Parker
Fluid Connectors

"Principles of Tube Line Fabrication"

Bulletin 4306-B5
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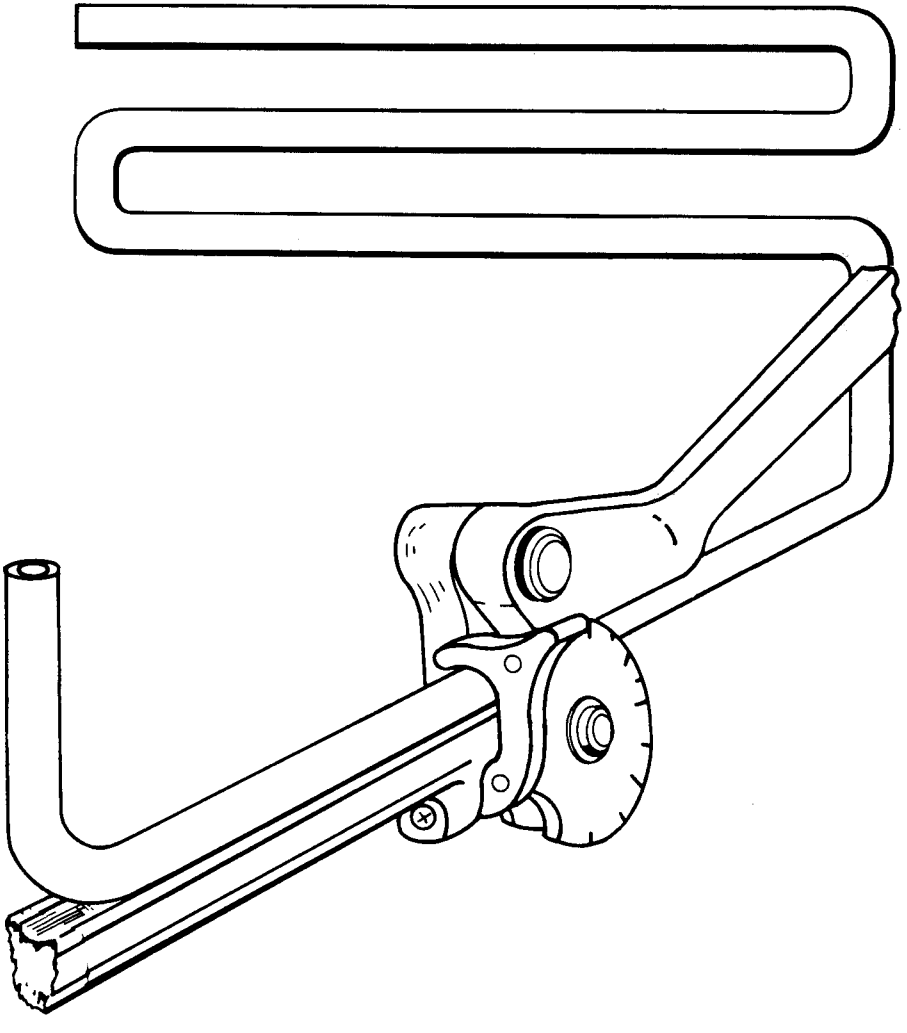
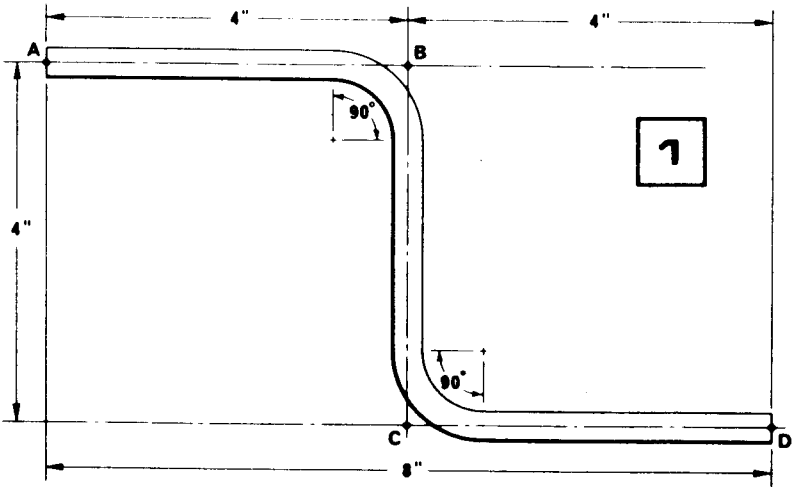


NOTES ON TUBE LINE FABRICATION

This "hand out" is yours to keep. It contains a number of important reminders and rules about tube bending which you may find helpful. Keep it handy for reference whenever necessary. When you have become skilled in the art of tube line fabrication these rules and suggestions will be second nature to you.

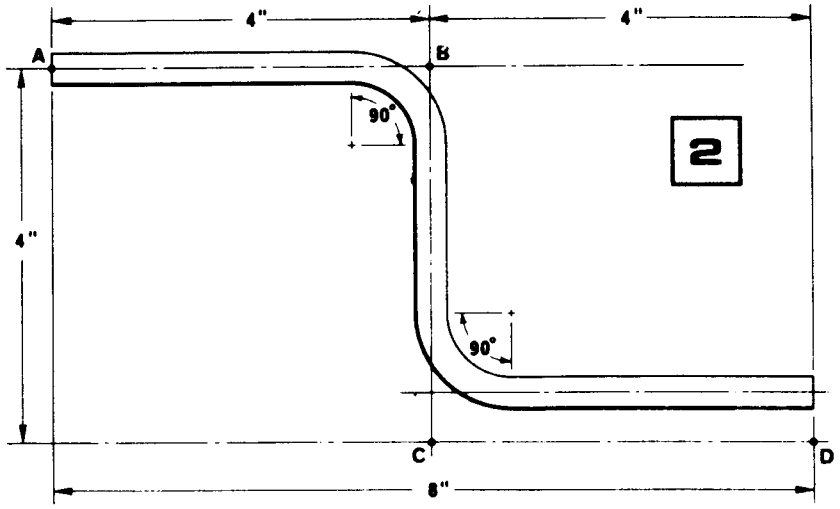
1. MEASURE EXACTLY - BEND ACCURATELY

These are the two most important rules which must be observed when fabricating a tube line. (Figure 1)



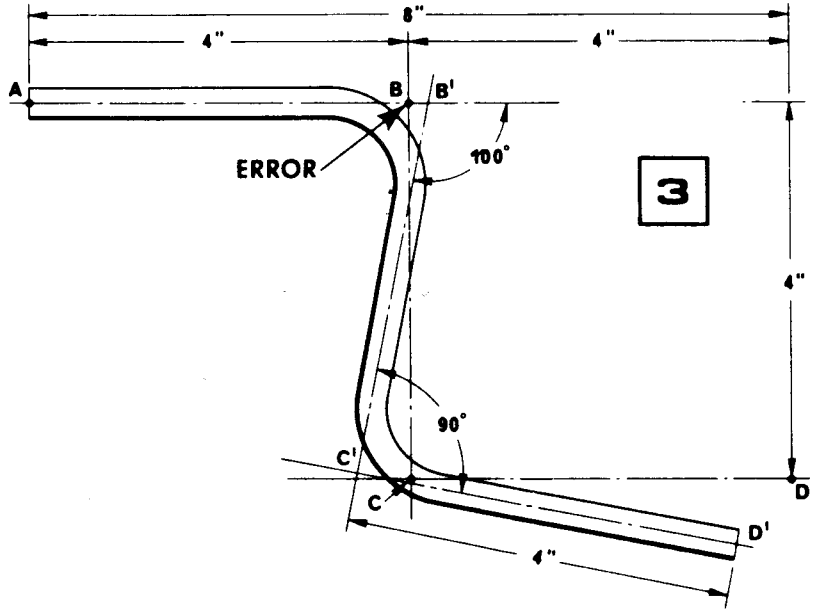
Accurate measurements coupled with exact angles must result in a tube line that will fit at points (A-D).

EXACT MEASUREMENT is required to insure that you obtain the desired distance between bends. If you do not measure exactly, the tube line will not fit. (Figure 2)



Measuring error on second leg (B-C) results in tube line that can not fit at point (D).

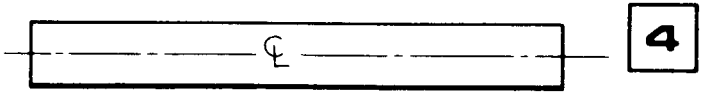
ACCURATE BENDING is necessary to achieve the exact angles required for the tube line. If you do not bend accurately, the tube line will not fit. (Figure 3)



YOU MUST ALWAYS MEASURE EXACTLY AND BEND ACCURATELY.

2. TUBE CENTERLINE BASIS FOR MEASUREMENT

The centerline of the tube is the basis for all tube line measurement. (Figure 4) Always measure from the centerline except for the first bend which is measured from the end of the tube. On most benders the edge of the radius block is at the centerline of the tube.



3. YOU CONTROL ACCURACY

Remember, only you can control the accuracy of your work. Use good, careful workmanship at all times.

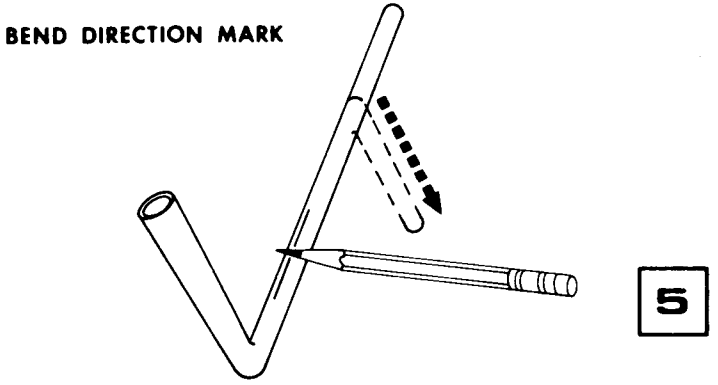
TUBE BENDING CHECK LIST

Follow this check list to insure good results on each bend.

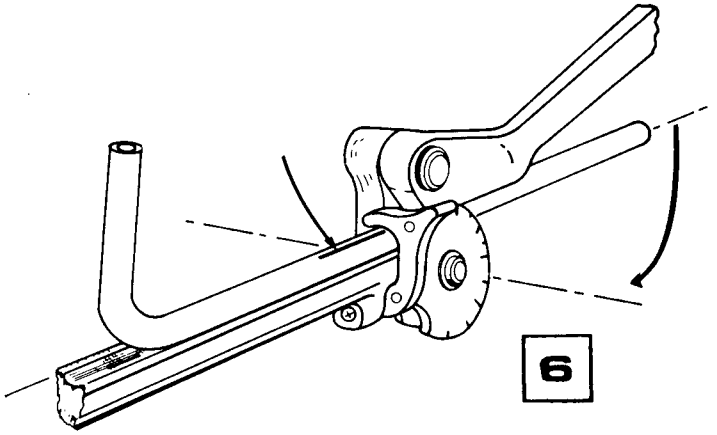
1. Measure and mark exactly. Insert tube in bender.
2. Always try to bend in the same direction! If you backbend, be sure to compensate for stretch or pickup.
3. Clamp tubing securely in bender.
4. Check to make certain length mark is tangent to desired angle on radius block or in line with the desired degree on the link member.
5. Bend accurately to the desired angle plus springback allowance.
6. Open bender, remove tube.
7. Double check bend angle with triangle.
8. Check measurement length with tape or rule.

KEEP TRACK OF CHANGES OF PLANE

Benders bend in only one direction. Changes in plane are accomplished by rotating the tubing in the bender. To insure that the tubing is correctly placed for the desired change in plane, a reference mark on the tube is very helpful.

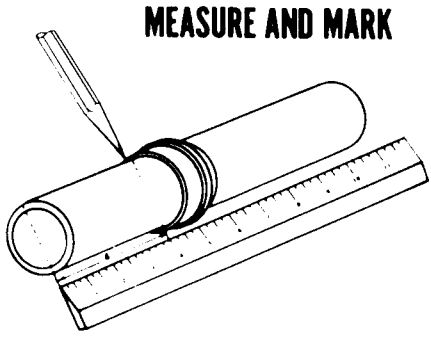


One method for keeping track of changes in plane is to use a longitudinal or lengthwise bend direction mark. (Figure 5) Put the mark on the side opposite the direction in which you wish to bend. When you put the tube in the bender, center the mark face up in the groove of the radius block. (Figure 6) This will insure that you bend in the correct direction. It also gives you a reference mark in case you must leave your work unfinished.



MARKING THE TUBE

Whenever you make a mark on tubing, use a sharp pencil. Use a ferrule or sleeve as a guide to scribe measurement marks all the way around the tube so that the mark is always visible. (Figure 7) Don't use grease pencils or crayons as these make too wide a line which can easily affect accuracy.



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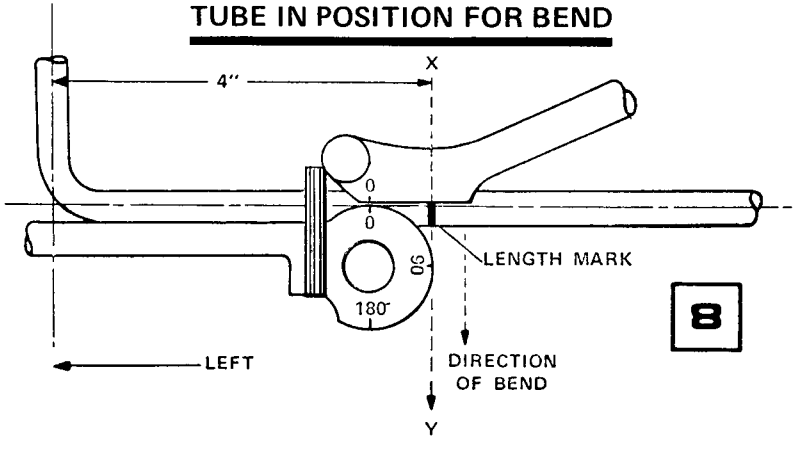
NEVER use a sharp tool to scratch marks onto tubing. Scratches create points where corrosion or stress concentration can ruin or dangerously weaken the tube.

RULES FOR POSITIONING TUBING IN BENDER

A line which is tangent to the desired angle mark on the radius block and which passes through the measurement mark at the centerline of the tube, is used to control the distance between bend centerlines. (Figure 8)



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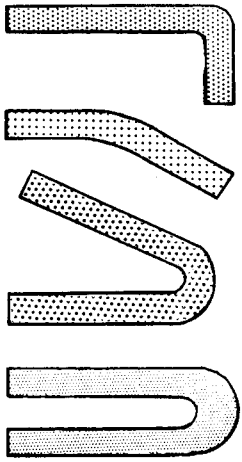
TUBE POSITONING RULES



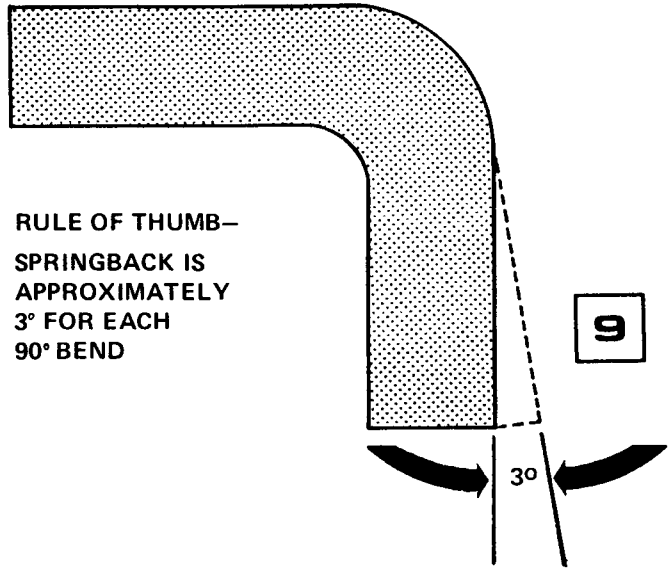
90° ANGLES - TANGENT FLUSH WITH LENGTH MARK.

ANGLES LESS THAN 90° - TANGENT INTERSECTS LENGTH MARK AT CENTERLINE.

ANGLES MORE THAN 90° - POSITION FOR A 90° BEND AND CONTINUE ON TO DESIRED ANGLE, I.E. 135°, 145°.

HORSESHOE OR U-BENDS - MEASURE FIRST LEG, POSITION FOR 90°, BEND AROUND TO 180°.

SPRINGBACK 90° BEND

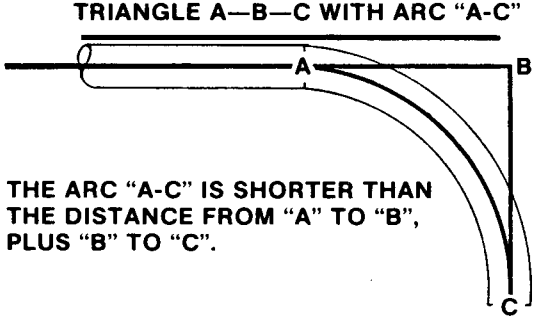


Compensate for springback:

1. Test a piece of the material before you start fabricating a line to see how much it springs back on a 90° bend.
2. Overbend by the amount of springback. For example, if the material springs back 3° on a 90° bend, bend to 93° to secure a finished 90° bend, or to 46½° to obtain finished 45° bend.
3. Remember, it is always better to underbend slightly. You can always bend a little more if needed, but it's almost impossible to remove or straighten a bend, especially with large-heavy wall tubing.

TUBE STRETCH OR PICKUP

When bent, tubing seems to stretch or pick up length. This is because it takes a curved shortcut across the inside of the angle. A good "rule of thumb" for most standard tubing materials and radius blocks is that the tubing will stretch approximately one tube diameter for each 90° of bend.



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Always try to bend in the same direction -- away from the original starting end. If you reverse the direction of bending (bending towards instead of away from the original starting end) you will "trap" the stretch. Thus, if you unknowingly make a reverse bend of 90°'s, you will trap approximately one tube O.D. and increase your length between bends by that amount.

If bend direction must be reversed, subtract one tube O.D. from the measured length for a 90° bend or one-half the O.D. for a 45° bend.

While our rule of thumb is approximately correct, the amount of stretch is related to the diameter of the radius block used. This chart (Figure 10) gives the actual increase in length that occurs with the most commonly used sizes of radius blocks.

As long as you measure and bend in the same direction, and measure centerline to centerline, "pickup" will not affect your actual center-to-center measurement.

$\frac{\pi \times D}{4}$ = ARC AC

π = 3.1416
D = DIAMETER OF RADIUS BLOCK

(LEGS AB + BC) - AC = GAIN
2R = D

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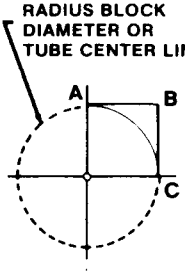
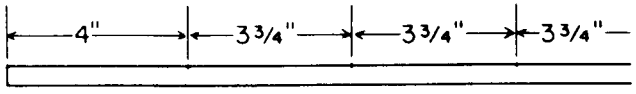
TUBING GAIN VS. RADIUS BLOCK SIZE

TUBE	SIZE	RADIUS OF BENDER (in inches)	GAIN
1/8	2	3/8	.17
3/16	3	7/16	.19
1/4	4	9/16	.29
5/16	5	11/16	.29
3/8	6	15/16	.50
1/2	8	1 1/2	.65
5/8	10	2	.86
3/4	12	2 1/2	1.08
1/8	14	3	1.29
1	16	3 1/2	1.62
1 1/4	20	3 3/4	1.62
1 1/2	24	5	2.15
2	32	8	3.45



PREMEASURING

You may premeasure a series of bends. Measure the first bend the correct length. Compensate for each bend after the first by subtracting the amount of gain from your chart for each 90°'s of bend to allow for stretch (Figure 11). Always custom measure for the last bend.



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"RULE OF THUMB" METHOD

Compensate each measurement after the first by subtracting one tube diameter for each 90° bend and ½ diameter for each 45° bend. Or use chart (11) for exact amount of gain.

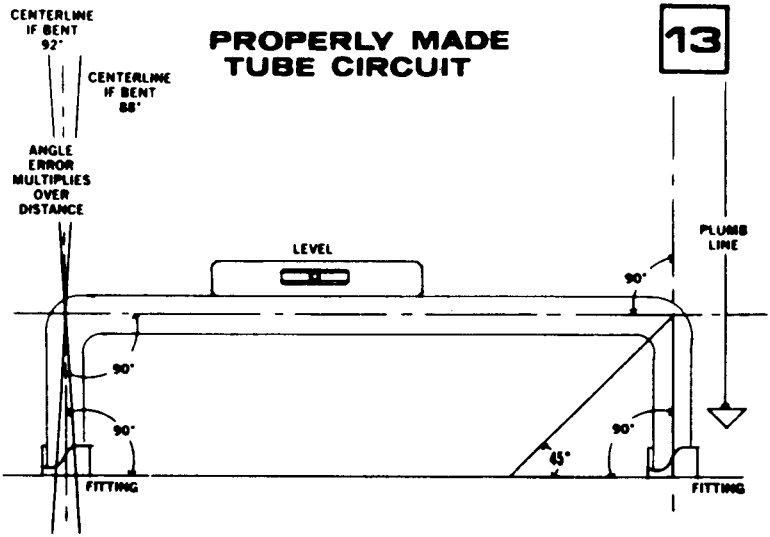
BEST WAY TO MEASURE

For maximum accuracy, measure and bend exactly for each individual bend in the tubing line. We recommend the practice of Measure and Bend, Measure and Bend, etc.

CHARACTERISTICS OF A WELL-MADE TUBING CIRCUIT

In a well-made tubing circuit or line, bends are accurate, measurement exact. The run is plumb, square and level. Tube ends rest firmly in the fittings and entry into the fittings is straight. Straight tube entry is very important to insure that fittings are not under stress and can be assembled without leaks. (Figure 12)

Remember too, that length magnifies bend angle errors. If the leg following the bend is fairly long, an error of 1° may result in the tube line missing the desired point completely.



TUBE CLAMPING

Once you've taken the time to make good bends and installed them, it's not enough to just let them lay suspended in mid-air. When tubing is left unsupported, shock and vibration will cause the tubing to shake, and inturn, cause the fittings to loosen and leak or even allow tube to fail through fatigue.

Tube support and clamping is a necessary requirement in the Fluid Power industry. Tubing can be clamped individually, in sets, and can also be stacked. The most important part of any clamping system is having enough clamps to attain the final result. That being, a well supported, vibration and noise free system.

Also, most manufacturers specify SAE and JIC approved components on their equipment. The best way to meet these specs concerning clamps is to utilize a clamp that employs both an upper and lower unit made of metal and a rubber split bushing which surrounds the tube or pipe and fits on the inside of the clamping units.

Parker-Hannifin offers a tube clamp support system by the name of "MULTI-CLAMP". Multi-Clamp can clamp and support tube from ¼" to 2" and pipe and hose from ¼" to 1½". It comes standard in steel and uses a rubber gromet around the tube for vibration dampening.

Below you will find a chart of recommended spacing between clamps. We suggest you clamp as close to each bend of the tube as possible; and you must clamp each side. This eliminates thrust in all directions.

TUBE O.D."	EQUIVALENT TUBE (mm)	FOOT SPACING BETWEEN SUPPORTS	SPACING IN METERS (Approx.)
¼" - ½"	6 - 13 mm	3 ft.	.9 m
⅜" - ⅞"	14 - 22 mm	4 ft.	1.2 m
1"	23 - 30 mm	5 ft.	1.5 m
1¼" & up	31 & up mm	7 ft.	2.1 m

For more information, write the Parker-Hannifin Corporation, 17325 Euclid Avenue, Cleveland, Ohio 44112. Catalog #4396, Parker Multi-Clamp.