Electrical Level 1

Hand Bending 26107-14

Objectives

When trainees have completed this session, they should be able to do the following:

1. Identify the methods for hand bending and installing conduit.
2. Determine conduit bends.
3. Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
4. Cut, ream, and thread conduit.

Performance Tasks

1. Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
2. Cut, ream, and thread conduit.

Introduction; Hand Bending Equipment

- Hand benders are available in various sizes and used to bend rigid conduit and electrical metallic tubing (EMT) up to 1¼" in diameter.
- The same bender can be used on different sizes of EMT and rigid because while their inside diameters vary, the outside diameters are roughly equal.

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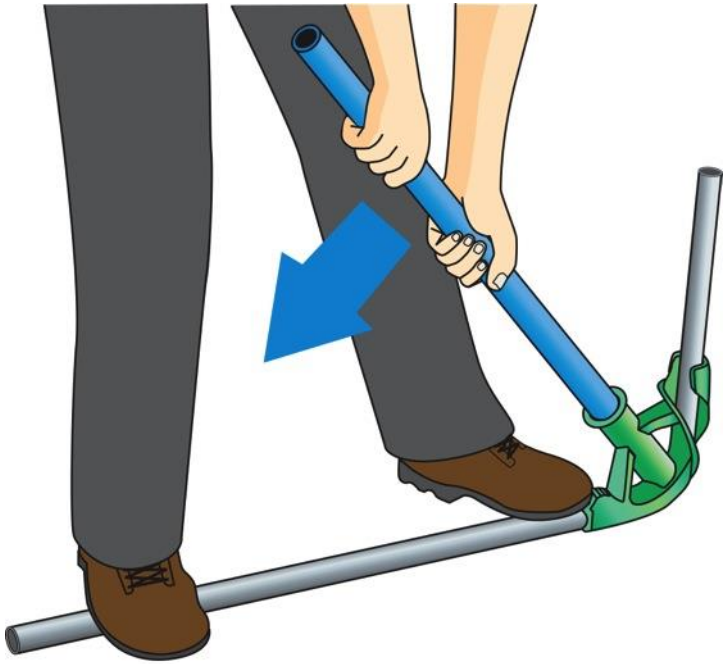
Pushing Down on the Bender to Complete the Bend

- To use a hand bender, place it on a flat, firm surface and bend down.
- Use both hand and foot pressure to ensure a good bend.



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Hickeys

- Hickeys are used for rigid metal conduit (RMC) and intermediate metal conduit (IMC) only.
- Hickeys make segment bends in small increments.

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Typical PVC Heating Units

- Polyvinyl chloride (PVC) conduit is bent using a special heating unit.
- After the PVC is heated, it is removed from the unit and the bending performed by hand.

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What's wrong with this picture?

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Typical Plug Set

- Plug sets are used for PVC that is 2" in diameter or larger.
- The plugs help prevent the PVC from flattening during a bend and are removed when the PVC has cooled. A damp sponge or cloth can be used to set the PVC faster.

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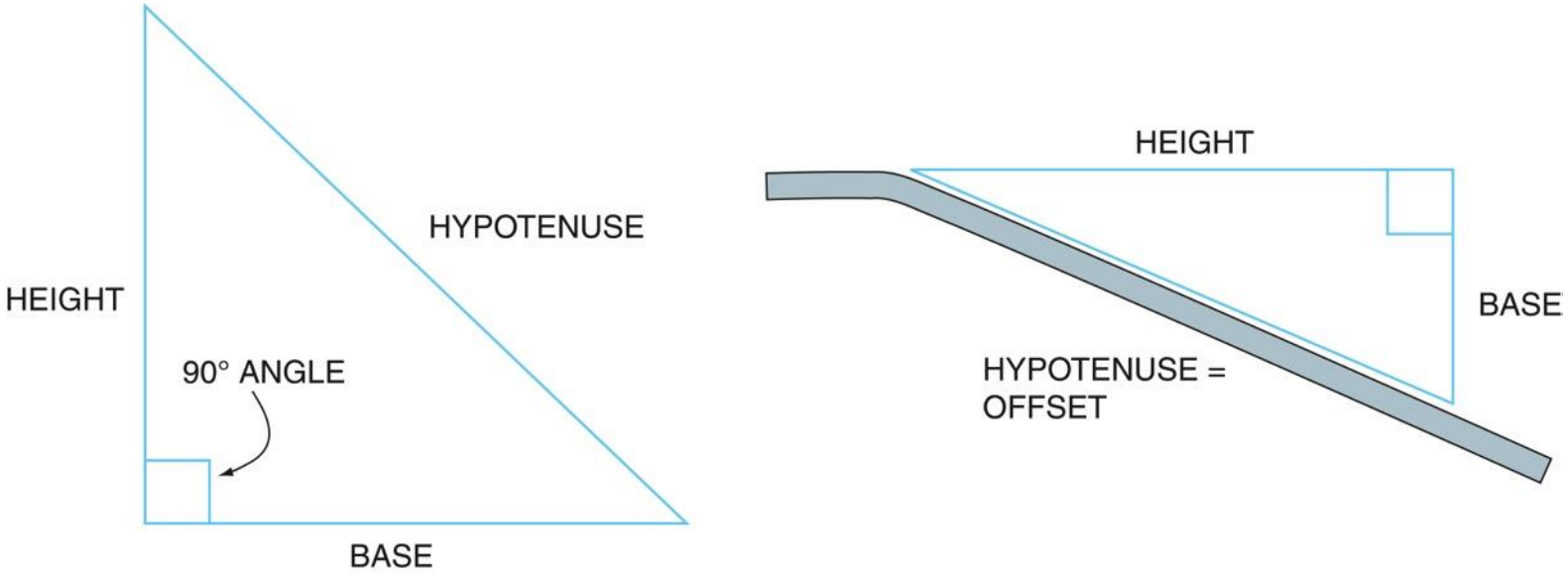
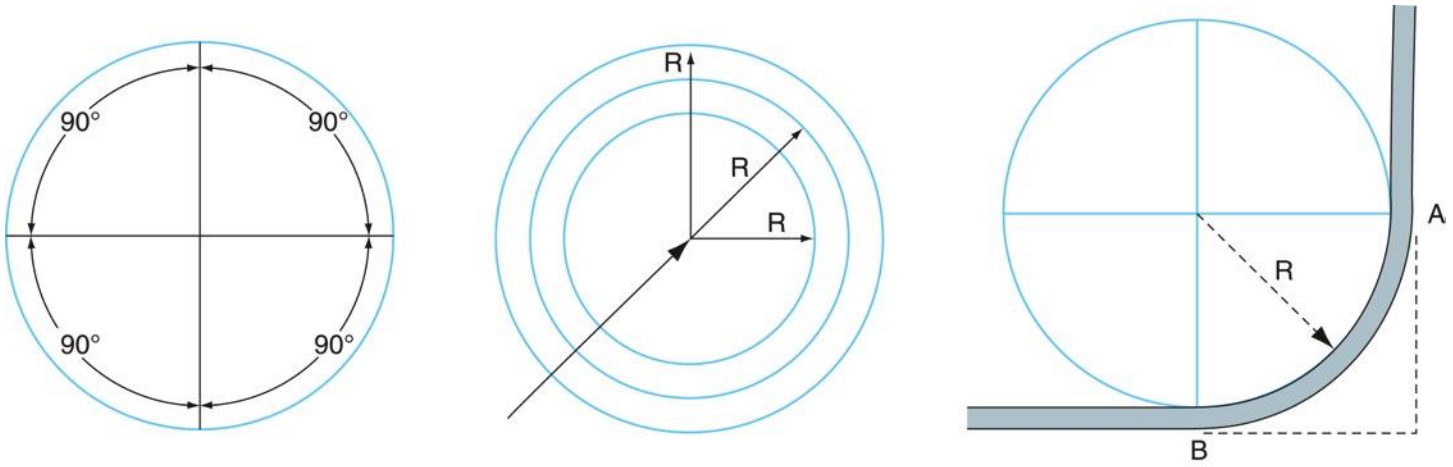
Geometry Required to Make a Bend

- The mathematics of right triangles can be applied to bends to find unknown values.
- In a bend, the offset forms the hypotenuse of the right triangle.



Circles and 90° Bends

- A 90° bend is ¼ of a circle.
- Concentric bends are made to 90° but each has a different radius so that they fit within one another.
- To calculate the circumference of a circle, multiply pi times the diameter (πD), or multiply two times pi times the radius (2πR).



Making a 90° Bend

- To make a bend, you must know the stub-up length and the take-up distance of the bender.
- The take-up is the amount of conduit that will be used to form the bend and is listed in the manufacturer's instructions for the bender.

Table 1 Typical Bender Take-Up Distances

EMT	Rigid/IMC	Take-Up
½"	—	5"
¾"	½"	6"
1"	¾"	8"
1¼"	1"	11"

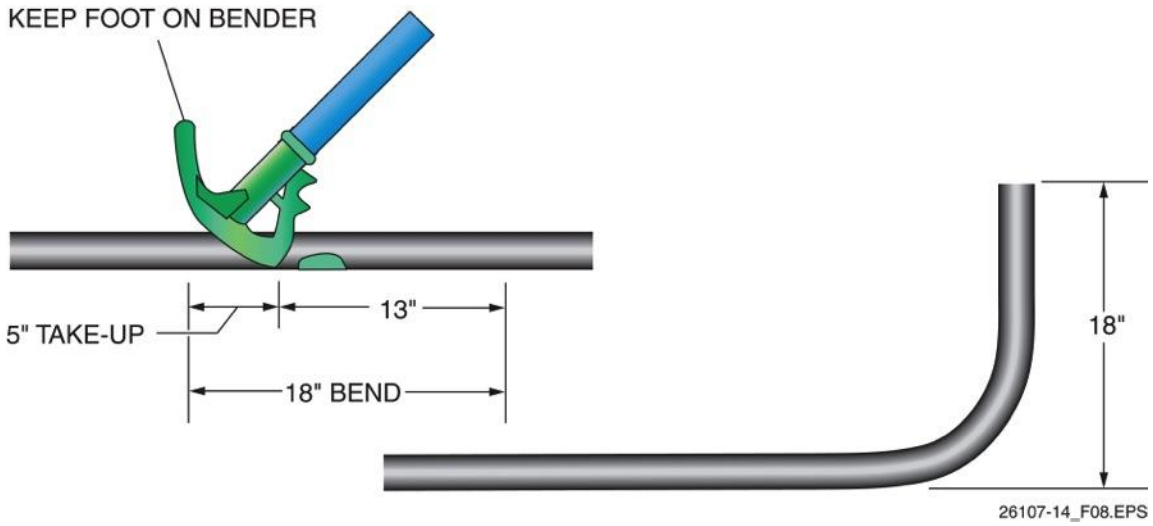
Performance Task

Make a 90° Bend

Have the trainees demonstrate how to make a 90° bend.

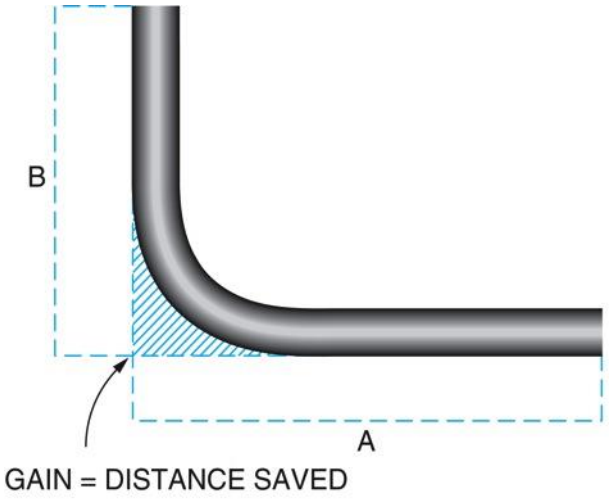
Bending an 18-inch Stub-Up

- To make a 90˚ stub-up, subtract the bender take-up from the stub-up height. Mark that distance on the conduit and line it up with the starting point on the bender.
- Hold the conduit with one foot and press the foot pedal with the other. Keep the bender perpendicular and bend in a single smooth motion.
- After making a bend, check it for accuracy using a level or square.



Gain

- Gain is the distance saved by the arc of a 90˚ bend. It is important to know the gain before cutting and threading conduit.
- The developed length of 90˚ bend can be found by adding the lengths of both sides and subtracting the gain.



Conduit Size	NEC® Radius	90° Gain
½"	4"	2⅝"
¾"	5"	3¼"
1"	6"	4"
1¼"	8"	5⅝"

TYPICAL GAIN TABLE

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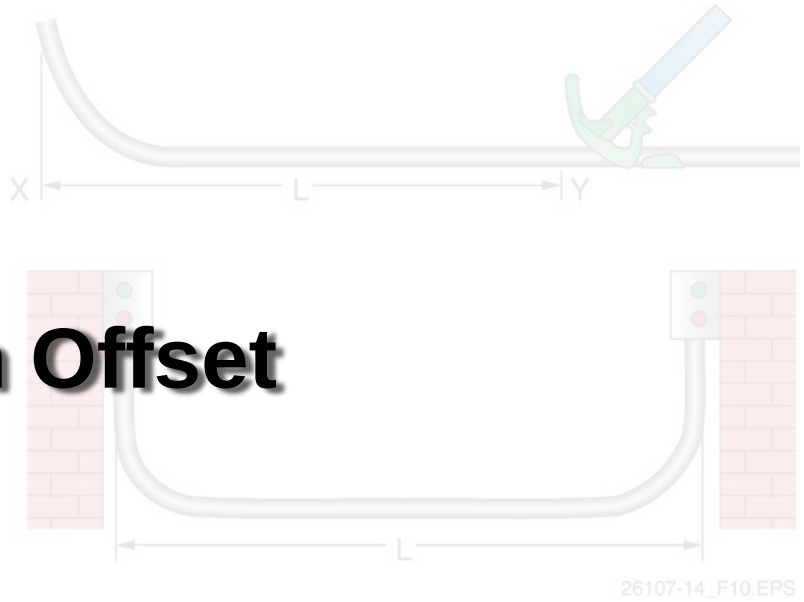
Next Session…

Making an Offset

- To make a back-to-back bend, make the first bend as usual, then measure the required distance between bends from the back of the first bend. Mark it on the conduit.
- Place the bender's back-to-back indicator mark at this point and bend up.



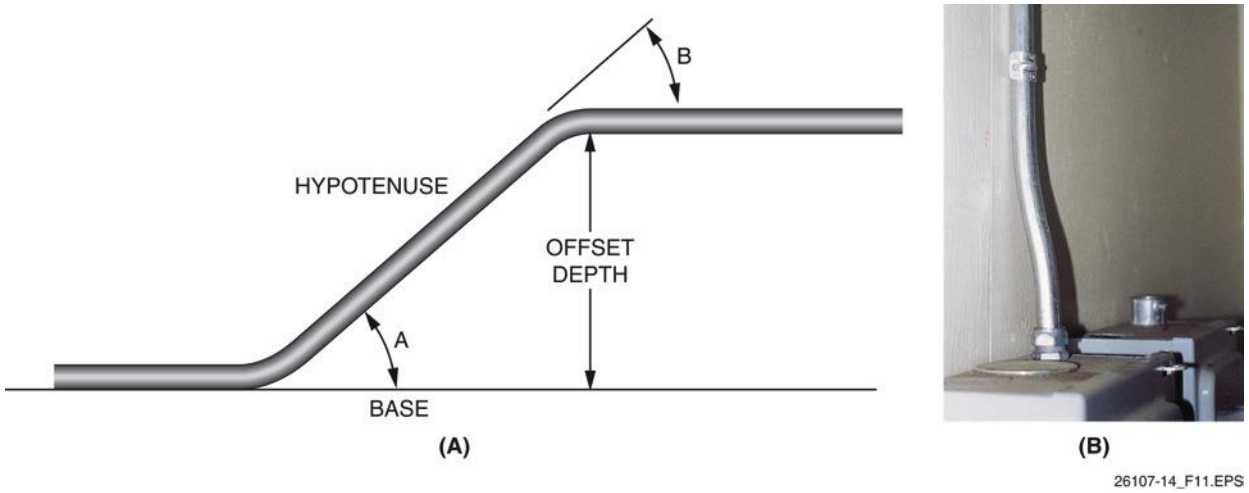
Performance Task

Make Back-to-Back Bends

This session will conclude with trainees making back-to-back bends.

Making an Offset

- An offset consists of two equal bends of less than 90° each and is used to route conduit over other objects.
- To avoid a difficult wire pull, use a shallow offset angle whenever possible.
- The distance between bends is equal to the depth of the offset times a multiplier.



Shrinkage Calculation

- Offset angle multipliers represent the cosecant of the related offset angle (rounded).
- The shrinkage must be multiplied by the height of the rise and subtracted from the developed length.

Table 2 Shrinkage Calculation

Offset Angle	Multiplier	Shrinkage (per inch of rise)
10° × 10°	6.0	1/16"
22½° × 22½°	2.6	3/16"
30° × 30°	2.0	1/4"
45° × 45°	1.4	3/8"
60° × 60°	1.2	1/2"

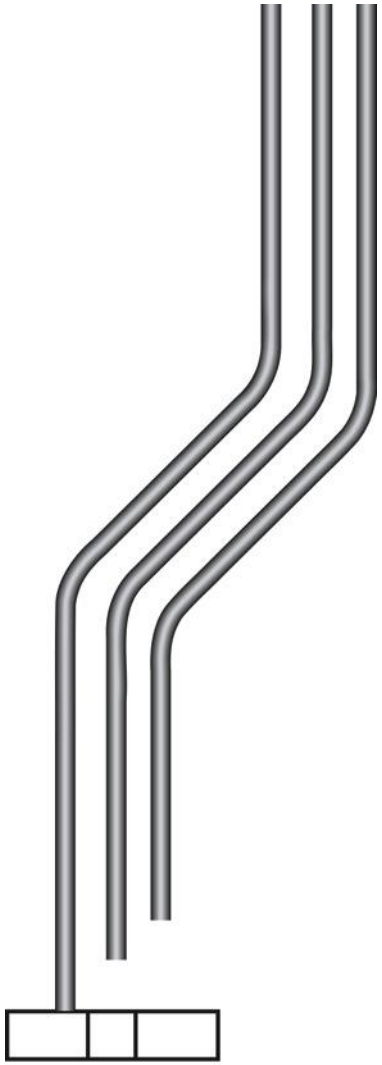
Common Offset Factors

Table 3 Common Offset Factors (in Inches)

Offset Depth	22½°		30°		45°		60°	
	Between Bends	Shrinkage	Between Bends	Shrinkage	Between Bends	Shrinkage	Between Bends	Shrinkage
2	5¼	⅜	—	—	—	—	—	—
3	7¾	9⁄16	6	¾	—	—	—	—
4	10½	¾	8	1	—	—	—	—
5	13	15⁄16	10	1¼	7	1⅞	—	—
6	15½	1⅛	12	1½	8½	2¼	7¼	3
7	18¼	1 5⁄16	14	1¾	9¾	2⅝	8⅜	3½
8	20¾	1½	16	2	11¼	3	9⅝	4
9	23½	1¾	18	2¼	12½	3⅜	10⅞	4½
10	26	1⅞	20	2½	14	3¾	12	5

Parallel Offsets

- The conduit length must be adjusted when making parallel offsets.
- The amount to be added is equal to the center-to-center spacing times the tangent of one-half the offset angle. Tangent values can be found in *Appendix A.*



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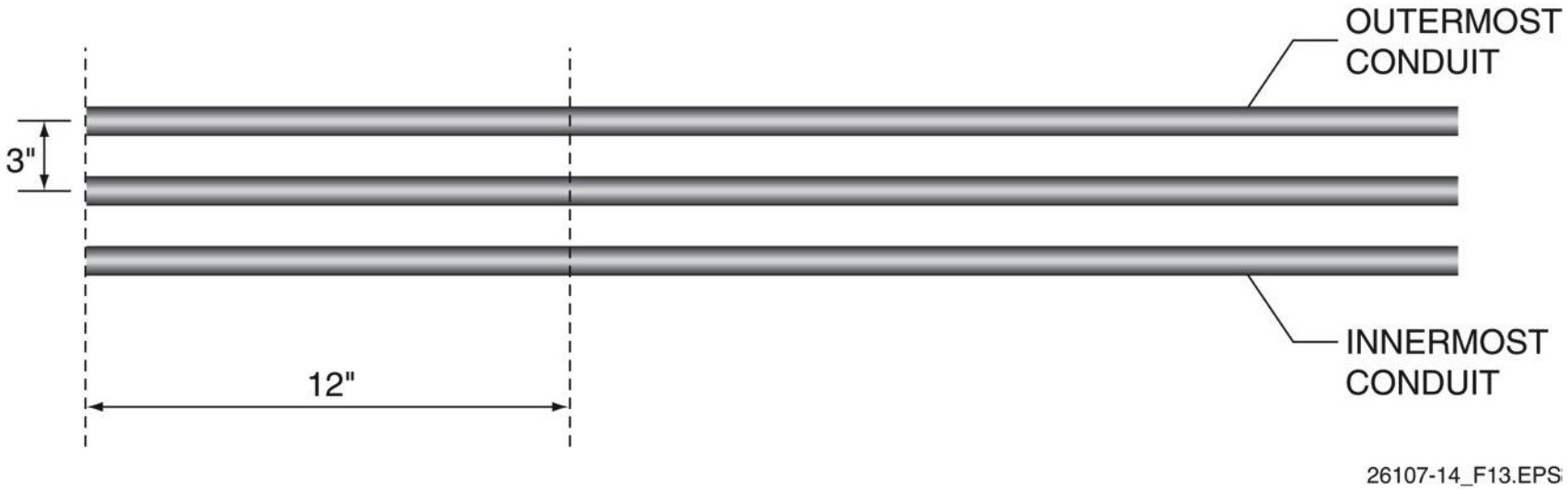
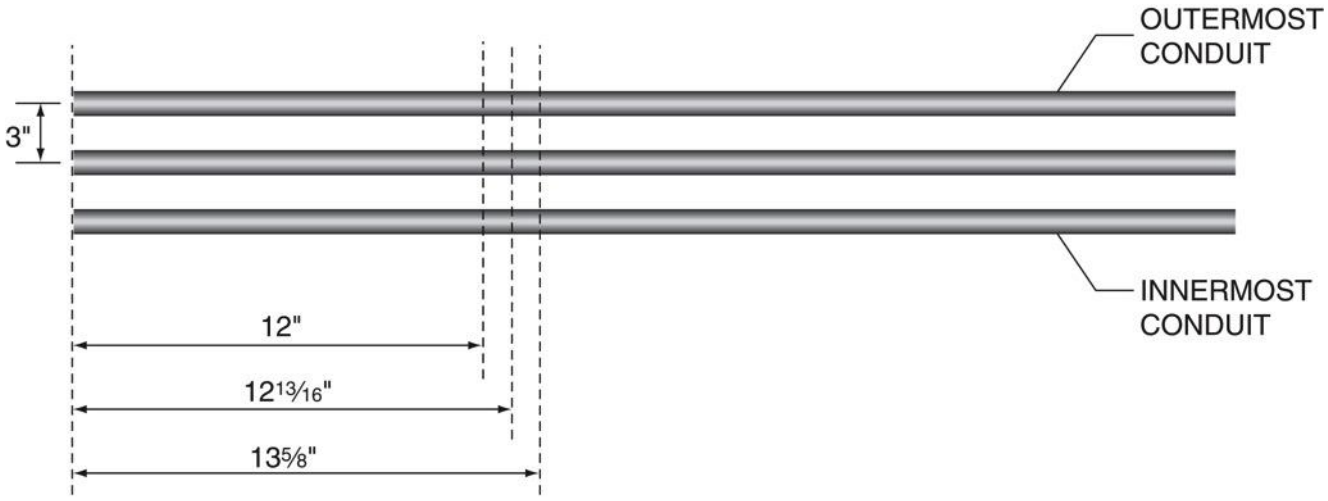
Center of First Bend

To create a parallel offset, first find the center of the first bend of the innermost conduit.



Successive Center Lines

- The starting point of the second conduit is found using the offset formula [12" + center-to-center spacing x TAN (½ offset angle)] and then added to the starting point measurement of the first pipe.
- This value is added again to find the starting point of the outermost pipe.



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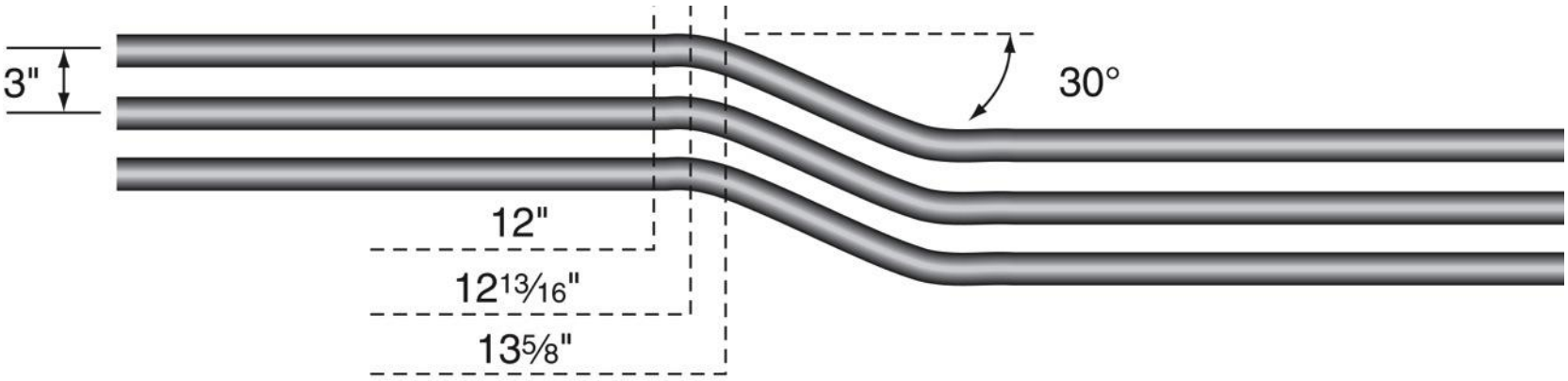
Parallel Offset Pipes



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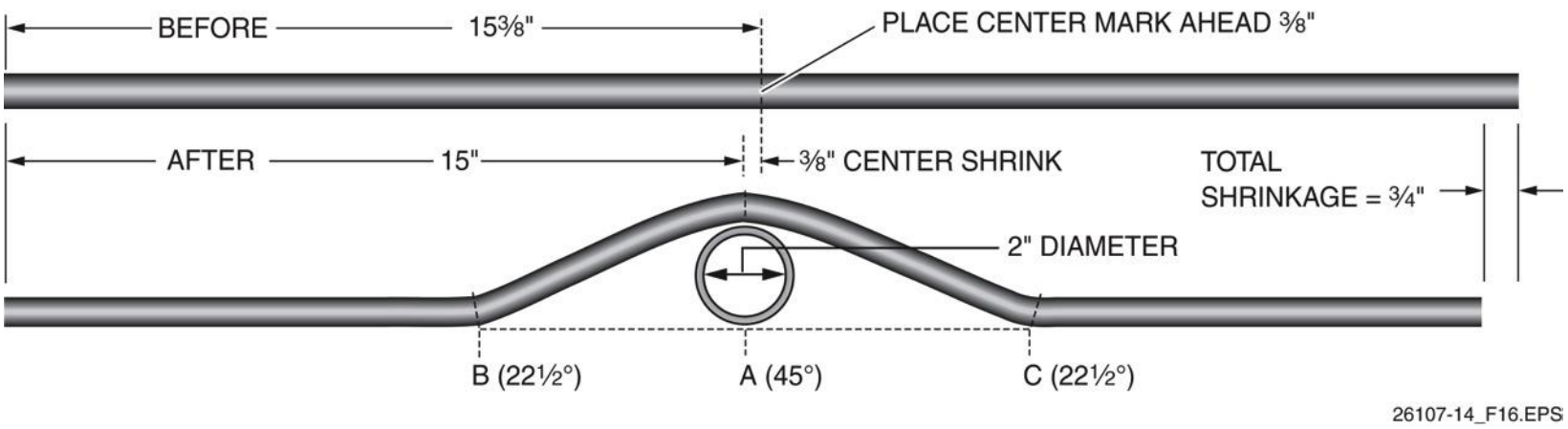
Performance Task

Make Offset Bends

Have the trainees demonstrate how to make offset bends.

Saddle Bends



- Saddle bends are used to route conduit around obstructions.
- Making a saddle bend will cause the conduit to shorten by a specified amount for every inch of saddle depth, depending on the size of the conduit.

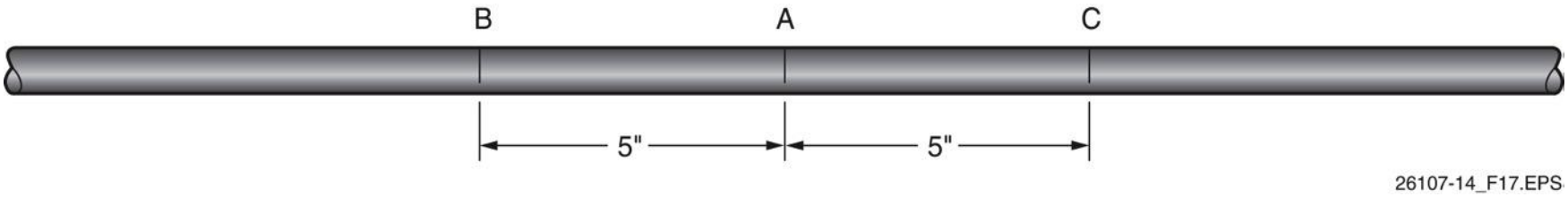
Shrinkage Chart for Saddle Bends

Table 4 Shrinkage Chart for Saddle Bends with a 45° Center Bend and Two 22 ½° Bends

Obstruction Depth	Shrinkage Amount (Move Center Mark Forward)	Make Outside Marks from New Center Mark
1	3/16"	2½"
2	3/8"	5"
3	9/16"	7½"
4	3/4"	10"
5	15/16"	12½"
6	1⅛"	15"
For each additional inch, add	3/16"	2½"

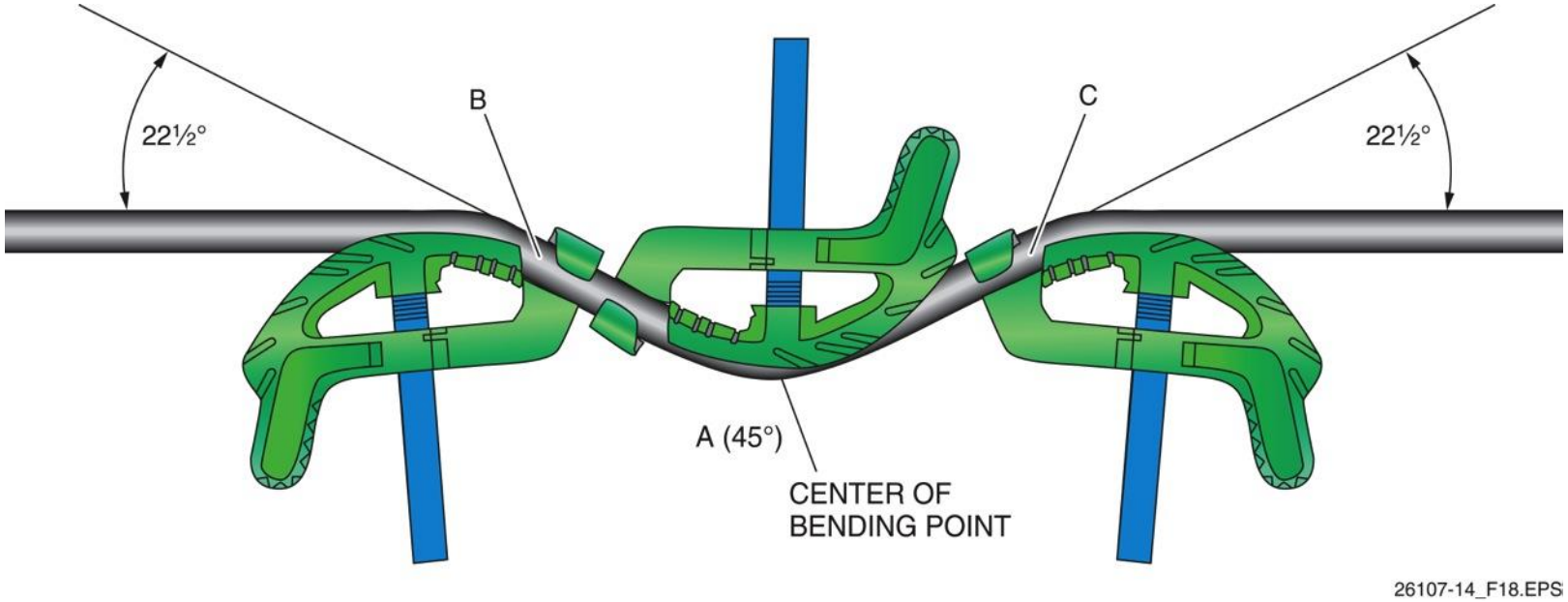
- The value from a shrinkage chart is added to the measurement from the end of the conduit to the centerline.
- This ensures that the bend will be centered over the obstruction.

Measurement Locations



Using the value for a two-inch obstruction found in the shrinkage chart, each bend is located 5" from the centerline.

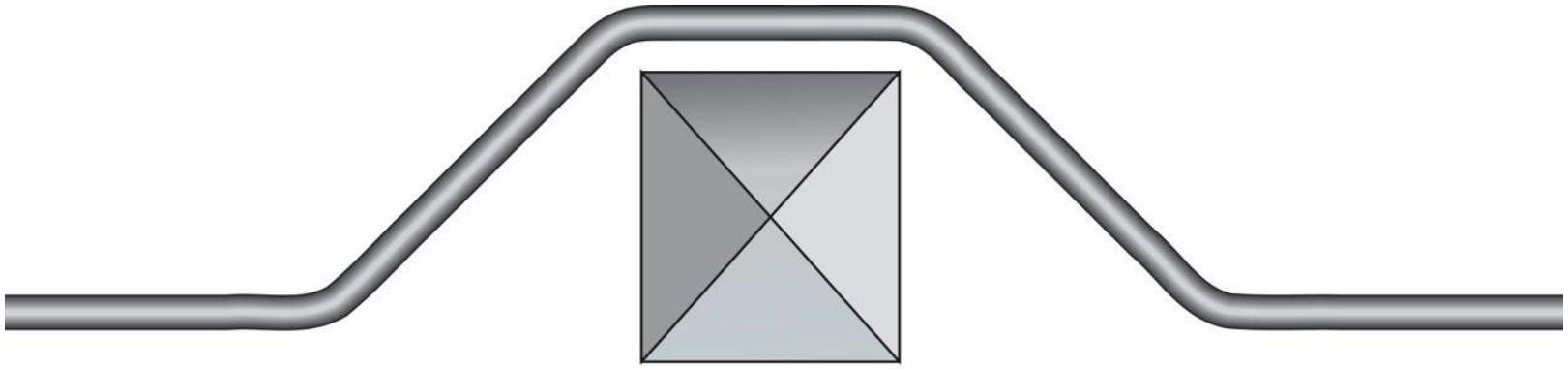
Location of Bends



This saddle contains one 45° and two 22½° bends. Note that the center mark is placed ahead to account for shrinkage.

Four-Bend Saddles

A four-bend saddle must be laid out carefully in order to avoid wasting conduit.



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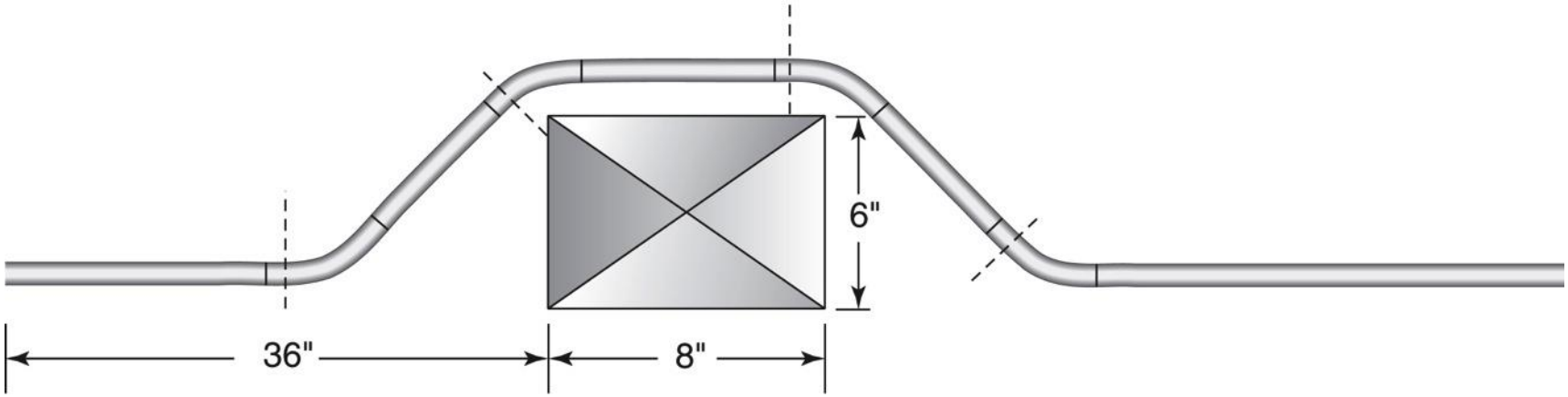
Four-Bend Saddle

A four-bend saddle is created using two offset bends.



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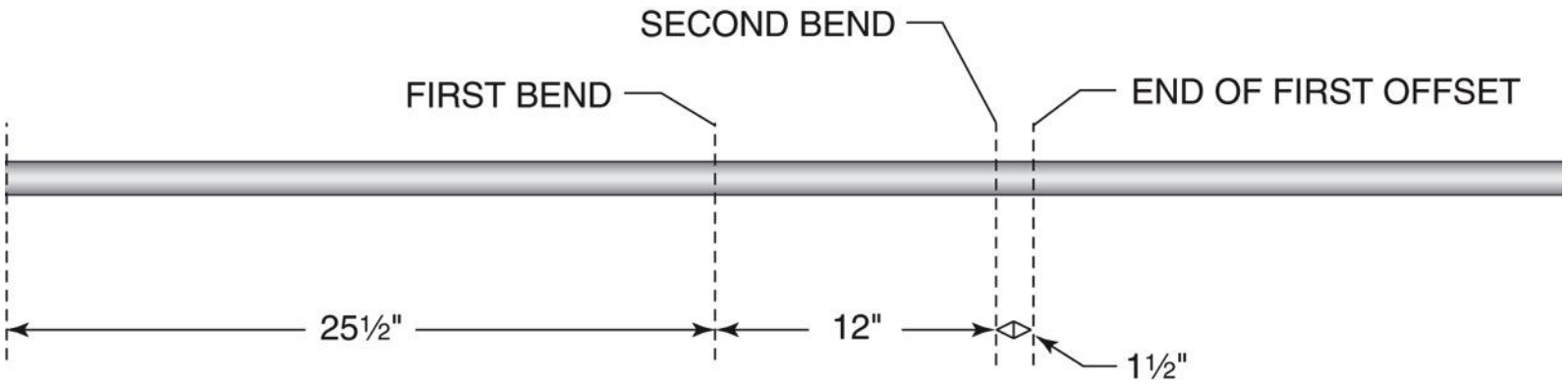
Four-Bend Saddle Measurements

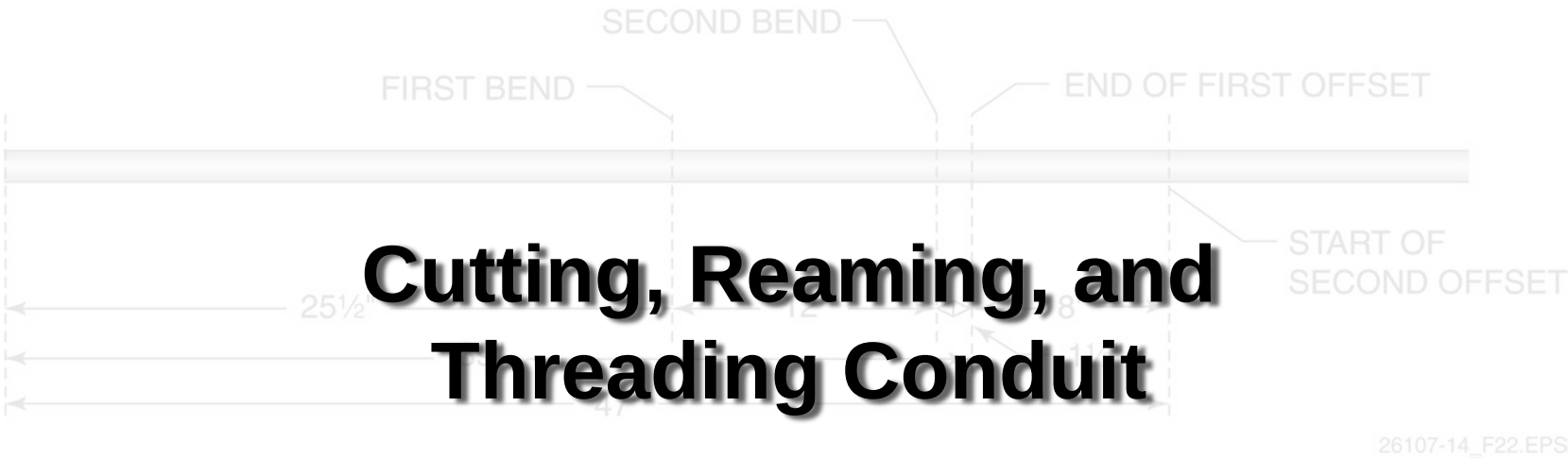
- To lay out a four-bend saddle, determine the height of the offset and the correct spacing, then bend the first offset.
- Mark the starting point for the second offset and bend the offset. Remember to use the multiplier for the offset angle and account for shrinkage.



Next Session…

Cutting, Reaming, and Threading Conduit

Second Offset Measurements

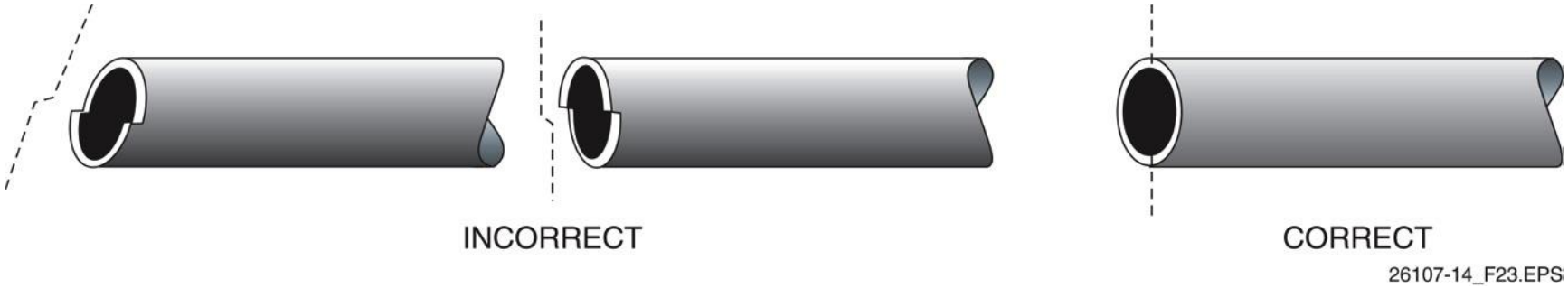


Performance Task

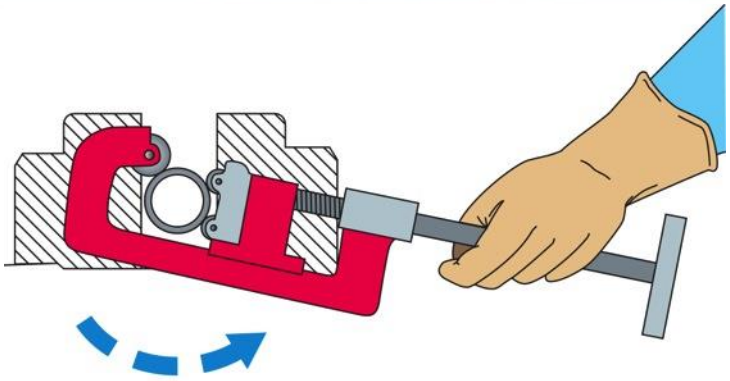
Make Saddle Bends

Have the trainees demonstrate how to make saddle bends.

Cutting, Reaming, and Threading Conduit



- RMC, IMC, and EMT are sold in 10' sections and normally cut to length using a hacksaw.
- Select the correct blade for the material being cut and make sure the cut is straight and smooth.



(A)

(B)

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Pipe Cutter Method

- Pipe cutters can be used on RMC and IMC.
- Turn the handle ¼ turn for each full turn around the conduit. Avoid overtightening.

Reaming Conduit

- After cutting, conduit must be reamed to remove any burrs or sharp edges.
- A file can be used when a reamer is not available.

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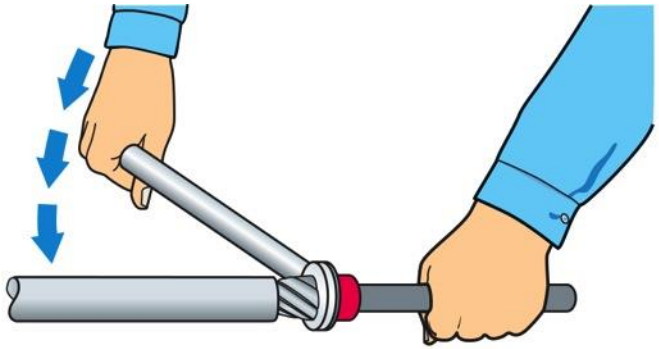
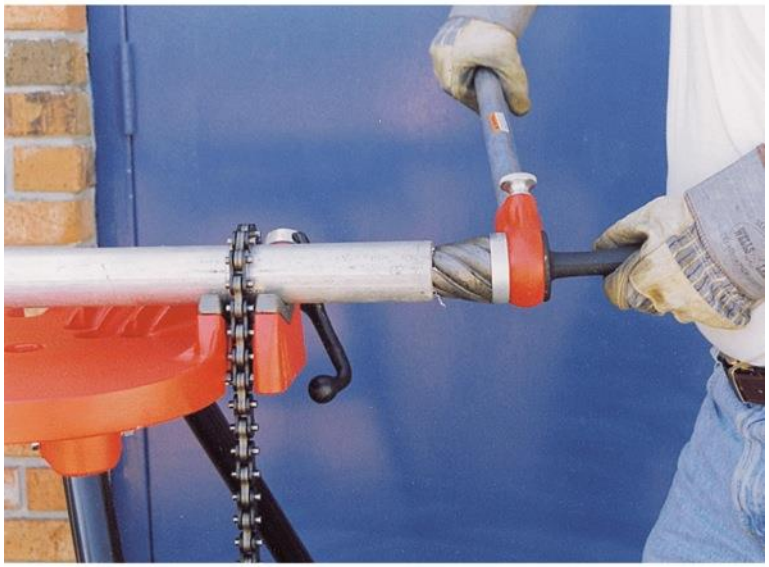


(A)



(B)

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Reamer Rotation

- Rotate a reamer in a downward motion.
- Remove the reamer by pulling back while continuing to rotate it.

Threading Conduit; Cutting and Joining PVC Conduit

- RMC and IMC can be threaded to accept threaded fittings.
- Ratchet threaders are available that produce from 8 to 18 threads per inch.
- PVC can be cut with a hacksaw and deburred with a pocket knife before joining with PVC cement.

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Performance Task

Cut, Ream, and Thread Conduit

This session will conclude with trainees cutting, reaming, and threading conduit.

Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

Next Session…

MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.