

## Lesson A5–4

---

# Applying Fuel Gas Welding (FGW) Processes and Techniques

---

**Unit A.** Mechanical Systems and Technology

**Problem Area 5.** Metal Fabrication

**Lesson 4.** Applying Fuel Gas Welding (FGW) Processes and Techniques

### **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: 3.** Construct with wood and metal.

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

1. Explain the fundamentals of fuel gas welding.
2. Explain how to select fuel gas welding equipment and supplies.
3. Describe how to set-up fuel gas welding equipment.
4. Explain how to operate fuel gas welding equipment.
5. Describe fuel gas welding techniques.
6. Identify safety practices that should be observed in fuel gas welding.

**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:

Burke, Stanley R., and T.J. Wakeman. *Modern Agricultural Mechanics*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 4)

Phipps, Lloyd J., and Carl L. Reynolds. *Mechanics in Agriculture*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 15)

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

*Oxyacetylene Welding and Cutting* (VAS 3001a). University of Illinois, Urbana, Illinois: ITCS Instructional Materials.

*Safety in the Shop* (VAS 3022a). University of Illinois, Urbana, Illinois: ITCS Instructional Materials.

## List of Equipment, Tools, Supplies, and Facilities

Writing surface  
Overhead projector  
Transparencies from attached masters  
Copies of student lab sheet  
Arc welder  
Fuel gas welding equipment and accessories  
Steel

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

Acetylene  
Blowpipe  
Carburizing flame  
Flashback  
Flash arrestors  
Neutral flame  
Oxidizing flame  
Oxygen  
Regulator

**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.

*Have an arc welder and fuel gas welder exhibited side by side. Ask students to determine the difference between them. Lead a discussion that the differences are not only physical in appearance, but also in the heat generated and processes that can be completed with each.*

## Summary of Content and Teaching Strategies

**Objective I:** Explain the fundamentals of fuel gas welding.

**Anticipated Problem:** What are the fundamentals of fuel gas welding?

- I. Oxyacetylene welding is a process by which two pieces of metal are joined together.
  - A. This process is built upon two fundamental principles.
    1. Acetylene burned with oxygen produces a flame so intensely hot that it can be used to melt and fuse metals.
    2. A stream of oxygen directed against a piece of iron or steel, which has been heated to its kindling temperature, causes the metal to burn away so that it can be used to cut or shape the metal as desired.
  - B. Each of the fuel gases have advantages and limitations.
    1. **Acetylene**,  $C_2H_2$ , is a fuel gas made of carbon and hydrogen, and is produced from the chemical reaction between calcium carbide and water.
      - a. Acetylene is colorless, but it has a distinct odor.
      - b. The acetylene flame produces a theoretical temperature of  $6300^{\circ}F$  and a measurable temperature of  $5800^{\circ}F$ .
      - c. Acetylene is stored in a free state under pressure greater than 15 psi. It can be made to break down by heat or shock and explode.
      - d. Under pressure of 29.4 psi, it becomes self-explosive and the slightest shock will set it off.
      - e. Acetylene, when dissolved in acetone, can be compressed into cylinders at pressures up to 250 psi.
      - f. The acetylene cylinder is filled with porous materials such as balsa wood, charcoal, shredded asbestos, organic pith, or Portland cement.
        - i. These materials are used to decrease the size of the open spaces in the cylinder.
        - ii. Acetone, a colorless, flammable liquid, is added until about 40 percent of the porous material is filled. The filler material acts as a sponge and absorbs the acetone, which in turn absorbs the acetylene.

- iii. The acetylene cylinder is equipped with safety plugs with a low-melting alloy center that melts at 212°F. Holes are too small to permit a flame to burn back into the cylinder, should the escaping acetylene become ignited.
  - g. One limitation to acetylene is the high cost of transporting the cylinders.
- 2. MAPP, methylacetylene propadiene, is a stabilized methylacetylene.
  - a. It combines the high energy characteristics of acetylene with the handling and storage features of liquefied petroleum gases.
  - b.  $C_3H_4$  has a flame temperature of 5300°F. The bushy flame makes welding difficult with MAPP gas.
  - c. Propane,  $C_3H_8$ , has a maximum flame temperature of 5300°F. The volume of oxygen required to develop the 5300°F produces an oxidizing flame that is unacceptable for welding iron and steel.
- C. The oxygen used in the oxyacetylene process is manufactured from liquid air and stored in hollow steel cylinders.
  - 1. **Oxygen** is a tasteless, colorless, odorless gas that is slightly heavier than air, and is nonflammable. When combined with other elements, it will support combustion.
  - 2. Commercial oxygen is supplied to users in seamless steel cylinders that are charged with oxygen to a pressure of about 2200 psi at 70°F. The pressure will increase and decrease as the temperature changes.
  - 3. The oxygen cylinder has a valve made of tobin bronze. Since bronze is soft, protection must be provided to prevent it from being broken or knocked off.
    - a. Such protection is provided by a steel cap that is threaded to the top of the cylinder that covers the valve during transportation and storage.
    - b. The oxygen cylinder valve has a double-seat, the second seat serving to prevent leakage around the valve stem and the valve when it is fully opened

*Use TM: A5–4A to illustrate temperatures and welding ranges for different metals. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 8 in Modern Agricultural Mechanics, Chapter 14 in Mechanics in Agriculture and Section 1 and 10 in Oxyacetylene Welding and Cutting (VAS 3001a) are recommended.*

**Objective 2:** Explain how to select fuel gas welding equipment and supplies.

**Anticipated Problem:** How are fuel gas welding equipment and supplies selected?

- II. Purchase equipment of good quality from a reliable dealer who will give you service. There are several pieces of equipment and procedures necessary for safe fuel gas welding.
  - A. Several sizes of cylinders are available for use in fuel gas welding.
    - 1. Large cylinders hold 244 cu. ft., medium cylinders hold 122 cu. ft., and small cylinders hold only 80 cu. ft. of oxygen.
    - 2. Common acetylene cylinders have volumes of 125 to 250 cu. ft.

- B. Oxygen and acetylene fittings are not interchangeable. Oxygen fittings have right-handed threads, while acetylene fittings have either left-handed threads or a smaller size right-hand connection.
- C. There is a regulator attached to each of the tank valves.
  - 1. The **regulator** is a device used to vary line pressure on a tank.
  - 2. Each regulator has a diaphragm adjusting screw to vary the line pressure, and has two gauges: one showing cylinder pressure and one showing line pressure.
- D. The hoses used are colored: one green and one red.
  - 1. The green hose is used for oxygen and has fittings with right-hand threads.
  - 2. The red hose is used for the fuel gas and has left-handed fittings.
  - 3. The hoses connect the blowpipe to the regulators. The **blowpipe** is a mixing chamber.
    - a. The two gases are mixed and delivered to the tip ready to burn.
    - b. The blowpipe has a valve to control the oxygen and one to control the acetylene.
  - 4. There are different tips that are attached to the blowpipe to perform different tasks. A welding tip is used for welding pieces together and a cutting attachment with a tip is used to cut metal. Special tips are available to perform other tasks such as heating.
- E. Welding goggles or face shields, filter out ultraviolet and infrared rays and protect the operator's eyes. A No. 4 lens is satisfactory for light-duty oxy-fuel gas welding.
- F. A friction lighter should be utilized to light the blowpipe.
- G. Gauntlet gloves, made of leather, asbestos, or other material that does not burn readily, should be worn when welding or cutting. Be sure the gloves are free from oil or grease because such materials are dangerous when in contact with oxyacetylene equipment.
- H. The cylinders should be chained in an upright position when used and stored. The safety caps should not be removed until the cylinders are secured.
  - 1. Oxy-fuel gas welders should be equipped with both reverse flow check valves and flash arrestors.
  - 2. Check valves prevent the reverse flow of gases into the acetylene and oxygen hoses when line pressure of one gas is greater than the other.
- I. **Flash arrestors** will extinguish any flame which attempts to go through them due to a flashback. They should be mounted on both the oxygen and acetylene lines at the regulators.
- J. A **flashback** is a fire inside the blowpipe. When a flashback occurs in an oxyacetylene unit, flame physically travels up the welding tip and through one or both of the hoses to the regulator.

Use TM: A5–4B and A5–4C as visual material for helping students to understand welding equipment. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 8 in *Modern Agricultural Mechanics*, Chapter 14 in *Mechanics in Agriculture and Section 1 and 10 in Oxyacetylene Welding and Cutting (VAS 3001a)* are recommended.

**Objective 3:** Describe how to set-up fuel gas welding equipment.

**Anticipated Problem:** How is fuel gas welding equipment set-up for use?

- III. Following proper procedures when setting-up the fuel gas welding equipment will insure that there are no gas leaks and accidents can be avoided. General procedures are as follows:
- A. Place the cylinders in a cart and fasten them together with a chain or fasten the cylinders in some other manner to prevent them from being tipped over during use or storage. If an acetylene cylinder is tipped on its side, it should be set upright for at least 30 minutes before being used.
  - B. All oxygen and some acetylene cylinders have iron caps to protect the cylinder valves. Remove the caps and stand to one side so you are not directly in line with tank valve. “Crack” the cylinder valves slightly, then, close them quickly. This will blow out all dust and other foreign matter.
  - C. Connect the acetylene regulator to the acetylene cylinder and the oxygen regulator to the oxygen tank. It should not be possible to interchange the regulators. To avoid confusion, the regulator with the larger numbers belongs on the oxygen tank.
  - D. Connect one end of the green hose to the outlet connection on the oxygen regulator and the other end to the oxygen connection on the blowpipe.
    - 1. Be sure the flash arrestor is attached to the regulator, and the hose is attached to the arrestor.
    - 2. If the unit does not have a built-in check valve, be sure one is put between the hose and the blowpipe.
  - E. Connect one end of the red hose to the outlet connection on the acetylene regulator and the other end to the acetylene connection on the blowpipe.
    - 1. Be sure the flash arrestor is attached to the regulator, and the hose is attached to the arrestor.
    - 2. If the unit does not have a built-in check valve, be sure one is put between the hose and the blowpipe.
  - F. Close both regulator valves by turning the regulator diaphragm screw counterclockwise until the screw is loose. Always close the regulator valves before opening the cylinder valves to prevent the tank pressure from damaging the regulator.
  - G. Standing to one side, not directly in front of the regulator, open the oxygen cylinder valve slowly. Wait until the cylinder pressure has registered on the high-pressure gauge before completely opening the valve. The oxygen tank valve is double seated and it should be opened completely to prevent loss of the high pressure oxygen around the tank valve.
  - H. Standing to one side, not directly in front of the regulator, open the acetylene valve slowly. This valve should never be opened more than one turn so that it can be shut off quickly. Always leave the T-wrench on the valve while you are working in case the fuel gas needs to be shut off quickly.

- I. Open the oxygen valve on the blowpipe about one-eighth of a turn. Turn the screw on the oxygen regulator clockwise until the desired pressure is reached on the oxygen low pressure gauge. Close the oxygen valve on the blowpipe.
- J. Open the acetylene valve on the blowpipe about one-eighth of a turn. Turn the screw on the acetylene regulator clockwise until the desired pressure is reached on the acetylene low pressure gauge. Close the acetylene valve on the blowpipe.
- K. Test for leakage by applying soapy water around the valves and connections. If a bubble appears at a valve or connection, a leak has been detected. It should be corrected before using the equipment. Be sure to use a grease-free soap.

*Again, display TM: A5–4B and TM: A5–4C to reinforce an understanding of the functions of various pieces of equipment. Use text material to strengthen student understanding of concepts. Chapter 8 in Modern Agricultural Mechanics, Chapter 14 in Mechanics in Agriculture and Section 2 in Oxyacetylene Welding and Cutting (VAS 3001a) are recommended.*

**Objective 4:** Explain how to operate fuel gas welding equipment.

**Anticipated Problem:** How is fuel gas welding equipment operated?

- IV. The correct lighting and shutting down procedures should be followed at all times.
  - A. The following is the correct lighting procedure.
    1. Place goggles or safety glasses and face shield on your forehead.
    2. Be sure regulator adjusting screws are turned out. The screw should turn freely.
    3. Standing to one side, not directly in front of the regulator, open the oxygen cylinder valve slowly, then open it all the way. Set the regulator at the correct working pressure. Open the oxygen blowpipe valve and fine tune the operating pressure. Close the oxygen blowpipe valve.
    4. Standing to one side, not directly in front of the regulator, open the acetylene cylinder valve slowly. Only open the tank valve  $\frac{1}{2}$  to  $\frac{3}{4}$  of a turn. Set the regulator at the correct working pressure. Open the acetylene blowpipe valve and fine tune the operating pressure. Close the acetylene blowpipe valve.
    5. Put on gloves, and lower goggles or face shield over eyes.
    6. With the friction lighter in the left hand at the tip of the blowpipe, and the blowpipe in the right hand, open acetylene blowpipe valve with the right thumb and forefinger one-eighth to one-quarter turn. Strike the friction lighter and adjust the acetylene level.
    7. Adjust the acetylene by opening the blowpipe valve until the flame leaves the tip about  $\frac{1}{4}$  inch. Close the valve very slowly until the flame is pulled back to the end of the tip. Open the valve slowly again, stopping just before the flame leaves the tip. This is the proper adjustment for most welding.
    8. Open oxygen blowpipe valve and set the desired flame type.
  - B. The correct shutting down procedure is as follows.

1. Close the acetylene blowpipe valve.
2. Close the oxygen blowpipe valve.
3. Close acetylene tank valve.
4. Close oxygen tank valve.
5. Open the acetylene blowpipe valve to drain the hose and release all pressure from the hose and regulator.
6. Turn out the pressure-adjusting screw on the acetylene pressure regulator by turning it counterclockwise.
7. Close the acetylene blowpipe valve.
8. Open the oxygen blowpipe valve to drain the hose and release all pressure from the hose and regulator.
9. Turn out the pressure-adjusting screw on the oxygen pressure regulator by turning it counterclockwise.
10. Close the oxygen blowpipe valve.
11. Wrap up hoses and put welding accessories in their proper place.

*Continued use of TM: A5–4C will be helpful. Use it as you discuss operating the blowpipe. Use text material to strengthen student understanding of concepts. Chapter 8 in Modern Agricultural Mechanics, Chapter 14 in Mechanics in Agriculture and Section 3 in Oxyacetylene Welding and Cutting (VAS 3001a) are recommended.*

**Objective 5:** Describe fuel gas welding techniques.

**Anticipated Problem:** What are the fuel gas welding techniques?

- V. The techniques involved in fuel gas welding include: setting the proper flame, preparing the pieces to be welded, knowing the common types of welds, holding and using the blowpipe and rod, and completing the different types of welds.
  - A. There are three types of oxyacetylene welding flames.
    1. The neutral flame is usually used for welding. A **neutral flame** will produce a smooth, shiny bead of the best quality.
    2. The **oxidizing flame** is caused by an excessive amount of oxygen, which produces a short white inner cone and a short envelope flame. An oxidizing flame will produce sparks that shower the weld area with droplets of metal and slag, leaving the weld zone weak and porous.
    3. The **carburizing flame** is caused by an excessive amount of acetylene and has a long, bluish outer flame.
      - a. A carburizing flame will cause the puddle to foam and boil, leaving a brittle, porous, and scaly weld area.
      - b. The carburizing flame is used for hard-surfacing.



- B. When possible, it is desirable to prepare by cutting, grinding, filing, or buffing a clean, bright surface for welding because such surfaces weld more easily than dirty or oxidized surfaces.
1. All rust and scale should be carefully removed before welding, because such impurities have a tendency to weaken a weld.
  2. The edges of metals over  $\frac{1}{8}$ , inch should be cut to form a V, with approximately a 45-degree angle to permit the complete fusion of the two pieces of metal.
    - a. If the pieces are  $\frac{3}{8}$  inch or more in thickness, it is usually desirable to cut a V on both the top and bottom sides of the two pieces of metal being welded.
    - b. The pieces to be welded should be placed about  $\frac{1}{16}$  inch apart to provide for the expansion and contraction of the metals and to permit the weld to penetrate deeply, through the bottom, if possible.
- C. The two most common types of welds are the butt weld and the fillet weld.
1. Types of welded joints frequently used are the butt joint, tee joint, corner joint, lap joint and edge joint.
  2. The common welding positions are downhand, horizontal, vertical, and overhead. The downhand weld is used most frequently and is the easiest weld to make.
- D. The blowpipe is usually held like a hammer or fishing pole when the operator is welding while standing, and like a pencil when the operator is welding while seated. It is desirable for the operator to hold the blowpipe in a comfortable way.
1. The recommended blowpipe position should be as follows.
    - a. Hold the blowpipe so that the tip will be inclined at a 45-degree angle to the surface to be welded and will point directly along the line of the weld.
    - b. Hold the tip so that the inner cone of the flame is about  $\frac{1}{8}$  to  $\frac{1}{16}$  inch above the surface of the metal.
  2. Before lighting the blowpipe, practice holding it and moving it in the motion used in welding.
  3. The blowpipe may be moved in a straight line, in a zigzag, or in a circular motion.
    - a. The circular motion is most frequently used.
    - b. Move the blowpipe in a series of connected ovals in a left-to-right direction, and along the line of welding.
    - c. Advance each successive oval about  $\frac{1}{16}$  inch. Make the oval about  $\frac{1}{4}$  inch wide and  $\frac{5}{16}$  inch long.
- E. Puddle strips, beading, fusion welding and bronze welding are the four basic types of welding.
1. The first step in learning to weld with oxyacetylene is to learn how to melt the base metal and how to control the molten puddle.
    - a. Start the flame at the edge of the steel piece and form a molten puddle about  $\frac{1}{4}$  inch in diameter and about  $\frac{1}{8}$  inch from the edge of the piece of steel.
    - b. Right-handed people start at the right-edge of the steel piece. Left-handed persons should start at the left-hand edge of the metal.

- c. The width of the puddle is about twice the thickness of the metal.
2. After learning to control the molten puddle, learning how to make a bead is next. Adding molten metal from a welding rod to the puddle as it progresses across the metal is called making a bead.
  - a. For a right-hand person, hold the welding rod in the left hand at a 45 degree angle so that the end of the rod will be within the outer envelope of the flame. Move the blowpipe in a circular motion and dip the rod into the center of the puddle each time the flame reaches the back of the circle. Raise the rod out of the puddle slightly as the flame is passed toward the front to the puddle, thus synchronizing the motions of the flame and the rod.
  - b. Maintain a molten puddle about  $\frac{1}{4}$  inch in diameter and move the rod and blowpipe slowly, straight ahead about  $\frac{1}{16}$  with each oval motion of the blowpipe.
  - c. Raise the rod out of the way of the flame to permit the flame to heat the metal ahead of the bead.
  - d. Lower the rod so that the flame will melt it, causing the welding rod to flow into the molten puddle. The end of the welding rod should touch the puddle on the downward stroke. The rod should not dip into the puddle.
3. A fusion weld is the next step after learning to make a bead. Two pieces of metal are welded together using a filler rod.
  - a. Select two pieces to be welded and space them so that the edges of the metal are  $\frac{1}{16}$  inch apart at one end and approximately  $\frac{1}{8}$  inch apart at the other.
  - b. Make a tack weld at each end of the pieces to hold them together.
  - c. Follow the same procedure and motion that was used in making a bead.
4. Bronze welding has some advantages over fusion welding.
  - a. Since bronze welding does not require a melting heat, it can be done faster than fusion welding, which saves time and gas. Considerably less expansion and contraction of parts occurs with bronze welding than with fusion welding.
  - b. Heat the base metal to a salmon red color. The bronze rod should not remain in the inner cone of the flame. The inner cone of the flame should not stay in one spot of the molten bronze. The intense heat will burn the bronze.
  - c. The same technique and movement that was used with fusion welding should be followed.

Use TM: A5-4D, A5-4E, A5-4F and A5-4G as visual material for understanding oxyacetylene flames, structure, welding position, and motions. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 8 in *Modern Agricultural Mechanics*, Chapter 14 in *Mechanics in Agriculture* and Section 6 and 7 in *Oxyacetylene Welding and Cutting (VAS 3001a)* are recommended.

**Objective 6:** Identify safety practices that should be observed in fuel gas welding.

**Anticipated Problem:** What safety practices should be observed when fuel gas welding?

VI. Because of the intense heat and other opportunities for accidents, safety is of extreme importance in fuel gas welding.

A. The following are some suggested practices and tips that will help to eliminate shop accidents when fuel gas welding.

1. To prevent oxygen and fuel cylinders from being tipped over accidentally, fasten them securely in an upright position with a chain or similar device before removing the safety cap.
2. Keep oil and grease away from oxygen cylinders and equipment. Oil and grease may catch fire or explode spontaneously in the presence of oxygen escaping from the cylinder or the equipment.
3. Check equipment connections periodically with a clean paint brush and grease-free, soapy water to be sure there are no leaks of oxygen or fuel gas. Test hoses by putting them in a pail of water and watching for bubbles. After making any new connections, test equipment immediately.
4. Check regulator gauge operation pressures carefully and follow recommendations.
5. Clear the area of all combustible materials before lighting the torch. Doing this may avoid an explosion or serious fire.
6. Cover your eyes with welding goggles or a colored face shield and put on gauntlet welding gloves before lighting the torch. Wear clothes suitable for the work being done.
7. Stand to one side, not directly in front of the regulator, when opening the cylinder valve. A defect in the cylinder valve may cause the gas to blow out, shattering the glass, and blowing it into your face. Open the valve slowly. If the gas in the tank is permitted to enter the regulator suddenly, it may cause damage to the equipment, and particularly to the regulator diaphragm.
8. Do not open the blowpipe valves more than  $\frac{1}{2}$  turn when lighting the torch.
9. Never use a match to light the torch. Using matches brings your fingers too close to the tip. The sudden ignition may cause burns.
10. Always use a spark igniter or friction lighter to light a welding torch. When lighting a torch, keep the tip facing downward and away from you. Lighting the torch while it is facing upward or outward may result in burns.
11. Make no attempt to relight a torch from hot metal. The gas does not always ignite instantly, and the accumulating gas may ignite violently. Light the acetylene first and add oxygen to the flame.
12. Be sure that other workers are in the clear before relighting a torch.
13. Do not walk with a lighted torch or lay down a lighted torch. Be certain the flame is out before laying down the torch. Never walk around with a lighted torch. Before

you light the torch, get into position for welding or cutting and remove all obstacles between you and the shut-off controls.

14. Before opening a cylinder valve, be sure the regulator valve is closed by turning it counterclockwise until it is loose.
15. If a flashback should occur, turn off the torch immediately, close the cylinder valves, and notify your instructor. A flashback has occurred when the flame disappears and burns back inside your equipment. There is a hissing, squealing sound. Smoke may come out the torch tip, and the handle may get hot. If the torch is not turned off promptly, fire may reach the hoses or the cylinder. Do not relight after a flashback until the equipment has been inspected closely, and perhaps repaired.
16. Never open the acetylene cylinder valve more than  $\frac{1}{2}$  to  $\frac{3}{4}$  of a turn. Leave the T-handle wrench in position at all times while welding. You should be able to turn off the acetylene cylinder valve promptly in case of fire.
17. Never do any welding on containers that may have held flammable substances. Leave this work to professionals.
18. When welding or cutting zinc or galvanized metals, make a special effort to avoid breathing the fumes which can make you feel ill.
19. Never use acetylene at a pressure greater than 15 psi. Follow the manufacturer's recommendations for the correct operating pressures for the metal being welded and for the tip size being used.
20. Do not smoke or allow anyone else to smoke near the oxy-fuel gas welder. If fuel gas were to leak from the unit, smoking could provide ignition and cause a fire or an explosion.
21. Keep the flame and heat away from the cylinder, hoses, and people. Be alert for fires at all times. Use the proper fire extinguisher or a fire blanket if necessary.
22. For most oxyacetylene welding, you will need a lens with shade No. 5.
23. Cylinders should not be stored near open fires, furnaces, or other heating devices, or in direct rays of the sun.
24. Keep cylinders away from electric wiring and away from the danger of striking an arc on them with an electric welder.
25. Oxygen cylinders are equipped with a double seating valve. Open the valve all the way to prevent oxygen from escaping around the valve stem.
26. Wear welding gloves to protect the hands against burns, sparks and molten metal.
27. Wear flame-resistant clothing. Never gas weld while you are wearing polyester clothing. Oily or greasy clothing may burn quickly if oxygen is fed into them. Ragged clothing is likely to catch fire. Because sparks may lodge in cuffs and rolled sleeves, turn trouser cuffs down and button sleeves at the wrist.
28. Low shoes are not recommended because sparks or slag may get into them.
29. Make certain that reverse flow-check valves and flash arrestors are installed on the oxygen and acetylene lines.

30. Be sure the cylinder valves are closed and the pressure is relieved from the hoses before you leave the work area.
31. Remove regulators and replace protective caps before transporting cylinders.
32. Store oxygen cylinders away from fuel gas cylinders.
33. Never use oxygen as compressed air to dust clothing. Clothing saturated with pure oxygen is highly combustible.
34. Handle hot metal with pliers or tongs. Do not leave hot metal on the welding table because unsuspecting persons may touch it and be burned.

Use text material to strengthen student understanding of concepts. Chapter 8 in *Modern Agricultural Mechanics*, Chapter 14 in *Mechanics in Agriculture* and Section 4 in *Oxyacetylene Welding and Cutting (VAS 3001a)* and Section 6 in *Safety in the Shop (VAS 3022a)* are recommended.

**Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle.

**Application.** The following lab activity will be helpful to students in applying the concepts of this lesson:

LS: A5-4A—Gas Welding Exercises

**Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance, on the application activity. A sample written test is attached.

## Answers to Sample Test:

### Part One: Matching

1 = c, 2 = f, 3 = a, 4 = e, 5 = b, 6 = d

### Part Two: Completion

1. downhand, horizontal, vertical, overhead
2. Oxygen
3. neutral, oxidizing, carburizing,
4. Acetylene
5. butt, fillet (T)

### Part Three: Short Answer

1. Fusion—The base metal is melted and there is mixing of the base metal with rod; Bronze—the base metal is not melted and there is no mixing of the base metal with rod, can be done faster, less expansion and contraction.
2. Standing—Held like a hammer or fishing pole. Sitting—Held like a pencil.

---

# Test

---

## Lesson A5-4: Applying Fuel Gas Welding (FGW) Processes and Techniques

### Part One: Matching

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

- |                |              |
|----------------|--------------|
| a. acetylene   | d. flashback |
| b. blowpipe    | e. oxygen    |
| c. carburizing | f. regulator |

- \_\_\_\_\_ 1. Caused by excessive amount of acetylene and has a long, bluish flame.
- \_\_\_\_\_ 2. Used to vary the line pressure.
- \_\_\_\_\_ 3. Colorless, but with a distinct odor.
- \_\_\_\_\_ 4. Travels through the green hoses.
- \_\_\_\_\_ 5. A mixing chamber.
- \_\_\_\_\_ 6. A fire inside the blowpipe.

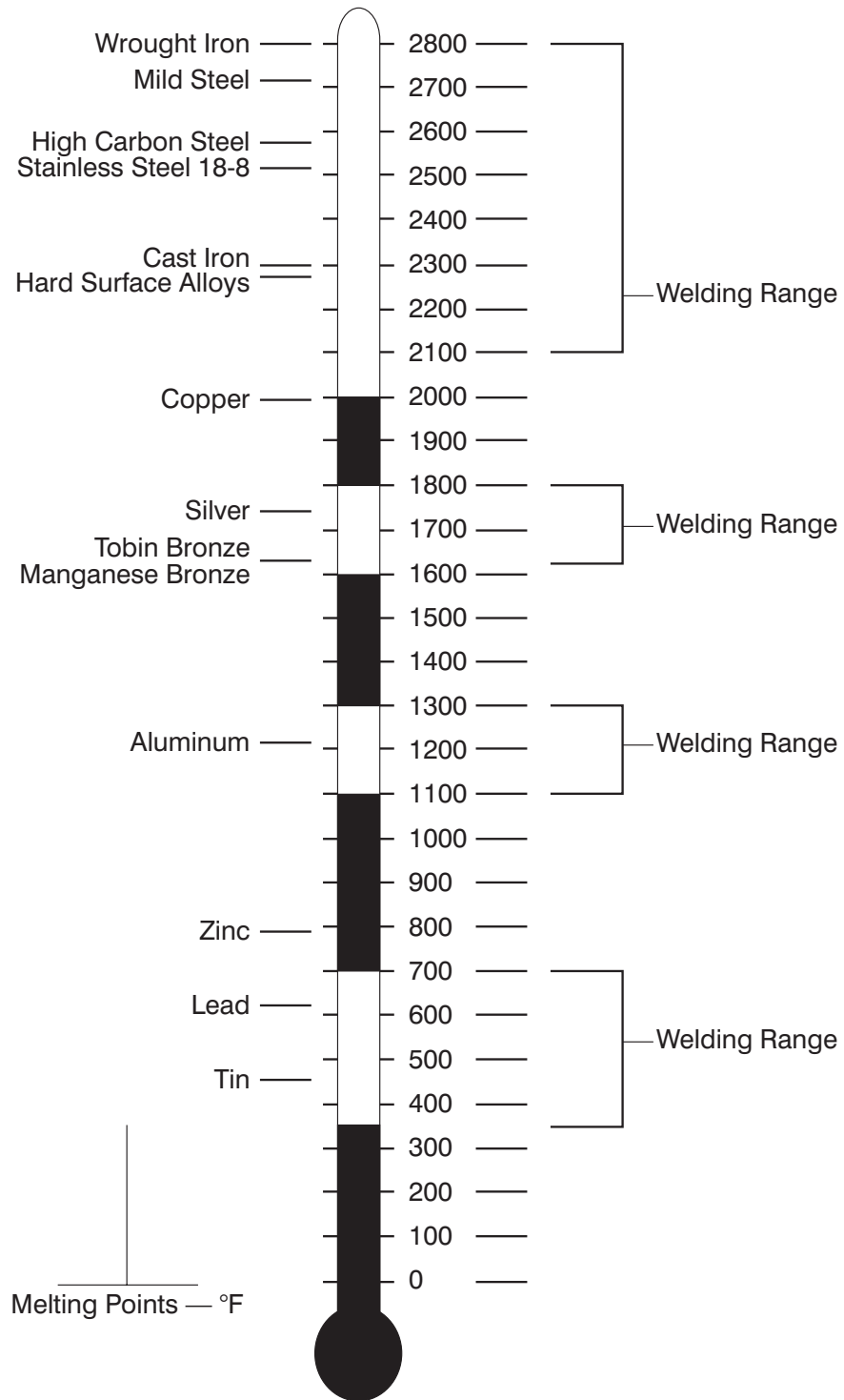
### Part Two: Completion

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

1. The common welding positions are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
2. \_\_\_\_\_ is a tasteless, colorless, odorless gas that is slightly heavier than air and is nonflammable.
3. The three types of oxyacetylene welding flames are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_.
4. \_\_\_\_\_ is a fuel gas made of carbon and hydrogen and is produced from the chemical reaction between calcium carbide and water.
5. The two most common types of welds are \_\_\_\_\_ and \_\_\_\_\_.

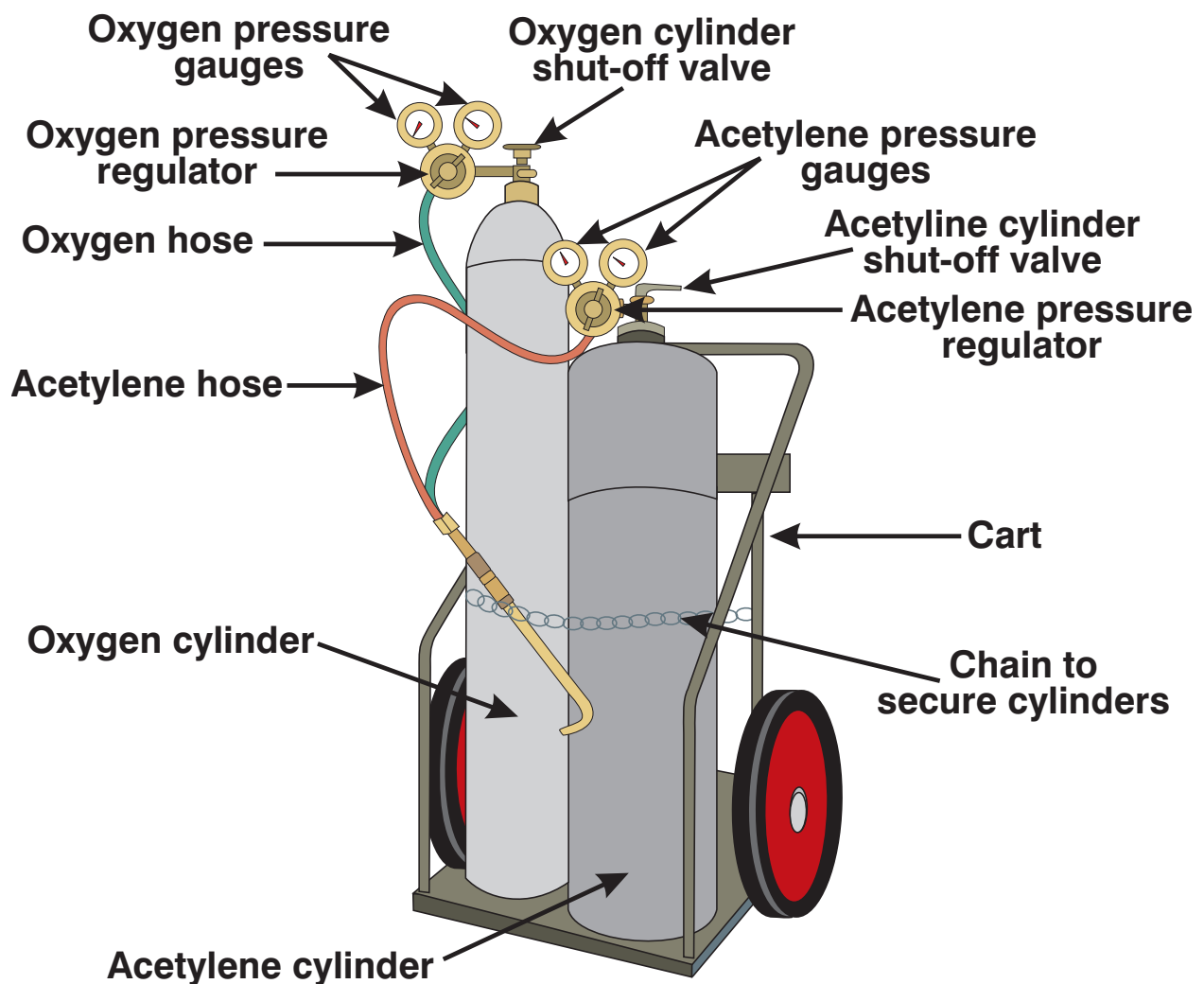


# TEMPERATURE DATA



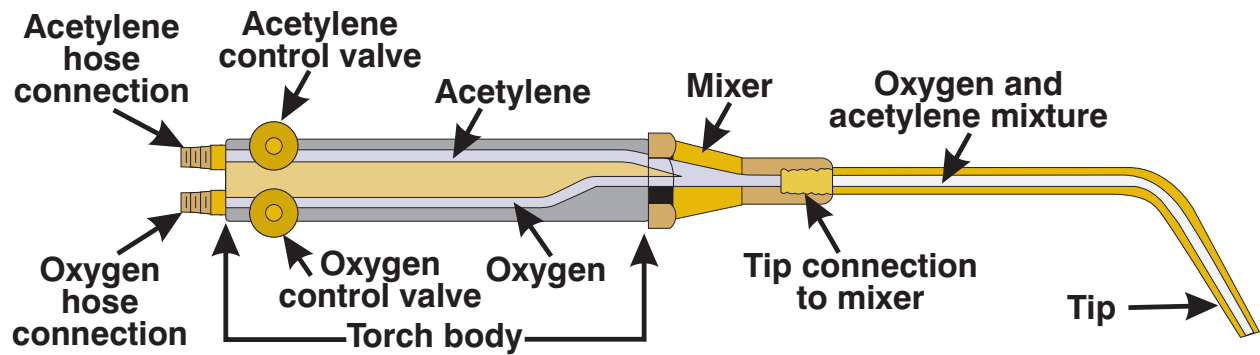


# MAJOR PARTS OF AN OXYACETYLENE WELDING AND CUTTING OUTFIT



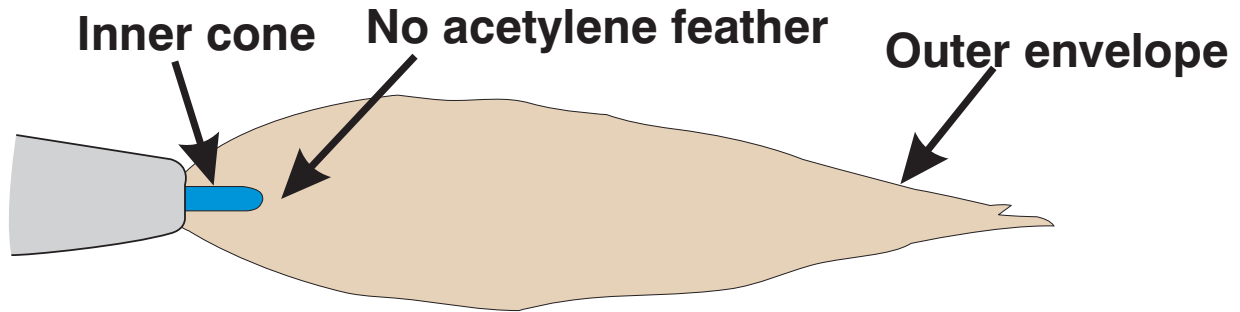
(Courtesy, Interstate Publishers, Inc.)

# BLOWPIPE DETAIL

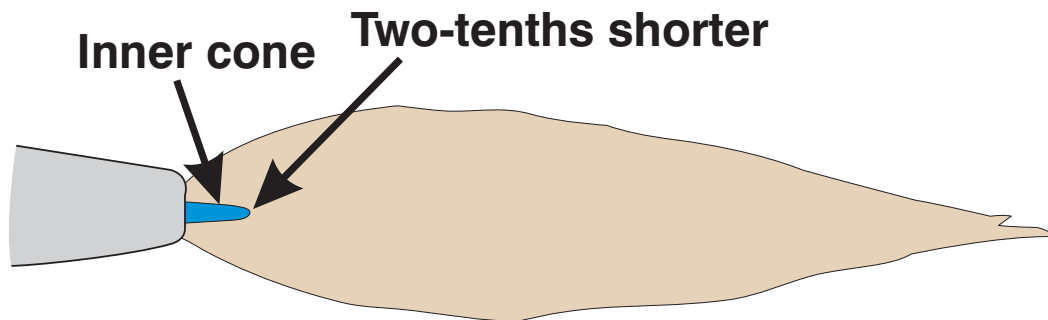


(Courtesy, Interstate Publishers, Inc.)

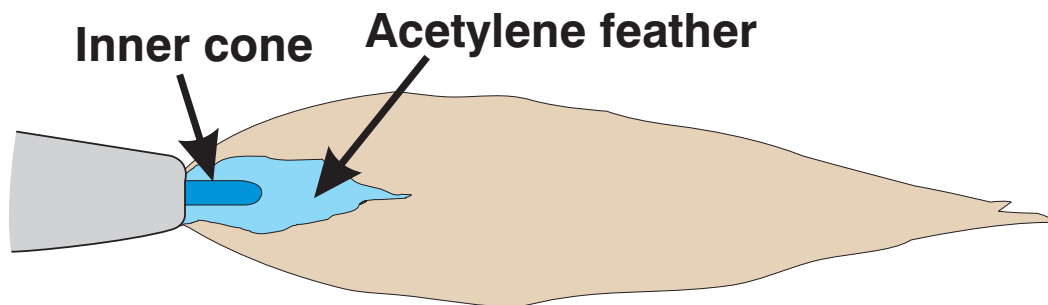
# FLAMES



**Neutral Flame**



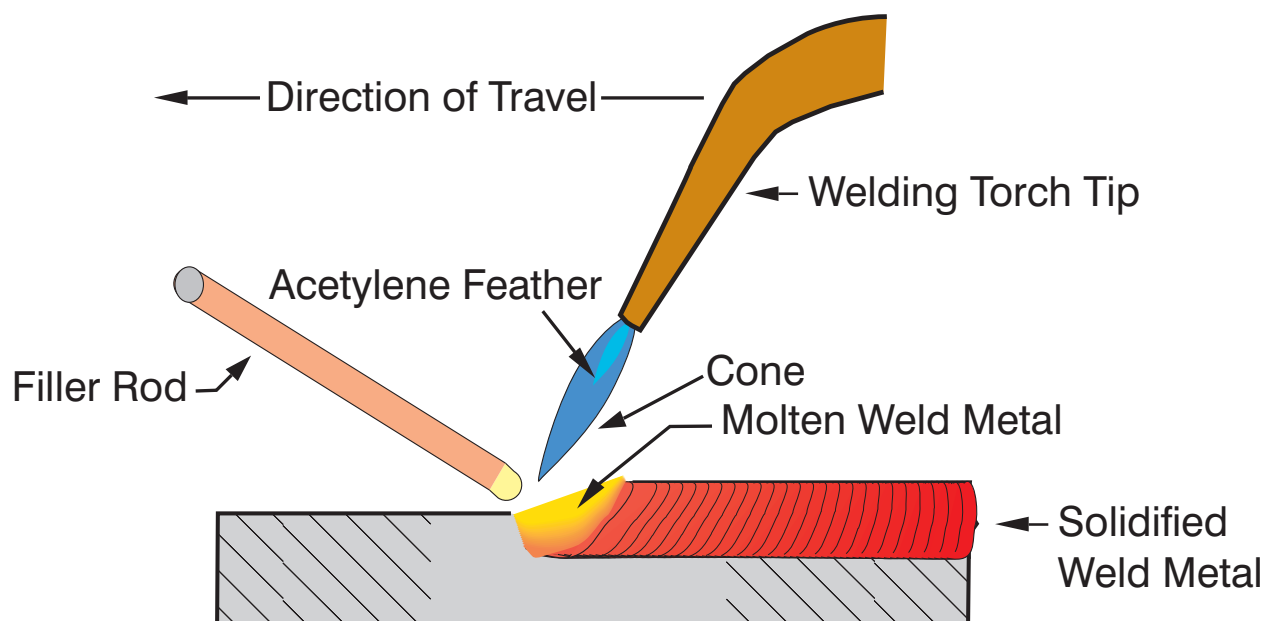
**Oxidizing Flame**



**Carburizing Flame**

*(Courtesy, Interstate Publishers, Inc.)*

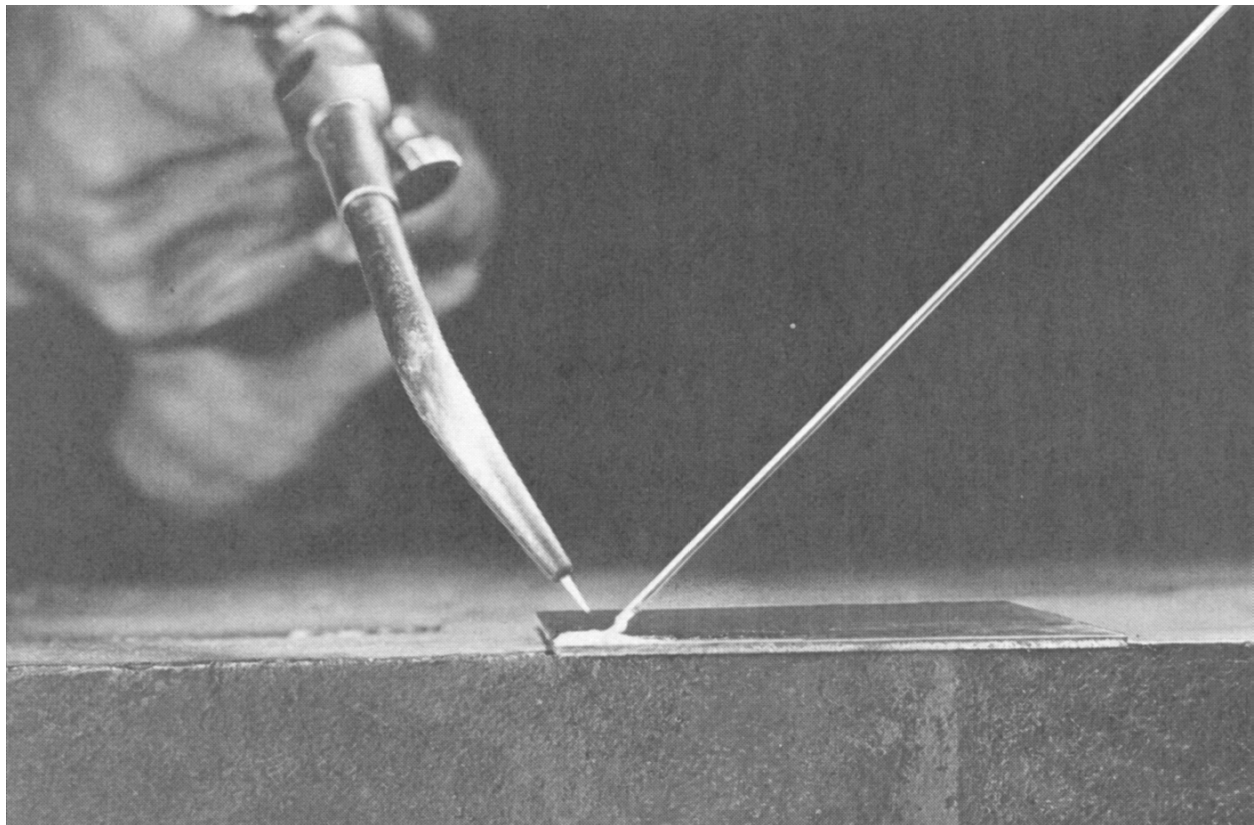
# OXYACETYLENE WELDING STRUCTURE



*(Courtesy, Interstate Publishers, Inc.)*

TM: A5-4F

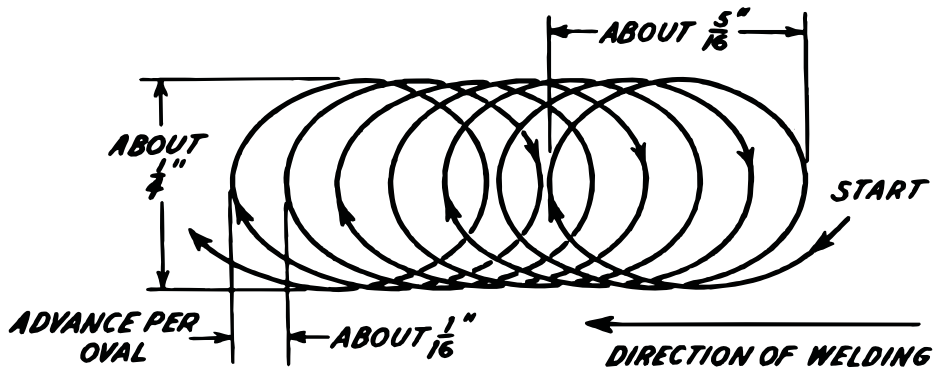
# OXYACETYLENE WELDING POSITION



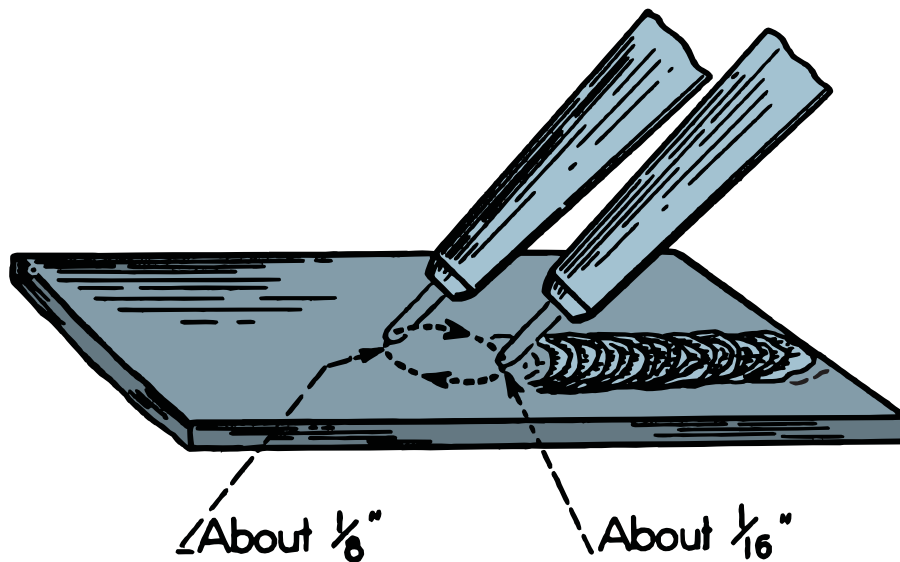
**The correct position of a blopipe and rod  
when the rod is lowered.**

*(Courtesy, Interstate Publishers, Inc.)*

# OXYACETYLENE WELDING MOTIONS



The blowpipe motion frequently used.



This view of the blowpipe motion shows how the flame is lifted at the front edge of the circle.

(Courtesy, Interstate Publishers, Inc.)

# Lab Sheet

## Gas Welding Exercises

Each student is to complete the following lab exercises in the order shown. A lab sheet should accompany each exercise. Before moving to the next exercise, gain instructor approval and directions.

- |                      |                        |                         |
|----------------------|------------------------|-------------------------|
| #1 Fusion Melt Strip | #5 Fusion Tee (Fillet) | #9 Brazing Tee (Fillet) |
| #2 Fusion Bead       | #6 Brazing Bead        | #10 Brazing Tin Can Lid |
| #3 Fusion Butt       | #7 Brazing Butt        | #11 Brazing Tin Can     |
| #4 Fusion Lap        | #8 Brazing Lap         |                         |

1. Lab exercise number and type of weld: \_\_\_\_\_
2. Welding position: \_\_\_\_\_
3. Type and size of rod used: \_\_\_\_\_
4. Type and thickness of base metal: \_\_\_\_\_
5. Acetylene setting: \_\_\_\_\_ Oxygen setting: \_\_\_\_\_

6. SCORECARD:

a. General appearance (smooth, uniform ripples)	5	4	3	2	1	0
b. Width (uniform)	5	4	3	2	1	0
c. Height (uniform)	5	4	3	2	1	0
d. Penetration	5	4	3	2	1	0
e. Starting	5	4	3	2	1	0
f. Stopping	5	4	3	2	1	0
g. Safety procedures followed	5	4	3	2	1	0
h. Other	5	4	3	2	1	0

i. TOTAL POINTS EARNED \_\_\_\_\_

7. Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

8. Grading scale	36-40	A- to A+
	32-35	B- to B+
	28-31	C- to C+
	24-27	D- to D+
	1-23	F
	0	0