5a is a modified BNi-5 composition with a reduced silicon content plus a small addition of boron. The presence of boron excludes this alloy from nuclear applications. Otherwise, the applications are similar to those of BNi-5. High-strength joints can

be produced. BNi-5a material can be used in place of BNi-1 filler metal where a reduced level of boron is desired. The brazing of thin-gauge honeycomb to sheet metal base parts is a typical application.

A7.6.8 BNi-6 brazing filler metal is free-flowing and is used in marginally protective atmospheres and for brazing low-chromium steels in exothermic atmospheres.

A7.6.9 BNi-7 brazing filler metal is used for the brazing of honeycomb structures, thin-walled tube assemblies, and other structures which are used at high temperatures. It is recommended for nuclear applications where boron cannot be used. The best results are obtained when it is used in the furnace brazing process. Microstructure and ductility of the joint are improved by increasing time at brazing temperature.

A7.6.10 BNi-8 brazing filler metal is used in honeycomb brazements and on stainless steels and other corrosion-resistant base metals. Since this filler metal contains a high percentage of manganese, special brazing procedures should be observed. As manganese oxidizes more readily than chromium, the hydrogen, argon, and helium brazing atmospheres must be pure and very dry, with a dew point of -70°F (-57°C) or below. The vacuum atmosphere must have low pressure and a low leak rate to insure a very low partial pressure of oxygen. It should be noted that the chemical composition and the melting characteristics of this filler metal will change when the manganese is oxidized or vaporized during brazing in gas or vacuum atmospheres. However, the effect of manganese is not a problem in an atmosphere of proper quality.

A7.6.11 BNi-9 brazing filler metal is a eutectic nickel-chromium-boron filler metal that is particularly well suited for diffusion brazing applications. Boron has a small molecular diameter, thus it diffuses rapidly out of the brazed joint, leaving the nickel-chromium alloy in the joint along with elements that diffuse from the base metal into the joint, such as aluminum, titanium, etc. Depending on the diffusion time and temperature, the joint remelt temperature can be above 2500°F (1371°C) and, depending on the base metal, the hardness can be as low as HRB70. With further diffusion time, the grains can grow across the joint, and it may appear as all base metal. The single solidus and liquidus temperature (eutectic) eliminates the possibility of liquation and thus helps in brazing thick sections that require slower heating.

A7.6.12 BNi-10 brazing filler metal is a high-strength material for high-temperature applications. The tungsten is a matrix strengthener which makes it useful for brazing base metals containing cobalt, molybdenum, and tungsten. This filler metal has a wide melting range and has been used for brazing cracks in .020 in. (0.5 mm) thick combustion chambers. It results in a layer of filler metal across the joint which acts as a doubler while the lower melting constituent is fluid enough to flow through the thin crack and produce a suitable brazement.

A7.6.13 BNi-11 brazing filler metal is a strong material for high-temperature brazement applications. The tungsten matrix hardener makes it suitable for brazing base metals containing cobalt, molybdenum, and tungsten. With its wider melting range, it is suitable for slightly higher than normal brazing clearances.

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

A7.8 BMg Classification (Magnesium). Brazing filler metal BMg-1 is used for joining AZ10A, K1A, and M1A magnesium alloys.

A7.9 Filler Metals for Vacuum Service. These brazing filler metals are specially controlled to fabricate high quality electronic devices where the service life and operating characteristics are of prime importance. Brazing filler metals for vacuum service should be used in a high-purity protective atmosphere in order to maintain the purity of the filler metal and to assure proper brazing and final brazement quality. It is very important in some applications that the brazing filler metal not spatter onto areas near the joint area. For this reason, this specification includes spatter test requirements, described in Section 11, Spatter Test, for the vacuum grade classifications.

In addition to these special grades, BCo-1 and all BNi brazing filler metals, except BNi-8, are suitable for vacuum service.

A8. Discontinued Classifications

A number of filler metal classifications have been discontinued during the numerous revisions of this specification, reflecting changes in commercial practice over the past 40 years. These discontinued filler metal classifications are listed in Table A2, along with the date they were last published.

TABLE A2
DISCONTINUED BRAZING FILLER METAL
CLASSIFICATIONS

AWS Classification	Last 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
BAISi-1	1956
BNiCr	1956
BCuAu-1	1956
BCuAu-2	1956
BAg-11	1962
BMg2	1962
BMg2a	1976
BAISi-6	1981
BAISi-8	1981
BAISi-10	1981
BAg-25	1981
RBCuZn-E	1981
RBCuZn-F	1981
RBCuZn-G	1981
RBCuZn-H	1981
BAg-12 BAg-14 BAg-15 BAg-16 BAg-17	The Committee chose not to use these numbers as they improperly appeared in another publication.