Designation: B32 – 20

Standard Specification for Solder Metal[1]

This standard is issued under the fixed designation B32; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers solder metal alloys (commonly known as soft solders) used in non-electronic applications, including but not limited to, tin-lead, tin-antimony, tin-antimony-copper-silver, tin-antimony-copper-silver-nickel, tin-silver, tin-copper-silver, and lead-tin-silver, used for the purpose of joining together two or more metals at temperatures below their melting points. Electronic grade solder alloys and fluxed and non-fluxed solid solders for electronic soldering applications are not covered by this specification as they are under the auspices of IPC – Association Connecting Electronic Industries.

1.1.1 These solders include those alloys having a liquidus temperature not exceeding 800°F (430°C).

1.1.2 This specification includes solders in the form of solid bars, ingots, powder and special forms, and in the form of solid and flux-core ribbon, wire, and solder paste.

1.2 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.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety, health, and environmental practices, and determine the applicability of regulatory limitations prior to use.*

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]

D269 Test Method for Insoluble Matter in Rosin and Rosin Derivatives

D464 Test Methods for Saponification Number of Pine Chemical Products Including Tall Oil and Other Related Products

D465 Test Methods for Acid Number of Pine Chemical Products Including Tall Oil and Other Related Products

D509 Test Methods of Sampling and Grading Rosin

E28 Test Methods for Softening Point of Resins Derived from Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E46 Test Methods for Chemical Analysis of Lead- and Tin-Base Solder (Withdrawn 1994)[3]

E51 Method for Spectrographic Analysis of Tin Alloys by the Powder Technique (Withdrawn 1983)[3]

E55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition

E87 Methods for Chemical Analysis of Lead, Tin, Antimony and Their Alloys (Photometric Method) (Withdrawn 1983)[3]

E88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition

2.2 *Federal Standard:* [4]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

2.3 *Military Standard:* [5]

MIL-STD-129 Marking for Shipment and Storage

3. Terminology

3.1 *Definitions:*

[1] This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.02 on Refined Lead, Tin, Antimony, and Their Alloys.

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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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, http://global.ihs.com.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

*A Summary of Changes section appears at the end of this standard

3.1.1 *producer, n*—the primary manufacturer of the material.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lot, n*—the term "lot" as used in this specification is defined as follows:

3.2.1.1 *Discussion*—For solid solder metal, a lot consists of all solder of the same type designation, produced from the same batch of raw materials under essentially the same conditions, and offered for inspection at one time.

3.2.1.2 *Discussion*—For flux–core solder, a lot consists of all solder of the same core mixture, produced from the same batch of raw materials under essentially the same conditions and offered for inspection at one time.

3.2.2 *lot number, n*—the term "lot number" as used in this specification refers to an alphanumeric or numerical designation for a lot which is traceable to a date of manufacture.

4. Classification

4.1 *Type Designation*—The type designation uses the following symbols to properly identify the material:

4.1.1 *Alloy Composition*—The composition is identified by a two-letter symbol and a number. The letters typically indicate the chemical symbol for the critical element in the solder and the number indicates the nominal percentage, by weight, of the critical element in the solder. The designation followed by the letters *A* or *B* distinguishes between different alloy grades of similar composition (see Table 1).

4.1.2 *Form*—The form is indicated by a single letter in accordance with Table 2.

4.1.3 *Flux Type*—The flux type is indicated by a letter or combination of letters in accordance with Table 3.

4.1.4 *Core Condition and Flux Percentage (applicable only to flux-cored solder)*—The core condition and flux percentage is identified by a single letter and a number in accordance with Table 4.

4.1.5 *Powder Mesh Size and Flux Percentage (applicable only to solder paste)*—The powder mesh size and flux percentage is identified by a single letter and a number in accordance with Table 5.

5. Ordering Information

5.1 Orders for material under this specification indicate the following information, as required, to adequately describe the desired material.

5.1.1 Type designation (see 4.1),

5.1.2 Detailed requirements for special forms,

5.1.3 Dimensions of ribbon and wire solder (see 9.2),

5.1.4 Unit weight,

5.1.5 Packaging (see Section 18),

5.1.6 Marking (see Section 17),

5.1.7 ASTM specification number and issue, marked on (*a*) purchase order and (*b*) package or spool, and

5.1.8 Special requirements, as agreed upon between supplier and purchaser.

6. Materials and Manufacture

6.1 The producer must have each lot of solder metal as uniform in quality as practicable and of satisfactory appearance in accordance with best industrial practices. Each bar, ingot, or other form in which the solder is sold must be uniform in composition with the entire lot.

7. Chemical Composition

7.1 *Solder Alloy*—The solder alloy composition is as specified in Table 1.

NOTE 1—By mutual agreement between supplier and purchaser, analysis may be required and limits established for elements or compounds not specified in Table 1.

7.2 *Flux (applicable to flux-core ribbon, wire, and solder paste):*

7.2.1 *Type R*—The flux is composed of Grade WW or WG gum rosin of Test Methods D509. The rosin shall have a toluene–insoluble matter content of not more than 0.05 weight % in accordance with Test Method D269, a minimum acid number of 160 mg KOH/1 g sample in accordance with Test Methods D465, a minimum softening point of 70°C in accordance with Test Methods E28, and a minimum saponification number of 166 in accordance with Test Methods D464. When solvents or plasticizers are added, they must be nonchlorinated.

7.2.2 *Type RMA*—The flux is composed of rosin conforming to 7.2.1. Incorporated additives provide a material meeting the requirements of 8.1.2 for type RMA. When solvents or plasticizers are added, they must be nonchlorinated.

7.2.3 *Type RA*—The flux is composed of rosin conforming to 7.2.1. Incorporated additives provide a material meeting the requirements of 8.1.2 for Type RA. When solvents or plasticizers are added, they must be nonchlorinated.

7.2.4 *Type OA*—The flux is composed of one or more water-soluble organic materials.

7.2.5 *Type OS*—The flux is composed of one or more water-insoluble organic materials, other than Types R, RMA, and RA, which are soluble in organic solvents.

7.2.6 *Type IS*—The flux is composed of one or more inorganic salts or acids with or without an organic binder and solvents.

8. Physical Properties and Performance Requirements

8.1 *Solder Paste*—Solder paste must exhibit smoothness of texture (no lumps) and the absence of caking and drying.

8.1.1 *Powder Mesh Size*—The solder powder mesh size shall be as specified (see 5.1.1 and 4.1.5) when the extracted solder powder is tested as specified in 13.4.

8.1.2 *Viscosity*—The viscosity of solder paste and the method used to determine the viscosity must be agreed upon between the supplier and purchaser. The following variables must be taken into account when relating one viscosity measurement to another type of viscometer used, spindle size and shape, speed (r/min), temperature of sample, and the use or non-use of a helipath.

8.2 *Requirements for Flux*—The flux must meet the physical and performance requirements specified in Table 6 as applicable.

8.2.1 *Solder Pool*—When solder is tested as specified in 13.3.2, there must be no spattering, as indicated by the presence of flux particles outside the main pool of residue. The

TABLE 1 Solder Compositions - wt% (range or maximum)

Alloy Grade	Composition, %[A]														Melting Range[B]				UNS Number
	Sn 1	Pb 2	Sb 3	Ag 4	Cu 5	Cd 6	Al 7	Bi 8	As 9	Fe 10	Zn 11	Ni 12	Ce 13	Se 14	Solidus °F	Solidus °C	Liquidus °F	Liquidus °C	
Section 1: Solder Alloys Containing Less than 0.2 % Lead[C]																			
Sn96	Rem	0.10	0.12	3.4–3.8	0.08	0.005	0.005	0.15	0.05	0.02	0.005	...	...	...	430	221	430	221	L13965
Sn95	Rem	0.10	0.12	4.4–4.8	0.08	0.005	0.005	0.15	0.05	0.02	0.005	...	...	...	430	221	473	245	L13967
Sn94	Rem	0.10	0.12	5.4–5.8	0.08	0.005	0.005	0.15	0.05	0.02	0.005	...	...	...	430	221	536	280	L13969
Sb5	94.0 min	0.20	4.5-5.5	0.015	0.08	0.005	0.005	0.15	0.05	0.04	0.005	...	...	...	450	233	464	240	L13950
E[D]	Rem	0.10	0.05	0.25–0.75	3.0–5.0	0.005	0.005	0.02	0.05	0.02	0.005	...	...	...	440	225	660	349	L13935
HA[D]	Rem	0.10	0.5–4.0	0.1–3.0	0.1–2.0	0.005	0.005	0.15	0.05	0.02	0.5–4.0	...	...	...	420	216	440	227	L13955
HB[D]	Rem	0.10	4.0–6.0	0.05–0.5	2.0–5.0	0.005	0.005	0.15	0.05	0.02	0.01	0.05–2.0	...	...	460	238	660	349	L13952
HN[D]	Rem	0.10	0.05	0.05–0.15	3.5–4.5	0.005	0.005	0.15	0.05	0.02	0.005	0.15-0.25	...	...	440	225	660	350	L13933
PT[D]	Rem	0.2	0.25–4.0	0.05–0.50	0.25–4.0	0.005	0.005	0.15	0.01	0.02	0.005	0.005	0.01-0.25	...	430	221	435	224	
AC[D]	Rem	0.10	0.05	0.2–0.3	0.1–0.3	0.005	0.005	2.75-3.75	0.05	0.02	0.005	0.001	...	...	403	206	453	234	L13964
OA[D]	Rem	0.2	0.05	0.05–0.3	2.0–4.0	0.005	0.005	0.5–1.5	0.05	0.04†	0.05	...	...	...	420	216	460	238	L13937
AM	Rem	0.10	0.8–1.2	0.4–0.6	2.8–3.2	0.005	0.005	0.15	0.05	0.02	0.005	...	...	...	430	220	446	230	L13938
TC	Rem	0.20	0.05	0.015	4.0–5.0	0.005	0.005	0.05	0.05	0.04	0.005	0.005	...	0.04-0.20	419	215	660	350	L13931
WS	Rem	0.10	1.0–1.5	0.2–0.6	3.5–4.5	0.005	0.005	0.02	0.05	0.02	0.005	...	...	...	440	225	660	350	L13939

[A] For purposes of determining conformance to these limits, an observed value or calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding method of Practice E29.

[B] Temperatures given are approximations and for information only.

[C] For alloys not identified, named elements shall conform to the following tolerances (wt%): <5 % ± 0.5 %, >=5 % ± 0.25 %; Impurity elements (maximum): Sb-0.5, Ag-0.015, Cu-0.08, Cd-0.005, Al-0.05, Bi-0.15, As-0.05, Fe-0.02, Zn-0.005.

[D] Grades E and OA are covered by U.S. patents held by Engelhard Corp, Mansfield, MA, and Oatey Co. Cleveland, OH respectively. Federated Fry Metals, Altoona, PA and Taracorp Inc., Atlanta, GA have applied for patents on grades AC and TC respectively. Grades HA, HB, and HN are covered by patents assigned to J. W. Harris Co., Cincinnati, OH. Grade PT is covered by a patent issued to Precise Alloys Corporation, Bronx, NY. Interested parties are invited to submit information regarding identification of acceptable alternatives to these patented items to the Committee on Standards, ASTM International Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

† OA value for FE 10 was corrected editorially.

TABLE 1 Solder Compositions - wt% (range or maximum) *(continued)*

Alloy Grade	Composition, %[A]														Melting Range[B]				UNS Number
	Sn 1	Pb 2	Sb 3	Ag 4	Cu 5	Cd 6	Al 7	Bi 8	As 9	Fe 10	Zn 11	Ni 12	Ce 13	Se 14	Solidus		Liquidus		
															°F	°C	°F	°C	
Section 2: Solder Alloys Containing Lead																			
Sn70	69.5–71.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.03	0.02	0.005	...	...	...	361	183	377	193	L13700
Sn63	62.5–63.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.03	0.02	0.005	...	...	...	361	183	361	183	L13630
Sn62	61.5–62.5	Rem	0.50	1.75–2.25	0.08	0.001	0.005	0.25	0.03	0.02	0.005	...	...	...	354	179	372	189	L13620
Sn60	59.5–61.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.03	0.02	0.005	...	...	...	361	183	374	190	L13600
Sn50	49.5–51.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.025	0.02	0.005	...	...	...	361	183	421	216	L55031
Sn45	44.5–46.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.025	0.02	0.005	...	...	...	361	183	441	227	L54951
Sn40A	39.5–41.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	361	183	460	238	L54916
Sn40B	39.5–41.5	Rem	1.8–2.4	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	365	185	448	231	L54918
Sn35A	34.5–36.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	361	183	447	247	L54851
Sn35B	34.5–36.5	Rem	1.6–2.0	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	365	185	470	243	L54852
Sn30A	29.5–31.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	361	183	491	255	L54821
Sn30B	29.5–31.5	Rem	1.4–1.8	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	365	185	482	250	L54822
Sn25A	24.5–26.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	361	183	511	266	L54721
Sn25B	24.5–26.5	Rem	1.1–1.5	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	365	185	504	263	L54722
Sn20A	19.5–21.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	361	183	531	277	L54711
Sn20B	19.5–21.5	Rem	0.8–1.2	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	363	184	517	270	L54712
Sn15	14.5–16.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	437	225	554	290	L54560
Sn10A	9.0–11.0	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	514	268	576	302	L54520
Sn10B	9.0–11.0	Rem	0.20	1.7–2.4	0.08	0.001	0.005	0.03	0.02	0.02	0.005	...	...	...	514	268	570	299	L54525
Sn5	4.5–5.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	586	308	594	312	L54322
Sn2	1.5–2.5	Rem	0.50	0.015	0.08	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	601	316	611	322	L54210
Ag1.5	0.75–1.25	Rem	0.40	1.3–1.7	0.30	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	588	309	588	309	L50132
Ag2.5	0.25	Rem	0.40	2.3–2.7	0.30	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	580	304	580	304	L50151
Ag5.5	0.25	Rem	0.40	5.0–6.0	0.30	0.001	0.005	0.25	0.02	0.02	0.005	...	...	...	580	304	716	380	L50180

[A] For purposes of determining conformance to these limits, an observed value or calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding method of Practice E29.

[B] Temperatures given are approximations and for information only.

TABLE 2 Form

Symbol	Form
B	Bar
I	Ingot
P	Powder
R	Ribbon
S	Special[A]
W	Wire

[A] Includes pellets, preforms, etc.

TABLE 3 Flux Type

Symbol	Description
S	Solid, no flux
R	Rosin, nonactivated
RMA	Rosin, mildly activated
RA	Rosin, activated
OA	Organic, water-soluble
OS	Organic, organic solvent-soluble (other than R, RMA, or RA)
IS	Inorganic acids and salts

TABLE 4 Core Condition and Flux Percentage

Condition Symbol	Condition		
D	Dry powder		
P	Plastic		
Percentage Symbol	Flux Percentage by Weight		
	Nominal	*Min*	*Max*
1	1.1	0.8	1.5
2	2.2	1.6	2.6
3	3.3	2.7	3.9
4	4.5	4.0	5.0
6[A]	6.0	5.1	7.0

[A] Not applicable to flux types R, RMA, and RA.

TABLE 5 Powder Mesh Size and Flux Percentage

Size Symbol	Powder Mesh Size	
A	<325	
B	<200	
C	<100	
Percentage Symbol	Flux Percentage by Weight	
	Min	*Max*
1	1	5
2	6	10
3	11	15
4	16	20
5	21	25
6	26	30
7	>30	

flux must promote spreading of the molten solder over the coupon to form integrally thereon a coat of solder that shall feather out to a thin edge. The complete edge of the solder pool must be clearly visible through the flux residue.

8.2.2 *Dryness*—When solder is tested as specified in 13.3.2, the surface of the residue must be free of tackiness, permitting easy and complete removal of applied powdered chalk.

8.2.3 *Chlorides and Bromides Test*—When the extracted flux is tested as specified in 13.3.6, the test paper will show no chlorides or bromides by a color change of the paper to off-white or yellow white.

8.2.4 *Copper Mirror Test*—When tested as specified in 13.3.7, the extracted flux will have failed the test if, when examined against a white background, complete removal of the copper film is noted, as evidenced by the white background showing through, and must be rejected. Discoloration of the copper due to a superficial reaction or to only a partial reduction of the thickness of the copper film is not cause for rejection.

9. Dimensions and Unit Weight

9.1 *Bar and Ingot Solder*—The dimensions and unit weight of bar and ingot solder will be as agreed upon between supplier and purchaser.

9.2 *Wire solder (solid and flux-cored)*—The dimensions and unit weight of wire solder are specified in 5.1.3 and 5.1.4. The tolerance on the specified outside diameter shall be ±5 % or ±0.002 in. (0.05 mm), whichever is greater.

9.3 *Other Forms:*

9.3.1 Dimensions for ribbon and special forms will be agreed upon between supplier and purchaser.

9.3.2 The unit weight of solder paste is specified in 5.1.4.

10. Workmanship, Finish, and Appearance

10.1 All forms of solder must be processed in such a manner as to be uniform in quality and free of defects that will affect life, serviceability, or appearance.

11. Sampling

11.1 Care must be taken to ensure that the sample selected for testing is representative of the material. The method of sampling consists of one of the following methods:

11.1.1 Samples taken from the final solidified cast or fabricated product.

11.1.2 Representative samples obtained from the lot of molten metal during casting. The molten sample is poured into a cool mold, forming a bar approximately ¼ in. (6.4 mm) thick.

11.2 *Frequency of Sampling*—Frequency of sampling for determination of chemical composition shall be in accordance with Table 7. For spools and coils, the sample is obtained by cutting back 6 ft (1.8 m) of wire from the free end and then taking the next 6 ft for test. In other forms, an equivalent sample is selected at random from the container.

11.3 *Other Aspects of Sampling*—Other aspects of sampling conforms in the case of bar and ingots, to Practice E88. For fabricated solders the appropriate reference is Practice E55.

12. Specimen Preparation

12.1 *Flux-Cored Ribbon and Wire Solder and Solder Paste*—Each sample of flux-cored ribbon or wire solder or solder paste is melted in a clean container under oil and mixed thoroughly. After the flux has risen to the top, the alloy is poured carefully into a cool mold (care should be taken to allow the flux and alloy to separate completely), forming a bar approximately ¼ in. (6.4 mm) thick. The bar is cleaned of flux residue and sampled for analysis as specified in 12.3.

12.1.1 *Flux Extraction Procedure:*

12.1.1.1 *Flux-Cored Solder*—The flux core is extracted as follows: Cut a length of the flux-cored solder weighing

TABLE 6 Requirements for Flux

Test	Type R	Type RMA	Type RA	Other Flux Types	Method Section
Weight of flux	see Table 4	see Table 4	see Table 4	see Table 4	13.3.1
Solder pool[A]	see 8.2.1	see 8.2.1	see 8.2.1	see 8.2.1	13.3.2
Spread factor[B]	80 min	80 min	80 min	not required	13.3.3
Dryness[C]	see 8.2.2	see 8.2.2	see 8.2.2	not required	13.3.4
Resistivity of water extract (Ω·cm)	100 000 min	100 000	50 000	not required	13.3.5
Chlorides and bromides[D]	see 8.2.3	see 8.2.3	not required	not required	13.3.6
Copper mirror[E]	pass	pass	not required	not required	13.3.7

[A] Applicable only to composition 60/40.
[B] Applicable only to composition 60/40 in the form of flux-core wire or solderpaste.
[C] Applicable only to composition 60/40 in the form of flux-core wire.
[D] Applicable only to flux-core wire and solderpaste.
[E] Applicable only to flux-core wire.

TABLE 7 Frequency of Sampling

Size of Lot, lb (kg)	Number of Samples (spools, coils, containers or pieces)
Up to 1000 (450), incl	3
Over 1000 to 10 000 (450 to 4500), incl	5
Over 10 000 (4500)	10

approximately 150 g and seal the ends. Wipe the surface clean with a cloth moistened with acetone. Place the sample in a beaker, add sufficient distilled water to cover the sample, and boil for 5 to 6 min. Rinse the sample with acetone and allow to dry. Protecting the solder surface from contamination, cut the sample into ⅜ in. (9.5 mm) (maximum) lengths without crimping the cut ends. Place the cut lengths in an extraction tube of a chemically clean soxhlet extraction apparatus and extract the flux with reagent grade, 99 % isopropyl alcohol until the return condensate is clear. The resistivity of water extract, copper mirror, and chlorides and bromides tests are performed using a test solution prepared by concentrating the solids content in the flux extract solution to approximately 35 % by weight by evaporation of the excess solvent. The exact solids content of the test solution are determined on an aliquot, dried to constant weight in a circulating air oven maintained at 85 ± 3°C.

12.1.1.2 *Solder Paste*—The flux is extracted as follows: Place 200 mL of reagent grade, 99 % isopropyl alcohol in a chemically clean Erlenmeyer flask. Add 40 ± 2 g of solder paste to the flask, cover with a watch glass, and boil for 10 to 15 min using medium heat. Allow the powder to settle for 2 to 3 min and decant the hot solution into a funnel containing filter paper, collecting the flux extract in a chemically clean vessel.

NOTE 2—The solution in isopropyl alcohol does not necessarily have to be clear. The resistivity of water extract and chlorides and bromides tests shall be performed using a test solution prepared by concentrating the solids content in the flux extract solution to approximately 35 % by weight by evaporation of the excess solvent. The exact solids content of the test solution shall be determined on an aliquot, dried to constant weight in a circulating air oven maintained at 85 ± 3°C.

12.2 *Solid Ribbon and Wire Solder*—Each sample of solid ribbon and wire solder is prepared in accordance with 12.1, as applicable.

12.3 *Bar and Ingot Solder*—Each sample piece is cut in half and one half marked and held in reserve. The remaining half is melted in a clean container, mixed thoroughly and poured into a cool mold, forming a bar approximately ¼ in. (6.4 mm) thick. Sampling is performed by one of the following methods:

12.3.1 *Sawing*—Saw cuts are made across the bar at equal intervals of not more than 1 in. (2.5 cm) throughout its length. If it is impractical to melt the bar or ingot as specified above, saw cuts are made across each piece at equal intervals of not more than 1 in. (2.5 cm) throughout its length. No lubricants are used during sawing. The specimen consists of not less than 5 oz (143 g) of mixed sawings.

12.3.2 *Drilling*—The bar is drilled at least halfway through from two opposite sides. A drill of about ½ in. (12.7 mm) in diameter is preferred. In drilling, the holes are placed along a diagonal line from one corner of the pig to the other. The drillings are clipped into pieces not over ½ in. (12.7 mm) in length and mixed thoroughly. The specimen consists of not less than 5 oz (143 g).

13. Test Methods

13.1 *Visual and Dimensional Examination:*

13.1.1 *Ribbon and Wire Solder (Solid and Flux-Cored)*—Ribbon and wire solder must be examined to verify that the dimensions, unit weight, and workmanship are in accordance with the applicable requirements.

13.1.2 *Solder Paste*—Solder paste must be examined for smoothness of texture (no lumps), caking, drying, unit weight, and workmanship in accordance with the applicable requirements.

13.1.3 *Bar and Ingot Solder*—Bar and ingot solder must be examined to verify that the unit weight, marking, and workmanship are in accordance with the applicable requirements.

13.2 *Alloy Composition*—In case of dispute, the chemical analysis is made in accordance with Test Methods E46, Method E51, and Methods E87.

13.3 *Flux:*

13.3.1 *Determination of Weight Percent of Flux:*

13.3.1.1 Select a minimum of 20 g of flux-core ribbon or wire or solder paste. Weigh the sample in a clean porcelain crucible determining the weight to the nearest 0.01 g. Heat until the solder is completely molten. Carefully stir the molten solder a few times to free any entrapped flux. Allow the solder to cool until it solidifies; clean thoroughly of flux residues and reweigh the solder.

13.3.1.2 *Calculation*—Calculate the weight percent of flux as follows:

$$F = \frac{C - S}{C} \times 100 \quad (1)$$

where:

F = weight percent of flux,
C = initial weight of solder sample, g, and
S = final weight of solder sample, g.

13.3.2 *Solder Pool (applicable only to composition 60/40)*—For each sample being tested, three coupons 1.5 in. (38 mm) square shall be cut from 0.063 in. (1.6 mm) thick sheet copper. For flux Type IA only, the coupons shall be cut from cold-rolled commercial sheet steel, approximately 0.063 in. thick. The coupons are degreased by immersion in trichloroethylene or other suitable short-chain solvent. Both surfaces of each coupon are cleaned to a bright finish, using a 10 % fluoroboric acid dip. The coupons are washed with tap water and dried thoroughly with a clean cloth. Approximately 0.2 g of flux-core ribbon or wire or approximately 2 g of solder paste is placed in the center of each coupon. (The area of the solder paste must not exceed that of a 0.375 in. (9.5 mm) diameter circle.) The solder is melted in an oven maintained at 315 ± 15°C. The solder pool is visually examined for thickness of edge. When the test is completed, each coupon is inspected for evidence of spattering of flux.

13.3.3 *Spread Factor (applicable only to composition Sn60, flux Types R, RMA, and RA in the form of flux-core wire or solder paste):*

13.3.3.1 *Preparation of Coupon*—Five coupons 2 in. (12.9 cm^2) square are cut from 0.005 in. (0.13 mm) thick electrolytic copper sheets. The coupons are cleaned in a 10 % fluoroboric acid dip. One corner of each coupon is bent upwards to permit handling with tweezers. The coupons are not handled with bare hands. The coupons are vapor-degreased and then oxidized for 1 h in an electric oven at 150 ± 5°C for testing of flux Types R and RMA and 205 ± 5°C for testing of flux Types RA. All coupons must be at the same level in the oven. All coupons are removed from the oven and placed in tightly closed glass bottles until ready for use.

13.3.3.2 *Procedure:*

(a) Flux-Cored Wire—Ten or more turns of 0.063-in. (1.6-mm) diameter flux-cored solder are tightly wrapped around a mandrel. The solder is cut through with a sharp blade along the longitudinal axis of the mandrel. The rings are slid off the mandrel and the helix removed by flattening each ring. The diameter of the mandrel must be of such a size so as to produce a ring weighing 0.500 ± 0.025 g. Ten rings are prepared. A solder ring is placed in the center of each one of the five coupons. The coupons are placed horizontally on a flat oxidized copper sheet in a circulating–air oven at 205 ± 5°C for 6 min + 10 s, with all coupons being at the same level. At the end of − 0, 6 min, the coupons are removed from the oven and allowed to cool. Excess flux residue is removed by washing with alcohol. The height, *H*, of the solder spot is measured to the nearest 0.001 cm, and the results averaged. Five additional solder-ring specimens are melted together in a small, porcelain combustion boat on a hot plate. The molten solder is stirred several times to free any entrapped flux. After cooling, the solder slab is removed from the boat, the excess flux removed by washing with alcohol, and the loss of weight in water determined to the nearest 0.001 g.

(b) Solder Paste—The coupons are removed from the bottles and weighed to the nearest 0.001 g. A metal washer with an internal diameter of 0.250-in. (6.4-mm) is placed in the center of each coupon and each opening is filled with solder paste. The excess solder paste is wiped off the washer using a spatula and then the washer is removed carefully. The coupons with solder paste are reweighed to the nearest 0.001 g.

NOTE 3—The thickness of the washer is such that the solder weighs from 0.45 to 0.55 g. The coupons are placed horizontally on a flat oxidized copper sheet in a circulating–air oven at 205 ± 5°C for 6 min + 10 s, with all coupons being at the same level. At the end of 6 min, the coupons are removed from the oven and allowed to cool. Excess flux residue is removed by washing with alcohol. The height, *H*, of the solder spot is measured to the nearest 0.001 cm, and the results averaged. An amount of solder paste equal to the total weight of solder paste on the five coupons is melted in a small, porcelain combustion boat on a hot plate. The molten solder is stirred several times to free any entrapped flux. After cooling, the solder slab is removed from the boat, the excess flux removed by washing with alcohol, and the loss of weight in water determined to the nearest 0.001 g.

13.3.3.3 *Calculation*—The loss in weight of the solder slab in water is divided by five. This is the volume, *V*, of the solder to the nearest 0.001 cm^3. The diameter, *D*, of the equivalent sphere is $1.2407^3\sqrt{V}$. The spread factor is calculated in accordance with the following formula:

$$\text{Spread factor}\,(\%) = (D - H)/D \times 100 \quad (2)$$

13.3.4 *Dryness (applicable only to composition Sn60, flux Types R, RMA, and RA in the form of flux-core wire)*—The dryness test is performed on samples prepared in accordance with 13.3.3.1 and 13.3.3.2(*a*) except that after heating the coupons in the oven, the flux residue is not removed. The coupons are allowed to cool for ½ h. Powdered chalk is dusted onto the surface of the residual flux and the ability to remove the chalk from the surface of the flux by light brushing is observed.

13.3.5 *Resistivity of Water Extract (applicable only to flux Types R, RMA, and RA)*—The resistivity of water extract is determined using the flux test solution. Five watch glasses and five acid/alkali resistant, tall form graduated beakers are thoroughly cleaned by washing in hot water detergent solution, rinsing several times with tap water followed by at least five rinses with distilled water. **Warning—**All beakers must be covered with the watch glasses to protect the contents from contaminants. The beakers' dimensions are such that when the conductivity cell is immersed in 50 mL of liquid contained therein, the electrodes are fully covered. Each cleaned beaker is filled to the 50 mL mark with distilled water. The beakers are immersed in a water bath maintained at 23 ± 2°C. When thermal equilibrium is reached, the resistivity of the distilled water in each beaker is measured at this temperature with a conductivity bridge using a conductivity cell with a cell constant of approximately 0.1. The resistivity of the distilled water in each beaker must not be less than 500 000 Ω · cm. If the resistivity of the water in any beaker is less than 500 000 Ω · cm, the complete process above must be repeated. Two of these beakers are retained as controls. Add 0.100 ± 0.005 cm^3