



# Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube<sup>1</sup>

This standard is issued under the fixed designation B 813; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>ε1</sup> NOTE—Paragraph 11.5 was editorially corrected in December 2001.

## INTRODUCTION

This specification covers a series of specific requirements for liquid and paste fluxes. It also incorporates a series of test methods that establish the procedures on how to measure these properties. The format of this specification initially defines the specification requirements followed by the specific test methods in the order in which they are to be performed.

### 1. Scope

1.1 This specification establishes the requirements and test methods for liquid and paste fluxes for joining by soldering of copper and copper alloy tube and fittings in plumbing, heating, air conditioning, mechanical, fire sprinkler, and other similar systems.

NOTE 1—This specification does not apply to fluxes intended for electronic applications.

1.2 Solder fluxes are to be tested in accordance with the requirements of this specification by an independent testing laboratory. Testing, measuring equipment, and inspection facilities shall be of sufficient accuracy and quality to comply with the requirements of this specification.

1.3 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The following hazard caveat pertains to Sections 11-19. *This standard does not purport to address the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

2.1 The following documents of the issue in effect on the date of materials purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*

B 32 Specification for Solder Metal<sup>2</sup>

B 88 Specification for Seamless Copper Water Tube<sup>3</sup>

B 88M Specification for Seamless Copper Water Tube [Metric]<sup>3</sup>

B 152/B 152M Specification for Copper Sheet, Strip, Plate, and Rolled Bar<sup>3</sup>

B 280 Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service<sup>3</sup>

B 846 Terminology for Copper and Copper Alloys<sup>3</sup>

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test<sup>4</sup>

D 1200 Test Method for Viscosity by Ford Viscosity Cup<sup>5</sup>

2.3 *Other:*

1986 Amendments to the Safe Drinking Water Act<sup>6</sup>

### 3. General Requirements

3.1 The flux shall be suitable for joining copper tube and fittings by soldering in the size ranges shown in Table 1 of Specifications B 88 and B 88M and Tables 4 and 5 of Specification B 280.

3.2 The flux shall remain active over the temperature range of the soldering operation, removing and excluding oxides from the metal surfaces in the joint.

3.3 The flux shall be suitable for use with all solders listed in Table 5 of Specification B 32 as well as the more recently developed solder alloys suitable for the applications in the scope of this specification.

3.4 The flux shall allow the solder to adequately wet and spread on the surfaces being soldered.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 02.04.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 05.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 06.01.

<sup>6</sup> Available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402.

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- 3.5 The flux residue shall be water flushable after soldering.
- 3.6 The flux residue shall not be corrosive after soldering.
- 3.7 The flux shall not release toxic fumes during the soldering operation or toxic substances into the water in the completed system.
- 3.8 The flux shall adhere to the copper and copper alloys under anticipated temperature, joint geometry, joint position, job site, and weather conditions.
- 3.9 The flux shall not contain more than 0.2 % lead in accordance with the 1986 Amendments to the Safe Drinking Water Act.

**4. Terminology**

4.1 For terms related to copper and copper alloys, refer to Terminology B 846 for terms specific to this standard.  
4.2 *Definition:*

4.2.1 *flux, n*—a chemically active substance that is used to remove and exclude oxides from the joint area during heating and that ensures that the melted solder will wet the surfaces to be joined.

**5. Spreading Factor**

5.1 Spreading of the solder is determined by measuring the height (*h*) of a solder bead on a standard test sheet following the specified heating cycle. Spread factor (SF) is calculated as follows:

$$SF = 100(1.0 - h) \tag{1}$$

where:

*h* = the maximum height of the solder bead, mm.

5.2 A flux is considered to have acceptably influenced the spreading of solder on the copper surfaces when the average spreading factor is at least 50 (see Section 13).

5.3 The spreading test shall show a balanced action by forming a regular and even solder layer.

**6. Aggressiveness Requirements**

6.1 From a standard test sheet on which a specimen has been prepared with solder (see Section 15), the resistivity of the aqueous solution shall be more than 100 000 Ω cm.

6.2 From a standard test sheet on which a specimen has been prepared without solder (see Section 16), the resistivity of the aqueous solution shall be more than 85 000 Ω cm.

**7. Corrosiveness Requirements**

7.1 There shall be a clear indication that in the areas of flux reaction, the sheets shall show a corrosion and residue-free surface comparable with the unwetted areas as determined by visual inspection in accordance with Section 17.

7.2 Corrosiveness shall be reported in accordance with one of the classifications listed as follows (see Test Method D 130):

Classification	Description
1	Slight tarnish
2	Moderate tarnish
3	Dark tarnish

**8. Viscosity Requirements**

8.1 The viscosity of liquid fluxes shall be less than 180 s as determined using a No. 2 Ford flow cup in accordance with Section 18.

**9. Residue Flushing Requirements**

9.1 Flushing of the residue shall be determined by weight loss.

9.2 The loss of weight of each sheet shall be determined by comparing the average weight before and after the test procedure. The weight loss of the flux residue shall be more than 99 % in accordance with Section 19.

$$\% \text{ Weight Loss } (d) = 100 - \frac{(c - a)}{(b - a)} \times 100 \tag{2}$$

where:

*a* = weight of degreased, flushing-test sheet, g;

*b* = weight of degreased, flushing-test sheet plus the weight of applied flux, g; and

*c* = weight of dried, flushing-test sheet after flushing, g.

**10. Sampling**

10.1 Samples of flux taken for the purpose of the tests listed in this specification shall be selected from the stock of the manufacturer and shall be representative of the material being evaluated.

**11. Specimen Preparation**

11.1 *Standard Quantity of Solder Metal*—A standard quantity of solder metal shall be a sample of 60:40 tin-lead (Alloy Grade Sn60), measuring 6.0 mm in diameter by 0.86 mm in thickness, weighing approximately 0.21 g, that has been degreased with trichloroethylene.

11.2 *Standard Quantity of Flux*—A standard quantity of flux shall be 0.003 mL as measured by a precision pipet or other volumetric measuring devices with equivalent precision.

11.3 *Standard Test Sheet*—A standard test sheet shall be a piece of copper 35 by 35 by 1 mm thick of Copper UNS No. C12200 (deoxidized high residual phosphorus) produced in accordance with Specifications B 152/B 152M.

11.3.1 *Preparation:*

11.3.1.1 The sheet is abraded three times with a waterproof sand or emery paper (Grit No. 360), each time perpendicular to the previous direction. One corner of each test sheet shall be bent upwards to permit handling. It is degreased with calcium carbonate mixed with water to a paste consistency with which the test sheet is rubbed using a wad of cotton. The residue is flushed off by a strong jet of tap water. The test sheet is considered to be degreased when it is completely moistened by water when flushed.

11.3.1.2 In any of the following steps in which the test sheets must be handled, use forceps or laboratory tongs. The sheet is then etched for 15 s in an etching solution formulated as follows:

(a) *Etching Solution*—(1-L etching solution contains 200-g chromic acid anhydride (CrO<sub>3</sub>) and 125-mL sulfuric acid (specific gravity 1.84) reagent grade, balance distilled water, diluted to 1 L.)

(b) Finally, the sheet is rinsed thoroughly with distilled water (60 to 70°C), immersed in ethanol (ACS Grade), and allowed to dry.

11.4 *Resistivity Test Specimen*—The resistivity test specimen is the condition of the standard test sheet on which have been deposited standard quantities of flux and solder metal

before they are placed in the oven.

#### 11.4.1 Preparation:

11.4.1.1 Remove test sheet from the liquid ethanol, allow to dry, and apply a standard quantity of flux. With a standard quantity of solder metal, spread the flux to an area of about 15 mm in diameter.

11.4.1.2 Place the test sheet with flux and solder metal in the oven where it remains for 3 min at a temperature of 275°C from the time the solder melts. Remove the specimen and allow to cool to room temperature.

11.5 *Flushing-Test Sheet*—The flushing-test sheet is a piece of copper 100 by 100 by 1.0 mm thick of Copper UNS No. C12200 (deoxidized high residual phosphorus) produced in accordance with Specifications B 152/ B 152M.

#### 11.5.1 Preparation:

11.5.1.1 The copper sheets shall have raised edges of 3 or 4 mm to avoid loss of flux. The sheets shall be degreased with trichloroethylene, flushed with water, and dried at a temperature of 50°C. Every sheet shall be weighed to 10-mg accuracy using a standard laboratory balance.

## 12. Test Methods

12.1 The properties enumerated in this specification shall be determined in accordance with the test methods given in Sections 13-19.

## 13. Spreading Test

13.1 *Scope*—The influence of the flux on the spreading of the fluid solder is indicated by the spreading factor obtained by the conditions detailed in Section 17.

#### 13.2 Apparatus:

13.2.1 *Oven*—The performance characteristics of the oven shall be such that the temperature has an accuracy of  $\pm 2.5^\circ\text{C}$ . The oven shall be equipped with a sight glass for visible control of the melting of the solder. It shall be possible to measure the oven temperature in close proximity to the test sheet. The test sheet shall be capable of being placed in the oven and removed from it exactly horizontally. To reduce cooling when the preheated test sheet is removed from the oven, it is placed on a plate in an exact horizontal position so as to be pushed in and out. The oven must be easy to heat to the preset temperature.

13.2.2 *Gilson Precision Pipet*, 3 to 25  $\mu\text{L}$ .

#### 13.3 Spreading Factor Procedure:

13.3.1 The spreading factor test specimen is the condition of the standard test sheet with a standard quantity of flux having been heated to 275°C for 30 s in the oven. Immediately afterwards, a standard quantity of solder metal is placed over the liquid flux and the test specimen is replaced in the oven.

13.3.2 The period for which the test sheet shall be outside the oven for application of the solder metal shall not exceed 10 s.

13.3.3 Remove test sheet from the ethanol, allow to dry, and apply a standard quantity of flux. Spread the flux with a standard quantity of solder metal to an area of about 15 mm in diameter and then remove the solder metal.

13.3.4 Heat the test sheet with flux for 30 s in an oven at 275°C. Afterwards, replace the standard quantity of solder metal that was used to spread the flux on the test sheet and heat

the assembly for 3 min at a temperature of 275°C in the oven.

13.3.5 After the test specimen has cooled to room temperature and been cleaned, measure the solder height by means of a flat micrometer three times, average the values, and calculate the spreading factor as in 5.1.

13.4 *Calculation*—After five tests, the highest and lowest figures are excluded. Calculate the average of the remaining three.

## 14. Aggressiveness Test

14.1 *Scope*—The aggressiveness of the flux is determined by means of a resistivity test by measuring the resistivity in  $\Omega$  cm of an aqueous solution of the flux residue. The conductivity cell to be used shall be kept immersed in distilled water at ambient temperature for a minimum of 24 h before use.

#### 14.2 Apparatus:

14.2.1 *Ohmmeter (Must Be Suitable for Use with Liquids)*—Cell constant shall be specified.

14.2.2 *Beakers—100 mL*—for this test shall be acid/alkali resistant, cleaned, and degreased. Finally, they shall be rinsed thoroughly with distilled water.

14.2.3 *Thermometers*—The temperatures shall be measured with cleaned thermometers having a scale that will accurately register the temperatures. The thermometer shall be immersed in a clean graduate measuring cylinder, filled with distilled water for a minimum of 24 h before use.

14.3 *Calculation*—After five tests, the highest and lowest figures are excluded and the average of the other three is used.

## 15. Resistivity Test—Soldered (see 6.1)

#### 15.1 Procedure:

15.1.1 Clean seven watch glasses and seven graduated beakers thoroughly by washing in hot water detergent solution, rinsing several times with tap water followed by rinsing three times with distilled water. Then add approximately 50 mL of distilled water to each beaker, cover with a watch glass, and boil for 2 min. Discard the water and repeat this boiling with fresh distilled water. Place each clean beaker upside down on tissue paper until they are needed. Fill each beaker to the 75-mL mark with distilled water. Immerse the beakers in a water bath maintained at 25°C. When this temperature is reached, measure the resistivity of the distilled water in each beaker. Make sure that the resistivity of the distilled water in each beaker is not less than 500 000  $\Omega$  cm. If the resistivity of the water in any beaker is less than 500 000  $\Omega$  cm, repeat the complete process just described. Retain two of these beakers as controls.

15.1.2 For determination of the resistivity, five of the test specimens indicated in 11.4 are used. After cooling the last sheet, five of the sheets (see 13.3.5) are placed in separate beakers filled with 75-mL distilled water. The test sheets are placed with the soldered surface down. The beakers are then covered with watch glasses. Heat all seven beakers simultaneously. As the contents of each beaker comes to a boil, time the boiling for 1 min. The beakers are then allowed to cool for 10 min. They are then cooled rapidly until a temperature of 25°C has been reached. When this temperature is reached, the test sheets are removed. Determine the resistivity of the aqueous solution in each of the seven beakers as follows:



15.1.2.1 Thoroughly rinse the conductivity cell in distilled water and immerse in a water control. Make ohmmeter reading.

15.1.2.2 Thoroughly rinse the conductivity cell with distilled water and immerse it in the aqueous solution of one sample. Make ohmmeter reading.

15.1.2.3 Thoroughly rinse conductivity cell in distilled water and immerse in the aqueous solution of the second water control. Make ohmmeter reading.

15.1.2.4 Thoroughly rinse the conductivity cell in distilled water. Measure resistivities of the remaining control and aqueous solutions.

15.1.2.5 Make sure that the resistivity of each of the controls is not less than 500 000  $\Omega$  cm. If the control value is less than 500 000  $\Omega$  cm, it indicates that the water was contaminated with water-soluble ionized materials; repeat the entire test. Calculate the average of the resistivities of the aqueous solutions of the flux residues in accordance with 14.3.

## 16. Resistivity Test—No Solder (see 6.2)

16.1 *Procedure*—Prepare seven watch glasses and seven graduated beakers as indicated in 15.1.1. For determination of the resistivity, five standard test sheets are used. The test sheets are heated for 2 min to 150°C after application of a standard quantity of liquid flux. After cooling, the test sheets are placed in separate beakers, filled with 75-mL distilled water. The test sheets are then placed with the surface down. The test then proceeds in accordance with 15.1.2.

## 17. Corrosiveness Test

### 17.1 *Apparatus*:

#### 17.1.1 *Desiccator*.

### 17.2 *Procedure*:

17.2.1 Remove the test sheet from the ethanol, allow to dry, and apply five times the standard quantity of flux (in accordance with 11.2). Heat the test sheet with the flux in an oven at 275°C for 3 min. From the moment the test sheet is taken out of the oven, no cleaning is permitted. Place the sheet in a desiccator on a stand over the water level. The flux residue must be removed as follows:

17.2.1.1 Use three standard test sheets. After 24 h, take the test sheets from the desiccator to judge the extent of corrosion, and

17.2.1.2 Thoroughly clean each test sheet by washing in a hot (75°C) detergent solution. Use only a soft brush, if necessary.

## 18. Viscosity Test

### 18.1 *Apparatus*:

18.1.1 *Flow Cup*, No. 2 Ford Cup (see Test Method D 1200).

### 18.2 *Procedure*:

18.2.1 Make viscosity determinations in a room free of drafts and rapid changes in temperature.

18.2.2 Level the instrument so that a cup will be filled level without a meniscus or overflow at one side.

18.2.3 Determine the time in seconds of viscosity as follows:

18.2.3.1 Close the orifice, for example, by holding a rubber stopper against it.

18.2.3.2 Fill the cup with the prepared specimen by overfilling the cup and scraping off the excess with a straight edge.

18.2.3.3 Pull the stopper away and simultaneously start the timing device, and

18.2.3.4 Measure the time until the first break in the stream.

## 19. Residue Flushing Test

### 19.1 *Procedure*:

19.1.1 On every copper sheet apply a quantity of 5.0 g of flux. Heat the sheets to 300°C within 30 s, as measured by a temperature indicator.

19.1.2 After cooling to room temperature, flush every sheet in a horizontal position for 30 s in a cold-water jet. The cold-water jet ( $\leq 25^\circ\text{C}$ ) of 1 L/min must be pressureless in free fall from 50 cm difference in level and equal over the entire surface of the sheet.

19.1.3 Dry the sheet at a temperature of 50°C. Each sheet must be weighed. Calculate loss of weight (see Section 9).

## 20. Retest and Rejection

20.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) shall be conducted again in accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirement of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods designated in the specification shall be followed. If, upon retest, failure occurs, the quantity of product represented by the test(s) shall be rejected.

## 21. Certification

21.1 When specified in the contract or purchase order, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. Also when requested, it shall include a copy of the Flux Evaluation and Certification Form (Fig. 1).

## 22. Package and Package Marking

22.1 The flux container shall be marked with: Trademark(s) or brand name(s) applicable to product batch code.

## 23. Keywords

23.1 aggressiveness test; copper and copper alloys; corrosiveness; flushing; liquid and paste fluxes; resistivity; soldering; spreading factor; tarnish; viscosity



SOURCE \_\_\_\_\_ PO# \_\_\_\_\_  
 SHOP ORDER# \_\_\_\_\_ LAB# \_\_\_\_\_  
 FLUX SAMPLE# \_\_\_\_\_  
 PHYSICAL APPEARANCE \_\_\_\_\_  
 PACKAGE \_\_\_\_\_  
 DATE \_\_\_\_\_

**STANDARD SPECIFICATION FOR  
 FLUX EVALUATION FOR SOLDERING APPLICATIONS  
 FLUX EVALUATION AND CERTIFICATION FORM**

**SPREAD TEST (mm)**

SAMPLE TEST#	AVERAGE*
1-S	_____
2-S	_____
3-S	_____
4-S	_____
5-S	_____

(50 min.)

\*The high and low figures are excluded from the average.

Spreading Factor = (1.0 - h) X 100

**AGGRESSIVENESS TEST (ohm-cm)**

SAMPLE TEST#	W/SOLDER	AVERAGE*	WO/SOLDER	AVERAGE*
1-A	_____		_____	
2-A	_____		_____	
3-A	_____		_____	
4-A	_____	_____	_____	_____
5-A	_____		_____	
6-A (CTRL)	_____		_____	
7-A (CTRL)	_____		_____	

(100,000 min.)

(85,000 min.)

\*The high and low figures are excluded from the average.

**CORROSIVENESS TEST**

SAMPLE TEST#	COMMENTS:
1-C	_____
2-C	_____
3-C	_____

**VISCOSITY TEST (applicable to liquid fluxes only)**

TIME OF FLOW: (seconds) \_\_\_\_\_ (180 seconds max.)

**FLUSHING TEST (see 9.1)**

SAMPLE	WT. BEFORE TEST (a)	WT. INCL. FLUX (b)	WT. AFTER FLUSH (c)	% WT. LOSS (d)**
1-F	_____	_____	_____	_____
2-F	_____	_____	_____	_____
3-F	_____	_____	_____	_____

\*\* d = 100 -  $\frac{(c-a)}{(b-a)}$  X 100

(% WEIGHT LOSS must exceed 99)

FIG. 1 Flux Evaluation and Certification Form



## **B 813**

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