

MERIT BADGE SERIES



FARM MECHANICS



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FARM
2008

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Requirements

1. Do the following:
 - a. Discuss with your counselor the safety equipment, tools, and clothing used while checking or repairing farm equipment. Use this equipment, tools, and/or clothing (when needed or called for) in meeting the requirements for this merit badge.
 - b. Draw a plan showing a well-equipped farm shop. Point out the shop's mandatory safety devices and features.
 - c. Find all the universal warning and safety symbols on a piece of equipment and explain what they mean.
 - d. Describe what a material safety data sheet (MSDS) is and tell why it is used. Obtain the MSDS for any engine coolant, oil, grease, fuel, hydraulic or transmission fluid, or other flammable or hazardous materials you use in meeting the requirements for this merit badge.
2. Explain how power is produced or transferred in a:
 - a. Diesel engine
 - b. Hydraulic system
 - c. Transmission or any other power system
3. Do TWO of the following:
 - a. Replace the handle of any tool found on the farm.
 - b. Organize a tool rack or a storage system for nails, bolts, nuts, and washers.
 - c. Using a hand file, properly dress the mushroomed head of a chisel or punch.
 - d. Using a hand file, correctly dress a screwdriver tip.
4. Do ONE of the following:
 - a. On an engine-powered machine: Grease all fittings, change the oil and oil filter, clean the air filter, clean the radiator fins, and replace the fuel filters.
 - b. For any engine-powered machine, create a pre-operational checklist; include checking the engine coolant, engine oil, hydraulic and/or transmission fluid, and battery voltage (using a voltmeter). Using your checklist, conduct a preoperational check of that machinery or equipment.
 - c. Prepare any farm machine for winter storage.
5. Visit an implement dealer. Interview the dealer technician or service manager for hints on good preventive maintenance. Ask why it is important, the costs, and what causes wear or damage. Report what you learn.
6. Explain each step in ONE of the following maintenance procedures:
 - a. Tightening hydraulic fittings
 - b. Checking the air filter
 - c. Cleaning a work piece with a wire-brush wheel
7. Find out about three career opportunities in farm mechanics. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.



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Machinery, Technology, and You

Even in the biggest city, you can find what you need to complete the requirements for the Farm Mechanics merit badge.

A lawn tractor with a 20-horsepower gasoline-fueled engine may weigh about 400 pounds. A farm tractor with a 500-horsepower diesel engine can weigh more than 40,000 pounds. But despite their variations in size, all tractors are more alike than they are different. For trouble-free operation, tractors and other engine-powered machines need proper lubrication. Engines need clean fuel, clean air, and clean filters. Hydraulic systems and transmissions must have the right amounts of the right fluids. Cooling systems must be properly maintained to avoid engine overheating.

If you live on a farm and help with the work, you probably have experience with this kind of machinery maintenance. But if you live in a town or city and you have seldom, or never, set foot on a farm or laid eyes on a big agricultural tractor, it is still possible for you to earn the Farm Mechanics merit badge. All you need are some basic hand tools, standard safety gear, and access to a lawn tractor of the type often used in urban locations. Or you might work on turfgrass equipment such as a fairway mower that is used for groundskeeping on a golf course. Work with your counselor to arrange for hands-on access to the necessary equipment, gear, and tools.



Careers in Agricultural Mechanics

People who are mechanically inclined will have numerous career opportunities in farm mechanics. Many employers are eager to hire trained diesel mechanics, heavy equipment technicians, small-engine repair and service specialists,



agricultural engineers, and mechanized systems managers, to name a few possible careers. Many mechanics-related fields have more open positions than there are qualified people to fill them. With the right training and education, you can turn your flair for machinery and your technical ability into a great career. To explore the many possibilities, talk with your merit badge counselor and see the careers section of this pamphlet.

This pamphlet can help guide you in fulfilling the requirements for the Farm Mechanics merit badge. It is not as complete, however, as the operator's manuals that come with equipment, so always use the operator's manual that came with a piece of machinery, and do your work under the supervision of a knowledgeable and responsible adult.

Agriculture employs many different kinds of tools and equipment, including pieces like tractors, combines, plows, planters, harvesters, balers, tillers, mowers, and harrows, not all of which can be described in this pamphlet. As you work on this merit badge, if you service a piece of equipment or handle a tool that is not described in this pamphlet, be sure to use the operator's manual as your guide and get advice from a knowledgeable adult.



Personal Protective Equipment

Personal safety gear offers protection, from head to toe, against many common work hazards. Use it.

Head Protection

A safety helmet or “hard hat” protects against head injuries. Wear a hard hat for construction work, machinery repair, or any work where there is a possibility of bumping your head or the chance of a falling object hitting your head. Lightweight “bump caps” give some protection but are not effective against hard hits. Use them for jobs where dangers to the head are not extreme.



Safety helmet

Protective equipment doesn't do any good unless you wear it.

Eye Protection

To help save your eyes from flying debris, dust, and other irritants, use eye protection when hammering, sawing, drilling, chiseling, grinding, spray painting, working in dusty areas or with chemicals, or doing anything that might cause an eye injury. Three basic types of protective eyewear are safety glasses, safety goggles, and face shields.

Look for the marking “ANSI Z87.1” on safety eyewear to be sure it meets American National Standards Institute requirements.



Safety glasses. Eyeglasses or sunglasses can protect against thrown objects only from the front. Clip-on or slip-on sideshields add protection for the sides. If you wear glasses, be sure they have impact-resistant lenses. Safety glasses have heavier lenses that withstand greater shocks than ordinary eyeglass lenses, and their wraparound or wrap-back designs provide side protection.

Safety goggles. Plastic goggles protect against impacts from the front and sides. Special unvented goggles also protect against chemical vapors or splashing.

Face shields. Face shields can protect the face from splashing, dust, and chaff, but they offer little protection against impact. If you need impact protection, wear safety glasses or goggles under the shield or get a special impact-resistant shield that is fitted to a hard hat. Be sure the face-shield headband fits properly; follow the manufacturer's instructions on correct fit.



For dusty work, wear a disposable dust mask. Avoid breathing chemical vapors or fumes. Use paints, solvents, and other chemicals only with proper ventilation. Work outdoors, if possible. Exhaust fumes from engines must be vented to the outside.



Wearing gloves, a mask, and eye protection is important when handling farm chemicals.

Hearing Protection

Sound levels as low as 85 to 90 decibels can damage hearing. Many farm machines—tractors, combines, chain saws, etc.—are louder than that. Wear earplugs or earmuffs whenever you are exposed to a continuous noise level of 90 decibels or higher. Wear hearing protectors when using power tools.

Earplugs. Rubber or plastic earplugs fit into the ear canal and are effective noise suppressors. A snug fit is important. Don't use cotton plugs. They get dirty quickly and are not as effective.

Earmuffs. Acoustical earmuffs are especially good for intermittent loud noises, as they are easy to put on and remove. Some farmers prefer them to earplugs, finding them more convenient. However, during certain types of operations and hot, sweaty weather, earmuffs may be less comfortable than earplugs.



Get the type of hearing protection that you prefer, and use it.

Hand Protection

Gloves can protect you against cuts, scrapes, chemicals, and skin irritation. Wear the right type of gloves for the job.

- **Leather gloves** protect hands against rough or sharp objects and give good gripping power.
- **Rubber, neoprene, vinyl, or coated gloves** are needed when working with chemicals, solvents, or petroleum products. Check the product label; it may specify the type of chemical-resistant gloves that can safely be worn with certain solvents or other products.
- **Canvas or cotton gloves** offer some protection when doing light work.

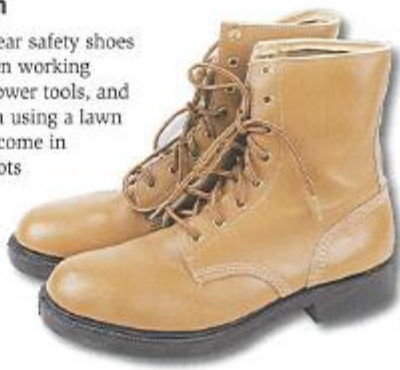
Keep your gloves clean. Replace worn or torn gloves.

Wear gloves that fit. Gloves that are too big can get caught in moving parts—you could lose a hand. Gloves that are too small are uncomfortable.



Foot Protection

It is a good idea to wear safety shoes for all farm jobs, when working around machinery, power tools, and livestock—even when using a lawn mower. Safety shoes come in many styles, from boots to oxfords, and are as comfortable as soft-toed shoes. The steel toes and puncture- and skid-resistant soles of safety shoes help protect your feet.



To help avoid foot injuries, wear boots with steel toe caps.

Body Protection

Aprons, rubber or vinyl garments, knee pads, and other types of padding can help protect your body, but just as important to your safety is your everyday clothing. It should fit comfortably but snugly. Loose or floppy clothing near moving parts is dangerous. Follow these guidelines when choosing what to wear.

- Button the cuffs of long-sleeved shirts. Avoid rolled-up sleeves.
- Wear pants or overalls with straight or tapered legs. Avoid baggy or cuffed pants.
- Wear shoes or boots with skid-resistant soles. (Safety shoes are best.)
- Wear a visored cap or hat for sun protection.
- Zip or button your jacket.
- Do not wear jewelry or dangling drawstrings that could catch in moving parts.
- Wear sunscreen to protect your skin.

Protective clothing and sunscreen help save your skin.

See the Signs

On all machinery that you operate, service, or repair, look for the hazard symbols. Know what the symbols mean. Observe all warnings and cautions. Follow the operating and maintenance instructions to avoid hazards and reduce your risk of injury. Here are some examples of warning signs you might see.





Farm Shop Tools

Do you have (or have access to) the necessary mechanic's tools? Do you know how to safely and properly use and care for them? Take the time to master the use of these tools; it will help you to avoid injuries and to do the job right.

Hand Tools

When using hand tools, follow four basic rules:

1. Select the right tool for the task.
2. Use the tool correctly.
3. Keep it in good condition.
4. Store the tool safely out of the way when it is not in use.



Use a tool for its intended purpose—never for anything else. A knife, for instance, is for cutting. Never pry with a knife. The blade can snap and go flying.

Screwdrivers

Use screwdrivers only to tighten or loosen screws. Never use them as punches, chisels, scrapers, or pry bars, or for any purpose other than turning screws.

For electrical work, always shut off the power (never work near live wires) and use insulated screwdrivers that are specially designed to protect against shock. Plastic or cushion grips on tools are mainly for comfort; they do not insulate you from electricity. Only a tool specified as "insulated" will give any degree of protection against electric shock.



Never carry a screwdriver in the pocket of your clothes. You could get stabbed.

Organize and store screwdrivers so it is easy to select the right tool for the task.

RIGHT—
HOW A SCREWDRIVER
SHOULD FIT THE
SCREW SLOT



WRONG—
POOR FIT DAMAGES
THE SCREWDRIVER
AND THE SCREW SLOT



Choose the correct
tip size and type
of screwdriver to
the screw.

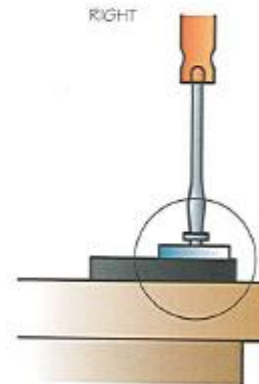
Use the correct screwdriver tip and size to fit the screw. A driver of the wrong size or type can slip out of the screw head and damage the work or stab you.

Do not use a screwdriver with a damaged tip. Worn tips slip more easily than sharp-edged tips. Dress a worn or rounded tip with a hand file to restore a straight, square edge. Throw away any screwdriver that has a split or broken handle.

Do not hold parts in your hand. Put the work on a flat surface or secure it in a vise to avoid piercing your skin with the screwdriver tip.



Use a hand file (never a grinding wheel) to dress a worn or damaged screwdriver tip.



Work on a bench to keep a screwdriver from gashing your skin. Keep the handle directly over the screw head and turn with smooth, even strokes while applying steady pressure.

Wrenches

Box and socket wrenches completely encircle a nut, bolt head, or fitting and grip it at all corners. Open-end wrenches have jaws that grip at two corners.



Wrenches are used for holding and turning nuts, bolts, and various threaded parts, fittings, and fasteners.

Use wrenches that fit. Select a wrench with an opening that exactly fits the nut. Wrenches that slip can damage bolt heads and nuts, skin your knuckles, and possibly cause you to lose your balance and fall.

Pull a wrench's handle toward you whenever possible. If it is not possible to pull toward you, use the open palm of your hand to push on the wrench handle.



To avoid injury, pull on the wrench or push with the open palm of your hand.

Never tilt or angle an open-end wrench. Be sure the nut or the bolt head is fully seated in the wrench's jaws.

Never use an extension to increase the length of a wrench handle. A wrench's handle was made long enough for the maximum safe force to be applied. Do not use a pipe on the handle to give you more leverage. Excessive force can break the wrench or bolt, or the wrench might slip and cause a fall. Don't hammer on a wrench unless it is designed for that type of use.

Do not use damaged wrenches. Discard any wrench with spread, nicked, or severely worn jaws on the open end or rounded, broken points on the box end. Discard wrenches with bent handles; straightening a bent wrench weakens it.

Hammers

Use the right type of hammer for the task.

- A *claw hammer* is for driving and (with the claws) pulling common nails.
- A *ball-peen hammer* is for striking steel chisels and punches and (with the rounded, ball-like end) shaping and bending soft metal.
- *Soft-face hammers* and mallets have two flat striking surfaces made of wood, rawhide, rubber, or plastic. Their nonmetallic surfaces will not strike sparks from metal objects. Use a soft-face hammer to bend sheet metal or strike metal parts without marring them. Use a wooden mallet for hitting wood or for tapping plastic-handled wood chisels. Never use a soft-face hammer for driving nails.



A *dead blow hammer* has a hollow head partially filled with steel shot to deaden the impact and prevent the hammer from bouncing or recoiling.



Grip the hammer near the end and strike the surface squarely. Do not extend your thumb along the hammer handle.

When using a hammer:

- **Wear eye protection.** Nails may shatter when struck, or the hammer face may chip. Wear safety glasses or goggles to protect your eyes from flying metal chips.
- **Strike surfaces squarely,** using the face of the hammer. Avoid glancing blows.
 - **Select the right hammer size for the task.** A light hammer will bounce off the work. One that is too heavy is hard to control.
 - **Grip the handle close to the end.** This gives solid, less tiring blows. It also lessens the chance of crushing your fingers between the handle and the piece you are working on if you happen to miss.

Never use a hammer with a loose or damaged handle. Keep handles tightly wedged in hammerheads. Replace cracked or splintered handles. Do not use a hammer handle for prying or bumping—handles are easily damaged.

Keep the handle dry and free of grease and oil. Swing in a direction to avoid hitting anyone should the hammer slip from your hand.

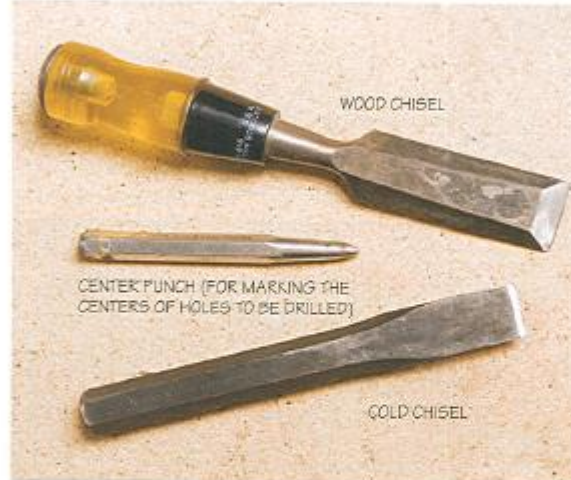


When you replace a hammer handle, make sure it fits the hammerhead. Wedge the handle securely in the head.

Chisels and Punches

A *cold chisel*—that is, a steel chisel used on cold metal—is blunt on the end that the hammer strikes. The blunt end is called the *struck face* or the *head*. At the other end is the cutting edge that is used for cutting, shaping, and removing metal.

A *punch* has a pointed end opposite its struck face. The working ends of punches are designed to mark metal, drive and remove pins and rivets, and align holes in different sections of metal parts or other materials.



On metal, use only a cold chisel meant for shaping or cutting metal. A wood chisel is a wood-cutting tool.

Nail sets are used to drive the heads of finishing nails below a wood surface. A nail set, like a punch, has a struck face and a pointed end. Despite its resemblance to a punch, however, a nail set should never be used for punching holes in metal, marking metal, aligning holes, or driving pins or rivets. Always use the right tool for the task.



Nail set

The proper hammer for striking a tool such as a chisel or punch will have a striking face about $\frac{3}{8}$ inch larger than the struck face of the tool. Never use a nail hammer to strike a steel chisel or similarly hardened object.

Choose a chisel only large enough for the task so that you use the full cutting edge. Using only a corner of a large chisel could break the corner, damage the cutting edge, and send a snapped piece of metal flying. Choose the smallest cold chisel that suits the task—but not so small that you risk breaking the tool.

When using a chisel or a punch:

- **Wear eye protection.** The face of the hammer or the end of the hammered tool can chip or shatter and send metal fragments flying.
- **Hold a chisel or punch with a protective holder** whenever possible, not with your hand.
- **Clamp the piece securely** in a bench vise. Cut or shave toward the vise's stationary jaw. Strike the tool squarely, not off center. Use a chisel's full cutting edge, not its point or corner. Always aim the cutting edge away from your body and hands.



Use the full cutting edge of the chisel.

When using a cold chisel, wear eye protection, secure the piece in a vise, and hold the chisel near the head of the tool. Use a holder to keep hands at a safe distance.

- **Do not use chisels and punches for prying.** They are hard and brittle, and excessive force could break them with a snap.
- **Never use a punch with a mushroomed head** or with a chipped or deformed point. Use a hand file to dress a mushroomed head to its original shape.
- **Never use a dull chisel** or one with a mushroomed head. A dull cutting edge can be dressed using a hand file or whetstone only, never a grinding wheel. File or stone away from the cutting edge, taking care to restore the edge's original shape and angle.



Hand Files

When using a hand file:

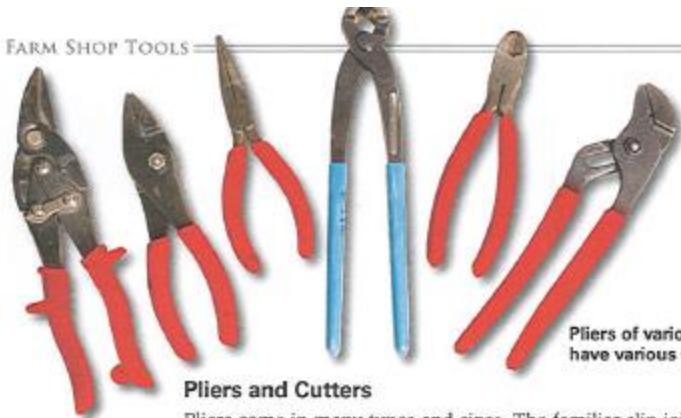
- **Always wear safety eyewear** when filing metal.
- **Fit a file handle on the tang** (the pointed end) to give you a safer and more controllable grip on the file.
- **Never use a file on metal harder** than itself.
- **Use a soft wire brush** or a special tool called a *file card* to clean debris from a file. Do not hit a file against another piece of metal or strike it against a hard surface to clean it. You could damage the tool.
- **Never use a file as a pry bar** or hammer. It could chip or break and injure you.

Use a hand file, *never* a grinding wheel, to dress the mushroomed head of a chisel or punch.



File card

Keep a handle on every file. This will keep the tang (the prong or pointed end where the handle attaches) from puncturing your palm or wrist if the file slips or catches. File handles typically are sold separately from files. Some handles are adjustable to fit any file.



Pliers of various types have various uses.

Pliers and Cutters

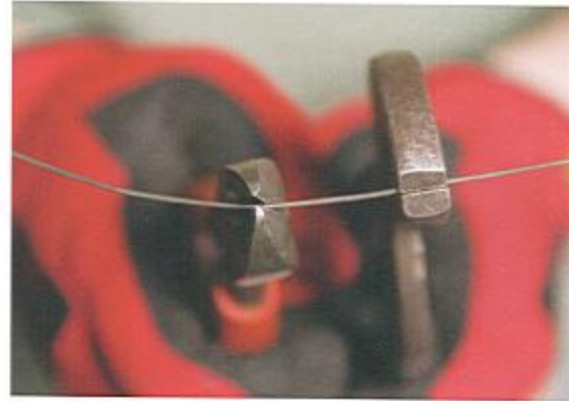
Pliers come in many types and sizes. The familiar slip-joint pliers are versatile tools designed for gripping, turning, and bending. Long-nose or needle-nose pliers will hold small objects and reach into tight places. Some pliers are specifically made for pulling, twisting, and cutting wire. End-cutting pliers or nippers are designed for cutting wire, nails, rivets, etc., close to the work surface.

Choose the right pliers or other tool for the task:

- **Do not substitute pliers for a wrench.** They do not grip as securely and can cause an injury or damage bolt heads and nuts.
- **Do not use pliers on the handle of a screwdriver** to get extra turning power.
- **Never use pliers as a hammer.** Never hammer on the handles of pliers.
- **Never extend the length of handles** with pipe to get more leverage. Use a larger pair of pliers or, if the task calls for it, a bolt cutter.
- **Do not bend stiff wire with light pliers.** Needle-nose pliers can be damaged if you use the tips to bend too-heavy wire. Use a sturdier tool.

Guard against eye injuries. Many types of pliers have jaws for cutting. Ends of wire often fly or whip through the air when cut. Wear eye protection, secure one end of the wire in a vise or step on it with your foot, and hold the other end with your free hand to keep the cutoff piece from flying away. Warn anyone in the area to stand clear to avoid being struck by flying pieces of wire.

Take care to avoid pinching your fingers between the handles of pliers.



When using cutting pliers, cover or secure the piece you are cutting. Cut at right angles to the wire. Do not rock the pliers from side to side or bend the wire back and forth against the cutting edges.



Bolt cutters

Different types of cutters are used to cut steel wire and cable, steel strapping, fencing, and bolts. When using cutters:

- **Use the proper cutter for the task.** Different cutters are designed to cut specific types and sizes of metals. Follow the manufacturers' instructions.
- **Wear safety goggles,** protective gloves, and safety shoes.
- **Remember that metal can fly** when it is cut. Cover the cutting jaws with a sturdy cloth or rag to keep shards of metal from taking wing.
- **Keep the cutting edges at right angles** to the material being cut. Do not rock the cutter or use it to pry or twist the material.

Power Tools

Use power tools only with adult supervision. Store tools safely to prevent damage to tools and cords and to prevent unauthorized use.

When you use a power tool to get a job done faster, also take the necessary safety precautions. Read and follow the operator's manual. Wear eye protection. Wear snug-fitting clothes to keep clothing from tangling with tools.



Give the task at hand your full attention. Stop if something distracts you. Keep guards and shields in place. Keep your hands clear of blades, bits, and other cutting edges or moving parts.

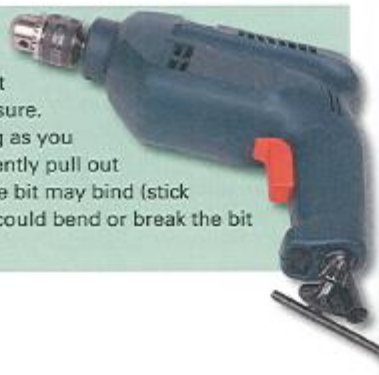
Many portable power tools are cordless. If you are using a tool that has a power cord, arrange the cord out of the way of the work. Be sure the switch is off before you plug in the power cord. Carry a portable power tool by its handle, not its cord. Keep your fingers away from the switch while you are carrying the tool.

Before making adjustments or changing bits or cutters, **always unplug the power cord.** Grasp the plug head, not the cord, and pull straight out from the wall outlet or extension cord. Repair or replace damaged extension cords and plugs.

Use power tools only for the work they are meant to do. Let each tool work at its own speed without forcing it. Keep a firm grip on handheld power tools so they do not get away from you. Turn off the switch immediately if the tool stalls or jams.

Use portable tools in areas free of flammable vapors and liquids. Sparks could cause a fire or explosion. Do not use a power tool in a wet or damp area.

When using an electric drill, let the drill do the drilling. Do not apply excessive pressure. Keep the drill running as you finish the hole and gently pull out the bit. Otherwise, the bit may bind (stick in the hole) and you could bend or break the bit trying to get it free.



Plug three-prong cords into grounded three-hole outlets. Never cut off the ground prong or use a two-prong adapter.

Drill Press

A drill press, like a portable electric drill, uses bits to bore holes. A drill press, however, is generally a free-standing or floor-mounted machine. It operates in a vertical (upright) position, and the drill is "pressed" to the work by a hand lever or by power.

When operating a drill press, wear goggles or safety glasses with side shields. But do not wear gloves—they could catch in the machine's rotating parts.

Use clamps to hold the work.

Never hold the work piece by hand. The drill bit could bite into it, wrenching it from your hand at high speed and whirling the work piece into you. The thinner the material, the more likely the bit will grab it. Sheet metal must be clamped; lay the piece on a wooden base (a scrap piece of wood) and clamp it firmly to the drill press table to keep it from spinning.

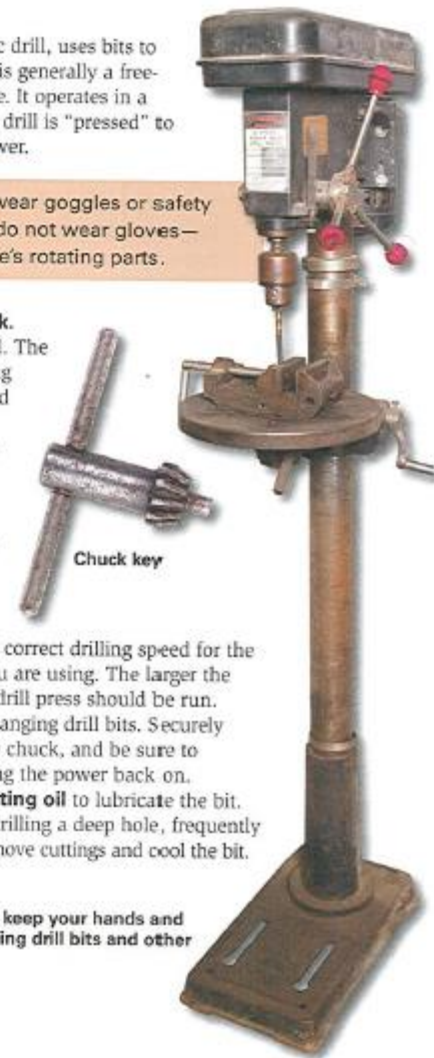
Do not force the tool. It

will perform better and safer at the correct drilling speed for the type of material and the bit size you are using. The larger the diameter of the bit, the slower the drill press should be run.

Shut off the power before changing drill bits. Securely lock drill bits or cutting tools in the chuck, and be sure to remove the chuck key before turning the power back on.

When drilling metal, use cutting oil to lubricate the bit. Make sure the drill bit is sharp. If drilling a deep hole, frequently raise the drill bit from the hole to remove cuttings and cool the bit.

When operating a drill press, keep your hands and fingers well away from spinning drill bits and other cutting tools.





Wear eye protection when using a grinder. Do not wear gloves.

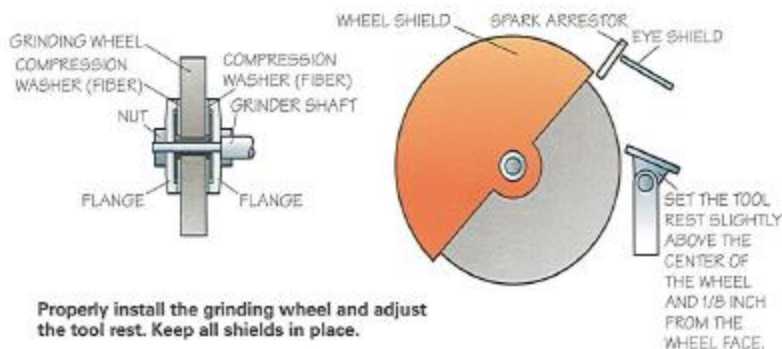
Stationary Grinders

When using these powerful tools, always follow safe working procedures.

- **Wear appropriate clothing**—long pants, long-sleeved shirt with the tail tucked in, leather or safety shoes. Do not wear gloves; they could catch on the grinding wheel.
- **Wear eye protection**—safety glasses and a face shield. Protect your eyes even if the grinder is equipped with a shatterproof eye shield.
- **Keep shields in place.** The eye shield and the wheel shield are both needed to protect you from flying fragments if the wheel breaks or shatters at high speed.
- **Before installing a new grinding wheel, check it for defects.** Tap the wheel gently with a light metal object. A clear ringing tone indicates a sound wheel. No ring indicates a defective wheel that should not be used.
- **Use compression washers and flanges** on each side of the wheel. Make sure the size of the arbor hole (the wheel's center hole) matches the diameter of the grinder shaft. If not, obtain and install bushings of the proper size.
- **Set the tool rest slightly above the center** and $\frac{1}{8}$ inch (3.2 mm) from the face of the grinding wheel. This position will help prevent thin work pieces and keep your fingers from getting wedged between the tool rest and the grinding wheel.



Before installing a new grinding wheel, make sure the grinder is unplugged.



Properly install the grinding wheel and adjust the tool rest. Keep all shields in place.

- **Make sure the speed of the grinder does not exceed the recommended speed** for the wheel. Check the motor template to determine grinder speed. The maximum recommended speed for the wheel is indicated on the label glued to the side of the wheel.
- **When starting the grinder, stand to one side** of the wheel, turn on the switch, and let the grinder reach operating speed before doing any grinding. Then grind with a light pressure until the wheel warms up. Cold wheels can shatter.
- **Grind only on the face of the wheel.** Side pressure may break the wheel if it is not specifically designed for side-pressure grinding.
- **Protect your fingers and hands.** Never adjust the tool rest while the wheel is turning. Use pliers or a locking wrench to hold small pieces to be ground. Position work pieces on the tool rest to prevent them from getting wedged between the tool rest and the wheel.
- **Grind with moderate pressure.** Forcing the piece against the wheel generates heat quickly, wears the grinding wheel out of round, and increases the chance that your fingers may slip onto the wheel.

Frequently dip the work piece in water to keep it cool.

Wire Wheel Brushes

When using a wire wheel brush:

- **Follow the safety rules for grinding.** Wear eye protection, use flanges to mount the brush, and set the tool rest properly, if one is used. Hold small pieces with pliers or a locking wrench. Do not wear gloves.
- **Hold the work piece at the proper angle.** Hold it with both hands at or below the horizontal center of the brush, and angled as shown. Do not push the edge of the work piece upward against the direction of wheel rotation. If you do, the wheel could jerk the piece out of your hands and hurt you.
- **Let the brush tips do the work.** Forcing the work piece against the brush increases wire breakage and the chance of snagging the work piece. Force does not make the wheel clean faster—it merely bends the wires.



Keep the work piece angled properly, in the direction of the wire brush rotation.

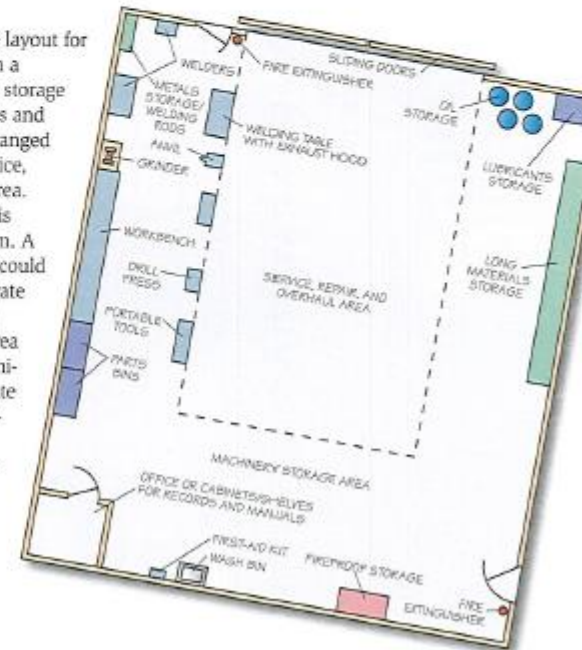


Shop Design and Management

A well-equipped, well-designed shop provides the tools and the space needed to service, repair, overhaul, and adjust farm machinery. Proper servicing and maintenance not only makes equipment last longer, but also saves money and helps protect the safety of those who use the equipment.

Shop Layout

Shown is one possible layout for a shop that is set up in a corner of a machinery storage building. Workbenches and places for tools are arranged to one side of the service, repair, and overhaul area. This might be all that is needed on a small farm. A bigger farm operation could have a shop in a separate building. And a larger shop might have an area for repairs and mechanical work that is separate from the service bay—the area equipped for routine servicing such as oil changes and lubrication.



Design Features

As you draw a plan of your own, consider some important features needed for a shop's safety and convenience.

- Fire extinguishers in the welding area and near entrance doors
- Well-stocked first-aid kit and emergency phone numbers within easy reach
- Separate, designated work areas (the welding area separated from the lubrication —“lube”—area to reduce fire hazards)
- A wall-mounted exhaust fan or an exhaust hood in the welding area
- An entry door across from the large machinery-access doors to serve as a fire exit and improve summer ventilation
- Oil and grease located near the large access doors so that servicing of machinery can be done inside or outside
- Floor space for large, free-standing power tools
- Storage space for nuts, bolts, screws, and parts
- Racks for long pieces of metal, pipe, and lumber
- Desk or shelves for keeping repair and service records and machinery manuals



Ceiling-mounted heaters leave clear working space below.

Use clear plastic jars to organize nails, screws, nuts, bolts, and washers. Plastic mayonnaise and peanut butter jars work well. Nail or screw the jar lids to the underside of a wooden or melamine shelf. (Be sure the nail or screw does not poke through the top of the shelf.) Then put each type of hardware in its own jar, and screw each jar onto its lid. The clear plastic lets you easily see the contents.



Shop Management

Plan a shop to be as hazard-free as possible, and then manage it to keep it that way.

- Keep all tools and service equipment in good condition. Use tools and equipment only for tasks they were designed to do. Put up tools after use.
- Keep floors and benches clean to reduce fire and tripping hazards. Clean up all oil spills.
- Clean up as you work, and clean the area completely once the project is done.
- Keep lighting, wiring, heating, and ventilation systems in good shape. Use ground fault circuit interrupters (GFCIs) to help prevent electrical shock.
- Lock the shop when necessary to prevent unauthorized use of tools, equipment, and supplies.
- Do not let anyone use tools or equipment unless they have been properly trained.
- Keep guards and other safety devices on power tools in place and functioning.



Workbenches, stationary tools, and main work areas should be well-lit.

Fire Safety

Be prepared to fight these types of fires:

- **Class A**—Wood, cloth, paper, etc., needing the quenching effect of water
- **Class B**—Burning liquids (oil, grease, gasoline) that require a smothering effect
- **Class C**—Fires in live electrical equipment (motors, switches, heaters) where a nonconducting extinguishing agent must be used

Every shop should have at least one dry chemical, tri-class (ABC) fire extinguisher. Make sure extinguishers are always within easy reach, close to the areas where fire hazards are greatest, and charged and ready to use.

Tri-class means the extinguisher is effective on all three types of fires.

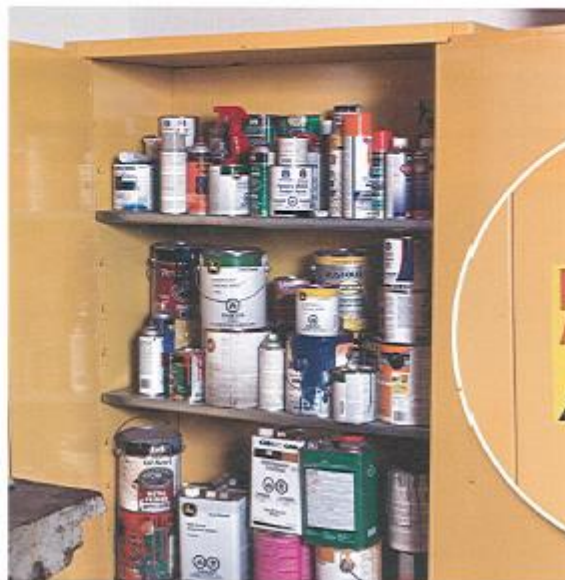


Never use water on a grease or oil fire, or on an electrical fire. Water spreads grease fires and may give you a fatal shock if used on an electrical fire. In case of fire, always call the fire department.

For more about fire extinguishers and how to use them, see the *Fire Safety* merit badge pamphlet.



Keep fire extinguishers visible and easy to reach. Mount extinguishers at shoulder level near doorways.



FLAMMABLE
KEEP FIRE AWAY

INFLAMMABLE
ANTONÓZASE ALEJADO DEL FUEGO

INFLAMMABLE
GARBEY LOIN DU FEU

Fireproof Storage

Every shop should have fireproof storage for flammable liquids, solvents, cans of paint, paint stripper, or other such materials that are kept in the work area. Fireproof cabinets should have secure locks, leakproof bottoms, and double walls made of steel that is heavy enough to withstand fires or explosions.

If you handle small amounts of flammable substances in a work area that does not have special fireproof cabinets, follow these general guidelines for safe storage:

- Keep containers tightly closed.
- Keep flammable liquids, cleanup rags, and oily or solvent-soaked rags in closed metal safety cans.
- Keep flammable materials away from open flames, sparks, frayed wiring, static electricity, and portable heaters.
- Do not store materials for long periods. See the manufacturers' instructions for storage and disposal.

Handle and store all chemicals according to the instructions on the labels.

Material Safety Data Sheets

A material safety data sheet, or *MSDS*, gives details about how to safely handle, use, and store a potentially hazardous material or product. The information on a data sheet is provided by the manufacturer and is meant to supplement the information listed on a product's label.



Data sheets tell what to do if a hazardous material is inhaled or swallowed, or comes into contact with the eyes or skin.

MSDSs should be readily available in a farm shop.

MSDSs vary in length depending on their format and content. They typically have either eight or 16 sections. The 16-section format is becoming standard. Although the MSDS may be organized in different ways, it must include certain information:

- **Company identification**—the name, address, and phone number of the company that makes or distributes the product
- **Product identification**—the material's brand name, trade name, product or chemical name

- **Composition, toxicity, and exposure limits**—the main ingredients in the material, including any hazardous ingredients, and how much of the material you can safely be exposed to
- **Health effects and first-aid measures**—the possible health hazards; effects on the body; how to recognize symptoms and treat overexposure
- **Fire and explosion hazards**—flammability, characteristics of burning, and firefighting procedures
- **Personal protection**—whether gloves, goggles, or other protective clothing or equipment is required for safe handling
- **Physical description**—what the material looks and smells like; its boiling point, melting point, density, and viscosity ("gooeyness"); how quickly it evaporates, etc.
- **Stability and reactivity**—what conditions could cause the material to react dangerously with other substances
- **Handling, storage, and transportation**—proper procedures for handling, storing, and moving the material to avoid accidents
- **Cleanup and disposal**—how to deal with accidental spills and leaks; instructions for safe disposal

Be sure to obtain and read the MSDS for all the materials you handle while working on the Farm Mechanics merit badge. Take time to understand the hazards and warnings, and follow the recommended safety practices.

Ask a farm equipment dealer or a tractor sales and service company for a copy of every MSDS you need. Check with companies that sell oil and lubricants, and those that service and repair hydraulic systems. Using the Internet (with your parent's permission), you often can find data sheets online; search for "MSDS" and the exact name of the product and its manufacturer. If you have trouble getting a current MSDS for a specific product, find the manufacturer's phone number on the product label and call to request a copy. Your merit badge counselor or shop teacher can also help you find the necessary data sheets.



Farm Power

Modern agriculture runs on engine-powered equipment. Farmers, ranchers, and mechanics must know how to safely operate, maintain, and repair all sorts of self-propelled farm machines—tractors, combines, harvesters, and many others. To complete the requirements for the Farm Mechanics merit badge, you will need to demonstrate your knowledge of proper equipment maintenance. Begin by learning the basics of how an engine works.



Engine-powered farm machines work in tough conditions and require regular preventive maintenance.

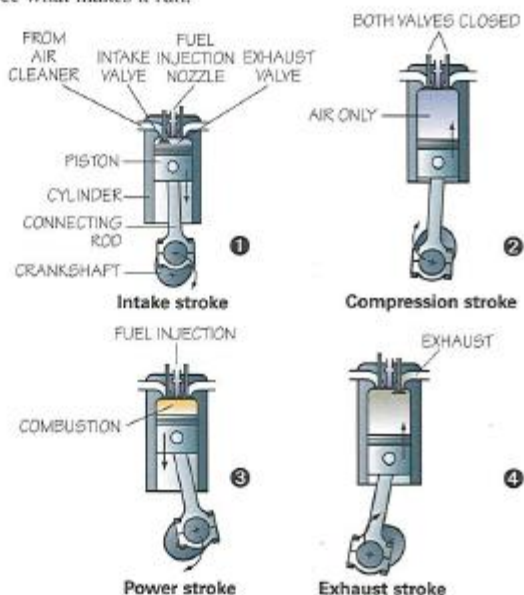
What Makes an Engine Run?

A series of controlled explosions—fuel burning inside the engine—pushes farm machines along on tires and tracks. The expanding gases from the burning fuel drive pistons. The pistons turn a shaft. The shaft turns gears, and the gears turn the wheels.



Most diesel engines used in agricultural machinery are four-cycle engines. Let's look at a four-cycle diesel engine and see what makes it run.

Air that is compressed enough gets hot enough to ignite diesel fuel. That's what happens in the cylinders of a diesel engine, so a diesel engine does not need spark plugs.



As shown in the illustration, a diesel engine has pistons and cylinders. Each cylinder has a fuel injector and valves. A connecting rod attaches to the piston, and the piston moves in the cylinder. The other end of the connecting rod attaches to the crankshaft.

The crankshaft turns and pulls the piston down (*the intake stroke*). The intake valve opens, sucking air into the cylinder. The shaft continues to turn and forces the piston up. Because the valves are closed, the air is squeezed (*the compression stroke*).

When the piston is almost to the top of the cylinder, the fuel injector sprays fuel into the cylinder. The air is so hot from compression that the fuel is ignited. The resulting combustion pushes the piston down (*the power stroke*). After the piston goes down, the exhaust valve opens and the burned gases rush out (*the exhaust stroke*). This whole procedure or cycle takes little time, and it takes place in every cylinder.

Engine Maintenance

The engine is the heart of a self-propelled machine. Regular maintenance helps prevent costly delays and breakdowns and keeps an engine working longer.

Lubrication

Change the engine oil regularly as recommended in the operator's manual, even if the oil looks or feels clean. Use a good-quality oil of the type recommended in the manual.

Changing an Engine's Oil and Oil Filter

Always change the oil while the engine is warm. Heated oil will drain more completely. Replace the oil filter each time the oil is changed. Here are the steps in proper oil changing.

Step 1—Make sure the engine is level.

Step 2—With the engine off but still warm, remove the drain plug and drain the oil into an appropriate receptacle. Let the oil drain for several minutes to completely remove used oil.

Step 3—Replace the drain plug. Tighten it securely but carefully to avoid stripping the threads.



Step 4—Wipe dirt from the area around the oil filter. Then remove the filter as the operator's manual instructs. Remove the old gasket and properly discard the old filter and gasket.

Step 5—Insert the new filter and install a new gasket. Before installing a new filter of the spin-on type, lightly oil the filter gasket with fresh, clean engine oil.

Step 6—Turn the filter until the seal touches the base. Then tighten no more than one-half turn, or as specified in the operator's manual.

Step 7—Recheck the drain plug to make sure it is secure.

Step 8—Add new oil of the recommended type and grade. Do not overfill. Check the operator's manual to see how much oil to use. Clean dirt or dust from around the filler plug before loosening the cap; be sure the tops of oil cans and funnels are clean so dirt does not get in the engine.



Step 9—Replace the filler plug. Start the engine and let it idle. Check for oil leaks at the drain plug and around the filter. Check the oil pressure gauge.

Step 10—Stop the engine. Remove the dipstick, wipe it with a clean rag, then reinsert it. Check that the oil comes up to the full mark. Add oil if required, but do not go over the full line.

Keep the crankcase filled to the proper level. Check the dipstick each time before using the tractor, and add oil as needed.

Air Intake System

An engine must breathe. A tractor engine takes in 12,000 to 15,000 gallons of air for each gallon of fuel used. The air must be clean—any dirt sucked in can quickly ruin an engine.

Engines are equipped with air cleaners that remove dirt and dust from the intake air. Most modern agricultural tractors have a dry-element air cleaner. Air entering the engine is filtered through a replaceable paper cartridge.



Use a droplight or a flashlight to check the condition of a dry-element (paper) air filter. Clean or replace a clogged filter.

Check the operator's manual to learn how to remove, clean, and replace the filter (or filters) on an engine-powered machine. Many dry-element air cleaners have a primary (outer) filter, a secondary (inner) filter, and a dust cup. To remove dust from the primary filter, tap it gently on the heel of your hand. Or use compressed air (at a pressure of no more than 30 pounds per square inch) and move up and down the pleats on the inside. Blow *only* on the inside of the filter, never on the outside. Using compressed air on the outside can force dirt into the filter and damage it.

To see if the filter is washable, check the instructions on the filter or in the operator's manual. Determine what cleaner or soap to use. (Never wash a dry-element filter in gasoline or a solvent.) Soak and swirl the filter in the cleaning solution. Then flush it with clear water from a garden hose, rinsing the filter from the inside out to remove all the cleaning solution. Let the