

## SOLDERING & BRAZING TIPS:

### SOLDERING AND BRAZING COPPER TUBE

Soldering and Brazing with capillary solder joint fittings is the most common system for joining copper tube. The American Welding Society defines soldering as a joining process which takes place below 840°F and brazing as a similar process which occurs above 840°F. The basic theory and technique of soldering and brazing are the same for all diameters ... the variables are: the amount of time, heat and filler metal required to complete a designated joint. A good joint is the product of a well trained craftsman who knows and respects the materials and methods he uses.

### BASIC STEPS IN JOINING PROCESS

**Measuring** - Measuring the length of the tube must be accurate. If the tube is too short it will not reach all the way into the socket of the fitting and a proper joint cannot be made.

**Cutting** - Cutting tube can be accomplished in a number of different ways to produce a satisfactory, square-end cut. The tube can be cut with a disc type tube cutter, a hacksaw, abrasive wheels, or stationary and portable bandsaws. Care must be taken that the tube is not deformed while being cut. Regardless of the cutting method used, the cut must be square with the run of the tube so that it will seat properly in the fitting socket.

**Reaming** - Most methods of cutting leave a small burr on the end of the tube. Unless these rough edges are removed, erosion / corrosion may occur due to local turbulence and increased velocities in the tube. Tools used to ream tube ends include the reaming blade on the tube cutter half-round or round files, a pocket knife, or a suitable deburring tool. With annealed tube, care must be taken not to get the tube end out-of-round by applying too much pressure. Both the inside and the outside of the tube may require removal of the burr. A properly reamed piece of tube will provide a smooth surface for better flow.

**Cleaning** - Cleaning is quickly and easily done. The removal of oxides and surface soil is crucial if filler metal is to flow properly. Oxides, surface soil and oil can interfere with the strength of the joint and this may result in the joint's failure. Mechanical cleaning is a simple operation. The end of the tube should be cleaned using sand cloth or nylon abrasive pads for a distance only slightly more than the depth of the fitting socket. The socket of the fitting should also be cleaned using sand cloth, abrasive pads, or properly sized fitting brushes. The same precautions, as when reaming the tube, should be observed. Copper is a soft metal; if too much material is removed, a loose fit will result and interfere with satisfactory capillary action in making the joint. The capillary space between tube and fitting is approximately .004 in. Solder or brazing filler metal can fill this gap by capillary action. This spacing is critical for the filler metal to flow into the gap and form a strong joint. Chemical cleaning may be utilized, providing the tube and fittings are thoroughly rinsed according to the manufacturer's recommendations furnished with the cleaner. This will help neutralize any acidic conditions that may exist. The surfaces, once cleaned, should not be touched with bare hands or oily gloves. Skin oils, lubricating oils and grease impair solder flow and wetting.

### TEMPERATURE RANGES

Up to this point, the joining process is the same for both soldering and brazing. The choice for soldering or brazing will depend upon operating conditions. Solder joints are generally used where the system temperatures do not exceed 250°F and brazed joints can be used where greater strengths are required, or where system temperatures are as high as 350°F. In actual practice, most soldering is done at temperatures about 350°F to 550°F, while brazing is done at temperatures ranging from 1100°F to 1550°. Because of the differences in the soldering and brazing processes, each will be discussed separately.

## SOLDERING:

**Applying Flux** - A non-aggressive soldering flux is recommended. Stir the flux before use. A good flux will dissolve and remove traces of residual oxides from the surfaces to be joined, protect the surfaces from re-oxidation during heating and promote the wetting of the surfaces by the solder. A thin, even coating of flux should be applied with a brush to both tube and fitting. Avoid the use of fingers to apply flux. Chemicals in the flux can be harmful if carried to the eyes of open cuts.

**Types of Solder** - There are a variety of solders available that will produce sound, leak-tight joints. Solders that are used for piping applications contain tin and varying amounts of either antimony, copper, lead or silver. Choice of solder will depend upon application and local codes. For potable water systems, solders which do not contain lead are the best choice.

**Assembly** - After both surfaces are properly fluxed, they should be assembled by placing the fitting on the tube, making sure the tube seats against the base of the fitting socket. A slight twisting motion is suggested to ensure even coverage by the flux. Remove the excess flux with a rag. Because of the heat that is required during soldering and brazing, only cotton rags should be used. Complete all prepared joints within a single work day. Care must be taken to assure that the tube and fittings are properly supported with a reasonable, uniform capillary space around the entire circumference of the joint. Uniformity of capillary space will ensure good filler metal penetration if the guidelines of successful joint making are followed. Excessive joint clearance can cause the filler metal to crack under stress or vibration.

CONTIUNUED ON NEXT PAGE

## SOLDERING & BRAZING TIPS CONTINUED FROM PREVIOUS PAGE

**Heating** - Because of the open flame and high temperatures required for soldering and the flammability of the gases used, safety precautions must be observed. The heat is generally applied by use of an air/fuel torch. These torches can use acetylene or a variety of LP gases. Electric resistance pliers can also be used. Heating should begin with the flame perpendicular to the tube. This preheat will conduct the initial heat into the socket for even distribution of heat inside and out. Preheating depends upon the size of the joint - experience will indicate the proper amount of time. The flame should now be moved onto the fitting. Move the flame from the fitting socket onto the tube a distance equal to the fitting socket. Touch the solder to the joint. If the solder does not melt, remove it and continue the heating process. Be careful not to overheat or direct the flame into the fitting cup. This action can cause the flux to burn and destroy its effectiveness. When the melting temperature has been reached, heat may be applied to the base of the cup to aid capillary action in drawing the solder into the cup.

**Applying Solder** - When the tube is in a horizontal position, start applying the solder slightly off-center of the bottom of the joint. 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 incompleated side to the top. Again, overlapping the solder. Molten solder will be drawn into the joint by capillary action regardless if the solder is being fed upward, downward or horizontally. **Cooling & Cleaning** - After the joint has been completed, natural cooling is best. Shock cooling may cause unnecessary stresses on the joint and may result in eventual failure. Clean off any remaining flux with a wet rag.

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### BRAZING:

**Applying Flux** - The fluxes used for brazing copper joints are different in composition from soldering fluxes. They cannot, and should not, be used interchangeably. Brazing fluxes are water based. Similar to soldering fluxes, brazing fluxes dissolve and remove residual oxides from the metal surfaces, they protect the metal surfaces from re-oxidation during heating and they promote the wetting of the surfaces to be joined by the brazing filler metal. Fluxes also provide the craftsman with an indication of temperature. Application of the flux is the same as when soldering. If the outside of the fitting and the heat affected area of the tube are covered with flux, it will prevent oxidation and greatly improve the appearance of the joint.

**Brazing Filler Metals** - There are two general types of brazing filler metals used for joining copper tube: BCuP (Brazing - Copper - Phosphorus) and BAg (Brazing - Silver). These brazing filler metals are classified according to their components. BCuP filler metals are preferred for joining copper tube and fittings. The phosphorus in these filler metals acts as a fluxing agent and the lower percentage of silver makes them relatively low cost filler metals. When using copper tube, wrought copper fittings and BCuP brazing filler metal, fluxing is an option due to the self-fluxing action of the phosphorus present in all components of the brazed joint. The choice of brazing filler metals depends upon four main factors:

- 1) dimensional tolerance of the joint
- 2) type and material of fitting (cast or wrought)
- 3) desired appearance
- 4) cost.

**Heating** - Oxy/fuel torches are generally used when brazing because of the higher temperatures required. Due to recent innovations in air/fuel torch tip design, they can now be used on a wider variety of sizes for soldering and brazing. When working with

temperatures this high, safety precautions must be followed and care taken to protect both the operator and the materials being used. The heating operation is the same as for soldering. First preheat the tube and then the tube and fitting. When the brazing filler metal starts to melt, apply the heat at the base of the fitting socket to help draw the brazing filler metal by capillary action.

**Applying Brazing Filler Metal** - Remember to allow the heat of the joint to melt the filler metal. Do not melt the filler metal with the torch. The melted filler metal will be drawn into the joint by capillary action. It is very important that the flame be in continuous motion and should not be allowed to remain on any one point long enough to burn through the tube or fitting. When the joint is complete, a continuous fillet should be visible completely around the joint. If the filler metal fails to flow, or has the tendency to ball-up, it indicates oxidation on the metal surfaces or insufficient heat on the parts to be joined. If the filler metal refuses to enter the joint and tends to flow over the outside of either part of the joint, it indicates that this part is overheated or that the other part is underheated.

**Cooling and Cleaning** - When the joint is complete, allow it to cool naturally. Flux residues can be removed by washing with hot water and brushing with a stainless steel wire brush.

### SUMMARY

If the parts to be joined are properly prepared, properly heated and the correct filler metal is used the finished joint should be sound. Soldered or brazed copper piping systems, when installed properly, will provide years of safe and reliable service. Proper training of the correct installation techniques, such as those just covered, will give the craftsman the ability to achieve consistently reliable soldered and brazed joints in all diameters. Prepared with technical assistance from the Copper Development Association.