Designation: B 828 – 02

Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings[1]

This standard is issued under the fixed designation B 828; 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.

1. Scope *

1.1 This practice describes a procedure for making capillary joints by soldering of copper and copper alloy tube and fittings.

1.2 This procedure is applicable to pressurized systems such as plumbing, heating, air conditioning, refrigeration, mechanical, fire sprinkler, and other similar systems. ASME B31.5 and B31.9 reference the techniques used for satisfactory joint preparation. It is also used in the assembly of nonpressurized systems such as drainage, waste, and vent.

1.3 It is not applicable to the assembly of electrical or electronic systems.

1.4 Tube and fittings are manufactured within certain tolerances to provide for the small variations in dimensions associated with manufacturing practice. Applicable specifications are listed in Appendix X1.

1.5 A variety of solders are available that will produce sound, leak-tight joints. Choice of solder will depend upon the type of application and on local codes. For potable water systems, only lead-free solders shall be used, some of which are described in Specification B 32.

1.6 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information purposes only.

1.7 *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 establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For hazard statements, see the warning statements in 6.4.1, 6.6.1, and 6.6.3.

2. Referenced Documents

2.1 *ASTM Standards:*

B 32 Specification for Solder Metal[2]

B 68 Specification for Seamless Copper Tube, Bright Annealed[3]

B 68M Specification for Seamless Copper Tube, Bright Annealed [Metric][3]

B 75 Specification for Seamless Copper Tube[3]

B 75M Specification for Seamless Copper Tube [Metric][3]

B 88 Specification for Seamless Copper Water Tube[3]

B 88M Specification for Seamless Copper Water Tube [Metric][3]

B 280 Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service[3]

B 306 Specification for Copper Drainage Tube (DWV)[3]

B 447 Specification for Welded Copper Tube[3]

B 640 Specification for Welded Copper and Copper Alloy Tube for Air Conditioning and Refrigeration Service[3]

B 641 Specification for Seamless and Welded Copper Distribution Tube (Type D)[4]

B 716 Specification for Welded Copper Water Tube[5]

B 716M Specification for Welded Copper Water Tube [Metric][5]

B 813 Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube[3]

B 846 Terminology for Copper and Copper Alloys[3]

2.2 *Other Documents:*

ASME B31.5 Refrigeration Piping[6]

ASME B31.9 Building Services Piping[6]

ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings[6]

ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings[6]

ASME B16.23 Cast Copper Alloy Solder Joint Drainage Fittings—DWV[6]

ASME B16.29 Wrought Copper and Copper Alloy Solder Joint Drainage Fittings—DWV[6]

ANSI/ASC Z49.1 Safety in Welding and Cutting[7]

3. Terminology

3.1 For terms related to copper and copper alloys, refer to Terminology B 846 for terms specific to this practice.

[1] This practice is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

Current edition approved Oct. 10, 2002. Published November 2002. Originally approved as B 828 – 92. Last previous edition B 828 – 00.

[2] *Annual Book of ASTM Standards,* Vol 02.04.

[3] *Annual Book of ASTM Standards,* Vol 02.01.

[4] Discontinued—see *1996 Annual Book of ASTM Standards,* Vol 02.01.

[5] Discontinued—see *1993 Annual Book of ASTM Standards,* Vol 02.01.

[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

[7] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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

3.2 *Definition:*

3.2.1 *soldering*—a group of joining processes that produce coalescence of materials by heating them to the soldering temperature and by using a filler metal (solder) having a liquidus not exceeding 840°F (450°C) and below the solidus of the base metals.[8]

3.2.1.1 *Discussion*—In actual practice, most soldering is done at temperatures from about 350 to 660°F (177 to 349°C).

4. Summary of Practice

4.1 To consistently make satisfactory joints, the following sequence of joint preparation and operations shall be followed:

(*1*) measuring and cutting,
(*2*) reaming,
(*3*) cleaning,
(*4*) fluxing,
(*5*) assembly and support,
(*6*) heating,
(*7*) applying the solder, and
(*8*) cooling and cleaning.

5. Significance and Use

5.1 The techniques described herein are used to produce leak-tight soldered joints between copper and copper alloy tube and fittings, either in shop operations or in the field. Skill and knowledge on the part of the operator or mechanic are required to obtain a satisfactorily soldered joint.

6. Procedure

6.1 *Measuring and Cutting:*

6.1.1 Accurately measure the length of each tube segment (Fig. 1) to ensure joint quality. If the tube is too short, it will not reach all the way into the cup of the fitting and a proper joint cannot be made. If the tube segment is too long, the possibility exists that system strain that negatively affects service life will be introduced.

6.1.2 Cut the tube to the measured lengths using tools that provide a square cut, for example, a disk-type tube cutter (Fig. 2), a hacksaw, an abrasive wheel, or with a stationary or portable band saw. Avoid deforming the tube during cutting. Regardless of method, the cut shall be made square with the run of the tube, so that the tube will seat properly in the fitting cup.

6.2 *Reaming:*

6.2.1 Ream all cut tube ends to the full inside diameter of the tube to remove the small burr created by the cutting operation. Failure to remove this rough edge by reaming is a leading cause of erosion-corrosion that occurs as a result of local turbulence and increased local flow velocity in the tube. A properly reamed piece of tube provides a smooth surface for better flow.

6.2.2 Remove any burrs on the outside of the tube ends created by the cutting operation to ensure proper entrance of the tube into the fitting cup.

6.2.3 Tools used to ream tube ends include the reaming blade on the tube cutter, half-round or round files (Fig. 3), a pocket knife (Fig. 4), and a suitable deburring tool (Fig. 5). With soft (annealed) tube, care must be taken not to deform the tube end by applying too much pressure.

6.2.4 Soft temper tube, if deformed, shall be brought back to its proper roundness and dimensions with a sizing tool. This tool consists of a plug and sizing ring.

6.3 *Cleaning:*

6.3.1 Clean all oxides and surface soil from the tube ends and fitting cups. The removal of all oxides and surface soil is crucial to proper flow of solder metal into the joint. Unremoved oxides, surface soil, and oils will interfere with capillary action, lessen the strength of the joint, and cause failure.

6.3.2 Lightly abrade the tube ends using sand cloth (Fig. 6) or nylon abrasive pads (Fig. 7) for a distance slightly more than the depth of the fitting cups.

6.3.3 Clean the fitting cups by using abrasive cloth, abrasive pads (Fig. 8), or a properly sized fitting brush (Fig. 9).

6.3.4 The capillary space between tube and fitting is approximately 0.004 in. (0.1 mm). Solder metal fills this gap by capillary action. This spacing is critical for the solder metal to

[8] *American Welding Society Welding Handbook, Welding Processes*, 8th ed., Vol 2, American Welding Society, 550 N.W. LeJeune Rd., Miami, FL 33126.

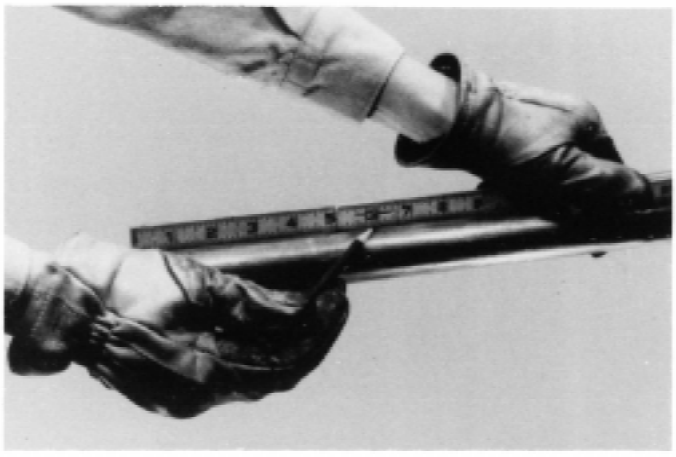

FIG. 1 Measuring

FIG. 2 Cutting

FIG. 3 Reaming: File

FIG. 4 Reaming: Pocket Knife

FIG. 5 Reaming: Deburring Tool

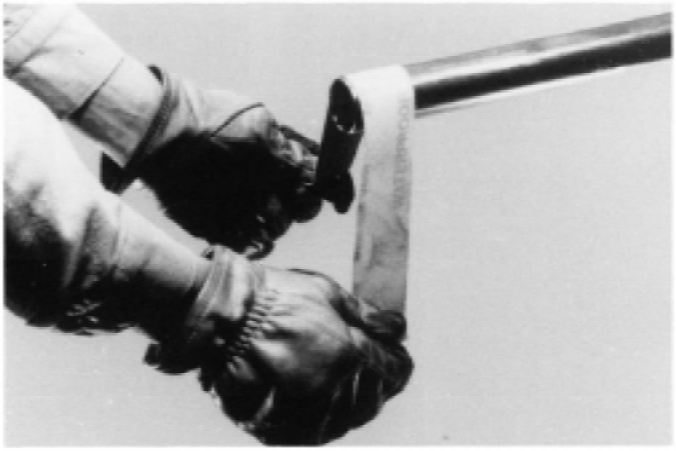

FIG. 6 Cleaning: Sand Cloth

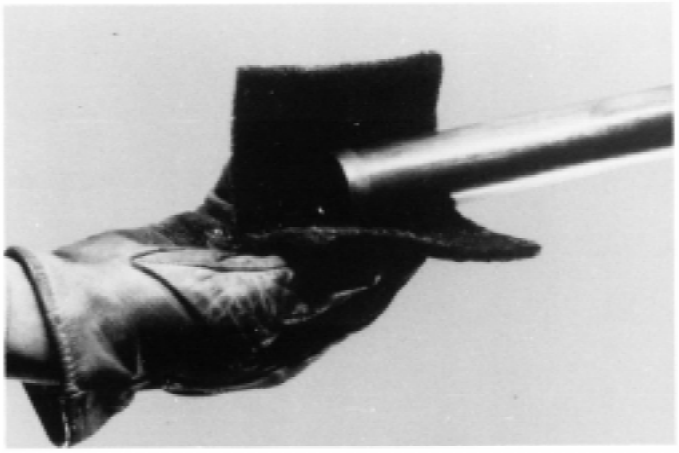

FIG. 7 Cleaning: Abrasive Pad

FIG. 8 Cleaning: Abrasive Pad

flow into the gap and form a strong joint. Copper is a relatively soft metal. Removal of too much material from the tube end or fitting cup will result in a loose fit and interfere with satisfactory capillary action in making the joint.

6.3.5 If chemical cleaning is used, the tube ends and fittings shall be thoroughly rinsed after cleaning in accordance with the recommended procedure furnished by the manufacturer of the

FIG. 9 Cleaning: Fitting Brush

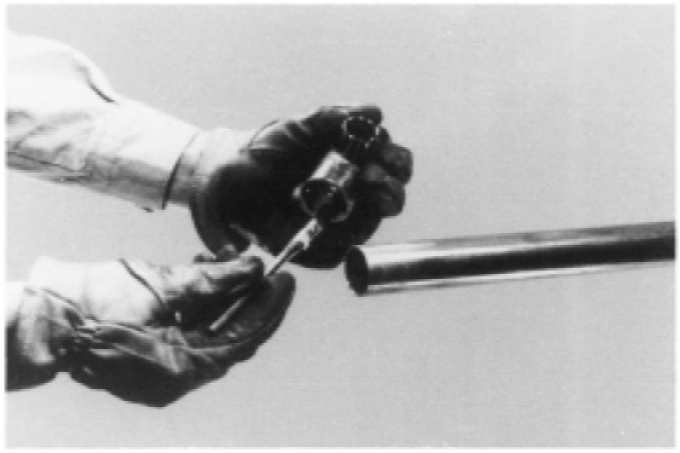

FIG. 11 Fluxing: Fitting

cleaner. Do not touch the cleaned surface with bare hands or oily gloves. Skin oils, lubricating oils, and grease impair solder metal.

6.4 *Applying Flux:*

6.4.1 Use a flux that will dissolve and remove traces of oxide from the cleaned surfaces to be joined, protect the cleaned surfaces from reoxidation during heating, and promote wetting of the surfaces by the solder metal, as recommended in the general requirements of Specification B 813. Apply a thin even coating of flux with a brush to both tube and fitting as soon as possible after cleaning (Figs. 10 and 11). (**Warning**—Do not apply with fingers. Chemicals in the flux are potentially harmful if carried to the eyes or open cuts.)

6.4.2 Use care in applying flux. Flux residue inside the tube has been known to cause corrosion and perforation of the tube and/or fitting wall long after the system has been installed.

6.5 *Assembly and Support:*

6.5.1 Insert tube end into fitting cup, making sure that the tube seats against the base of the fitting cup (Fig. 12). A slight twisting motion ensures even coverage by the flux. Remove excess flux from the exterior of the joint with a cotton rag (Fig. 13).

FIG. 12 Assembly

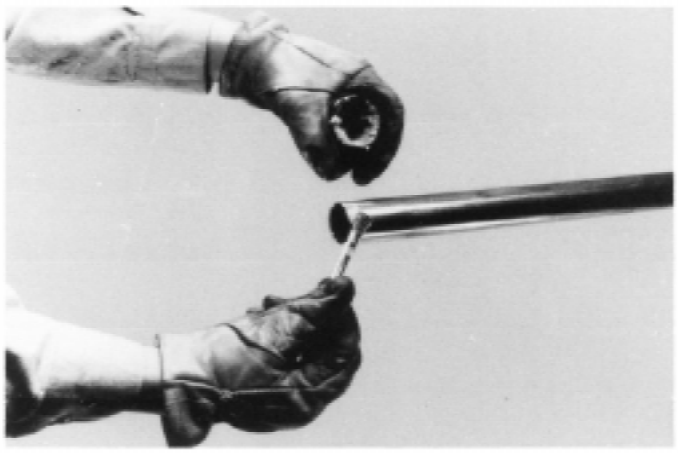

FIG. 10 Fluxing: Tube

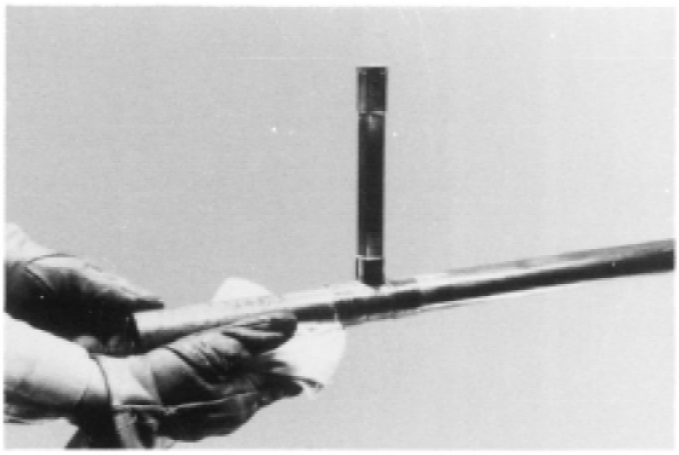

FIG. 13 Removing Excess Flux

6.5.2 Support the tube and fitting assembly to ensure a uniform capillary space around the entire circumference of the joint. Uniformity of capillary space will ensure good molten solder metal capillary flow (Fig. 14). Susceptibility to solder

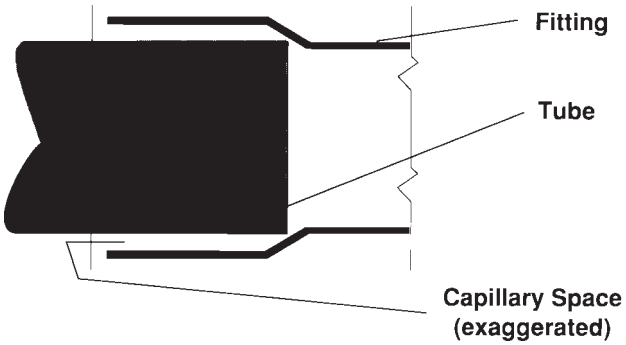

FIG. 14 Desirable Joint Configuration

metal cracking under conditions of stress or vibration is increased in joints with excessive joint clearance.

6.5.3 The joint is now ready for soldering. Joints prepared and ready for soldering shall be completed the same day and not left unfinished overnight.

6.6 *Heating:*

6.6.1 (**Warning**—When dealing with an open flame, high temperatures and flammable gases, safety precautions must be observed as described in ANSI/AWS Z49.1.) Begin heating with the flame perpendicular to the tube (Fig. 15). The copper tube conducts the initial heat into the fitting cup for even distribution of heat in the joint area. The extent of this preheating depends upon the size of the joint. Experience will indicate the amount of time needed.

6.6.2 Next, move the flame onto the fitting cup (Fig. 16).

6.6.3 Then alternate the flame from the fitting cup back onto the tube a distance equal to the depth of the fitting cup. With the torch at the base of the fitting cup touch the solder to the joint. If the solder does not melt, remove it and continue the heating process. (**Warning**—Care must be taken not to overheat the joint or to direct the flame into the face of the fitting cup. Overheating the flux will destroy its effectiveness and not allow the solder to enter the joint properly.)

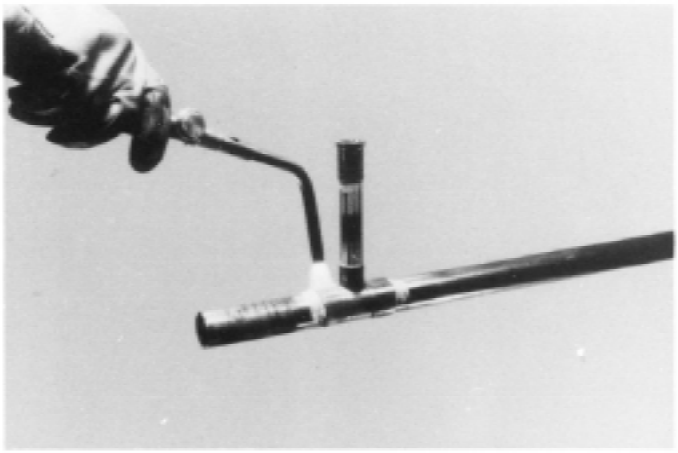

FIG. 16 Preheating: Fitting

6.6.4 When the melting temperature of the solder has been reached, apply heat to the base of the cup to aid capillary action in drawing the molten solder into the cup towards the heat source.

6.6.5 Heat is generally applied using an air/fuel torch (Fig. 17). Such torches use acetylene or liquefied petroleum (LP) gas. Electric resistance soldering tools (Fig. 18), which use heating electrodes are an alternative when use of an open flame is a concern (see 6.6.1).

6.7 *Applying Solder:*

6.7.1 For joints in a horizontal position, start applying the solder metal slightly off-center at the bottom of the joint (Figs. 19 and 20). Proceed across the bottom of the fitting and up to the top center position. Return to the point of beginning, overlap the starting point, and then proceed up the incompleted side to the top, again, overlapping the solder metal.

6.7.2 For joints in the vertical position, make a similar sequence of overlapping passes starting wherever it is convenient.

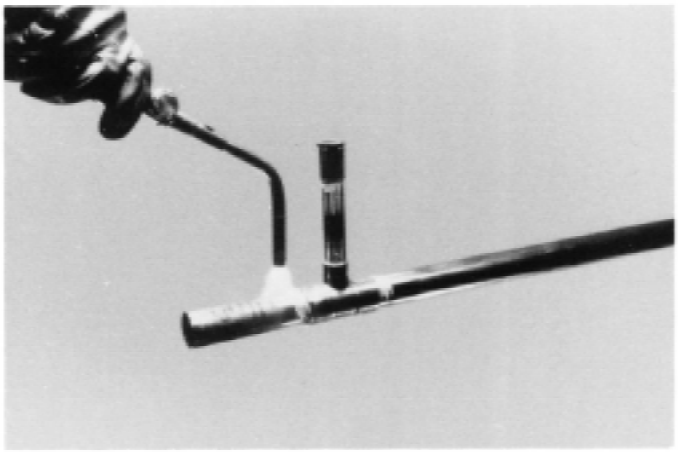

FIG. 15 Preheating: Tube

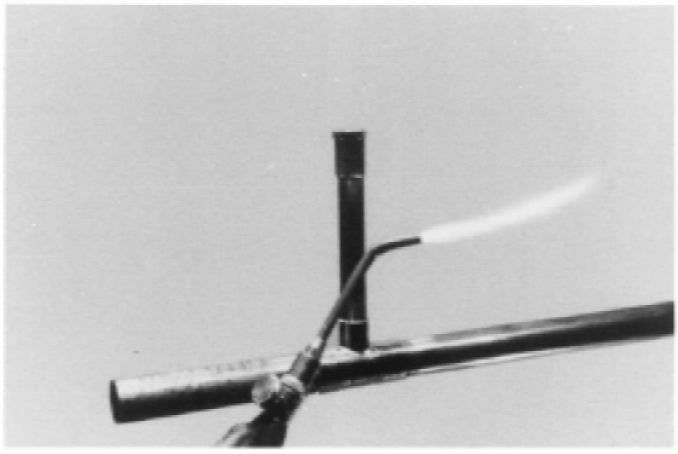

FIG. 17 Heating: Air/Fuel Torch

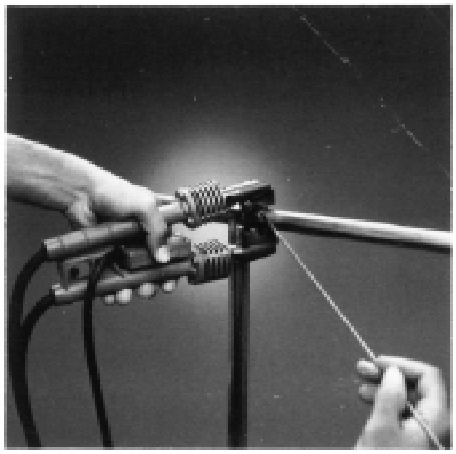

FIG. 18 Electric Resistance Hand Tools Suitable for Soldering Copper Tube

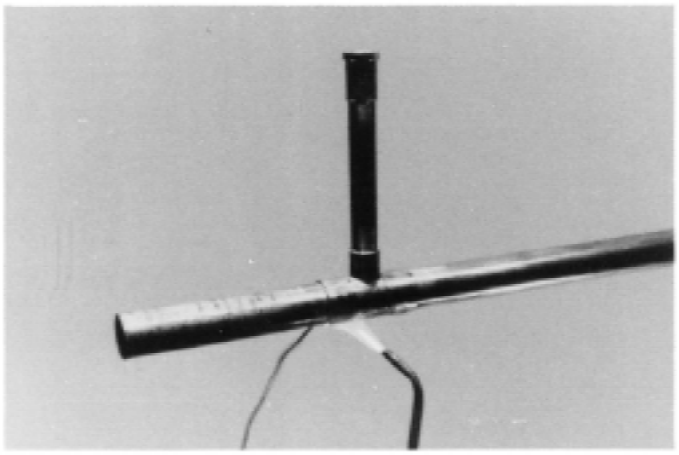

FIG. 19 Soldering

6.7.3 Solder joints depend on capillary action drawing free-flowing molten solder into the narrow clearance between the fitting and the tube. Molten solder metal is drawn into the joint by capillary action regardless of whether the solder metal is being fed upward, downward, or horizontally.

6.7.4 Flux, applied first, acts as a cleaning and wetting agent and, when properly applied, permits uniform spreading of the molten solder over the surfaces to be joined. Capillary action is most effective when the space between the surfaces to be joined is between 0.002 and 0.005 in. (0.05 to 0.125 mm).

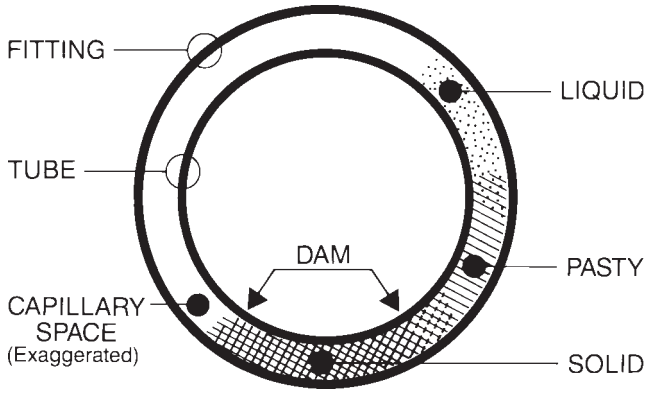

FIG. 20 Schematic of Solder Joint in Horizontal Position

6.8 *Cooling and Cleaning:*

6.8.1 Allow the completed joint to cool naturally. Shock cooling with water will cause unnecessary stress on the joint. When cool, clean off any remaining flux residue with a wet rag (Fig. 21).

7. Testing

7.1 Test all completed assemblies for joint integrity. Follow testing procedure prescribed by applicable codes governing the intended service.

8. Keywords

8.1 assembly; capillary; cleaning; cooling; copper; corrosivity; fittings; flux; heating; reaming; soldering

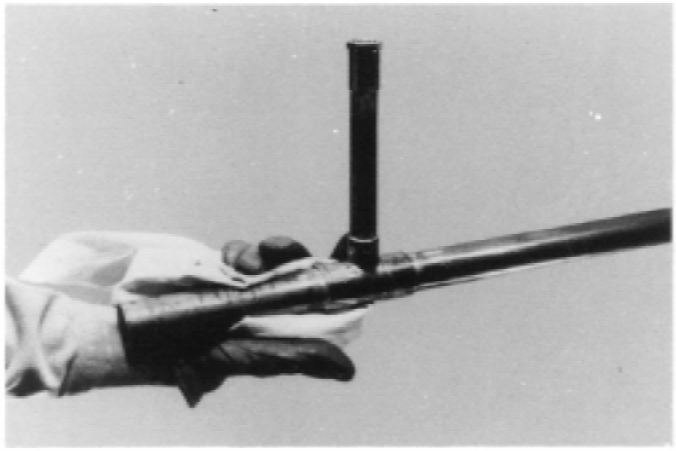

FIG. 21 Cleaning

APPENDIX

(Nonmandatory Information)

X1. TUBE AND FITTINGS DIMENSIONS AND TOLERANCES

X1.1 For dimensions and tolerances for tube and fittings for plumbing, heating, air conditioning, refrigeration, mechanical, fire sprinkler and drainage, waste and vent systems, refer to the specifications listed in Table X1.1 and Table X1.2.

TABLE X1.1 Tube Specifications

ASTM Specifications	Size Range	Application
B 68	1/32–10 in., incl	General engineering
B 68M	0.8–250 mm, incl	General engineering
B 75	1/32–10 in., incl	General engineering
B 75M	0.8–250 mm, incl	General engineering
B 88	1/4–12 in., incl	General plumbing/water
B 88M	6–308 mm, incl	General plumbing/water
B 280	1/8–4 1/8 in., incl	Air conditioning and refrigeration
B 306	1 1/4–8 in., incl	Drainage, waste and vent
B 447	1/4–3 1/2 in., incl	General engineering
B 640	1/8–4 1/8 in., incl	Air conditioning and refrigeration
B 641	1/4–3 in., incl	General engineering
B 716	1/4–12 in., incl	General plumbing/water
B 716M	6–308 mm, incl	General plumbing/water

TABLE X1.2 Fitting Specifications

ASME/ANSI	Size Range	Application
B16.18	1/4–12 in., incl	General plumbing/water
B16.22	1/8–8 in., incl	General plumbing/water Air conditioning and refrigeration, sprinkler
B16.23	1 1/4–8 in., incl	Drainage, waste and vent
B16.29	1 1/4–4 in., incl	Drainage, waste and vent

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 828 – 00) that may impact the use of this standard.

(*1*) Sections 6.1.1, 6.2.1, and 6.3.1 have been modified to replace nonmandatory language with mandatory language.