Lesson 1: Common Hand Tools for Woodworking

Before beginning a woodworking project, workers must be familiar with shop safety rules and knowledgeable about common hand tools. Hand tools are usually used for smaller projects or where power tools or machines would be inefficient. For example, when smoothing a small piece of lumber, a hand plane is more practical than a power plane. An agricultural mechanics shop should have a good selection of hand tools to accommodate a large variety of woodworking projects.

Basic Shop Safety Procedures

The following are general safety procedures that apply to almost every work situation.

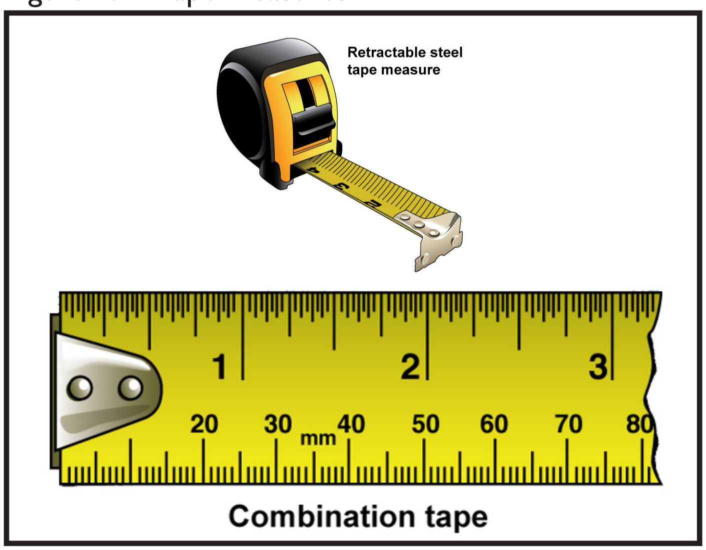
- Adhere to instructions.
  - Read labels and warnings on containers and tools.
  - Follow the manufacturer's recommendations for use and maintenance of a specific tool.
  - Pay attention to signs posted in the work area.
  - Follow the instructor's directions.
- Wear safety glasses in the shop at all times.
- Wear protective gear such as gloves, earplugs, and safety shoes if appropriate.
- Do not wear loose-fitting clothing that could get caught in a moving part.
- Wear a hair net to prevent long hair from getting caught in a tool.
- Keep work areas clean and free of clutter.
- Inspect each tool before using it to make sure it is working properly.
- Tell the instructor about any damaged tool.
- Do not use a tool that is not working properly.
- Return each tool to its proper place of storage.

Common Measurement Tools

Measurement tools are used to ensure accuracy and consistency of a project. They are used for determining linear measurements such as length and width and area measurements such as square feet. They are also used for checking if work is square or level. Some common measurement tools are as follows. The basics are introduced here and more information is provided in Unit III, Lesson 1: Common Measurements and Measurement Tools.

A tape measure is typically used for making straight measurements and taking measurements around objects (circumference). Tape measures are available that use the U.S. customary system, metric system, and a combination of the two systems. See Figure 1.1.

Figure 1.1 - Tape Measures

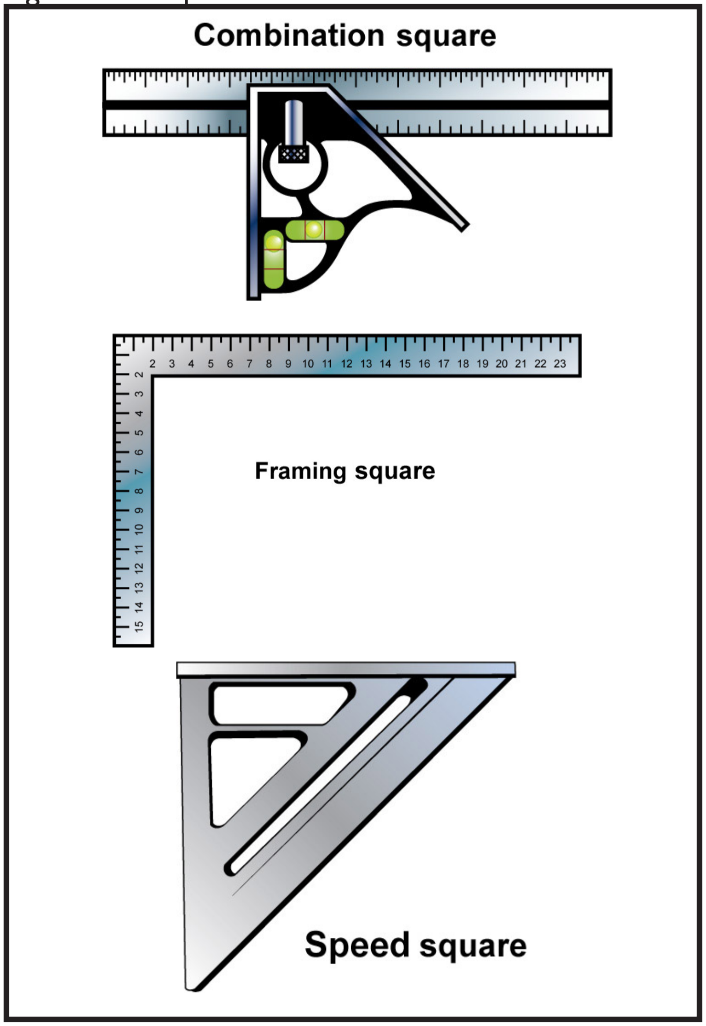


A combination square consists of multiple tools and its uses include a rule, marking gauge, level, and try square for inside and outside measurements.

A framing square, an L-shaped metal measuring device, is used for framing and laying out stairs.

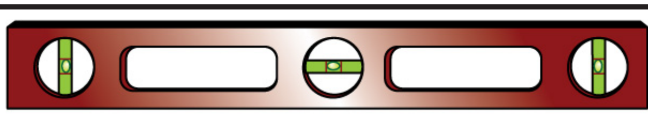
A speed square is shaped like a triangle but functions as a square. Its uses include laying out stairs and rafters and measuring and marking miter cuts. See Figure 1.2.

Figure 1.2 - Squares



A level generally consists of a bar of wood or aluminum with transparent tubes (horizontal for level and vertical for plumb), each containing an air bubble. It is a device used to determine if an object is level or plumb. See Figure 1.3.

Figure 1.3 - Level



Horizontal tube - checks level
Vertical tube - checks plumb

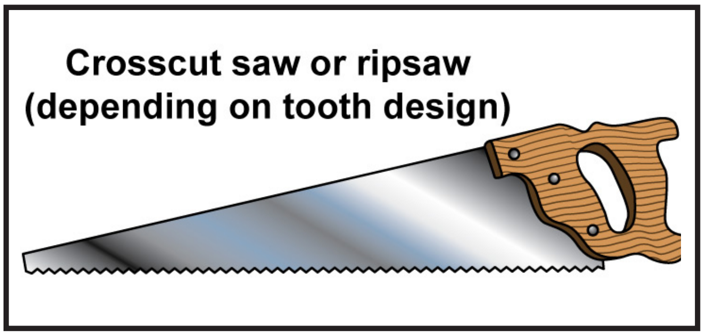
Common Cutting Tools

All saws are similar in that they are used for cutting material. They have a steel blade with teeth on the edge that is fastened to a wood or plastic handle. However, the design of the saw determines what type of cut it will make and what material it will most effectively cut. The following are some common handsaws used in woodworking. The functions of these saws are covered in more detail in Unit III, Lesson 2: Working With Saws.

A ripsaw is used to make straight cuts with the grain of the wood. The teeth of a ripsaw are chisel-shaped and most cutting is done on the forward stroke.

A crosscut saw is used to make straight cuts across the grain of the wood. The teeth of a crosscut saw are pointed like a knife and cut on both the forward and backward strokes of the blade. See Figure 1.4.

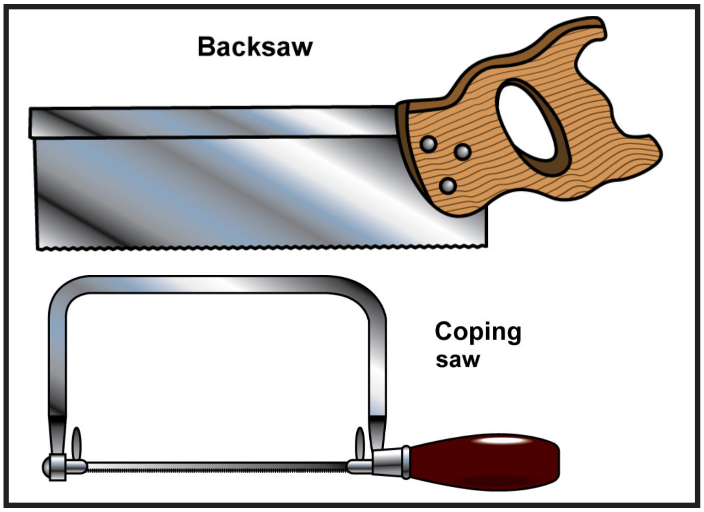
Figure 1.4 - Crosscut Saw or Ripsaw



A backsaw is commonly used in cutting joints. It is frequently positioned in a miter box (device used to guide the angle of a cut) to make very accurate cuts in smooth lumber. This saw is similar to a crosscut saw, but it has a reinforced, metal spine and finer cutting teeth.

A coping saw is used to make irregular or curved cuts in wood. This saw's blade is extremely thin and narrow and can make very fine cuts. See Figure 1.5.

Figure 1.5 - Other Common Handsaws



Common Smoothing and Shaping Tools

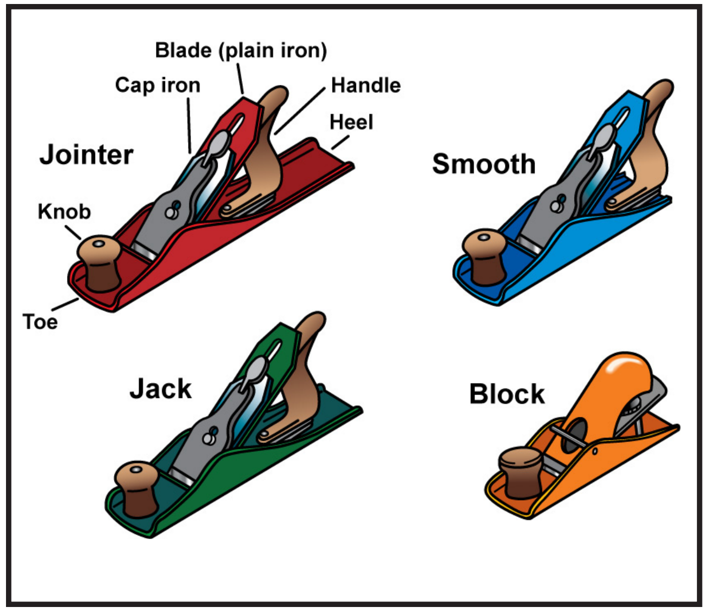
After the major cuts are made, smoothing and shaping tools are used to remove small amounts of wood to refine the surface of the stock. The tools in this group include planes, chisels, files, rasps, and forming tools.

Planes are designed for working on edges, ends, and faces of boards. They are used for trimming boards to size, beveling and chamfering edges, and squaring uneven stock. The blade of a plane, called the plane iron, should be set parallel to the bottom or sole of the plane to avoid cutting the stock unevenly or jamming the plane. When using a plane, it is preferable to make a series of cuts rather than trying to remove too much stock at once, which could also jam the plane or over¬- cut the mark. When the stock is cut square, the shaving should be the same width as the stock or, for larger surfaces, the same width as the cutting edge.

Common planes and their lengths include jointer (22 to 28 in.), fore (18 in.), jack (11 to 15 in.), smooth (6 to 10 in.), and block (4 to 6 in.). The jointer and fore planes are best for smoothing long edges and surfaces. The jack plane is a good all-purpose smoothing tool and is also used for working on rough surfaces and removing marks such as mill marks.

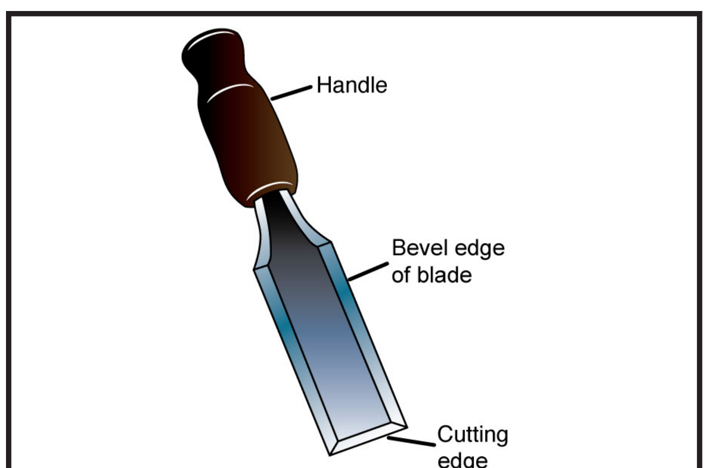
The smaller smooth plane is an efficient plane for home use. All four of these planes cut with the bevel edge down. The block plane, the smallest plane, can be used with one hand, whereas the other planes require two-hand operation. It is used for close work, particularly on the end grain of wood. Unlike the others, the block plane cuts with the bevel edge up. See Figure 1.6.

Figure 1.6 - Common Types of Planes



Chisels are tools that can remove thick or thin shavings of wood, depending on how they are held, and can be used in places that are inaccessible to saws or planes. They can also be used for cutting precise grooves for making joints. Similar to the iron in a plane, a chisel has a blade with a flat side and a beveled edge. The blade of a chisel is attached to a wood or plastic handle. See Figure 1.7.

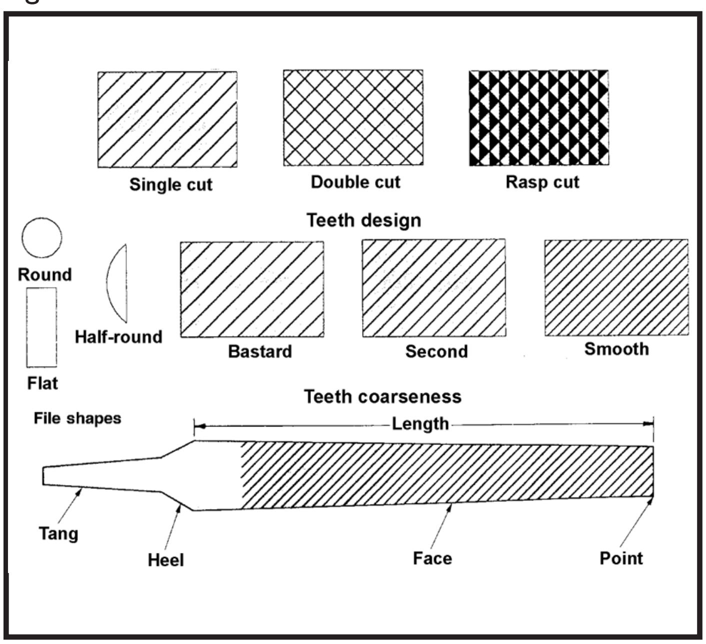
Figure 1.7 - Wood Chisel



In making joints, a chisel is used for cutting a dado (square or rectangular groove made to receive another board) and a rabbet (cut at the end of a board made to receive another board). Holding the chisel with the bevel side down makes a deeper cut and holding it with the bevel side up makes a lighter, planing cut. A mallet is used to strike the handle rather than a hammer to avoid damaging the chisel.

Files and rasps are useful for forming and smoothing irregular shapes such as curves and holes. They are classified by shape (triangular, half-round, round, and flat), length (6 in., 8 in., 10 in., and 12 in.), teeth design (single cut, double cut, and rasp cut), and teeth coarseness (bastard, second cut, and smooth). See Figure 1.8. The wood to be filed must be put in a vise or other device to hold it firmly. Files should be held at a slight angle to the work, with filing done from the edge to the center to avoid splintering the wood. To avoid puncture wounds from the tang (smooth, pointed end), always use a file with a handle. A file card or brush is used to clean the teeth to keep them free of material.

Figure 1.8 - Files



Rasps are classified as files, but most woodworkers refer to them as rasps. Rasps are similar to files but have teeth that are separate and raised and not in continuous rows. They are better suited for rough work and forming because they remove material more quickly than files.

To maintain files and rasps, keep them dry to avoid rust. In addition, avoid dropping them and storing them with other files to prevent dulling their teeth.

Other tools in the shaping and smoothing category are called forming tools such as those commercially known as Surform. These tools have characteristics and functions that are similar to planes, files, and rasps. They frequently resemble these tools and can sometimes be used in place of them. The main differences between the forming tools and other shaping tools are that the blades in the forming tools are replaced and not resharpened and the open back design of the forming tools eliminates clogging. Varying the angle of a forming tool changes the degree of the cut, ranging from removing a lot of wood quickly to achieving a polished appearance.

Common Drilling and Boring Tools

Both drilling and boring tools are used to cut holes in wood. However, the term "drilling" is typically used for cutting holes 1/4 in. or smaller and the term "boring" is used for cutting holes larger than 1/4 in. The most common tools for drilling and boring are the hand drill and brace.

A hand drill, generally used for cutting holes 1/4 in. or smaller, consists of a handle, crank, and chuck for holding twist drills (replaceable bits that do the cutting). See Figure 1.9. When turning the crank and gears, the bit turns faster than the handle, which in turn reduces the turning power to the bit. The size of a hand drill is determined by its chuck capacity; two common sizes are the 1/4-in. and 3/8-in. models.

A brace, generally used for cutting holes larger than 1/4 in., consists of a head, handle, ratchet, and chuck for holding bits such as auger bits (common bits for drilling large holes). See Figure 1.10. A brace operates by turning an offset handle, which provides the leverage for turning larger bits. The size of a brace is determined by its sweep, the diameter of the circle made by the handle as it turns. The purpose of the ratchet is to permit boring in tight areas where a full sweep of the handle cannot be made.

Figure 1.9 - Hand Drill

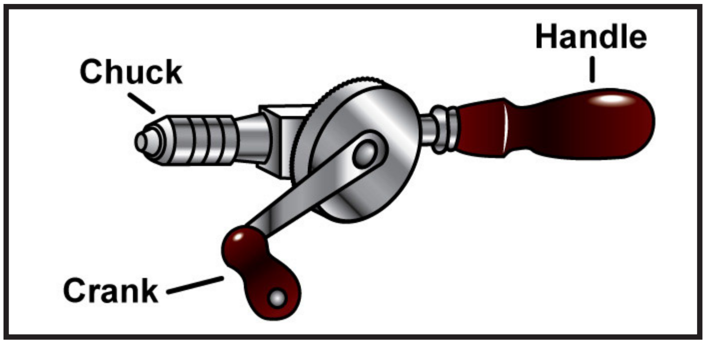
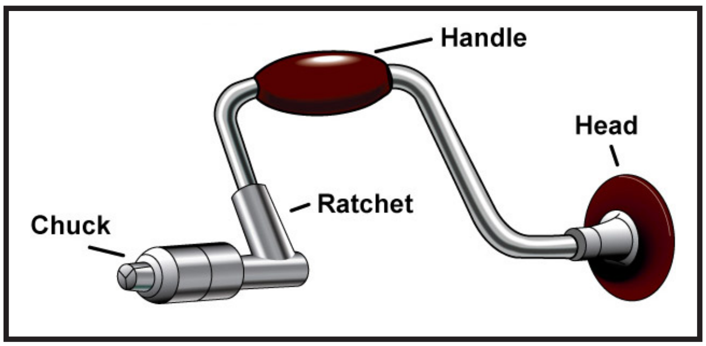


Figure 1.10 - Brace

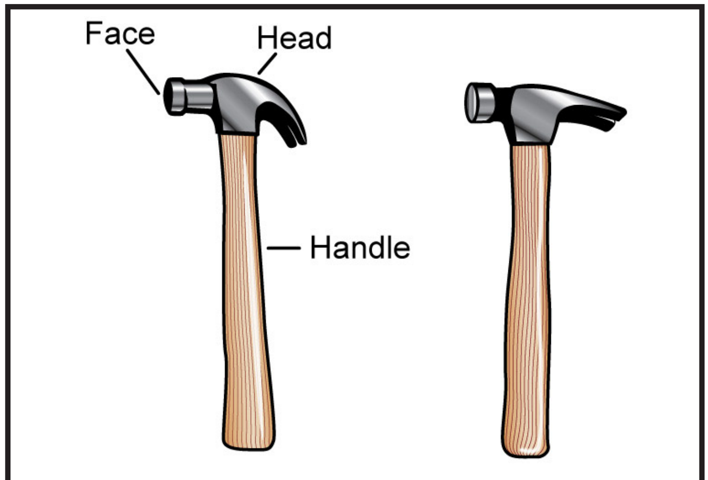


Common Tools and Materials for Fastening

The tasks of joining one or more pieces together or attaching an object to a wall are common to most woodworking projects. To perform these tasks, woodworkers need to use fasteners and adhesives. Common tools used to apply fasteners are hammers and screwdrivers and common fasteners include nails, screws, and adhesives.

A claw hammer, consisting of a metal head and a wood or plastic handle, is used to drive nails into wood and remove nails. See Figure 1.11. The size of a hammer is determined by the weight of its head. Many woodworkers prefer to have one hammer for light work (9- or 10-oz hammer) and one for heavier jobs (14- to 16-oz hammer). When removing nails with the claw of the hammer, a wood block placed under the head increases the leverage and protects the work surface. For removing longer nails, another prying tool called a wrecking bar is recommended.

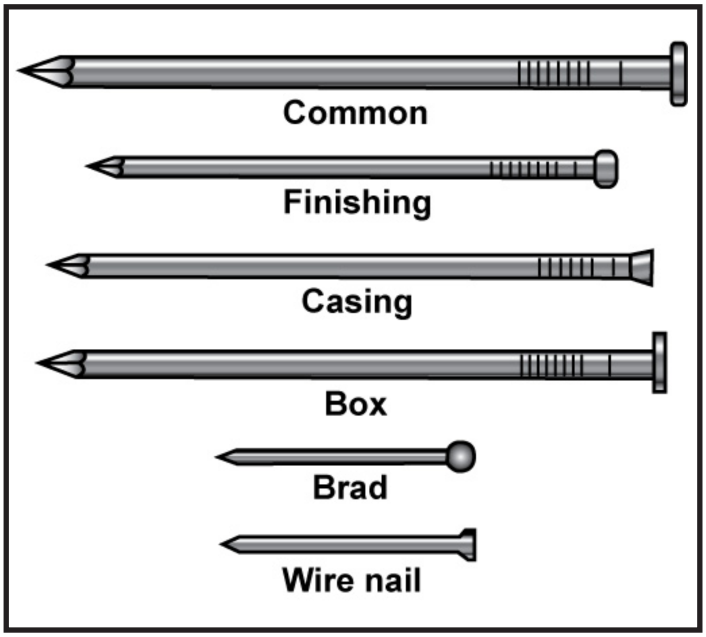
Figure 1.11 - Hammers



Nails come in a wide variety of shapes and sizes. It is important to choose the right kind and size of nail to avoid splitting or distorting the wood. The length of a nail from head to point is designated by the penny system. The letter "d" is used to indicate penny. For example, a two-penny nail is 1 in. long and written as "2d." A gauge system is used to measure the diameter of a nail. With most nails, the gauge number decreases as the diameter of the nail increases.

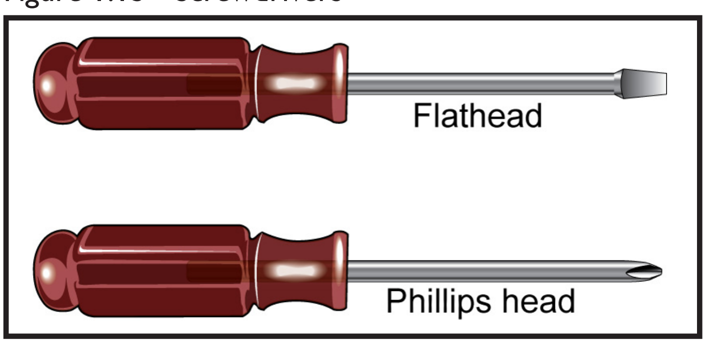
Some types of nails available include common, finishing, casing, box, brad, and wire. Two of the most frequently used nails for woodworking are common nails and casing nails. Common nails have flat heads and are used in framing and rough construction, where appearance is not as important. Casing nails have small, cone-shaped heads and are used in cabinetry work such as door casings, where the head is countersunk and covered. See Figure 1.12.

Figure 1.12 - Common Types of Nails



Screwdrivers, consisting of a handle, metal blade, and tip, are used to drive screws. For efficient operation, the screwdriver's tip should fit the slot of the screw as closely as possible. For example, using a tip that is too thin for the slot can bend the tip and using a tip that is too thick for the slot reduces leverage. Using the correct size screwdriver provides ample leverage and makes the screwdriver less likely to slip. Common types are the standard or flathead, which has a flat, bladelike tip, and the Phillips, which has a pointed tip. See Figure 1.13. Standard sizes are designated by the bar length and width of the tip and Phillips sizes come in point sizes.

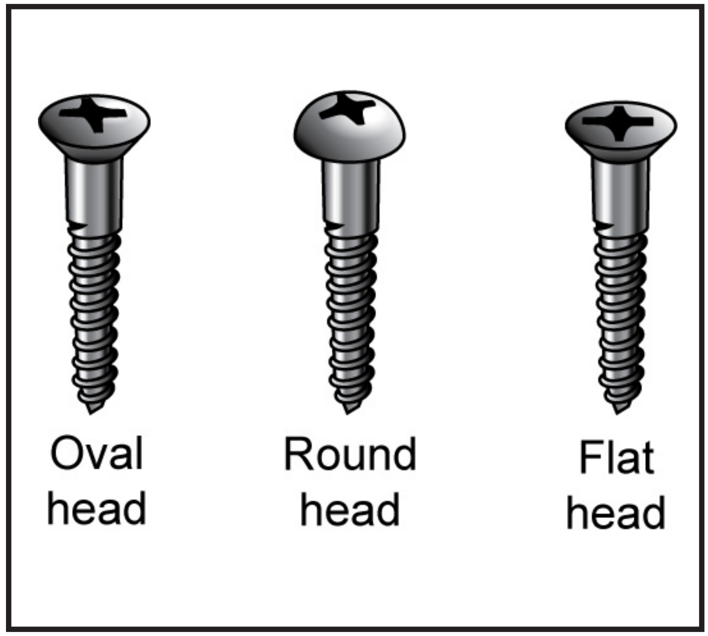
Figure 1.13 - Screwdrivers



Screws are used to provide more holding power than nails and when a project requires disassembly. They come in varying lengths (1/4 to 6 in.) and gauges (0 to 24).

Common woodworking screws include the oval head, which has a head that fits partially below and above the surface; round head, which has a head that fits on top; and flat head, which has a head that fits flush with the surface of the stock. See Figure 1.14.

Figure 1.14 - Common Types of Screw Heads



As an alternative to metal fasteners, woodworkers can also use adhesives. An adhesive is a substance that sticks or bonds two materials together. The adhesives group includes adhesives, made from synthetic materials; cements, made from rubber-based materials; and glues, made from natural materials. Selecting the right adhesive depends on many factors such as the setting rate, water resistance, flexibility, and sandability.

Summary

Woodworking in agricultural mechanics requires the skillful use of a wide variety of hand tools. Workers should be familiar with tools for measuring, cutting, smoothing and shaping, drilling and boring, and fastening and should know how to pick the right tool for the job.

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Lesson 2: Common Hand Tools for Metalworking

This lesson covers the common tools for metalworking in a similar fashion to the previous lesson on woodworking. As with woodworking, hand tools continue to have an important function in metalworking in agricultural mechanics. It is important to become familiar with shop safety rules and the names and functions of the tools before beginning a metalworking project.

Basic Shop Safety Procedures

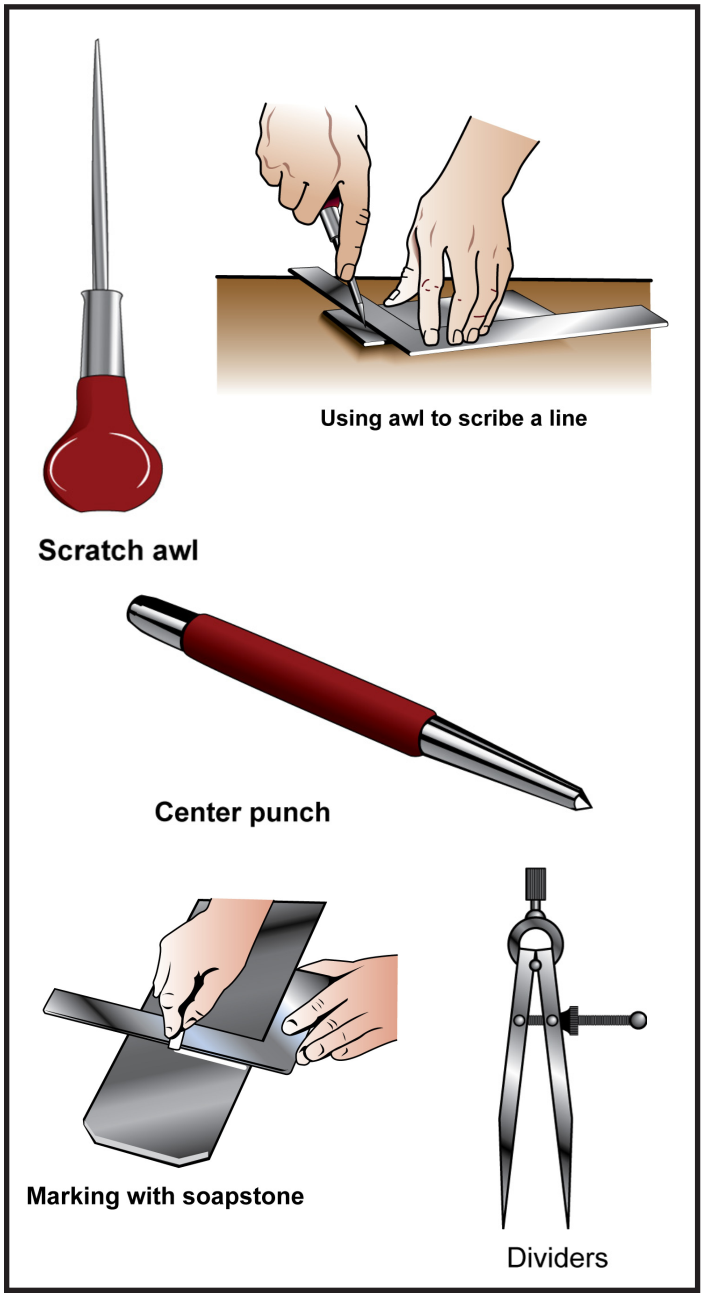
The following are general safety procedures that apply to almost every work situation.

- Adhere to instructions.
    - o Read labels and warnings on containers and tools.
    - o Follow the manufacturer's recommendations for use and maintenance of a specific tool.
    - o Pay attention to signs posted in the work area.
    - o Follow the instructor's directions.
- Wear safety glasses in the shop at all times.
- Wear protective gear such as gloves, earplugs, and safety shoes if appropriate.
- Do not wear loose-fitting clothing that could get caught in a moving part.
- Wear a hair net to prevent long hair from getting caught in a tool.
- Keep work areas clean and free of clutter.
- Inspect each tool before using it to make sure it is working properly.
- Tell the instructor about any damaged tool.
- Do not use a tool that is not working properly.
- Return each tool to its proper place of storage.

Common Marking Tools

A sharp pencil with hard lead works well for marking wood, but pencil marks rub off of metal easily and do not show up. Consequently, other marking tools are used for metal that either adhere to or scratch the surface of metal. Some common tools for marking metal are as follows. See Figure 2.1.

Figure 2.1 - Common Marking Tools



A scratch awl is used with a straight edge to scratch straight lines in metal. It consists of a pointed metal shaft attached to a wood or plastic handle and must be kept sharp to ensure fine, accurate markings.

Dividers are used for scribing arcs and circles on metal. They also are used to transfer dimensions from one scale or object to another item. They consist of two steel legs with sharp points.

Soapstone, a soft, gray rock, is cut into thin pieces and used like a pencil to mark metal. The stone marks the surface of metal rather than scratches it and is harder to rub off than chalk or pencil marks.

A permanent marker that has a hard tip and fine point can also be used to mark an accurate line on metal. A marker is safer to use than an awl and its mark is harder to rub off than pencil or chalk marks.

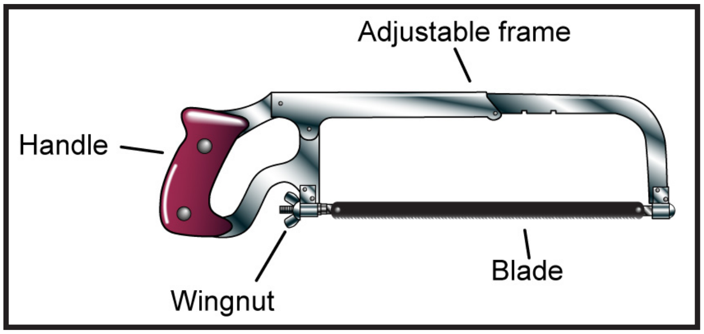
A center punch is a pencil-shaped tool that is used to make a small dent in metal for marking the center of a hole and starting a twist drill bit. It is made of steel with the end ground to a 90-degree angle. To mark a hole, the point of the punch is positioned on the metal and the other end is tapped lightly with a hammer.

Common Cutting Tools

Metals are not as easy to cut as wood, so tools for cutting or shaping metal are more limited. The following common metalworking hand tools cut metal and remove unwanted material in different ways.

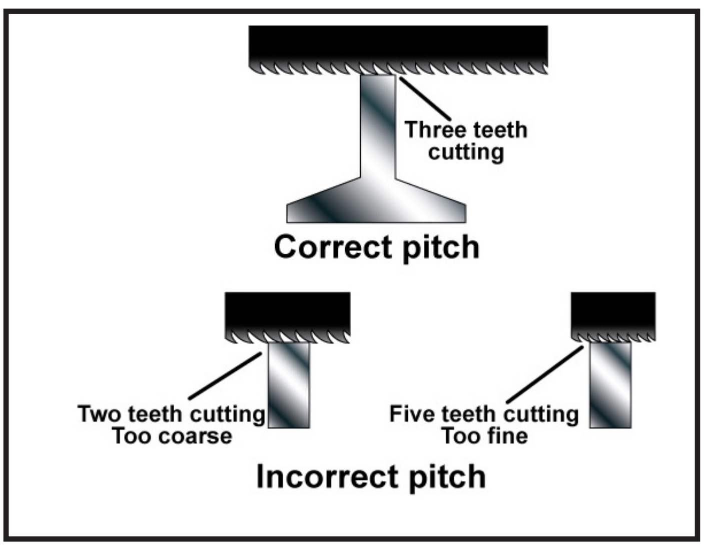
A hacksaw is one of the most useful cutting tools for metal. These saws consist of a handle, frame, blade, and wingnut. See Figure 2.2. They use two types of blades: a solid (all-hard) blade or a flexible blade. A solid blade is good for long-term use and is mainly used for cutting tool steel, cast iron, and larger pieces of mild steel. Good for short-term hard use, a flexible blade is typically used for cutting channel iron, tubing, copper, and aluminum. The entire blade of a solid blade is hardened, whereas only the teeth of a flexible blade are hardened.

Figure 2.2 - Hacksaw



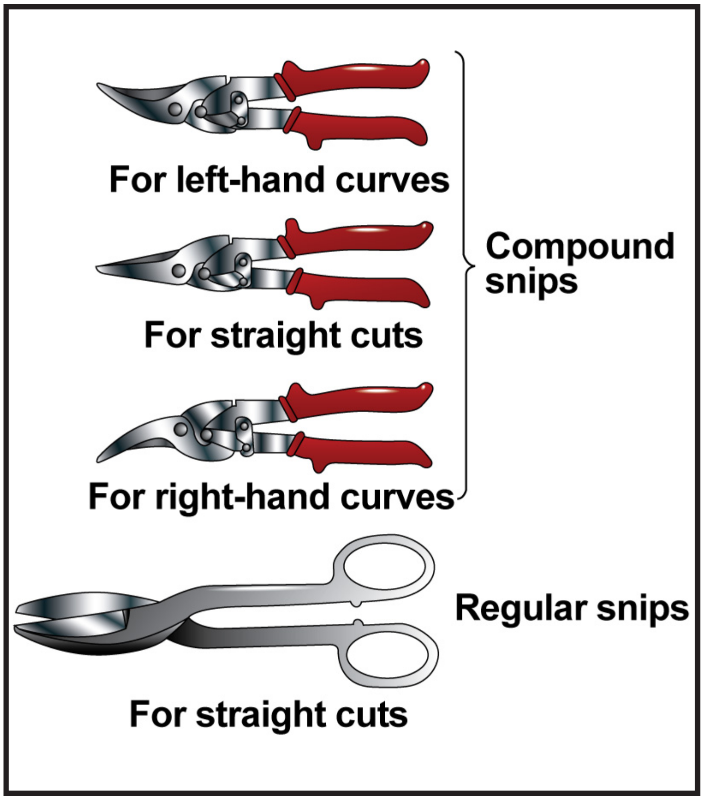
The blade of a hacksaw is designed to cut on the forward stroke and must be installed so that the teeth face the front of the saw, away from the handle. In selecting the correct blade for the material to be cut, the most important factor is its pitch (number of teeth per inch). Another consideration is comparing the size of the metal to be cut with the pitch to ensure the blade will have three teeth on the metal at all times. This will help eliminate clogging the teeth (too many teeth) and prevent breaking the teeth (too few). See Figure 2.3.

Figure 2.3 - Hacksaw Pitch



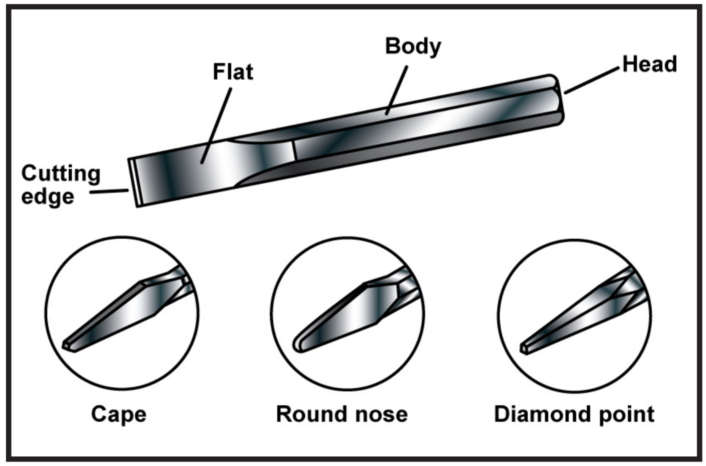
Shears or snips are scissorlike tools for cutting metal such as wire and sheet metal. Regular snips do all their work by the force applied by the operator. They are useful for cutting thin metal. Aviation or compound snips have compound handles that increase leverage for cutting heavier stock. See Figure 2.4.

Figure 2.4 - Snips



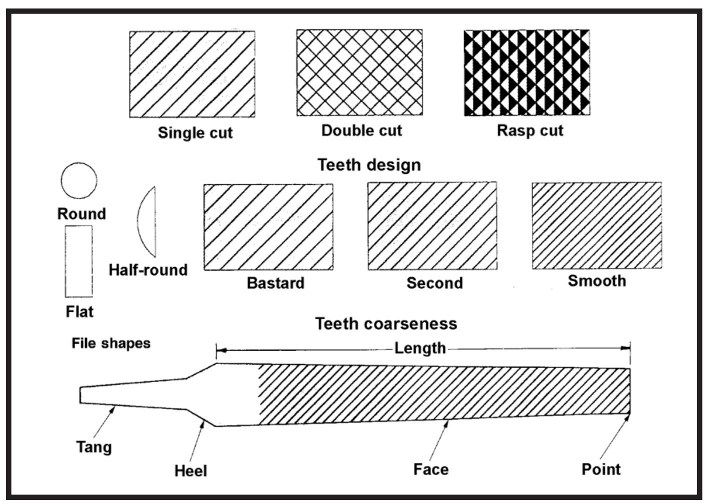
Cold chisels are used for chipping (removing or cutting pieces of metal) and shearing (cutting metals apart). The basic design of a chisel is a cutting edge, body, and head. See Figure 2.5. To operate a chisel, the cutting edge is positioned on the work and the head is hit with a hammer. Common types of chisels, named according to their cutting edge, include flat, cape, round nose, and diamond. The flat chisel is the most common and is used for cutting and shearing. The cape, round-nose, and diamond chisels are used for cutting grooves. A chisel's cutting edge and head must be kept ground to the proper angle and shape for safe use.

Figure 2.5 - Cold Chisel



Files are used to change the shape of the work, remove material, and finish the surface. As with woodworking files, files for metalworking are available in different cuts, shapes, and coarseness. The cuts of metalworking files include single (parallel rows of teeth all going the same direction), double (teeth that cross one another), rasp (individual teeth that are raised and sharp), and curved (teeth in a curved pattern). Common shapes of the file itself are flat, round, and half round, and the different coarseness of cuts are bastard, second, and smooth. See Figure 2.6.

Figure 2.6 - Files



Depending on the purpose of the filing, there are various techniques for stroking a file. One technique, cross-filing, is used to remove a lot of material quickly. This technique involves using a double-cut file and crossing the strokes of the file. See Figure 2.7. Another technique, draw filing, is used to produce a flat surface with a fine finish. Draw filing involves using a single-cut file held at a 90-degree angle to the stock and pulling or pushing the file along the length of the work. See Figure 2.8. In either technique, the metal to be filed must be put in a vise or other device to hold it firmly. In addition, files should always be used with a handle on the tang (smooth, pointed end) to prevent serious injury.

Figure 2.7 - Cross-Filing

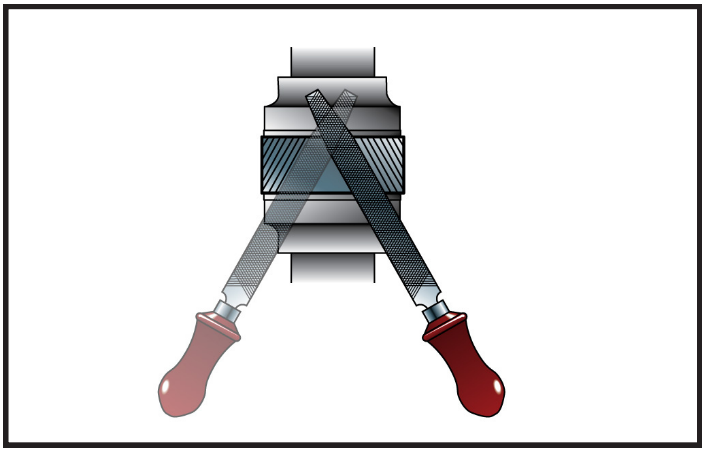
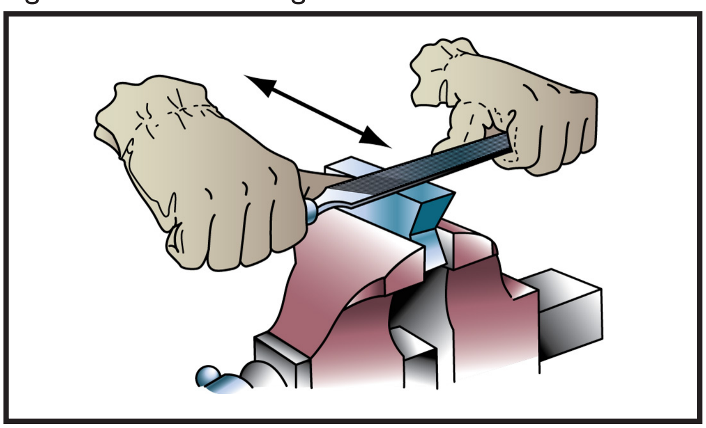


Figure 2.8 - Draw Filing



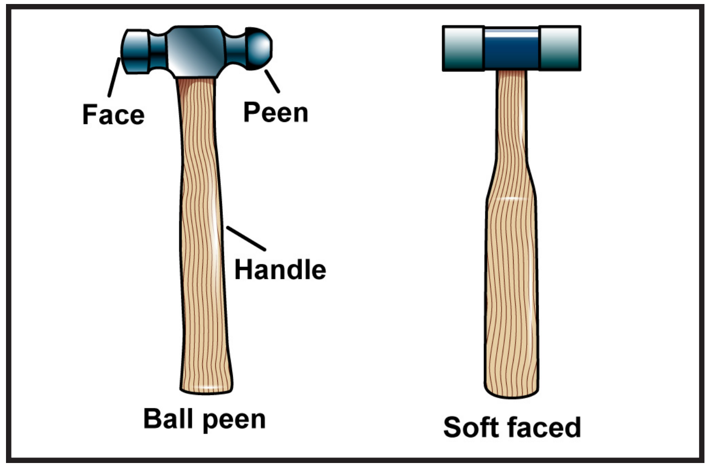
Other Common Tools

The following tools are used for various purposes such as shaping metal, driving other tools, and fastening parts together.

A ball-peen hammer, a frequently used tool in metalworking, delivers flat blows, bends stock, or shapes the surface with rounded dents. This hammer consists of a handle attached to a steel head that has a rounded end (peen) and flat end (face). It is available in different sizes based on the head weight, ranging from approximately 2 oz to 3 lb. Selecting the size depends on the type of work and the force required.

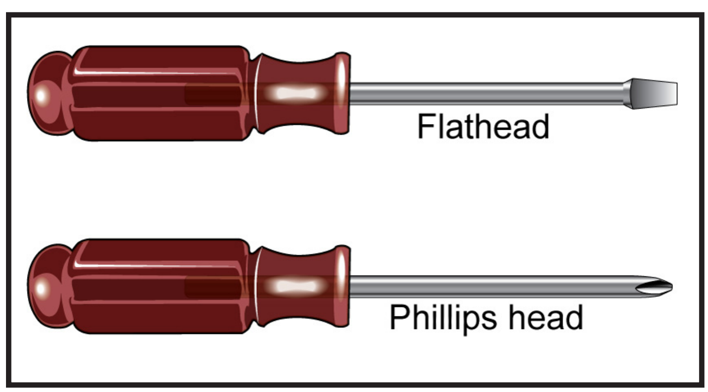
A soft-faced hammer is used in assembly and disassembly work where a steel-faced hammer could damage parts or surfaces. The face of this hammer is typically made of soft materials, such as plastic, rawhide, brass, or wood. See Figure 2.9.

Figure 2.9 - Common Hammers



Screwdrivers, consisting of a handle, metal blade, and tip, are used to drive screws. For efficient operation, the screwdriver's tip should fit the slot of the screw as closely as possible. For example, using a tip that is too thin for the slot can bend the tip and using a tip that is too thick for the slot reduces leverage. Using the correct size screwdriver provides ample leverage, making the screwdriver less likely to slip. Common types are the standard or flathead, which has a flat, bladelike tip, and the Phillips, which has a pointed tip. See Figure 2.10. Standard sizes are designated by the bar length and width of the tip and Phillips sizes come in point sizes.

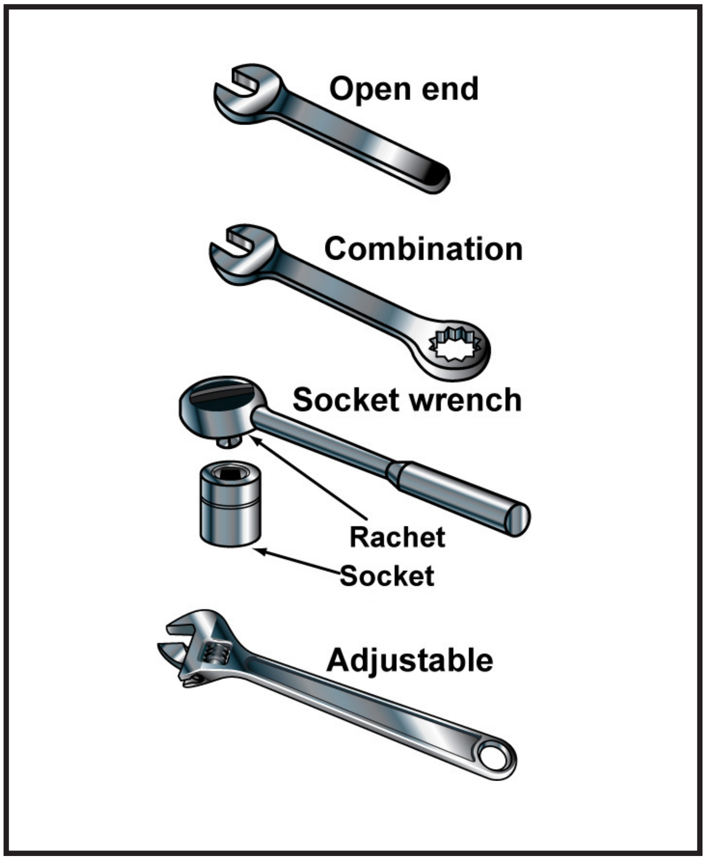
Figure 2.10 - Screwdrivers



Solid wrenches, nonadjustable steel tools that are one piece, are designed to fit specific bolt or nut sizes and are used for tightening and loosening. These wrenches are available in U.S. customary and metric sizes. The types include open end, box end, combination (one end open, one end box), and socket. See Figure 2.11.

Adjustable wrenches are designed to adjust to different nut or bolt sizes. Because of its versatility, an adjustable wrench can replace many solid wrenches and can be used on odd-size nuts. An adjustable wrench needs to be seated and tightened properly to the nut so that it does not slip. The common types include adjustable open end, pipe, and monkey.

Figure 2.11 - Common Wrenches



Summary

Metalworking in agricultural mechanics requires the skillful use of a wide variety of hand tools. Workers should be familiar with tools for marking, cutting, shaping, driving other tools, and fastening parts together. They should also know how to pick the right tool for the job.

Credits

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Lesson 1: Safe Use and Maintenance of Power Tools for Woodworking

Many woodworking tasks in agricultural mechanics are done with power tools because their speed and efficiency can make woodworking tasks much quicker and easier. Before using power tools for woodworking, it is essential to be familiar with the parts and functions of the tools and how to operate them safely. This lesson identifies some common power tools (portable and stationary) and discusses safety precautions and maintenance procedures related to these tools.

Common Sources of Power for Woodworking Tools

Power tools used in agricultural mechanics are powered by various means. Electricity, including battery packs, and compressed air (pneumatic power) are common sources of power for woodworking tools. There are specific safety precautions for each of these types of power.

Safety Precautions for Electric and Pneumatic Power Tools

Each year many agricultural workers incur injuries while working with power tools. Unsafe use of power tools can result in injuries ranging from minor cuts and bruises to severe lacerations, finger amputations, and eye punctures from flying objects. Massive bleeding from severe injuries and electrocution can cause death. Tool operators sometimes add to the hazards by taking shortcuts to save time, disregarding warnings, not knowing how a tool works, and not using safety precautions appropriate for each tool. Safety precautions for electric and pneumatic tools are as follows:

Electric and Battery-Powered Tools

- Always unplug a tool or disconnect it from its battery before inspecting it and making adjustments.
- Only use a tool that is double insulated or has a grounded plug.
- Always plug a tool into an outlet with a ground-fault circuit interrupter (GFCI or GFI). A GFCI will shut off the power if a short occurs. If an outlet is not equipped with a GFCI, a portable GFCI can be plugged into a grounded outlet.
- Do not stand on wet ground or a wet surface while operating an electric tool.
- Make sure stationary power tools are anchored to the floor.
- Make sure all guards and shields are in place and vents are clear of debris before turning on a tool.
- Do not bend the power cord sharply, do not use the cord to pull the plug from the outlet, and do not use the cord to carry the tool. Such actions could break the cord. A broken power cord could cause an electrical shock.
- Use only the battery specified by the manufacturer for the tool being used.
- Use only the type of recharger designed for the batteries being used.
- Always store battery packs safely so that no metal can come in contact with the terminals. This can short-circuit the battery and cause sparks, fire, or burns.

Pneumatic Power Tools

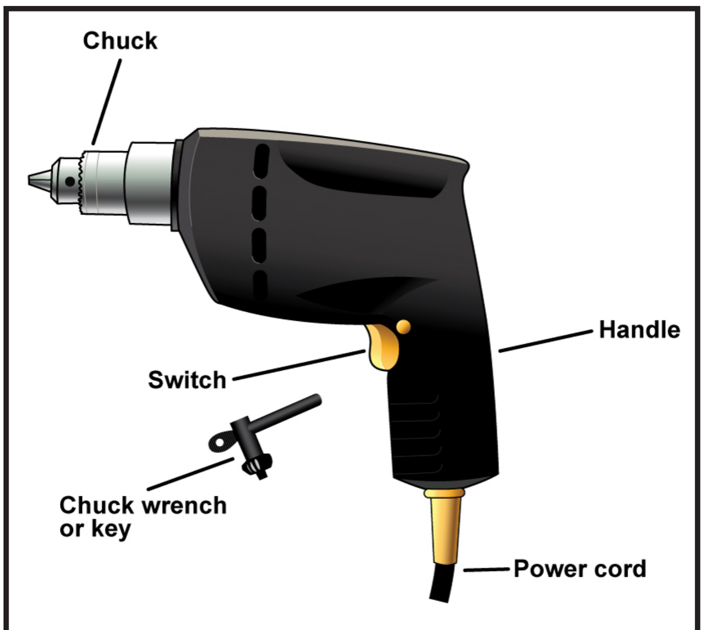
- Disconnect pneumatic tools for all inspections and adjustments.

- Do not join or separate quick-disconnect couplings on high-pressure lines when bystanders are nearby.
- Do not use compressed air for cleanup if the air pressure is 30 lb per sq in. (psi) or greater.
- Do not point an air stream at anyone. High-pressure air can drive dust into the eyes, damage eardrums, or cause other injuries.
- Check couplings and air lines for evidence of wear and damage.
- Make sure air tanks and lines are free of moisture and appropriate filters are in place.
- Follow the manufacturer's recommendations for hose size and maximum air pressure.
- Oil pneumatic tools regularly according to manufacturer recommendations.

Portable Drills

Portable power tools, such as a drill, are particularly useful because they can easily be taken to the job site, do not require extensive setup, and are relatively affordable. Main parts of a portable drill include an on/off switch, power cord, handle, chuck (the part that holds the drill bit), and chuck key. See Figure 1.1. A chuck key is used to loosen and tighten the chuck. Portable drills are used to do various woodworking jobs, such as drilling and boring, driving and removing screws, and operating hole saws. Drills can also be used for sanding and polishing.

Figure 1.1 - Portable Drill



Portable drills come in different sizes. The size of a drill is based on the maximum size of drill bit that the chuck will hold. For example, with a 1/4-in. drill, the chuck holds a bit with a shank that is no larger than 1/4 in. Some drills have only one motor speed while others have different speeds. Variable-speed drills are useful for driving screws. Screws can be removed by reversing the drill.

Safety precautions for a portable drill include the following:

- Choose the right drill bit for the job. For example, do not put a square-shank bit in an electric drill.
- Make sure the bit is tight in the chuck. Use the key in each hole of the chuck to tighten the bit. Be sure to remove the chuck key before starting the drill to avoid throwing the key.
- Make sure work is held securely in place. Use a clamp or vise to hold a small piece of work.
- Hold the drill perpendicular to the work to avoid binding the bit.
- Remove the bit from the drill after completing the job.

Basic maintenance procedures for a portable drill include the following:

- Keep parts lubricated according to the manufacturer's instructions.
- Sharpen or replace dulled drill bits.

Portable Circular Saws

Portable circular saws are available in different sizes. Main parts of a circular saw include an on/off switch, power cord, angle scale (used for setting the depth of the blade's cut), base, angle adjustment lock, handle, blade guard, and blade. See Figures 1.2 and 1.3. The size of a circular saw is determined by the diameter of the largest blade it will hold.

Figure 1.2 - Portable Circular Saw

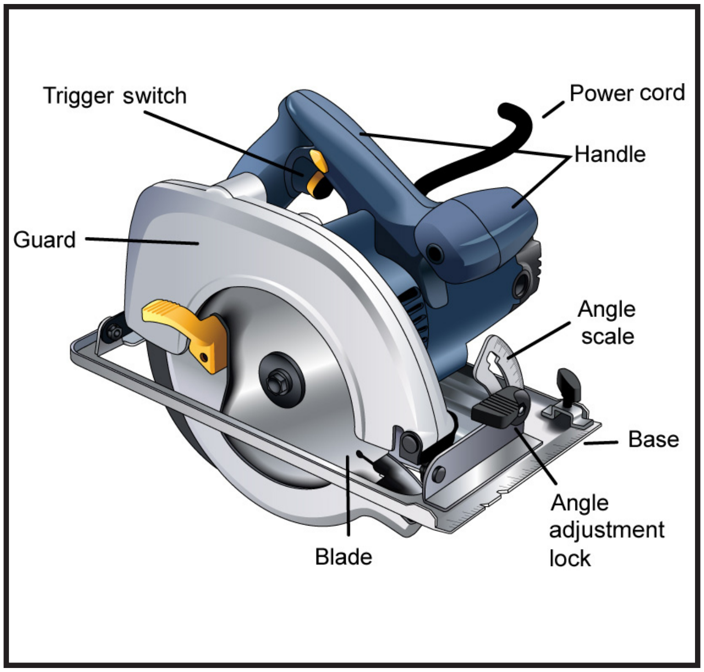
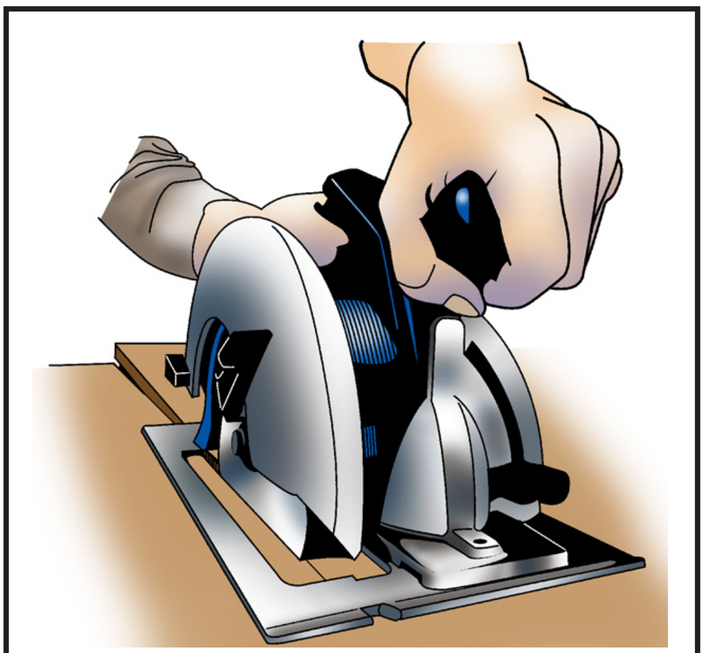


Figure 1.3 - Using a Circular Saw



As the saw's name suggests, the blade of a circular saw is round and it spins in a circle during cutting. Circular saws are commonly used for making rip cuts, cross-cuts, bevel cuts, and angle cuts for mitering. Different types of blades are used for different kinds of cuts. For example, a blade with large teeth may be chosen for fast, rough cutting and a blade with small teeth may be chosen for finer cutting. The blade can be adjusted to cut at different depths. Because the blade rotates upward, splintering occurs on the topside of the piece. For this reason, the best side of the piece should be placed face down when sawing with a circular saw.

Safety precautions for a portable circular saw include the following:

- Choose the right blade for the cut.
- Make sure base and angle adjustments are correct for the cut and are tightly in place.
- Back the saw slightly away from the work before turning it on.
- Allow the saw to reach full speed before beginning to cut.
- Cut only in a straight line to avoid binding the blade.
- Wait until the blade stops moving before setting the saw down.

Basic maintenance procedures for a portable circular saw include the following:

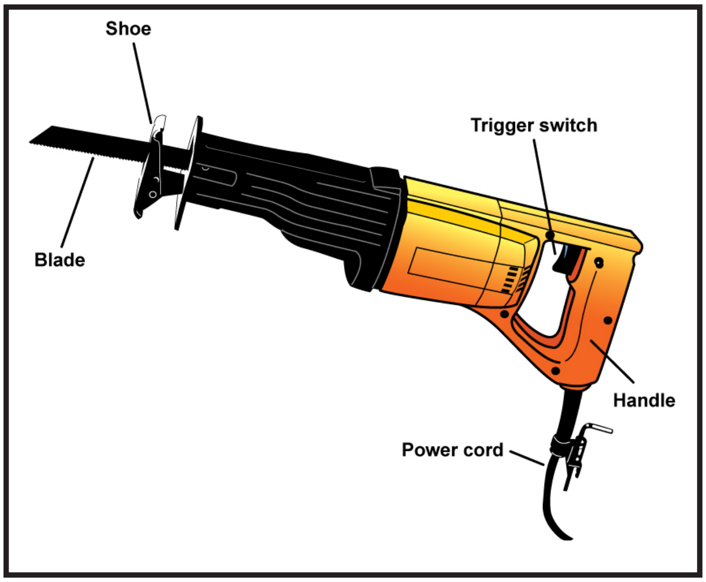
- Make sure the blade guard always moves freely. Small pieces of wood can become caught in the blade guard, preventing it from covering the blade properly when the saw is not in use.
- Clean, sharpen, or replace blades that are gummy or dull.

Reciprocating Saws

A reciprocating saw is another common portable power tool that is useful for work in close areas where it would be difficult to operate a circular saw.

Main parts of a reciprocating saw include an on/off switch, power cord, handle, shoe, and blade. See Figure 1.4. With this saw, the blade moves up and down. The shoe is placed against the work for stability. The shoe can be adjusted in or out to control the depth of the cut. Different kinds of blades can be used to make different types of cuts.

Figure 1.4 - Reciprocating Saw



This heavy-duty saw can be used to make relief cuts, irregular cuts, crosscuts, and pocket cuts. Relief cuts are made in the waste portion of a piece, almost to the actual cutting line. Relief cuts can be a helpful step for creating curved edges in a piece. Pocket cuts are made at the edge of a piece to form a three-sided indentation, or pocket, at the edge. The blades for a reciprocating saw have a narrow and straight shape and are available in different types for cutting wood, metal, plastic, and plaster.

Safety precautions for a reciprocating saw include the following:

- Choose the right blade for the cut.
- Choose the right speed for the cut. Use a low speed to cut dense, hard material and a high speed to cut softer material.
- Make sure the saw is at working speed before cutting.
- Hold the shoe against the work at all times.

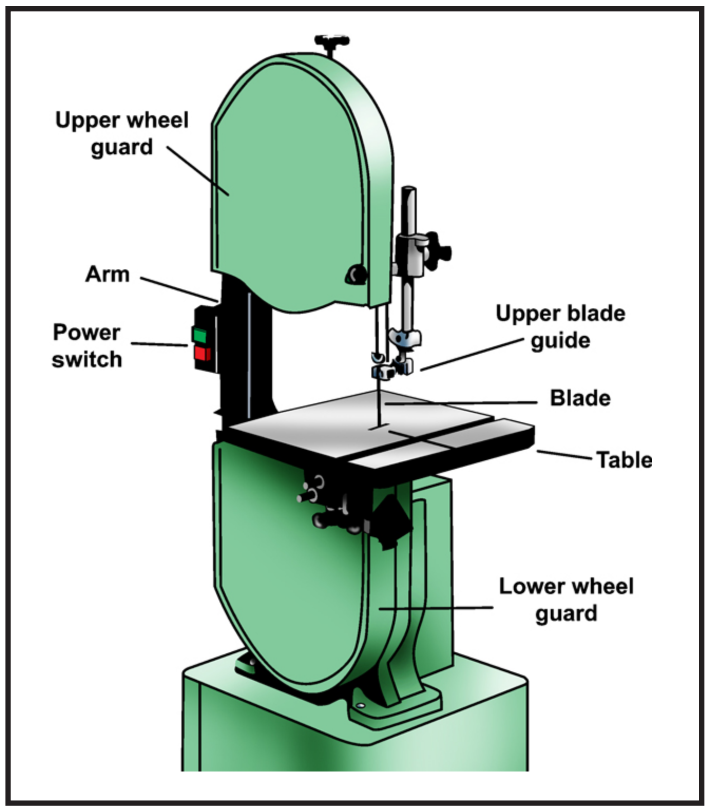
Basic maintenance procedures for a reciprocating saw include the following:

- Follow the manufacturer's recommendations for regular service.
- Inspect and replace blades as needed.

Band Saws

A band saw is a large machine that must be anchored to the floor. Main parts of a band saw include an on/off switch, upper and lower wheels and wheel guards, table, upper and lower blade guides, and arm. The wheels, guards, and blade guides are located above and below the table. See Figure 1.5. The blade is thin and forms a continuous loop that runs over the two wheels and through the two blade guides.

Figure 1.5 - Band Saw



The size of a band saw is determined by the diameter of its wheels. For example, a 14-in. band saw has 14-in. wheels. Band saws can be used for making straight and irregular cuts, arcs, curves, and bevels.

Band saw blades vary in width, thickness, teeth size, and teeth spacing. A narrower blade has fine teeth and is used for cutting sharp curves. A wider blade has coarse teeth and is used for cutting large curves.

Safety precautions for a band saw include the following:

- Use the right blade for the cut. Teeth should be pointing downward.
- Make sure the blade tension is tight.
- Place the guide within 1/8 in. of the work.
- Take special care in planning the cut, making sure that both the work piece and the waste piece of wood can be controlled so neither one hits the arm of the saw.
- Turn off the saw immediately if the blade "clicks" or breaks. A clicking noise could mean that the blade is cracked.
- Turn off the saw before backing out of a cut.

Basic maintenance procedures for a band saw include the following:

- Maintain proper blade tension.
- Maintain proper blade tracking. The blade should stay in the center of the wheels.
- Repair or replace broken blades.

Table Saws

A table saw works similarly to a portable circular saw, but it is much larger and is anchored to the floor. Main parts of a table saw include an on/off switch, blade height adjustment wheel, rip fence, miter groove, blade guard, table, and blade angle adjustment wheel. See Figure 1.6. This stationary saw is equipped with either a tilting table or a tilting arbor, which can be adjusted for making angle cuts. The blade is mounted in the tilting arbor. The rip fence acts as a guide for making straight cuts. A push stick is used for making rip cuts in narrow or short pieces. See Figure 1.7.

Figure 1.6 - Table Saw

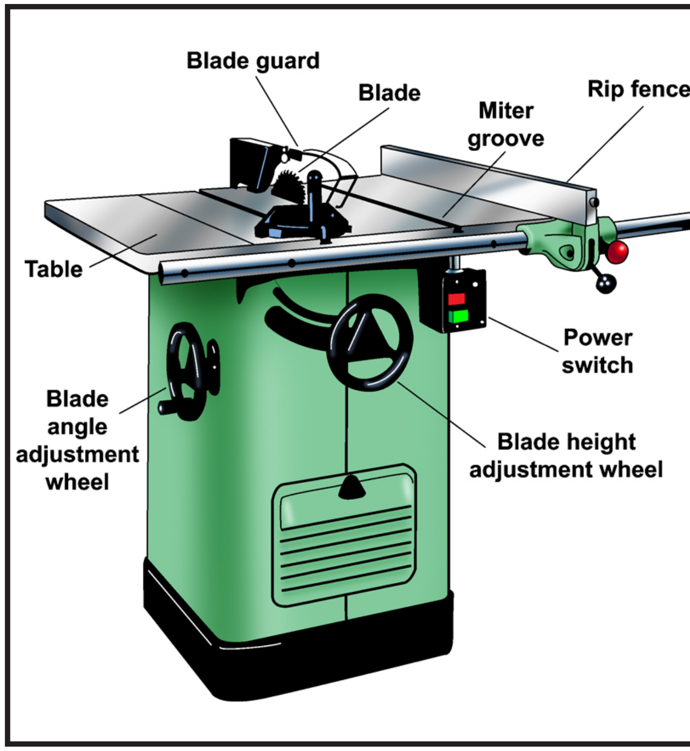
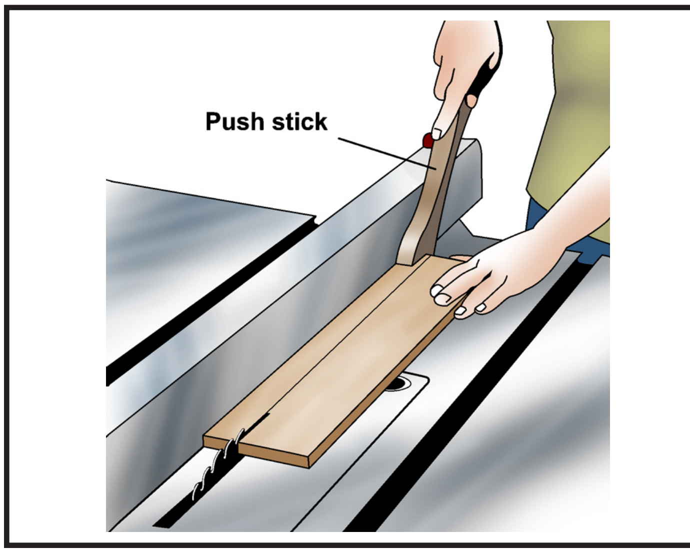


Figure 1.7 - Using a Push Stick When Cutting With a Table Saw



Different types of blades are used for ripping, crosscutting, mitering, beveling, and joint making. Certain type of blades can perform special functions, such as cutting dados. The size of a table saw is determined by the largest diameter of blade it can hold. An 8-in. saw is useful for cutting small pieces and a 10-in. or 12-in. saw is useful for cutting large pieces or making rough cuts.

Safety precautions for a table saw include the following:

- Check the blade. Make sure it is right for the cut and make sure the teeth point in the direction of the blade's rotation.
- Adjust the blade to the correct angle and height for the cut.
- Stand to the side of the blade and do not reach across the table.
- Keep hands at least 6 in. from the blade.
- Use a push stick for guiding small pieces.

Basic maintenance procedures for a table saw include the following:

- Check the blade to be sure it is not warped.
- Regularly remove sawdust. A collection of sawdust could cause the motor to overheat.
- Use silicone or powdered graphite, not oil, on screw threads to keep them moving freely. With oil, screw threads could become gummed up with sawdust.
- Remove rust on unpainted parts with oiled steel wool.
- Remove excess oil after cleaning with steel wool and coat the area with paste wax.

Shapers

A shaper is a stationary power tool that is used for shaping edges, making moldings, and cutting joints. Main parts of a shaper include an on/off switch, spindle height adjustment wheel, miter gauge groove, spindle, cutter guard, and adjustable fence. See Figure 1.8. The spindle holds the cutter. The adjustable fence is used as a guide for straight cuts.

Cutters come in different shapes for making cuts of different patterns, including decorative edges. See Figure 1.9. The size of the shaper is determined by the diameter of the spindle.

Figure 1.8 - Shaper

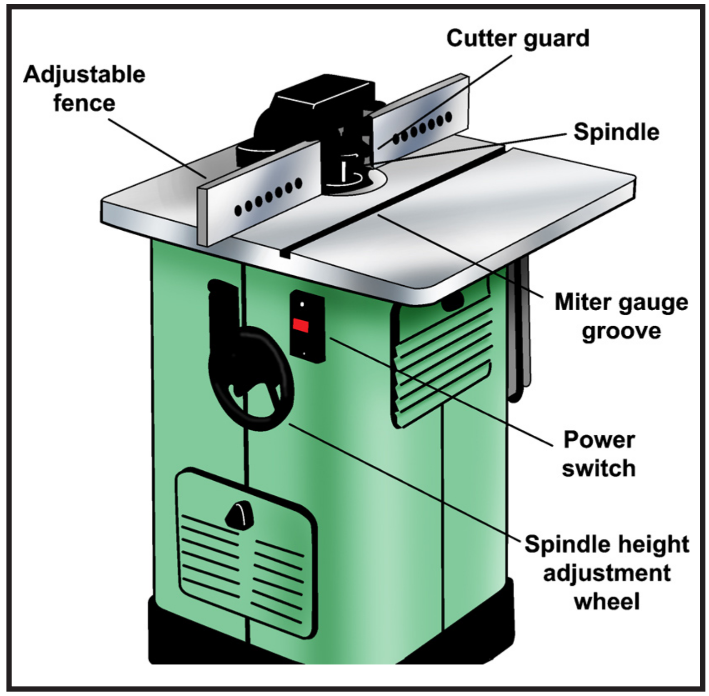
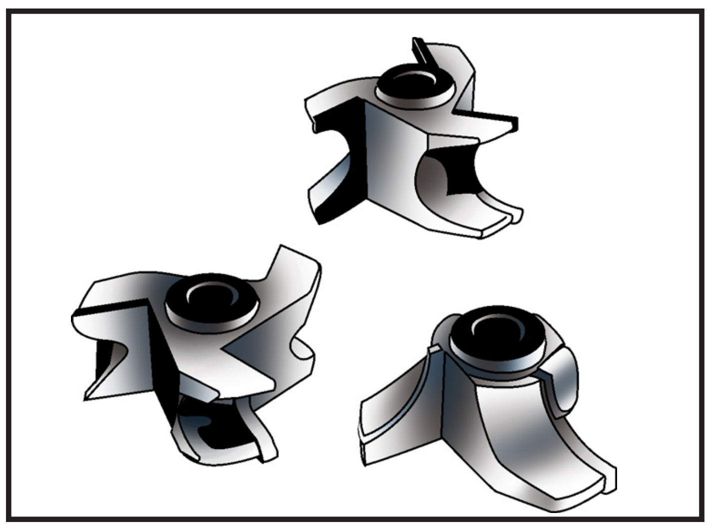


Figure 1.9 - Examples of Different Cutters



Safety precautions for a shaper include the following:

- Check all adjustments and locking nuts before using the machine.
- Check the rotation of the cutter and feed the work into the cutter opposite the direction of rotation.
- Make sure the piece has no warps or cracks that could cause it to be thrown.
- Always use proper guards and clamps.
- Use a holder or a push stick to guide the work when the piece is less than 1 ft in length.

Basic maintenance procedures for a shaper include the following:

- Follow the manufacturer's recommendations for lubrication. Oil is generally a good lubricant for areas where sawdust does not collect. Silicone is good for areas where sawdust collects.
- Inspect belts and follow the manufacturer's specifications for proper tension.

Jointers

Jointers come in different sizes and perform functions similar to those of a hand plane. Small jointers are portable and large jointers are stationary. Main parts of a jointer include an on/off switch, infeed table adjustment levers, infeed table, tilting fence, cutter guard, and outfeed table. See Figure 1.10. The three main adjustable parts are the infeed table, tilting fence, and outfeed table. The outfeed table must be set at the same height as the cutter edges at the highest point of their rotation. See Figure 1.11. This adjustment is important to avoid tapering or biting the surface.

Figure 1.10 - Jointer

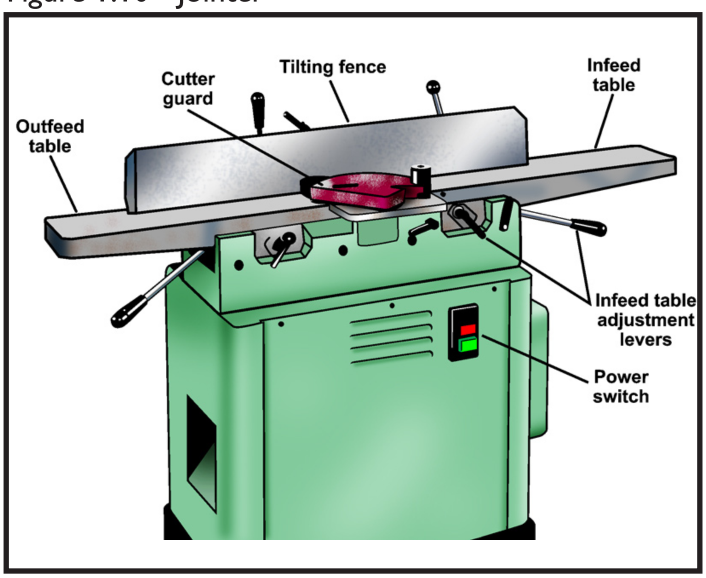
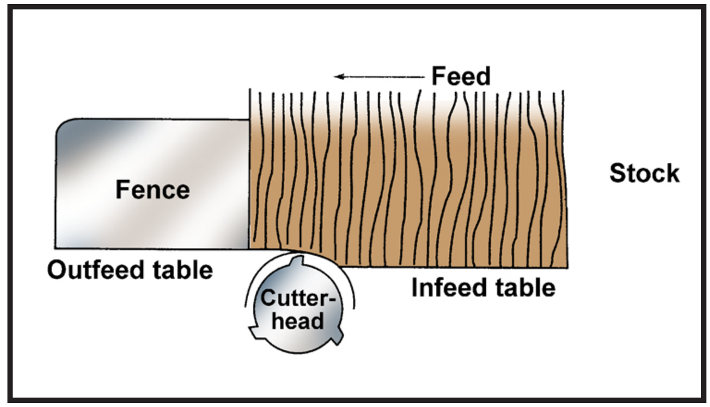


Figure 1.11 - Poper Adjustment of Outfeed Table on Jointer



Jointers are used for planing edges and surfaces and for cutting bevels and chamfers. The jointer is equipped with a cylinder that holds knife blades. This cylinder is called the cutterhead. The length of the knife blades determines the size of the jointer and the maximum width of board it will cut.

Safety precautions for a jointer include the following:

- Make sure the table and fence adjustments are correct for the job. Do not exceed the recommended maximum cuts.
- Do not use the machine to work on a piece that is less than 12 in. long or 3/8 in. thick.
- Cut with the grain of the wood.
- Make sure the piece is free of knots and splits.
- Keep hands at least 6 in. from the cutterhead.
- Use a push stick and feather board when necessary.

Basic maintenance procedures for a jointer include the following:

- Keep knives sharp. Dull knives can cause kickback.
- Follow the manufacturer's recommendations for lubricating the machine. It may be necessary to take some of the machine apart to reach places that require lubrication.
- Replace sealed bearings when they are worn.

Summary

Power tools can help make woodworking tasks quick, but they are dangerous. To prevent injury, users must follow general shop safety precautions and specific safety measures for each type of tool. Electricity, batteries, and compressed air are common sources of power for woodworking tools and there are general safety measures for electric and pneumatic power tools. Common portable power tools include portable drills, circular saws, and reciprocating saws. Larger stationary machines include band saws, table saws, shapers, and jointers.

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Lesson 2: Safe Use and Maintenance of Power Tools for Metalworking

Many of the machines, tools, and buildings used in agriculture are made of metal and thus a thorough knowledge of power tools for metalworking is essential when working in agricultural mechanics. Before using power tools for metalworking, it is important to be familiar with the parts and functions of the tools and to know how to operate them safely. This lesson identifies some common power tools (portable and stationary) and discusses safety precautions and maintenance procedures related to these tools.

Common Sources of Power for Metalworking Tools

Electricity, including batteries, and compressed air (pneumatic) are two of the most common sources of power for metalworking tools. The specific safety considerations for each of these types of power are discussed below.

Safety Considerations for Electric and Pneumatic Power Tools

Each year many agricultural workers incur injuries while working with power tools. These injuries range from minor cuts and bruises to severe lacerations, finger amputations, and eye punctures from flying debris. Massive bleeding from severe injuries and electrocution can cause death. Tool operators sometimes add to the hazards by taking shortcuts to save time, disregarding warnings, and not using safety precautions appropriate for each tool. Safety precautions for electric and pneumatic tools are the following:

Electric and Battery-Powered Tools

- Always unplug a tool or disconnect it from its battery before inspecting it and making adjustments.
- Only use a tool that is double insulated or has a grounded plug.
- Always plug a tool into an outlet with a ground-fault circuit interrupter (GFCI or GFI), which will shut off the power if a short occurs. If an outlet is not equipped with a GFCI, a portable GFCI can be plugged into a grounded outlet.
- Do not stand on wet ground or a wet surface while operating an electric tool.
- Make sure stationary power tools are securely anchored to the bench or floor.
- Make sure guards and shields are in place and vents are clear of debris before turning on a tool.
- Do not bend a power cord sharply, do not use a cord to pull the plug from the outlet, and do not use a cord to carry the tool. Broken power cords can cause an electrical shock.
- Use only the battery specified by the manufacturer for the tool being used.
- Use only the type of recharger designed for the batteries being used.
- Always store battery packs safely so that no metal can come in contact with the terminals. This can short-circuit the battery and cause sparks, fire, or burns.

Pneumatic Power Tools

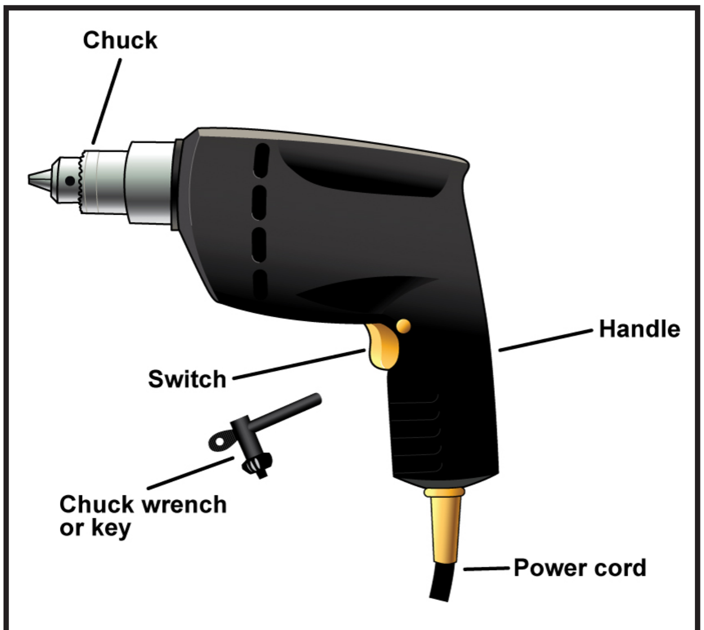
- Disconnect pneumatic tools for all inspections and adjustments.
- Do not join or separate quick-disconnect couplings on high-pressure lines when bystanders are nearby.

- Do not use compressed air for cleanup if the pressure is 30 lb per sq in. (psi) or greater.
- Do not point an air stream at anyone. High-pressure air can drive dust into the eyes, damage eardrums, and cause other injuries.
- Inspect couplings and air lines regularly for evidence of wear and damage.
- Make sure air tanks and air lines are free of moisture and appropriate filters are in place.
- Follow the manufacturer's recommendations for hose size and maximum air pressure.
- Oil pneumatic tools regularly according to the manufacturer's recommendations.

Portable Drills

Portable power tools, such as a drill, are particularly useful because they are easy to take to the job site, do not require extensive setup, and are relatively affordable. Main parts of a portable drill include an on/off switch, power cord, handle, chuck (the part that holds the drill bit), and chuck key. See Figure 2.1. A chuck key, or wrench, is used to loosen and tighten the drill bit in the chuck. In metalworking, the word "drill" is often used to refer to a drill bit.

Figure 2.1 - Portable Drill



Depending on the type of drill bit, portable drills are used for many tasks in metalworking, including drilling and boring, driving and removing screws, sanding, polishing, and powering hole saws. Portable drills come in different sizes. The size of a drill is determined by the maximum size of drill bit the chuck will hold. For example, a 1/4 in. drill will hold a bit with a shank no larger than 1/4 in. Many specialized metalworking drills are also available.

The basic drill bit used in metalworking is a general-purpose one that can be used on a number of materials and in a variety of situations. Drill bits used in metalworking are commonly made of carbon steel, high-speed steel, and cemented carbide. Of these three materials, carbon steel is the weakest and cemented carbide is the strongest. High-speed steel withstands higher speeds and lasts longer than carbon steel. Cemented carbide withstands very high speeds and outlasts high-speed steel and carbon steel.

Some drills have only one motor speed while others have different speeds. Variable-speed drills are useful for driving screws. Screws can be removed by using the reverse setting.

Safety considerations for a portable power drill include the following:

- Choose the right drill bit for the job. For example, do not use a square-shank bit in an electric drill.
- Make sure the bit is tight in the chuck. Use the chuck key in each hole of the chuck to tighten the bit. Be sure to remove the key before starting the drill to avoid throwing the key.
- Use a center punch to mark stock when working with metal. The indentation helps guide the bit.
- Make sure the work is held securely in place. Use a clamp or vise to hold a small piece.
- Hold the drill perpendicular to the piece to avoid binding the bit.
- Remove the bit from the drill after completing the job.

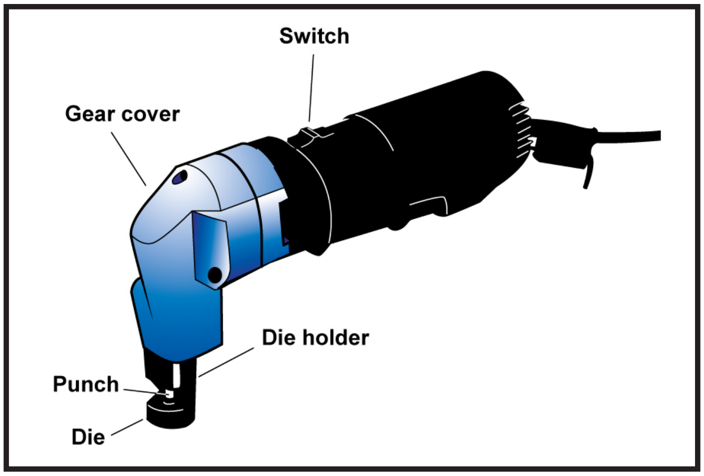
Maintenance considerations for a portable power drill include the following:

- Keep parts lubricated according to the manufacturer's instructions.
- Sharpen or replace dulled drill bits.

Portable Power Nibblers

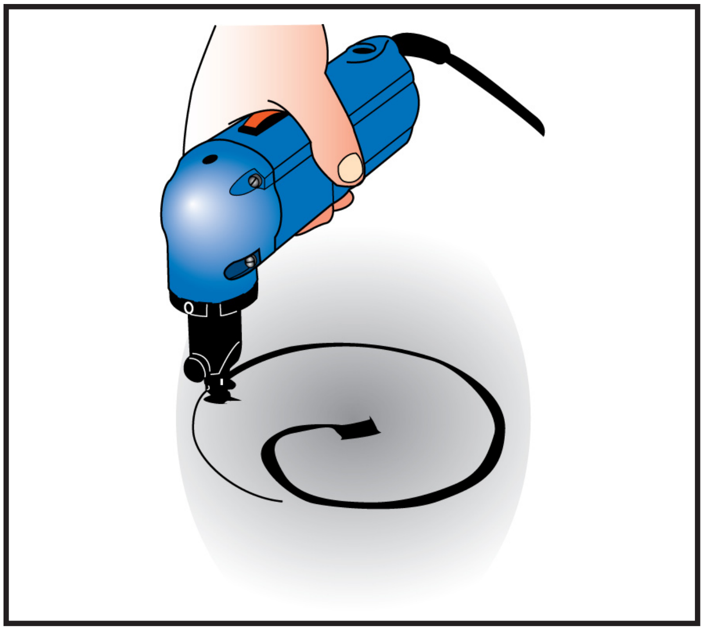
Portable power nibblers are convenient for taking to the work site to cut sheet metal quickly and efficiently. Main parts of a power nibbler include an on/off switch, gear cover, punch, die, and die holder. See Figure 2.2.

Figure 2.2 - Portable Power Nibbler



A power nibbler performs functions similar to those of hand shears or snips, but it is more versatile and gets the job done quicker. A power nibbler can make straight, curved, and interior cuts. It can cut thin metal that is bent or formed. Interior cuts are made in metal by using a hollow punch or other tool to make a small hole at the center of the planned cut. The power nibbler is then used to cut the desired shape. See Figure 2.3. Power nibblers are designed to eject metal cuttings down and away from the operator, which is a good safety feature of this tool.

Figure 2.3 - Power Nibbler Making an Interior Cut



Safety considerations for a portable power nibbler include the following:

- Wear eye protection when doing metalwork.
- Wear gloves when handling metal with sharp, cut edges.
- Do not use compressed air or the hands to remove metal chips and cuttings.

Maintenance considerations for a portable power nibbler include the following:

- Make sure the chip-ejection hole is clear of debris.
- Follow the manufacturer's recommendations for regular service.

Cold Circular Cutoff Saws

A cold circular cutoff saw has a flat, round blade and is used for cutting metal to length, making straight or miter cuts, and cutting soft or unhardened metals. Larger models of this type of saw are stationary, similar to the table saw used in woodworking. (See Unit II, Lesson 1 for information about a table saw.) Main parts of a cold circular cutoff saw include an on/off switch, table, blade, guard, handle, motor, and fence. See Figure 2.4. The circular saw can be used on materials such as aluminum, copper, machine steel, and stainless steel.

Figure 2.4 - Cold Circular Cutoff Saw

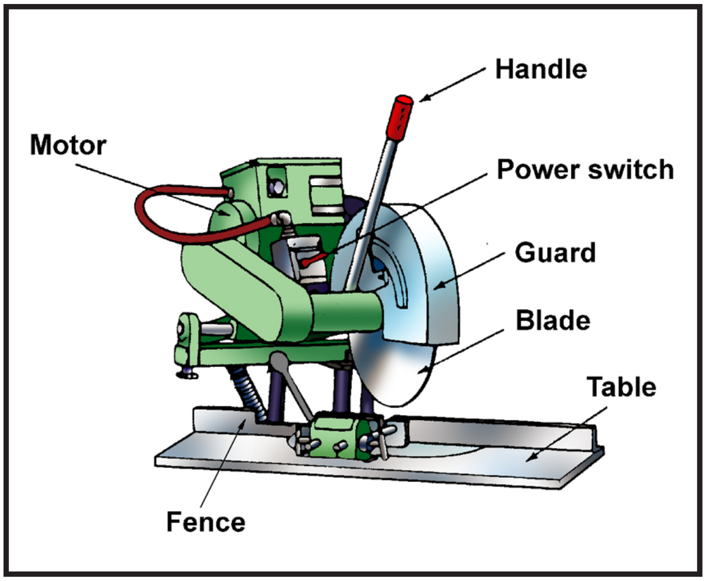
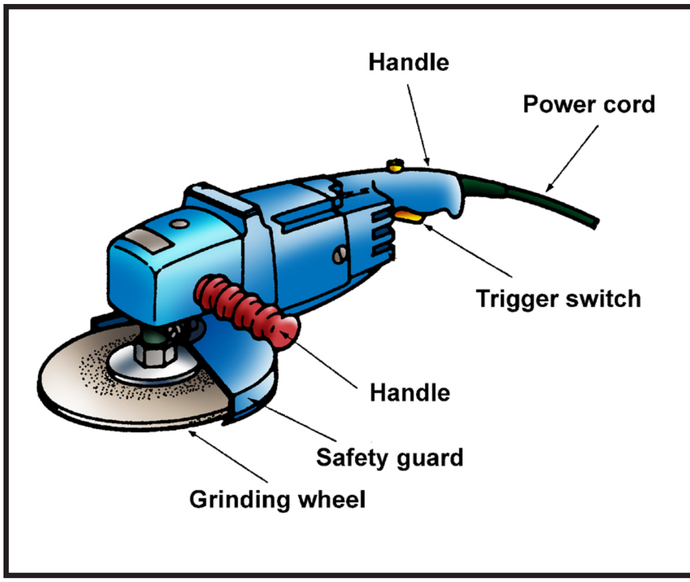


Figure 2.5 - Portable Grinder



Safety considerations for a cold circular cutoff saw include the following:

- Wear eye protection when doing metalwork.
- Wear gloves when handling metal with sharp, cut edges.
- Do not use compressed air or the hands to remove metal chips and cuttings.

Maintenance considerations for a cold circular cutoff saw include the following:

- Follow the manufacturer's recommendations for regular service.
- Clean, sharpen, or replace dull blades.

Portable Grinders

A portable grinder is a lightweight tool for grinding, shaping, and cleaning metal. It is useful for performing resurfacing work, such as removal of rust and paint. Grinders work by abrasion, which means the surface of the grinding wheel acts like a cutting tool to remove unwanted material. Main parts of a portable grinder include an on/off switch, grinding wheel, safety guard, handle, and power cord. See Figure 2.5. Some models are equipped with flexible sanding wheels for sanding wood and metal.

Grinding wheels are available in different textures of abrasive material. A wheel with a coarse texture is used for shaping metal and preparing metal for welds, whereas a wheel with a medium texture is used for sharpening tool blades. Grinders can also be used with wire brushes to remove rust.

Safety considerations for a portable grinder include the following:

- Wear appropriate face and eye protection.
- Wear additional protective clothing, such as a dust mask or respirator, if needed.
- Choose the right wheel or disc for the job. It should be rated to turn at speeds higher than the machine will produce.
- Secure small pieces in a clamp or vise.
- Examine the work area to identify areas where sparks might fall and make sure there is no fire hazard. Do not grind metal near combustibles.

Maintenance considerations for a portable grinder include the following:

- Inspect grinding wheels regularly. Do not use wheels that are damaged or out of round.
- Do not use wheels that are less than half of their original diameter.
- Remove the wheel or disc after use.
- Store the grinder and accessories in their proper place.

Bench Grinders

A bench grinder does work similar to a portable grinder, but it is a stationary machine mounted on a bench. Main parts of a bench grinder include an on/off switch, grinding wheels, safety shields, and adjustable tool rest. See Figure 2.6. The adjustable tool rest is used for supporting and guiding small objects for grinding. See Figure 2.7.

Figure 2.6 - Bench Grinder

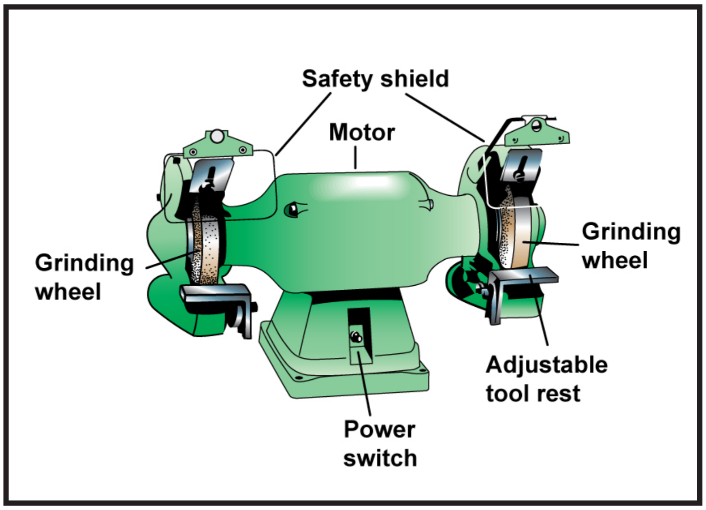
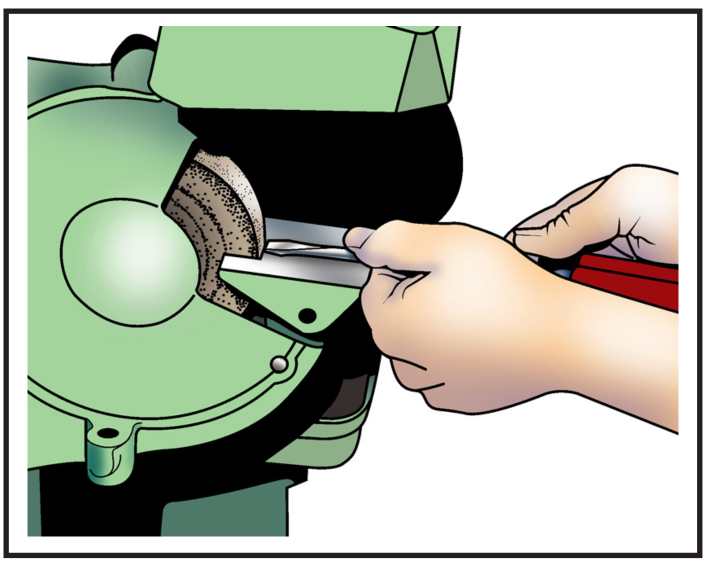


Figure 2.7 - Reconditioning a Screwdriver on a Bench Grinder, With Tool Supported by the Tool Rest



Bench grinders are used for sharpening and reconditioning tools and for shaping and cleaning metal. Another type of stationary grinder is called the pedestal grinder. It is similar to a bench grinder but is larger and is anchored to the floor. Both a bench grinder and a pedestal grinder have a double-shafted motor, which allows a wheel to be mounted on each side. Usually one wheel is coarser in texture and is used for removing material from the surface of the piece. The other wheel is finer in texture and is used for finishing work.

Safety considerations for a bench grinder include the following:

- Wear appropriate eye and face protection.
- Wear additional protective clothing, such as a leather apron or an appropriate filter or respirator, if needed.
- Adjust the tool rest for the job.
- Stand to the side of the wheel when starting the grinder and let the wheel run for a short period before using it. Wheels that are going to break usually do so within the first minute of use.
- Move the work slowly back and forth across the face of the wheel to avoid overheating the metal.
- Do not force work into the grinding wheel. Allow the speed and grit of the wheel to do the work.

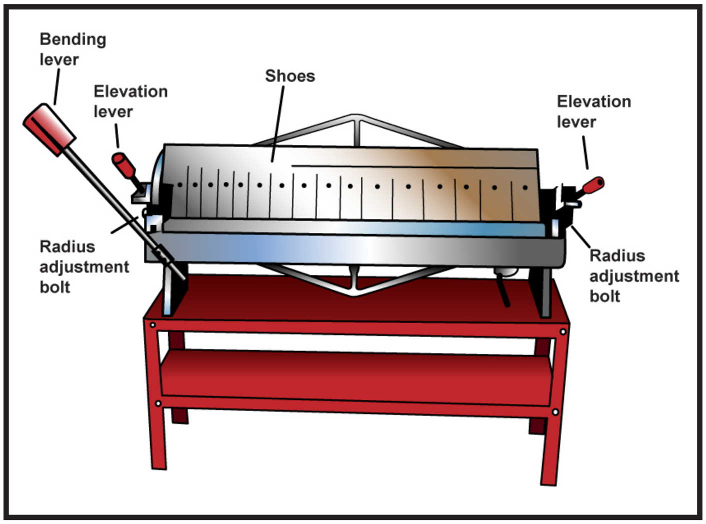
Maintenance considerations for a bench grinder include the following:

- Do not use the wheel to grind soft metals, such as copper and aluminum. They quickly clog the grinding wheel. For soft metals, use an abrasive belt grinder.
- Inspect wheels frequently. Replace wheels that have been damaged or dropped or are too worn to be reconditioned.
- Recondition used wheels to restore their abrasive work surface and bring them back into round. This is called dressing. Receive proper instruction and permission before dressing a wheel.

Sheet Metal Brakes

Many small repair jobs in agricultural mechanics, such as bending metal, are performed by hand, but machines like folders and brakes can do larger jobs better and faster. Hand-operated sheet metal brakes are available in a variety of sizes, from smaller bench-mounted models to industrial-sized brakes. Main parts of a brake include the radius adjustment bolts, bending lever, elevation levers, and shoes. See Figure 2.8.

Figure 2.8 - Sheet Metal Brake



Sheet metal brakes are used for making angle and radius bends, seaming, flattening, and punching. These brakes increase work force by using cams and levers and can exert thousands of pounds of pressure.

Safety considerations for a sheet metal brake include the following:

- Keep fingers clear of the working mechanism.
- Leave bending machines closed when not in use.

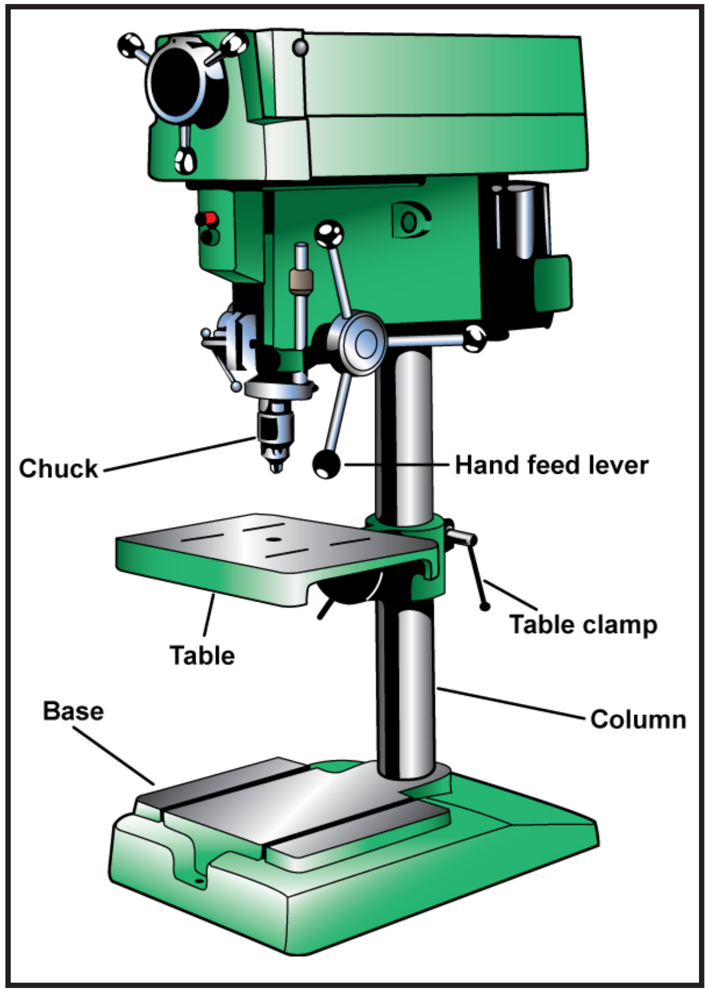
Maintenance considerations for a sheet metal brake include the following:

- Follow the manufacturer's recommendations for regular service.

Drill Presses

A drill press performs operations similar to those of a portable drill, but it is a large stationary machine capable of heavier work. Common uses for drill presses are drilling or boring holes and countersinking (making a recess where a screw can be driven). Main parts of a drill press include an on/off switch, column, table clamp, hand feed lever, chuck, table, and base. See Figure 2.9. The hand-feed lever lowers and raises the chuck, which holds the drill bit.

Figure 2.9 - Drill Press



Drill presses are available in bench and floor models. The size of a drill press is determined by doubling the distance between the front edge of the column and the center of the drill bit.

Safety considerations for a drill press include the following:

- Secure the piece before beginning to drill. Clamp the piece on the left side of the table to keep it from rotating.
- Use a center punch to mark and start the hole.
- Choose the right bit for the material and for the drill. Straight-shank bits should be used with geared chucks and taper-shank bits with taper chucks.
- Make sure the table is properly aligned before turning on the drill press to avoid drilling into the table.
- Reduce the pressure as the drill breaks through the work.

Maintenance considerations for a drill press include the following:

- Inspect bits regularly. Sharp bits cut better and are less likely to break.
- Follow the manufacturer's recommendations for regular care. Light grease on the spindle spline provides lubrication and reduces noise.

Summary

Power tools can help make metalworking tasks quick and efficient, but they can be dangerous to use if an operator does not know how they work and what safety procedures to follow. Electricity, batteries, and compressed air are common sources of power for metalworking tools. It is important to follow the general safety precautions for electric and pneumatic tools. Portable power tools commonly used in metalworking include drills, nibblers, and grinders. Stationary machines include cold circular cutoff saws, bench grinders, sheet metal brakes, and drill presses.

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Lesson 1: Common Measurements and Measurement Tools

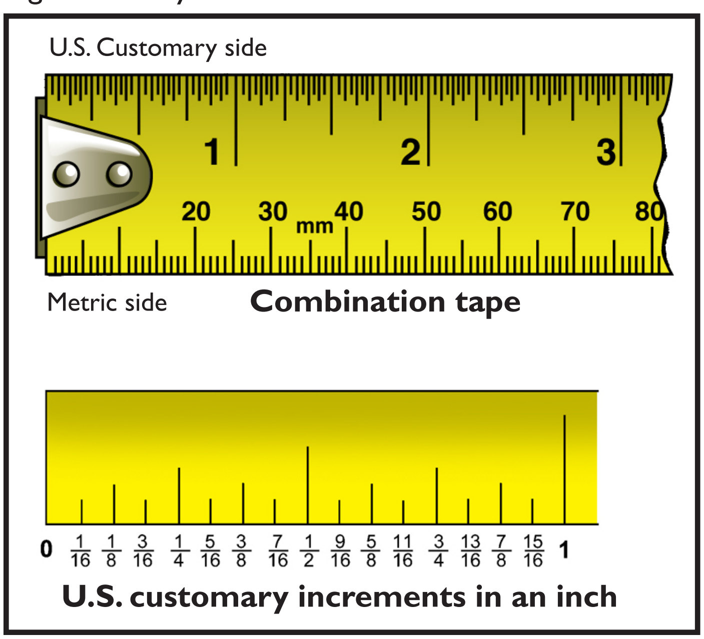
Measuring and layout tools play an important role in woodworking projects, especially at the planning stage. Workers design the project on paper, then transfer the dimensions to the stock, and begin the cutting and assembling. Understanding the units of measurement and knowing how to use the measurement tools are essential to a successful project.

Common Systems and Increments of Linear Measurement

Projects constructed in agricultural mechanics require the ability to take correct measurements and to convert one unit of measurement to another.

The two common systems of linear measurement (measuring in a straight line) are the U.S. customary system and the metric system of measurement. See Figure 1.1. The U.S. customary system, also known as English, is the one most commonly used in the United States.

Figure 1.1 - Systems of Measurement



This system includes units such as yards, feet, inches, and fractions of an inch. The agricultural mechanics student will most often use this system in course work. The metric system is used widely around the world and its practices are becoming more prevalent in the United States, namely in the automotive industry. This system includes measurements such as meters, centimeters, and millimeters.

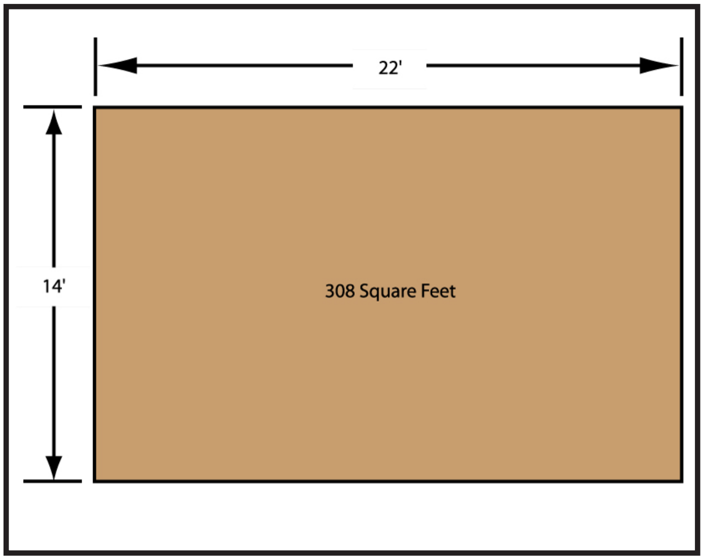
The most basic measurements to make in any agricultural mechanics project are linear measurements. Linear measurement means measuring in a straight line and being able to do so accurately enables workers to determine dimensions like length, width, and height. Straight-line measurements also include finding diameter (distance across the middle of round stock) and circumference (distance around round stock). Other ways objects are commonly measured include area and volume.

Finding Area

In many instances, objects such as a floor cannot be measured simply by a linear method. The length and width of an object must be calculated to measure the surface area of an object. Measuring the area of a wall involves multiplying its length by its height. This is also written as A=LxH. Measuring the area of a floor or board involves multiplying its length by its width, written as A=LxW. For example, a floor that is 22 ft long by 14 ft wide is 308 sq ft. In the case of a square floor, multiplying one side by itself (S2) is another formula to find area. See Figure 1.2.

Area measurements are commonly expressed in square feet or square yards. A square foot is calculated by multiplying the length of an object in feet by the width of the object in feet. A square yard is calculated by multiplying the length of an object in yards by the width of an object in yards. There are 9 sq ft in 1 sq yd.

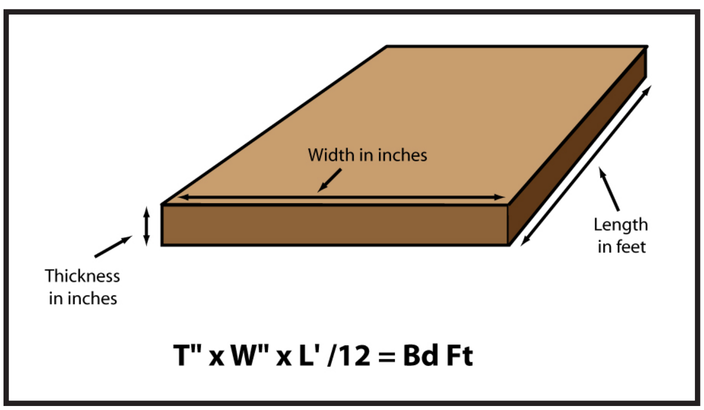
Figure 1.2 - Finding Area



Calculating Board Feet

Calculating board feet (BF or bd ft) is a common way of calculating the volume of wood used in a project. The way to measure the board feet in a piece of wood is to multiply the thickness in inches by the width in inches by the length in feet and divide by 12 (T" x W" x L' / 12). See Figure 1.3. A board foot is a piece of lumber 1 in. thick, 12 in. wide, and 12 in. long, or 144 cubic in.

Figure 1.3 - Calculating Board Feet



When several boards with the same measurements are being used, include the number of boards as a multiplier in the formula. See the following examples.

2 in. x 4 in. x 14 ft board
2 x 4 x 14 / 12 = 9.333 bd ft

3 2 in. x 4 in. x 14 ft boards
3 x 2 in. x 4 in. x 14 ft / 12 = 27.999 bd ft

Boards that are less than 1 in. thick are figured as 1 in. Boards that are more than 1 in. thick are figured using their nominal dimension (rough unfinished measurement). See Figure 1.4. Items like molding and dowel rod are measured in linear feet rather than board feet. This is strictly a measurement of their length.

Figure 1.4 - Lumber Sizes

Nominal vs. Actual Sizes of Lumber
(in Inches)

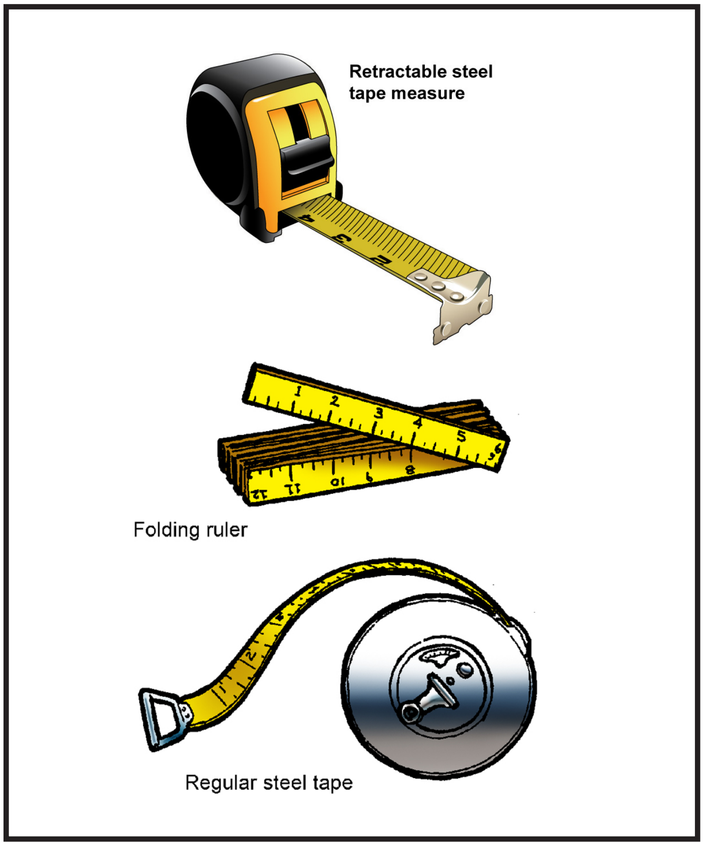
Nominal*	Actual**
1 x 2	3/4 x 1 1/2
1 x 3	3/4 x 2 1/2
1 x 4	3/4 x 3 1/2
1 x 5	3/4 x 4 1/2
1 x 6	3/4 x 5 1/2
1 x 8	3/4 x 7 1/4
1 x 10	3/4 x 9 1/4
1 x 12	3/4 x 11 1/4
2 x 2	1 1/2 x 1 1/2
2 x 3	1 1/2 x 2 1/2
2 x 4	1 1/2 x 3 1/2
2 x 6	1 1/2 x 5 1/2
2 x 8	1 1/2 x 7 1/4
2 x 10	1 1/2 x 9 1/4
2 x 12	1 1/2 x 11 1/4
3 x 4	2 1/2 x 3 1/2
4 x 4	3 1/2 x 3 1/2
4 x 6	3 1/2 x 5 1/2
6 x 6	5 1/2 x 5 1/2
8 x 8	7 1/2 x 7 1/2

* Nominal - rough-cut measurement before planing
** Actual - measurement after planing

Common Measuring Tools and Their Uses

Measuring tools are essential when laying out and constructing a project. These tools are used to determine specific dimensions such as length, width, height, and area of an object. Whereas these tools do not require a great deal of maintenance, they still need to be cleaned and oiled to prevent them from rusting or drying out. Check the tools periodically for accuracy and avoid dropping them; dropping the tools may cause them to become inaccurate. The following are some of the common tools and their uses. See Figure 1.5.

Figure 1.5 - Tape Measures and Folding Ruler

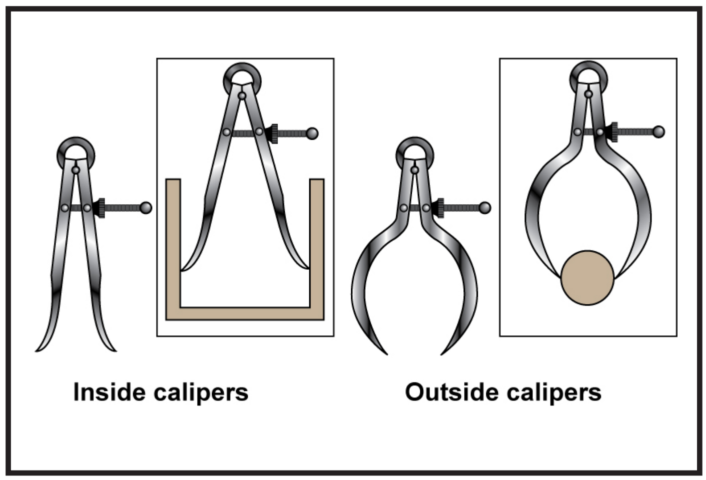


A folding ruler is a ruler made of wood, plastic, or metal that can be folded for easy storage. These rulers are generally 6 ft long and are used when exact measurements are not required. Some folding rulers have an inset sliding metal ruler that extends for making inside measurements. Periodically oiling the joints of a folding ruler will make it easier to operate and prolong its life.

A tape measure is a flexible measuring device that rolls or retracts into a case. It can range in length from 2 ft to hundreds of feet and can be made of steel or cloth. A tape measure is typically used for making straight measurements and taking measurements around objects (circumference). One type of tape measure called a combination rule combines U.S. customary and metric measurements and is useful for making quick, approximate conversions. Avoid bending the metal tapes because this may affect the accuracy of the tool and prevent it from retracting. Lightly oiling a measuring tape will promote ease of use and long life.

A caliper is a device that measures diameter or thickness of an object. An inside caliper measures the inside diameter of an object, such as the inside of a pipe. An outside caliper measures the outside diameter of an object, such as the outside of a dowel. See Figure 1.6.

Figure 1.6 - Calipers



A compass and divider are tools that inscribe arcs and circles. They also are used to transfer dimensions from one scale or object to another item. A compass has one steel leg and a pencil to mark on wood or paper and a divider has two steel legs to mark on dark metal. See Figure 1.7.

A framing square is an L-shaped, metal measuring device with a 16-in. leg (tongue) and a 24-in. leg (body) that meet at a right angle (heel). Some of its uses include framing, laying out stairs, drawing angles for cutting, and checking for squareness. Occasionally oiling a framing square will keep it free from rust. See Figure 1.8.

Figure 1.7 - Compass and Dividers

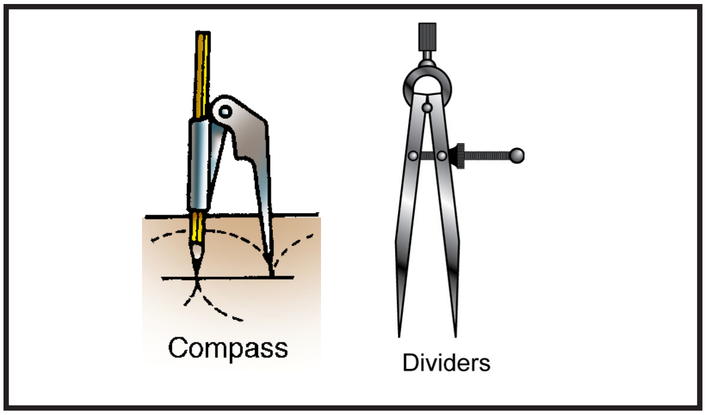
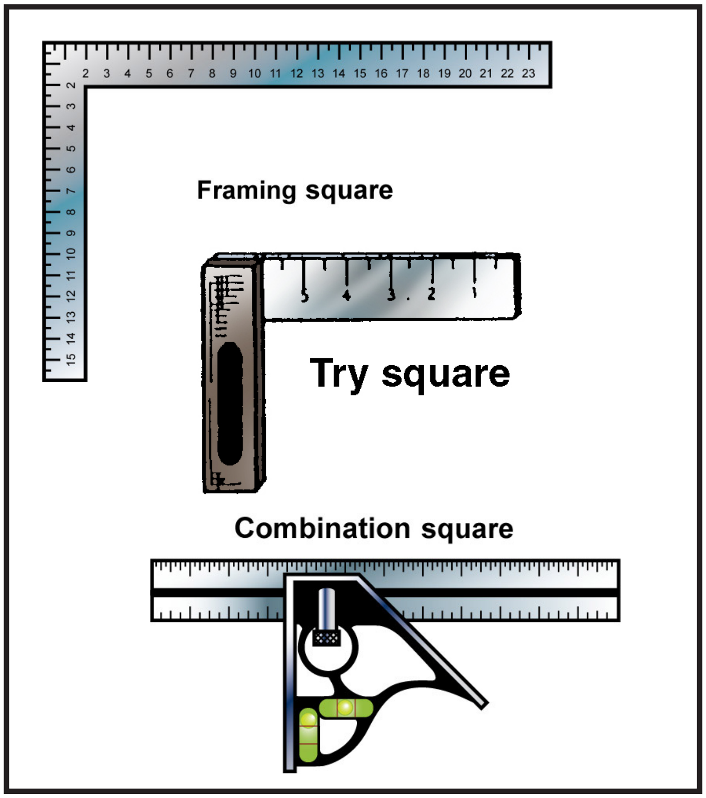


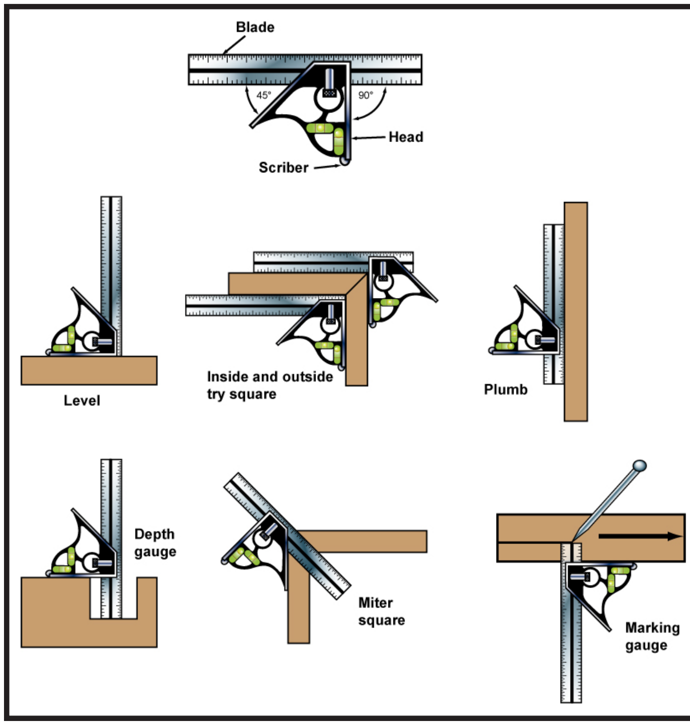
Figure 1.8 - Types of Squares



A combination square is so named because unlike ordinary squares it consists of multiple tools. This tool features a metal, removable ruler for measuring and two bubbles (one for leveling and the other for plumbing an object). It can be used as a plumb, level, scale, marking gauge, and miter square. It can also be used as a try square for inside and outside measurements. See Figures 1.8 and 1.9.

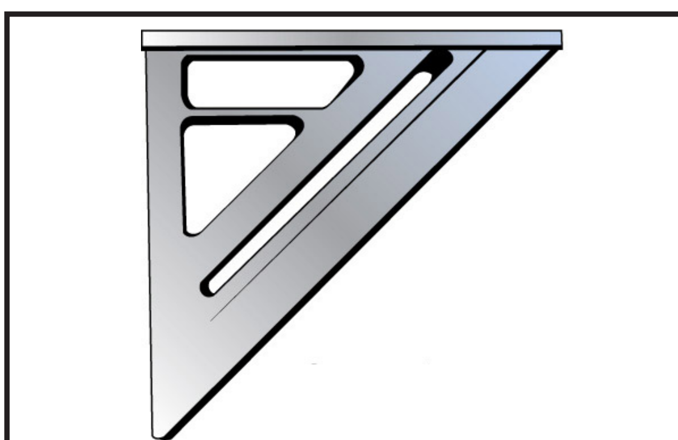
A try square, so named because it is used to try or test the accuracy of cuts, consists of a metal graduated blade set into a metal or wood handle. The blade and handle form a right angle. This tool is used for marking lines at right angles to prepare for cutting, checking a board's thickness to determine if it measures the same throughout its length, and testing an edge for squareness. Some try squares have an edge on the handle that forms a 45-degree angle for mitering. See Figure 1.8.

Figure 1.9 - Uses of a Combination Square



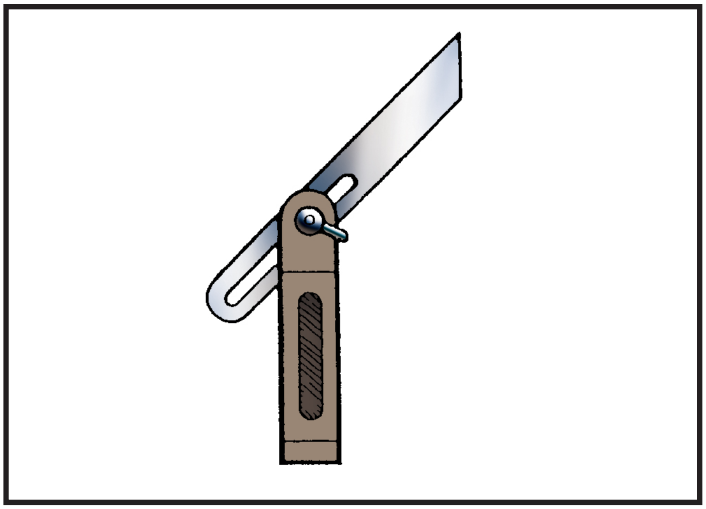
A speed square is shaped like a triangle but functions as a square. Two sides of the triangle have scales of measurement and the third side has an extended surface for butting up square with the edge of the work. Its uses include laying out stairs and rafters and measuring and marking miter cuts. See Figure 1.10.

Figure 1.10 - Speed Square



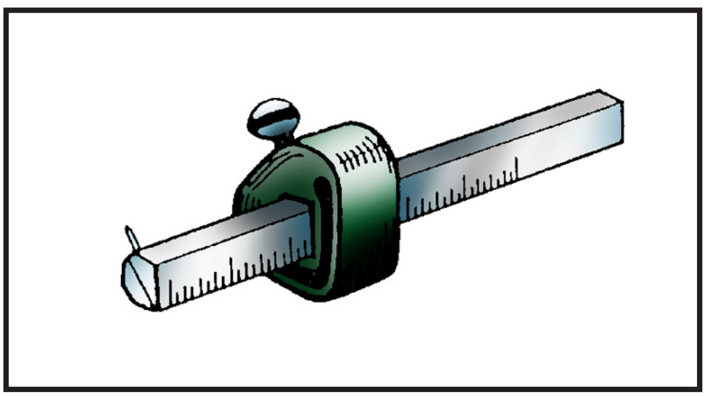
A sliding T-bevel consists of a body, blade, and locking device. The angle of the T-bevel is set by using a protractor and then the blade is locked in place. This tool is used for laying out and checking angles, bevels, and chamfers and as a guide for drilling holes at an angle. See Figure 1.11.

Figure 1.11 - Sliding T-Bevel



A marking gauge is made of wood or metal and consists of a graduated blade for measuring, a head with a faceplate that can be locked in place against the edge of the stock, and a pin for marking. It is used for scribing parallel lines to the edge or end of the stock. See Figure 1.12.

Figure 1.12 - Marking Gauge



A chalk line is a piece of cord that has had chalk applied to it. Snapping a chalk line is a quick method to mark a thin, straight line on a flat surface such as a floor, wall, or piece of lumber. See Figure 1.13.

A plumb line is a string with a piece of metal (plumb bob) tied at the end. The plumb bob hangs vertically straight and is used to establish a vertical reference point and check the plumbness of walls and structures. See Figures 1.14 and 1.15.

Figure 1.13 - Snapping a Chalk Line

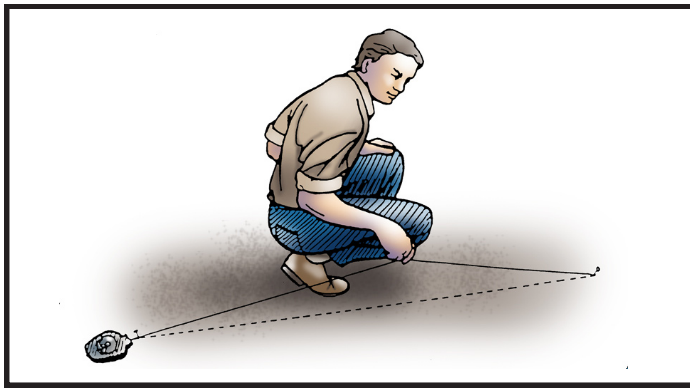


Figure 1.14 - Using a Plumb Bob and Square

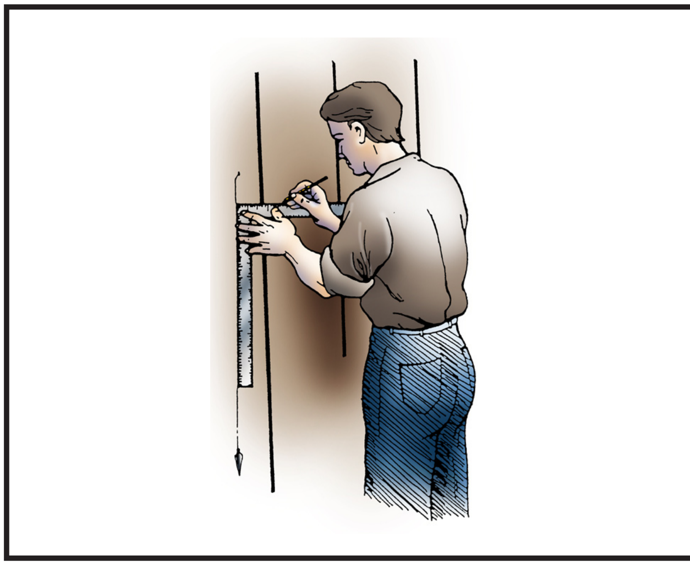
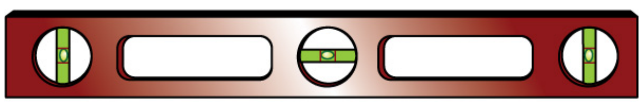


Figure 1.15 - Using a Plumb Bob to Locate a Point

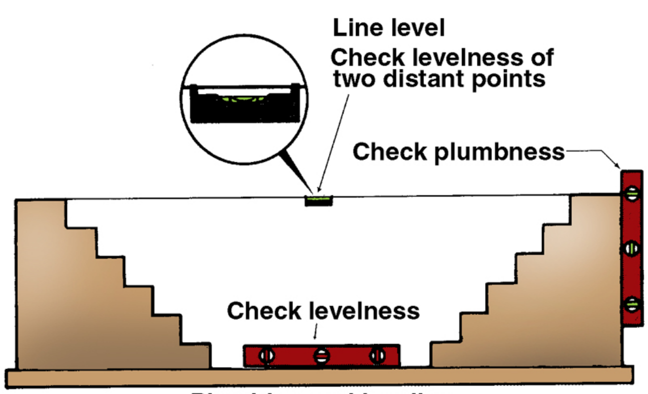
A level is a device used to determine if an object is level or plumb. It generally consists of a bar of wood or aluminum with transparent tubes (horizontal for level and vertical for plumb), each containing an air bubble. See Figure 1.16. The level is placed on a horizontal or vertical surface and the position of the air bubble is used to determine if the surface is level or plumb. See Figure 1.17. Some levels, called line levels, are made to attach to a line that is stretched tight between two distant points to find if the ends are at the same height.

Figure 1.16 - Level



Horizontal tube - checks level
Vertical tube - checks plumb

Figure 1.17 - Plumbing and Leveling



Plumbing and leveling

Summary

The two common systems of measurement are the U.S. customary system and the metric system. Woodworkers need to be able to make linear measurements and calculate the area of an object and board feet of lumber. Understanding these systems and knowing how to use measurement tools for layout and construction are essential to a successful woodworking project.

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Lesson 2: Working With Saws

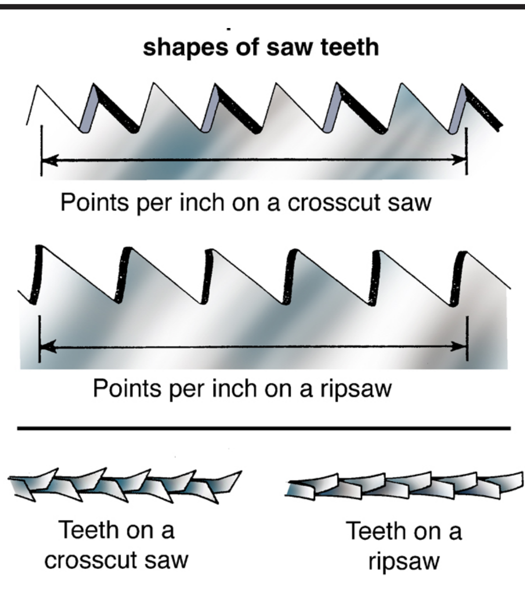
Sawing with the proper technique is essential to a successful woodworking project. This lesson covers general procedures for cutting with a handsaw and power saw, as well as safety considerations. Your instructor must be present to show the step-by-step procedures for specific saws and cuts and guide you through them.

Cutting With a Handsaw

Selecting the Saw Blade

The first step to making a cut is selecting the correct handsaw. If making a crosscut such as cutting a board to length by cutting the end off, choose a saw blade with pointed, knife-like teeth for cutting across the grain. The number of teeth varies depending on the purpose of the saw. Crosscut saws with fewer tooth points per inch (7) are used for coarser cuts or for cutting unseasoned wood. For general use, an 8- to 10-point saw is sufficient. For finer cutting, 11- or 12-point saws are used. If making a rip cut such as cutting a board along its length, choose a saw blade with chisel-shaped teeth for cutting with the grain. Ripsaws normally have 5 1/2 tooth points per in. See Figure 2.1.

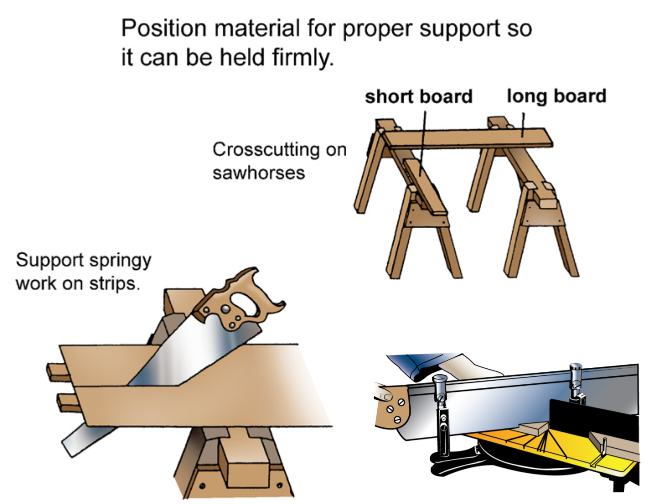
Figure 2.1 - Choosing a Saw



Marking and Securing the Stock

To mark the stock, use a straightedge and hard lead pencil to make a fine line. The finer the line, the more accurate the final cut is likely to be. The method used to secure the stock depends on the size of the stock and cut to be made. Smaller pieces can be held in a vise. Larger pieces can be held firmly in place on a sawhorse with the noncutting hand or in a clamping device. Ensure that the extra (waste) material and the mark are over the end of the sawhorse or work surface. This prevents the stock from binding against the saw as the cut is made. A miter box can be used for precise angle cuts. See Figure 2.2.

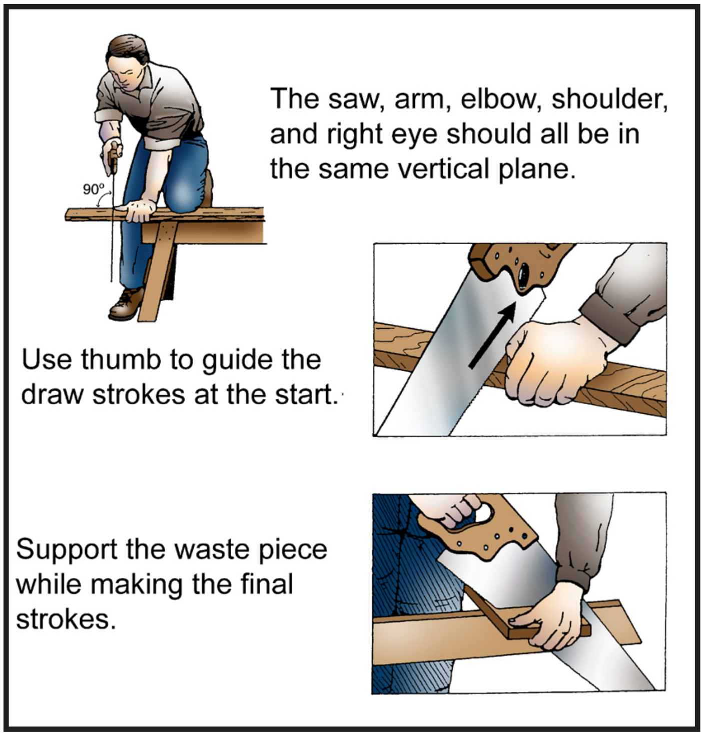
Figure 2.2 - Methods of Supporting Boards When Sawing



Starting the Cut

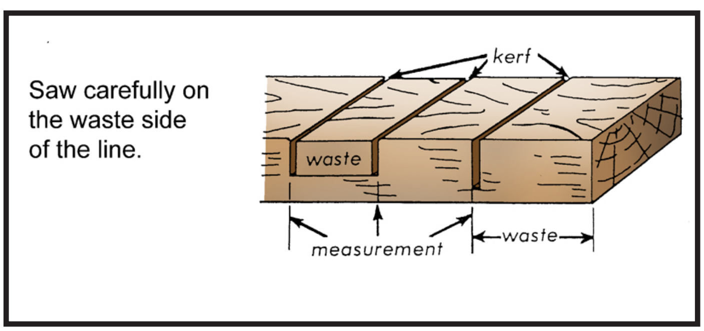
Put on protective eyewear and ensure that others in the work area are wearing protective eyewear as well. When grasping the saw handle, position the index finger along the handle to improve control. See Figure 2.3.

Figure 2.3 - How to Hold a Saw



Set the blade on the waste side of the mark. Be sure to position yourself so parts of your body will not be cut if the saw slips from the stock. Using the thumbnail of the noncutting hand as a guide, slowly draw the saw back along the line to begin, being careful not to cut your thumb. When the cut is started, move your thumb out of the way. The cut or groove the saw makes is called the kerf. See Figure 2.4.

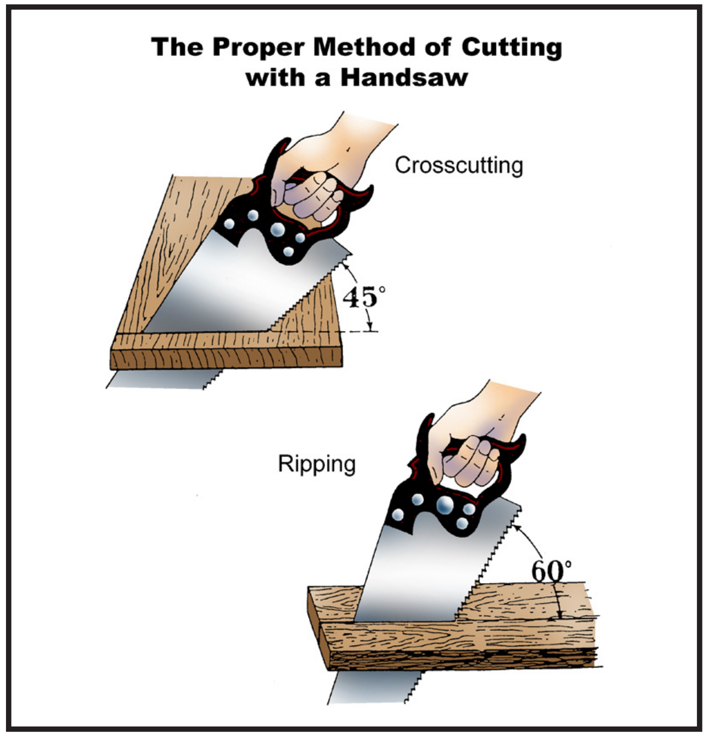
Figure 2.4 - Kerf and Waste Portion of Stock



Making the Cut

Hold the saw at a 45-degree angle for crosscutting and a 60-degree angle for ripping. See Figure 2.5. Be sure your wrist, elbow, and shoulder are in line with the cut.

Figure 2.5 - Proper Angle to Hold a Saw

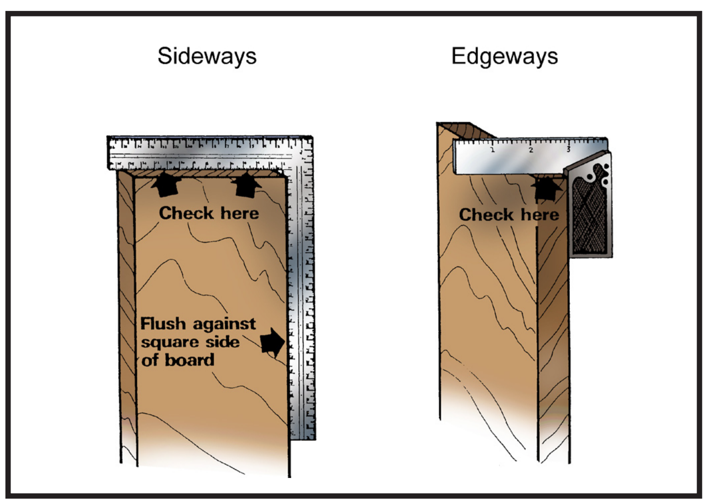


Cut with long, even strokes, keeping your eyes on the same vertical plane as the cut. At the end of the cut, support the waste piece of material so it doesn't splinter the edge of the stock or bind the blade.

Finishing the Task

Lay the saw down with the teeth positioned so that no one can be cut if he or she brushes up against the blade. Check the cut with a square. See Figure 2.6. When finished, return the materials and equipment to their assigned places in the shop.

Figure 2.6 - Using a Square to Check Straightness of a Cut



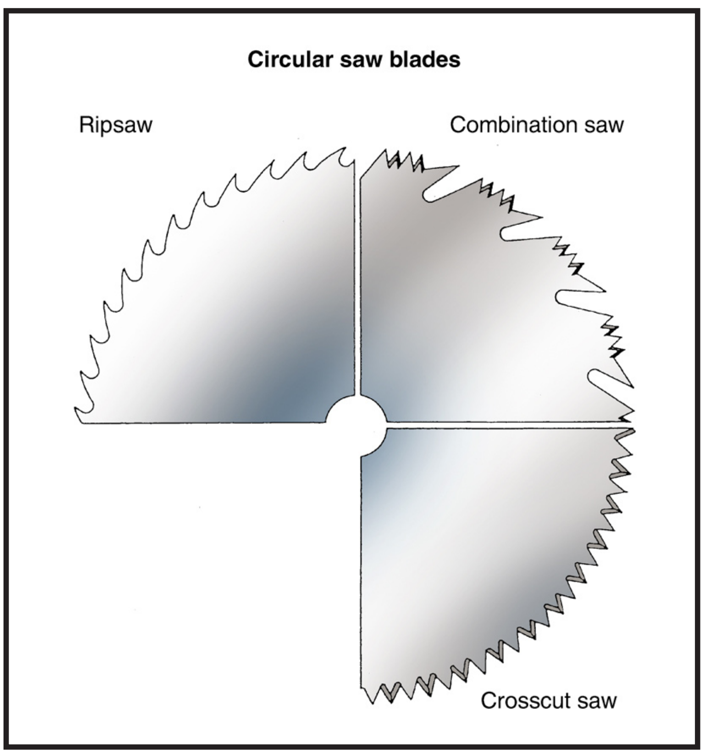
Cutting With a Power Saw

Caution: Unplug the saw from the power supply before inspecting the saw, making adjustments, or changing the blade. Do not use a damaged saw or blade and report the damage to the instructor.

Selecting the Saw Blade

The correct saw blade depends on the material to be cut and the cut to be made. The names of common power saw blades describe their purpose (e.g., crosscut, rip, and combination). See Figure 2.7. A combination blade is used for both crosscutting and ripping. It is also important to make sure the blade is sharp for smooth operation. If changing a blade, install the blade using the manufacturer's instructions. Check all guards and ensure they are installed correctly for the saw being used. Remember that even though they are similar, the blade of a portable circular saw and the blade of a table saw are installed the opposite way. Inspect the saw for damage and report any damage to the instructor.

Figure 2.7 - Types of Power Saw Blades



Planning the Cut

Evaluate whether the size of the stock requires a clamp, push stick, or other device. Short, narrow stock requires a push stick. Longer stock requires an assistant or a support with rollers to support the stock. Decide how the stock should be positioned to avoid splintering the better side. For example, because a portable circular saw cuts from the bottom up, the good side of the stock should be placed down. Use a straightedge and hard lead pencil to lay out a fine cutting mark.

Making the Cut

Put on protective eyewear and ensure that others in the work area are wearing protective eyewear as well. Be sure the tool is properly grounded and the cord will not get tangled in the work. Adjust the blade so that the teeth clear the thickness of the board by 1/4 in. and check that the stock is firmly secured. Ensure the saw is at full speed before cutting the stock. Keep hands clear of the cutting line and if using a table saw, stand to the side of the blade and do not reach across it. If the saw is not functioning properly or doesn't sound right, turn it off immediately and report it to the instructor.

Finishing the Task

When finished, turn off the power and stay with the tool until it has come to a complete stop. Check the cut with a square. Clean up dust and scraps following shop procedures and return materials and equipment to their assigned places.

Summary

Proper cutting with a hand saw or power saw requires selecting the correct blade and saw, planning the cut, marking and securing the stock, carefully making the cut, cleaning the area and equipment, and putting the tool in its assigned place. All these steps must be done with the operator focusing on the task and practicing the safety precautions.

Credits

Agricultural Construction: Volume II. University of Missouri-Columbia: Instructional Materials Laboratory, July 1989.

Agricultural Mechanics Unit for Agricultural Science I. University of Missouri-Columbia: Instructional Materials Laboratory, July 1982.

Cooper, E.L. *Agricultural Mechanics: Fundamentals and Applications* (3rd ed). Albany, NY: Delmar Publishers, 1997.

Feirer, J.L. *Furniture and Cabinet Making*. Peoria, IL: Bennett Publishing Company, 1983.

Wagner, W.H., Smith, H.B. *Modern Carpentry*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2000.

Zimmerman, F.W., McWard, L.J. *Exploring Woodworking: Fundamentals of Technology*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 1999.

Lesson 3: Working With Drills

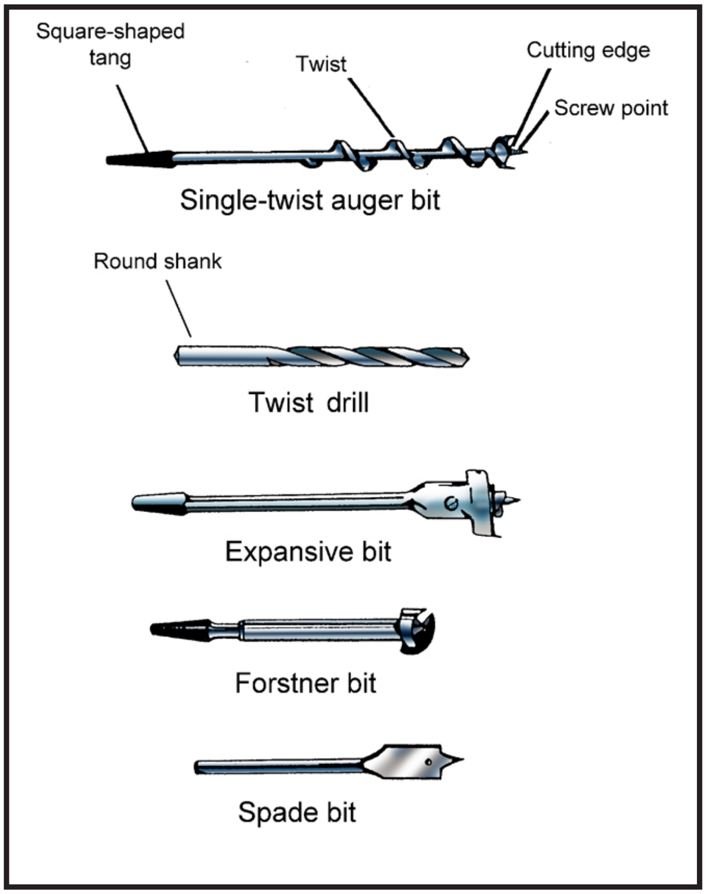
Just about every woodworking project in agricultural mechanics will require drilling or boring of holes. Whether these holes are for fasteners, dowels, or creating space for a saw blade, it is important to select the right tools and perform the proper technique in making the holes. This lesson covers general procedures for boring a hole with a handheld drill as well as related safety considerations. Your instructor must be present to demonstrate the step-by-step procedures for specific drills and guide you through them.

Common Drill Bits

Drill bits are available in many shapes and sizes for various functions. Besides basic hole drilling bits, there are specialized bits such as countersink bits for recessing screw heads or screwdriver bits for driving and removing screws. The two basic types, based on the back of the bit or shank, are the round- or straight-shank bits and square-shank bits. The latter have a tapered square tang on the end. The round-shank bits are used in hand drills and portable electric drills, whereas the square-shank bits are used in braces. Some of the common bits (auger, expansive, Forstner, spade, and twist drills) are discussed below. See Figure 3.1. Note that the auger, expansive, Forstner, and spade drill bits are available in both square and round shanks for use in braces and portable power drills.

For boring (making holes 1/4 in. and larger) in wood, an auger bit is used. An auger bit is typically sized by the size of hole it will bore in 16ths of an inch. For example, a number 4 bit will bore a 4/16 in. (1/4 in.) hole. This bit has a screw point at the tip for pulling the bit into the wood, a cutting edge for making the hole, and a twist for clearing the waste out of the hole. The end that fits in the chuck of the drill is called the tang.

Figure 3.1 - Common Types of Drill Bits



Another type of auger bit, called an expansive bit, has cutters that can be adjusted to bore more than one size of hole. Because of its versatility, this bit can take the place of several auger bits. Adjusting an expansive bit typically consists of loosening a setscrew, moving the cutters to the desired position, and tightening the setscrew.

A Forstner bit is used for making holes that do not go all the way through the stock. It is designed without a screw point at the tip so that it does not split the other side of the wood. This bit makes a smooth, flat-bottomed hole and is useful for smoothing the bottom of a hole made by an auger bit. It is also good for enlarging existing holes.

A spade or speed bit is shaped like a flat spade with a cutting edge that has a sharp triangular point in the middle. It is useful for counterboring (partially enlarging a hole so a screw head can be driven below the surface of the stock). The width of the spade is the size of the hole it will make. The cutting edges can be resharpened or reshaped for different purposes (e.g., shaping the cutting edge in a curve to make a hole with a round bottom).

Twist drills or twist drill bits are available for use on a variety of materials. These bits, used in hand drills and portable electric drills, have a round shank and a body with twisted flutes. Similar bits with square shanks called bit-stock drills are used in braces. A newer type of twist drill is available with a brad point at the end to help it stay in place when starting a hole.

Boring a Hole With a Handheld Drill

Using a Brace

The first step to drilling or boring a hole is selecting the correct drill bit. Use the information in the previous section for guidance. The bit for a brace must have a square tang to fit in the chuck. Ensure you are using the right bit for the stock and the type of hole being made. Inspect the brace for damage and report any damage to the instructor.

To lay out the holes, use a square and a hard lead pencil to lightly draw the lines and locate the exact position of the holes. Make a small hole with a scratch awl where the lines intersect (center point of the hole) to create a recess for the bit to start; this keeps the bit from slipping. Install the bit in the chuck and tighten the jaws by hand.

Put the stock to be bored in a vise or clamp it to a workbench to keep it firmly in place. Use two try squares as a guide for the bit. (See the Methods to Make Straight Holes section in this lesson for more details.)

Put on protective eyewear and ensure that others in the work area are wearing protective eyewear as well. Check to see that the bit is centered in the brace. Guide the tip of the bit into the starter hole and use the squares as a reference point to keep the brace perpendicular to the stock. If possible, drill with the bit vertical to the work to help maintain the perpendicular angle.

Turn the brace clockwise, using even pressure and keeping the bit straight up and down between the squares. Keeping the drill at the correct angle will avoid binding the bit. If boring a deep hole, it is recommended to remove the bit part way through the hole to clear the waste and let the bit cool. Reduce the pressure when nearing the other side. When the bit begins to break through, stop and remove the bit from the hole. Removing the bit before finishing the hole helps to prevent the stock from splitting. (See Techniques to Avoid Splitting the Wood in this lesson for more details.) Turn the stock over, reposition the squares, and finish boring the hole.

Remove the work from the securing device and inspect it. Remove the bit from the brace when finished. Clean up all dust and scraps per shop procedures and return the bit, brace, and other materials to their assigned places.

Using a Portable Power Drill

Caution: Disconnect the power drill from the power supply before inspecting the tool or making any adjustments. Do not use a damaged drill or bit, and report the damage to the instructor.

The first step in drilling or boring a hole is selecting the correct drill bit. Use the information in the first section of this lesson for guidance. The bit for a portable power drill must have a round shank to fit in the chuck. Ensure you are using the right bit for the stock and the type of hole being made. Inspect the drill for damage.

To lay out the holes, use a square and a hard lead pencil to lightly draw the lines and locate the exact position of the holes. Make a small hole with a scratch awl where the lines intersect (center point of the hole) to create a recess for the bit to start; this keeps the bit from slipping. Install the bit in the chuck and tighten the jaws using the chuck key in each hole then remove the key.

Caution: Be sure to remove the chuck key after tightening is complete. If the key is left in the chuck during use, it can fly out and cause injury or damage.

Put a piece of scrap stock under the stock to be bored; this helps to prevent the back of the stock from splitting. (See Techniques to Avoid Splitting the Wood in this lesson for more details.) Clamp them to a workbench to keep them firmly in place. Use two try squares as a guide for the bit. (See the Methods to Make Straight Holes section in this lesson for more details.)

Put on protective eyewear and ensure that others in the work area are wearing protective eyewear as well. Do a visual check of the bit to make sure it is centered in the drill. Plug the drill in, turn it on, and watch the rotation of the bit to ensure it is straight (not installed at an angle). Turn the drill off and guide the tip of the bit into the starter hole. Use the squares as a reference point to keep the drill perpendicular to the stock. If possible, drill with the bit vertical to the work to help maintain the perpendicular angle.

Ensure the cord is clear of the work and turn the drill on. Use even pressure and keep the bit straight up and down between the squares. Keeping the drill at the correct angle will avoid binding the bit. If boring a deep hole, it is recommended to remove the bit part way through the hole to clear the waste and let the bit cool. Lighten up on the pressure as the drill breaks through the stock, being careful not to bore all the way through the scrap or into any table or clamp underneath. Release the power switch and wait until the drill comes to a complete stop.

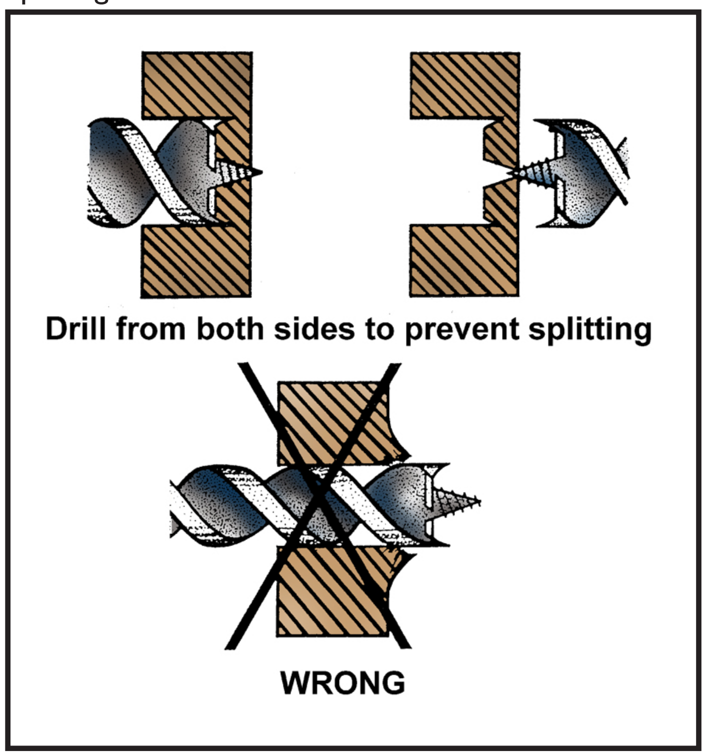
Remove the work from the securing device and inspect it. Unplug the drill and remove the bit when finished. Clean up all dust and scraps per shop procedures and return the bit, drill, and other materials to their assigned places.

Techniques to Avoid Splitting the Wood

To avoid splitting the back of the wood when making a hole, use one of two methods.

- Remove the bit when the screw point begins to break through the stock. Then insert the bit on the other side of the stock and finish boring the hole. See Figure 3.2.

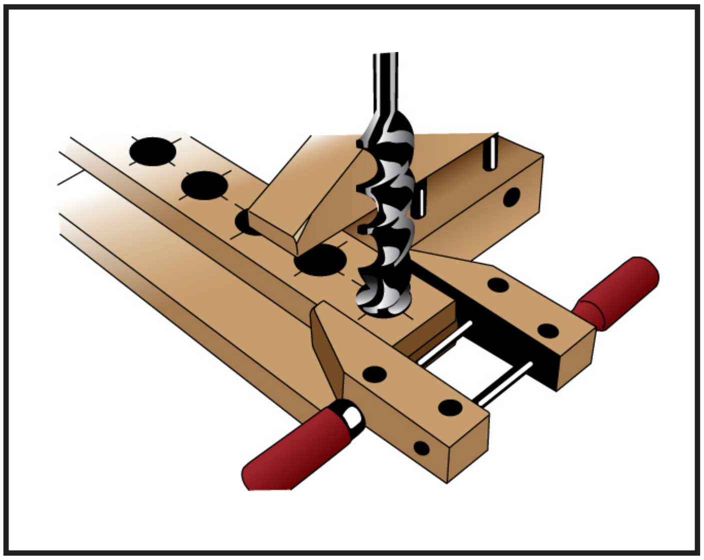
Figure 3.2 - Drilling From Both Sides to Avoid Splitting Wood



- Clamp a piece of scrap wood under the stock. The scrap stock supports the edges of the hole and as the bit bores into the scrap, it helps to cleanly and completely finish the hole. Be careful not to mar the face of the good board with the clamp. See Figure 3.3.

To avoid splitting the sides of a narrow stock, especially when making a large hole, put it in a clamp to provide support to both sides.

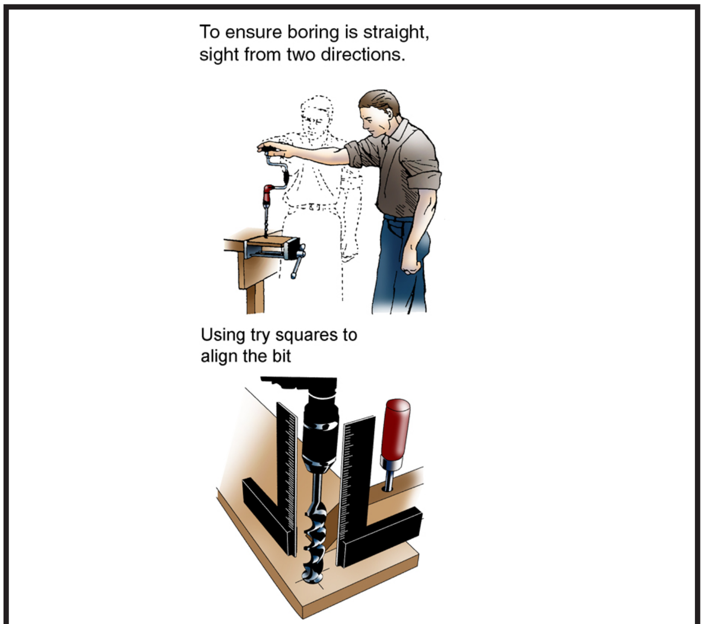
Figure 3.3 - Using Waste Stock and a Clamp to Avoid Splitting Wood



Methods to Make Straight Holes

To help in making a straight hole, use one of two methods. See Figure 3.4.

Figure 3.4 - Methods for Making Straight Holes



- When the bit is positioned at the starting point on the work, have a student or the instructor view the bit from two different angles to ensure the bit is perpendicular to the work.
- Set two try squares at 90 degrees to each other on both sides of the hole to be drilled. The squares will serve as a guide to keep the bit perpendicular to the work.

Summary

Making straight and accurate holes with a drill requires selecting the correct bit, marking and securing the stock, and using even pressure to make the hole. After drilling is completed, the work area should be cleaned and tools and materials should be put back in their assigned places. The drilling procedure must be done with the operator focusing on the task and practicing the safety precautions.

Credits

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Umstattd, W.D., Davis, C.W. *Modern Cabinetmaking*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2000.

Wagner, W.H., Kicklighter, C.E. *Modern Woodworking*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 1996.

Wagner, W.H., Smith, H.B. *Modern Carpentry*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2000.

Zimmerman, F.W., McWard, L.J. *Exploring Woodworking: Fundamentals of Technology*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 1999.

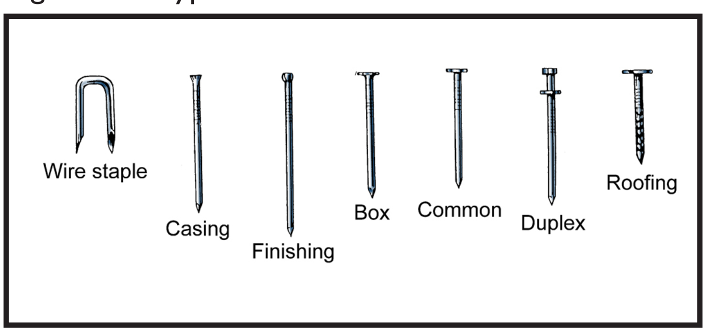
Lesson 4: Using Fasteners

When choosing and using fasteners in woodworking, one must consider many factors and perform the proper technique to produce a strong hold or bond. This lesson discusses common fasteners (nails, screws, and adhesives) and provides application guidelines as well as safety considerations. Your instructor must be present to demonstrate the step-by-step procedures for using specific fasteners and guide you through them.

Common Types of Nails and Their Uses

Nails are one of the most widely used types of fasteners for woodworking and are available in a wide variety of shapes and sizes. It is important to choose the right kind and size of nail to avoid splitting or distorting the wood and ensure maximum holding strength. The length of a nail from head to point is designated by the penny system. The letter "d" is used to indicate penny. For example, a two-penny nail is 1 in. long and written as "2d." A gauge system is used to measure the diameter of a nail. With nails, the gauge number decreases as the diameter of the nail increases. Common types of nails (common, box, finishing, casing, roofing, duplex, and wire staple) and their uses are as follows. See Figure 4.1.

Figure 4.1 - Types of Nails



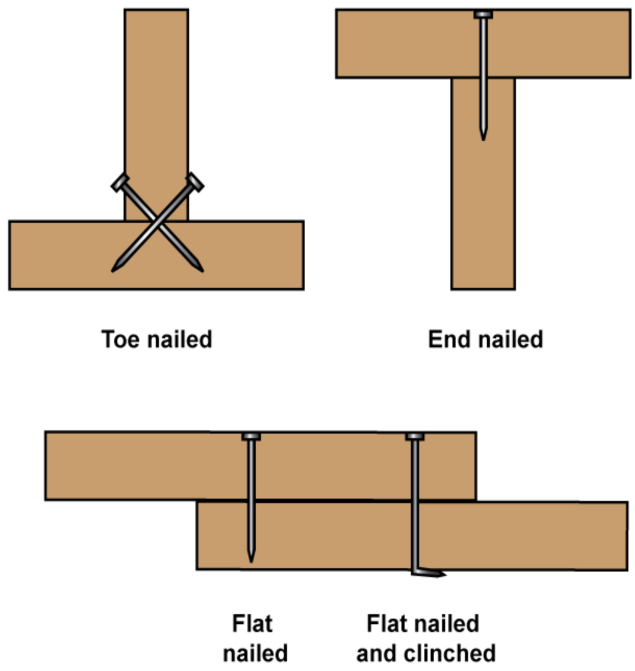
- Common nails have flat heads and are used in framing, rough nailing, and board fencing where appearance is not as important.
- Box nails are similar to common nails but have a smaller diameter and head. These nails are used for light construction and on types of wood that split easily.
- Finishing nails are a good choice for doing interior finishing, such as cabinetwork, trim, and furniture work. These nails have small rounded heads and are usually countersunk (driven flush with the work), so the heads barely show.
- Casing nails are similar to finishing nails but are heavier and have small, cone-shaped heads. These nails are used for window and door frames and similar work.
- Roofing nails are used with rolled roofing and composition shingles. Their large flat heads help to hold the soft material without pulling through.
- Duplex nails have two heads, with the lower one being larger. These nails are used in temporary construction such as constructing forms for concrete. With the upper head being above the surface, this nail can easily be removed with a claw hammer. Another use is nailing electric fencing to posts.
- Wire staples, shaped like a U, are commonly used in fence construction, such as nailing wire fencing to wooden posts. Their size is indicated by their length and width.

Methods of Fastening Wood With Nails

Two basic methods of fastening wood with nails are straight nailing and toe nailing.

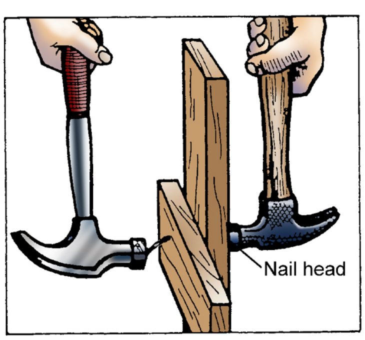
- Straight nailing is nailing directly through the top piece into the one underneath. More specific types of straight nailing are end nailing, flat nailing, and clinch nailing. See Figure 4.2.

Figure 4.2 - Methods of Fastening With Nails



- o End nailing is nailing through the thickness of one piece straight into the end of another piece. This method does not produce a strong hold and sometimes glue is used as well.
- o Flat nailing is nailing two flat pieces together. In this method the nails should be staggered so that they are less likely to split the wood.
- o Clinch nailing is flat nailing and bending the end of the nail into the second piece of stock. This provides a stronger hold than flat nailing. See Figure 4.3.

Figure 4.3 - Clinch Nailing



Use two hammers to clinch nails. Hold one hammer at the nail head and use the second one to bend and flatten nail.

- Toe nailing is driving nails in at an angle to increase the holding strength. This method is commonly used when fastening two pieces of wood at right angles as in framing. See Figure 4.2

Using Nails to Fasten Wood

Selecting the Nails

In selecting the nail, it is important to use the right type of nail for the job. For example, finishing nails would not be an effective fastener for roofing shingles. In addition, it is essential to choose the right size of nail. Generally, a nail that is three times as long as the thickness of the top piece will produce the best results.

Selecting the Driving Tool

To select a claw hammer, consider the size of the nails and the weight of the head of the hammer. For example, a light hammer (7 oz) is better for driving brads and finishing nails, whereas a heavy hammer (16 to 20 oz) is better for driving large nails and spikes. If it is necessary to remove large nails, a wrecking bar may be needed.

Following Safety Procedures

When fastening with nails, the person using the hammer and everyone in the work area should wear protective eyewear. It is important to inspect the hammer before using it to ensure that the head is firmly attached, the face is clean, and that the handle is not broken. Do not use a damaged hammer. Report the damage to the instructor. In addition, do not use a hammer on material that can damage the head, such as concrete.

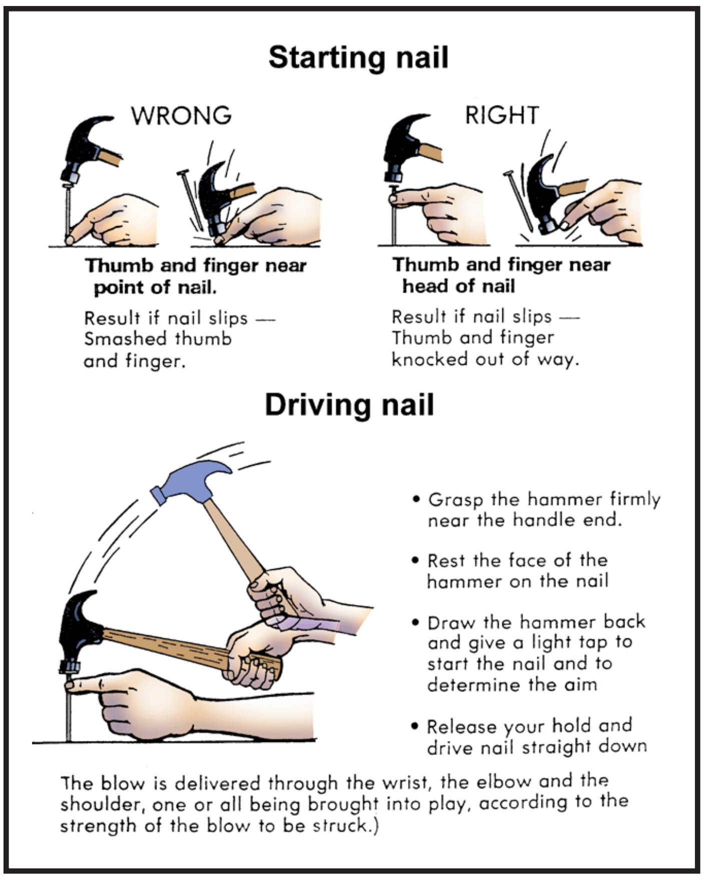
Preparing to Nail

If precision is required, lay out the hole pattern with a hard lead pencil. When nailing two pieces of different thicknesses, the thinner piece should be nailed to the thicker one to ensure the thin piece will not come off the end of the nail. If nailing in hard wood, it may be necessary to drill a pilot hole a little smaller than the diameter of the nail to avoid splitting the wood.

Starting the Nail

The positioning of your fingers on the nail is important to prevent injury. When setting the point of the nail on the stock, hold the nail with the thumb and index finger high on the nail. See Figure 4.4. This improves the chances that fingers will be pushed clear rather than smashed by a missed stroke. Hold the hammer close to the end of the handle and keep your eyes focused on the nail head. To start the nail, just lightly tap it and then remove the steadying hand when the nail stands on its own.

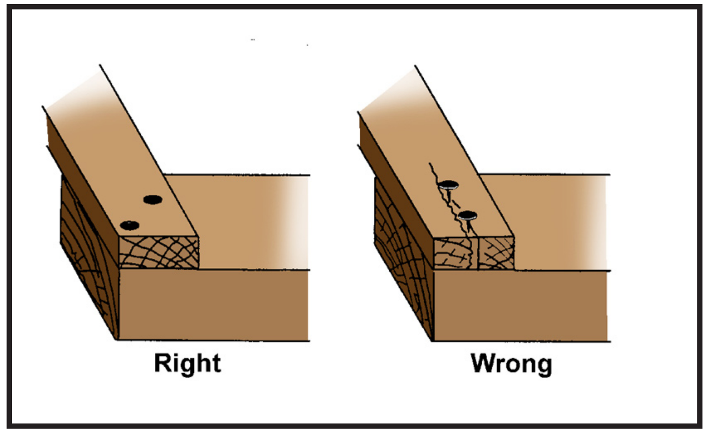
Figure 4.4 - Starting and Driving a Nail



Driving the Nail

To hammer the nail straight and efficiently, use full, even strokes with the wrist and arm. See Figure 4.4. Keep the face of the hammer flat against the nail head. Avoid hitting the wood with the hammer, as this will mar the surface. Stop hammering when the head of the nail is flush with the surface of the stock. If necessary to drive the head of the nail below the surface, a nail set may be needed. Additional nails should be staggered to help prevent splitting the wood. See Figure 4.5.

Figure 4.5 - Staggering Nails to Avoid Splitting the Wood



Finishing the Task

Inspect the work, clean the work area of debris, and return the materials and equipment to their assigned places.

Common Types of Screws and Their Uses

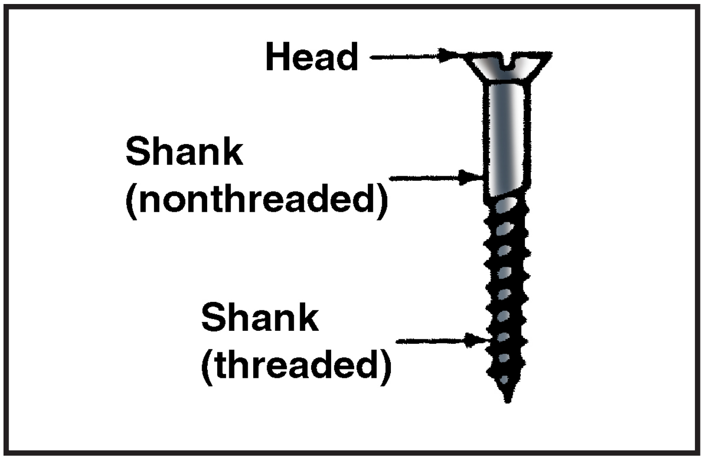
Screws do the same job as nails but have a threaded shank that provides a stronger hold. And unlike nails, screws can be removed easily without damaging the wood. Therefore, they are used for projects where assembly and disassembly of parts are required. They are also measured by length and diameter but unlike nails, the gauge number increases with the diameter instead of decreases.

When choosing screws for a woodworking project, be aware that they are classified by the material they hold, material they are made from, finish, shape of their head, and the tool used to install them.

Material They Hold

Wood screws, as the name describes, are specifically designed to hold wood. The shank of a wood screw is threaded at the bottom and unthreaded at the top to pull the top piece of stock against the bottom. See Figure 4.6. Sheet metal screws have wide threads that run the length of the shank and allow the metal to sit between the threads. These screws can also fasten metal to wood or be used on fiberboard. Another type of screw, called a lag screw, has an extremely coarse thread for use in fastening structural timber and anchoring masonry. See Figure 4.7.

Figure 4.6 - Parts of a Screw



Material They Are Made From and Finish

Screws are commonly made from steel or brass and have different finishes. Steel screws can have blued, galvanized, chromium, or nickel finishes for various purposes. For example, the purpose of the blued finish on a steel screw is to inhibit rust. Brass screws are selected for their high-quality appearance and ability to hold up in high-moisture conditions.

Shape of the Head and Tool Used

Common woodworking screws include the flat head, which has a cone-shaped head that is countersunk to fit flush with the surface of the stock; round head, which has a head that fits on top; and oval head, which has a head that fits partially below and above the surface. See Figures 4.7. See Figure 4.8 for common types of sheet metal screws. These heads may have either a single slot or a slot shaped like a cross that is recessed in the middle. The single-slotted screws require a standard screwdriver to install them and the recess-slotted screws require a Phillips screwdriver. See Figure 4.9. For best results when installing screws, the width of the tip of a standard screwdriver should be the same width as the screw slot, and the tip of a Phillips screwdriver should touch the bottom and fit tightly in a Phillips head screw.

Figure 4.7 - Types of Wood Screws

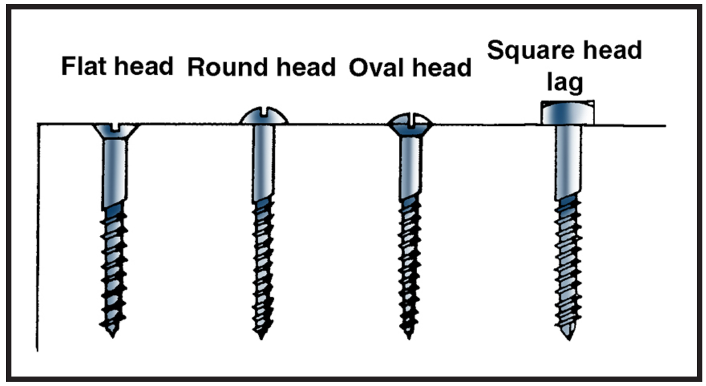


Figure 4.8 - Types of Sheet Metal Screws

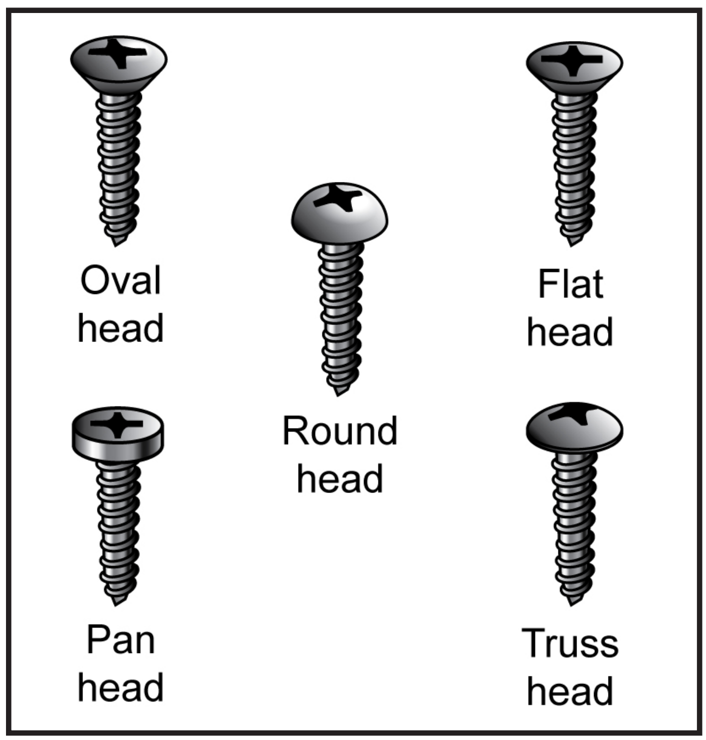
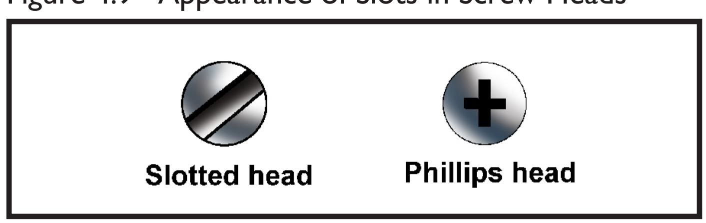


Figure 4.9 - Appearance of Slots in Screw Heads



Using Screws to Fasten Wood

Selecting the Screws

Selecting screws takes careful consideration because of the wide variety of sizes and shapes available. It is important to use the right type of screw for the job. For example, if fastening in the end grain of the stock, choose a longer screw for extra holding power. Generally, a screw that is three times as long as the thickness of the top piece will produce the best results.

Selecting the Driving Tool

To select a screwdriver, consider the size of the screw slot and the type of slot. For efficient operation, the screwdriver's tip should fit the slot of the screw as closely as possible. For example, using a tip that is too thin for the slot can bend the tip and using a tip that is too thick for the slot reduces leverage. Using the correct size screwdriver provides ample leverage and makes the screwdriver less likely to slip.

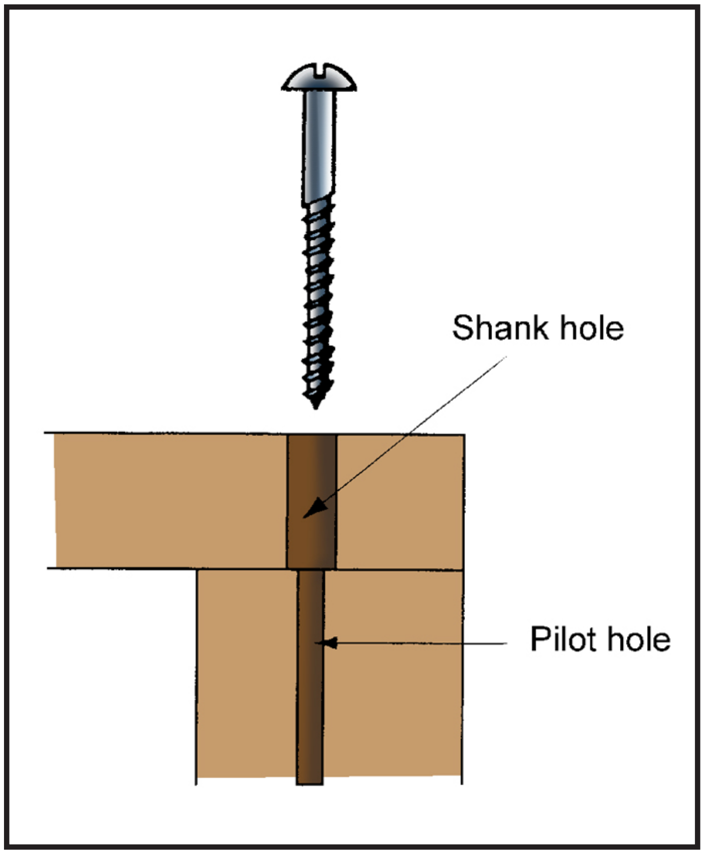
Following Safety Procedures

Persons using tools and everyone in the work area should wear protective eyewear. It is important to inspect the screwdriver and drill for damage. Do not use a damaged screwdriver or drill and report the damage to the instructor. Follow safety and usage steps for the type of drill being used.

Marking and Drilling the Pilot and Shank Holes

Pilot and shank holes should be drilled to aid in setting the screw. See Figure 4.10. Lay out the hole pattern with a hard lead pencil. To determine the size of the pilot and shank holes needed, consult a chart or compare the screw to different bits until the correct ones are found. The pilot hole should be the same size as the center (core) of the screw, not the diameter of the threads. The bit for the shank hole should be the same diameter of the shank of the screw. Ensure both pieces of stock are secured and drill the pilot hole through both pieces of wood to a depth equal to the length of the screw. If the bit is too long, mark the correct depth with a piece of tape or use a gauge to drill the hole. Then use the shank drill to drill through the first piece of wood only. If necessary, use a countersink to enlarge the top of the hole until the screw sits flush with the work.

Figure 4.10 - Drilling Pilot and Shank Holes Before Setting the Screw



Setting the Screw

Assemble the pieces using a screwdriver that properly fits the screw slot. Do not apply too much pressure or the screw head may be damaged or come off. This is especially true with brass screws because they are a softer metal. If the screw is difficult to turn, it may mean the pilot and shank holes are too small.

Finishing the Task

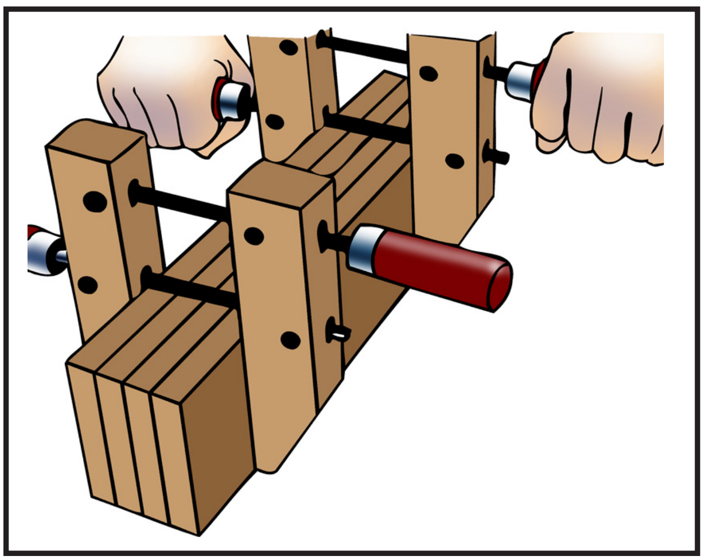
Inspect the work, clean the work area of debris, and return the materials and equipment to their assigned places.

Adhesive Considerations and Types

Adhesives are often used in woodworking to laminate wood or other materials. They are also used in addition to metal fasteners to provide a stronger bond. When choosing from the wide selection of adhesives available, it is important to check the label of the adhesive for the following information as related to the woodworking project.

- Safety - It is essential to understand the toxicity and flammability of the product and carefully follow the instructions for proper use and ventilation.
- Assembly time - After applying the adhesive, this is the time the worker has to assemble the pieces. This factor is especially important if the project has numerous pieces.
- Clamp or set time - This is how long the pieces need to remain clamped after the adhesive has been applied. See Figure 4.11.

Figure 4.11 - Using Clamps to Hold Wood Together Until Adhesive Dries



- Curing time - After the adhesive sets, this is the time required for the bond to reach full strength.
- Materials to bond - Adhesives are made with different chemical properties to work on specific materials such as wood, metal, or plastic.
- Environment for the project - Adhesives have various abilities to withstand water, heat, or solvents on the materials. For example, a water-resistant adhesive should be used for fastening an outdoor bench.

Some of the common types of adhesives used for woodworking are the following:

- Polyvinyl adhesives (PVA) "white glue" - This adhesive lacks heat and moisture resistance and is good for interior woodwork. It is convenient, ready to use, has a short clamp time, and cures in 24 hours.
- Aliphatic resin glue "yellow glue" - This adhesive lacks moisture resistance and is good for interior woodwork. It is similar to PVA but stronger and more resistant to varnish, lacquer, and paint. It sands easily.
- Solvent-base contact cement - This adhesive is used for bonding laminates to wood. It is quick drying and can be highly toxic and flammable. Check with the manufacturer for specifications.
- Water-base contact cement - This adhesive can be used with plastics and lacquered surfaces but should not be used with metal or wood veneer. It is a nontoxic, nonflammable alternative to solvent-base cements.
- Epoxy cement - This adhesive is extremely strong and waterproof and can be used for joints in high-stress areas. It comes in two parts that must be mixed and is expensive for large applications. The setting speed can be controlled and after curing it can be sanded. Epoxy can produce heat in the curing process that can warp materials or burn skin. Consult the manufacturer's specifications for other safety considerations.

Summary

Nails are known for their fast and easy use, whereas screws provide a stronger hold and easy assembly or disassembly of parts. Adhesives are an alternative that can be used alone or as a supplement to nails or screws to create a stronger bond. Whichever fastener is chosen, using the proper procedure for applying the fastener and following safety rules is essential to a successful woodworking project.

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Lesson 1: Sharpening and Reconditioning Hand Tools

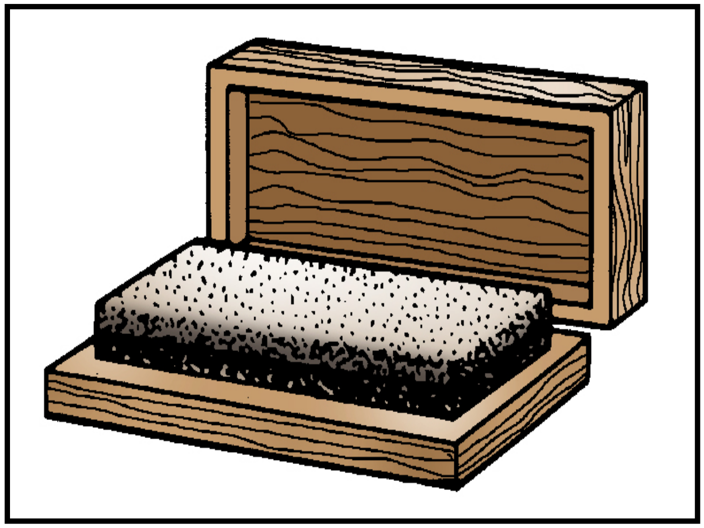
Many hand tools used in agricultural mechanics will become dull and misshapen over time. Workers then have to decide whether to maintain the tools or buy new ones. Sharpening and reconditioning tools to their original condition has many advantages including a safer tool that performs more easily and produces high-quality work. In addition, tools are a major investment and maintaining them is less expensive than replacing them with new ones. This lesson discusses common tools and procedures used to sharpen and recondition. Your instructor must be present to demonstrate the step-by-step procedures for specific tools and guide you through them.

Common Tools Used for Sharpening

Files are common tools used to sharpen the blades on other tools. They are available in different styles and coarseness, including files for specific jobs such as chain saw files. Coarser files are used to sharpen larger blades, such as those of a lawn mower or ax. Fine-toothed files are used for smaller tools, such as a wood chisel. Before filing a tool, the worker should put on gloves and secure the tool in a vise or other device to hold it firmly in place. A file cuts on the forward stroke only, so it should be lifted off the object on the backward stroke. See Unit I, Lessons 1 and 2 for more detail about files.

Another type of sharpening tool, a stone, is commonly used after grinding to bring knife blades to a fine edge. See Figure 1.1. These stones are made from natural or synthetic materials and are available in different configurations. Some synthetic stones have two types of grit, a coarse side and finer side. Bench stones are typically kept in a box that is set on a bench for use. Hand stones are held in the hand during use, and stone wheels are mounted on a power grinder. Stones are often used with water or oil to clean the stone and facilitate sharpening. When sharpening a tool on a stone, the worker should put on gloves and hold the blade away from himself or herself.

Figure 1.1 - Bench Stone in Its Carrying Case



The bench grinder is a common power tool used for rough sharpening and to produce the correct bevel on tool blades. Refer to Unit II, Lesson 2 for more information, including safety and maintenance. General procedural information is discussed below.

Using a Bench Grinder to Sharpen or Recondition Tools

Selecting the Wheel

In selecting the wheel, it is important to use the right grit (degree of coarseness) for the job. For example, a wheel with fine grit would not be efficient for removing burrs and sharpening a large tool. As the grit number increases, abrasives become finer; therefore, a 120-grit wheel is finer than a 60-grit wheel. Medium-grit wheels are acceptable for most tool-sharpening jobs. In addition, the wheel must be the correct rating for the speed of the motor; check the owner's manual for this information.

Following Safety Procedures

Ensure the grinder is unplugged when changing the wheel and follow instructions in the owner's manual. A face shield, leather apron, and appropriate filter or respirator are recommended when using the grinder. Inspect the wheel and do not use a wheel that is damaged or out of round. If damaged, consult you instructor about dressing or replacing the wheel. Dressing the wheel means to use a tool to make the diameter perfectly round and the face square. It also involves cleaning debris from the abrasive material. Because a defective wheel generally breaks within the first minute of use, stand to the side of the wheel when starting the grinder and let the wheel run before using.

Preparing to Grind

Examine the tool to be sharpened or reconditioned and compare it to a similar tool in good condition to determine the correct design and shape to be attained. See Figure 1.2. Always grind the tool back to its original edge or shape. For example, if reconditioning a screwdriver, use a screw slot to gauge the thickness and width of the blade. See Figure 1.3. Before grinding the tool, adjust the tool rest so it will be 1/16 in. from the wheel and at the proper angle.

Figure 1.2 - Different Shapes of Tool Edges

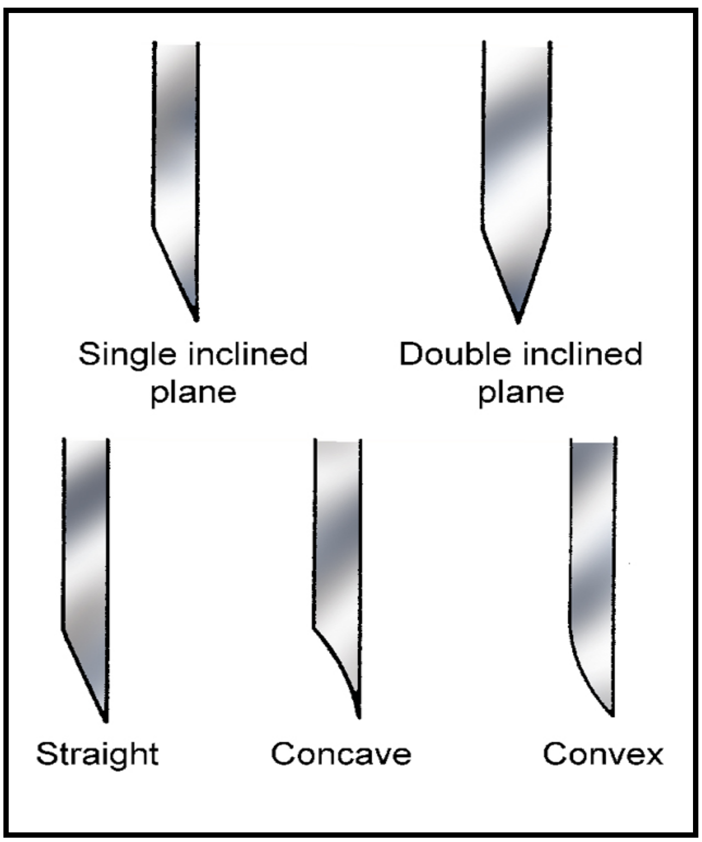
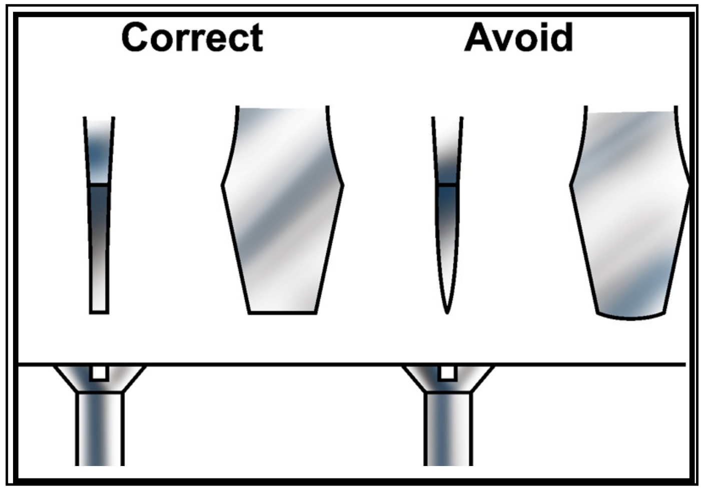


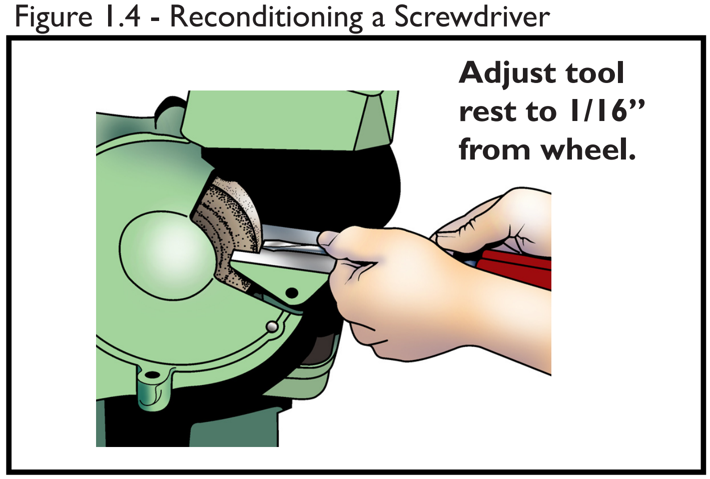
Figure 1.3 - Checking Shapes of Screwdriver Tip and Fit in Screw Slot



Grinding the Tool

It is important to move the tool slowly across the face of the wheel to avoid overheating the metal. Do not apply extreme pressure to the tool; allow the grinding wheel to do the work. Only grind on the face of the wheel, never the sides. See Figure 1.4. Use cutting oil or water as needed to clean the stone or cool the blade of the tool. Overheating the tool and allowing it to cool slowly will draw its temper, or soften the tool.

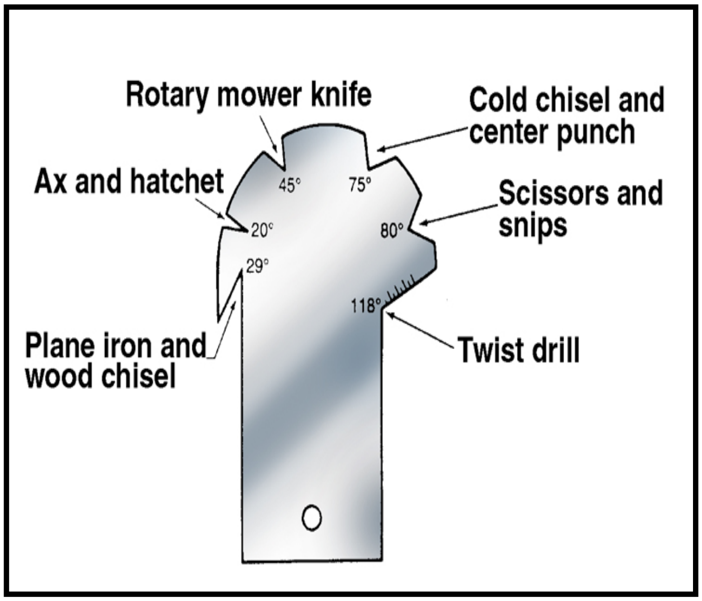
Figure 1.4 - Reconditioning a Screwdriver



Finishing the Task

Check the edge or shape of the tool for accuracy; a tool sharpening gauge can be used to check the angle of a number of tools. See Figure 1.5. Clean the work area of debris, and return the materials and equipment to their assigned places.

Figure 1.5 - Tool Sharpening Gauge



Summary

Hand tools that are in good condition are necessary for high-quality work and safe operation. To restore tools to their original condition, they can be sharpened and reconditioned using tools such as files, stones, and bench grinders. Sharpening and reconditioning tools rather than buying new ones also saves money.

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Lesson 1: Safety and Maintenance for Arc Welding

Arc welding, a process that uses the heat from an electric arc to join pieces of metal together, is commonly used in agricultural mechanics for construction and repair. Welding can pose hazards such as burns and electric shock, but it is a safe process when the welding equipment is installed correctly and the operator is well trained and follows the safety precautions. This lesson discusses the hazards of arc welding and the ways to avoid such hazards so that accidents can be prevented. It does not cover every possible risk. Your instructor can provide other safety rules for the particular work setting or welding process. Learning how to weld safely is as important as learning the skill itself.

Safety and Health Risks

Four major risks associated with arc welding are electric shock, burns from fire, burns from arc rays, and breathing hazards.

Electric Shock

Arc welders produce relatively low voltage, but electric shock is possible if proper safety precautions are not followed. Electric shock can happen if the welder is not properly installed, the equipment is defective or damaged, or adjustments are made when the welder is connected to the power. Electric shock can also occur if the operator does not wear the proper protective clothing. All electrical conductors on the welder and in the work area can be dangerous if they are not insulated. A conductor is any material that allows electric current to flow easily.

Burns and Fire

The arc produced by an arc welder can reach temperatures in excess of 9,000°F., which poses a great risk for burns and fire. Skin burns can occur from hot metal or spattering molten metal. Burns can also occur from the steam given off by hot metal after it is immersed in water. Fires can start when welding is performed in a booth that is not fireproof or that is near combustible or flammable materials, such as trash, feed, oil, or gasoline.

Burns From Arc Rays

The arc welder produces light rays that can cause first- and second-degree burns within minutes of exposure to the skin or flash burns of the eyes within seconds. These rays cannot be seen and their effects are not felt until after exposure. The light that is reflected off surfaces during the welding process is as dangerous as the direct light. There is a great risk of burns from arc light if proper protective clothing and eyewear are not worn. Workers in the area are also at risk of burns.

Breathing Hazards

All welding processes produce fumes and gases that are given off from the electrode flux and melting metal. Breathing hazards can be from oxygen displacement and from toxic fumes and gases. Oxygen displacement occurs when the arc, flame, fumes or gases replace the oxygen in the air. Oxygen displacement can cause asphyxiation. Exposure to toxic fumes and gases given off in the welding process can cause symptoms such as coughing, a tightness in the chest, nausea, and a metallic taste in the mouth. Toxic fumes and gases are a particular problem with some of the metals, such as those that are painted or coated with grease or other chemical agents. Plated metals also pose a risk of exposure to toxic substances. For example, brass, galvanized, or cadmium-plated metals give off highly toxic fumes. Gases are especially hazardous when welding is done in a confined space. One type of gas is ozone, which is caused by ultraviolet radiation during the welding process. Ozone is extremely irritating to the nose, eyes, mouth, and lungs.

Avoiding Electric Shock

The following safety precautions should be followed to help prevent shock or electrocution.

- **Make sure the welder is properly installed and hooked up.** Welders should be installed by or under the supervision of a qualified electrician. The welder itself should be properly grounded, which helps prevent injury from stray current. When inspection is done to make sure the welder is grounded, it is important to not confuse the grounding device with the ground clamp that attaches to the work. The welder should have a power disconnect switch within close reach of the operator for quick, emergency shutoff. The welder should be on its own circuit with a fuse or breaker of the appropriate size.

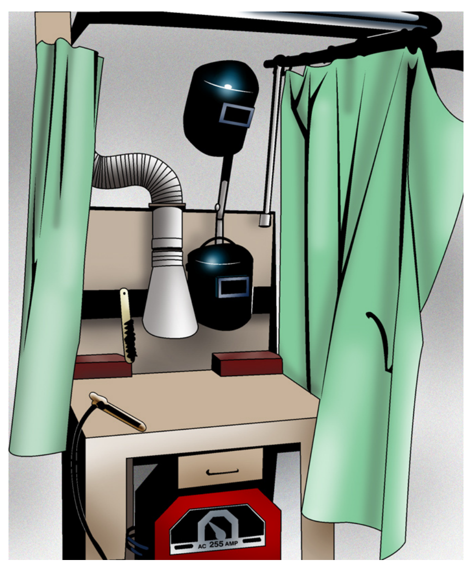
- **Inspect equipment for damage or defects.** The wire and cable connections should be kept tight and clean, because bad connections can heat up and cause dangerous arcs or melting. Do not use electrode holders or cables that are damaged or display poor insulation.
- **Disconnect the welder from the power source before making any repairs.** This includes the power switch on the welder and the main power disconnect switch.
- **Do not change the current setting while the machine is under a load.** The term "under a load" refers to the time in which there is an arc between the electrode and the work. Making adjustments while welding may cause damage to the switch and in turn injury to the person throwing the switch.
- **Keep clothing, gloves, floors, and equipment dry.** Even a small amount of moisture can conduct electricity and cause electric shock. If work must be done in a wet area, the operator should stand on a dry board or rubber mat and wear rubber gloves under the welding gloves to prevent electric shock. Similarly, if it is necessary to stand on a conductive material such as steel, the operator should stand on a dry board or a rubber mat. If the operator is perspiring, rubber gloves should be worn under the welding gloves. The electrode should never be changed when gloves are wet or when standing on a wet surface.
- **Do not put the electrode holder in water to cool it.**
- **Do not use water to put out electrical fires or any fire near the welder.** Water can damage the equipment or cause a shock hazard. Use an appropriately rated fire extinguisher to put out a fire.
- **Remove the electrode from the holder when the work is finished and disconnect the welder from the power source.**

Avoiding Burns and Fires

The following safety precautions should be followed to help prevent burns and fire.

- **Make the work area as fire resistant as possible.** In a shop environment, welding should only be done in a designated area and in a booth constructed of fireproof or fire-resistant materials such as metal sheeting or concrete blocks. The booth should have fire-resistant curtains across its opening to protect people in the area from harmful arc rays. See Figure 1.1. Like the walls of the booth, the floor should be made of a fire-resistant material such as concrete. Cracks in the floor should be repaired to prevent sparks or molten metal from collecting in them. The work area should be clean and free of trash, grease, oil, and other flammable materials. In case a person's clothes catch on fire, a fire blanket should be available to wrap around the person to smother the fire. An appropriately rated fire extinguisher, first-aid kit, and safety equipment should be kept within easy reach. Aisles and stairs should be kept free of obstacles to allow a quick exit in case of fire.

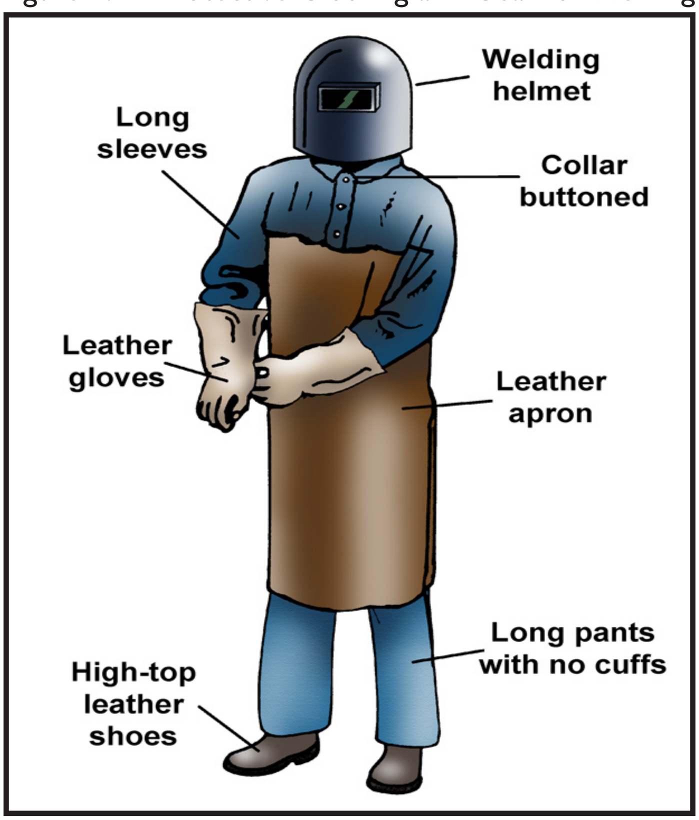
Figure 1.1 - Welding Booth



- **Be careful with hot work pieces.** Handle hot metal with tongs or pliers, not gloved or bare hands. If metal pieces are cooled in water, do so carefully to avoid steam burns. Do not walk around the shop with hot metal. If hot metal must be left where others could be in contact with it, carefully mark it "Hot" with soapstone or chalk.

- **Wear appropriate clothing and safety gear.** Various types of safety gear are required to prevent injury from sparks, hot metal, rays from the arc, and flying debris. See Figure 1.2.
  - o Hands and feet - Leather gauntlet-style gloves and high-top leather shoes should be worn to protect the hands and feet.
  - o Body - Clothing should be made of wool or cotton, not a synthetic material. It should be dark and tightly woven, which also helps block arc rays. Shirts should be long sleeved and the sleeves and front of the shirt should be buttoned, including the top collar button. Pants should come down over the tops of the boots and not have cuffs. Sparks could fall in cuffs.

Figure 1.2 - Protective Clothing and Gear for Welding



Long-sleeved fire-resistant coveralls provide excellent protection. Other protective gear, such as leather aprons and leather sleeves, are also available and should be worn as needed. Clothing with tears or frayed areas should not be worn because the skin might not be protected and the shreds of material could easily catch fire from sparks. Clothing made of synthetic materials should not be worn because such fabrics can burn readily and give off poisonous gases when they are burning. Pockets should not contain flammable materials, such as matches or butane lighters, which could potentially catch fire or explode.
  - o Head and eyes - A cap and safety goggles should always be worn. Safety glasses or goggles and additional head and eye protection such as a flameproof skullcap or face shield should be worn as needed to avoid burns when chipping hot slag from welds. When welding, an arc welding helmet should be worn for protection against harmful arc rays. (See the section on arc rays for more details.)
- **Do not attempt to heat, cut, or weld containers such as tanks, drums, and barrels.** These types of containers may have been used to store flammable substances such as gasoline. If so, the welding process could cause a big explosion and fire. Even though a container looks clean, it may still have fumes that could catch fire.

Avoiding Arc Rays

The following safety precautions should be followed to help prevent burns from arc rays during the welding process.

- **Wear a welding helmet with a filter lens classified as no. 10 or higher, depending on the work being done.** Manufacturers of welding equipment provide recommendations for appropriate lenses. Welding helmets are available in different types, including some that have a flip-up or fixed shaded lens. A flip-up lens allows work, such as chipping, to be done without removing the helmet. See Figure 1.3 and Figure 1.4. If a helmet with a flip-up lens is not used, safety glasses must be worn under the helmet. Inspect helmets and their lens assembly to make sure they are undamaged and the gaskets are fitting properly to avoid light leaks. Do not use a helmet or lens that is damaged. In addition to the helmet, dark, tightly woven clothing protects the body from exposure to arc rays. All persons in the welding area should wear eye protection, such as flash glasses, to avoid eye injury from the reflected light. Before starting a weld, the operator should always say "cover up" as a warning for others to protect themselves.

Figure 1.3 - Helmet with a Flip-Up Filter Lens

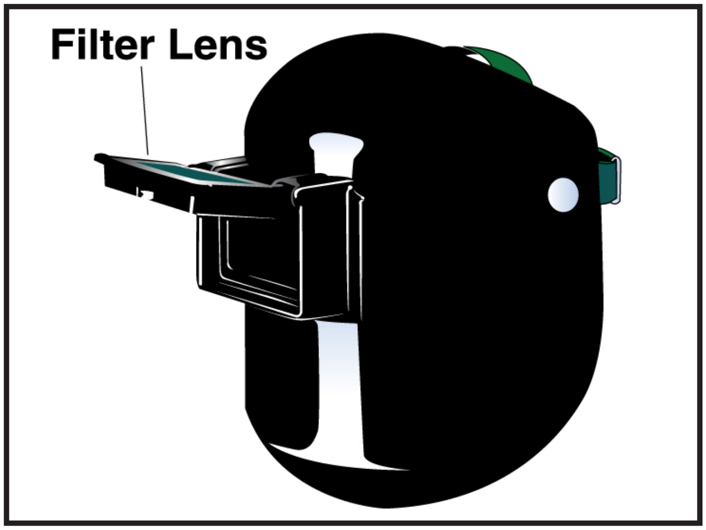
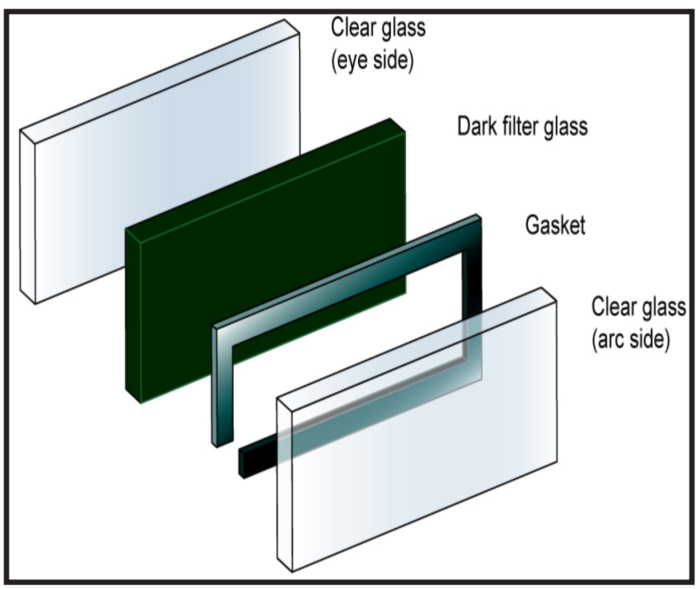


Figure 1.4 - Parts of a Filter Lens on a Welding Helmet



Avoiding Breathing Hazards

The following safety precautions should be followed to help prevent respiratory problems.

- **Work in an area with adequate ventilation.** Working outdoors or in a large shop with high ceilings and natural ventilation is best.
- **Use forced ventilation if natural ventilation is not sufficient.** Forced ventilation, such as hoods and exhaust fans, is probably needed in small shops and in shops with many welders operating at the same time. Forced ventilation may also be required if welding is being performed on metals that contain extremely toxic substances. The ventilation system should be as close to the work as possible.
- **Supplement ventilation as needed with an appropriate respirator.** Respirators may be required depending on the size of the work area, ventilation available, and the type of metal being welded. Different types of respirators are available. Some models supply fresh air and other models are designed to filter specific contaminants. See Figure 1.5.

Figure 1.5 - Respirator with a Powered Air Purifier

- **Clean metal before welding.** It is important to remove chemicals from the metal so they do not mix with the other fumes produced by welding and create a worse breathing hazard. It is also safer and easier to establish an arc on a clean surface than a dirty surface.
- **Operate engine-powered welders in well-**

ventilated areas or with the exhaust vented directly outdoors. This is to prevent carbon monoxide, a poisonous gas produced by gas and diesel engines, from building up in the shop.

Care and Maintenance of Arc Welding Equipment

Regular maintenance of welding equipment and inspection of the equipment before each use are critical for safe operation.

- **Inspect the electrode holder frequently to be sure it is not damaged or in need of repair.** Defective jaws, loose connections, and poor insulation are electric shock hazards.
- **Keep cables free of oil and grease.** These substances on the cables may cause them to catch fire.
- **Run cables so that they will not be damaged or cause a tripping hazard.** Be sure that cables will not be exposed to sparks and molten metal and are not located where the operator or others must walk or stand. In temporary work sites, keep cables covered to protect them from traffic.
- **Do not shut off or start the welder with the electrode or electrode holder in contact with the work or the welding table.** This prevents the possibility of damage to the welder. The electrode holder should be hung from an insulated hanger when it is not in use.
- **Keep the welder and electrodes dry.**
- **Do not allow dust to accumulate on the transformer coils.** Dirty coils can start a fire, short out electrical components, and cause other equipment failures.

Summary

The arc welding process has potential safety risks like electric shock, burns and fire, burns from arc rays, and breathing hazards. Following safety precautions, maintaining the welding equipment, and inspecting it before each use will help prevent injuries to the welder and others in the work area.

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Lesson 2: Parts and Setup for Arc Welding

After understanding the rules for safe welding, the next step is to learn about welding terminology and the equipment required to make a weld. Many methods of joining metal together have been created through the years. This lesson focuses on shielded metal arc welding and the different types of welding machines and equipment that are used for this process.

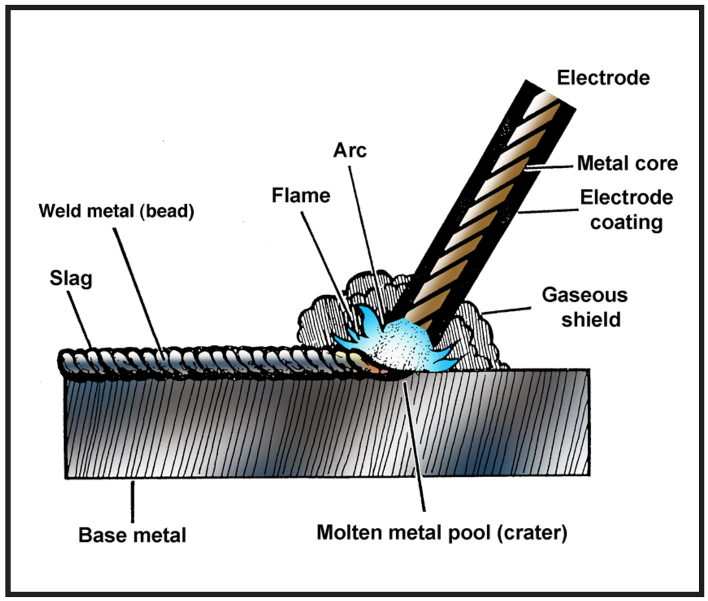
Welding

Welding is a blanket term that includes a wide variety of processes. A basic definition of welding is a process in which materials are joined by fusing them together. This process is done by the addition of heat, pressure, or a combination of heat and pressure. It may be done with or without the addition of new material (filler). In some cases, pressure is all that is needed to fuse metals together, but filler is used to create a totally fused joint. Filler materials include metal, plastics, and glass.

Arc welding encompasses a large group of processes in the welding family. These welding processes use a discharge of electricity (an arc) to heat materials and join them. The procedure may be done with or without pressure or filler. One of the processes in the arc welding group, shielded metal arc welding (SMAW), is the focus of this lesson. SMAW is frequently used in agricultural mechanics. Reasons for its popularity include the following: 1) electricity is an economical power source, 2) the welding equipment is portable and relatively inexpensive, 3) welds can be done quickly with dependable results, and 4) students can become proficient welders quickly. Common uses of SMAW are constructing farm equipment, repairing broken parts, and resurfacing metals that have become worn.

SMAW uses heat from the arc and filler material deposited from a flux-coated metal rod (electrode) to weld. See Figure 2.1. The arc is a heavy current that flows across the gap between the electrode and the metal. This type of welding is called "shielded" because a cloud of gases formed by the burning flux shields the weld as it is being made. Flux and impurities in the metal rise to the top of the weld and form a layer, called slag, that is later chipped away. SMAW has a variety of other names including "arc welding," "rod welding," and "stick welding." In this unit, "arc welding" will refer to SMAW, but it is useful to know that there are other kinds of arc welding as well.

Figure 2.1 - Shielded Metal Arc Welding



Equipment Required for SMAW

Equipment for making welds includes a welding machine, electrode cable, ground cable, electrode holder, ground clamp, and electrode.

Welding Machine

Arc welding machines (also called welders) are manufactured to provide the power source (electric current) in one of two ways. One type consists of a motor- or engine-driven alternator or generator to produce electric current. The other type is a transformer that takes high-voltage electric current and changes it to low voltage so that the welder can use it.

Electrode and Ground Cables or Leads

Two cables are connected to the arc welder to carry current to the work and back to the welding machine. One cable ends in an electrode holder that is used to grip the electrode and the other cable ends in a ground clamp that carries current between the work and the welding machine to complete the circuit. The size of these cables is determined by their diameter as indicated by gauge; as the gauge number goes down, the cable gets larger in diameter. It is important that the cables be the right diameter for their length, because an incorrect size can cause overheating or voltage drop. For example, if cables are too small in diameter for the welding machine, they may not provide adequate current and in turn the arc will not be as effective. Cables can be made of copper or aluminum wire and are covered with a material such as rubber for insulation and protection. Cables should be cared for and inspected frequently, because they may be exposed to impact, sharp edges, sparks, oil, and other damage during the welding process.

Electrode Holder

An electrode holder is an insulated handle that the operator uses to grip the electrode while welding.
Most electrode holders have a similar appearance, with the major parts being an insulated handle, double-contact jaw, and release lever. The insulated handle protects the welder from electrical shock and the release lever is used to clamp and unclamp an electrode in the jaws. Electrode holders are available in different sizes for carrying different amounts of current and sizes of electrodes. Holders should be used at or below their maximum amperage rating to avoid overheating. To reduce operator fatigue, select the smallest holder that will safely carry the amperage used. Burning electrodes too short can damage the holder. Electrodes should be burned down to approximately 2 in. to reduce waste and protect the holder. Holders should be cleaned and worn parts replaced as needed to keep them in working order.

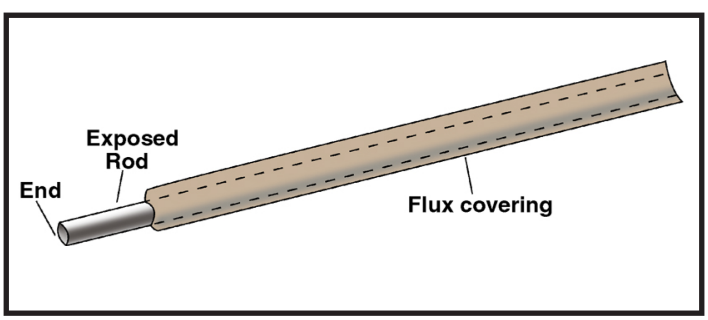
Ground Clamp

A ground clamp carries current between the work and the welding machine. Clamps are also sized according to the current being used. It is important to use the correct clamp and ensure that it is securely attached to avoid overheating. A loose clamp can also cause electrical current to damage the equipment. Before attaching a clamp to the work or table, the area to be clamped should be cleaned to ensure a good connection. Clamps are available in different configurations, including C-clamps and swiveling clamps for welds that must be rotated.

Electrode

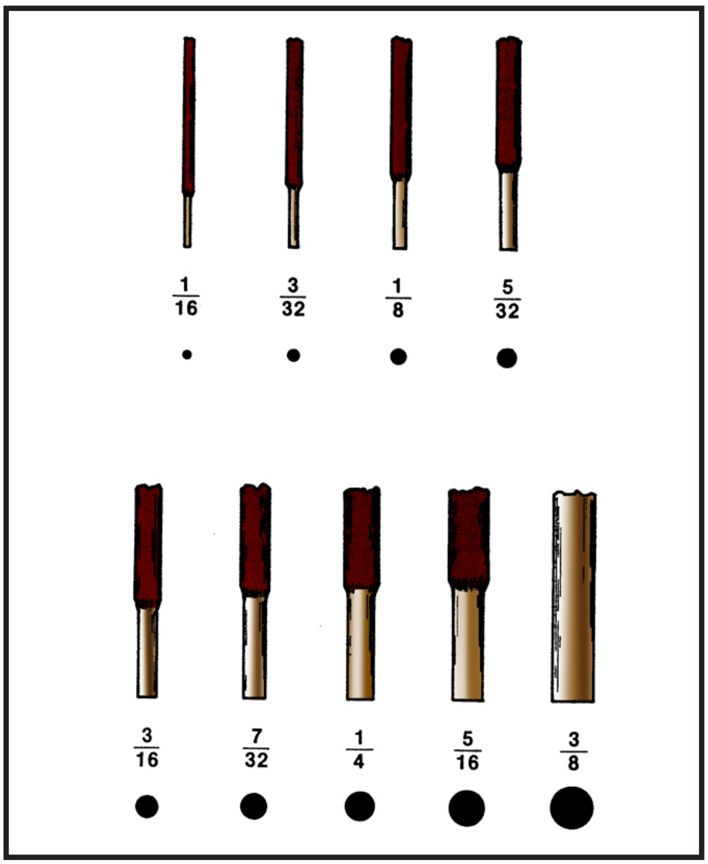
An electrode is a metal rod that the welder uses to establish an arc between the electrode and the metal. The parts of an electrode are a solid metal core and a flux coating. See Figure 2.2. The solid metal core provides filler to the weld as it melts. Depending on the type of electrode, the flux coating may do any or all of the following: 1) add filler to the weld, 2) stabilize the arc, 3) produce a gas shield that protects the weld, 4) add flux, which removes impurities from the weld that rise to the top along with the flux to form a protective layer over the weld called slag, 5) add alloying elements to improve the weld, and 6) determine the polarity (positive or negative) of the electrode.

Figure 2.2 - Parts of an Electrode



Electrodes are available in different lengths and diameters for a wide variety of welding needs. See Figure 2.3. For example, the E6013 electrode is designed to weld in all positions (flat, vertical, overhead, and horizontal) and can be used with either AC or DC current. See Table 1 on the next page for the American Welding Society classification of electrodes. The diameter of an electrode is determined by the diameter of the metal core, not including the flux coating. Electrode lengths commonly range from 9 in. to 18 in.

Figure 2.3 - Different Diameters of Welding Electrodes



To produce the best quality weld, it is important to choose the right electrode for the job. Some, but not all, of the factors for choosing an electrode are 1) type of metal being welded and its tensile strength, 2) thickness of the metal, 3) weld position (flat, vertical, overhead, etc.), 4) experience of the welder, 5) rate at which the filler should be added, and 6) type of electric current being used.

Types of Arc Welding Current

Welding machines are designed to use different types of electrical current. The three kinds are AC welders that use alternating current, DC welders that use direct current, and AC/DC welders that can use either alternating or direct current.

AC welders are commonly used on farms because they are inexpensive, use a small amount of electricity, and can perform most of the welds required. These welders use current that is continuously changing direction, which means the electrode and the work are switching from positive to negative while the weld is being made. This switching produces even heating and welds of moderate penetration.

DC welders may be driven by electric motors or gas or diesel engines and are valued for their ability to change current direction. Because the engine-driven welders are portable, they are also chosen when welding is required in the shop and the field. Unlike AC welders, DC welders use current that flows one way only; however, the direction can be changed depending on how the welder is set.

Changing the current to positive or negative is called changing polarity and this affects the characteristics of the welds produced. For example, when the electrode is positive, welds tend to have deeper penetration of the base metal (the piece being welded) and when the electrode is negative, it tends to melt and deposit material faster, which is especially useful when working with thin metal.

Table 1
Electrode Classification

AWS Classification	Type of Covering	Welding Position[a]	Type of Current[b]
E6010	High cellulose sodium	F,V,OH,H	dcep
E6011	High cellulose potassium	F,V,OH,H	ac or dcep
E6012	High titania sodium	F,V,OH,H	ac or dcen
E6013	High titania potassium	F,V,OH,H	ac, dcep or dcen
E6019	Iron oxide titania potassium	F,V,OH,H,	ac, dcep or dcen
E6020	High iron oxide	H-fillets F	ac or dcen ac, dcep or dcen
E6022[c]	High iron oxide	F,H	ac or dcen
E6027	High iron oxide, iron powder	H-fillets F	ac or dcen ac, dcep or dcen
E7014	Iron powder, titania	F,V,OH,H	ac, dcep or dcen
E7015	Low hydrogen sodium	F,V,OH,H	dcep
E7016	Low hydrogen potassium	F,V,OH,H	ac or dcep
E7018	Low hydrogen potassium, iron powder	F,V,OH,H	ac or dcep
E7018M	Low hydrogen iron powder	F,V,OH,H	dcep
E7024	Iron powder, titania	H-fillets,F	ac, dcep or dcen
E7027	High iron oxide, iron powder	H-fillets F	ac or dcen ac, dcep or dcen
E7028	Low hydrogen potassium, iron powder	H-fillets,F	ac or dcep
E7048	Low hydrogen potassium, iron powder	F,OH,H,V-down	ac or dcep

Notes:

a. The abbreviations indicate the welding positions as follows:
F = Flat
H = Horizontal
H-fillets = Horizontal fillets
V-down = Vertical with downward progression
V = Vertical } For electrodes 3/16 in. (4.8mm) and under, except 5/32 in. (4.0mm)
OH = Overhead } and under for classifications E7014, E7015, E7016, E7018, and E7018M.

b. The term "dcep" refers to direct current electrode positive (dc, reverse polarity). The term "dcen" refers to direct current electrode negative (dc, straight polarity).

c. Electrodes of the E6022 classification are intended for single-pass welds only.

Reprinted with permission from the AWS. Source: American Welding Society (AWS) Committee on Filler Metal, 1991, Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding, ANSI/AWS A5.1-91, Miami: American Welding Society, Table 1.

Summary

SMAW, a process frequently used in agricultural mechanics, requires a welding machine, electrode cable, ground cable, electrode holder, ground clamp, and electrode. The welding machine may be designed to use AC, DC, or AC/DC current. AC models are widely used for their ability to meet most welding needs inexpensively, whereas DC models are popular for their portability and ability to change current direction.

Credits

Agricultural Mechanics Unit for Agricultural Science I. University of Missouri-Columbia: Instructional Materials Laboratory, July 1982.

Althouse, A.D., Turnquist, C.H., Bowditch, W.A., Bowditch, K.E. *Modern Welding*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2000.

Bowditch, W.A., Bowditch, K.E. *Welding Technology Fundamentals*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 1997.

Cooper, E.L. *Agricultural Mechanics: Fundamentals and Applications* (3rd ed). Albany, NY: Delmar Publishers, 1997.

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Lesson 3: Basic Use of an Arc Welder

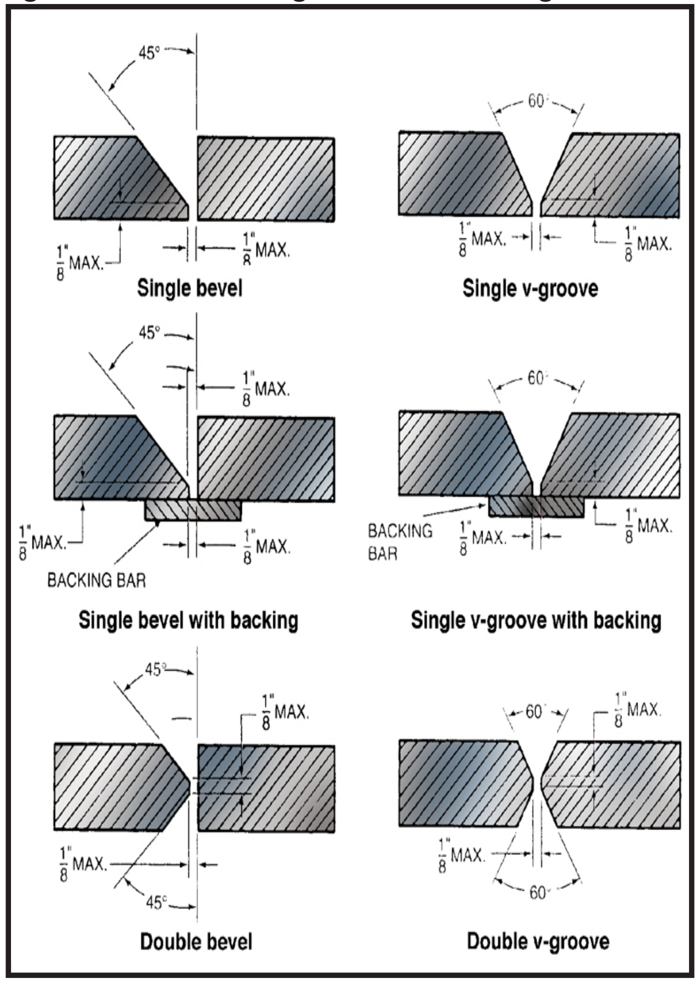
Learning how to strike an arc and run a bead is the basis for welding and mastering these skills requires much practice. This lesson provides basic guidelines for preparing the metal and starting the welding procedure. Your instructor must be present to demonstrate the step-by-step procedures for welding joints and guide you through them.

Preparing Metal for Welding

Welders in agricultural mechanics weld metals that are in various conditions, from new to rusty and corroded. To achieve a weld of good strength and appearance, it is important to clean the metal to be welded. Cleaning the metal eliminates the impurities that can reduce the strength of the weld. In addition, removing chemicals, finishes, or other materials on the surface is an important safety measure; these substances can mix with welding fumes to form toxic gases. Methods for cleaning base metal include using a portable or bench grinder, hand wire brush, sandblasting unit, and approved solvents or detergents.

After cleaning, metal 1/4 in. or more in thickness should be beveled before welding to increase the penetration of the weld. Beveling is cutting a groove along the edge of the metal and is accomplished by flame cutting, grinding, gouging, or machining. The different bevel designs used in welding include single bevel, single bevel with backing, double bevel, single V-groove, single V-groove with backing, and double V-groove. See Figure 3.1. Some factors for choosing whether to bevel one or both sides are the position of the joint, joint design, and application of the joint.

Figure 3.1 - Bevel Designs Used in Welding

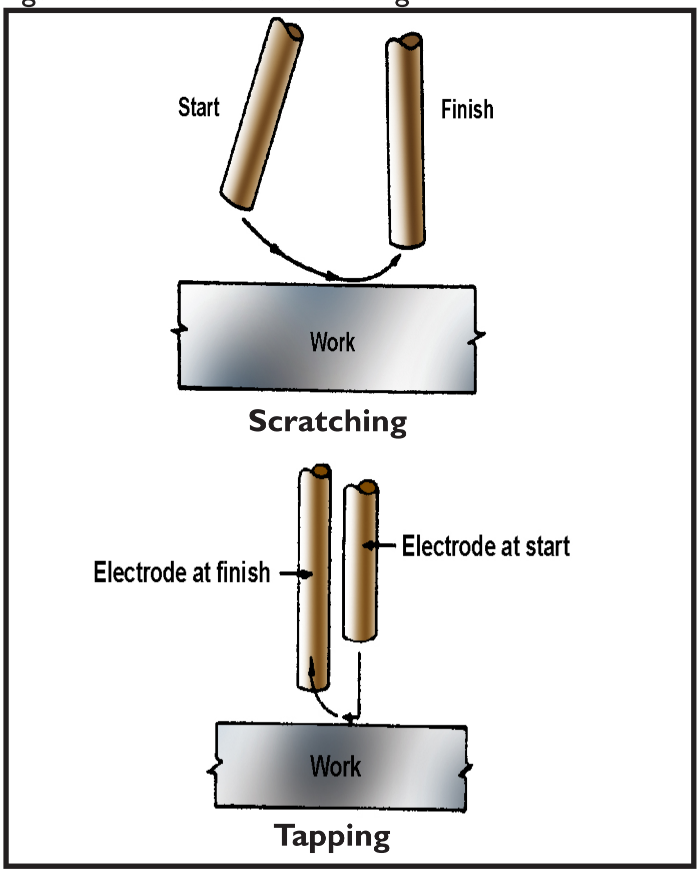


Striking an Arc

After preparing the metal, the first step in the actual welding process is striking an arc. Mastering this step takes a lot of practice. Striking an arc can be done by one of two methods: scratching or tapping. In the scratching method, the electrode is moved a short distance across the base metal at an angle, similar to striking a match, then brought back down until proper arc length is reached. In the tapping method, the electrode is brought straight down until it touches the base metal, is lifted up, and brought back down (pecking motion) until proper arc length is reached. A beginning welder should try both methods to see which is easiest. See Figure 3.2.

The correct distance for arc length (distance between electrode and the metal) varies, but it is roughly equal to the diameter of the electrode. One common problem is leaving the electrode on the metal too long and causing it to stick to the surface (called freezing). If this occurs, the welder can try quickly raising the electrode to free it or releasing the electrode from the holder and breaking it loose from the weld. Once the arc is established, it should be held in one place until a small puddle of melted metal forms (the weld pool). When the weld pool is the desired size, the welder begins running the bead (the line of electrode filler and base metal produced as the electrode is moved along the work area).

Figure 3.2 - Methods of Striking an Arc



Types of Beads

A welder produces one of two basic patterns (stringer and weave) when running a bead. See Figure 3.3. To make a stringer bead, the welder moves the electrode forward in a straight line. This type of bead should be approximately two to three times as wide as the diameter of the electrode. Making stringer beads will help the beginning welder practice important skills such as starting the weld at the correct location, maintaining the correct arc length, holding the electrode at the appropriate angle, feeding and moving the electrode at a consistent rate, and stopping the bead at the desired location. After becoming proficient at making stringer beads, a welder should practice making weaving beads in a wide variety of patterns. See Figure 3.4. A weaving bead is made by moving the electrode from side to side while also moving forward along the line of the joint. It can be up to six times the diameter of the electrode in width. The stringer bead is commonly used for building up worn surfaces. Various patterns of the weaving bead are used when welding deep or wide areas and to produce optimum penetration at the edge of a weld.

Figure 3.3 - Basic Patterns for Running a Bead

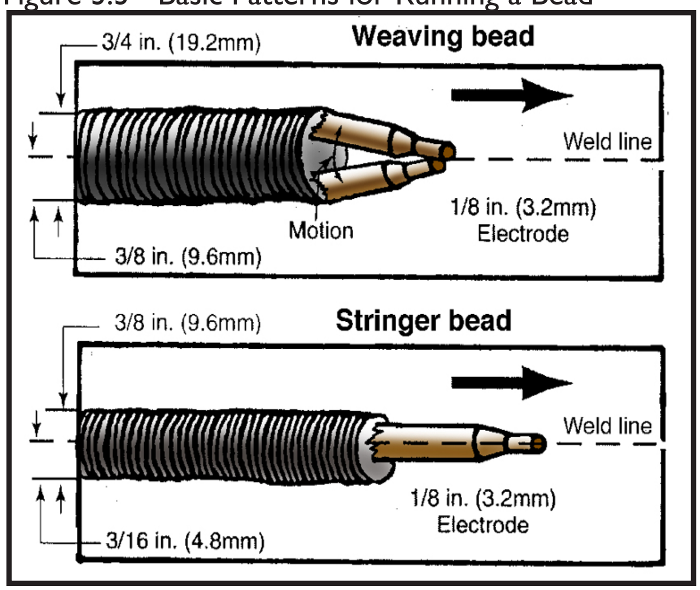
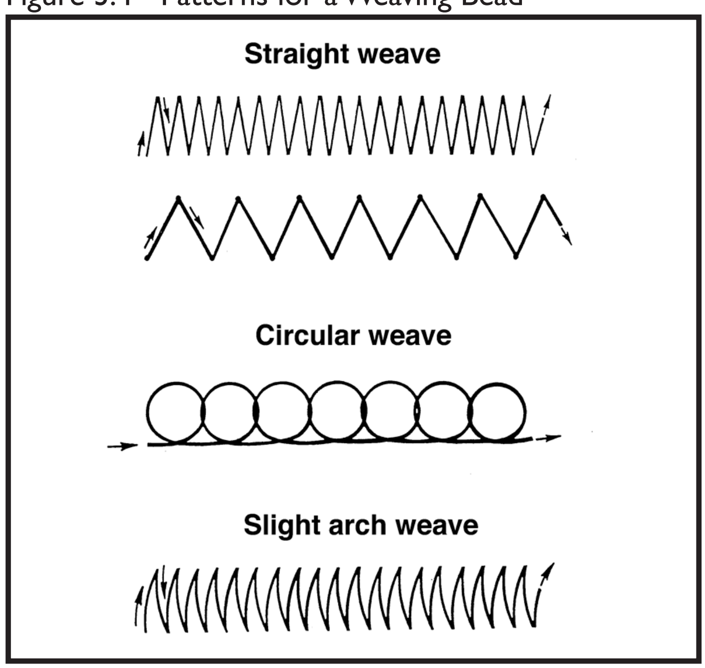


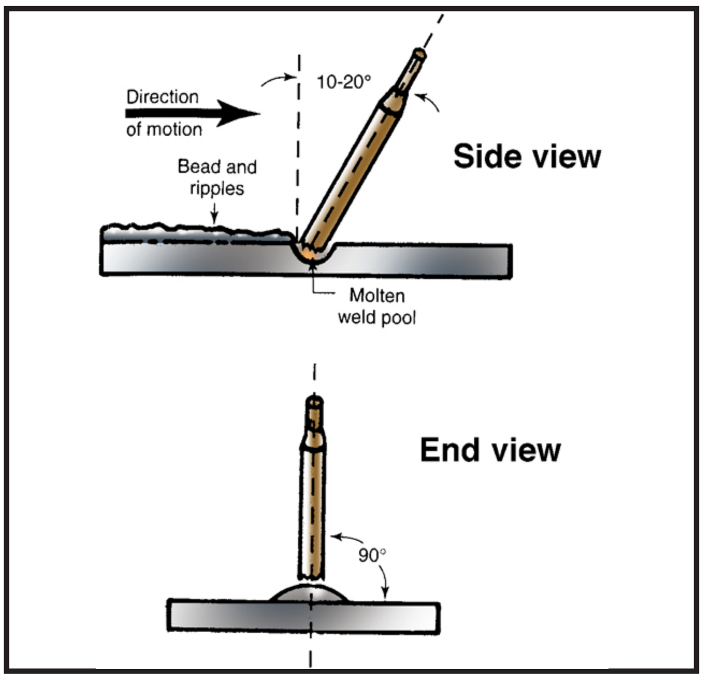
Figure 3.4 - Patterns for a Weaving Bead



Factors That Influence the Bead Condition

To produce a strong weld with a good appearance, a welder must be able to make a clean, dense bead that is a consistent size. A properly formed bead should have evenly spaced semicircular ripples. The bead should be an even width along its length. The electrode angle can vary, but it is generally inclined 10 to 20 degrees in the direction of travel. See Figure 3.5.

Figure 3.5 - Angle of the Electrode



Getting in a comfortable position for welding is important to making good beads. Right-handed welders usually work best from left to right and left-handed welders from right to left. After removing the slag from the bead with a chipping hammer or wire brush, the welder must be able to "read" the bead and know if it was made correctly. After evaluating the bead, the welder should change a setting or technique so that the next weld will be a better quality. Below are welding variables and causes for improperly formed beads.

- Speed of travel
  - o If moving the electrode too slow, the bead will be too wide and thick and the ripples will appear flattened.
  - o If moving the electrode too fast, the bead will be too low and narrow and the ripples will appear pointed instead of round. See Figure 3.6.
- Amperage (current) setting
  - o If the current is too low, the bead will appear narrow, built up, and stringy. The arc will be hard to strike and it will be difficult to keep it running.
  - o If the current is too high, the bead will be too wide and low with large amounts of spatter. See Figure 3.7.
- Length of arc
  - o If the length is too short, the bead will be built up and produce poor penetration. The electrode will tend to stick to the base metal.
  - o If the length is too long, the bead will be too low, wider than desired, and with little buildup. Spatter from metal dropping outside the weld pool is likely. See Figure 3.8.

Figure 3.6 - Effect of Speed of Electrode Movement on Bead

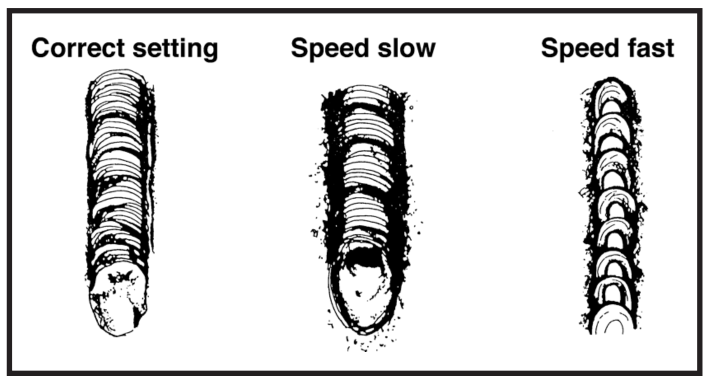


Figure 3.7 - Effect of Current Setting on Bead

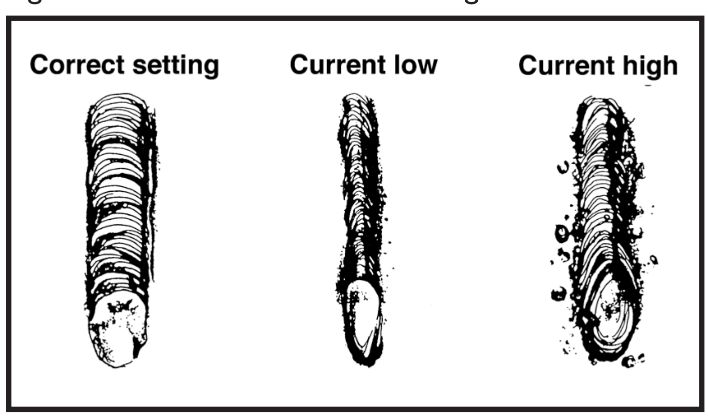
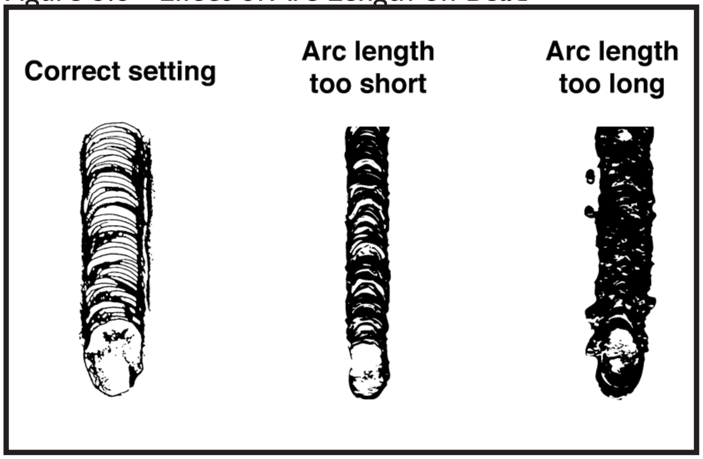


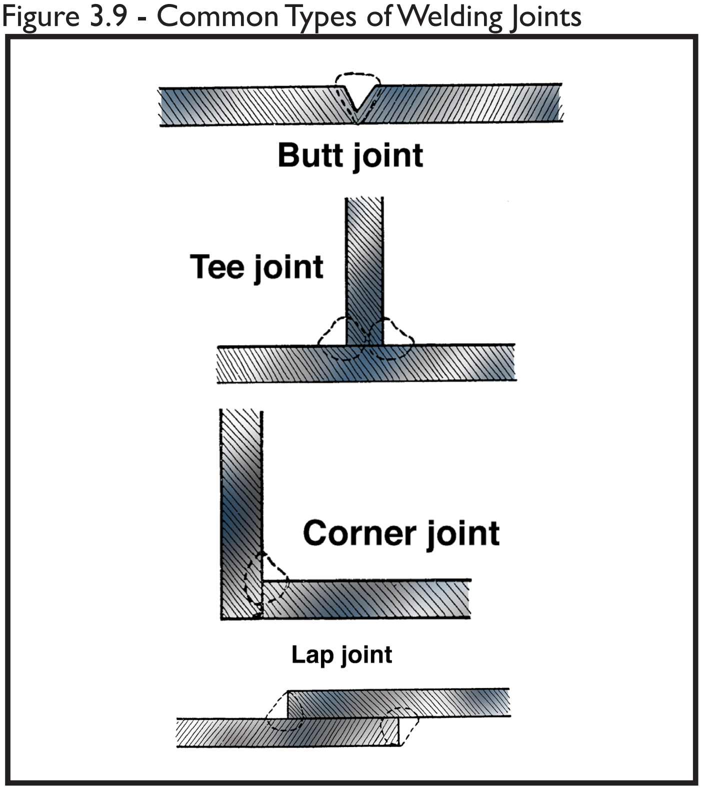
Figure 3.8 - Effect of Arc Length on Bead



Common Welding Joints

A welder uses the skill in running a bead to fasten two pieces of metal together to make a joint. The basic welding joints are the butt and fillet and most other joints are a variation of these. In a butt joint, the edges or ends of two pieces of metal are welded together. Before welding a butt joint, the pieces must be positioned parallel to each other, with a space between them of about the thickness of the electrode core. In a fillet joint, two pieces of metal are welded together at a 90-degree angle. Types of fillet joints include the tee, corner, and lap joints. See Figure 3.9.

Figure 3.9 - Common Types of Welding Joints



Summary

The SMAW process includes preparing the metal, striking an arc, running a bead, cleaning the bead, and evaluating the quality of the bead. Being able to run a strong bead is the basis of welding and much practice is required to become proficient. To improve the quality of a bead, a welder must be able to evaluate the bead for defects and correct variables such as the speed of travel of the electrode, amperage setting, and length of the arc. Welders use their skill to run beads to make butt and fillet joints.

Credits

Agricultural Construction: Volume I. Arc Welding Project Construction. University of Missouri-Columbia: Instructional Materials Laboratory, July 1989.

Agricultural Mechanics Unit for Agricultural Science I. University of Missouri-Columbia: Instructional Materials Laboratory, July 1982.

Althouse, A.D., Turnquist, C.H., Bowditch, W.A., Bowditch, K.E. *Modern Welding.* Tinley Park, IL: The Goodheart-Willcox Company, Inc., 2000.

Bowditch, W.A., Bowditch, K.E. *Welding Technology Fundamentals*. Tinley Park, IL: The Goodheart-Willcox Company, Inc., 1997.

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Lesson 1: Safety and Maintenance for Arc Welding

Arc welding, a process that uses the heat from an electric arc to join pieces of metal together, is commonly used in agricultural mechanics for construction and repair. Welding can pose hazards such as burns and electric shock, but it is a safe process when the welding equipment is installed correctly and the operator is well trained and follows the safety precautions. This lesson discusses the hazards of arc welding and the ways to avoid such hazards so that accidents can be prevented. It does not cover every possible risk. Your instructor can provide other safety rules for the particular work setting or welding process. Learning how to weld safely is as important as learning the skill itself.

Safety and Health Risks

Four major risks associated with arc welding are electric shock, burns from fire, burns from arc rays, and breathing hazards.

Electric Shock

Arc welders produce relatively low voltage, but electric shock is possible if proper safety precautions are not followed. Electric shock can happen if the welder is not properly installed, the equipment is defective or damaged, or adjustments are made when the welder is connected to the power. Electric shock can also occur if the operator does not wear the proper protective clothing. All electrical conductors on the welder and in the work area can be dangerous if they are not insulated. A conductor is any material that allows electric current to flow easily.

Burns and Fire

The arc produced by an arc welder can reach temperatures in excess of 9,000°F., which poses a great risk for burns and fire. Skin burns can occur from hot metal or spattering molten metal. Burns can also occur from the steam given off by hot metal after it is immersed in water. Fires can start when welding is performed in a booth that is not fireproof or that is near combustible or flammable materials, such as trash, feed, oil, or gasoline.

Burns From Arc Rays

The arc welder produces light rays that can cause first- and second-degree burns within minutes of exposure to the skin or flash burns of the eyes within seconds. These rays cannot be seen and their effects are not felt until after exposure. The light that is reflected off surfaces during the welding process is as dangerous as the direct light. There is a great risk of burns from arc light if proper protective clothing and eyewear are not worn. Workers in the area are also at risk of burns.

Breathing Hazards

All welding processes produce fumes and gases that are given off from the electrode flux and melting metal. Breathing hazards can be from oxygen displacement and from toxic fumes and gases. Oxygen displacement occurs when the arc, flame, fumes or gases replace the oxygen in the air. Oxygen displacement can cause asphyxiation. Exposure to toxic fumes and gases given off in the welding process can cause symptoms such as coughing, a tightness in the chest, nausea, and a metallic taste in the mouth. Toxic fumes and gases are a particular problem with some of the metals, such as those that are painted or coated with grease or other chemical agents. Plated metals also pose a risk of exposure to toxic substances. For example, brass, galvanized, or cadmium-plated metals give off highly toxic fumes. Gases are especially hazardous when welding is done in a confined space. One type of gas is ozone, which is caused by ultraviolet radiation during the welding process. Ozone is extremely irritating to the nose, eyes, mouth, and lungs.

Avoiding Electric Shock

The following safety precautions should be followed to help prevent shock or electrocution.

- **Make sure the welder is properly installed and hooked up.** Welders should be installed by or under the supervision of a qualified electrician. The welder itself should be properly grounded, which helps prevent injury from stray current. When inspection is done to make sure the welder is grounded, it is important to not confuse the grounding device with the ground clamp that attaches to the work. The welder should have a power disconnect switch within close reach of the operator for quick, emergency shutoff. The welder should be on its own circuit with a fuse or breaker of the appropriate size.

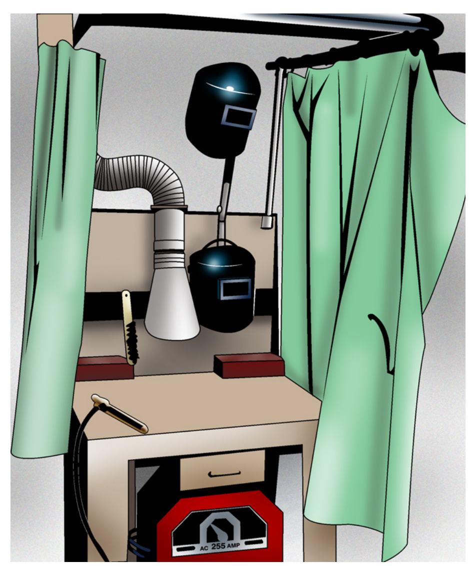
- **Inspect equipment for damage or defects.** The wire and cable connections should be kept tight and clean, because bad connections can heat up and cause dangerous arcs or melting. Do not use electrode holders or cables that are damaged or display poor insulation.
- **Disconnect the welder from the power source before making any repairs.** This includes the power switch on the welder and the main power disconnect switch.
- **Do not change the current setting while the machine is under a load.** The term "under a load" refers to the time in which there is an arc between the electrode and the work. Making adjustments while welding may cause damage to the switch and in turn injury to the person throwing the switch.
- **Keep clothing, gloves, floors, and equipment dry.** Even a small amount of moisture can conduct electricity and cause electric shock. If work must be done in a wet area, the operator should stand on a dry board or rubber mat and wear rubber gloves under the welding gloves to prevent electric shock. Similarly, if it is necessary to stand on a conductive material such as steel, the operator should stand on a dry board or a rubber mat. If the operator is perspiring, rubber gloves should be worn under the welding gloves. The electrode should never be changed when gloves are wet or when standing on a wet surface.
- **Do not put the electrode holder in water to cool it.**
- **Do not use water to put out electrical fires or any fire near the welder.** Water can damage the equipment or cause a shock hazard. Use an appropriately rated fire extinguisher to put out a fire.
- **Remove the electrode from the holder when the work is finished and disconnect the welder from the power source.**

Avoiding Burns and Fires

The following safety precautions should be followed to help prevent burns and fire.

- **Make the work area as fire resistant as possible.** In a shop environment, welding should only be done in a designated area and in a booth constructed of fireproof or fire-resistant materials such as metal sheeting or concrete blocks. The booth should have fire-resistant curtains across its opening to protect people in the area from harmful arc rays. See Figure 1.1. Like the walls of the booth, the floor should be made of a fire-resistant material such as concrete. Cracks in the floor should be repaired to prevent sparks or molten metal from collecting in them. The work area should be clean and free of trash, grease, oil, and other flammable materials. In case a person's clothes catch on fire, a fire blanket should be available to wrap around the person to smother the fire. An appropriately rated fire extinguisher, first-aid kit, and safety equipment should be kept within easy reach. Aisles and stairs should be kept free of obstacles to allow a quick exit in case of fire.

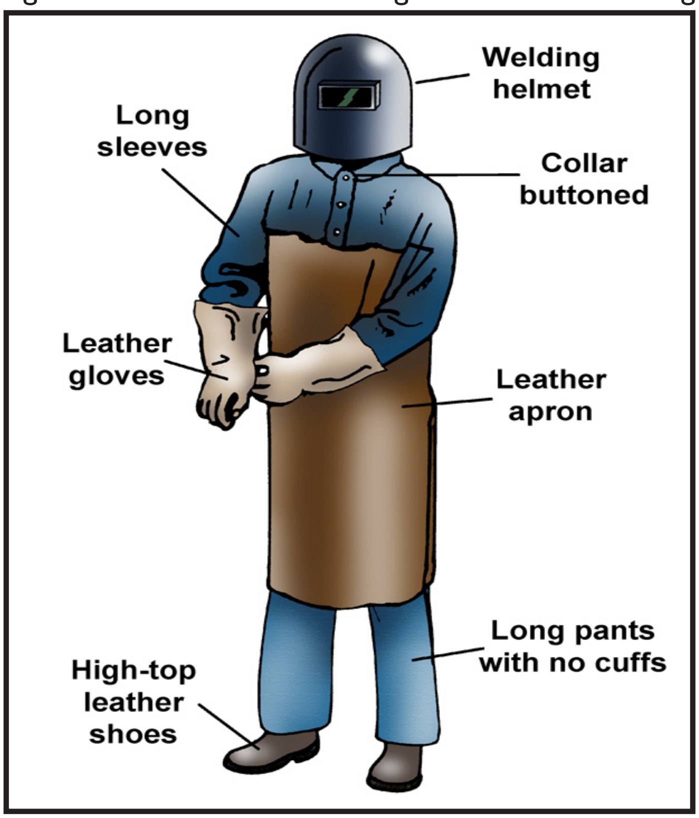
Figure 1.1 - Welding Booth



- **Be careful with hot work pieces.** Handle hot metal with tongs or pliers, not gloved or bare hands. If metal pieces are cooled in water, do so carefully to avoid steam burns. Do not walk around the shop with hot metal. If hot metal must be left where others could be in contact with it, carefully mark it "Hot" with soapstone or chalk.

- **Wear appropriate clothing and safety gear.** Various types of safety gear are required to prevent injury from sparks, hot metal, rays from the arc, and flying debris. See Figure 1.2.
  - o Hands and feet - Leather gauntlet-style gloves and high-top leather shoes should be worn to protect the hands and feet.
  - o Body - Clothing should be made of wool or cotton, not a synthetic material. It should be dark and tightly woven, which also helps block arc rays. Shirts should be long sleeved and the sleeves and front of the shirt should be buttoned, including the top collar button. Pants should come down over the tops of the boots and not have cuffs. Sparks could fall in cuffs.

Figure 1.2 - Protective Clothing and Gear for Welding



Long-sleeved fire-resistant coveralls provide excellent protection. Other protective gear, such as leather aprons and leather sleeves, are also available and should be worn as needed. Clothing with tears or frayed areas should not be worn because the skin might not be protected and the shreds of material could easily catch fire from sparks. Clothing made of synthetic materials should not be worn because such fabrics can burn readily and give off poisonous gases when they are burning. Pockets should not contain flammable materials, such as matches or butane lighters, which could potentially catch fire or explode.
  - o Head and eyes - A cap and safety goggles should always be worn. Safety glasses or goggles and additional head and eye protection such as a flameproof skullcap or face shield should be worn as needed to avoid burns when chipping hot slag from welds. When welding, an arc welding helmet should be worn for protection against harmful arc rays. (See the section on arc rays for more details.)
- **Do not attempt to heat, cut, or weld containers such as tanks, drums, and barrels.** These types of containers may have been used to store flammable substances such as gasoline. If so, the welding process could cause a big explosion and fire. Even though a container looks clean, it may still have fumes that could catch fire.

Avoiding Arc Rays

The following safety precautions should be followed to help prevent burns from arc rays during the welding process.

- **Wear a welding helmet with a filter lens classified as no. 10 or higher, depending on the work being done.** Manufacturers of welding equipment provide recommendations for appropriate lenses. Welding helmets are available in different types, including some that have a flip-up or fixed shaded lens. A flip-up lens allows work, such as chipping, to be done without removing the helmet. See Figure 1.3 and Figure 1.4. If a helmet with a flip-up lens is not used, safety glasses must be worn under the helmet. Inspect helmets and their lens assembly to make sure they are undamaged and the gaskets are fitting properly to avoid light leaks. Do not use a helmet or lens that is damaged. In addition to the helmet, dark, tightly woven clothing protects the body from exposure to arc rays. All persons in the welding area should wear eye protection, such as flash glasses, to avoid eye injury from the reflected light. Before starting a weld, the operator should always say "cover up" as a warning for others to protect themselves.

Figure 1.3 - Helmet with a Flip-Up Filter Lens

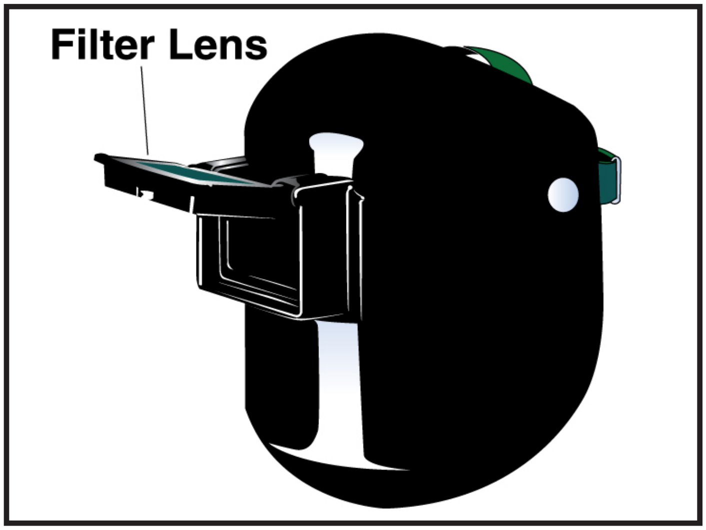
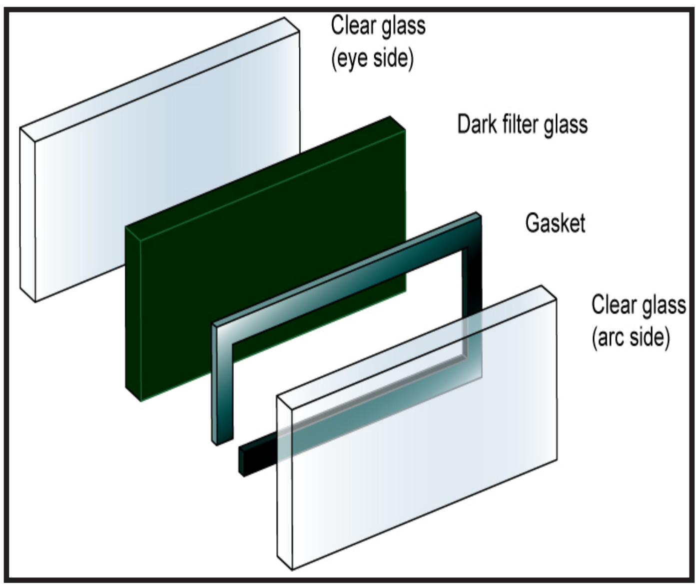


Figure 1.4 - Parts of a Filter Lens on a Welding Helmet



Avoiding Breathing Hazards

The following safety precautions should be followed to help prevent respiratory problems.

- **Work in an area with adequate ventilation.** Working outdoors or in a large shop with high ceilings and natural ventilation is best.
- **Use forced ventilation if natural ventilation is not sufficient.** Forced ventilation, such as hoods and exhaust fans, is probably needed in small shops and in shops with many welders operating at the same time. Forced ventilation may also be required if welding is being performed on metals that contain extremely toxic substances. The ventilation system should be as close to the work as possible.
- **Supplement ventilation as needed with an appropriate respirator.** Respirators may be required depending on the size of the work area, ventilation available, and the type of metal being welded. Different types of respirators are available. Some models supply fresh air and other models are designed to filter specific contaminants. See Figure 1.5.

Figure 1.5 - Respirator with a Powered Air Purifier

- **Clean metal before welding.** It is important to remove chemicals from the metal so they do not mix with the other fumes produced by welding and create a worse breathing hazard. It is also safer and easier to establish an arc on a clean surface than a dirty surface.
- **Operate engine-powered welders in well-**

ventilated areas or with the exhaust vented directly outdoors. This is to prevent carbon monoxide, a poisonous gas produced by gas and diesel engines, from building up in the shop.

Care and Maintenance of Arc Welding Equipment

Regular maintenance of welding equipment and inspection of the equipment before each use are critical for safe operation.

- **Inspect the electrode holder frequently to be sure it is not damaged or in need of repair.** Defective jaws, loose connections, and poor insulation are electric shock hazards.
- **Keep cables free of oil and grease.** These substances on the cables may cause them to catch fire.
- **Run cables so that they will not be damaged or cause a tripping hazard.** Be sure that cables will not be exposed to sparks and molten metal and are not located where the operator or others must walk or stand. In temporary work sites, keep cables covered to protect them from traffic.
- **Do not shut off or start the welder with the electrode or electrode holder in contact with the work or the welding table.** This prevents the possibility of damage to the welder. The electrode holder should be hung from an insulated hanger when it is not in use.
- **Keep the welder and electrodes dry.**
- **Do not allow dust to accumulate on the transformer coils.** Dirty coils can start a fire, short out electrical components, and cause other equipment failures.

Summary

The arc welding process has potential safety risks like electric shock, burns and fire, burns from arc rays, and breathing hazards. Following safety precautions, maintaining the welding equipment, and inspecting it before each use will help prevent injuries to the welder and others in the work area.

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Lesson 2: Cutting With Oxyfuel

Oxyfuel processes are useful for a wide variety of agricultural work. Becoming an efficient welder takes practice, knowledge of the equipment and its setup, and properly performing the cutting procedure. Because of the nature of the process, strict observation of the safety rules is critical. This lesson discusses oxyfuel processes and focuses on the equipment required and proper technique for oxyacetylene cutting. Your instructor must be present to demonstrate the step-by-step procedures for cutting metal and guide you through them.

Oxyfuel Processes

Oxyfuel refers to a group of processes in which oxygen and a combustible fuel gas are combined to make a flame. The flame can reach temperatures of 5,000°F to 6,000°F, which is hot enough to melt or cut most metals. These processes are commonly used in agricultural mechanics to heat, weld, cut, braze, and hardface metal. In oxyfuel cutting, the fuel gas flame heats the metal and a stream of oxygen then cuts the metal. Typical kinds of cuts include cutting flat steel, round-bar steel, and cast iron; beveling; and making holes. Oxyfuel cutting can save time and money by accurately cutting several thicknesses of metal at once and completing the task quicker than a power saw.

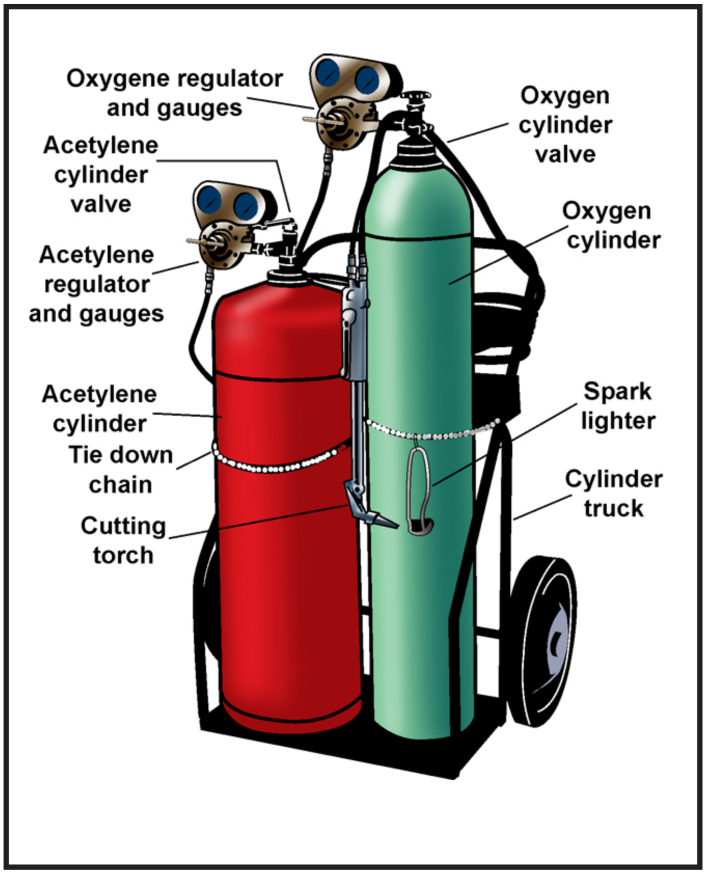
The oxygen used in oxyfuel processes is not air. Air in the atmosphere is composed of approximately 21% oxygen, 78% nitrogen, and 1% other gases. Oxygen manufacturers use various methods to change atmospheric air to pure oxygen. The fuel gases used in oxyfuel processes include acetylene, propane, natural gas, hydrogen, butane, and methylacetylene-propadiene (MPS). Each of these gases has different properties and may not be used for all functions or perform them equally well. Acetylene is a gas used in many agricultural mechanics shops because of its versatility in performing many functions well. It is also chosen because it can make a clean, accurate cut and the flame it produces is easily regulated.

"Oxyacetylene," one of the oxyfuel processes, is a term created from combining the words oxygen and acetylene. In this lesson, "oxyfuel" will refer to oxyacetylene, but it is important to remember that other fuel gases are available. If other fuels are used, accessories and procedures designed for those fuels must be used.

Major Parts of an Oxyfuel Outfit

Many agricultural mechanics shops have at least one oxyfuel outfit, which is usually a portable cart or truck that contains the equipment needed for oxyfuel cutting. The major parts of the outfit include the cylinders, regulators and valves, gauges, hoses, and cutting torch. See Figure 2.1.

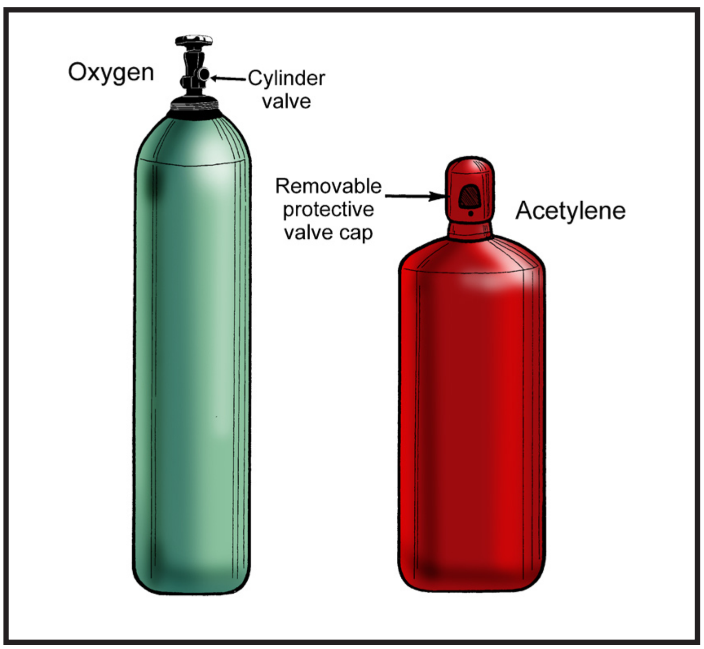
Figure 2.1 - Parts of an Oxyfuel Outfit



Cylinders

Each outfit has two cylinders (oxygen and acetylene) that are designed to hold gases under high pressure. See Figure 2.2. Both types of cylinders are made of steel and come in a variety of sizes to meet users' needs. The oxygen cylinder includes a back-seating valve that controls gas flow from the tank. This means when the tank is in use, the valve must be opened all the way to prevent leakage around the valve. The acetylene cylinder valve is only opened one fourth to one half turn when in use, so it can be shut down quickly in an emergency. Whichever device is used to open the acetylene cylinder valve, a handle or valve wrench, the device must be left in place during use to allow for quick shutoff. Protective valve caps should be in place when cylinders are not in use to protect the valve from damage. The cylinders are held in an upright position on the cart by chains or another safety device.

Figure 2.2 - Oxygen and Acetylene Cylinders



Regulators and Valves

These devices, which are attached to both cylinders, control the flow of gases through the outfit. The purposes of the regulators are to reduce high-storage pressure to a lower working pressure and to maintain a steady working pressure even if the cylinder pressure changes. A regulator typically has a cylinder pressure gauge and a working pressure gauge to provide pressure readings. See Figures 2.3 and 2.4. Not all regulators are the same; they are designed to be used with specific gases and operating pressures.

Figure 2.3 - Acetylene Regulator and Gauges

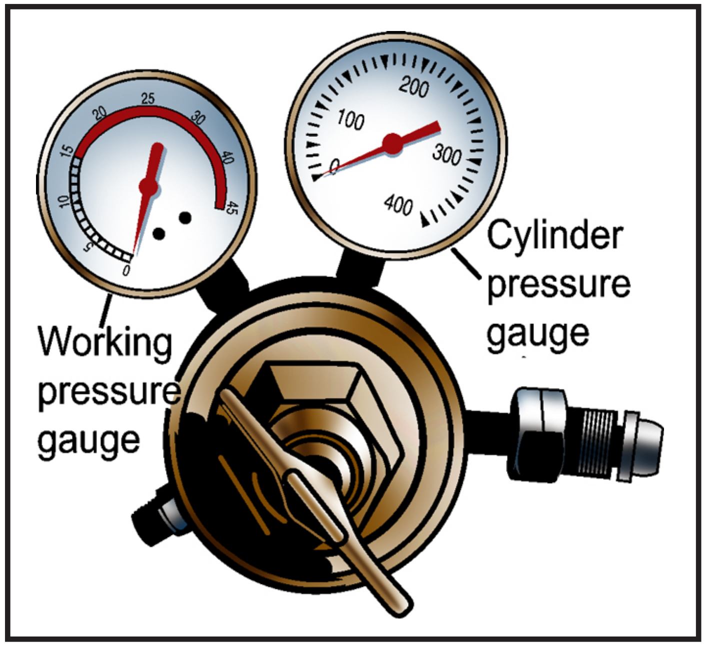
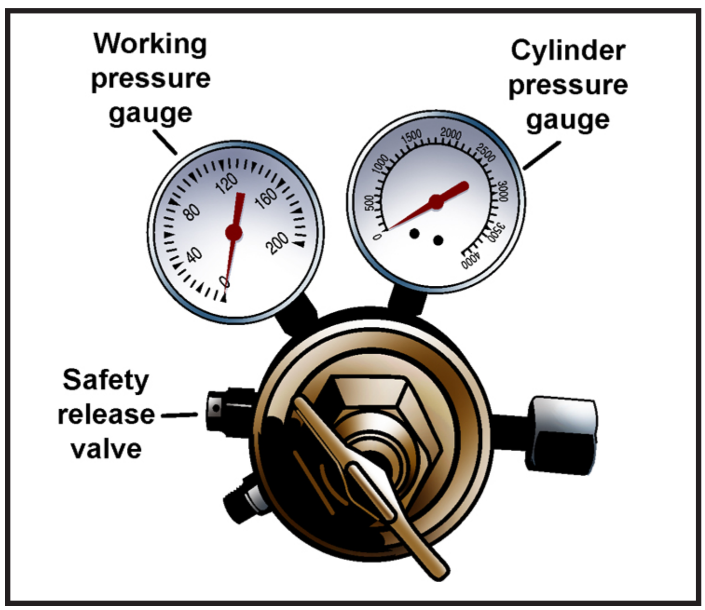


Figure 2.4 - Oxygen Regulator and Gauges



Valves in an oxyfuel outfit perform valuable safety functions for the process. Types of valves include cylinder valves, torch valves, check valves, and safety release valves. A cylinder valve is located at the top of the cylinder and can be opened by a handle or valve wrench to adjust the flow of gas.

A torch has two valves, one for oxygen and the other for gas, which are turned by hand to control the gas flow into the torch. Check valves may be located at the torch or regulator and function to prevent gas from flowing the wrong way. Regulators may be equipped with safety release valves that release gas to lower excessive pressure. Some valves reset after excess pressure is released or a flashback (flame burning back up into the outfit) occurs. To maintain valves, it is important to follow the manufacturer's instructions for the valves on the outfit.

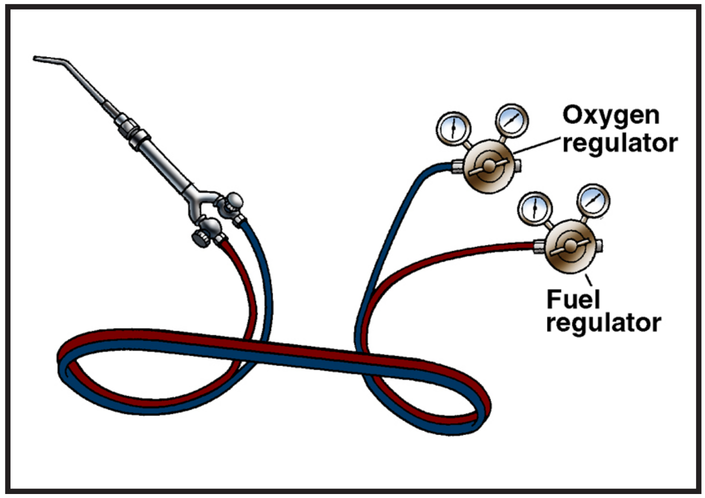
Gauges

Regulator gauges include the cylinder pressure gauge, which measures pressure in the cylinder, and the working pressure gauge, which measures the pressure going into the line. Gauges indicate pressure in pounds per square inch gauge (psig) or in kilopascals (kPag). Gauges include markings beyond the range of normal or safe operation. Acetylene working pressure gauges may be marked up to 30 psig, but acetylene pressure should be kept below 15 psig for safe operation.

Hoses

An oxyfuel outfit has two hoses, one that carries oxygen from the cylinder to the torch and the other that carries acetylene. See Figure 2.5. One end of the oxygen hose is connected to the oxygen cylinder regulator and the other end is connected to the torch. The acetylene hose is connected to the acetylene cylinder regulator and the torch. Hoses come in different sizes according to the hose's inside diameter and are made of several layers of rubber for strength. They are generally available in two colors: green and red. Green is used for oxygen and red is used for acetylene. However, it is important to remember that these colors are not standardized and hookup may differ from one outfit to another. Always check hoses as part of basic setup procedure, particularly when working with an unfamiliar outfit. Hoses should not be switched from one gas to another; this can create a combustible mixture in the hose.

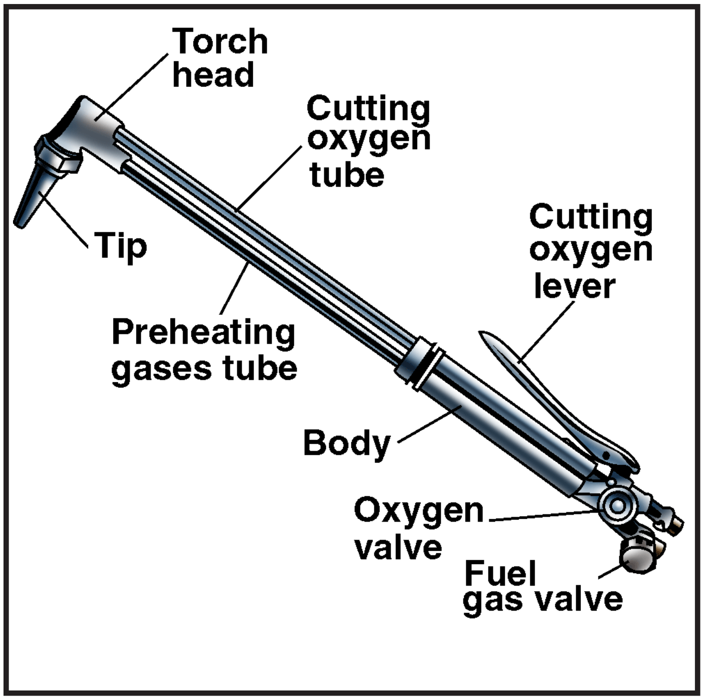
Figure 2.5 - Hoses on an Oxyfuel Outfit



Cutting Torch

A cutting torch, which mixes the oxygen and fuel gas to produce the desired flame, is the tool held by the operator to make the cut. See Figure 2.6. The oxygen comes out the center opening in the torch tip and the fuel gas comes out another opening or openings in the tip. A cutting torch may be part of a welding-cutting combination set or a torch designed for cutting only. The cutting torch differs from the welding torch by having the additional oxygen passage through the center. This stream of oxygen supports combustion and pushes slag out of the way, allowing the torch to make a cut. Major parts of a cutting torch are the fuel gas valve, oxygen valve, cutting oxygen lever, body, cutting oxygen tube, preheating gases tube, head, and tip. Cutting tips are designed in various shapes, angles, and numbers of fuel gas openings to accommodate the type of work being done.

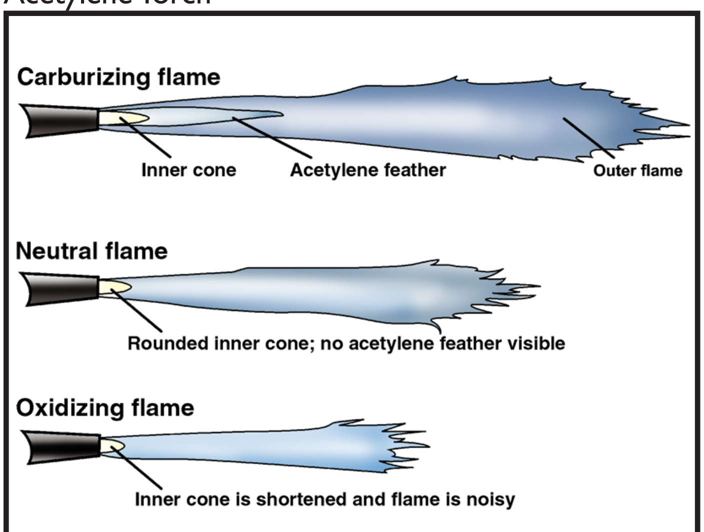
Figure 2.6 - Cutting Torch



Flame Types

The three types of flame an oxyacetylene torch can produce are carburizing, neutral, and oxidizing. See Figure 2.7. They are described in the list below. In adjusting the oxyacetylene flame, a welder will start out with a carburizing flame and make adjustments to attain a neutral flame for the cutting operation. The carburizing and oxidizing flames are mainly used for special applications.

Figure 2.7 - Three Types of Flame Produced by Acetylene Torch



- Carburizing (carbonizing) flame - This flame is low-temperature and may add carbon to the cut or weld. In this flame, too much acetylene is present and three distinct parts of the flame are visible. It may be used for some brazing or welding procedures.
- Neutral flame - This flame does not add carbon or burn the work with oxygen; it is the best choice for most welding and cutting tasks. It is a balance of acetylene and oxygen and has an inner core of flame that is rounded on the end.
- Oxidizing flame - This flame is high temperature and may add oxygen to the cut or weld. Too much oxygen is present in this flame, the flame is noisy, and the inner cone is shortened. It is not recommended for most operations because it may burn the work.

When using the outfit for cutting, the flame must be adjusted to neutral, with and without the oxygen stream.

Factors That Affect a Cut

Much practice is required to perfect the cutting technique. When making a cut, it is important for the welder to get in a comfortable position that allows free movement of the torch hand. The welder should be braced against a stable object to ensure a steady cutting movement. Even a slight movement off the cutting line can cause an irregularity in the cut. Other factors that can affect the cut are discussed below.

Cutting Tip

The tip must be designed to fit the torch head, because tip seats can vary greatly among manufacturers. See Figure 2.8. Considerations in choosing a tip include the appropriateness for the type of cut, the material being cut and its condition, and the thickness of the material. See Figure 2.9. Consult the instructor's or manufacturer's recommendations. The tip should be clean and in good condition to allow the gas to flow freely and produce an effective flame. A dirty or clogged tip can become damaged or overheat. A dirty or clogged tip should be cleaned with a tool designed for this purpose. Slag on the end of a tip can be removed with fine sandpaper. When attaching the tip to the torch head, at least two preheating openings should be in line with the cutting line. See Figure 2.10.

Figure 2.8 - Dirrerent Torch Tip Designs

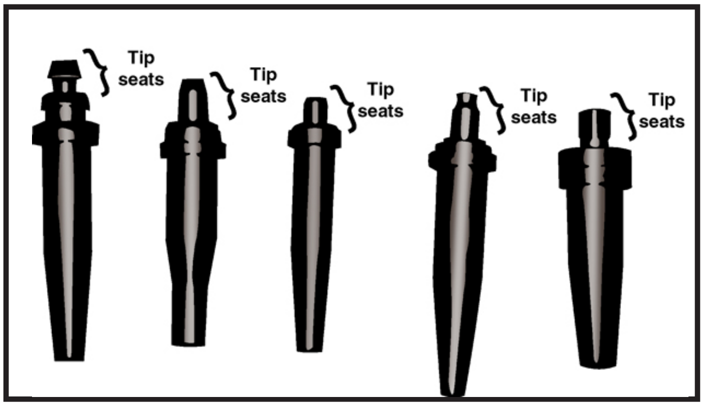


Figure 2.9 - Common Cutting Tips and Their Uses

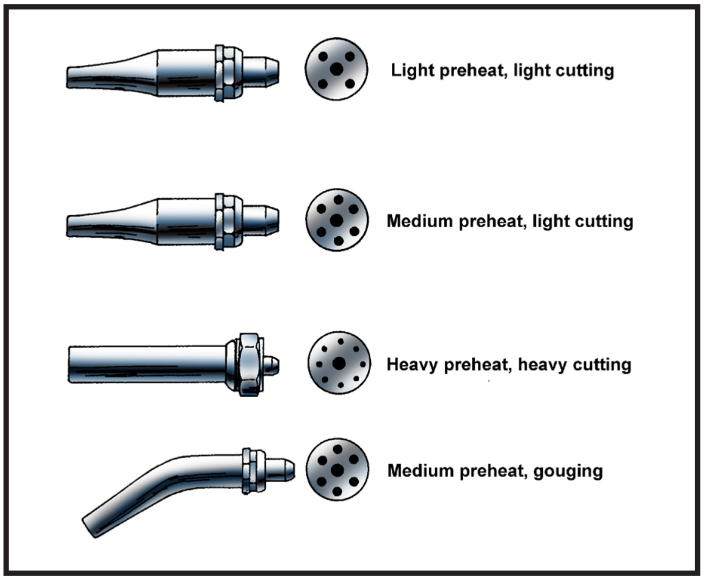
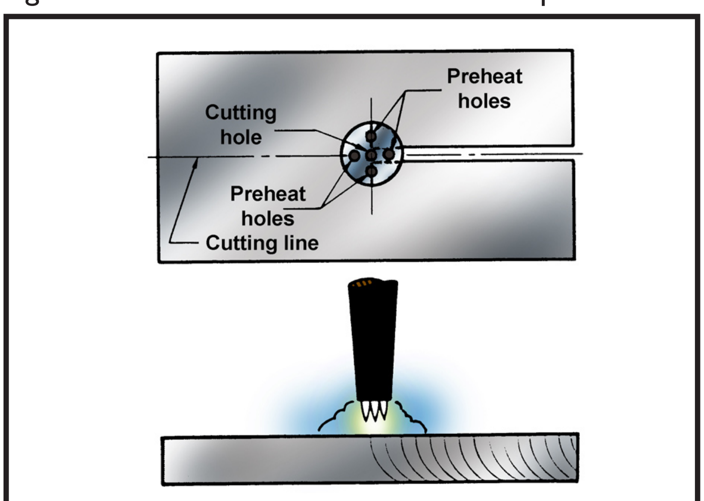


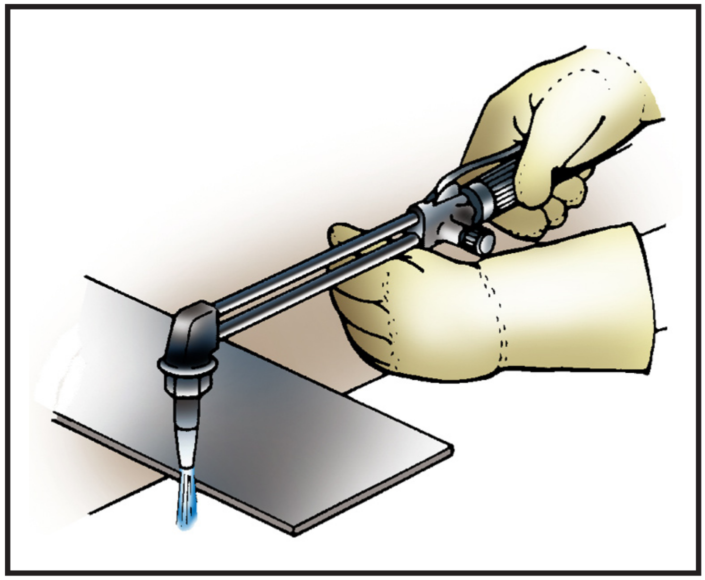
Figure 2.10 - Position of Holes in Torch Tip



Torch Position

To start a cut on an edge, the welder should hold the torch so that the flame angles slightly away from the work. See Figure 2.11. The edge will preheat sooner and allow the cut to begin quicker. To start other cuts, the welder should hold the torch straight over the point to be cut. The noncutting hand can be positioned under the torch and used for a guide while the torch hand controls the oxygen lever and makes the cut. Most cuts are made with the torch at a right angle to the work. A slight leading angle can be used for straight cuts or a greater angle can be used for cutting thin stock if needed.

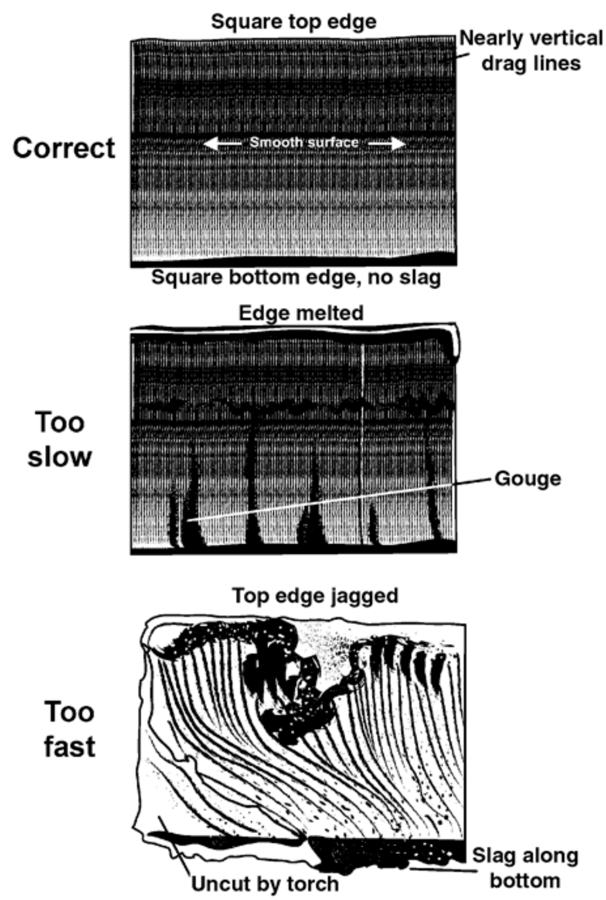
Figure 2.11 - Position of the Torch when Starting a Cut on an Edge



Speed of Travel

The appearance of the cut is affected by the speed at which the torch is moved in making the cut. See Figure 2.12. If the correct speed is used, the drag lines (lines made on the edge during cutting) are nearly vertical and the top and bottom edge are smooth and square. If the torch is moved too slowly, the drag lines are irregular and the stream tends to wander and gouge the cut. In addition, the flame may melt the top edge of the cut. If the torch is moved too fast, the drag lines tend to break, the top edge may be jagged, and the cut may not go all the way through the material.

Figure 2.12 - Cross-section of Metal Showing the Results of Moving the Torch at the Correct Speed, Too Slowly, and Too Fast



Pressure

If correct gas pressure is used, the cut should be smooth and the top and bottom edges square. Too much pressure can distort the cut by dishing out the top or pushing out the bottom. When too little pressure is used, the cut may not go all the way through the material.

Summary

Oxyfuel processes are used in agricultural mechanics to heat, weld, cut, braze, and hardface metal. Oxyacetylene cutting, which uses acetylene to preheat the metal and oxygen to cut the metal, is one of the more common oxyfuel processes used. Major parts of an oxyfuel cutting outfit are the oxygen and acetylene cylinders, valves and regulators, gauges, hoses, and cutting torch. Part of the mastery of oxyacetylene cutting is recognizing the flame types and various factors that can affect the quality of the cut.

Credits

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Lesson 1: Finishing With Paint

Most tools, equipment, and structures used in agriculture are made of materials, such as wood or metal, that will deteriorate when exposed to elements in the environment. To protect these valuable investments from damage and to improve their appearance, a protective coating of paint is often applied. This lesson provides basic guidelines for paint safety, preparing to paint, and applying paint. Your instructor must be present to demonstrate the step-by-step procedures for painting and guide you through them.

Safety Precautions for Painting

As with all tasks in agricultural mechanics, safety considerations must come first. If not used properly, paints and solvents can cause fire, poisoning, eye and skin irritation, and respiratory problems. Using painting equipment improperly can cause fire and other accidents. The following safety precautions should be observed.

- **Follow safety procedures for all equipment and materials.** This includes equipment, such as steam cleaners, sanders, and ladders, as well as paints and solvents. Read the labels on finishing materials to check for warnings about toxicity and flammability. Follow manufacturer's instructions for safe operation of equipment.
- **Wear appropriate protective clothing.** Wear safety glasses or goggles to protect eyes from splattered paints or solvents. Be aware of the location of an eye-washing station in case of an accident. Wear an approved respirator to protect the respiratory system from dust or toxic fumes. Wear rubber gloves to protect hands from burns and irritation when handling bleaches, solvents, or other dangerous materials.
- **Work in a well-ventilated area.** Apply finishing materials outdoors or if indoors, ensure that plenty of fresh air is available. Supplement natural ventilation with forced ventilation, such as an exhaust fan, if needed. Wear an approved respirator when required or when ventilation is inadequate.
- **Keep sparks and flames out of the work area.** Many of the materials used in painting, including the cleanup rags, are flammable. The vapors and gases these materials produce are flammable as well. Do not smoke or allow others in the area to smoke. Keep equipment that can cause a spark away from finishing materials and the work area.
- **Have an approved fire extinguisher readily available.** Be aware of the location of the fire extinguisher and know how to use it.
- **Observe safe cleanup procedures.** Clean spills as they happen to prevent accidents. Use the appropriate solvent or cleaning solution for the task. Store chemicals in approved containers and flammable finishes and solutions in a fireproof cabinet. Keep the work area clear of debris and dispose of cleanup rags properly. Wash hands after working with chemicals that are toxic or could harm skin.

Preparing Surfaces for Paint

For best paint adherence, durability, and appearance, the surface to be painted must be properly prepared. The preparation required depends on whether the surface is new or previously finished.

Wood

New wood surfaces may only require cleaning of surface dirt and grease using approved cleaning solutions. If the wood has surface marks and defects, such as mill marks or dents, these should be sanded or filled as well. Ensure that the wood is dry before sanding and follow the grain of the wood. With painted surfaces, sometimes only loose paint may need to be removed. However, if the paint is in bad condition, it should be removed using paint stripper, a wire brush, or sandpaper. A power method, such as a wheel mounted on a power drill, can make this process quicker. If a very smooth finish is desired, a thorough sanding is done or a chemical paint remover is used to remove all residue. After the paint is removed, the wood is washed with water and detergent. The wood is sanded if a smooth finish is desired and dusted off with a tack rag. The last step is applying an appropriate primer coat to seal the wood and improve the durability of the paint.

Metal

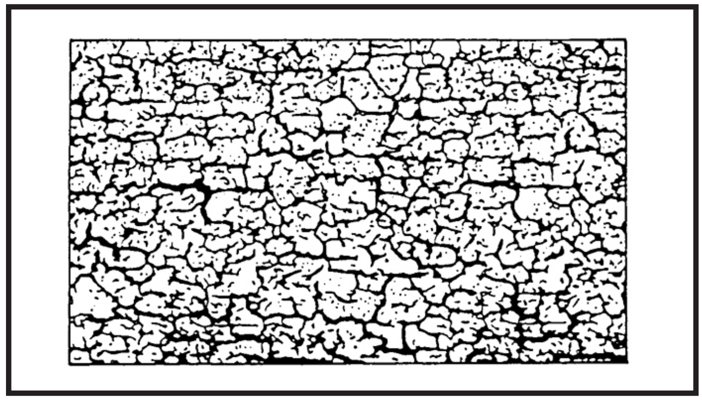
The surface dirt, grease, and rust on metal should be cleaned with a steam cleaner, high-pressure washer, or approved cleaning solution. Gasoline is too hazardous to use. Loose paint and rust can be removed by wire brushing or sanding. Pitted areas can be smoothed by these methods as well. Removing paint and rust is commonly done by hand and with power tools. The metal is then cleaned with a preparatory solvent, wiped with a cloth, allowed to dry, and coated with an appropriate primer coat that inhibits rust formation.

Common Paint Failures

When paint fails, it is a waste of time, money, and effort. The object is not protected and the work must be done again. It is important for painters to be able to recognize common painting problems and change their technique, paint, or condition they paint in to prevent failures. The following is a list of common painting problems.

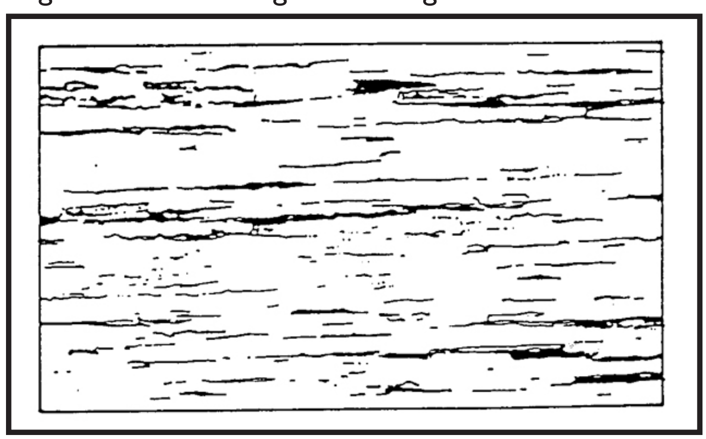
- Alligatoring
  - o Possible causes: applying a harder, less oily coat of paint over a softer, oilier one; applying a new coat before the previous coat has dried. See Figure 1.1.

Figure 1.1 - Alligatoring of the Paint



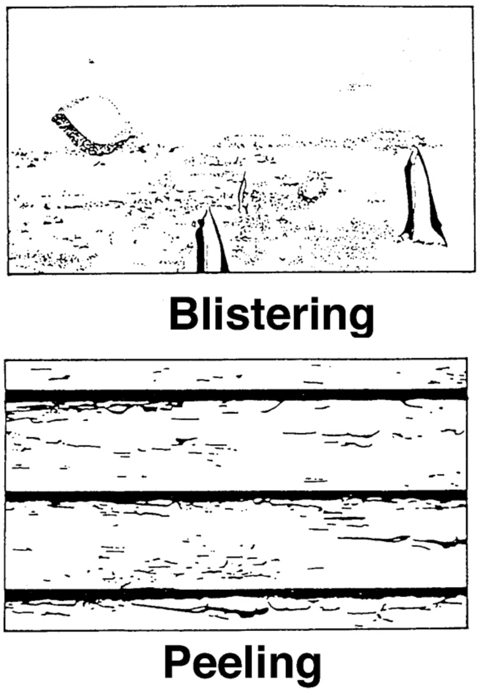
  - o Solutions: applying progressively flexible coats of paint; allowing more drying time between coats.
- Cracking and scaling
  - o Possible causes: paint becomes hard and brittle and cannot expand and contract with the wood; often a problem of low-quality paint; aggravated by applying paint too thickly. See Figure 1.2.

Figure 1.2 - Cracking and Scaling of the Paint



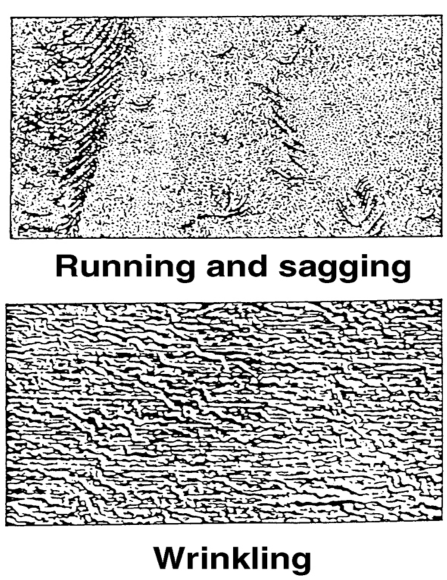
  - o Solutions: using high-quality paint; applying more thin coats instead of a single thick coat of paint.
- Blistering and peeling
  - o Possible causes: moisture pushes the paint off the surface; can also be caused by heat. See Figure 1.3.

Figure 1.3 - Blistering and Peeling of the Paint



- o Solutions: removing source of moisture; repairing any leaks or cracks, improving ventilation, ensuring the area is completely dry before repainting; avoiding heat blistering by not painting in direct sunlight.
- Running, sagging, and wrinkling
  - o Possible causes: applying paint too thickly. See Figure 1.4.

Figure 1.4 - Running, Sagging, and Wrinkling of the Paint



- o Solution: applying more thin coats instead of a single thick coat of paint.

Other common paint failures deal with the environment. Paint may fail if applied in cold or wet weather. Painting should be done when it is 65°F or warmer. Painting in damp weather or early in the morning or late in the evening, when dew is likely to form on the work, should also be avoided.

Selecting Paintbrushes

Paintbrushes are commonly used for smaller jobs in agricultural mechanics, such as trims on doors or windows. Good-quality brushes of the correct size will make a paint job much easier. For example, a brush that is 3 1/2 in. to 4 in. wide is useful for covering larger surfaces, whereas a 1-in. brush can be purchased to efficiently paint trim or corners. See Figure 1.5. The major parts of a brush are the handle, nails, metal ferrule, and bristling material. The tip of the bristles is called the trim and the part of the bristles near the ferrule is called the heel. See Figure 1.6.

Figure 1.5 - Types of Paintbrushes

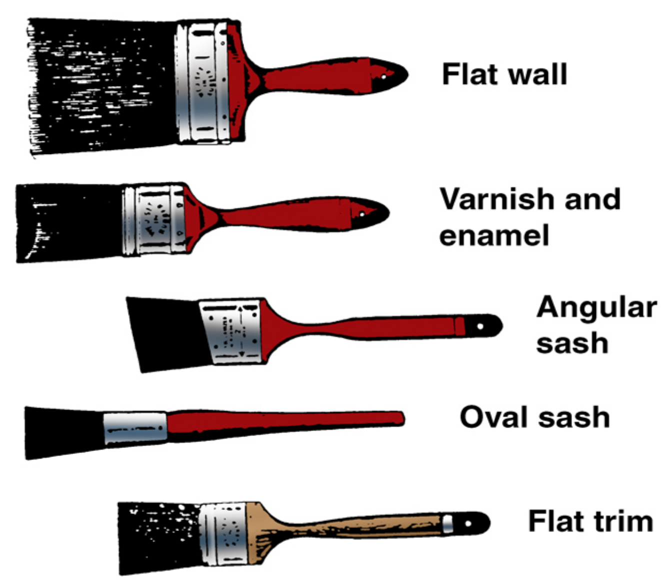
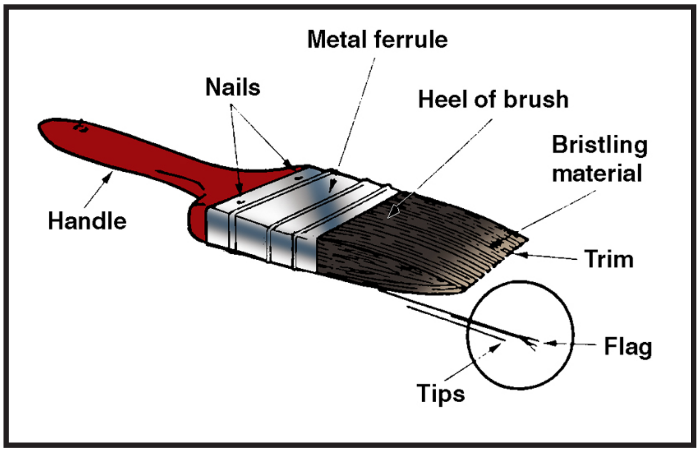


Figure 1.6 - Parts of a Paintbrush



Paintbrushes are available with two types of bristles: natural and synthetic blend. Natural bristles work best with oil-based finishes, including lacquer and shellac, but don't work well with water-based finishes. Synthetic-blend brushes are available for use with all finishes. Qualities of a good paintbrush include bristles with split or "flagged" ends that help hold paint; bristles that keep an even, sharp edge when pressed against a smooth surface and spring back when bent; bristles that taper smoothly from ferrule to tip; bristles that are not loose or don't come out; and an overall shape that is well proportioned and balances easily in the hand.

Using a Paintbrush

Using the right painting technique is essential to obtaining a high-quality paint job. Loose bristles should be removed before using the brush. To paint, the brush should be held with the back of the handle between the thumb and first finger and with the other fingers on the ferrule. This position may change as needed for the area to be painted.
See Figure 1.7. When dipping the brush into the finish, only about one-third of the bristles should be covered. The bristles are then touched to the inside edge of the container to remove excess finish. This helps to prevent dripping. The paint should be applied in light, even strokes with the brush at a slight angle to the surface. The trim end of the brush is used on the surface, never the side. As a general rule, a surface should be painted by working from the highest point down.

Figure 1.7 - Methods of Holding a Paintbrush

The strokes should be with the grain when painting wood. To help prevent uneven spots in the finish, adjoining sections are painted before the paint dries and strokes are not repeated over painted areas. Any drips on other surfaces should be cleaned up as soon as possible before the paint dries.

Cleaning and Storing Paintbrushes

To preserve the quality of paintbrushes and prolong their life, they must be cleaned and stored properly after each use. The first step in cleaning is to wipe as much paint as possible from the brush with a cloth or paper towel. After using latex paint, the brush can be cleaned with soap and water. When using oil-based paint, the brush can be cleaned with turpentine or another thinning agent and then soap and water. Excess liquid can be removed from the brush by spinning the handle between your hands with the brush inside an empty container. See Figure 1.8.

Figure 1.8 - Spinning Paintbrush to Remove Excess Liquid

When storing the brush dry, it should be wrapped in heavy paper and fastened with a rubber band or string to keep bristles in their proper shape. The brush should then be stored flat to avoid bending the bristles. See Figure 1.9. Brushes that are used regularly can be stored wet by suspending them in clean solvent with the bristles tightly covered. See Figure 1.10. The bristles must not touch the bottom of the solvent container, because this can cause them to curl permanently.

Figure 1.9 - Storing a Paintbrush in a Paper Wrapper

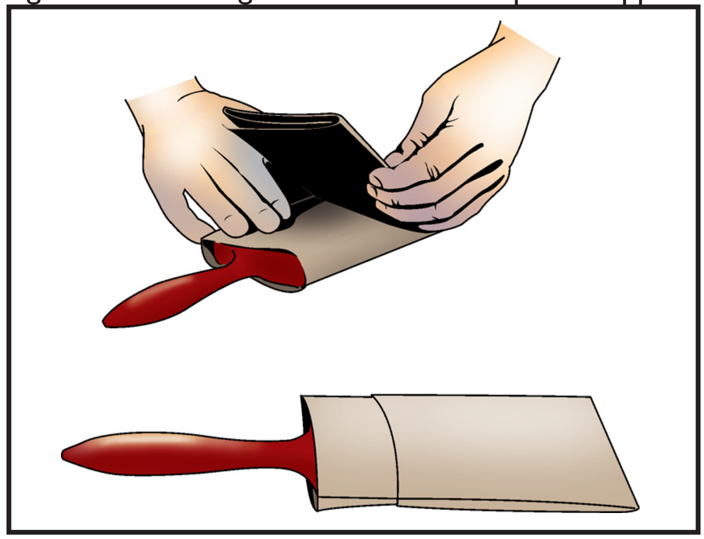


Figure 1.10 - Storing a Paintbrush in a Solvent

Estimating the Amount of Paint Needed

Estimating the amount of paint needed for a project is a simple calculation that can save time and money. By buying the correct amount of paint, the painter will not have to run to the store to buy more paint and will avoid spending money on unneeded paint. A gallon of most paints will cover 400 to 500 sq ft, but it is best to consult the manufacturer's specifications on the product to see how many square feet a quart or gallon of the paint should cover. Remember that 4 quarts equals 1 gallon. Another consideration when buying paint is the condition of the surface. If it is rough, porous, or unpainted, it can take more paint than a smooth painted surface. Considering the time and money that can be lost stopping to buy more paint, it is better to have a little extra paint than not enough. In addition, if the paint is customized for color or content, it can be can be difficult to match if more must be purchased later.

The steps for calculating the amount of paint are as follows.

1. Determine how many square feet are in the project to be painted.
2. Divide the number of square feet of the project by the number of square feet covered by the quart or gallon, whichever is closer to the size of the project.
3. Round up to the next whole number, if the answer isn't a whole number.

The result is the amount of paint needed for one coat of paint. Keep in mind that paint is frequently cheaper by the gallon. If the job calls for more than 2 qt of paint, it may be cheaper to buy the gallon.

For example, below is the calculation for applying one coat of paint to a room that has 2 walls that are 10 ft x 20 ft and two walls that are 10 ft x 15 ft The paint being used covers 400 sq ft per gallon.

10 ft x 20 ft = 200 sq ft x 2 walls = 400 sq ft
10 ft x 15 ft = 150 sq ft x 2 walls = 300 sq ft
400 sq ft + 300 sq ft = 700 sq ft
700/400 = 1.75 gallons

The room may be painted with one gallon and three quarts, but it is probably more cost-effective to purchase two gallons in case the surface requires more.

Summary

The two main reasons for painting tools, equipment, and structures are to prevent deterioration and to improve appearance. Safety must be the first consideration when working with finishing materials and equipment. Skilled painters know that achieving paint adherence, durability, and good appearance depend on several factors: properly preparing the surface, recognizing and preventing paint failures, and selecting and maintaining a quality paintbrush. The technique of using a paintbrush is also important to a successful paint job. Another part of the painting process that saves time and money is calculating the amount of paint to cover a surface before purchasing the paint.

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