4. Using the same procedure as for manual cutting, light the torch and adjust the torch height. The tip of the preheat flames should be 1/16"-1/8" (1.6 mm-3.2 mm) above the base metal.

5. Turn on the machine and start the magnetic tracer motor. The tracer rotates and follows the pattern. The torch follows the tracer movement.

6. After the cut is completed, shut off the tracer motor. Shut down the cutting torch and cutting outfit.

Figure 22-17. The magnetic pattern tracer is mounted above the cutting torch. As the follower rotates and follows the pattern, the cutting torch travels a duplicate path over the metal. (ESAB Welding and Cutting Products)

Summary

Oxyfuel gas cutting (OFC) is a process used to cut metal by rapidly oxidizing or burning it. The heat of a gas flame and pressurized pure oxygen are used in this process.

The ignition temperature for steel is 1500°F (816°C). When the steel attains this temperature, a jet stream of high-purity (99% +) oxygen is directed at it. This stream of oxygen rapidly burns away all of the steel in the kerf (the slot that is produced during cutting).

Various gases are used as the fuel for oxyfuel gas cutting. These gases include acetylene, hydrogen, natural gas, propane, and MPS (methylacetylene-propadiene). Acetylene and MPS are the most commonly used fuel gases in industry.

The edges of metal produced by oxyfuel gas cutting should be smooth and straight. A good cut depends on the welder's skills. Cut quality is also affected by the cutting tip selected and the oxygen pressure used.
Motor-Driven Beam-Mounted Torches and Electronic Tracer

The oxyfuel gas cutting torch is mounted on a strong beam. Several cutting torches may be mounted on the same beam. This allows the motor-driven beam-mounted torch machine to cut several parts at the same time. See Figure 22-15.

A dense black drawing of the part to be cut is made on a white background. The outline of the drawing is followed by the electronic eye on a motor-driven electronic pattern tracer. See Figure 22-16. As the pattern shape changes, the electric eye follows the edge of the pattern. It will not stray more than .003" (.076 mm) from the drawing image.

The pattern tracer is electrically connected to two drive motors. As the tracer moves along the outline, it signals the drive motors on the beam. The motors move the beam on which the torches are mounted. All moves that the tracer makes are duplicated by all the torches on the beam.

The beam-mounted torch(es) and electronic tracer are used as follows:

1. Place the drawing on the pattern table under the electronic pattern tracer.
2. Turn on the cutting outfit using the same procedure as for manual cutting.
3. Adjust the light beam on the electronic tracer to the line on the drawing.
4. Light and adjust each torch separately. The flame should be 1/16"--1/8" (1.6 mm--3.2 mm) above the base metal. The torches should also be perpendicular to the surface of the metal. The drive motor speed is adjusted on the electronic tracer control panel.
5. Turn on the cutting oxygen at each torch and pierce a hole in the metal.
6. Start the beam drive motors.
7. Start the tracer. The torches move as the tracer moves.
8. Shut off the tracer and drive motors when the cut is completed. Turn off all the torches.
9. Shut down the cutting outfit in the same manner as for manual cutting.

Motor-Driven Magnetic Tracer and Torch

The motor-driven magnetic tracer and torch is a relatively inexpensive cutting machine. This type of cutting machine works best with shapes that are not too complex. The tracer will not hold as well as a sharp angle, but very well. One torch is generally mounted on this type of cutting machine.

A motor-driven magnetic tracer and cutting machine is shown in Figure 22-17. A steel pattern must be used when duplicating parts. The pattern is firmly mounted directly above the cutting torch. A cylindrical magnetic tracer, or follower, follows the outline of the steel pattern. The tracer is rotated by a small motor and held in contact with the pattern by magnetism. The tracer is mounted directly above and on the exact centerline of the cutting torch. Therefore, the torch follows the movement of the tracer as it moves around the pattern. The part that is cut out will be an exact duplicate of the pattern. Parts cut by this method are not as accurate as those cut with an electronic tracer.

The magnetic motor-driven tracer and torch are used as follows:

1. Mount the steel pattern in position.
2. Place the magnetic tracer in contact with the pattern.
3. Adjust the torch angles.
Cutting Machines and Pattern Tracers

Oxyfuel gas cutting machines make high-quality cuts at a faster rate than manual flame cutting. Cutting machines are often used to make long cuts. They are also used to cut multiple pieces with close tolerances. The basic types of cutting machines are:

- Electric motor-driven carriage and track.
- Motor-driven beam-mounted torch and electronic tracer.
- Motor-driven magnetic tracer and torch.

Electric Motor-Driven Carriage and Track

An electric motor-driven carriage uses a variable-speed motor to carry a cutting torch along a straight or curved track. See Figure 22-14. The speed of the motor can be adjusted to control the speed of the cut. Torch movement and flame height are consistent because the torch moves along a track. High-quality cuts can be made using a track-mounted carriage.

The cutting torch used on a motor-driven carriage has a different appearance from a manual cutting torch. It still has conventional oxygen and acetylene valves. A small lever is used to operate the cutting oxygen valve. Using the rack-type gear on the cutting machine allows the welder to adjust the flame height by moving the torch up and down. The torch can also be adjusted horizontally to align it with the cutting line.

Only one cutting torch is usually mounted on the carriage. Torch angle, flame height, and cutting speed can be adjusted on the carriage. A clutch switch is used to engage and disengage the carriage drive mechanism.

An oxyfuel gas cutting torch mounted on a motor-driven carriage is used as follows:

1. Set up the track or circle cutting attachment.
2. Adjust the torch height so the flames are about 1/16”–1/8” (1.6 mm–3.2 mm) above the base metal. Adjust the torch to the appropriate angle for the metal being cut. Refer to the Torch Position subhead under Manual Cutting. Adjust the forward speed for the carriage. Figure 22-1 suggests forward speeds to be used with various metal thicknesses. This speed may be increased, when possible, with a motor-driven carriage.
3. Turn on the cutting outfit using the same procedure as for a manual torch.
4. Light the preheating flames and adjust for a neutral flame.
5. Begin preheating the metal at the edge of the part.
6. Engage the forward drive clutch when the steel becomes orange-red (1500°F/816°C).
7. Disengage the drive clutch when the cut is completed. Disengaging the clutch stops the carriage.
8. Shut off the torch and shut down the cutting outfit using the same procedure as for a manual torch.

Exercise 22-4 Machine Cutting

Use any available cutting machine.

1. Obtain a piece of mild steel that measures at least 6” × 6” (152 mm × 152 mm). The piece should be at least 1/4” (6.4 mm) thick. Obtain a pattern, if required.
2. Refer to the procedures for setting up and adjusting your cutting machine.
3. Make cuts as directed by the instructor.
4. When the cuts are completed, shut off the drive motors and turn off the torch(es). Shut down the cutting outfit.

Inspection:

The finished part should be an exact duplicate of the pattern. The edges should be smooth. Slag should not be present.
Exercise 22-2 Manually Cutting Straight Edges—Using Steel Angle

1. Obtain a piece of mild steel that measures at least 1/4" × 6" × 6" (6.4 mm × 152 mm × 152 mm).
2. Using soapstone or chalk, mark out three lines on the surface 1 1/2" (38 mm) apart. Refer to the following figure.

   ![Diagram of steel angle with dimensions](image)

3. Select the correct cutting tip. Use a tip with 4–6 preheating orifices, if possible. See Figure 20-29.
4. Turn on the station and set the correct pressures. Light the torch and adjust for neutral preheating flames.
5. Obtain a piece of angle iron that measures at least 1" × 1" × 7" (25 mm × 25 mm × 178 mm).
6. Lay one leg of the angle flat, with other leg perpendicular to the base metal. Position the angle just off the line to be cut to allow for the tip thickness. Clamp the angle firmly in place.
7. Hold the tip 5°–15° from vertical. The centerline of the tip should be aligned with the line to be cut. The preheating flames should be about 1/16"–1/8" (1.6 mm–3.2 mm) above the metal.
8. Squeeze the oxygen cutting valve when the metal turns an orange-red color (1500°F/816°C). The cut will begin.
9. Slide the cutting torch tip along the steel angle and progress at a constant rate to complete the cut.
10. Repeat the process for the next two lines.

Exercise 22-3 Manually Cutting Beveled Edges—Using Steel Angle

1. Obtain a piece of mild steel that measures at least 1/4" × 6" × 6" (6.4 mm × 152 mm × 152 mm).
2. Using soapstone or chalk, mark out three lines on the surface 1 1/2" (38 mm) apart. Refer to the following figure.

   ![Diagram of steel angle with dimensions](image)

3. Select the correct cutting tip. Install the tip in the torch.
4. Turn on the station and set the correct pressures. Light the torch and adjust for neutral preheating flames.
5. Obtain a piece of angle iron that measures at least 1" × 1" × 7" (25 mm × 25 mm × 178 mm).
6. Position the steel angle on its legs, as in Figure 22-13. Clamp the angle in place.
7. Hold the cutting torch tip on the incline of the clamped steel angle. The centerline of the tip should be aligned with the line to be cut. The preheating flames should be about 1/16"–1/8" (1.6 mm–3.2 mm) above the metal.
8. Squeeze the oxygen cutting valve when the metal turns an orange-red color (1500°F/816°C). The cut will begin.
9. Progress at a constant rate to complete the cut.
10. Repeat the process for the next two lines.
Exercise 22-1 Manually Cutting Straight Edges—Freehand

1. Obtain a piece of mild steel that measures at least 1/4" x 6" x 6" (6.4 mm x 152 mm x 152 mm).

2. Using soapstone or chalk, mark out three lines on the surface 1 1/2" (38 mm) apart. Refer to the following figure.

3. Select the correct cutting tip. Use a tip with 4-6 preheating orifices, if possible. Install the tip in the torch.

4. Turn on the station and set the correct pressures. Light the torch and adjust for neutral preheating flames.

5. Place your left hand on the table. Rest the torch in the left hand. As the cut progresses, slide the torch through your left hand. This prevents the torch from shaking.

6. For a right-handed welder, start the cut at the right and progress toward your left.

7. Hold the tip 5°-20° from vertical. The centerline of the tip should be aligned with the line to be cut. The preheating flames should be about 1/16"-1/8" (1.6 mm-3.2 mm) above the metal.

8. Squeeze the oxygen cutting valve when the metal turns an orange-red color (1500°F/816°C). The cut will begin.

9. Progress at a constant rate to complete the cut.

10. Repeat the process for the next two lines.

Figure 22-12. Guiding the cutting torch through the left hand. A—Left hand is held near the torch head. B—Torch is slid through left hand as cut progresses.

Figure 22-13. A steel angle (angle iron) used as a guide to make a beveled cut.
Torch Position

The torch angle for cutting will vary with the thickness of the metal. The centerline of the cutting tip should be perpendicular to the surface of the metal to form square edges.

The cutting tip should be tilted backward 5°–20° from vertical when cutting with the correct size tip, Figure 22-9. This allows the welder to see into the kerf.

As the thickness of the metal increases, the cutting tip should be held closer to vertical and not tilted backward. When cutting very thick metal, the work angle should approach 0° so that the cutting tip is nearly vertical, Figure 22-10.

When cutting very thin metal (under 1/8" [3.2 mm] thick), even the smallest tip size available may produce too much heat for a quality cut. In this case, lower the torch to 15°–20° from horizontal. This angle increases the amount of material being cut and allows a larger tip to produce a clean cut, Figure 22-11.

Hand Position

A cutting torch must be held with two hands. As the cut progresses, the torch is slid through the support hand, as shown in Figure 22-12. A 4"–8" (102 mm–203 mm) cut may be made before moving the support hand.

A piece of steel angle (angle iron) may be used as a guide to make straight or beveled cuts, Figure 22-13. The angle may be clamped to the part for use as a straight edge. The torch tip is slid along the angle.
When oxyfuel gas cutting, the base metal must be **preheated** (heated to its ignition temperature) before cutting oxygen is applied. The ignition temperature for steel is about 1500°F (816°C). The small orifices in the cutting tip supply the preheating flames. These flames preheat the metal ahead of the oxygen stream and also heat the sides of the kerf. The cutting tip should be placed into the torch so that it aligns with the cutting line as shown in **Figure 22-7**. A minimum of two preheating orifices should line up with the cutting line. A kerf is formed under the cutting oxygen jet. The quality of the kerf depends on the following:
- Cutting tip size.
- Oxygen pressure.
- Torch forward speed.

**Figure 22-6.** The effect of using too much oxygen when cutting steel. Notice how the kerf widens at the bottom of the plate to create a bell-mouthed kerf.

**Figure 22-7.** Correct alignment of the preheating orifices on the cutting line. At least two preheating orifices should align with the cutting line.

- Steady torch movement.
- Torch tip angle.
- Distance of preheat flames from the base metal.

**Figure 22-8** shows a good cut and several unacceptable cuts. The characteristics of each cut are also given.

**Figure 22-8.** Typical edge conditions resulting from oxyfuel gas cutting operation: (1) A good cut in 1" (25 mm) plate. The edge is square, and the drag lines are essentially vertical and not too pronounced. (2) The preheat flames were too small for this cut and the cutting speed was too slow, causing bad gouging at the bottom. (3) The preheat flames were too long, with the result that the top surface melted over. The cut edge is irregular and there is an excessive amount of adhering slag. (4) The oxygen pressure was too low, with the result that the top edge melted over because of the slow cutting speed. (5) The oxygen pressure was too high and the nozzle size too small, with the result that control of the cut was lost. (6) The cutting speed was too slow, with the result that the irregularities of the drag lines are emphasized. (7) The cutting speed was too fast, resulting in a pronounced break in the drag line and an irregular cut edge. (8) The torch travel was unsteady, resulting in a wavy and irregular cut edge. (9) The cut was lost and not carefully restarted, causing bad gouges at the restarting point. (AWS)
Figure 22-2. Circle cutting torch attachment. This attachment allows welders to turn the torch accurately and make precise circular cuts. (Lenco-NLC, Inc.)

Figure 22-3. The cutting torch is easily connected to a straight-line cutting attachment. A—Straight-line cutting attachment. B—The attachment is designed to hold the torch tip steady for the length of the cut. It can be used freehand or

Figure 22-4. One edge has a very clean cut with very little slag, while the other side has considerable slag.

Figure 22-5. An oxyacetylene cut in progress. A—Note the slag at the bottom of the kerf. B—Cutting oxygen slows down as it travels through the metal. Drag results from the oxygen.
The ignition temperature for steel is 1500°F (816°C). One or more oxyfuel gas flames are used to heat steel to this temperature when oxyfuel gas cutting. Steel is a bright red or orange-red color at this temperature. When the steel attains a temperature of 1500°F (816°C), a jet stream of high-purity (99% +) oxygen is directed at it. This stream of oxygen rapidly oxidizes, or burns, the steel. A continuous cut is made on the steel if the 1500°F (816°C) temperature and oxygen jet are maintained.

Various gases are used as the fuel for oxyfuel gas cutting. These gases include acetylene, hydrogen, natural gas, propane, and MFS (methylacetylene-propadiene). Acetylene and MFS are the most commonly used fuel gases in industry.

**Oxyfuel Gas Cutting Equipment**

Oxyfuel gas cutting equipment is essentially the same as oxyfuel gas welding equipment. The main differences in the cutting and welding outfits are in the oxygen regulator and the torch. A larger volume of oxygen at a higher pressure is needed for cutting very thick steel. An oxygen regulator with a larger volume capacity and higher-pressure indications is needed for cutting heavy metal.

**Preparing to Cut**

The step-by-step procedure for assembling an oxyfuel gas cutting outfit is explained in Chapter 21. Select either a cutting torch or a cutting torch attachment and connect it to the hoses. Check the cutting station to ensure it is assembled correctly and all gas connections are tight and leakproof. Be sure to select the proper size cutting tip when preparing to cut. Cutting tip sizes are identified by numbers ranging from 00-8. The numbers are stamped on the tip when they are made. Most cutting tip manufacturers use the same tip numbering system. Figure 22-2 suggests cutting oxygen and acetylene pressures for use with various cutting tips. Suggested tip sizes for use with various metal thicknesses are also shown.

Proper protective clothing must be worn for oxyfuel gas cutting. Coveralls and a shirt or jacket that buttons to the collar must be worn. All clothing must be flame resistant. Pant legs should have no cuffs or folds. A cap should be worn to protect hair from sparks and hot metal. Gloves must be worn to protect the hand. Welding goggles with a #5-#6 filter lens should be worn.

Review Chapter 20 for a thorough overview of oxyacetylene cutting and welding equipment and supplies and Chapter 1 for general safety considerations. Also, review the procedures listed in Chapter 21 for turning on and shutting down an oxyacetylene cutting outfit. Note the differences in the procedures used for the cutting torch and the cutting torch attachment.

**Manual Cutting**

The edges of metal produced by oxyfuel gas cutting should be smooth and straight. A good cut depends on the welder’s skills. Cut quality is also affected by the cutting tip size and the oxygen pressure used. Very accurate circles and straight lines can be cut manually by using a circle cutting attachment, Figure 22-2, or straight line cutting attachment, Figure 22-3.

Slag is iron oxide. It may form on the underside of the metal being cut. Figure 22-4 shows a plate that was turned over to reveal the slag. Slag that is easily removed is acceptable. Hard slag (slag that cannot be easily removed) is unacceptable. Enough oxygen pressure must be used to cut through the metal without leaving hard slag.

The slot or opening produced in the metal when cutting is the kerf. See Figure 22-5. The kerf should be as narrow as possible. A wide kerf requires more oxygen to make a good cut. The width of the kerf is determined by the size and shape of the cutting tip. Too much oxygen pressure may result in a bell-mouthed kerf,

![Figure 22-1](image)

**Table**

<table>
<thead>
<tr>
<th>Material thickness, inches</th>
<th>1/8</th>
<th>1/4</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1 1/2</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended tip number</td>
<td>00</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Acetylene pressure setting, psig</td>
<td>3-5</td>
<td>3-5</td>
<td>3-5</td>
<td>3-5</td>
<td>3-7</td>
<td>3-7</td>
<td>5-10</td>
<td>5-10</td>
<td>6-12</td>
<td>7-13</td>
<td>8-14</td>
<td>10-15</td>
<td></td>
</tr>
<tr>
<td>Cutting speed range, in./min.</td>
<td>27-30</td>
<td>26-29</td>
<td>20-24</td>
<td>17-21</td>
<td>14-18</td>
<td>13-17</td>
<td>12-15</td>
<td>8-11</td>
<td>7-9</td>
<td>6-8</td>
<td>5-6</td>
<td>4-5</td>
<td>3-4</td>
</tr>
</tbody>
</table>
Chapter 22
Oxyfuel Gas Cutting

Learning Objectives

After studying this chapter, you will be able to:

- List fuel gases that are used for oxyfuel gas cutting.
- Turn on and adjust manual oxyfuel gas cutting equipment.
- Perform cuts manually with a cutting torch or cutting torch attachment.
- Describe the procedure for shutting down oxyfuel gas cutting equipment.
- Identify the basic types of cutting machines.
- Turn on and adjust oxyfuel gas cutting machines.
- Perform cuts with an oxyfuel gas cutting machine.
- Describe the procedure for shutting down oxyfuel gas cutting machines.

Technical Terms

- bell-mouthed kerf
- burning
- cutting machine
- electric motor-driven carriage
- electronic pattern tracer
- hard slag
- ignition temperature
- kerf
- motor-driven beam-mounted torch
- motor-driven magnetic tracer
- oxyfuel gas cutting (OFC)
- preheated slag

Oxyfuel Gas Cutting Principles

Oxyfuel gas cutting (OFC) is a process used to cut metal by rapidly oxidizing it. The heat of a gas flame and pressurized pure oxygen are used in this process. Most materials, including steel, will burn. Oxyfuel gas cutting is also referred to as "burning" or "flame cutting" by some welders.

If the temperature of paper is raised to its ignition temperature, the paper will burn. The ignition temperature is the temperature at which a material will burn if enough oxygen is present. Oxygen must be present for burning to occur. When paper is burned, the oxygen comes from the air.
When oxyfuel gas cutting, the base metal must be preheated before cutting oxygen is applied. The small orifices in the cutting tip supply the preheating flames. The cutting tip should be installed in the torch so that minimum of two preheating orifices line up with the cutting line.

The torch angle for cutting will vary with the thickness of the metal. The centerline of the cutting tip should be perpendicular to the surface of the metal to form square edges. The cutting tip should be tilted backward 5°–20° from vertical when cutting with the correct size tip. As the thickness of the metal increases, the cutting tip should be held closer to vertical. When cutting very thin metal, lower the torch angle to 15°–20° from horizontal to increase the thickness of the material being cut.

A cutting torch must be held with two hands. As the cut progresses, the torch is slid through the support hand.

Oxyfuel gas cutting machines make high-quality cuts at a faster rate than manual flame cutting. An electric motor-driven carriage uses a variable-speed motor to carry a cutting torch along a straight or curved track.

A motor-driven beam-mounted torch consists of one or more torches mounted on a strong beam and is capable of cutting multiple parts at one time. A motor-driven electronic pattern tracer allows the beam-mounted torches to cut parts by following a predrawn pattern.

The motor-driven magnetic tracer and torch is a relatively inexpensive cutting machine that follows a steel pattern to cut parts.

---

Review

Questions

Write your answers on a separate sheet of paper. Please do not write in this book.

1. Oxyfuel gas cutting is also known as ____ or ____ in the trade.
2. What color is steel at its ignition temperature? What is its ignition temperature?
3. Name four fuel gases that may be used in oxyfuel gas cutting.
4. What is the minimum number of preheat orifices that should line up with the cutting line?
5. The torch tip is normally held at a ____°–____° angle from vertical.
6. When cutting metal under 1/8" (3.2 mm) thick, the torch should be lowered to ____°–____° from horizontal.
7. Explain how and why manual oxyfuel gas cutting is a two-handed operation.
8. List three devices used to guide a cutting machine along a line or pattern.
9. True or False? As the thickness of the metal increases, the cutting tip should be angled further from perpendicular to the surface.
10. Sketch a bell-mouthed kerf.