Cutting and Soldering Copper Pipe

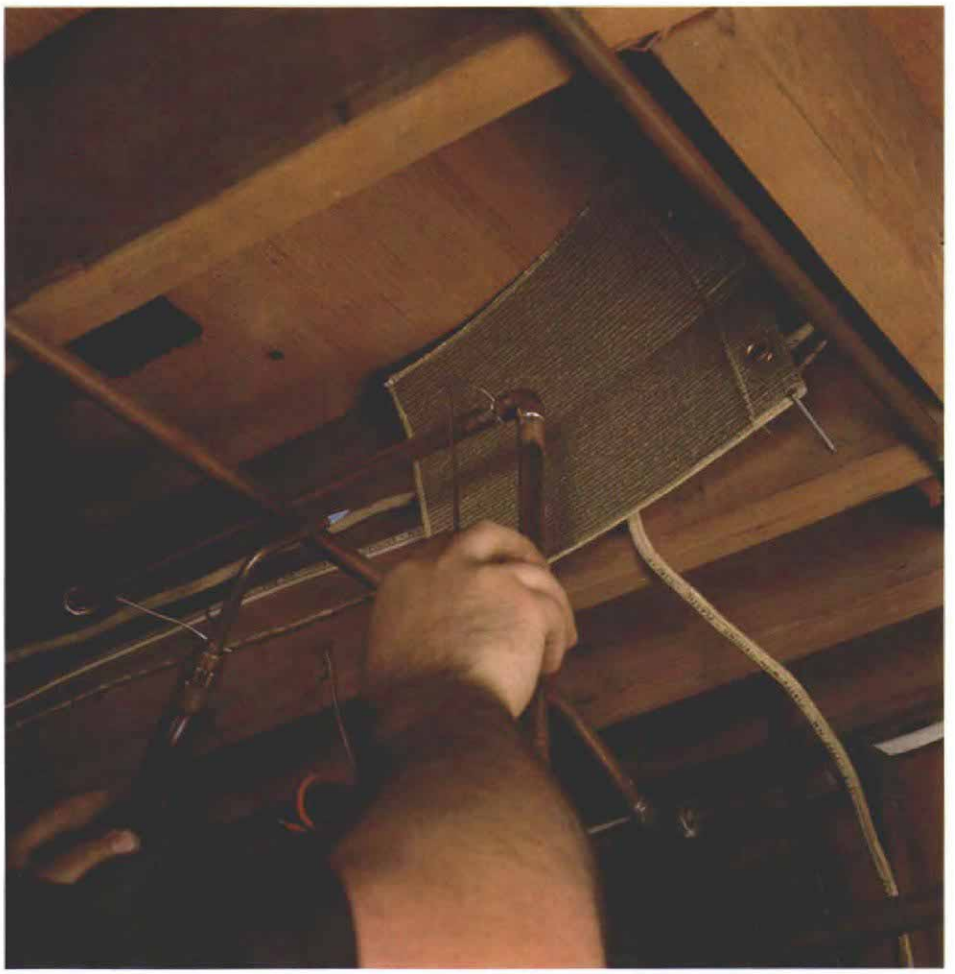
Clean the fittings carefully and heat them completely to get neat, leak-free joints

by Peter Hemp

One evening a few years back, I had an emergency call to repair a leak in the copper service pipe buried beneath the front lawn of a nearby building. The problem had occurred at a ¾-in. copper tee where the supply pipe for an outdoor faucet (hose bib) branched out vertically. I shut off the water-meter valve, but upstream, on the other side of the leak, the building's main shutoff was defective and would not close completely. With the leak at such a low elevation, the system could not be drained thoroughly. The leaky fitting had been installed within the past year, so I decided to try soldering a new riser into the existing tee. The residual water in the line meant that I had to use a special torch that would generate enough target heat to melt the solder in the joint despite the water.

As I worked hunched over my hole in the lawn, the trickle of water in the heated pipe was converted to steam and vented in a jet out the top of the pipe. Suddenly, someone in the house opened a faucet that allowed cold water to surge back into the pipe I was soldering. When the cold water hit the heated fitting, it boiled instantly, sending a cascade of scalding water out of the pipe and over my back. The resulting burns took months to heal.

Although this case was more painful than usual, soldering pipes is as big a part of everyday plumbing as sawing wood in carpentry, and you do have to be careful. The process of soldering copper pipe basically involves polishing and applying flux to both the pipe and the fitting before putting them together. Flux helps solder form a strong bond with copper pipe. After the pipe is heated, solder is melted into the joint, where it hardens and forms a seal. The process is also known as sweating because when the copper pipe gets hot enough for the solder to flow, tiny droplets resembling beads of sweat appear on the pipe and fitting. A scientist told me that the droplets are actually hydrochloric acid from flux.



Shield surrounding areas from the torch. To prevent a fire, wood framing and electrical wiring are protected by the flame-resistant, woven-glass fabric inserted behind the pipe. In this picture the solder has begun to melt, and the plumber has backed the flame away from the pipe.

Copper pipe is not necessarily round—Even though copper tubing is sold as rigid, copper is a fairly soft metal and is susceptible to damage during handling. I always trim about ½ in. off the factory end of the pipe to get rid of any defects and to let the rollers of the tubing cutter reshape the pipe if it is out of round.

I mark the length on the pipe lightly with a mini-hacksaw (top photo, facing page). Hacksaw marks won't rub off and are easier to see than pencil lines. Next I place the tubing cutter on the pipe and tighten the screw handle until the cutting wheel comes to rest on the cutting mark. I then give the screw another half-turn and rotate the cutter around the pipe a full 360° twice (center left photo, facing page) with the cutting wheel trailing the rollers. Once I'm sure that the cutting wheel is staying in its initial groove, I continue the cut, tightening the handle another half-turn for every two complete revolutions of the cutter.

When the cutting wheel finally comes through the tube wall, it leaves a tiny ridge on the inside edge of the tube. This ridge is extremely sharp and can lead to nasty cuts. It can be removed by inserting a tapered reamer and returning the pipe to its full bore. Most cutters have a stationary triangular blade for this purpose (center right photo, facing page).

Every pipe end has to be polished—Regardless of how clean or scuff-free a pipe appears, it's imperative to polish every end with plumber's sand cloth (sidebar p. 89). I use an approximately 4-in. long piece of sand cloth and

try to polish the end of the pipe by at least ¼ in. more than the depth of the fitting socket.

First I loosely drape the sand cloth over the pipe, dividing the cloth roughly in half. Then I curl my forefinger around the cloth and the pipe to the base of my thumb, squeezing the sand cloth gently against the pipe (photo bottom left). I rotate the pipe back and forth with my left hand while rotating the sand cloth on the other end of the pipe in the opposite direction with my right.

Next I clean the inside of each leg of the fitting with a wire fitting brush (photo bottom right). And I always dry-fit each pipe section and its corresponding fittings to make sure everything fits.

Apply flux both to the pipe and to the fitting—When pipe and fitting have been cleaned, it is time to don latex gloves and apply the flux (top photos p. 88). Using an acid brush, I apply a liberal coat of flux on the male pipe end and a thinner but even coat inside the female fitting, making sure to go all the way to the bottom of the fitting socket. I then shove both pieces together and remove excess flux that has accumulated at the edge of the fitting.

I roll out a length of solder from the roll and bend 2 in. back from the end into a roughly 45° angle. If possible, I position the pipe and fitting so that they lie flat, letting them hang off the edge of a bench surface or holding them lightly in the jaws of a vise.

You should always have pipe inserted into every opening of a fitting before applying heat and solder. If a joint socket is left open, chances are it will "tin," or receive a solder buildup. When the joint socket cools off, it will be impossible to insert a pipe into this opening without reheating the fitting.

Capillary action sucks solder into the joint—When I have everything ready to solder, I light my torch and adjust the flame. I use the common plumber's choice, a secondary-combustion torch, which has a blue feather in the flame. The point of this feather should be crisp, not fuzzy (photo facing page). The hotter burning swirl-combustion torches, such as the one I was using when I got scalded, should have a squared-off flame without a long, thin yellow flame shooting out of the center.

When the flame is right, I train the tip of the feather on the fitting socket and move it back and forth from the socket to just off the edge of the fitting onto the pipe. I repeat this motion for about 30 seconds, or until "sweat beads" appear on the pipe and fitting.

If no beads appear, the temperature of the pipe can be checked by touching the tip of the solder to the joint of fitting and pipe. If the metal is not yet hot enough, the solder will leave no residue or stick just slightly, leaving a small piece of hard solder on the edge of the fitting. If this happens, I resume the back-and-forth motion with the flame. When the pipe becomes hot enough, the little glob of hard solder sitting on the edge of the fitting will suddenly liquefy and be sucked into the joint. At this point, I pull the flame back from the pipe and move the tip of solder around the edge of the fitting, feeding the

Mark the tubing with a mini-hacksaw. Measurements marked with a hacksaw won't rub off the way pencil and ink do.

Tubing cutter must be square to pipe. Align the cutter by tightening the handle and making a couple of revolutions. If the cutter is staying in its groove, continue the cut, tightening the handle every couple of revolutions.

Reaming removes the burr on the inside of the pipe. The triangular blade on the tubing cutter is inserted into the pipe and turned a couple of times to eliminate the sharp edge left from cutting.

Plumber's sand cloth polishes the end of the pipe. To ensure a good bond for the solder, the ends of the pipe are polished with a short length of sand cloth that is rotated on the pipe until the pipe shines.

A round wire brush polishes the inside of the fitting. A wire brush that matches the diameter of the pipe is inserted in the fitting and twisted to polish the inside of the fitting all the way to the bottom.

Apply an even coat of flux to the pipe. An acid brush full of flux is held against the pipe while the pipe is rotated to deliver a thin, even coat. Gloves protect the plumber's hands.

Don't forget to apply flux to the fitting. It is important to apply flux to the fitting as well as to the pipe before soldering. Flux cleans the copper when heated and prevents oxidation.

Solder melts and flows into the joint. After the pipe and fitting are assembled and heated, the flame is removed, and the solder melts into the heated joint.

solder into the joint (photo bottom left). It is not necessary to circle the pipe with the solder. If the pipe has been prepped properly, capillary action should distribute the solder throughout the joint. If the pipe cools before I finish a joint, I bring back the flame until the solder reliquefies.

Once the gap between the pipe and the fitting is full of solder, droplets of molten solder will drip out of the bottom of the joint. When that happens, I turn off the torch and let the joint cool, taking care not to disturb the pipe and fitting until the shiny, silvery color of the solder turns frosty. Even vibrations from a carpenter driving nails nearby can spoil a soldered joint. If the joint is disturbed before solder has solidified, it may leak and probably should be reheated until the solder in the joint liquefies to reseal the joint.

While the solder is molten, excess can be wiped off with a damp rag. If the pipe and fitting get too hot while the flame is applied, the flux may start to bum, causing the solder to roll off the pipe instead of flowing into the joint. If a lot of smoke appears while the joint is heated, the flux is probably burning. When this happens, I move the flame farther back off the pipe and fitting and bring the temperature back up slowly, touching the solder to pipe at the fitting until the solder melts and flows.

When soldering a series of vertical joints, I start by warming the lowest joint first. Because hot air rises, the next joint up will be warming up while I'm soldering the one below. This method conserves energy and time.

It's important to keep in mind that capillary action, not gravity, pulls the solder into the joint, regardless of whether the joint is horizontal or vertical. However, once the joint is full, excess solder will drip out, making it more difficult to keep vertical joints tidy.

Safety should always be a primary concern—House plumbing can be dangerous work, and getting burned or scalded is not the only concern. No discussion of plumbing would be complete without mentioning items needed to accomplish these tasks safely and comfortably.

Eye protection is of primary importance while I'm soldering as well as in all phases of plumbing. When working with saws and drills, falling debris is a constant nuisance. You should pick a type of eye protection that you are comfortable with—that way, you'll use it. I generally use safety glasses with side shields.

I also consider hand protection a must for plumbers because of where we put our hands when we work and because of the harsh chemicals in fluxes, lubricating oils and sealants. Many plumbers wear disposable gloves, which are sold in drugstores and at health-supply outlets. □

Peter Hemp is a residential plumber based in Albany, California. He is the author of Installing and Repairing Plumbing Fixtures *and* Plumbing a House, *a basic plumbing manual from which this article was adapted. Both books were published last fall by The Taunton Press. Special thanks to Joe Carmody, The Plumbing Doctor of southern Rhode Island, for his help with the photos in this article. Photos by Roe A. Osborn.*

Tools for Cutting and Soldering Copper Pipe

Tubing cutters

Tubing cutters come in a variety of sizes, but I use the Ridgid #151 (Ridge Tool Co., 400 Clark St., Elyria, Ohio 44036; 216-323-5581) for most of my pipe cutting. The #151 cuts everything from ¼-in. refrigeration tube to 1½-in. copper pipe. Besides the #151, the Ridgid #104 is indispensable for cutting already installed copper tube up to ¾ in. This little knuckle buster works where there is no swing room for a bigger cutter. Beware of less expensive cutters that tend to thread the pipe instead of tracking in one groove. These cheaper cutters also have a tendency to slip off the pipe, causing the pipe to deform.

Plumber's sand cloth

Sand cloth, used for polishing pipe before soldering, is fabric-backed with a fine abrasive grit on its face. It comes in rolls of various lengths and is about 1½ in. wide. I usually can polish all the pipe and fittings for a house with 1 ft. or less of good-quality cloth.

Avoid cheaper sand cloth with paper backing because it turns to mush when wet. Good-quality fabric sand cloth can be dried and reused after it gets wet.

Brushes for polishing fittings

These round wire brushes are used for cleaning the inside of fittings. They come in different sizes for different diameters of pipe. They tend to wear out quickly on the job, but I usually can plumb a whole house with one brush per pipe size. Combination fitting/pipe brushes that clean both the fitting and the outside of the pipe supposedly eliminate the need for sand cloth. But sand cloth seems to do a better job on the outside of the pipe.

Flux

Good flux is critical for successful soldering. It cleans the pipe when heated and prevents surface oxidation of the metal, allowing the solder to form a strong bond. There are many good brands, but one of the most popular is Nokorode (Nokorode, a division of M. W. Dunton Co., P. O. Box 232, 3 Bridal Ave., West Warwick, R. I. 02893; 800-556-6538). This lead-free paste flux spreads easily, even when it goes on wet surfaces.

Solder

Until fairly recently 50/50 lead/tin solder was the norm for pipe soldering regardless of how the pipe was to be used. However, federal regulations now require solder with a greatly reduced lead content (5%) or lead-free solder for freshwater-delivery piping. Although it takes some getting used to, I find that lead-free solder is easier to use than either the old 50/50 or the newer 5% leaded solder.

Torch lighters

The most popular torch lighter among plumbers is the flint-and-steel striker. These strikers have a minute piece of flint that rides across a piece of rough metal, causing a spark. Another option is the Lightnin' Bug made by World Wide Welding (Nasco Inc., 2100 Old Highway 8, St. Paul, Minn. 55112; 612-780-2000), which emits an electric arc when squeezed. A butane cigarette lighter should never be used to light a torch. Plumbers and welders have been injured or killed when butane lighters have exploded while being used to light a torch.

Tools for cutting and soldering copper pipe. This photo shows all the tools needed for basic pipe sweating. Starting in the background: fire extinguisher; acetylene torch with A tank; flame-resistant fabric panel; plumber's sand cloth; lead-free solder; flux; mini-hacksaw; fitting brush; tubing cutter for close quarters; tubing cutter; flint striker for lighting torches; and disposable latex gloves.

Torches and tips

The most common torch for do-it-yourselfers is the small disposable propane cylinder with a spin-on torch tip. This torch, however, is impractical for the serious plumber.

Acetylene is the torch of choice of most professional plumbers. Acetylene tanks are portable and refillable, and they come in two sizes. I use the smaller A tank because it holds enough gas for me to do an entire house, yet it's small enough to drag around for repair work. The torch tip is on the end of a 10-ft. hose, so the torch is convenient to use when I'm working on a ladder or in a crawlspace.

A third, less common torch option is MAPP gas, a mixture of gases including acetylene and polypropylene. MAPP gas should be used only with a swirl-combustion torch tip. It generates less heat than an acetylene torch with a swirl tip, but more than propane. Like propane, MAPP gas comes in disposable cylinders. At around $10 each, these cylinders are potent but expensive.

The most common and versatile torch tip is the secondary-combustion tip, which can be adjusted for use around combustible materials. If water is present in pipe, the much hotter swirl-combustion tip might be necessary to generate the amount of heat needed to melt the solder.

Fire protection

Whenever I'm soldering, I keep a fire extinguisher close at hand. Soldering near combustible material such as house framing is sometimes unavoidable, and flame shields should be used. Pieces of sheet metal work for this purpose. But plumbing suppliers carry aluminized baskets and woven-glass materials that are temperature-resistant. These materials are flexible enough to fit where stiff sheet metal is impractical. Although not flameproof, these materials can be used quite a few times before they burn through.—*P. H.*