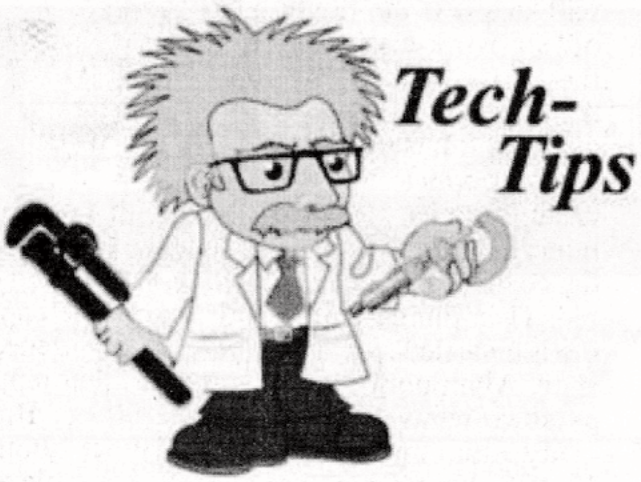
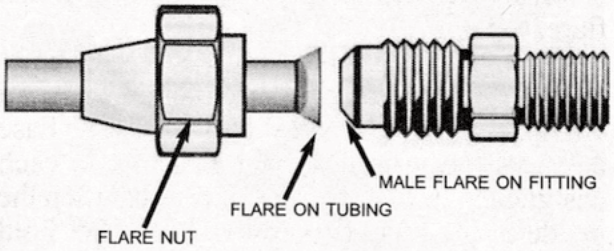


How To Flare (and Double Flare) Tubing

Often joining two sections of tubing requires an intermediary fitting. The two most common types used in automotive application are 'compression' and 'flare.' A typical compression fitting consists of a special nut and a collar. Briefly, the nut is slipped over the end of the tubing (with the threaded end facing the cut end of the tubing) and then the collar is inserted over the tubing*. A threaded fitting on or in between the second segment of tubing will screw into the nut. As the nut is tightened over the collar, the collar will slightly pinch the tubing assuring a tight fit.

The use of a compression fitting requires no modification to the tubing. If the joint requires a flare fitting, the tubing must be distorted (flared) to assure a tight, leakproof fit. Typical flaring is best done on copper or aluminum tubing, although it can be used on soft steel. Stainless steel generally requires special equipment to assure a proper flare so we will not address that material here. Flared connections offer a high degree of long-term reliability and for this reason are often used in inaccessible locations or applications where the fitting will not be disturbed and is not subjected to flexing or bending.



The threaded segment has a special male flare on one end. The other end may consist of a flare, compression or other thread to accommodate another type of fitting. Be sure that the threaded portion fits your needs and application.

Tubing is available in a variety of sizes measured by the outside diameter of the tube. 3/16", ¼" 5/16" and ½" are the most common, with the ¼" being used most often in most automotive applications.

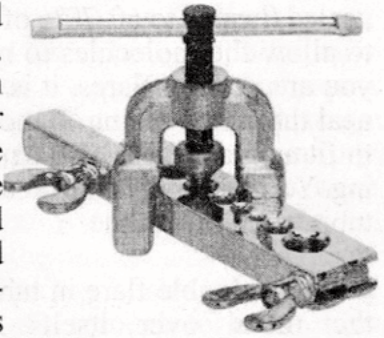
Before we get to the actual process of flaring a tube end, a word of caution. Flaring distorts and stretches the metal. The finished thickness of the flare will be less than the original wall thickness of the tubing. This is more than adequate for most automotive uses – vacuum lines, fuel lines – but NOT for brake lines. When the brake pedal (of a hydraulic brake system) is applied, the pressure is magnified many times. For that reason a special flare must be used; one which folds the metal over itself doubling the metal's thickness at the flare. This is known as a double flare, and we will look at that method of flaring as well. I repeat though, NEVER use a single flare for hydraulic brake lines.

* Newer types of compression fittings have the collar pre-pressed into the nut. Slip the nut over the tubing with the open end facing the cut end, and simply tighten it onto the threaded portion.

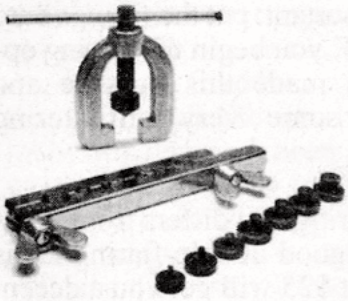
Next Spring we plan on re-printing a two-part article by Bill Cannon (from 1996) on the various types of fittings used for fuel and oil lines. It contains more information on fittings than included in this article. It alters nothing in this article, but does offer additional information.

Special tools are required for flaring (or double flaring) tubing. Fortunately these tool sets are relatively inexpensive. For high-volume or professional use where speed and accuracy are important, production quality flaring tools are available. Their cost, though, is often considerably more than the home auto mechanic wishes to spend for the occasional flare.

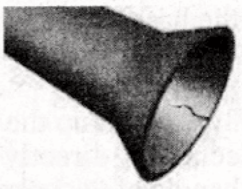
A typical single-flare tool consists of a clamp base and a screw-down yoke. The base has a variety of holes machined into it, each designed to hold a specific size tube. Often the inside of the holes are grooved to better hold the tubing and prevent slipping. The screw-down yoke clamps over the base. In the center of the yoke is a threaded rod with a tapered cone on the bottom. The cone is machined to 45° (the characteristics in accordance with the Society of Automotive Engineers SAE J533 Standard - Flares for Tubing). The one cone will generally be adequate for most commonly used sized tubing.



A double flaring tool will have a similar base and yoke/cone, but will also have a set of dies designed to accurately set the double flare. Each die is sized to fit a particular tubing. Use of the correct die assures a clean, secure double-flare.

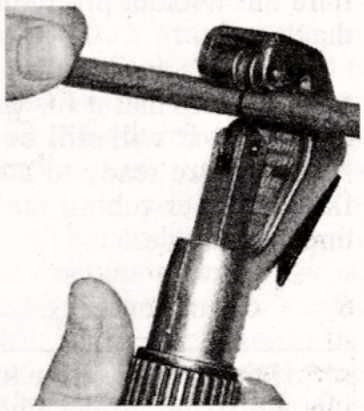


Annealing the tubing might be necessary if the tubing is old or work-hardened. Work-hardening is an internal migration, and reformation of the molecules within the metal causes a normally soft metal to get very hard and brittle. (Bend a paper clip once or twice and there is no problem. Do it much more and the metal work-hardens, becomes brittle and will snap.) If the tubing is old or work-hardened, as the metal is stretched in making the flare, it will often split. It is very easy to anneal copper; aluminum is a bit trickier. Hold the tubing with a pair of pliers, and heat the end (three inches or so) of the copper tubing with a torch until it is cherry red. Then plunge it into cool water. The copper is annealed and has returned to its softened state. Aluminum requires more critical temperature control. It anneals at 800° F. But many aluminum alloys will melt at about 1200°F so a temperature crayon (available at welding supply stores) is almost a necessity.



Instructions on How to Flare

1. Cut the end of the tubing square using a tube cutter. (See *Skinned Knuckles*, March 2015 for the correct procedure for using a tubing cutter.) After cutting, the tube must be reamed to the full inside diameter leaving no inside burr. Tubing that is out of round should be resized back to round or discarded. Failure to complete either of these steps can lead to an inadequate seal of the flared joint and, ultimately, to joint failure. Dirt, debris and foreign substances should be removed from the tube end.



2. Slip the flare nut onto the end of the copper pipe with the open end facing the cut end of the tubing. Move it back out of the way to allow for working room. Place the end of the tubing in the base of the flaring tool, inserted into the correct size hole. The cut end of the tube should be flush with the top (flat side) of the base, or possibly could extend

about 1/32" above**. Tighten the clamps on the base. If the tubing is in the correct hole, it will not crimp or deform.

3. Clamp the yoke in place with the cone centered directly over the tubing. Turn the handle of the yoke clockwise to lower the flaring cone. Tighten it down until the cone is firmly seated inside the base. The end of the tubing will flare out as you do this. Care should be taken not to over-tighten the cone and cause cracking or deformation of the new flare or the tube.

4. Remove the copper tubing from the base, and examine the ends for splits. Bring the nut back up to the end of the flared tubing. The final flared tube end should have a smooth, even, round flare of sufficient length to fully engage the mating surface of the flare nut without protruding into the threads.

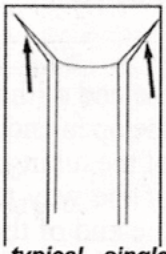
5. Verify that it fits snugly in the bottom of the nut. It will still be loose at this time. Now you are ready to attach the end of the flared copper tubing nut to the end of the threaded nipple.

6. Check for leaks.

** If the cut end of the tubing extends too far above the surface of the base (the cut end should be flush or less than 1/32" above the base), the finished flare may be too big to fit within the female flare nut.

The following article was first published by Skinned Knuckles in the November 2007 issue.

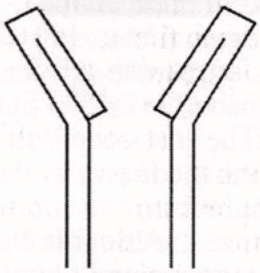
What is a Double Flare?



A typical single flare stretches the metal making it too thin for safety in brake lines.

Two things are happening here, and understanding them is extremely important. First, the wall of the copper tubing is stretched to achieve the flare. (If you have ever made a single flare and allowed too much tubing to extend beyond the flaring tool, you've noticed that the edges of the flare are going to split.) The second thing that happens is known as work-hardening of the copper. The molecules of copper are rearranged each time the metal (either sheet copper, wire or tubing) is bent. Because of the nature of copper these molecules 'tangle' with each other and the metal gets rigid or stiff. Once this happens, if you continue to bend the copper, splits and breaks will occur. When copper is formed or extruded into wire or tubing, it has to be annealed (heated to 60-70% of the melting point) to allow the molecules to recover. But when you are making flares, it is impractical to anneal the flared tubing. Bending copper tubing to fit as brake lines also causes work hardening. You cannot risk the breaking of the copper tubing in a brake line.

A double flare in tubing actually folds the metal over itself making the flared end stronger than before. Double flaring is rather simple, but the procedures are critical. Let me mention this right now, and then I'll repeat it several times more in this article - it's that important: put the fittings onto the tubing BEFORE you begin the flaring operation. We've all made this mistake and called ourselves some very unflattering names.



A double flaring tool differs from a single flaring tool. A good double-flaring kit is inexpensive - about $25 will get you a decent one. It consists of a set of double-flare dies, a tubing holder (base) and a press (yoke) which applies the flares to the tube. Double-flaring kits are available in both SAE and metric sizes. They are not interchangeable. The dies will not fit the tubing, if they are not the correct size. The tubing holder will not clamp the tubing properly either and could pinch or de-

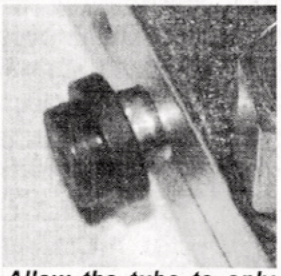
form it. Double check when purchasing to be sure that the kit is marked "SAE" or 'metric' and that it is the right one for your needs.

Double flaring can easily be done on soft steel or copper tubing when assembling brake lines, but don't try it on stainless steel (too hard).

The tubing should be cut with a tubing cutter, not a hacksaw. The tubing cutter will give a square, clean end. Put the tubing into the cutter, align the blade with the measurement marks that you have made on the tubing, and tighten the blade so that it lightly contacts the tubing. Hold the tube and rotate the cutter. After each rotation tighten the blade just a little bit more. Tightening the blade too much at one time will deform the tubing.

You will notice that after the cut is completed the end of the tubing is slightly compressed. Use the deburring tool on the tubing cutter or a drill bit of the same size as the inside diameter of the tubing. Rotate the drill bit by hand just to clean up the edge. Use a fine file to slightly chamfer the outside edge of the tubing.

(Here's the second time I mention it): Put the fitting onto the tube. Put the end of the tube into the tubing holder (you will notice that the hinged holder has a series of holes each designed for a particular size tube. Be sure to use the correct hole). You will further notice that on one side of the tool the hole is recessed and the other side is flat. Use the recessed side. Allow the tubing to extend the same amount as the shoulder of the double flare adapter. More is NOT better.



Allow the tube to only extend a length equal to the shoulder of the adapter that you are using.

Insert the adapter into the tube end.

Follow the instructions that came with the double-flaring tool for best results, but in general, insert the correct adapter into the exposed end of the tubing. Lightly oil the cone-shaped press and install the press over the tubing/adapter. Tighten the cone onto the adapter until the adapter contacts the tubing holder. Back off on the cone just enough so that the adapter can be removed from the tube end. The adapter has formed a bell-mouth on the tubing.

Tighten the cone into the tubing, This will fold the tubing onto itself thus strengthening the flare. Now is the time - if you have forgotten - to slip the fittings over the other end of the tubing before putting the flare onto the second end.

The completed double flare will be considerably stronger and more pressure resistant than a single flare, very necessary in an hydraulic brake system.

For safety's sake, rather than use pure copper as brake lines where it is possible that work-hardening could crack or split the metal, we suggest that you use Cunifer, a special alloy of copper (cu), nickle (ni), and iron (fe) which does not work harden as does pure copper. It is currently available through the Eastwood Company as BrakeQuip Copper Nickel Tubing.

Although more expensive than pure copper tubing, it is easier to work and will outlast pure copper without work-hardening.

Using A Double Flaring Tool

Fig. 1 - End of tubing must be square. Debur the inside of the tubing and slightly chamfer the outside edge. Place tubing in correct hole and allow it to extend an amount equal to the shoulder of the adapter.

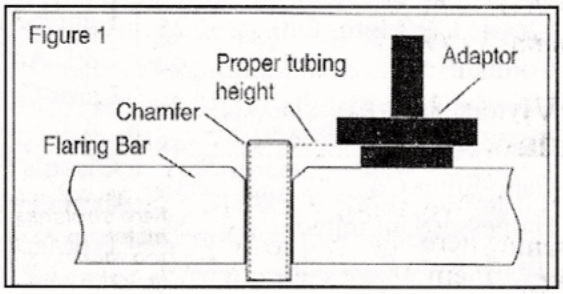
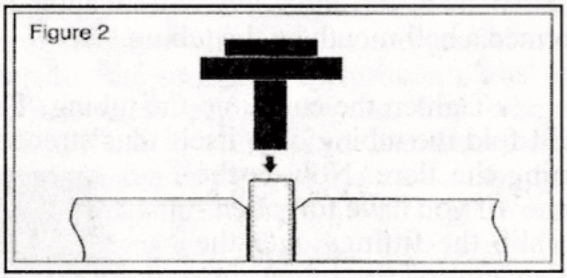
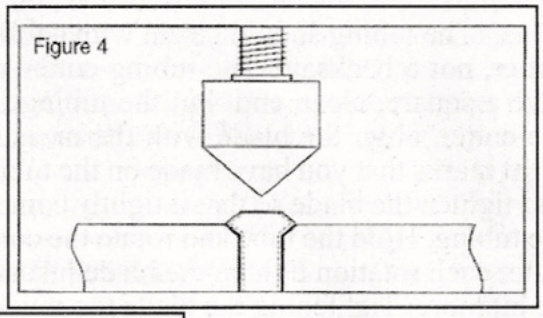


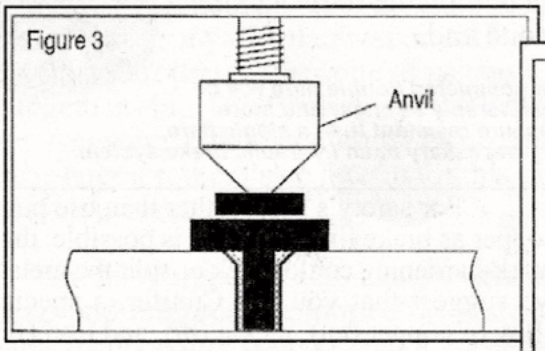
Fig. 2 - Put the adapter into the end of the tube.
Fig. 3 - Place the cone tip onto the adapter, and tighten until the adapter touches the face of the tubing holder.

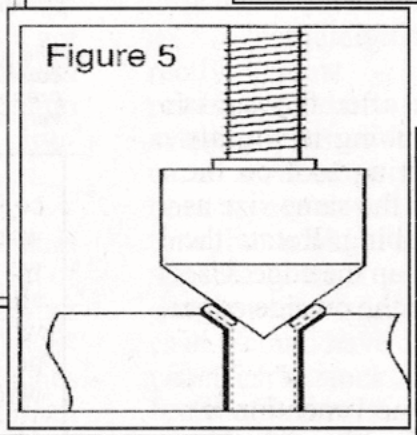
Fig. 4 - Remove adapter. End of tube should be bell shaped.
Fig. 5 - Place cone over tubing end and tighten until tubing folds down over itself.
Fig. 6 - Remove tool and the strong double flare is completed.

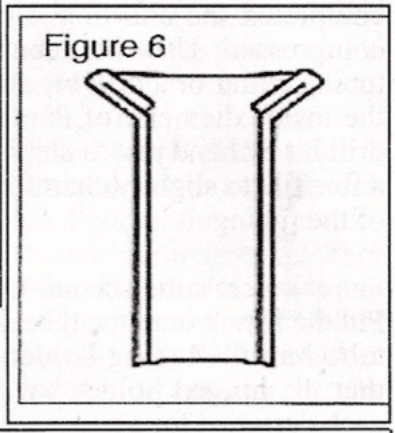
Illustrations courtesy of Performance Tool®











It is possible to flare pure copper and copper/nickel/iron (cunifer) tubing with the hand flaring tools discussed above. Steel and stainless steel brake lines require special equipment because the steel/stainless tubing is so hard. Equipment for flaring steel tubing is available, but often is too expensive for the home-restorer for the occasional set of brake lines which he might need. If your club has a tool-lending program, an hydraulic flaring kit might make a valuable addition to it.

S.K.