

# Using Metal Cutting Processes and Techniques

**P**REPARING METAL for fabrication may require forming and/or cutting. These procedures can be accomplished with specific equipment, such as hacksaws and files. Common and distinct characteristics of metal are durability, strength, and hardness. As a result of these characteristics, a limited number of tools are needed compared to those required for woodworking.



## Objective:



Explain the processes and techniques of metal cutting.

## Key Terms:



cape chisels  
chisels

diamond-point chisels  
double-cut file

file  
flat chisels  
hacksaw  
rasp

round-nose chisels  
single-cut file  
snips/shears

## Metal Cutting

Metal may be cut by the means of hot or cold cutting processes and techniques. Cold metal cutting is conducted with tools (e.g., hacksaws, files, snips, and cold chisels). Hot metal cutting is performed with oxyfuels, which are a combination of pure oxygen and a combustible fuel gas (e.g., acetylene, MAPP gas, propane, and natural gas).

## COLD METAL CUTTING EQUIPMENT

Cold metal may be cut with a hacksaw, cut-off saw, band saw, bolt cutter, file, snips, shears, or a cold chisel. Cold metal cutting tools are divided into categories depending on their power source: hand or power. The operator provides the power for operating the hand tools, while power tools rely on a source other than the operator.

### Hacksaw

The tool most often used for cutting metal is the hacksaw. A **hacksaw** is a saw with a frame and a blade designed for cutting metal. It is designed so new blades can be installed easily. Hand hacksaw blades are made in 8-inch, 10-inch, and 12-inch lengths, with 14, 18, 24, or 32 teeth per inch. Hacksaw blades can be purchased with an undulated, alternate, or raker tooth arrangement pattern. Low-quality blades have an undulated teeth arrangement.

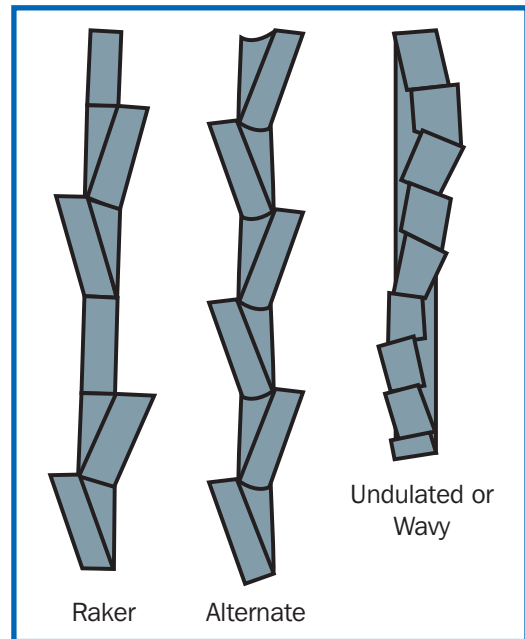


FIGURE 1. Hacksaw teeth patterns.

TABLE 1. Types of Hacksaw Blades

Types of Blades	Purpose
All hard blades are hardened throughout.	They are used for sawing heavy work, tool steel, cast iron, and brass.
Flexible blades have only hardened teeth.	They are used for sawing light and hollow materials.

### Files

A **file** is a tool made of hardened high-carbon steel, with flat or rounded surfaces that are made rough with teeth or grit. It is used for smoothing surfaces or sharpening metal objects. A file can be classified according to its length and shape, teeth design, and teeth coarseness. The coarseness of a file varies with the length. The length of a file is the distance between its heel and point. The file shapes are triangular, half-round, round, and flat.

**TABLE 2. Types of Files**

Design of Teeth	Teeth Characteristics	Coarseness
<b>Single-cut file</b>	The teeth are all going in the same direction.	Different degrees of coarseness are available in a single-cut file: Bastard is coarse grade. Second cut is medium grade. Smooth is fine grade.
<b>Double-cut file</b>	The teeth are going in two directions and cut faster than those in a single-cut file.	Different degrees of coarseness are available in a single-cut file: Bastard is coarse grade. Second cut is medium grade. Smooth is fine grade.
<b>Rasp</b>	The teeth are sharp and pointed.	A rasp has raised, sharp, individual teeth used for shaping wood and for horses' hooves for shoeing (not appropriate for steel).
Curved tooth	The teeth follow a half-round pattern.	It is very coarse (designed to cut soft metals, such as aluminum and copper).

### Cutters

Bolt cutters provide a fast and efficient method of cutting bolts, rods, and other small metals. The capacity of the bolt cutter is stamped on the handle and ranges from  $\frac{3}{16}$  inch to  $\frac{3}{4}$  inch.

**Snips/shears** are large scissor-like tools for cutting sheet metal and fabrics; they are divided into regular or compound aviation. Regular snips/shears are used for light cutting. In contrast, compound or aviation snips/shears are used for heavy cutting. Snips/shears are used for cutting straight, left-hand, or right-hand curves.

### Chisels

**Chisels** are tools made to cut cold metal. When using cold chisels, remember that the chisels must be harder than the metal they are intended to cut. **Flat chisels** are chisels used for chipping, removing metal from a flat surface, and cutting sheet metal. **Cape chisels** are chisels used for cutting narrow, flat grooves and slots. **Round-nose chisels** are chisels used to cut concave grooves. **Diamond-point chisels** are chisels used to cut v-shaped grooves.

### Power Tools

The power hacksaw has a reciprocating movement that operates similar to the hand hacksaw. However, it cuts much faster. The frame holds a rigid blade that is  $\frac{3}{4}$  inch to 1 inch wide and 12 inches to 18 inches long. Blades are available with fine to coarse teeth.

A horizontal band saw has a blade that travels on wheels and moves through rollers and guides; it saws parallel to the ground. Blade movement is forward at all times, so it cuts continuously, which results in faster cutting than the power hacksaw.

A metal cut-off saw, also known as a chop saw, uses a circular blade lowered into the material being cut. The cutting blade is an abrasive disc that provides a straight and clean cut. Meanwhile, the power shear can cut flat, angle, and other structural steel faster and cleaner than by hand or by power saw.



## BROADENING AWARENESS...

### AMAZING ASPECTS: Be Safe

General safety practices for cutting cold and hot metal include the following:

- Obtain the instructor's permission before using any tool or machine.
- Keep the work area and tools clean.
- Wear industrial quality eye protection to protect eyes from sparks and metal chips.
- Wear protective clothing.
- Protect your hair and scalp by restraining long hair and by wearing a cap.
- Keep your mind on your work. Avoid loud talking or disruptive behavior.
- In the event of an emergency, all students involved in or observing the emergency should call for help immediately.
- Know the location and use of fire extinguishers and fire blankets. Know the approved procedure for exiting the laboratory.
- Report all injuries or accidents to the instructor immediately, no matter how slight.
- Always use the right size tool, and use it only for its intended purpose.
- Be certain that stock to be worked is securely fastened in a vise or by clamps.
- Mount vises, anvils, and clamps securely for metalwork.
- Work in a well-ventilated area.
- When lifting heavy objects, obtain help.
- To avoid the possibility of accidental burns, keep hot metal in a safe place until it cools.
- Before leaving the laboratory or work station, make certain the heat source is shut off and cool.
- Do not perform hot metalwork on wood floors or near flammable materials. Never work on containers that have been used for storage of combustible material.
- Keep cables and hoses from coming in contact with hot metal and sharp objects. Never point a flame at cables or hoses.

## COLD METAL CUTTING PROCESSES AND TECHNIQUES

Proper tool procedures and maintenance practices must be followed to correctly cut cold metal. Safety glasses and safety procedures are especially important with metalwork. The operator should be aware of proper tool procedures and tool use prior to beginning. Cold metal tools require maintenance practice (e.g., cleaning and sharpening). The following are simple steps required for proper tool use.

### Using a Hacksaw

1. Wear safety glasses.
2. Select a blade with enough teeth per inch so two or three teeth are in contact with the metal at all times. There must be few enough teeth to the inch to allow the gullets to carry off the chips without clogging.
3. Fasten the blade into the hacksaw frame with the teeth pointing away from the handle of the saw. Make sure the blade is fastened securely so it will not twist and break.
4. Mark the stock at the point at which it is to be cut.
5. Place the stock in the vise, with the mark about  $\frac{1}{2}$  inch from the jaws. Sawing close to the jaws of the vice makes the sawing easier because the piece is held firmly and does not spring back and forth.
6. Place the saw on the mark. Then pull it toward you using a little pressure to start the kerf. To help get the saw started in the proper place, a notch can be cut at the mark with a file.
7. Apply slight pressure on the forward strokes of the hacksaw, and release the pressure on the return strokes to insure proper cutting and to lessen the danger of breaking the blade.
8. Run the saw evenly, using long strokes, with all the teeth cutting to prevent wear on a small portion of the blade, thus shortening the blade's life.

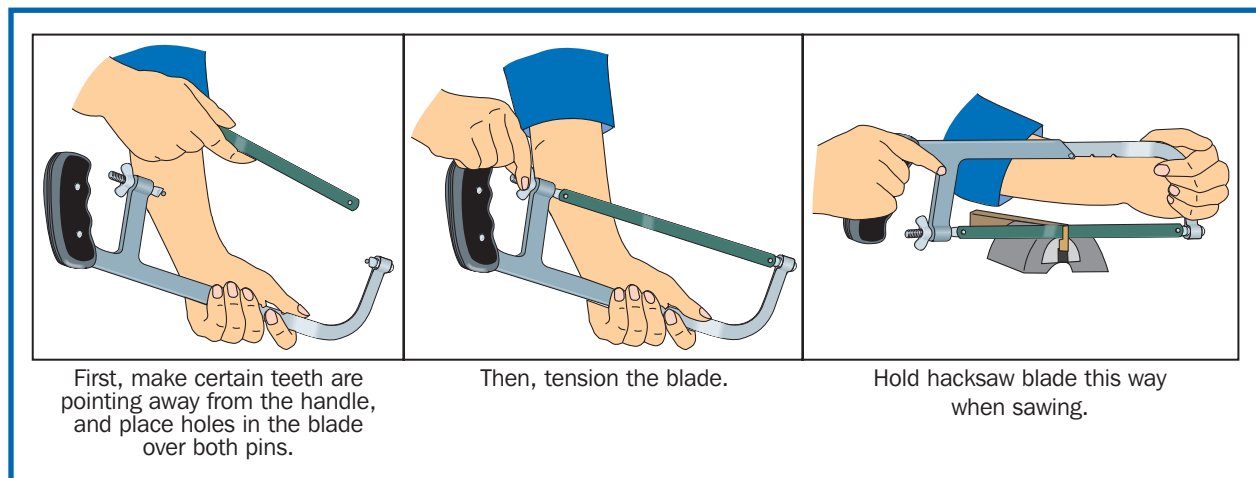


FIGURE 2. Installing a blade and proper holding of the hacksaw.

- Thin metal can be cut more easily with a hacksaw if a thin piece of wood is clamped on each side. Saw through the metal and wood pieces simultaneously.
- Similar procedures should be followed when using a horizontal band saw.

### **Using a Chisel**

- Wear safety glasses.
- Mark the material to be chiseled.
- Select the correct chisel for the job. Make sure the edge is in good condition.
- Place the stock in a vise, or clamp it to the table. Watch the edge of the chisel as you work.
- Sharp, quick blows are best. Reset the chisel after each blow.
- The angle of the cutting edge of a chisel should be approximately 65 degrees, with the cutting edge slightly rounded.
- In removing metal, hold the chisel at an angle that will keep the surface of the work and the lower bevel of the chisel parallel.
- When cutting heavy, round stock, cut halfway through, and then turn the stock and make the rest of the cut from the opposite side.

### **Using a File**

- Wear safety glasses.
- Mark the material to be filed.
- Place the stock in a vise, or clamp it to the table.
- Select the correct file for the job.
- File teeth usually slant toward the point of the file and, therefore, cut only on the forward stroke.
- A handle should be placed on the tang of the file.
- Hold the handle of the file against the palm of the hand, with the thumb on the top of the handle.
- Hold the point of the file with the thumb and index finger of the other hand.
- Use pressure on the forward stroke only, and use only enough pressure to make the file cut evenly. Do not bear down hard on a new file, or the teeth will be ruined. A new file should be broken in by using it first on brass or bronze.
- Lift the file on the return stroke.
- Do not take more than 30 to 40 strokes a minute. Excessive speeds will ruin the file and the work.

12. Rubbing chalk on a file before it is used will help prevent it from becoming clogged. If a file becomes clogged, it may be cleaned with a file card, pick, and brush.
13. Do not use a file on material harder than the file.
14. Store files in separate holders to prevent their rubbing together or knocking against other tools. The teeth are brittle and thus are easily dulled or broken.

### Using Snips or Shears

1. Wear safety glasses.
2. Mark the material to be filed.
3. Place the stock in a vise, or clamp it to the table.
4. It is advisable to wear gloves when handling and working with sheet metal.
5. Select the correct shears for the job. Select a pair of shears that are sharp and free of nicks.
6. A piece of scrap should be cut first to be sure the shears are heavy enough.
7. Shears are used in the same manner as scissors. For them to work well, the metal must curl or lift up and out of the shear as the cut progresses.

### Using Power Tools

1. Wear safety glasses. Hearing protection may be needed.
2. Mark the material to be cut.
3. Be sure the saw is properly adjusted, and the blade in the machine should be designed to cut the kind of material you are using.
4. Place the stock on the table of the saw, and use the vise or clamp to hold it securely.
5. Hold the handle with one hand, and turn on the switch.
6. Lower the saw into and through the material to be cut, using a slow and deliberate motion.
7. After the cut is made, let the saw rise. Then turn off the switch.
8. After the saw has stopped turning, release the handle and remove the material.



FIGURE 3. Cutting metal with a cutoff saw.

## Using a Power Hacksaw

1. Be sure safety glasses are worn.
2. Mark the material to be filed.
3. Make sure the saw is properly adjusted and that the blade in the machine is designed to cut the kind of material to be cut.
4. Place the frame in the raised position.
5. Adjust the vise on the machine to hold the metal at the desired angle.
6. Position the metal in the vise on the machine and tighten securely.
7. Turn on the machine.
8. Lower the frame slowly and carefully until the blade is on the stock and is starting to cut.
9. If equipped with coolant, turn it on.
10. Stay near the machine while it is cutting.
11. Switch off the machine when the cut is finished if it does not turn off automatically.
12. Remove all scrap metal, and clean up all metal dust and coolant.

## HOT METAL CUTTING EQUIPMENT

Hot metal can be cut with a hardy or a hot cutter, fuel gas equipment, arc welder, or plasma cutter. Metal is measured and marked before it is heated. Use a center punch to mark the location. Pencil or chalk marks will burn off. Using the hardy or a hot cutter to cut hot metal is a delicate process that may require the help of another person.

### Fuel Gas

Fuel gas welding equipment with a cutting attachment is a useful and popular way to cut metal. When oxygen strikes a preheated metal surface, it causes the metal to burn or oxidize. The oxygen combines with the heated iron to form a molten metal and

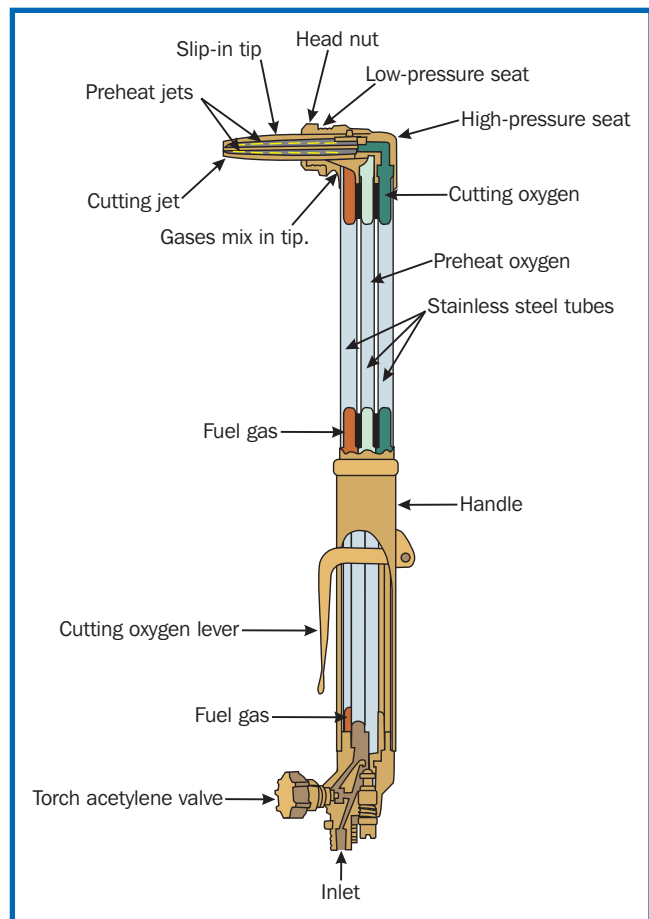


FIGURE 4. Oxyacetylene cutting attachment parts.



slag that flows or is blown away, exposing more metal to the oxygen jet. The tip of a cutting blowpipe has several small holes located around a larger hole in the center of the tip. The small holes permit the oxyacetylene mixture to pass through them. They provide flames to preheat the metal before it is cut. The large hole in the middle of the tip supplies a jet of oxygen under high pressure that does the actual cutting after the metal is preheated to a red heat.

### Arc Welding Electrode

The arc welding electrode can be used for cutting metal. An electrode is useful for cutting cast iron, for cutting in inaccessible places, and for cutting small jobs. The use of an arc is usually considered to be the best method of cutting cast iron because cast iron does not oxidize with heat.

### Plasma Arc Cutters

Plasma arc cutters work by sending an electric arc through a gas passing through a constricted opening. The gas can be shop air, nitrogen, argon, oxygen, etc. This elevates the temperature of the gas to the point it enters a fourth state of matter: plasma. As the metal being cut is part of the circuit, the electrical conductivity of the plasma causes the arc to transfer to the work. The restricted opening or nozzle the gas passes through causes it to squeeze by at a high speed. The high speed gas cuts through the molten metal. The gas is also directed around the perimeter of the cutting area to shield the cut. Plasma cutters are ideal for cutting mild and stainless steel, aluminum, brass, and copper.

Computer numerically controlled (CNC) plasma cutters fully automate the shape production process. These machines can be relatively inexpensive units that operate via personal computers. Those used with expensive, limited-production computers made specifically for running the burning machines may cost as much as \$100,000.

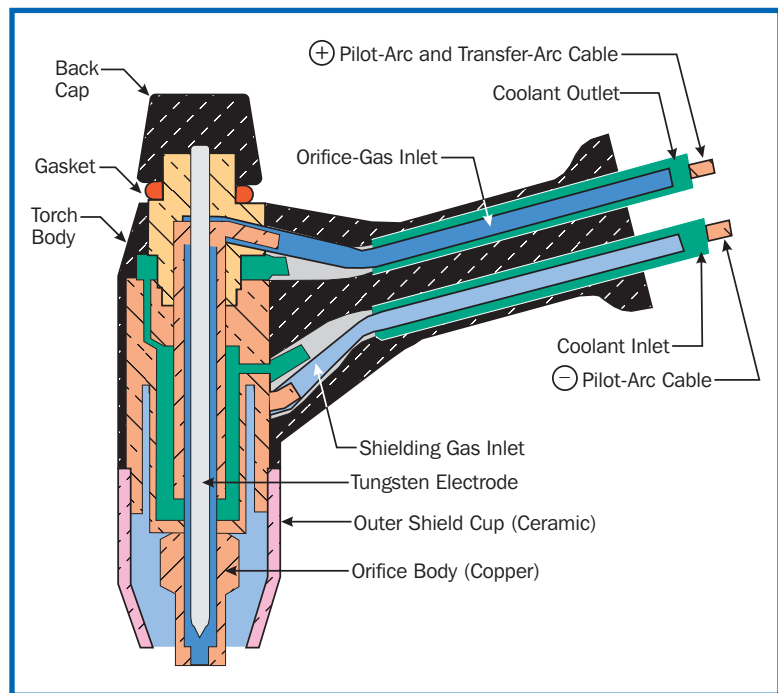


FIGURE 5. Plasma arc torch parts.

## HOT METAL CUTTING PROCESSES AND TECHNIQUES

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Proper tool procedures and maintenance practices must be followed to correctly cut hot metal. Safety glasses, welding gloves, and safety procedures are especially important when working with hot metal. The operator should be aware of proper tool procedures and uses. Hot metal equipment also requires maintenance practices. The following are simple steps required for proper usage:

### **Using the Hardy**

1. Place the hot metal over the hardy in line with the cut.
2. Strike the metal directly over the hardy until the cut is almost through.
3. Finish the cut by striking the metal just beyond the cutting edge of the hardy.
4. When finishing the cut, be careful not to strike the cutting edge of the hardy with the hammer.

### **Using the Hot Cutter**

1. Be sure safety glasses and gauntlet or welding gloves are worn.
2. Place the hot metal flat on the anvil, and set the cutting edge of the handled hot cutter at the mark.
3. Strike the head of the hot cutter with a hammer until the metal is cut almost through.
4. Cool the hot cutter frequently in water to prevent drawing its temper.
5. Slide the metal over until the cut is just past the edge of the anvil. Finish the cut with light blows of the hammer. Be careful not to let the cutting edge of the hot cutter come in contact with the face of the anvil. The anvil face is made of hardened steel and will dull or break the cutter.
6. To help prevent flattening the end of round stock, use a combination of the hardy and hot cutter.

### **Using Fuel Gas**

1. Mark a line with a center punch about 1 inch from the edge of the piece of steel. Make several marks along the line, or use a scribe to make a line.
2. Place the piece of steel on the welding table so the mark clears the edge of the table by at least 1 inch. A piece of metal clamped to the metal to be cut may be used as a guide.
3. Wear safety glasses. Put on a gas welding face shield or goggles and gloves.
4. Light the cutting blowpipe.
5. Follow the same procedures for lighting, adjusting, and shutting down the blowpipe as in fuel gas welding.

6. Check to see that a neutral flame is present.
7. Hold the blowpipe with the nozzle perpendicular to the surface of the metal, with the inner cones of the preheating flames at the edge of the piece of steel and about  $\frac{1}{16}$  inch above the chalk line.
8. Hold the blowpipe steady at this spot until the steel becomes a bright red. Then slowly press down the cutting-oxygen valve lever. A bright red color indicates that the steel is near the melting point.
9. Move the blowpipe slowly along the cut-off line, cutting completely through the metal as the cutting proceeds.



FIGURE 6. Cutting steel.

### Using an Arc Welding Electrode

1. Wear safety glasses.
2. Put on an electric welding face shield and gloves.
3. When cutting flat metal, which is thicker than the electrode, the metal to be cut is placed in a flat or horizontal position.
4. Strike the arc where the cut is to be made, and allow the heat of the arc to form a crater of molten metal.
5. Move the electrode back and forth to force the molten metal from the cut or kerf.
6. A downward pushing motion coupled with a quick upward motion helps force the molten metal from the cut.

### Using a Plasma Cutter

1. Wear safety glasses.
2. Turn on the machine, and set it to the manufacturer's recommendations.
3. Put on an electric welding face shield and gloves.
4. Hold the plasma arc gun with the contact tip perpendicular to the surface of the metal at the edge of the piece of steel and no closer than  $\frac{1}{16}$  inch above the cut-off line.
5. Depress the trigger on the gun and move slowly along the cut-off line, cutting completely through the metal as the cutting proceeds.
6. When the cut is complete, let loose of the trigger to extinguish the arc.

## Summary:

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Metal fabrication requires numerous steps and knowledge of specific tools. Metal cutting allows for steel to be heated to the point where it burns and is removed. Metal cutting can also be accomplished with cold metal tools, such as a chisel or a hacksaw.

Cold metal may be cut with a hacksaw, cut-off saw, band saw, bolt cutter, file, snips/shears, or a cold chisel. Cold metal cutting tools are divided into categories depending on their power source: hand or power. Hot metal can be cut with a hardy or a hot cutter, fuel gas equipment, an arc welder, or a plasma cutter.

Safety practices are important to follow when working with cold or hot metalwork. Safety glasses should be used at all times. Wearing protective clothing and providing attentiveness to the work environment are essential safety practices.

## Checking Your Knowledge:

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1. What is used to mark metal when preparing for a hot metal cut?
2. What is the difference between a single-cut file and a double-cut file?
3. What are the proper steps when using snips/shears?
4. What types of hot metal tools are used when making a cut?
5. How can an operator in an agricultural shop be safe when cutting metal?

## Expanding Your Knowledge:

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You are assigned to purchase a new metal cutting saw for your agricultural shop. Compare different machines. Research the safety features. Read the following article to assist you in finding the right saw: <http://www.metalcuttingsaw.net>.

## Web Links:

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### **Metalwork—Bench Tools—Files**

<http://www.practicalstudent.com/subjects/metalwork/benchtools/pages/files.html>

### **Using Tools**

<http://www.using-tools.com/chisels.htm>

### **Using a Hand-Held Plasma Cutter**

<http://www.thefabricator.com/article/plasmacutting/using-a-hand-held-plasma-cutter>