25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

Tech Tips 007

PRACTICAL WELDING TODAY®

Brazing copper and copper alloys

When to use it and how to do it

By Myron T. Havis
March 13, 2007

It is important to be able to identify when brazing is suitable for joining copper or copper alloys, how it is applied, and which filler metals to use.

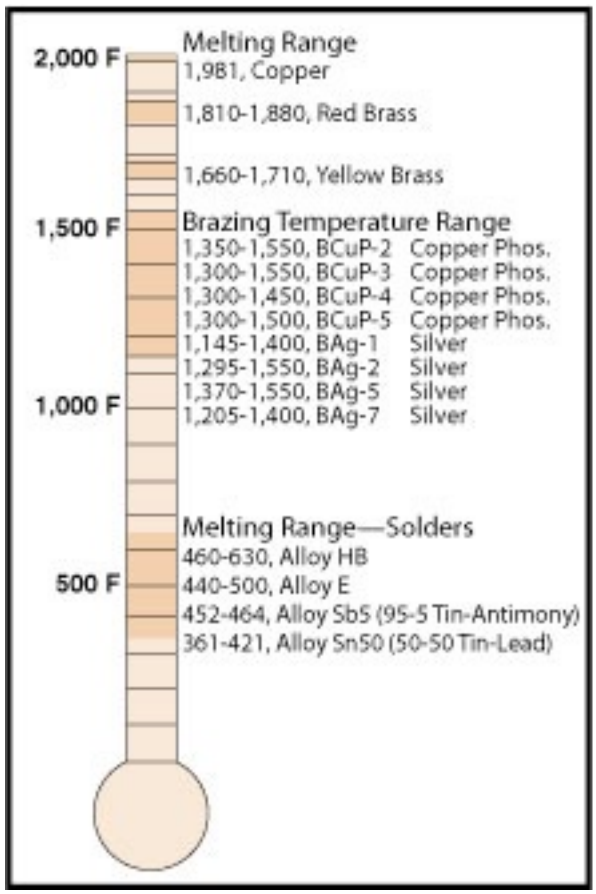

Figure 1
Brazing takes place above 840 degrees F but below the melting point of the base metal. Source: CDA, Copper Tube Handbook.

25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

Four processes to consider when joining copper and copper alloys are mechanical couplings, welding, soldering, and brazing. Brazing is suitable for small parts and when high joint strength is required. According to the American Welding Society (AWS), the strength of a brazed joint can meet or exceed that of the metals being joined. It is important to know when to choose brazing and how to perform the process.

From a process standpoint, soldering and brazing are essentially the same. The only differences are the filler metals used and the amount of time and heat required to complete the joint. AWS defines soldering as a joining process that takes place below 840 degrees F, while brazing takes place above 840 degrees F but below the melting point of the base metal. In actual practice for copper systems, most soldering is done at temperatures from about 450 degrees F to 600 degrees F, while most brazing is done at temperatures from 1,100 degrees F to 1,500 degrees F. When brazing copper tube, however, the annealing of the tube and fitting that results from the higher heat can cause the rated pressure of the system to be less than that of a soldered joint.

Copper's melting point is 1,981 degrees F (liquidus) and 1,949 degrees F (solidus). For brazing, it is important to know the melting points of the metals to be joined and the filler metal. The difference between the solidus and liquidus state is the melting range, which may be important when selecting a filler metal. It indicates the width of the working range for the filler metal and the speed with which the filler metal solidifies after brazing. Filler metals with narrow ranges, with or without silver, solidify more quickly and, therefore, require careful application of heat. The liquidus temperature is the minimum at which brazing will take place. See **Figure 1** for the melting ranges of some common brazing metals.

To Braze or Not to Braze

25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

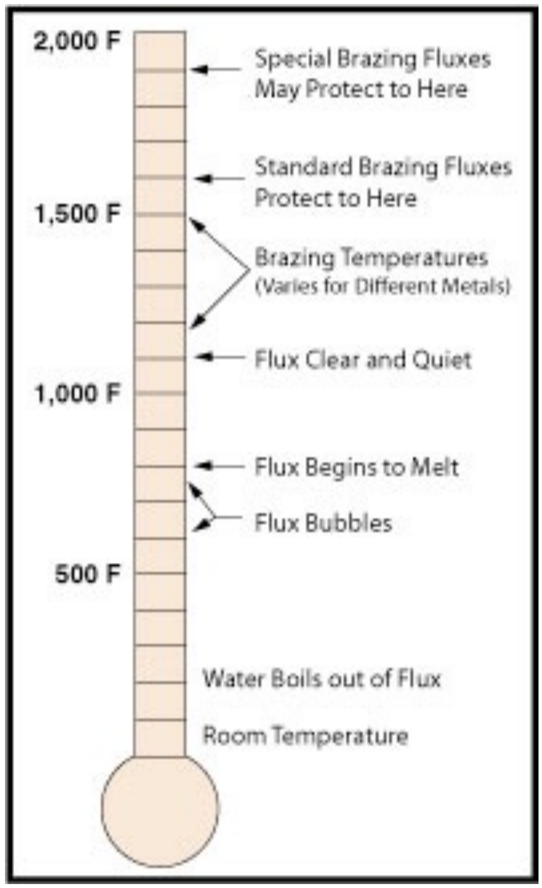

Figure 2
The table shows how fluxes respond at various temperatures and at what maximum temperature the flux will protect the metal. Source: CDA, Copper Tube Handbook.

According to Lucas-Milhaupt's What Brazing Is All About (**www.lucasmilhaupt.com**), the choice to braze comes down to five factors:

1. The size of the parts to be joined. Brazing is more often used for small parts and requires heating a broad surface to bring the filler material to its flow point, which is often impractical with large pieces.
2. Thickness of the metal sections. The broader heat and lower temperature used in brazing, as opposed to welding, permit the joining of sections without warpage or metal distortion. The intense heat of welding may burn through or warp a thin section.

25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

3. Joint configuration. Brazing needs no manual tracing, and the filler metal is drawn through the joint area by capillary action, which works with equal ease on straight, irregular, or tubular joints.
4. Nature of the base metals. For joining dissimilar metals, brazing won't melt one or both of the metals if the filler metal is metallurgically compatible with both base metals and has a melting point lower than either of the metals to be joined. Note that copper alloys can be readily brazed to other metals, such as cast iron, tool and stainless steels, nickel alloys, and titanium alloys.
5. Number of joints to be made. If you are making many joints, manual brazing is quick and simple, and automated brazing may be accomplished inexpensively using simple production techniques.

Brazing Fluxes

Brazing fluxes for copper are water-based, dissolve and remove residual oxides from the metal surface, protect the metal from oxidation during heating, and promote wetting of the surfaces to be joined. Brazing fluxes also provide you with an indication of temperature (see **Figure 2**).

Commonly Used Brazing Filler Materials for Copper and Copper Alloys*

AWS Classification	UNS No.	Composition, wt. %								Brazing Temperature Range	
		Ag	Cu	Zn	Cd	Sn	Fe	Ni	P	°F	°C
BAg-1	P07450	44-46	14-16	14-18	23-25	—	—	—	—	1,145-1,400	618-760
BAg-1a	P07500	49-51	14.5-16.5	14.5-18.5	17-19	—	—	—	—	1,175-1,400	635-760
BAg-2	P07350	34-36	25-27	19-23	17-19	—	—	—	—	1,295-1,550	702-843
BAg-3	P07501	49-51	14.5-16.5	13.5-17.5	15-17	—	—	2.5-3.5	—	1,270-1,500	688-816
BAg-5	P07453	44-46	29-31	23-27	—	—	—	—	—	1,370-1,550	743-843
BAg-6	P07503	49-51	33-35	14-18	—	—	—	—	—	1,425-1,600	774-871
BAg-7	P07563	55-57	21-23	15-19	—	4.5-5.5	—	—	—	1,205-1,400	652-760
BAg-8	P07720	71-73	Bal.	—	—	—	—	—	—	1,435-1,650	780-899
BAg-18	P07600	59-61	Bal.	—	—	9.5-10.5	—	—	—	1,325-1,550	718-843
BCu-1	C14180	—	99.9 min	—	—	—	—	—	0.75	2,000-2,100	1,093-1,149
RBCuZn-A	C47000	—	57-61	Bal.	—	0.25-1.0	—	—	—	1,670-1,750	910-955
RBCuZn-C	C68100	—	56-60	Bal.	—	0.8-1.1	0.25-1.2	—	—	1,670-1,750	910-955
RBCuZn-D	C77300	—	46-50	Bal.	—	—	9-11	—	0.25	1,720-1,800	938-982
BCuP-2	C55181	—	Bal.	—	—	—	—	—	7.0-7.5	1,350-1,550	732-843
BCuP-3	C55281	4.8-5.2	Bal.	—	—	—	—	—	5.8-6.2	1,325-1,500	718-816
BCuP-4	C55283	5.8-6.2	Bal.	—	—	—	—	—	7.0-7.5	1,275-1,450	691-788
BCuP-5	C55284	14.5-15.5	Bal.	—	—	—	—	—	4.8-5.2	1,300-1,500	704-816

*Refer to ANSI/AWS A5.8, *Specification for Filler Metals for Brazing and Braze Welding*.

Figure 3

This table, a reference for brazing all copper and copper alloys, includes information for selecting the proper filler materials and fluxes, surface preparation, and atmospheres for brazing. Source: AWS, Welding Handbook.

25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

The most commonly used fluxes and brazing filler materials for copper and copper alloys are shown in **Figure 3**, and a guide to their use is shown in **Figure 4**. This and other detailed information can be found in *The Welding Handbook*, 8th Edition, Vol. 8, published by the American Welding Society and available from the Copper Development Association under the title *Welding Copper and Copper Alloys*, A1050-72/97.

Guide to Brazing Copper and Copper Alloys

Material	Commonly Used Brazing Filler Metals	AWS Brazing Atmospheres[c]	AWS Brazing Flux	Remarks
Coppers	BCuP-2[a], BCuP-3, BCuP-5[a], RBCuZn, BAg-1a, BAg-1, BAg-2, BAg-5, BAg-6, BAg-18	1, 2, or 5	FB3-A, C, D, E, I, J	Oxygen-bearing coppers should not be brazed in hydrogen-containing atmospheres.
High Coppers	BAg-8, BAg-1	Note b	FB3-A	—
Copper-Nickel	BAg-1a, BAg-1, BAg-2, BAg-18, BAg-5, BCuP-5, BCuP-3	1,2, or 5	FB3-A, C, E	Stress relieve before brazing.

a. Protective atmosphere or flux is not required for brazing copper with BCuP fillers.
b. Furnace brazing without flux is possible if the parts are first nickel or copper plated. Braze following the procedures recommended for nickel or copper.
c. Hydrogen, inert gas, or vacuum atmospheres usually are also acceptable (AWS Type 7, 9, or 10). Brazing atmospheres are listed below.

Figure 4a
This copper brazing guide lists commonly used filler metals, fluxes, atmospheres, and special considerations. Source: AWS, Welding Handbook.

The Process

The same basic steps are used for brazing as for soldering, with the only differences being the use of fluxes, filler metals, and the amount of heat used.

25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

AWS Brazing Atmosphere	Source	Maximum Dew Point of Incoming Gas
1	Combusted fuel gas (low hydrogen)	Room temp.
2	Combusted fuel gas (decarburizing)	Room temp.
3	Combusted fuel gas, dried	-40°F (-40°C)
4	Combusted fuel gas, dried (carburizing)	-40°F (-40°C)
5	Dissociated ammonia	-65°F (-54°C)
6A	Cryogenic and purified N_2+H_2	-90°F (-68°C)
6B	Cryogenic and purified N_2+H_2+CO	-20°F (-29°C)
6C	Cryogenic and purified N_2	-90°F (-68°C)
7	Hydrogen, deoxygenated and dried	-75°F (-59°C)
9	Purified inert gas	—
10	Vacuum	—

Figure 4b

In general, both lap and butt joints can be made. Be sure to remove all oxides and surface oils with abrasive cloth, pads, or brushes before joining the metals. Such contaminants interfere with the proper flow of filler metal and may lessen the joint strength or cause failure. Chemicals cleaners may be used if they are thoroughly rinsed off, but be sure you don't touch the clean surface with bare hands or oily gloves.

Apply a thin, even coating of flux with a brush to both surfaces soon after cleaning. Do not apply the flux with your fingers because the chemicals in the flux can be harmful if it comes in contact with your eyes, mouth, or open cuts. Copper-phosphorus and copper-silver-

25811 Jefferson Avenue
Murrieta, CA 92562
T 19517637077
F 19517637074
davidp@earthshield.com
http://www.jpspecialties.com

phosphorus metals (BCuP) are considered self-fluxing on copper-base metals.

Support the surfaces securely and ensure an adequate capillary space between them for the flow of the molten brazing filler. Excessive joint clearance can lead to cracking under stress or vibration. A joint clearance of 0.001 to 0.005 in. will develop the maximum joint strength and soundness.

Use only the amount of heat necessary to melt and flow the filler metal. Overheating the joint or directing the flame into the capillary space can burn the flux, destroying its effectiveness and preventing the filler metal from entering the joint properly. Apply the heat around the joint area to draw the filler metal into the capillary space. 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.

Allow the completed joint to cool naturally. Shock cooling with water may stress or crack it. When it is cool, clean off any remaining flux residue with a wet rag and test all completed assemblies for joint integrity.