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Copper Tubing Joints Made Right

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Tips for SOLDERING AND BRAZING COPPER TUBING

While soldering and brazing of copper tube and fittings are relatively simple operations, to achieve good joints, care must be taken not to delete or misapply any steps

BY ANDY KIRETA, JR.

Although soldering and brazing are the most common methods of joining copper tube and fittings, they are often the least understood. It is this lack of understanding that can develop into poor installation techniques and lead to poor or faulty joints. Investigations into the common causes of joint failures revealed several factors contributing to faulty joints, including the following:

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- Improper joint preparation prior to soldering.
- Lack of proper support and/or hanging during soldering or brazing.
- Improper heat control and heat distribution through the entire joining process.
- Improper application of solder or brazing filler metal to the joint.
- Inadequate amount of filler metal applied to the joint.
- Sudden shock cooling and/or wiping the molten filler metal following soldering or brazing.
- Pretinning of joints prior to assembly and soldering.

The basic theory and technique of soldering and brazing are the same for all diameters of copper tube. The only variables are the filler metal and the amount of time and heat required to complete a given joint. The American Welding Society (AWS) defines soldering as a joining process that takes place below 840°F and brazing as a process that takes place above 840°F but below the melting point of the base metals. In actual practice for copper systems, most soldering is done at temperatures from about 350 to 600°F, while most brazing is done at temperatures ranging from 1100 to 1500°F.

The choice between soldering and brazing generally depends on the operating conditions of the system and the requirements of the governing construction codes. Solder joints are generally used where service temperature does not exceed 250°F, while brazed joints can be used where greater joint strength is required or where system temperatures are as high as 350°F.

Although brazed joints offer higher joint strength in general, the annealing of the tube and fitting that results from the higher heat used in the brazing process can cause the rated pressure of the system to be less than that of a soldered joint. This fact should be considered in choosing which joining process to use.

Soldering and brazing operations are inherently simple, but deletion or misapplication of a single part of the process may mean the difference between a good joint and a failure.

The Joining Process

Regardless of the process, soldering or brazing, the same basic steps should be followed, with the only differences being the fluxes, filler metals, and amount of heat used. The following outlines the basic requirements for consistently making a high-quality soldered or brazed joint:

- Measuring and cutting
- Reaming
- Cleaning
- Fluxing
- Assembly and support
- Heating
- Applying the filler metal
- Cooling and cleaning.

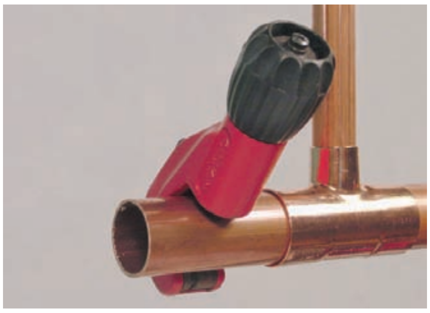

Fig. 1 — Cutting tube with a disc-type tool.

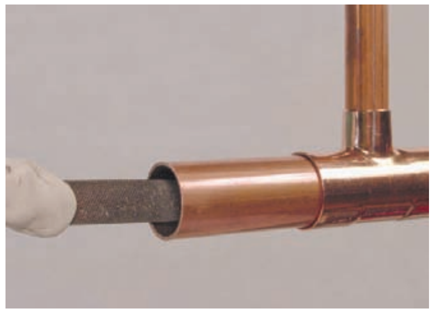

Fig. 2 — A round file or other devices can be used to ream the tube ends.

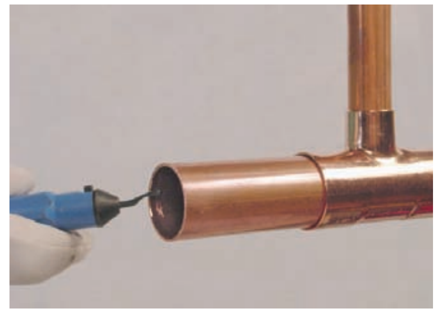

Fig. 3 — A deburring tool for reaming tube ends.

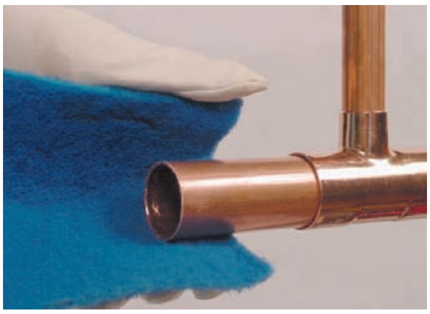

Fig. 4 — Tube ends are cleaned with a nylon abrasive pad or sand cloth.

Fig. 5 — Fitting cups must also be cleaned.

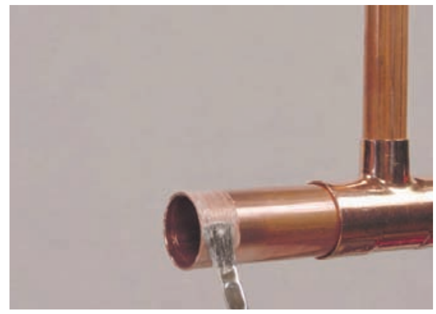

Fig. 6 — Flux is applied to the tube soon after cleaning.

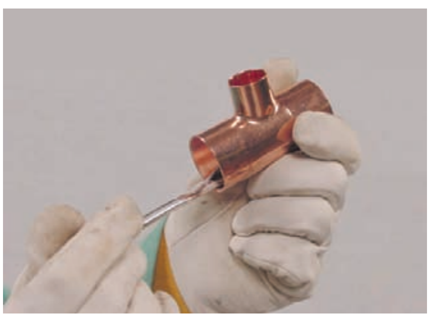

Fig. 7 — Flux is also brushed onto the fitting.

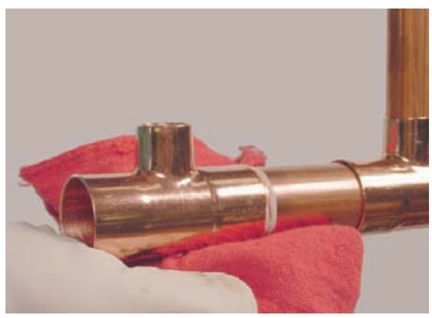

Fig. 8 — Excess flux must be removed.

Measuring and Cutting

Accurately measure the length of each tube segment. Inaccuracy can compromise 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, system strain may be introduced that could affect service life.

Cut the tube to the measured length. Cutting can be accomplished in a number of different ways to produce a satisfactory squared end. The tube can be cut with a disc-type tube cutting tool (Fig. 1), a hacksaw, an abrasive wheel, or a stationary or portable band saw. Care must be taken to ensure the tube is not deformed while being cut. Regardless of the method, the cut must be square to the run of the tube so the tube will seat properly in the fitting cup.

Reaming

Ream all cut tube ends fully inside the tube to remove the small burr the cutting operation creates. If this rough, inside edge is not removed by reaming, erosion/corrosion may occur due to local turbulence and increased local flow velocity in the tube. A properly reamed tube provides an undisturbed surface for smooth, laminar flow.

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

Tools used to ream tube ends include the reaming blade on the tube cutting device, half-round or round files (Fig. 2), a pocketknife, and a suitable deburring tool (Fig. 3). With soft tube, care must be taken not to deform the tube end by applying too much pressure.

Soft temper tube, if deformed, can be brought back to roundness with a sizing tool consisting of a plug and sizing ring.

Cleaning

Removal of all oxides and surface soil from the tube ends and fitting cups is crucial to proper flow of filler metal into the joint. Failure to remove them can interfere with capillary action and may lessen the strength of the joint and cause failure.

The capillary space between tube and fitting is approximately 0.004 in. Filler metal fills this gap by capillary action. This spacing is critical because it determines whether there is a proper flow of filler metal into the gap, ensuring a strong joint.

Lightly abrade (clean) the tube ends using sand cloth or nylon abrasive pads (Fig. 4) for a distance slightly more than the depth of the fitting cup.

Clean the fitting cups by using abrasive cloth, abrasive pads, or a properly sized fitting brush — Fig. 5. Copper is a relatively soft metal. If too much material is removed from the tube end or fitting cup, a loose fit may result in a poor joint.

Chemical cleaning may be used if tube ends and fittings are thoroughly rinsed after cleaning according to the procedure furnished by the chemical manufacturer. Do not touch the cleaned surface with bare hands or oily gloves. Skin oils, lubricating oils, and grease impair adherence of filler metal.

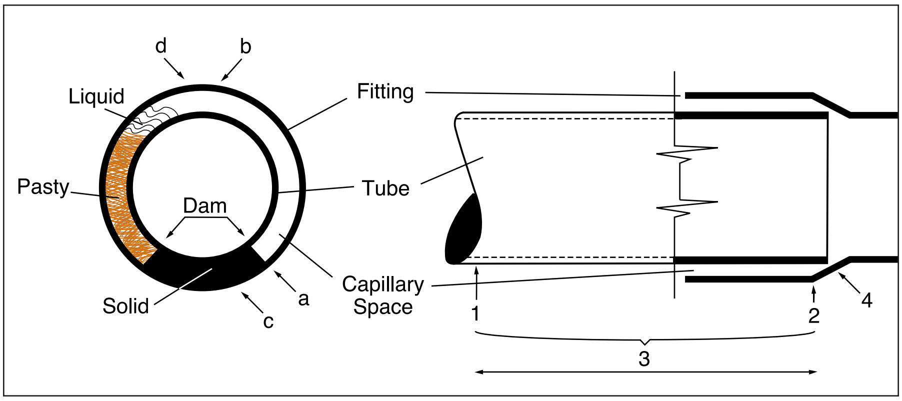

Fig. 9 — Uniformity of capillary space helps ensure good capillary flow. Positions 1–4 illustrate heating of the tube; positions a–d illustrate heating the fitting cup.

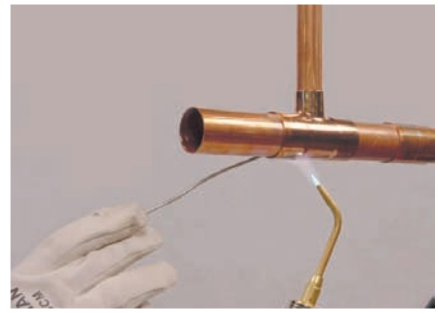

Fig. 10 — Heat is usually applied with a torch.

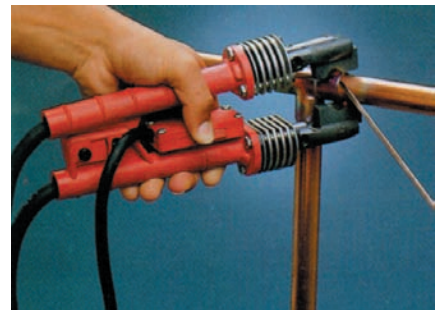

Fig. 11 — Heat can also be applied with an electric resistance soldering tool.

Fig. 12 — After cooling, clean off any flux residue.

Soldered Joints

Fluxing

Use a soldering 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 ASTM B 813. Apply a thin, even coating of flux with a brush to both tube and fitting as soon as possible after cleaning (Figs. 6, 7).

Note: Do not apply with fingers. Chemicals in the flux can be harmful if carried to the eyes, mouth, or open cuts.

Use care in applying flux. Careless workmanship can cause problems long after the system has been installed. If excessive amounts of flux are used, flux residue can cause corrosion. In extreme cases, such flux corrosion could perforate the wall of the tube, fitting, or both.

Assembly and Support

Insert tube end into fitting cup, making sure the tube is seated against the base of the fitting cup. A slight twisting motion ensures even coverage by the flux. Remove excess flux from the exterior of the joint with a cotton rag — Fig. 8.

Support the tube and fitting assembly to ensure an adequate capillary space around the entire circumference of the joint. Uniformity of capillary space will ensure good capillary flow (Fig. 9) of the molten solder metal. Excessive joint clearance can lead to solder metal cracking under conditions of stress or vibration.

Heating

Note: When dealing with an open flame, high temperatures, and flammable gases, safety precautions as described in ANSI/AWS Z49.1, *Safety in Welding, Cutting, and Allied Processes,* must be observed.

Begin heating with the flame perpendicular to the tube (Fig. 9, position 1). 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 on the size of the joint. Preheating of the assembly should include the entire tube circumference to bring the entire assembly up to a suitable preheat condition. However, for joints in the horizontal position, avoid directly preheating the top of the joint to avoid burning the soldering flux. The natural tendency for heat to rise will ensure adequate preheat of the top of the assembly. Experience will indicate the amount of heat and time needed.

Next, move the flame onto the fitting cup (Fig. 9, position 2). Sweep the flame alternately between the fitting cup and the tube a distance equal to the fitting cup's depth (Fig. 9, position 3). Again, preheating the circumference of the assembly as described above, with the torch at the fitting cup's base (Fig. 9, position 4), touch the solder to the joint. If the solder does not melt, remove it and continue heating.

Caution: Do not overheat the joint or direct the flame into the face of the fitting cup. Overheating could burn the flux, which will destroy its effectiveness, and the solder will not enter the joint properly.

When the solder melts, apply heat to the base of the cup to aid capillary action in drawing the molten solder into the cup toward the heat source. Heat is generally applied using an oxyfuel torch — Fig. 10. Such torches use acetylene or an LP gas. Electric resistance soldering tools can also be used — Fig. 11. They employ heating electrodes and should be considered when an open flame is a concern.

Applying Solder

For joints in the horizontal position, start applying the solder metal slightly off-center at the bottom of the joint (Fig. 9, position a, and Fig. 11). When the solder begins to melt from the heat of the tube and fitting, push the solder straight into the joint while keeping the torch at the base of the fitting and slightly ahead of the point of application of the solder. Continue this technique across the bottom of the fitting and up one side to the top — Fig. 9, position b. The now-solidified solder at the bottom of the joint has created an effective dam that will prevent the solder from running out of the joint as the sides and top are being filled.

Return to the point of beginning, overlapping slightly (Fig. 9, position c), and proceed up the uncompleted side to the top, again overlapping slightly — Fig. 9, position d. While soldering, small drops may appear behind the point of solder application, indicating the joint is full to that point and will take no more solder. Throughout this process, you are using all three physical states of the solder: solid, pasty, and liquid. For joints in the vertical position, make a similar sequence of overlapping passes starting wherever convenient.

Table 1 — Solder Requirements for Solder Joint Pressure Fittings (length in inches)

Normal Wt. in lb or Standard Size (in.)	O.D. of Tube (in.)	Cup Depth of Fitting (in.)	Joint Clearance (in.) 0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010	at 0.010 clearance per 100 joints
1/4	0.375	0.310	0.030	0.060	0.089	0.119	0.149	0.179	0.208	0.238	0.268	0.298	0.097
3/8	0.500	0.380	0.049	0.097	0.146	0.195	0.243	0.292	0.341	0.389	0.438	0.486	0.159
1/2	0.625	0.500	0.080	0.160	0.240	0.320	0.400	0.480	0.560	0.640	0.720	0.800	0.261
5/8	0.750	0.620	0.119	0.238	0.357	0.476	0.595	0.714	0.833	0.952	1.072	1.191	0.389
3/4	0.875	0.750	0.168	0.336	0.504	0.672	0.840	1.008	1.176	1.344	1.512	1.680	0.548
1	1.125	0.910	0.262	0.524	0.786	1.048	1.311	1.573	1.835	2.097	2.359	2.621	0.856
1 1/4	1.375	0.970	0.341	0.683	1.024	1.366	1.707	2.049	2.390	2.732	3.073	3.415	1.115
1 1/2	1.625	1.090	0.454	0.907	1.361	1.814	2.268	2.721	3.175	3.628	4.082	4.535	1.480
2	2.125	1.340	0.729	1.458	2.187	2.916	3.645	4.374	5.103	5.833	6.562	7.291	2.380
2 1/2	2.625	1.470	0.988	1.976	2.964	3.952	4.940	5.928	6.916	7.904	8.892	9.880	3.225
3	3.125	1.660	1.328	2.656	3.985	5.313	6.641	7.969	9.297	10.626	11.954	13.282	4.335
3 1/2	3.625	1.910	1.773	3.546	5.318	7.091	8.864	10.637	12.409	14.182	15.955	17.728	5.786
4	4.125	2.160	2.281	4.563	6.844	9.125	11.407	13.688	15.969	18.250	20.532	22.813	7.446
5	5.125	2.660	3.490	6.981	10.471	13.962	17.452	20.943	24.433	27.924	31.414	34.905	11.392
6	6.125	3.090	4.846	9.692	14.538	19.383	24.229	29.075	33.921	38.767	43.613	48.459	15.815
8	8.125	3.970	8.259	16.518	24.777	33.035	41.294	49.553	57.812	66.071	74.330	82.589	26.955
10	10.125	4.000	10.370	20.739	31.109	41.478	51.848	62.218	72.587	82.957	93.326	103.696	33.845
12	12.125	4.500	13.970	27.940	41.910	55.881	69.851	83.821	97.791	111.761	125.731	139.701	45.596
							Average Actual Consumption(a)						For Estimating Purpose(b)

(a) Actual consumption depends on workmanship.
(b) Includes an allowance of 100% to cover wastage and loss.
Note: Flux requirements are usually 2 oz per lb of solder.

Table 2 — Filler Metals for Brazing

AWS Classification(a)	Principal Elements, % Silver (Ag)	Phosphorus (P)	Zinc (Zn)	Cadmium (Cd)	Tin (Sn)	Copper (Cu)	Temperature (°F) Solidus	Liquidus
BCup-2	—	7.00–7.5	—	—	—	Remainder	1310	1460
BCup-3	4.8–5.2	5.8–6.2	—	—	—	Remainder	1190	1495
BCup-4	5.8–6.2	7.0–7.5	—	—	—	Remainder	1190	1325
BCup-5	14.5–15.5	4.8–5.2	—	—	—	Remainder	1190	1475
BAg-1(b)	44–46	—	14–18	23–25(b)	—	14–16	1125	1145
BAg-2(b)	34–36	—	19–23	17–19(b)	—	25–27	1125	1295
BAg-5	44–46	—	23–27	—	—	29–31	1225	1370
BAg-7	55–57	—	15–19	—	4.5–5.5	21–23	1145	1205

(a) ANSI/AWS A5.8, *Specification for Filler Metals for Brazing.*
(b) WARNING: BAg-1 and BAg-2 contain cadmium. Heating when brazing can produce highly toxic fumes. Avoid breathing fumes. Use adequate ventilation. Refer to ANSI/Z49.1:1999, *Safety in Welding, Cutting, and Allied Processes.*

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 flow is upward, downward, or horizontal.

Capillary action is most effective when the space between the surfaces to be joined is between 0.002 and 0.005 in. A certain amount of looseness of fit can be tolerated, but too loose a fit can cause difficulties with larger size fittings.

For joining copper tube to solder-cup valves, follow the manufacturer's instructions. The valve should be in the open position before applying heat, and the heat should be applied primarily to the tube. Commercially available heat-sink materials can also be used for protection of temperature-sensitive components.

The amount of solder consumed when adequately filling the capillary space between the tube and either wrought or cast fittings may be estimated from Table 1. The flux requirement is usually two ounces per pound of solder.

Cooling and Cleaning

Allow the completed joint to cool naturally. Shock cooling with water may stress or crack it. When cool, clean off any remaining flux residue with a wet rag — Fig. 12. Whenever possible, based on end use, completed systems should be flushed to remove excess flux and debris. Use a soldering flux meeting the requirements of ASTM B 813.

Testing

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

Brazed Joints

Strong, leaktight brazed connections for copper tube may be made by brazing with filler metals that melt at temperatures in the range between 1100 and 1500°F (Table 2). Brazing filler metals are sometimes referred to as "hard solders" or "silver solders." Avoid these confusing terms.

The temperature at which filler metal starts to melt on heating is the solidus temperature; the liquidus temperature is the higher temperature at which the filler

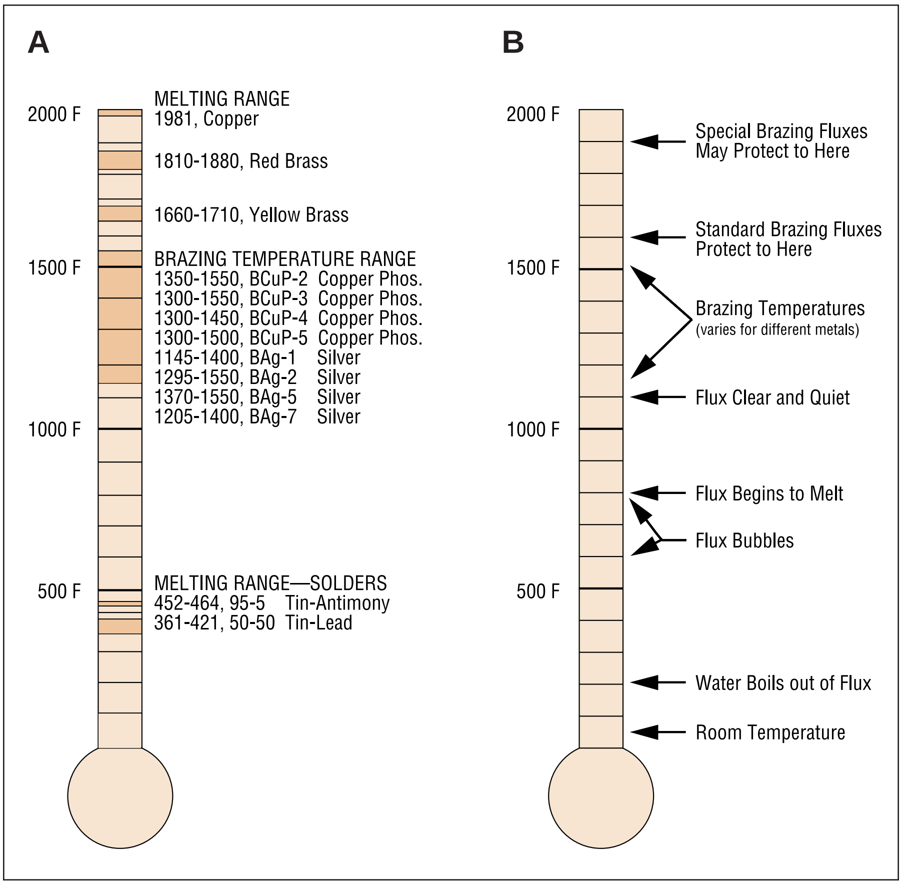

Fig. 13 — A — Ranges for common brazing filler metals; B — brazing fluxes offer an indication of temperature.

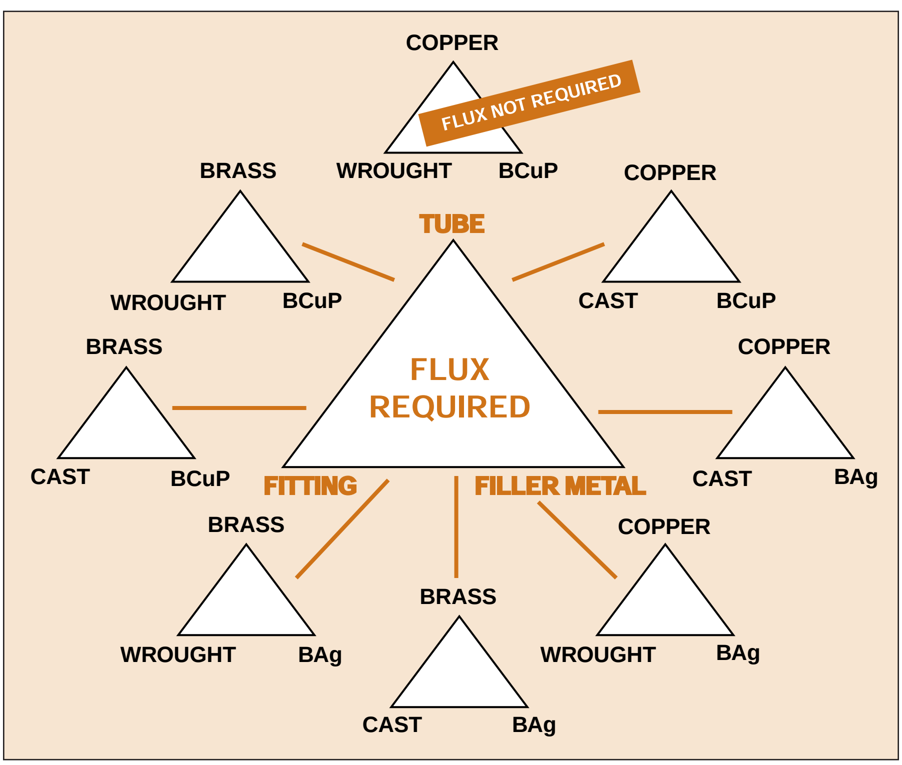

Fig. 14 — Different types of copper and copper-alloy tube, fittings, and filler metals need flux for brazing.

metal is completely melted. The liquidus temperature is the minimum temperature at which brazing will take place.

The difference between solidus and liquidus is the melting range and may be of importance when selecting a filler metal. It indicates the working range for the filler metal and the speed with which the filler metal will become solid after brazing. Filler metals with narrow ranges, with or without silver, solidify more quickly and, therefore, require careful application of heat. The working ranges of common brazing filler metals are shown in Fig. 13A.

Brazing Filler Metals

Brazing filler metals suitable for joining copper tube are of two classes: 1) the BCuP series alloys containing phosphorus and 2) the BAg series alloys containing a high silver content. The two classes differ in their melting, fluxing, and flowing characteristics, and this should be considered in selection of a filler metal (Table 2). While any of the listed filler metals may be used, those most commonly used in plumbing, HVAC refrigeration, and fire sprinkler systems are BCuP-2 (for close tolerances); BCuP-3, 4, or 5 (where close tolerances cannot be held); and BAg-1, BAg-5, and BAg-7. The BCuP series filler metals are more economical than the BAg series and are better suited for general piping applications. BAg series filler metals should be used when joining dissimilar metals or when their specific characteristics are required. For joining copper tube, any of these filler metals will provide the necessary strength when used with standard solder-type fittings or commercially available short-cup brazing fittings.

According to the American Welding Society, the strength of the brazed joint will meet or exceed that of the tube and fitting being joined when the joint overlap and the depth of filler metal penetration is a minimum of three times the thickness of the thinner base metal (tube or fitting) and a well-developed fillet is present.

The strength of a brazed copper tube joint does not vary much with the different filler metals but depends mainly on maintaining the proper clearance between the outside of the tube and the cup of the fitting. Copper tube and solder-type fittings are accurately made for each other, and the tolerances permitted for each assure the capillary space will be within the limits necessary for a joint of satisfactory strength.

The rated internal working pressures of brazed copper tube systems at service temperatures up to 350°F (the temperature of saturated steam at 120 lb/in.^{2}) are shown in Table 3. These pressure ratings should be used only when the correct capillary space has been maintained.

Table 3 — Pressure-Temperature Ratings of Soldered and Brazed Joints

Joining Material[d]	Service Temperature, °F	Fitting Type	Maximum Working Gauge Pressure ($lb/in.^2$) for Standard Water Tube Sizes[a] Nominal of Standard Size, in. 1/8 through 1	1 1/4 through 2	2 1/2 through 4	5 through 8	10 through 12
Alloy Sn50 50-50 Tin-Lead Solder[e]	100	Pressure[b]	200	175	150	135	100
		DWV[c]	—	95	80	70	—
	150	Pressure[b]	150	125	100	90	70
		DWV[c]	—	70	55	45	—
	200	Pressure[b]	100	90	75	70	50
		DWV[c]	—	50	40	35	—
	250	Pressure[b]	85	75	50	45	40
		DWV[c]	—	—	—	—	—
	Saturated Steam	Pressure	15	15	15	15	15
Alloy Sb5 95-5 Tin-Antimony Solder	100	Pressure[b]	635	560	375	340	340
		DWV[c]	—	390	325	330	—
	150	Pressure[b]	635	505	375	340	280
		DWV[c]	—	225	185	190	—
	200	Pressure[b]	540	410	330	300	230
		DWV[c]	—	180	150	155	—
	250	Pressure[b]	290	220	175	160	120
		DWV[c]	—	95	80	80	—
	Saturated Steam	Pressure	15	15	15	15	15
Alloy E	100	Pressure[b]	635	560	375	340	320
		DWV[c]	—	255	210	215	—
	150	Pressure[b]	505	385	310	280	215
		DWV[c]	—	170	140	140	—
	200	Pressure[b]	400	305	245	225	170
		DWV[c]	—	135	110	115	—
	250	Pressure[b]	340	260	210	190	145
		DWV[c]	—	115	95	95	—
	Saturated Steam	Pressure	15	15	15	15	15
Alloy HB	100	Pressure[b]	635	560	375	340	340
		DWV[c]	—	370	310	315	—
	150	Pressure[b]	635	560	375	340	320
		DWV[c]	—	255	210	215	—
	200	Pressure[b]	470	360	290	265	200
		DWV[c]	—	155	130	135	—
	250	Pressure[b]	455	350	280	255	195
		DWV[c]	—	155	125	130	—
	Saturated Steam	Pressure	15	15	15	15	15
Joining materials melting at or above 1100°F[f]	Pressure-temperature ratings consistent with the materials and procedures employed.						
	Saturated Steam	Pressure	15	15	15	15	15

Note: For extremely low working temperatures in the 0 to – 200°F range, it is recommended that a joint material melting at or above 1100°F be employed.
(a) Standard water tube sizes per ASTM B 88.
(b) Ratings up to 8 in. in size are those given in ASME B16.22, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*, and ASME B16.18, *Cast Copper and Copper Alloy Solder Joint Fittings*. Rating for 10 to 12 in. sizes are those given in ASME B16.8, *Cast Copper and Copper Alloy Solder Joint Pressure Fittings.*
(c) Using ASME B16.29, *Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings — DWV*, and ASME B16.23, *Cast Copper Alloy Solder Joint Drainage Fittings — DWV.*
(d) Alloy designations are per ASTM B 32.
(e) The Safe Drinking Water Act Amendment of 1986 prohibits the use in potable water systems of any solder having a lead content in excess of 0.2%.
(f) These joining materials are defined as *brazing alloys* by the American Welding Society.

Fluxes

The fluxes used for brazing copper joints are different in composition from soldering fluxes. The two types cannot be used interchangeably. Brazing fluxes are water based, whereas most soldering fluxes are petroleum based. Similar to soldering fluxes, brazing fluxes dissolve and remove residual oxides from the metal surface, protect the metal from reoxidation during heating, and promote wetting of the surfaces to be joined by the brazing filler metal.

Brazing fluxes also provide the craftsman with an indication of temperature — Fig. 13B. If the outside of the fitting and the heat-affected area of the tube are covered with flux (in addition to the end of the tube and the fitting cup), oxidation will be minimized and the appearance of the joint will be greatly improved. The fluxes best suited for brazing copper and copper alloy tube should meet the requirements of AWS A5.31, Type FB3-A or FB3-C.

Figure 14 illustrates the need for brazing flux with different types of copper and copper-alloy tube, fittings, and filler metals when brazing.

Assembly

Assemble the joint by inserting the tube into the socket against the stop and turn, if possible. The assembly should be firmly supported so it will remain in alignment during the brazing operation.

Applying Heat and Brazing

Apply heat to the parts to be joined, preferably with an oxy-fuel torch with a neutral flame. Air-fuel is sometimes used on smaller sizes. Heat the tube first, beginning about 1 in. from the edge of the fitting, sweeping the flame around the tube in short strokes at right angles to the axis of the tube — Fig. 12, position 1.

It is very important the flame be kept in motion and not remain on any one point long enough to damage the tube. The flux may be used as a guide for how long to heat the tube. The behavior of flux during the brazing cycle is described in Fig. 13B.

Switch the flame to the fitting at the base of the cup — Fig. 12, position 2. Heat uniformly, sweeping the flame alternately from the fitting to the tube until the flux becomes quiet. Avoid excessive heating of cast fittings because of the possibility of cracking.

When the flux appears liquid and transparent, start sweeping the flame back and forth along the axis of the joint to maintain heat on the parts to be joined, especially toward the base of the cup of the fitting — Fig.12, position 3. The flame must be kept moving to avoid melting the tube or fitting.

For 1-in. or larger tube, it may be difficult to bring the whole joint up to temperature at one time. It will frequently be desirable to use an oxyfuel, multiple-orifice heating tip to maintain a more uniform temperature over large areas. Mild preheating of the entire fitting is recommended for larger sizes, and the use of a second torch to retain a uniform preheating of the entire fitting assembly may be necessary in larger diameters. Heating can then proceed as outlined in the steps above.

Apply the brazing filler metal at a point where the tube enters the socket of the fitting. When the proper temperature is reached, the filler metal will flow readily into the space between the tube and fitting socket, drawn in by the natural force of capillary action.

Keep the flame away from the filler metal itself as it is fed into the joint. The temperature of the tube and fitting at the joint should be high enough to melt the filler metal. Keep both the fitting and tube heated by moving the flame back and forth from one to the other as the filler metal is drawn into the joint.

When the joint is properly made, filler metal will be drawn into the fitting socket by capillary action, and a continuous fillet of filler metal will be visible completely around the joint. To aid in the development of this fillet during brazing, the flame should be kept slightly ahead of the point of filler metal application. Stop feeding as soon as you see a complete fillet.

Horizontal and Vertical Joints

When brazing horizontal joints, it is preferable to first apply the filler metal slightly off-center at the bottom of the joint, proceeding across the bottom and continuing up the side to the top of the joint. Then, return to the beginning point, overlapping slightly, and proceed up the uncompleted side to the top, again, overlapping slightly. This procedure is identical to that used for soldering.

Also, similar to the soldering process, make sure the operations overlap. On vertical joints, it is immaterial where the start is made. If the opening of the socket is pointing down, care should be taken to avoid overheating the tube as this may cause the brazing filler metal to run down the outside of the tube.

Removing Residue

After the brazed joint has cooled, remove the flux residue using warm water and a clean cloth, brush, or swab. Remove all flux residue to avoid the risk of the hardened flux temporarily retaining pressure and masking an imperfectly brazed joint. Wrought fittings may be cooled more readily than cast fittings, but allow all fittings to cool naturally before wetting.

General Hints and Suggestions

If the filler metal fails to flow or has a tendency to ball up, it indicates oxidation on the metal surfaces or insufficient heat on the parts to be joined. If tube or fitting starts to oxidize during heating, there is too little flux. If the filler metal does not enter the joint and tends to flow over the outside of either member of the joint, it indicates one member is overheated or the other is underheated.

Testing

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

Purging

Some installations, such as medical gas and ACR systems, require the addition of an inert gas during the brazing process. The purge gas displaces oxygen from the interior of the system while it is being subjected to the high temperatures of brazing and therefore eliminates the possibility of oxide formation on the interior tube surface. Purge gas flow rates and methods of application should be included in the Brazing Procedure Specifications for these applications.

If You Need More Info

For further information about soldering, brazing, or welding of copper and copper alloys, contact the Copper Development Association, (212) 251-7200, visit *www.copper.org*, or e-mail *staff@cda.copper.org*. ◆

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