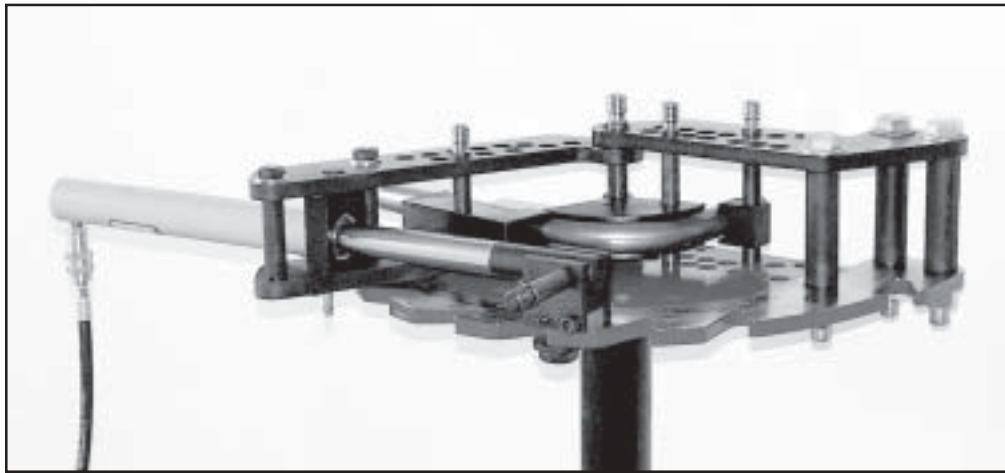


MODEL 4 TUBE BENDER

Assembly & Operating Instructions

Revision 2



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Unpacking & Parts List

The basic Model 4 bender is shipped in 2 packages. Package 1 contains the lower frame only. Package 2 contains all other parts needed for assembly, excluding the hydraulic cylinder, pump and hose. If these items were also ordered with the bender, they will arrive in their own separate boxes. Upon receiving both packages verify that neither package shows any signs of damage and that all parts are present. If a package has been damaged and parts are either missing or damaged, you must immediately contact our sales office.

PACKAGE 1 CONTENTS:

1 Lower frame

PACKAGE 2 CONTENTS:

1 Instruction manual

1 Upper frame

11 3/4" S.A.E. washers

3 3/4" x 2" flat head screws

3 3/4" nuts

3 1 1/2" diameter frame sleeves

3 1" x 8" bolts

6 1" S.A.E. washers

3 1" nuts

1 1" x 8" diameter frame pin

2 7/8" x 8" frame link pins

1 7/8" x 6 1/4" drive link pins

1 Drive link - Lower

1 Drive link - Upper

1 3/4"-16 x 5" long bolt (Outside drive link bolt)

1 3/4"-16 x 4 1/2" long bolt (Inside drive link bolt)

2 1" diameter drive link sleeves

1 Hydraulic swivel block

1 Pusher block with 1" diameter flange bolt welded in place

1 Pusher block handle

1 3/16" roll pin

1 1 1/2" diameter pushrod (screws into hydraulic cylinder)

1 Bronze pivot block

2 1/2" diameter shoulder bolts

1 3/8" nylock nut

1 Anti-Springback lever

1 1/2"-20 x 1" long bolt

1 1/2" S.A.E. washer

1 3/4" diameter x 3/8" long sleeve (for anti-springback lever)

1 1/2" threaded spring pin

1 1/2"-20 fine thread nut (will be installed on spring pin)

1 spring

1 1/4" x 1 1/2" long socket head bolt

2 1/4" nuts

Assembly

1) The bender may be mounted to anything rigid enough not to twist or move during the bending operation. To mount the bender, drill three 3/4" holes through your mounting surface. You can use the frame holes as a guide. Place two 3/4" washers on the top of each drilled hole. These washers will act as spacers to insure that the bender pins, when installed, will be completely pass through the lower frame holes. If you purchased the optional pedestal, position the washers over the slots as shown in figure 1.



Figure 1

2) Refer to figure 2. Using three 3/4" x 2" long flat head bolts, three 3/4" nuts and three 3/4" washers, tightly secure the frame to your mounting surface/pedestal. Using three 1 1/2" diameter frame sleeves, three 1" diameter x 8" long bolts, six 1" washers and three 1" nuts, install the upper frame onto the lower frame. Lightly tighten the bolts. Next install the 1" frame pin as shown in figure 2. Using a small square placed against the 1" pin, move the upper frame around until the frame pin is perfectly vertical. Tighten all three 1" bolts.

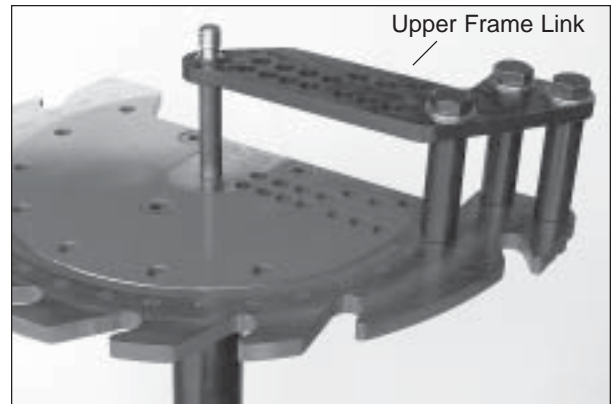


Figure 2 - Upper frame installed

4) Remove the 1" frame pin. Locate the lower drive link. It will have two 3/4" tapped holes in it and a recess milled out of its bottom side's center. Place it on the lower frame with its inside 1" hole over the lower frame's 1" center hole and its milled recess facing down. Replace the 1" frame pin. Locate the hydraulic cylinder's swivel block. Examining the swivel block you will see the word 'TOP' stamped into it. Insert the swivel block into the lower drive link's remaining 1" hole with the word 'TOP' facing up. Your Model 4 should now look like figure 3.

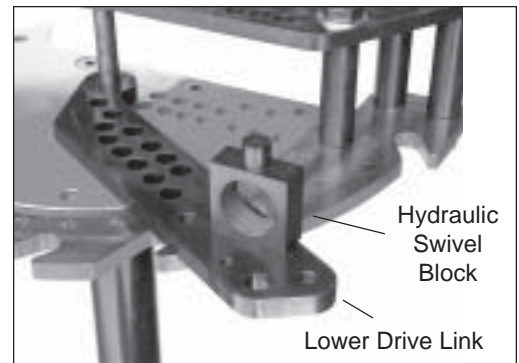


Figure 3

3) Refer to figure 4 for this step. Remove the 1" frame pin. Locate the upper drive link. Place it in the bender so that it aligns with the lower drive link and engages the swivel block's upper shaft. Reinstall the 1" frame pin. Place the two 1" diameter drive link sleeves between the two drive links aligned with the 3/4" holes. Place a 3/4" washer onto the 3/4"-20 x 5" long bolt. Install it into the outside 3/4" sleeve and lightly tighten. Place a 3/4" washer onto the 3/4"-20 x 4 1/2" long bolt. Install it into the inside 3/4" sleeve and tighten securely. Remove the whole drive link assembly and turn upside down. Look on the bottom side of the lower link and verify that the inside 3/4" bolt threads do NOT protrude out of the link. If it does, it will severely scratch the frame's machined surface. Also the bender's links will not ride properly on the lower frame. The only way this should be able to occur would be if the longer 5" bolt was installed where the 4 1/2" bolt should be.

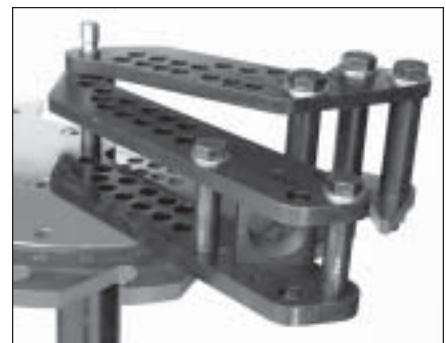


Figure 4 - Drive links installed

4) Invert the drive link assembly as shown in figure 7.

Locate the parts listed below:

- 1 Anti-Springback lever
- 1 1/2"-20 x 1" long bolt
- 1 1/2" S.A.E. washer
- 1 3/4" diameter x 3/8" long sleeve
- 1 1/2" threaded spring pin
- 1 1/2"-20 fine thread nut
- 1 1/4" x 2" long socket head bolt
- 2 1/4" nuts
- 1 Spring

Place the 1/2" washer onto the 1/2"-20 x 1" long bolt. Next place the 3/4" diameter sleeve onto the bolt also. This sleeve acts as a spacer. Study figures 5 and 7 carefully and then position the anti-springback lever as shown. Install the bolt, washer and sleeve through the anti-springback lever and into the lower drive link. Tighten securely. Verify that the lever rotates freely.

Install the 1/2"-20 fine thread nut onto the spring pin about half way up. Install the spring onto the spring pin as shown in figure 6. Screw the spring pin into the lower link until it starts to protrude out the other side of the drive link. Back it off 1 to 2 turns, to make sure it doesn't protrude, and tighten the 1/2" nut.

Install a 1/4" nut onto the 1/4" x 2" long socket head bolt. Adjust the 1/4" nut so that when the bolt is installed in the anti-springback lever, the 1/4" nut on the other side of the anti-springback lever can be completely installed with only 1 thread visible. This will put the bolt's head roughly even with the spring pin's head. Remove the 1/4" bolt. Being careful not to turn the 1/4" nut already installed, insert the bolt's head through the open loop of the spring. Holding the bolt, stretch the spring and insert the bolt back into the 1/4" hole in the anti-springback lever. Install the other 1/4" nut onto the bolt from the top side of the anti-springback lever and tighten. Remember that only one thread of the 1/4" bolt should be visible from the top side of the anti-springback lever. Figures 6 and 7 show the complete assembly correctly installed. Note that the outside 3/4" bolt protrudes out of the bottom of the lower drive link and that the inside 3/4" bolt does NOT.

Install the completed drive link assembly into the bender. The easiest way to do this is from the rear of the bender. Insert the drive link assembly with the open 1" holes between the 1" holes in the frame. Insert the 1" frame pin. Now rotate the drive link assembly counterclockwise until it rest on the machined upper surface of the frame. If it does lay flat, the upper frame link will need to be loosened and repositioned until the 1" frame pin is perfectly vertical. Rotate assembly until the degree scale reads 30 to 60 degrees on the right side of the lower drive link.

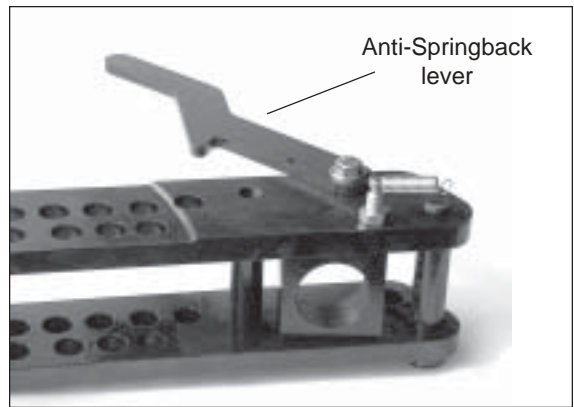


Figure 5 - Anti-springback lever



Figure 6 - Spring installation



Figure 7 - Lever system installed

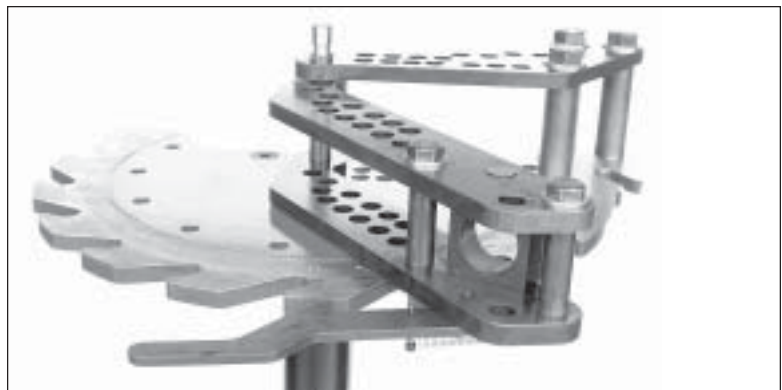


Figure 8

5) Locate the parts shown in figure 9 and listed below:

- 1 Pusher Block
- 1 Pusher Block Handle
- 1 Bronze Pivot Block
- 1 Pushrod (1 1/2" diameter)
- 2 1/2" x 2 1/2" long shoulder bolts
- 1 3/16" roll pin
- 1 3/8" nylock nut
- 1 1" diameter welded flange bolt

NOTE: This bolt is shown as a separate item in figure 9 for easier identification. However, it has already been welded into the Pusher Block.

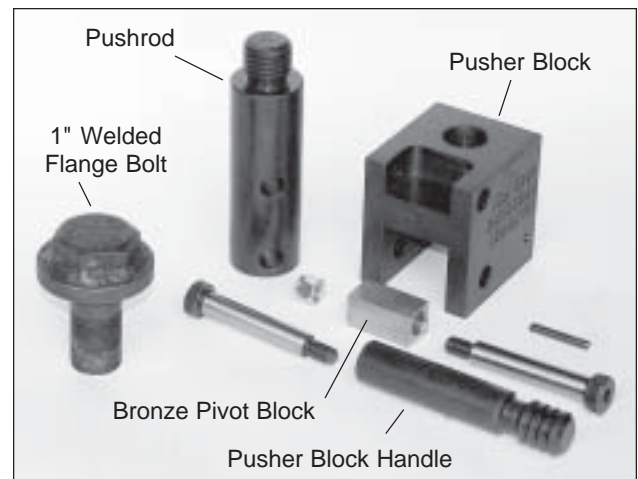


Figure 9 - Pusher assembly

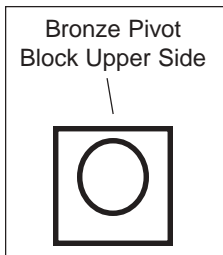


Figure 10

Examine the bronze pivot block. You will notice that the 1/2" hole has been offset drilled to one side as shown in figure 10. The distance from the hole's edge to the pivot block's side will be less than the other three sides. This is the pivot block's upper side. Now examine the pusher block. You will see a 1 1/2" slot milled completely through its top surface and on its bottom you will

see a smaller recess milled into its front edge. Note: The pusher block shown in figure 9 is bottom side up so that the milled recess can be clearly seen. This recessed area is where the bronze pivot block is installed. Hold the pusher block so that the engraving on its side is right side up and facing you. Position the bronze pivot block into the lower recess so that its upper surface is facing up (the hole is offset to the top). From the engraved side of the pusher block, insert one of the two 1/2" shoulder bolt and secure tightly with the 3/8" nylock nut. When completed it should look like figure 11. The pivot block must also be protruding out of the bottom of the pusher block approximately 1/16" as shown in figure 12. If it's not, it's installed wrong and must be reinstalled.

As shown in figure 13, position the pushrod into the pusher block's upper slot. The 1/2" hole in the pushrod nearest to the end should be lined up with the 1/2" hole in the pusher block. Insert a 1/2" shoulder bolt into the pusher block from the side opposite the engraving. Install the pusher block handle onto this shoulder bolt and tighten. Lay the pusher block down on the side opposite the engraving. Slightly rotate the pushrod so that the 1/2" hole in its middle is under the 3/16" hole drilled into the engraved side of the pusher block. Being careful not to mar the engraved face of the pusher block, hammer in the 3/16" roll pin until it is flush with the pusher block's surface. Figure 11 shows this step completed.



Figure 11 - Pusher block



Figure 12



**Figure 13
Pusher assembly complete**

6) Screw the hydraulic cylinder completely into the hydraulic swivel block. If when tightened the cylinder's quick disconnect hose fitting is not facing in the downward direction, loosen the cylinder until it does face in the downward direction. The cylinder will have a little play in its threads. This is normal and will not cause any problems.

Screw the completed pusher block assembly into the cylinder. You may need to rotate the drive links to the rear of the bender in order for the handle to clear the main frame as the pusher block is screwed into the cylinder. Rotate the pusher block so that the handle is facing toward you. Rotate the drive links until the pusher block is positioned approximately as shown in figure 14.

Using the handle, move the 1" welded flange bolt into one of the lower frame's teeth. When the bender is under load, the rear of the pusher block should rise approximately 1/16" above the face milled flat of the lower frame. With the bronze pivot block protruding out of the bottom of the pusher block 1/16", this should make the pusher block ride flat when bending. This will eliminate any side loads on the hydraulic cylinder, therefore preventing any unnecessary wear in the cylinder.



Figure 14 - Pusher block engaged

IMPORTANT NOTE: Looking at figure 14, you will see a hole drilled through the drive links just outboard of the cylinder pivot block. NEVER OPERATE THE BENDER HYDRAULICALLY WITH A PIN IN THIS HOLE, AS IT WILL DAMAGE THE CYLINDER HOUSING BEYOND REPAIR. This hole is only used when the bender has the optional manually pulled handle installed.

7) Next attach the hose to the pump in its correct port. If you have your own pump or purchased a pump with your bender and it wasn't the 2 HP model, follow the directions included with the pump. If you purchased the preferred 2 HP pump as shown in figure 15, you can look at the photo as a reference. Wrap 2 to 3 layers of teflon tape around the male threads on the hydraulic hose. Looking at the bender from the electric motor side, screw the hose into the right side upper port. Wrap 2 to 3 layers of teflon tape around the 1/2" pipe plug and screw it into the left side upper port. Make sure both are tightened snugly.

Attach the hose to the cylinder's quick disconnect fitting and hand tighten only. Plug the pump into the proper electrical outlet. Note: Upon start up, if the pump acts like it's not getting enough current, take these steps to fix the problem. First use a heavy gauge (12 gauge or heavier), short electrical extension cord. The shorter the better. If using 110 volts, make sure the electrical circuit breaker is rated at least 30 amps. As a general rule, if when the bender is operating, the electrical extension cord feels hot, it's too small. Also if the electrical relay operates erratically when pressed, it's probably a sign of an electrical supply problem.

Pressing the pump control buttons will extend the cylinder under pressure or release the pressure, thereby retracting the cylinder using its internal spring return. If neither button is pressed the cylinder will hold its position. The 2 HP pump is relatively fast. It's easy to overshoot the desired bend angle. To prevent this from happening, follow this procedure: Press the cylinder extend button and hold down until the bender is 3-5 degrees before the desired angle. Now quickly tap the button on and off until the bender edges up to the proper degree. With practice you should easily be able to advance the cylinder as little as 1/5 of a degree. Note the 5000 p.s.i. pressure gauge shown in figure 15. This gauge is not included with the pump, but is highly recommended. A good quality gauge can be purchased at any hydraulic supply business. Simply tee it into the pressure hose as shown in figure 15.



Figure 15

Installing Die Sets

The Model 4 bender comes with 4 pins. Locate the pins listed below:

- 1 1" Diameter x 8" Frame Pin
- 2 7/8" Diameter x 8" Long Frame Pins (Long Pin)
- 1 7/8" Diameter x 6 1/4" Long Drive Pin (Short Pin)

A Die Set consists of the 3 parts listed below:

- 1 Forming Die (Circular in shape, usually with a groove)
- 1 Pressure Die (The part that slides along the workpiece)
- 1 U-Block (A small square block that retains the workpiece, also usually has a groove)

STEP 1 - INSTALL THE FORMING DIE

Forming Die Installation

There are two styles of forming dies. One has a square block welded to its backside as shown in left side of figure 17. The other doesn't as shown in right side of figure 17. The method of die installation depends on what style you have.

Installing a Die without a welded block:

Using the 1" frame pin, place the forming die into the bender with its rounded side forward as shown in figure 18. The forming die will normally only have one other hole drilled through it, as shown on the right side of figure 17. This hole is very close to the die's edge, usually within a 1/8"-1/4". If there is more than one hole, use the hole closest to the die's edge. Model 1, 2 and 3 die sets will work in the Model 4, however they usually will have 3 to 5 holes drilled through them. So with those dies you would only use the hole closest to the flat side of the die.

Rotate the die until the hole in the die lines up with one of the NUMBERED holes 1 - 4 in the frame (not the lettered holes). Insert one of the two long 7/8" frame pins through the frame and die. This pin will prevent the die from rotating when the bender is operating.

Installing a Die with the welded block:

Using the 1" frame pin, place the forming die into the bender as shown in figure 19 with the welded block closest to the frame bolts. The die shown has multiple drive holes drilled in it. Only the one closest to the die's flat side (it will be the one nearest to the welded block) needs to be used. A long 7/8" frame pin has been installed in the hole closest to the die's welded block. Installed this way the welded block serves no function. This would be the case if a Model 3 die set was being used in the Model 4.

If the forming die does NOT have any drive holes, only a welded block, then install the die as shown but do not use a 7/8" pin. In this case, when the bender is operating, the welded block on the die will rotate clockwise and contact the workpiece, thus preventing the die from rotating. Note that if the die has a welded block and drilled drive holes you can use either the welded block or the first drive hole.



Figure 16 - Die styles

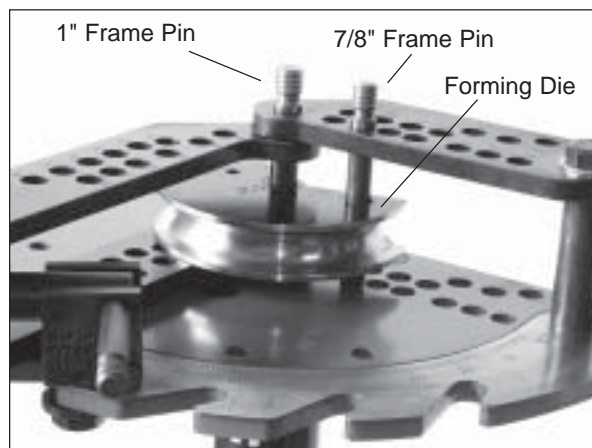


Figure 17 - Die installed

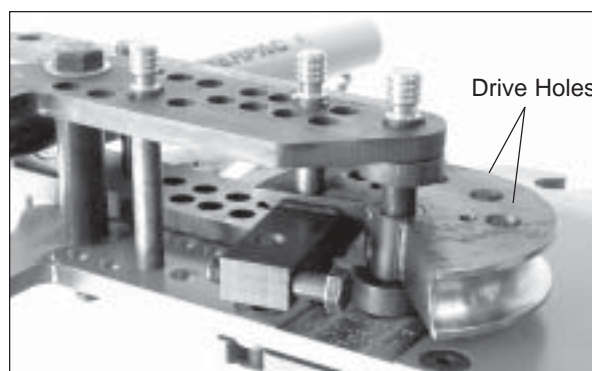


Figure 18 - Die with welded block

STEP 2 - INSTALL THE PRESSURE DIE

Pressure Die Installation

Pressure dies are machined to exacting standards and must be installed in the proper orientation. Depending on whether the die set is for pipe, round or square tubing follow the appropriate directions below.

ROUND TUBING OR PIPE

The pressure die is shown in figure 19. For round tubing and pipe, the pressure die will have two circular grooves machined on each end, a leading and a trailing groove. The trailing side groove is machined at an angle. This angled groove provides better control of the workpiece than a straight groove, resulting in a better bend quality. However, the pressure die **MUST** be installed in the bender's drive links with the angled groove closest to the forming die. If the pressure die is installed upside down, that is with the angled groove forward, it will try to dig into the workpiece and bend quality will suffer.

Engraved into the pressure die will be the O.D. size of the tubing or pipe and the correct hole number that it should be installed into the drive links with.

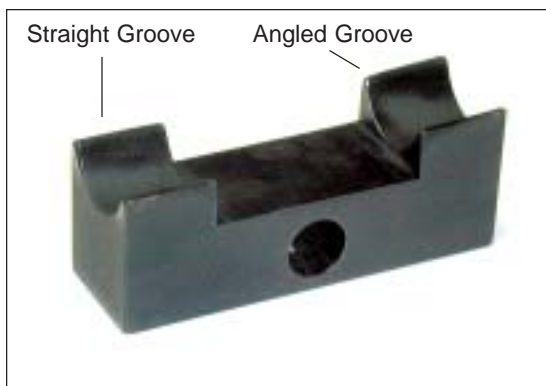


Figure 19 - Tube or pipe Pressure Die

Referring to figures 21 and 22. After the forming die has been installed, rotate the drive links counter-clockwise until they are parallel with the upper frame link. Place the tubing or pipe to be bent through the middle of the drive links as shown. Next place the pressure die between the drive links with the angled groove closest to the forming die. The angled groove should now be towards the rear of the bender and on your right side. Insert a short 7/8" pin through the drive links and the pressure die in the exact hole number engraved into the pressure die.

NOTE: The angled groove supports the tube during the bending process, thereby preventing it from excessively flattening on the outside. Never install the pressure die upside-down with the angled groove not at the point of bend (closest to the forming die). It can damage the pressure die and severely gouge your tube or pipe. Also, if the pressure die is placed in a hole# other than the one marked on it, bend quality will suffer. If the tube or pipe is flattening a large amount on the outside, check to make sure the pressure die is installed in the correct drive link hole.

Figure 22 - Pressure Die installed - back

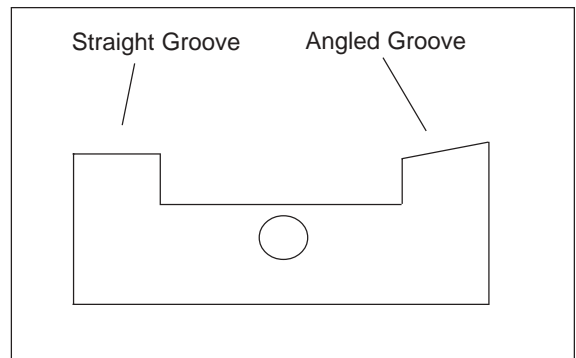
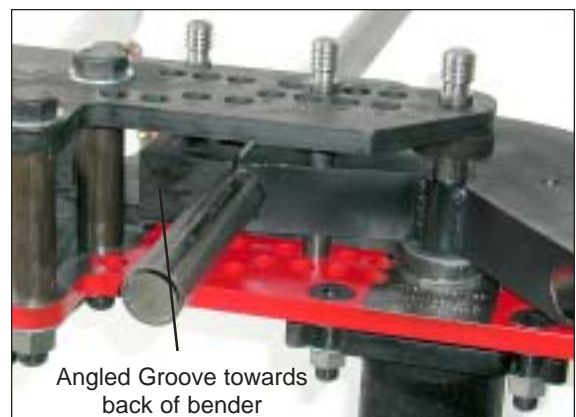


Figure 20 - Top view drawing



Figure 21 - Pressure Die installed - front



STEP 3 - INSTALL THE U-BLOCK

Shown in figure 23 is the U-Block installed in the bender. Normally the pressure die would have already been installed, but for a clearer view of the u-block it has been removed.

Looking at the top of the upper frame you will see two rows of 7/8" holes with letters or numbers beside them. The front seven row holes (1,2,3,4,E,F,G) are in a straight line and the back seven holes (A,B,C,D,5,6,7) are staggered. The back side holes are the ones where the U-Block pin is normally installed as shown in figure 23.

PROCEDURE:

The forming die, pressure die and workpiece (tube or pipe) have already been installed in the bender in the previous two steps.

Position the workpiece where you want it bent. Referring to figure 24, push the workpiece away from you firmly. This will seat the workpiece in between the forming die and pressure die, removing any play.

Install the u-block and long 7/8" frame pin into one of the 7/8" back side holes AS CLOSE TO THE 1" FRAME PIN AS POSSIBLE. This is why you had to push the workpiece away from you. Figure 26 shows the complete die set installed as seen from the back side of the bender.



Figure 23 - U-block installed



Figure 24 - Pushing workpiece



Figure 25 - Installing pin in back hole



Figure 26 - Die set installed as seen from back side of bender

SQUARE TUBING

Square tube die sets are installed in the same way as round tube die sets with the exception of the pressure die. Square tube pressure dies do not have an angled groove, just one long straight groove. Therefore, all you need to do is install it in the correct hole# as marked on it.

Operation

STEP 1 - Figure 27 & 28

Using your hands, rotate the drive links clockwise until the workpiece is firmly seated in the die set with no play. With the cylinder fully retracted, extend the cylinder while guiding the pusher block into the first ratchet tooth on the frame. **DO NOT PLACE YOUR HANDS ANYWHERE ON THE PUSHER BLOCK EXCEPT ON THE HANDLE. THIS WILL PREVENT ANY POSSIBLE PINCH POINT. ALWAYS KEEP YOUR HANDS OUTBOARD OF THE BENDER WHEN OPERATING. BE CAREFUL!!!**

Extend the cylinder lightly until the workpiece is securely seated in the die set but has NOT started to bend. Look on the lower rightside of the lower drive link and note the degree reading as shown in figure 28. Two to eight degrees is normal, but may vary. This initial degree reading is called the lead-in angle. You need to add 3 angles together in order to obtain a correct bend angle.

- 1) The lead-in angle. This accounts for the bender and die set clearances.
- 2) The desired bend angle. This is the actual angle of bend you want the finished bend to be.
- 3) The springback angle. All workpieces will springback when pressure is removed after bending. Usually on the order of 2-8 degrees, depending on the yield strength of the workpiece and the amount of bend. A tube that springs back 3 degrees at 90 degrees of bend may spring back 5-6 degrees at 180 degrees of bend. The only way to determine springback values is by trial and error. Once you know the correct values for a specific workpiece (material, wall thickness, angle of bend) write it down so you can use the same value next time.

$$\text{Lead-In} + \text{Desired bend angle} + \text{Springback angle} = \text{Degree reading on bender when finished}$$

STEP 2 - Figure 29 & 30

Engage the anti-springback lever by pushing it in towards the frame teeth. While watching the degree markings on the bender start extending the cylinder. If making a bend over 55 degrees go ahead and quickly stroke out the cylinder until around 50 degrees or so. Just before the anti-springback lever engages the frame's ratchet teeth stop the cylinder. Try to stop it as close as you can without the anti-springback lever actually clicking into the frame tooth. Now rapidly tap the cylinder extend button until the anti-springback lever engages the frame tooth. You do not want to go too far, because that would defeat the purpose of the lever. You want to be able to retract the ram with as little springback as possible. Refer to figure 30.



Figure 27 - Engaging 1st ratchet tooth



Figure 28 - Lead-in degree reading



Figure 29 - Ram extended



Figure 30 - Lever engaged

STEP 3 - Figure 31

Fully retract the hydraulic ram as shown in figure 31.



Figure 31 - Retracting cylinder

STEP 4 - Figure 32

Engage the next tooth and continue. The second stroke of the ram will take the bend to over 90 degrees. Bends of 120 - 130 degrees will generally require another stroke.



Figure 32 - Engaging next tooth

A QUICK EXAMPLE BEND

As an example, let's say you want to bend a piece of 1 1/4" schedule 40 pipe 90 degrees. Place a mark on the pipe where you want the bend to start. Install the pipe and the die set into the bender. Position the mark on the pipe at the point on the forming die where the bend will start. Engage the first tooth and preload the pipe by lightly extending the ram. As shown in figure 28, note the lead-in angle. Let's say it shows 4 degrees. For this size pipe, a springback angle of 3-4 degrees is normal is average. So let's use 3 1/2 degrees. Now add up the 3 degree values.

- 4 degrees of lead-in angle
- 90 degrees of desired bend angle
- 3 1/2 degrees of springback
- 97 1/2 Degrees total**

Extend the ram out until the degree reading is over 50 degrees and just before the lever engages stop the ram. Quickly tap the ram extend button until the anti-springback lever fully engages, but just barely. Retract and reengage the ram as shown in figure 32. Continue bending until around 95-96 degrees and stop. Quickly tap the button until the degree reading is 97 1/2. Disengage the lever and remove the finished pipe.

EXAMPLE BEND

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 below example 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:

- 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 33.
- 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:

$$20 \frac{1}{4}" - 6 \frac{1}{2}" - 3/4" - 1/8" = 12 \frac{7}{8}"$$

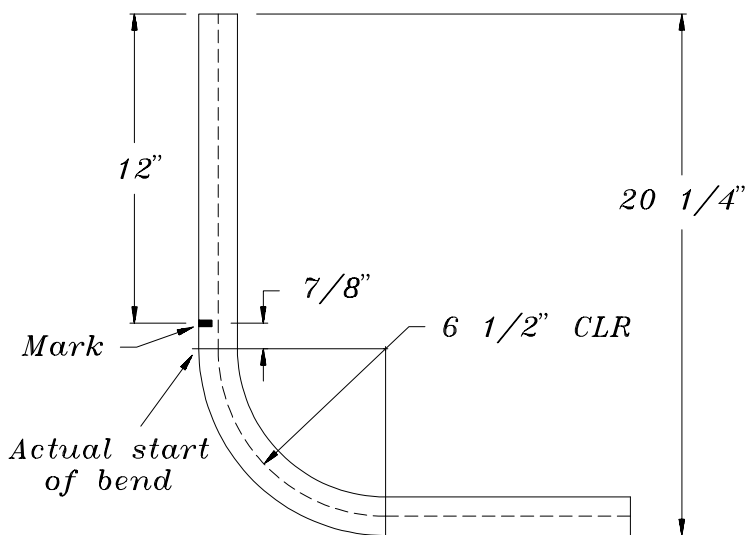


Figure 34

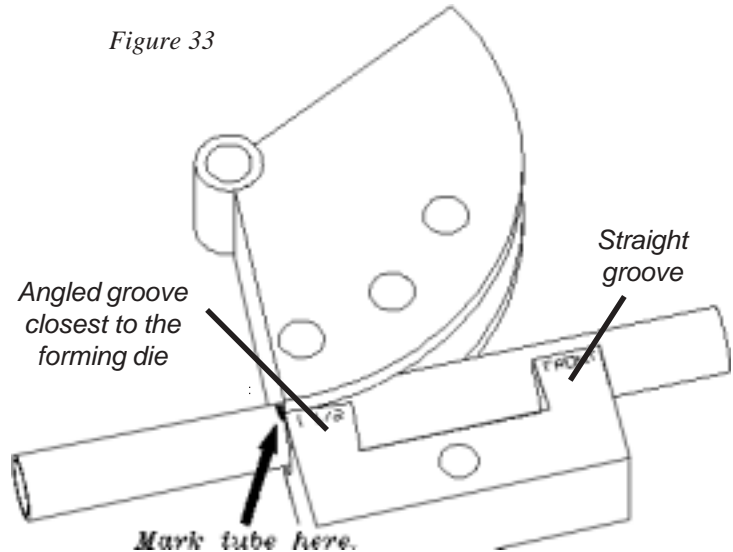


Figure 33

Now subtract from the 12 7/8" the original 12" we had marked earlier and you 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 35 below is the desired hoop. The Bending Die has a centerline radius (CLR) of 6 1/2". The tube O.D. is 1 1/2". We determined earlier that the Bend Start measurement is 3/4" behind the edge of this particular Bending Die set.

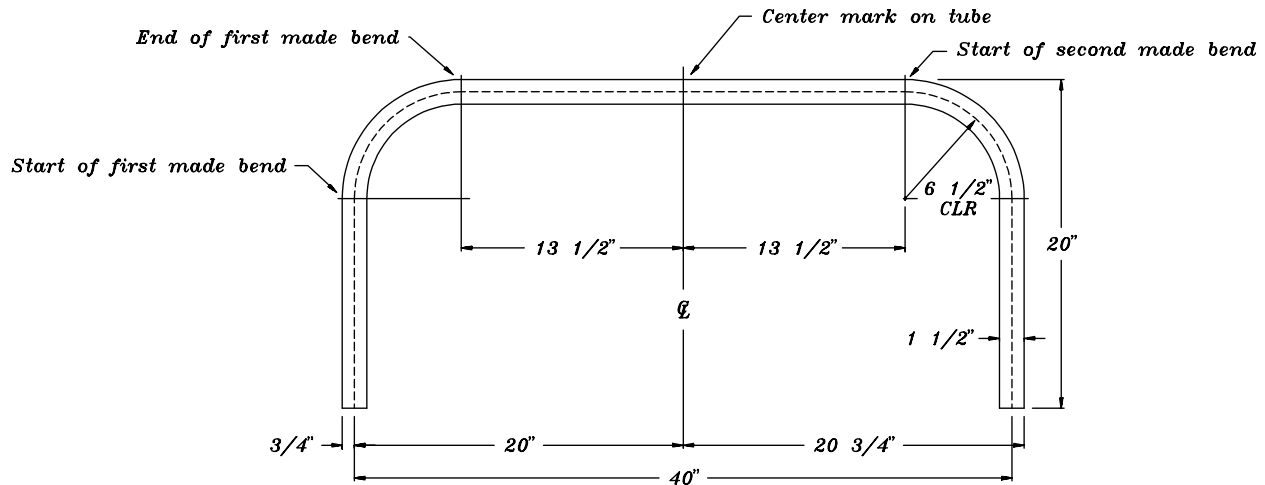


Figure 35- Example hoop.

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

$$6 \frac{1}{2}'' \text{ (CLR of bend)} \times 90 \text{ (Number of degrees of bend)} \times .0175 = \text{Length of tubing used in a bend.}$$

Using the formula above we get $6 \frac{1}{2}'' \text{ (CLR of bend)} \times 90 \text{ (Degrees of bend)} \times .0175 = 10.2375$. Let's round this off to $10 \frac{1}{4}''$ inches ($10.250''$). This is the amount of tubing used in the bend. We have two bends so we double this and get $20 \frac{1}{2}''$. Add to this the straight sections and we get $20 \frac{1}{2}''$ (tubing in bends) + 27 (the center section) + $13 \frac{1}{2}''$ for the left upright + $13 \frac{1}{2}''$ for the right upright = $74 \frac{1}{2}''$ 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 than to add it. So let's add $2''$ to $74 \frac{1}{2}''$.

2) We cut our tube to $76 \frac{1}{2}''$. It's generally easier to work from the center out when making two bends in a tube. Divide $74 \frac{1}{2}''$ by 2 and our center point is $37 \frac{1}{4}''$ from the end of the tube. Place a mark on the tubing $37 \frac{1}{4}''$ in from one edge and mark the tubing so you will know which side is the $37 \frac{1}{4}''$ side and which side is $39 \frac{1}{4}''$. Notice we didn't use the $76 \frac{1}{2}''$ measurement that we cut our 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 $37 \frac{1}{4}''$ side.

3) Using the method described on page 11 we determine that the tube should extend $12 \frac{5}{8}''$ from the edge of the Bending Die. Below is the equation from page 4.

$$20'' \text{ (Height of hoop)} - 6 \frac{1}{2}'' \text{ (CLR of die)} - \frac{3}{4}'' \text{ (1/2 of tube's dia.)} - \frac{1}{8}'' \text{ (Springback)} - \frac{3}{4}'' \text{ (Bend Start)} = 11 \frac{7}{8}''.$$

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 $20 \frac{3}{4}''$ from the outside edge to our $37 \frac{1}{4}''$ center mark. However after measuring from our center mark to the outside edge of the bend we now have $21''$ and not the planned $20 \frac{3}{4}''$. This $\frac{1}{4}''$ increase is due to springback and the tube stretching in the area of the bend.

If we now repeated 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 is two ways to do it.

FIRST METHOD:

Look at figure 35 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 36. This measurement should read:

$$40" \text{ (width of hoop)} - 3/4" \text{ (radius of tube not in bending die)} - 1/8" \text{ (springback allowance)} = 39 \text{ } 1/8"$$

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

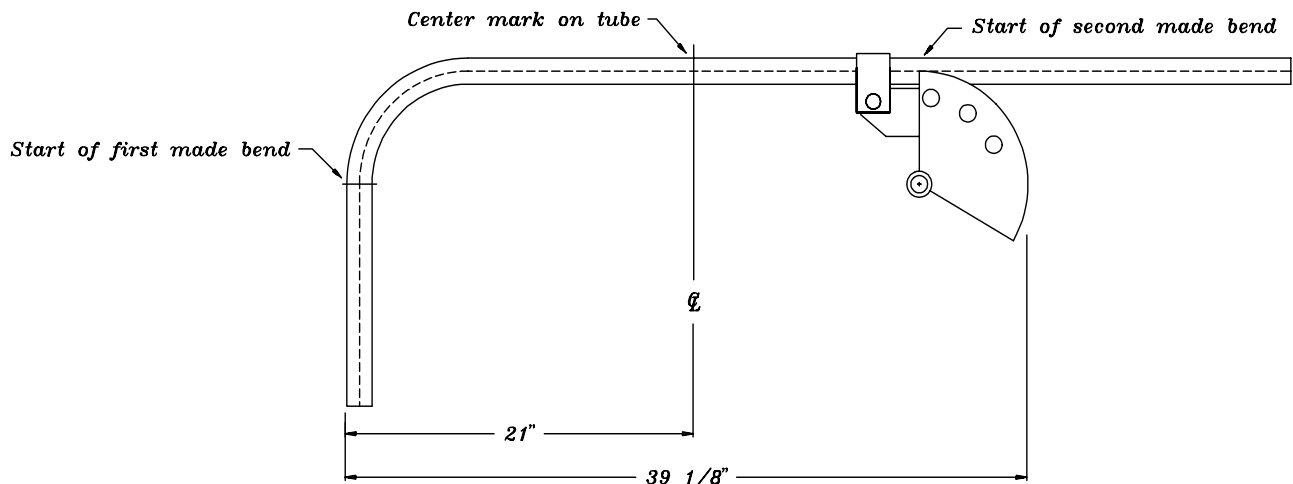


Figure 36

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 36. 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:

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

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:

$$12 \text{ } 3/4" + 2" \text{ (extra tubing)} + 1/2" \text{ (growth for both bends)} = 15 \text{ } 1/4"$$

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.

Thank you for purchasing the Model 4 Bender. Any further questions please call.