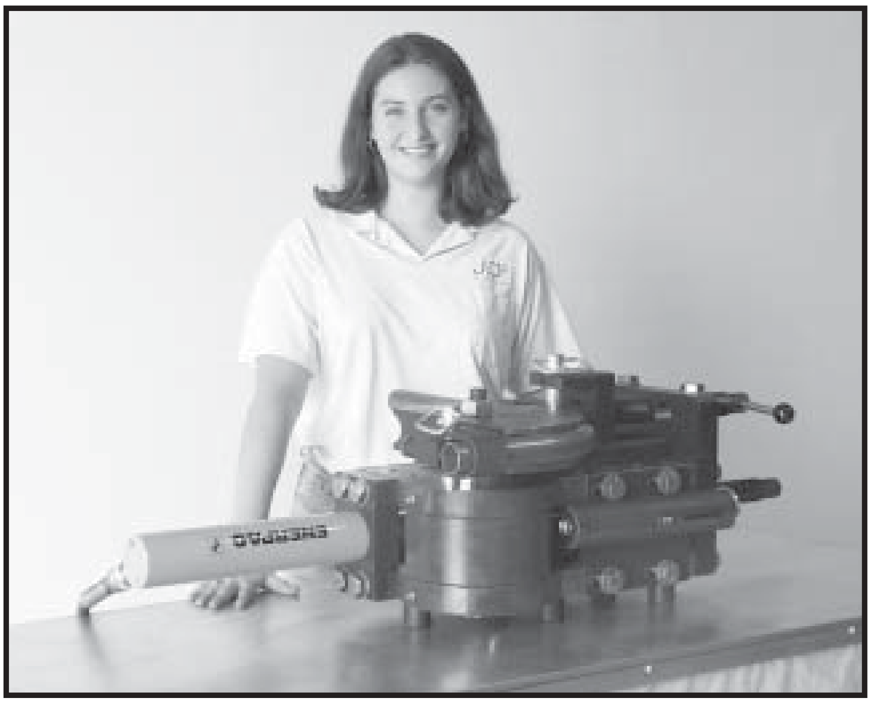
JD²

Model 6 Bender

Setup and Operation
Manual



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Initial Bender Unpacking and Assembly

NOTE: If your Model 6 Bender already has the hydraulic cylinder installed by the factory you may disregard any references to it's installation. However you should still read this section completely.

1) Remove the two 5/8" bolts that secure the bender to its shipping pallet. These bolts will not be used and may be discarded. The two spacer feet that these bolts held in place will be re-installed in step 2.
2) Towards the rear of the bender on its upper surface, you will find two 5/8" flat head bolts lightly screwed into two free tapped holes. Using these two bolts, install the two feet onto the bender's bottom side the same way the other three are already installed.
3) Remove the 1" nut and washer from the threaded stud extending out from the center of the spindle. If there are any 7/8" or 1" diameter pull pins on the center thread, remove them also. Do not remove the 3/4" dowel pins from the spindle's upper surface.
4) Looking between the two side rails on the leftside of the bender, you will see a flat bronze bearing. Just behind this bearing, towards the cylinder, you will see a socket head cap screw. If you look to its right, you will see a 1" threaded stud protruding out the backside of the chain puller assembly. Using your fingers, wiggle this threaded stud and you will notice it fits loosely in its hole and that it also moves freely forward and backwards approximately 1/16"-1/8" (1-2 mm). This is normal and is critical to the proper operation of this bender. This liberal clearance insures that the cylinder does not experience a side load on its ram during the bending cycle.
5) Using a hex wrench, remove this bolt (shown in the figure A-1 as the STUD BOLT) and slide the cylinder stud out through the back of the bender. Now if you take this bolt and hold it so that its threads ride inside the cylinder stud's groove, you will notice that the groove is wider than the screw threads. The screw threads should move freely side to side in the stud's groove. When this bolt is installed into the bender, it is extremely important that it rides freely inside this groove. Set the bolt aside until a later step.

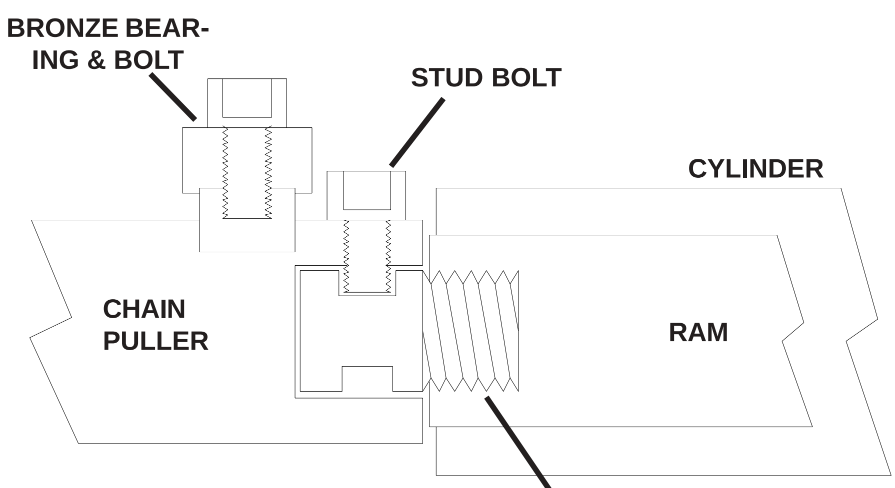


Figure A-1

6) Remove the hydraulic cylinder from its box and look at the end of its ram check to see if a plug is installed in its center hole. If so, remove it and discard. It will not be used later and serves no purpose in the operation of the bender. You should now see a 1"-8 threaded hole in the end of the cylinder's ram. Take the cylinder stud that you removed earlier and completely screw it into the cylinder ram's hole. When the stud is installed properly, the threads should not be visible. Once again, notice the groove machined into the stud. In a later step, the bolt that was removed will ride in this groove when installed.
7) Thread the cylinder into the threaded cylinder block mounted on the bender until the cylinder's

forward edge is even with the backside of the block (the side closest to the spindle). The cylinder should NOT be tightened all the way down. When in the correct position the cylinder's forward edge will be very close to even with the cylinder mounting block's backside and the hose coupling on the backside of the cylinder will be pointing down. The cylinder will also be slightly loose on the threads. The cylinder stud should also have slid up into the chain puller assembly.

8) Look between the side rails into the tapped hole where you earlier removed the bolt. Insure that the cylinder stud's groove is positioned beneath the tapped hole so that the screw, when installed will ride in the groove with no binding. If it's off to one side or the other, you may need to slide the chain puller assembly a little to help the threads enter the groove.
9) Install the bolt and tighten. When tight, the screw's threads should NOT bottom out into the cylinder stud. The chain puller assembly should also be slightly loose. If it's not, the bender's return spring may not be able to fully retract. Also the side bearings will not be able to freely slide along the side rails, thereby putting an undesirable side load on the cylinder ram. As a quick check to verify proper installation, use your hand and slightly move the degree indicator block forward and backward. While doing this look between the two leftside rails and you should see the backside of the chain puller assembly move away from the cylinder's ram approximately 1/16" (1 mm). If it doesn't, the installation is incorrect and problems will most likely occur when the bender is put into operation.
10) Install the pump hose onto the cylinder coupling. Engage the pump and run the ram out until it is fully extended. Open the pump pressure relief valve. The spindle should return to its starting point.
11) The bender does not have to be bolted to a stand or table. It can simply rest on its own feet. However, if you desire to bolt the bender down securely, you can do this with the two long 5/8" bolts you removed earlier. In this way the bender's feet become spacers. Congratulations, the bender is now ready for use.

Regular Bender Maintenance

Every 1000 bends or so, grease the two spindle bearings using the two grease fittings on the side of the bender. Use only a non hardening grease. White lithium grease works well. Also using a spray can lubricant, such as 'CRC Power Lube with Teflon', spray the chain and the inner bearing sliding surface. We also use this same lubricant on the tubing and pressure dies when we do bending in house. It's a clear liquid with excellent rust preventive properties. We highly recommend its use if possible.

Pump and Cylinder Selection Guide

The Model 6 Bender has been designed with affordable scalability in mind. In plain English that simply means you only pay for the speed & power you actually need. The charts below will help you determine your requirements.

Bending Torque and Cylinder Selection: The M6B comes standard with a 10 ton hydraulic cylinder. Also offered as an option are 5 and 15 ton cylinders. The 5 and 10 ton cylinders can be operated continuously at their maximum pressure of 10,000 p.s.i. The 15 ton cylinder can be operated at a maximum of 8000 p.s.i. Note: the 5 ton cylinder will not make a complete 180^o bend and is therefore not generally recommended. Figure 1 shows the calculated bending torque in inch pounds for the 3 different cylinder options. These figures exclude frictional losses, which will lower the actual bending torque. In order to determine the most cost effective pump and cylinder combination, it is necessary to know the torque required to bend the specific workpiece and the desired speed of bend. To find the bending torque required, you can call our sales office and ask for technical support or refer to data sheets that list examples of various shapes, materials, wall thickness and radius of bend. Bending torque data sheets may also be attained from our Internet site. As a general rule, the 15 ton cylinder is the most practical selection. It can operate the bender at its maximum bending torque when combined with a 10,000 p.s.i. pump. If your bending requirements are below 25,000 in./lbs., a 15 ton cylinder when combined with a low cost, 3000 p.s.i. pump rated at 1 to 2 gal./min. flow, delivers incredible bending speed. Refer to figure 2 to find the volume in cubic inches required to complete the desired bend. Example: Using a 15 ton cylinder to make 180^o bends would require 28.3 cu./ins. volume of oil.

	5 ton	10 ton	15 ton
2000 PSI	5,720	11,440	17,100
3000 PSI	8,580	17,160	25,650
5000 PSI	14,300	28,600	42,750
10000 PSI	28,600	57,200	68,640 (80% max)

Figure 1 - Inch/Pounds of Bending Torque

	45^o	90^o	135^o	180^o
5 ton	2.2	4.5	6.7	8.9
10 ton	5	10.1	15.2	20.2
15 ton	7.1	14.1	21.2	28.3

Figure 2 - Cubic inches volume required at specific degrees of bend

Hydraulic Pump Selection: There are many possibilities ranging from inexpensive air/hydraulic pumps typically costing under $400 to the more expensive electric pumps costing $800 and up. Pumps are flow rated in cubic inches (or gallons) per minute volume at specific pressures. Figure 3 list several pumps and their respective in.^{3}/min flow rates at the specified pressure. The 5 and 10 ton cylinders both use the same style ‘Enerpac’ quick disconnect hose fitting. Therefore, if you already have a pump, all you need to do is have a hose made up with the proper disconnect fitting. The last three pumps listed in figure 3 refer to standard AC power units. They are relatively inexpensive and very fast, however, they are not as powerful as the 10,000 psi pumps. Typical bending speeds for these pumps are under 4 seconds for a 90^o bend. Also, keep in mind that the pump can be quickly and easily changed to suit the job.

	Type / Control	HP	Maximum Pressure	Flow Rate			
				2,000 p.s.i.	**3,000 p.s.i.**	**5,000 p.s.i.**	**10,000 p.s.i.**
Enerpac PAT-1102N	Air / Foot Pedal	---	10,000	37	32	23	8
Enerpac PUJ-1200B	Electric / Jog	1/2	10,000	32	30	25	20
Enerpac PER-2321	Electric / Jog	1	10,000	42	42	42	42
Enerpac PUM-3209B	Electric / Jog	1 1/8	10,000	60	60	60	60
Enerpac PEM-3302B	Electric / Valve	1 1/2	10,000	60	60	60	60
Enerpac PEM-5305G	Electric / Valve	3	10,000	120	120	120	120
1/2 gal./min. pump	Electric / Valve	?	2000-3000	115	115	-	-
1 gal./min. pump	Electric / Valve	?	2000-3000	231	231	-	-
2 gal./min. pump	Electric / Valve	?	2000-3000	462	462	-	-

Figure 3 - Specifications of various hydraulic pumps

Using the Charts: As an example, suppose you want to bend 2” schedule 40 pipe to 90 degrees. First off, 2” schedule 40 pipe requires a 15 ton cylinder and 8000 psi of pump pressure. Therefore any of the 10,000 psi pumps will work. If speed isn’t a concern, an air/hydraulic pump such as the PAT-1102N will work fine. Figure 3, indicates that the pump will flow at least 8 in.^{3}/min. Figure 4 shows the bend time is approximately 90 seconds. If speed is a concern, then the PEM-5305G is the pump of choice. Flowing 120 in.^{3}/min., its bend time is only 8 seconds. Another example: Production bending of 1” tubing to 180^o. Figure 2 shows a 10 ton cylinder needs 20.2 in.^{3}. Using a 2 gal./min. pump yields a very fast bend time of 2.6 seconds. If you need further assistance, please contact our sales office.

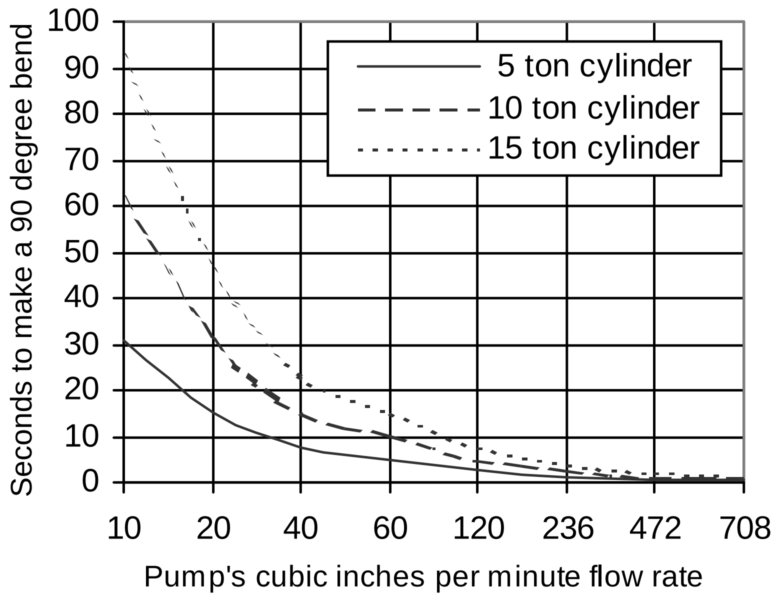


Figure 4 - Bending speed chart

Loading and Bending

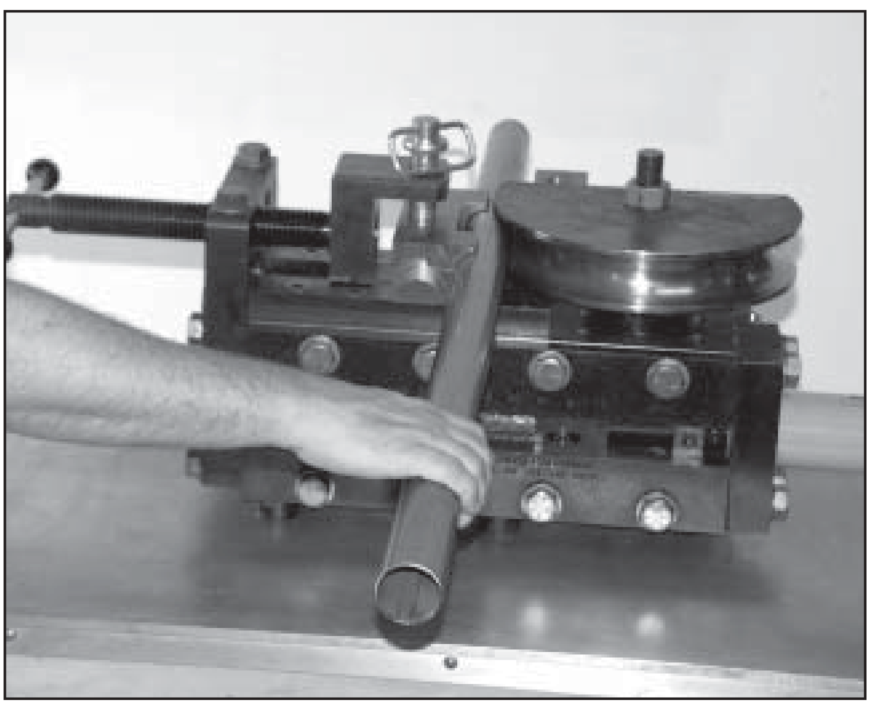
1) First, examine the bottom of the forming die where the drive pin holes have been machined. There will be either three or four 3/4” holes. If there are only three holes you may need to remove the drive pin from the spindle’s upper surface that is closest to the spring tube assembly. If there are four holes, verify that all four 3/4” drive pins are inserted completely into the spindle. The general rule is: *All drive pin holes in the forming die must have a corresponding 3/4” drive pin inserted into the spindle*.

2) Install the forming die onto the spindle with the die’s flat side (tube/pipe clamp side) towards the spring tube assembly. Install and tighten the 1” threaded die nut.

   IMPORTANT: Look under the die and visually verify that the die’s lower machined surface is perfectly flat on the spindle’s upper surface. If the die is not flush with the spindle, the spindle drive pins will be under a bending load instead of the designed shear load. This may damage the spindle and forming die.

3) Using the 1” pin, install the pressure die into the bending block as shown below. The pressure die will be marked with the word ‘TOP’ on its upper surface. It is important that it is installed with this side facing up.

4) Insert the workpiece (tubing, pipe, etc.) into the bender. It is not necessary to install the workpiece clamp (u-strap) at this time. Using the pressure screw handle, turn the pressure screw in until the workpiece is protruding out the rightside of the bender as close to 90 degrees as possible. This can easily be done, as shown in the picture below, by simply holding back pressure on the workpiece with your right hand as you turn the pressure screw in. If the workpiece is not at 90 degrees with the bender the pressure die will not be in its proper position. This may cause a reduction in bend quality.



NOTE: For repetitive bending (such as mass production) where the bender's bend stop is used, it is vitally important that the pressure screw be returned to the same spot for every bend. The easiest way to accomplish this is to place a mark on one side the handle's shaft. *Note: Later model benders may already have a three groove mark on one side of the handle.* Take note where the handle is positioned during the bending operation and simply repeat it for every bend. If the operator positions the handle either perfectly vertical or horizontal during the initial setup it is very easy to return the pressure screw to its proper starting position by using the mark on the handle.

5) Install the forming die's workpiece clamp. This may be a U-Strap, a swing clamp or a positive clamping system, depending on the forming die. If it's a U-Strap make sure the 7/8" U-Strap pin is adjusted so that it cannot make contact with the bender's upper machined surface. This is done by relocating the clevis pin in the U-Strap pin to the appropriate hole so that the U-Strap pin is slightly above the bender's upper surface and completely through the entire U-Strap. If the U-Strap pin extends too far below the U-Strap, it may severely scrape the bender's upper surface. Also if the U-Strap pin is not completely through the U-Strap, the U-Strap will be bent out of shape and will need to be replaced.

6) Engage the pump and advance the cylinder's ram until all play has been removed from the die set's clamping system and the workpiece is held firmly into the bender.

7) Adjust the side indicator block so that the arrow points to 0 degrees.

8) Spray the workpiece with a liquid lubricant such as 'CRC's Power Lube W/Teflon' or its equivalent. Advance the ram while watching the side degree indicator. When the bend is complete, release the pump's relief valve and remove the workpiece. The spindle will now return to its starting position.

   NOTE: You may not need to retract the pressure screw to remove the workpiece. This can save a considerable amount of time when mass production bending.

Adjusting the Bend Stop

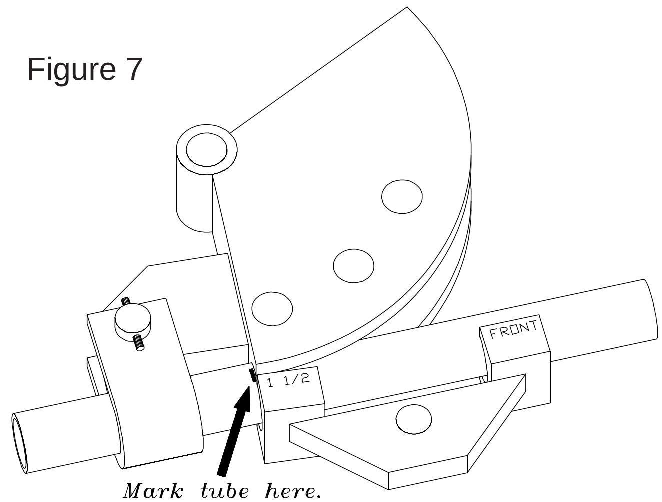
When the bender has completed the bending operation, but before you release the pump's relief valve, screw the bend stop screw in until it firmly makes contact with the chain puller block. Now when you make your next bend the ram will contact the bend stop screw and stop the bending operation. As soon as the bender stops bending, release the pump's relief valve to prevent the pump from overheating.

Example Bends

The first thing you need to do is to determine the actual starting location of a bend produced by the Bending Die you installed in the bender. This can vary between die sets and must be checked for every die set purchased. In the example below we are using 1 1/2" O.D. tubing and a Bending Die with a Center Line Radius of 6 1/2".

Here's the procedure:

Figure 7



A) Place a piece of tubing (app. 2 1/2' long) into the bender so that exactly 12" extends out from the edge of the die to the end of the tubing when the tubing is fully seated in the Bending Die's groove. Place a little bending pressure on the tube so as to seat the tubing in the Bending Die. Not enough to start bending the tubing just enough to seat it in the groove. *NOTE: If you lay a small length of tubing in the groove of a Bending Die you will notice the tubing does not seat to the bottom of the groove. The Bending Dies are deliberately machined this way so that during the bending operation a side force is developed in the tubing. This helps to reduce flat spotting and wrinkles.*

B) Using a Black Magic Marker mark a line on the tubing precisely at the edge of the die. See figure 7.

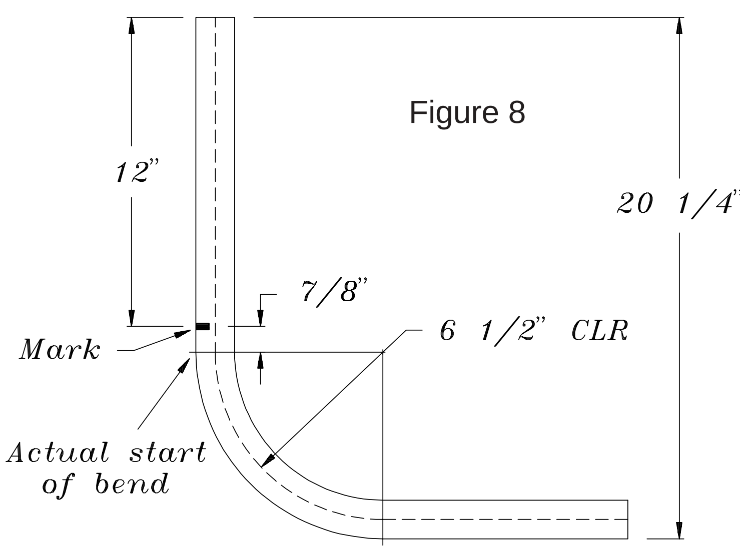
C) Bend the tube to an exact 90 degrees. Use a carpenters square to check the angle. You will have to overbend the tube a little to account for springback. How much to overbend will come with practice. If you overbend the tube a little don't worry. Because cold worked steel has memory, you can place the tube in a vise or anything else that will retain it, and simply unbend it. Obviously this only works for small amounts of overbend. If the tubing is underbent, it will be necessary to put it back into the bender.

D) With the tube bent correctly to 90 degrees locate the actual start of the bend. To do this, measure from the end of the tube to the far end of the 90 degree bend. In the example in figure 8 this came out at 20 1/4". Subtract 6 1/2" for the centerline radius (CLR) of the Bending Die, another 3/4" for the radius of the tubing not seated in the die, and 1/8" for springback. (Substitute the CLR and tube radius to match your die set). The 1/8" figure for springback is an approximation, not an exact figure. However it is usually very close to the real thing and may be used without worry to determine the actual starting location of the bend. So:

20 1/4" - 6 1/2" - 3/4" - 1/8" = 12 7/8"

Now subtract from the 12 7/8" the original 12" we had marked earlier and you

Figure 8



find that the bend will actually start 7/8" in from the edge of the bending die. Now we know for example, if we want 40" from the end of the tubing to the start of the bend, we must subtract 7/8" from 40" and set the tubing 39 1/8" from the edge of the Bending Die.

Another example, you want 36" from the bottom to the top of a rollbar. Tube size is 1 3/4" and you have an actual bend start 1/2" inside of the Bending Die's edge. The CLR of the Bending Die is 7 1/2". So: 36" - 1/2" (Actual Bend start) - 7 1/2" (CLR of die) - 7/8" (Half of the tubing diameter) - 1/8" (Springback) = 27". Set the tube 27" from the edge of the Bending Die and make the bend.

Example hoop :

Preparation is the key to making accurate bends. To make multiple bends in one section of tubing you will need a universal protractor. The protractor is then clamped, using a machinist v-block and a radiator hose clamp, to the tube. Make sure the pointer indicates '0' before making your first bend. Also using a carpenter's level, make sure the tube is entering the bender level. On the second bend if you turn the tube so that the pointer again reads '0' and the carpenter's level indicates the tube is level, both bends will be on the same plane with no noticeable twist.

First step is to draw a sketch of the intended shape and all measurements. Figure 9 below is the desired hoop.

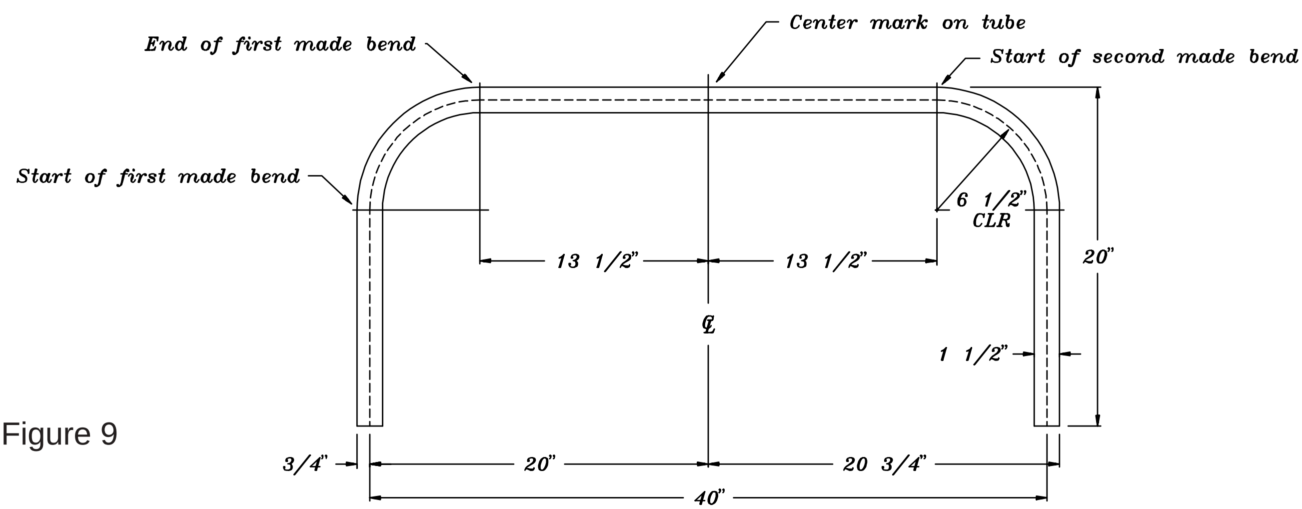


Figure 9

The Bending Die has a centerline radius (CLR) of 6 1/2". The tube O.D. is 1 1/2". We determined earlier, using the method described on page 4, that the Bend Start measurement is 3/4" behind the edge of this particular Bending Die set.

1) Determine the total length of tubing needed. Using a calculator and the formula below let's add it all up.

6 1/2" (CLR of die) x 90 (Degrees of bend) x .0175 = ***Length of tubing used in a bend.***

Using the formula above we get 6 1/2" (CLR of bend) x 90 (Degrees of bend) x .0175 = 10.2375. Let's round this off to 10 1/4" inches (10.250"). This is the amount of tubing used in the bend. We have two bends so we double this and get 20 1/2". Add to this the straight sections and we get 20 1/2" (tubing in bends) + 27 (the center section) + 13 1/2" for the left upright + 13 1/2" for the right upright = 74 1/2" of tubing needed. It's usually a good idea to leave a couple of inches extra on the end. Remember, it's easier to remove tubing then to add it. So let's add 2" to 74 1/2".

2) We cut the tube to 76 1/2". It's generally easier to work from the center out when making two bends in a tube. Divide 74 1/2" by 2 and the center point is 37 1/4" from the end of the tube. Place a mark on the tubing 37 1/4" in from one edge and mark the tubing so you will know which side is the 37 1/4 side and which side is 39 1/4". Notice we didn't use the 76 1/2" measurement that we cut the tubing to. This way we only have to cut 2" off one end of the finished tube instead of 1" off each end. The first bend is made on the short 37 1/4" side.

3) Using the method described on page 4, we determine that the tube should extend 12 5/8" from the edge of the Bending Die. Below is the equation from page 4.

20" (Height of hoop) - 6 1/2" (CLR of die) - 3/4" (1/2 of tube's dia.) - 1/8" (Springback) - 3/4" (Bend Start) = 11 7/8".

After making the bend we have half our hoop completed. The top of the bend is 20" from the bottom of the tube.

4) Now for the other bend. First we need to determine how much the tube stretched in the bend area. From figure 9 we see that the tube should be 20 3/4" from the outside edge to our 37 1/4" center mark. However, after measuring from our center mark to the outside edge of the bend, we now have 21" and not the planned 20 3/4". This 1/4" increase is due to springback and the tube stretching in the area of the bend.

If we now repeat the second bend, using the same 12 5/8" from the end of the tubing + 2" for the extra tubing we allowed, we would end up with a hoop 1/2" too wide. This is because the 1/4" stretch developed in the first bend will also be developed in the second bend, giving us 1/2" total increase in width. Not a good deal if you only want a 40" wide hoop. So what's the solution. Actually there are two ways to do it.

FIRST METHOD:

Look at figure 9 and notice the second bend starts at the top of the hoop and not at the top of the upright as the first bend did. Also the start of the second bend is drawn as 13 1/2" from the center mark. If you take the 13 1/2" measurement and subtract the 1/4" of growth that was developed in the first bend and another 1/4" to compensate for the second bend's growth you end up with 13". Subtract another 3/4" to account for the 3/4" Bend Start location on the Bending Die set and we have a final setting of 12 1/4". Notice we did not subtract an 1/8" for springback. This is accounted for already in the 1/4" we added for the second bend's growth. Set the tube so that the Bending Dies edge is exactly 12 1/4" from the center mark. Make sure the universal protractor reads '0' and the carpenter's level is centered. As one final check, you can also measure from the far side of the completed bend to the edge of the bending die. See figure 10. This measurement should read:

40" (width of hoop) - 3/4" (radius of tube) - 1/8" (springback allowance) = 39 1/8"

Make the second bend. Measure the height of the second upright and cut off the extra tubing we allowed for earlier.

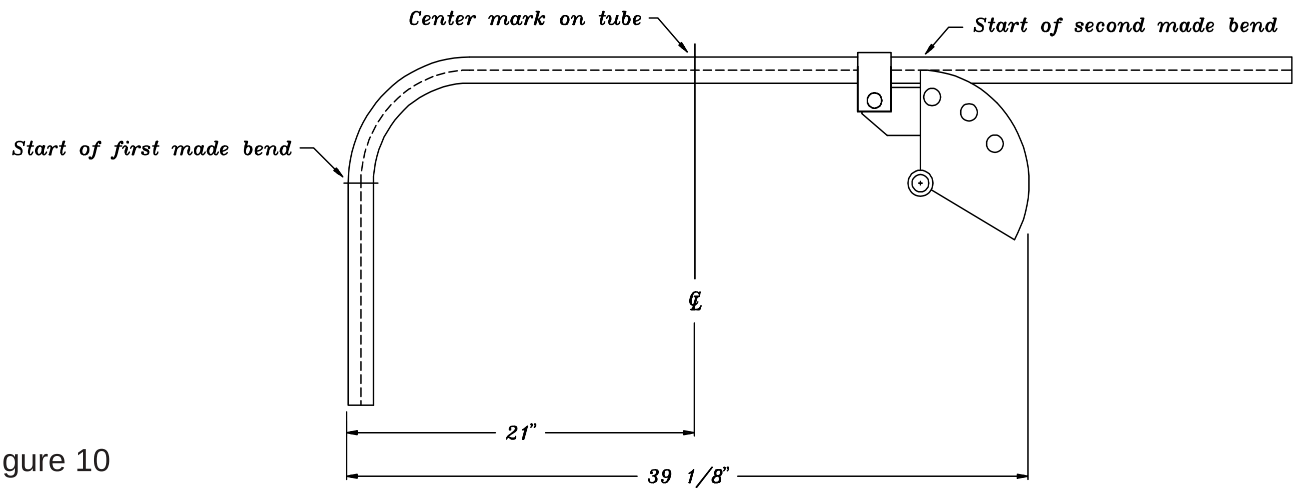


Figure 10

SECOND METHOD:

The second method is basically the opposite of the first method. The second bend will start at the bottom of the upright and *NOT* at the top of the hoop as in the first method and as shown in figure 10. We use the same method as used to bend the first bend with a few exceptions. First calculate the starting point for the second bend as shown below:

20" (total height of hoop) - 6 1/2" (CLR of bending die) - 3/4" (Bend Start) = 12 3/4"

Add 2" to account for the extra tubing we allowed earlier. Also add the 1/4" growth developed in the first bend and another 1/4" for the second bend. DO NOT ADD 1/8" SPRINGBACK. Once again this is already accounted for in the 1/4" growth of the second bend. We end up with:

12 3/4" + 2" (extra tubing) + 1/2" (growth for both bends) = 15 1/4"

Set the tube's end at 15 1/4" from the Bending Die's edge. Make sure the universal protractor reads '0' and the carpenter's level is centered. Make the second bend. Measure the height of the second upright and cut off the extra tubing we allowed for earlier.