

Lesson A3-17

Working with Copper Tubing

Unit A. Mechanical Systems and Technology

Problem Area 3. Construction Systems

Lesson 17. Working with Copper Tubing

New Mexico Content Standard:

Pathway Strand: Power, Structural and Technical Systems

Standard: VIII: Plan, implement, manage, and/or provide support services to facility design and construction; equipment design, manufacture, repair, and service; and agricultural technology.

Benchmark: VIII-B: Follow architectural and mechanical plans to construct building and facilities.

Performance Standard: 1. Identify and select appropriate building materials. 3. Construct with wood and metal.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Discuss how to select copper tubing and fittings.
2. Discuss how to measure, mark, cut, and ream copper tubing.
3. Discuss how to join copper tubing with solder, flare fittings, and compression fittings.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the lesson:

Black & Decker. *The Complete Guide to Home Plumbing*. Minnetonka, Minnesota: Creative Publishing, 1998.

Burkybile, Carl. *Designing, Installing, Maintaining, and Repairing Plumbing Systems*. University of Illinois: Information Technology & Communication Systems (U3056).

Herren, Ray V., and Elmer L. Cooper. *Agricultural Mechanics Fundamentals & Applications*. Albany, New York: Delmar Publishers, 2002. (Textbook, Chapter 35)

Hogan, Elizabeth L. *Basic Plumbing Illustrated*. Menlo Park, California: Sunset Publishing Corp., 1992.

Hometime Video. *Plumbing*. Sponsored by Chevrolet Trucks.

Phipps, Lloyd J., et al. *Introduction to Agricultural Mechanics*, Second Edition. Upper Saddle River, New Jersey: Prentice Hall Interstate, 2004. (Textbook, Chapter 16)

Other Resources. The following resources will be useful to students and teachers:

Burke, Stanley R., and T.J. Wakeman. *Modern Agricultural Mechanics*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 16)

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of student lab sheet
Copper tubing, fittings, and tools

Terms. The following terms are presented in this lesson (shown in bold italics):

Compression fittings
Compression screw
Die block
Flared fitting
Flaring tool
Flexible (soft) tubing
Rigid (hard) tubing
Sweat fitting

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Show students copper tubing, the various fittings, a soldered joint, a flared joint, and a compression joint. Tell students that with this lesson they will learn how to select fittings and join copper tubing for supply lines.

Summary of Content and Teaching Strategies

Objective I: Discuss how to select copper tubing and fittings.

Anticipated Problem: What copper tubing and fittings do I need?

- I. Copper tubing is only used for water and fuel lines. It is sturdy, durable, light-weight, and easy to work with.
 - A. Copper tubing is sold as rigid (hard) or flexible (soft). Four grades or weight of tubing from the heaviest to the lightest are: K, L, M, and DWV. Type M is the weight of tubing recommended for most supply line situations.
 - B. Tubing is sized by inside diameter (I.D.) or outside diameter (O.D.). **Rigid (hard) tubing**, sold in 10 foot lengths, is a stiff, strong tubing joined with soldered joints. **Flexible (soft) tubing**, available in $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ inch diameter rolls 60 foot long, is thinner, softer, cheaper, and easier to bend.
 - C. Both types of tubing can be joined by soldering. **Sweat fitting** copper tubing refers to soldering fittings onto the tubing. **Flared fittings** are a technique used to joint soft tubing where the end of the tubing is spread out or flared and a flare nut is tightened against a threaded flared fitting. **Compression fittings**, used on small flexible lines for appliances, have a compression ring and threaded nut to seal joints.
 - D. Soldered fittings include couplings, elbows (45 and 90 degree), tees, caps, reducers, and unions (see description in Lesson A3–16). Flare fittings include flare nuts, caps, elbows, tees, plugs, and unions. Compression fittings involving the nut and compression ring are most often tightened onto a union, a fixture, or a shutoff valve.

Utilize the recommended textbooks to help students in comprehending these topics. They contain detailed information on the content of this objective. Use TM: A3–17A to present the advantages of copper tubing versus other types of pipe. Bring samples of copper fittings to class and have students identify them.

Objective 2: Discuss how to measure, mark, cut, and ream copper tubing.

Anticipated Problem: How is copper tubing measured, marked, cut, and reamed?

- II. Measuring, marking, cutting, and reaming copper tubing are easy skills to master.
 - A. When measuring tubing, be sure to allow for the segment of the pipe that goes into the fittings. Flexible tubing should be unrolled and straightened out for accurate measuring. Mark the tubing with a three-cornered file or scratch awl.
 - B. Copper tubing is cut with a hacksaw or a tubing cutter. The hacksaw has a tendency to bend the tubing and leave a rough cut. To use a copper tubing cutter, place the tubing between the cutting wheel and the two guide rollers and tighten the cutter a little each time you circle the tubing. It is easier to use and results in a squarer, smoother cut than a hacksaw.
 - C. The disadvantage of using the tubing cutter is that a burr is left on the inside of a tubing cut. Use the reamer attached to the tubing cutter or a round file to ream the burr out of the tubing.

Refer students to assigned readings in the recommended resources texts. They contain basic information on these topics that will be helpful in understanding the objective. Demonstrate measuring, marking, cutting, and reaming copper tubing. If this is not possible, use TM: A3-17B to illustrate the use of a tubing cutter. Have the students perform these tasks and gain these skills.

Objective 3: Discuss how to join copper tubing with solder, flare fittings, and compression fittings.

Anticipated Problem: How is copper tubing joined?

- III. The best technique for joining copper tubing depends on the type of tubing used, rigid or flexible, and the location of the tubing (supply line, hooking up a fixture, hooking up an ice maker refrigerator, etc.).
 - A. Both rigid and flexible copper tubing may be joined to fittings by soldering. Begin by using fine steel wool, emery cloth, or a tubing cleaner to clean and brighten the outside of the tubing and the inside of the fitting. Coat the end of the tubing and the inside of the fitting with a layer of flux. Rotate the tubing slightly to spread the flux evenly in the fitting as it is pushed tightly onto the tubing. Apply heat, with a propane or air-acetylene torch, evenly around the joint until the flux begins to sizzle. Every few seconds test the heat of the joint by touching the solder to it. When the right temperature is reached the solder will melt and be drawn into the joint by capillary action. Care should be taken not to melt the solder with the torch and merely drop it on the copper tubing. Watertight joints can only be achieved by solder being drawn into a clean and properly heated joint. Finish the joint by wiping off excess solder with steel wool while the joint is still warm.
 - B. To join soft tubing with a flared fitting, slip the flare nut onto the tubing and then flare the tubing. A **flaring tool** includes a split die block and compression screw with a T-

handle to tighten it. The **die block** is a split metal clamp with holes to match the common sizes of tubing. Insert the tubing into the die block with the end extending slightly above the surface of the beveled side and tighten the thumb screws. The **compression screw** hooked onto the die block uses a cone-shaped end on a threaded shaft, tightened with a T-handle to flare out at a 45 degree angle at the end of the tubing. The flared end is placed next to a threaded flare fitting and the flare nut is slid up and hand tightened to the fitting. After hand tightening, use one open-end wrench for holding the fitting and another for turning the flare nut. The compressing of the flared tubing against the fitting provides a tight seal. This technique is recommended for use with gas lines. To join tubing with a compression fitting, slide the compression nut and then the compression ring onto the tubing. Using an open-end wrench, tighten the compression nut to the threaded compression fitting. This technique is often used to fasten supply lines to shut-off valves.

Assign readings in the recommended resource texts to help students in comprehending these topics. Learn to identify copper tubing tools. Use TM: A3–17C and TM: A3–17D to illustrate joining copper tubing. Use the Plumbing video to show soldering copper tubing. Demonstrate soldering and flaring copper tubing. Have students perform the tasks and develop the skills in joining copper tubing (LS: A3–17A).

Review/Summary. Use the transparencies to review the types of copper tubing, types of fittings, and the use of tools to measure, mark, cut, ream, and join tubing. Compare rigid and flexible tubing. Compare the use of soldered, flared, and compression joints.

Application. Use LS: A3–17A to measure, mark, cut, ream, and join (soldered and flared) copper tubing.

Evaluation. Take the written test and evaluation the skill demonstrated of the lab sheet.

Answers to Sample Test:

Part One: Matching

1 = a, 2 = b, 3 = c, 4 = g, 5 = f, 6 = e, 7 = h, 8 = d

Part Two: Completion

1. Rigid (or) Hard, flexible (or) soft
2. hacksaw
3. copper tubing cutter
4. Reaming
5. steel wool or tubing brush, flux
6. propane, air-acetylene
7. flexible or soft

8. steel wool
9. Flared
10. Compression

Part Three: Short Answer

Copper tubing is sturdy, durable, light weight, and easy to work with. Compression fittings take less time than soldering or flaring fittings.

Test

Lesson A3–17: Working with Copper Tubing

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

- | | |
|-------------------------|---------------------------|
| a. compression fittings | e. flaring tool |
| b. compression screw | f. flexible (soft) tubing |
| c. die block | g. rigid (hard) tubing |
| d. flared fitting | h. sweat fitting |

- _____ 1. Fitting that uses a ring and pressure to make the water seal.
- _____ 2. Hooked onto the die block and uses a cone shaped end on a threaded shaft with a T-handle.
- _____ 3. A split metal block with holes to match the common sizes of tubing.
- _____ 4. Copper tubing that can only be joined with soldered joints.
- _____ 5. Copper tubing that can be joined with soldered joints, flared joints, or compression joints.
- _____ 6. Compression screw and the die block as a set.
- _____ 7. Uses solder to form a joint with copper tubing and a fitting.
- _____ 8. Uses a beveled tubing end with a tightened fitting to make the seal.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. _____ or _____ copper tubing comes in 10' lengths while _____ or _____ copper tubing comes in 60 foot rolls.
2. Cutting copper tubing with a _____ tends to bend the tubing and leave a rough cut.
3. Cutting copper tubing with a _____ results in a smooth, square cut but leaves a burr inside.
4. _____ is the process of removing the burr inside of cut copper tubing.
5. When sweat fitting copper tubing, clean the outside of the tubing and inside of the fitting with _____. Apply a coat of paste _____.

6. Heat the fitting joint to be soldered with a _____ or _____ torch.
7. Flared fittings can only be used with _____ copper tubing.
8. Clean off excess solder by wiping the joint with _____.
9. _____ fittings are most often used for gas lines.
10. _____ fittings are often used to fasten supply fixture supply lines to shutoff valves.

Part Three: Short Answer

Instructions. Provide information to answer the following questions.

1. What advantages does copper tubing offer for plumbing?

2. What advantage do compression fittings have over soldered and flared fittings?

ADVANTAGES/ DISADVANTAGES OF PIPE MATERIALS

Material	Advantages/Disadvantages
Copper: Pipe	Easy to assemble; susceptible to freeze damage
Tubing	Requires fewer fittings than pipe; more expensive than pipe
Galvanized Steel	Strong; high cost; corroded by soft (acidic) water; susceptible to scale; resists rust
Plastics: CPVC	Lightweight; use with hot water; joined by cement; more expensive than PVC
PVC	Low cost; lightweight; joined by cement; cold water only

TM: A3-17B

USING A TUBING CUTTER TO CUT RIGID COPPER



(Courtesy, Interstate Publishers, Inc.)

After each rotation of the cutter, the cutting wheels are tightened by turning the handle at left.

SOLDERING COPPER TUBING JOINTS



Clean with emery cloth, wire brush, or steel wool.



Apply flux to the outside of the pipe/tubing and inside of the fitting.



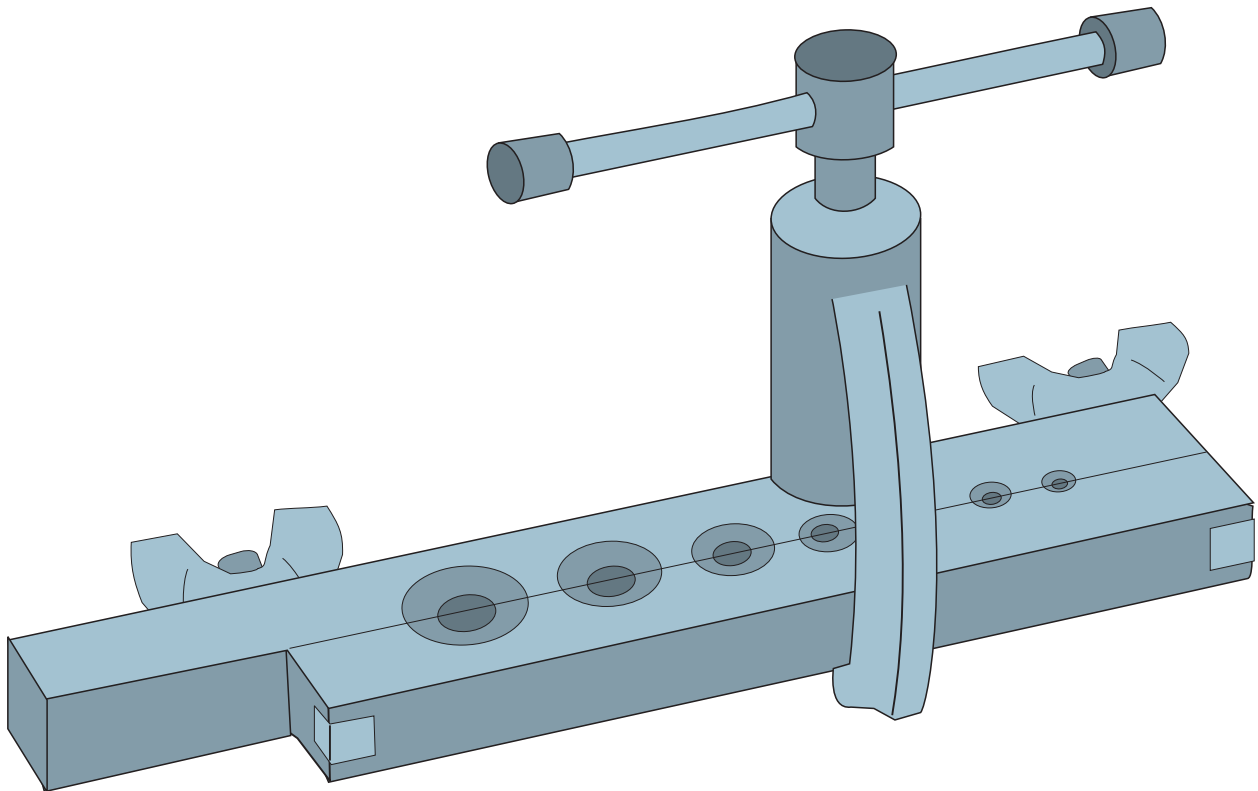
Fit the two pieces firmly together.



Touch the solder to the pipe/tubing where it joins the fitting. The heating action will pull the molten solder into the joint.

(Courtesy, Interstate Publishers, Inc.)

FLARING TOOL



(Courtesy, Interstate Publishers, Inc.)

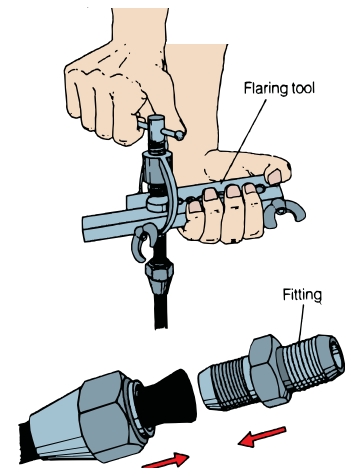
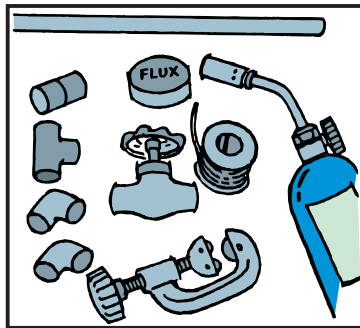
**A flaring tool is used to flare
the ends of soft copper tubing.**

Lab Sheet

Measuring, Marking, Cutting, Reaming, and Joining Copper Tubing

Materials:

- $\frac{3}{8}$ inch flexible copper tubing
- $\frac{1}{8}$ inch copper coupling
- $\frac{1}{8}$ inch flare nut
- $\frac{1}{8}$ inch flare union
- Fine steel wool
- Solder
- Flux and flux brush



Tools:

- Copper tubing cutter with reamer
- Propane torch
- 2 open end wrenches or adjustable wrenches

Check as completed:

- _____ 1. Unroll enough copper tubing to measure 6 inches of tubing.
- _____ 2. Mark the tubing with a scratch awl or three-cornered file.
- _____ 3. Use the tubing cutter to cut the tubing.
- _____ 4. Ream the cut end of the tubing.
- _____ 5. Use the steel wool to clean the outside of one end of the tubing and the inside of the coupling.
- _____ 6. Use the flux brush to coat the outside of the cleaned tubing end and the inside of the coupling.
- _____ 7. Insert the tubing into the coupling.
- _____ 8. Secure the tubing in a vise being careful not to tighten the vise enough to bend the tubing.
- _____ 9. Heat the tubing and fitting with a propane torch.
- _____ 10. When the flux begins to sizzle, test the heat by touching the solder to the joint.
- _____ 11. Continue heating until the heated copper melts the solder and it is pulled into the joint by capillary action.

- _____ 12. Shut off the torch and clean the excess solder off with steel wool
- _____ 13. Slide the flare nut onto the other end of the copper tubing
- _____ 14. Insert the end of the tubing into the die block, tighten, position the compression screw, and tighten the T-handle flaring a 45 degree angle on the end of the tubing
- _____ 15. Tighten the flare nut onto the flare union.