INTERNATIONAL

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Standard Specification for Brazing Filler Metals for Electron Devices[1]

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1. Scope

1.1 This specification covers requirements or filler metals suitable for brazing internal parts and other critical areas of electron devices in a nonoxidizing atmosphere (Note 1).

1.2 These materials are available in strip or wire or preforms made by blanking the strip or bending the wire. Powders are also available.

NOTE 1—Brazing filler metals for general applications are specified in AWS Specification A 5.8.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B214 Test Method for Sieve Analysis of Metal Powders

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

F19 Test Method for Tension and Vacuum Testing Metallized Ceramic Seals

2.2 *American Welding Society:*[3]

A 5.8 Specification for Brazing Filler Metals

C 3.2 Method for Evaluating the Strength of Brazed Joints

C 3.3 Recommended Practices for Design, Manufacture and Inspection of Critical Brazed Components

3. Classification

3.1 Brazing filler metals which are vacuum grade and are classified on the basis of chemical composition shown in Table 1. The difference between Grade 1 and 2 is the allowable impurity content. Grade 1 requires generally lower levels of impurities.

4. Ordering Information

4.1 Orders for material to this specification shall include the following information:

4.1.1 Quantity,

4.1.2 Dimensions and tolerances (Table 2),

4.1.3 Form (rod, bar, wire, etc.),

4.1.4 AWS classification (Table 1),

4.1.5 Grade 1,

4.1.6 Special requirements or exceptions, and

4.1.7 *Certification*— State if certification is required.

5. Materials and Manufacture

5.1 The brazing filler metals shall be vacuum grade and fabricated by any method that yields a product conforming to the requirements of this specification.

6. Chemical Composition

6.1 The finished brazing filler metal shall conform to the chemical composition shown in Table 1 for Grade 1 material.

7. Mechanical Properties

7.1 Unless otherwise specified, wire shall be furnished in soft temper most suitable for hand feeding or ring winding on mandrels. A minimum elongation of 10 % in 2 in. (50.8 mm) indicates that the wire is annealed.

7.2 Unless otherwise specified, strip shall be furnished in hard as-rolled temper to facilitate clean blanking of thin shims or preforms. A maximum elongation of 5 % in 2 in. (50.8 mm) designates the strip as hard.

8. Dimensions and Permissible Variations

8.1 These materials must conform to the dimensional limitations listed in Table 2 for strip, wire, and preforms or to Table 3 for the size distribution of powdered brazing filler metals.

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[1] This specification is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.03 on Metallic Materials, Wire Bonding, and Flip Chip.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126.

TABLE 1 Chemical Composition Requirements (in Wt. %) for Vacuum Grade Filler Metals for Electron Devices[A,B,C]

NOTE 1—All finished material shall be reasonably smooth and bright and free from dirt, oil, grease, or other foreign material.

NOTE 2— A complete designation of specified material must include the grade designation number (for example, BVAg-6b, Grade 1).

NOTE 3—Single values shown are maximum percentages, except where otherwise specified.

AWS Classification	UNS Designation	Ag	Au	Cu	Ni	Co	Sn	Pd	In	Zn	Cd	Pb	P	C
Grade 1-Vacuum grade filler metals														
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 - Vacuum grade filler metals														
BVCu-1x	C14181	. . .	. . .	99.99 min.	. . .	. . .	. . .	. . .	. . .	0.002	0.002	0.002	0.002	0.005

[A] All vacuum grade filler metals are considered to be spatter free (refer to Melting Test, Section 10).
[B] 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, Tl, S, Cs, Rb, Sc, Hg, Tc, Sr, and Ca) are limited to 0.001 % max each for Grade 1 vacuum grade filler metals and 0.002 % max each for Grade 2 vacuum grade filler metals. The accumulative total of all these high vapor pressure elements including zinc, cadmium, and lead is limited to 0.010 % max. The total of other impurities not included in the preceding list is limited to 0.05 % max, except for BVCu-1x, which shall be 0.01 max.
[C] For the braze alloys shown, analysis shall regularly be made only for the major alloying elements specified and the elements Zn, Cd, Pb, P, C (by Melting Test), Hg, Mg, and Sb. However, the presence of the other elements (listed above in Footnote B), with a vapor pressure higher than 10^{-7} Torr at 932°F (500°C), outside the limits specified shall constitute cause for rejection of the material.

TABLE 2 Dimensional Tolerances (All Plus or Minus)

Width Tolerances, in. (mm)		
Thickness	8 in. (200 mm) wide and under	Over 8 in. (200 mm) wide
Less than 0.020 (0.5)	0.005 (0.125)	0.015 (0.38)
0.020 to 0.050 (0.5 to 1.25), incl	0.010 (0.250)	0.015 (0.38)
Thickness Tolerances—Strip		
Thickness, in. (mm)	8 in. (200 mm) wide and under	Over 8 in. (200 mm) wide
Up to 0.002 (0.05), incl	0.0002 (0.005)	0.0005 (0.0125)
Over 0.002 to 0.003 (0.05 to 0.075), incl	0.0003 (0.0075)	0.0006 (0.015)
Over 0.003 to 0.004 (0.075 to 0.10), incl	0.0004 (0.010)	0.0007 (0.018)
Over 0.004 to 0.006 (0.10 to 0.15), incl	0.0005 (0.0125)	0.0008 (0.02)
Over 0.006 to 0.013 (0.15 to 0.33), incl	0.0010 (0.025)	0.0013 (0.033)
Over 0.013 to 0.021 (0.33 to 0.53), incl	0.0015 (0.038)	0.0018 (0.046)
Over 0.021 to 0.026 (0.53 to 0.66), incl	0.0020 (0.05)	0.0020 (0.05)
Over 0.026 to 0.050 (0.66 to 0.125), incl	0.0020 (0.05)	0.0050 (0.125)
Camber Tolerances—Strip (Edgewise Bowl)		
0.5 in. (12.5 mm) max in 6 ft (1.8 m)		
Diameter Tolerances—Wire		
Diameter, in. (mm)	Tolerance, in. (mm)	
0.010 to 0.020 (0.250 to 0.5)	0.0003 (0.0075)	
Over 0.020 to 0.030 (0.5 to 0.75)	0.0005 (0.0125)	
Over 0.030 to 0.040 (0.75 to 1.0)	0.0007 (0.018)	
Over 0.040 to 0.050 (1.0 to 1.25)	0.0008 (0.02)	
Over 0.050 to 0.060 (1.25 to 1.5)	0.0010 (0.025)	
Over 0.060 to 0.080 (1.5 to 2.0)	0.0015 (0.038)	
Over 0.080 to 0.250 (2.0 to 6.3)	0.0020 (0.05)	

TABLE 3 Standard Sieve Analyses[A]

100 mesh	through No. 60 sieve—100 % min through No. 100 sieve—95 % min
140°C mesh	on No. 100 sieve—trace on No. 140 sieve—10 % max through No. 325 sieve—20 % max
140°F mesh	on No. 100 sieve—trace on No. 140 sieve—10 % max through No. 325 sieve—55 % max
325 mesh	on No. 200 sieve—trace on No. 325 sieve—10 % max through No. 325 sieve—90 % min

[A] These are standard ASTM sieve sizes selected from Table 2 of Specification E11. Sieve tests are conducted in accordance with the latest edition of Test Method B214.

9. Finish

9.1 The surface of strip, wire, or preforms shall be as smooth and free of dirt, oxide, pits, deep scratches, seams, slivers, stains, scale, blisters, edge cracks, trimming burrs, waves, wrinkles, and other defects as best commercial practice will permit.

10. Melting Test (for Cleanness and Spatter)

10.1 *Requirements*— Since cleanness and spattering are important considerations in the use of these materials, a special melting test is used to determine their suitability. For this test, the melting temperatures required are listed in Table X1.1. The material shall also comply with the requirements of 10.2.4.

10.2 *Procedure:*

10.2.1 The melting test is performed on an "as-received" sample. Cut approximately 1 g (with clean, dry tools) into a clean, dense polycrystalline 99.5 % alumina crucible or clean, fused silica crucible or boat which has been precleaned by air firing at 2012°F (1100°C), min, and stored in a dry, dust-free location until required.

10.2.2 Place samples and crucible in a dense polycrystalline or fused silica combustion tube muffle or equivalent, purge with dry −40°F (−40°C) hydrogen, and heat to 36°F (20°C) above the liquidus, hold for 10 min, and then cool to under 149°F (65°C) before stopping the hydrogen flow and removing the sample for inspection.

NOTE 2—If the sample does not melt under these conditions, the composition is wrong or the temperature measurement is incorrect.

10.2.3 If it is desired also to test for spattering, bridge the crucible or boat by a nickel channel whose legs are designed to allow a small clearance, 0.06 in. (1.6 mm) max. above the crucible. An additional requirement is that the bridge be no more than 0.38 in. (9.5 mm) above the metal bead.

10.2.4 Examine the metal bead at 5× magnification. Just a light smokiness with no discrete black specks is the worst that is permitted. Since this examination depends on experience and judgment, standards can be developed by running carbon determinations and comparing with the maximum carbon limitation listed in Table 1.

10.2.5 If the spatter test is run, examine the bottom side of the nickel bridge, also at 5× magnification, for evidence of any spatter.

11. Rejection

11.1 The seller's responsibility will be limited to replacement of any filler metal that does not conform to the requirements of this specification.

12. Certification

12.1 A certification, when requested by the user, based on the manufacturer's quality control that the material conforms to the requirements of this specification, shall be furnished upon request of the purchaser, provided the request is made at the time of cost quotation and at the time of order placement.

13. Packaging and Marking

13.1 *Packaging*—The brazing filler metal shall be packaged in such a way that it will arrive at its destination clean and undamaged.

13.2 *Marking*—All packages of brazing filler metal shall be marked with:

13.2.1 AWS specification numbers and classifications,

13.2.2 Seller's name and trade designation,

13.2.3 Size or part description in the case of preforms.

13.2.4 Net weight or scale count in the case of preforms, and

13.2.5 Lot, control or heat number.

14. Keywords

14.1 braze alloys; electron devices; melting test for cleanness and spatter

APPENDIX

(Nonmandatory Information)

X1. GUIDE TO AWS CLASSIFICATION OF VACUUM GRADE FILLER METALS FOR ELECTRON DEVICE APPLICATIONS

X1.1 General

X1.1.1 This guide is appended to this specification as a source of information; it is not mandatory and does not form a mandatory part of this specification. It has been prepared as an aid to users of vacuum grade brazing filler metals to help them determine which classification of filler metal is best for a particular application.

X1.1.2 This specification is intended to provide both the supplier and the user of brazing filler metals with a means of production control and a basis of acceptance through mutually acceptable standard requirements.

X1.1.3 Brazing filler metals are metals that are added when making a braze. They have melting points below those of the metals being brazed and above 840°F (450°C) with properties suitable for making joints by capillary attraction between closely fitted surfaces.

X1.1.4 All classifications of filler metals in this specification are considered to be spatter-free.

X1.2 Method of Classification

X1.2.1 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, in part, on the base materials and filler metal used. Therefore, a classification method based on mechanical properties would be misleading since it would only apply to the specific combination of base material and filler metal that generated the data. If a user of brazing filler metal desires to determine the mechanical properties of a given base metal, filler metal, and joint design combination, tests should be conducted using either Test Method F19 or the latest edition of AWS Method C 3.2.

X1.2.2 Vacuum grade brazing filler metals are standardized into four groups of classifications as follows: silver, gold, palladium and copper. These classifications are used for joining applications for vacuum tubes and other electron devices. For these critical applications, it is necessary to hold the high vapor pressure elements to a minimum, as they usually become" emitters" during operation of the device. Each classification is available in two grades, Grade 1 and Grade 2; Grade 1 to indicate the most stringent requirements on emitter impurities and Grade 2 to indicate less stringent requirements on emitter impurities. The only exception to this is BVCu-1x which is incorporated into this specification as Grade 2 only.

X1.2.3 The basic groups of classifications of vacuum grade brazing filler metals as shown in Table 2, are indicated by the principal element in their chemical composition. In a typical example, such as BVAg-8b, Grade 1, the B is for brazing filler metal. The V designates the filler metal as being vacuum grade. Ag stands for silver indicating that silver is the principal element in this particular brazing filler metal. (Similarly, Au is for gold, Pd is for palladium, and Cu is for copper). The designation -8b indicates a particular chemical analysis within the group. The grade suffix number indicates the requirements on emitter impurities. All classifications and grades of brazing filler metals in this specification are considered to be spatter-free.

X1.3 Brazing Procedure Considerations

X1.3.1 *Solidus and Liquidus*—Solidus and liquidus are used instead of melting and flow points. The terms solidus and liquidus are defined as follows:

X1.3.1.1 *Solidus*—The highest temperature at which the metal is completely solid; that is, the temperature at which melting starts.

X1.3.1.2 *Liquidus*—The lowest temperature at which the metal is completely liquid; that is, the temperature at which freezing starts.

X1.3.2 *Liquation*—Table X1.1 in this appendix lists the solidus, liquidus, and recommended brazing temperature range for the various vacuum grade brazing filler metals. When using some brazing filler metals (particularly those with a wide range between the solidus and liquidus), the several constituents of the filler metals tend to separate during the melting process. The lower melting constituent will flow, leaving behind a "skull" of high melting constituent. This occurrence, called liquation, is undesirable since the unmelted skull does not contribute significantly to the actual brazed joint; it does not flow into the joint. However, where fit-up is poor, a filler metal with a wide temperature range will usually fill the joint more easily.

X1.3.3 Vacuum grade filler metals should be used in a high purity atmosphere to maintain the purity of the filler metal and to assure proper brazing and final brazement quality, using a recommended brazing temperature as found in Table X1.1.

X1.3.4 Brazing requires an understanding of procedures which are beyond the scope of this appendix. The latest edition of the American Welding Society Brazing Manual should be referred to for particulars on specific procedures. Also, the latest edition of AWS C 3.3 Recommended Practices for Design, Manufacture and Inspection of Critical Brazed Components[3] should be referred to for information on procedures for critical components.

X1.4 Operating Characteristics and Usability

X1.4.1 *BVAg (Silver) Classifications* —Brazing filler metals of the BVAg classifications are used for joining most ferrous and nonferrous metals in high purity atmospheres.

X1.4.1.1 BVAg-O brazing filler metal has the same liquidus and solidus temperature well above most other silver brazing filler metals and, therefore, is excellent for use as the first braze

TABLE X1.1 Solidus, Liquidus, and Brazing Temperature Ranges

AWS Classification	Solidus		Liquidus		Brazing Temperature Ranges	
	°F	°C	°F	°C	°F	°C
BVAg -0	1761	961	1761	961	1771–1900	961–1038
-6b	1435	779	1602	872	1600–1800	871–982
-8	1435	779	1435	779	1436–1650	779–899
-8b	1435	779	1463	795	1470–1650	799–899
-18	1115	602	1325	718	1325–1550	718–843
-29	1155	624	1305	707	1305–1450	707–788
-30	1485	807	1490	810	1490–1700	810–927
-31	1515	824	1565	852	1565–1625	852–885
-32	1650	900	1740	950	1740–1800	950–982
BVAu -2	1635	891	1635	891	1635–1850	891–1010
-3	1832	1000	1886	1030	1886–1931	1030–1055
-4	1740	949	1740	949	1740–1840	949–1004
-7	2015	1102	2050	1121	2050–2110	1121–1154
-8	2190	1200	2265	1240	2265–2325	1240–1274
-9	1814	990	1850	1010	1850–1940	1010–1060
-10	1755	955	1778	970	1778–1868	970–1020
BVPd-1	2245	1230	2255	1235	2225–2285	1235–1252
BVCu-1x	1981	1083	1981	1083	2000–2100	1093–1149

in step brazing operations. It is excellent for very close joint tolerances, wets most metals and is very ductile.

X1.4.1.2 BVAg-6b brazing filler metal has better wetting characteristics on ferrous metals than BVAg-8 due to its higher copper content. It has a much broader melt range than BVAg-8 and can be used in step brazing with BVAg-8.

X1.4.1.3 BVAg-8 brazing filler metal is the silver-copper eutectic composition. Since it melts and flows at one temperature it is very fluid and useful in tight fitting joints. It works best on copper and copper alloys. It can be used on stainless steel and nickel base alloys although its wetting action on these metals is slow. Higher brazing temperatures will improve its flow and wetting.

X1.4.1.4 BVAg-8b brazing filler metal is similar to BVAg-8 except it contains a small addition of nickel. The nickel addition renders the flow of this alloy a little more sluggish but gives improved wetting action on ferrous alloys. It shows a decrease in fluidity and an increase in remelt temperature on copper and silver base metals.

X1.4.1.5 BVAg-18 brazing filler metal is similar to BVAg-8 except it contains an addition of tin. This tin addition helps promote wetting on ferrous and nickel base alloys. Being a lower melting filler metal than BVAg-8, it is useful in step brazing applications.

X1.4.1.6 BVAg-29 brazing filler metal is the lowest melting filler metal of the low vapor pressure alloys. The indium content of this filler metal improves wetting action on ferrous alloys over that obtainable with BVAg-8.

X1.4.1.7 BVAg-30, -31, and -32 brazing filler metals are silver-copper alloys which have been alloyed with different amounts of palladium. They provide better wetting than BVAg-8 on nickel, iron-nickel and iron-nickel-cobalt to moly-manganese seals. They can also be used in step brazing operations. BVAg-32 is similar in application to BVAu-4.

X1.4.2 *BVAu (Gold) Classifications* —Brazing filler metals of the BVAu classifications are used for the brazing of iron, nickel and cobalt base metals where resistance to corrosion and oxidation is required. Due to their low rate of base metal interaction they are commonly used on thin base metals. These alloys are commonly used in step brazing.

X1.4.2.1 BVAu-2 brazing filler metal is the lowest melting of the gold-copper series. It has good flow on copper, nickel, and iron-nickel base metals.

X1.4.2.2 BVAu-3 brazing filler metal is commonly used for metal/ceramic braze joints between metallized alumina ceramic and either unalloyed Molybednum or controlled expansion alloys.

X1.4.2.3 BVAu-4 brazing filler metal is used on a wide range of high temperature nickel base and ferrous alloys. It exhibits excellent wetting action and flow along with good strength, oxidation resistance, and ductility.

X1.4.2.4 BVAu-7 brazing filler metal is primarily used for joining high strength, corrosion and oxidation resistant alloys where good strength at elevated temperatures is required.

X1.4.2.5 BVAu-8 brazing filler metal is used to join nickel base alloys, stainless steels, molybdenum, and tungsten. It can also be used on titanium where fast braze cycles are employed.

X1.4.2.6 The (BVAu-10) and (BVAu-9) brazing filler metals are commonly used for metal/ceramic braze joints between metallized alumina and controlled expansion alloys.

X1.4.3 BVPd-1 brazing filler metal is a high strength, high temperature filler metal used on stainless steels, molybdenum, tungsten, and nickel base alloys.

X1.4.4 BVCu-1x brazing filler metal is excellent in step brazing and in applications where very tight joint clearances must be held. It has excellent wetting and flow characteristics on ferrous metals as well as on nickel and cobalt base alloys.