**Soldering**

**Description**

Students will prepare copper pipe and fittings for soldering. Students will then solder and pressure test the system.

## Lesson Outcomes

The student will be able to:

* Prepare copper pipe and fittings for assembly
* Solder copper pipe and fittings
* Test soldered joints
* Disassemble copper fittings

## Assumptions

* The teacher should be aware of potential dangers involved in soldering, and safety should be a primary concern.
* Students should be familiar with tools and procedures.
* Students should wear eye protection and be aware of the danger of getting burned.
* Adequate ventilation or working outside will reduce exposure to fumes.
* Fire extinguishers should be readily accessible.

## Terminology

**Fitting**: an object used to connect several pieces of piping material.

**Flux**: an acid paste material used to assist in the process of soldering copper pipe and fittings. It assists the solder to flow smoothly.

**Hose bib**: a globe valve that has been adapted for attaching a garden hose.

**Rough in**: the process of having plumbing systems installed, tested, and inspected before the building enters the finishing stage.

**Sand cloth**: an open-mesh sanding material used to clean copper pipe and fittings in preparation for soldering.

**Solder**: a metal alloy used to join metal objects without heating them to their melting point. The current industry standard is lead-free and tin-based.

**Soldering**: the process in which two or more metal pieces are joined together with a metal (alloy) having a lower melting temperate.

**Striker**: a friction device that uses a flint to light gas flame torches.



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License unless otherwise indicated.

## Estimated Time

2–6 hours

## Recommended Number of Students

Soldering is an individual activity but preparation for soldering could be done with a partner.

## Facilities

* + Shop setting with flat, stable working surface (student benches).
  + Access to a water hose connection is required for testing. Alternatively, a hydrostatic pump could be used.
  + A chain vise is highly recommended but not mandatory.

## Tools

* + Copper tubing cutters. Ridgid Model #10 or equivalent (Figure 1)
  + Turbotorch X-5MC air/acetylene regulator or equivalent
  + Acetylene B tank. Propane or MAPP gas tanks may also be used (Figure 2).
  + Flint striker
  + 1/2" fitting brush (Figure 3)



**Figure 1—**Tubing cutters ensure a straight, square cut.



**Figure 2—**Acetylene B tank and regulator shown with a handle and accessory hook



**Figure 3—**A fitting brush is the best way to clean the inside of copper fittings.

## Materials

* Flux suitable for soldering copper
* Lead-free solder
* Open-mesh sand cloth
* ½" copper fittings (an assortment of 90° elbows, tees, caps, and hose connectors, depending on activity)
* ½" type L copper pipe (available in 12' lengths)
* Clean rags

## Resources

#### How copper pipe and fittings are made

https://[www.youtube.com/watch?v=uk8PLBAfmpM](http://www.youtube.com/watch?v=uk8PLBAfmpM)

#### How to cut various types of plumbing pipes

https://[www.thisoldhouse.com/how-to/how-to-cut-plumbing-pipes-and-tubing](http://www.thisoldhouse.com/how-to/how-to-cut-plumbing-pipes-and-tubing)

#### Tips and tricks for soldering

<http://www.youtube.com/watch?v=83K7yfzWGFo>

#### How to solder

<http://www.youtube.com/watch?v=doqoEJJOdYA>

**Demonstation**

Working with copper pipe and fittings is an exciting way for students to learn about the plumbing trade. The process of planning, constructing, and testing models the procedure found on job sites. In addition, the potential danger of working with torches can help students to understand the need for safety procedures.

## Assembly Demonstration

1. Cut the pipe to the given dimension using tubing cutters.
2. Ream both ends of the tube to allow maximum flow through the pipe.
3. Use the sand cloth to clean the outside of the copper pipe for a distance of approximately 2" (Figure 4).
4. Use a fitting brush to clean the inside shoulder of the fitting (Figure 5).



**Figure 4—**Polishing the outside of the pipe ensures good bonding between the pipe and solder.



**Figure 5—**Polishing the inside of a fitting with a fitting brush. An alternate solution is to use sand cloth and a pinky finger.

1. Apply a thin layer of flux on the outside of the pipe and the inside of the fitting (Figure 6).



**Figure 6—**Flux will allow the solder to freely flow around the pipe.

1. Insert the pipe into the fitting and rotate 90°.
2. Making sure to point the tip of the torch away from the user, open the valve on the handle one-half turn.
3. Use the striker to ignite the flame.
4. Point the tip of the blue flame onto the centre of the fitting.
5. When the flux begins to bubble, touch the tip of the solder to the joint area between the pipe and the fitting.



**Figure 7—**Heat should be applied at the centre of the fitting to draw the solder into the shoulder.

1. If the solder does not melt, continue to heat the shoulder of the fitting.
2. If the solder does melt, pull the torch tip away from the fitting and allow the solder to run into the fitting.
3. Continue to alternate application of heat and solder until a continuous bead of solder is visible around the circumference of the pipe.
4. Solder the other shoulders of the fitting using the method above.
5. Excess solder will gather at the bottom of the fitting and form a “grape.” The tip of the solder or a rag can be used to remove the grapes. Additional heat may need to be applied.
6. When all fittings are soldered, turn the torch handle valve fully off (clockwise).
7. Allow the fittings to cool, then remove the excess flux with a clean rag.
8. Excess flux must be completely removed from piping. Its acidic nature will colour the copper green, as corrosion occurs within hours of soldering.

## Disassembly Demonstration

Removing copper fittings from pipe is a technique that can be frustrating to novice students. Although the procedure for lighting the torch is the same as for assembling copper fittings, the technique for disassembly requires patience. Some tips for removing fittings are:

* All water must be drained from the piping system. Any water will cool the copper enough that the solder will not melt.
* At least one end of the system must be open to atmospheric pressure. An enclosed system will tend to create a situation in which the solder will not melt.
* When removing fittings, water pump pliers must be placed in the corner of the fitting (Figure 8). Students tend to grab the shoulder of the fitting, ovalling the fitting and crimping it into place.
* Adding flux or solder may assist the solder to become more free-flowing.
* Pulling a fitting off pipe is more a matter of technique than of brute strength. Short tugs in the lateral direction will prove more successful than strong rotational pulls.
* Students should be aware that the removed fittings will be hot. They should be placed carefully on a table or into a bucket of water.



**Figure 8—**Copper fittings should be grasped at the corner so they don’t bind on the pipe.

# Activity 1: Solder an Enclosed Loop and Then Pressure Test

### B

A

**Figure 9—**Copper loop. Adapter is soldered on for pressure test.

Have students construct the copper loop. Provide students with centre-to-centre dimensions for A and B.

**Procedure**

1. Cut the pipe using the tubing cutters.
2. Clean the pipe and fittings.
3. Flux the outside of the pipe and the inside of the fittings.
4. Solder the pipe **following all safety procedures**!
5. Clean excess flux.
6. Visually inspect all joints.
7. Pressure test the loop.

## Teacher Notes

* Teacher management of torches will ensure their safe usage. A good technique may be to designate an assembly area with fittings and pipe, and a soldering area with several

torches. Torches should be secured in an upright position or located where they cannot be tipped over. A bungee cord around a table leg and the tank is the simplest solution.

* The fumes generated from soldering can be problematic. If ventilation is not adequate, a fan could be set up to draw fumes away from students. Alternatively, tables or chain vises could be set up outside.
* The visual inspection of a soldered joint allows the student to reheat and re-solder a joint

if necessary before pressure testing. Once water is introduced as part of testing, soldering cannot be conducted: i.e., all water must be completely drained before soldering.

* Water piping is most easily pressure-tested by soldering a hose bib to the student project, then connecting it to a hose.

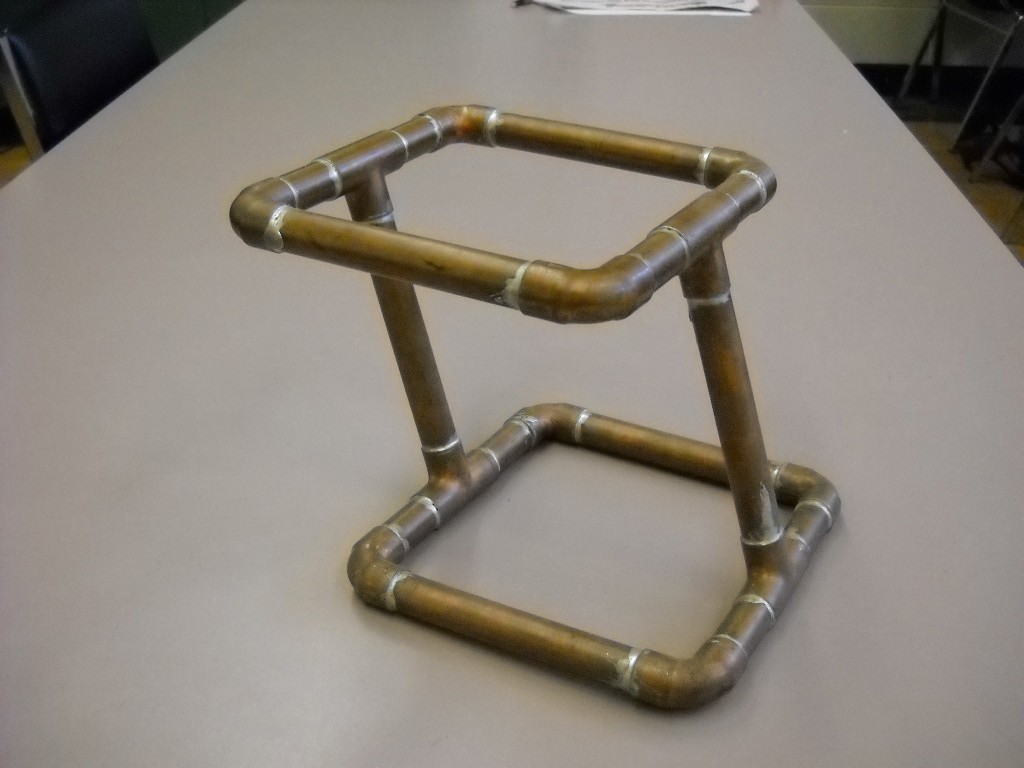
# Activity 2: Students Design and Create a Copper Sculpture

**Figure 10—**Copper sculpture

Using a maximum of 10 elbows and 6 tees, design a unique copper sculpture that will be soldered.

## Procedure

1. Draw an isometric of your sculpture in the given area.
2. Have your teacher approve the design.
3. Construct your sculpture!



**Figure 11—**Good soldering technique can be developed while allowing individual creativity.

# Activity 3: Integrated Activity

A copper rough-in could be integrated into a full bathroom rough-in that includes a drainage system and fixtures. Due to the high cost of copper pipe and fittings, an alternative to completing an entire copper system is to create copper outlets that could be connected to PEX piping (Figure 12).



**Figure 12—**An adapter can be used to connect the copper outlet pipe to a PEX piping system.

## Evaluation Guidelines

* Solder must be bright and smooth. Dull grey colour or a coarse finish indicates the solder was not completely melted.
* Excess flux removed.
* Ability to hold water.
* Piping is prepared to meet given dimensions.
* Tidy housekeeping.
* Student follows safety procedures.

## Related Discussion

#### Past practice of lead-based solder

Lead has been used to seal piping systems since the time of the Romans. Its use was greatly reduced (if not outright banned) in the 1980s when the detrimental effects of trace amounts of lead were studied.

#### Cost and ease of copper pipe systems versus PEX systems

PEX (or crimped) water lines can be installed without the use of flame torches. It is not uncommon to hear of a building damaged or destroyed by the careless use of a torch.

#### Production and environmental impact of piping production

Copper must be mined and has a significant environmental impact.