MERIT BADGE SERIES





FARM MECHANICS



Scouting America

How to Use This Pamphlet

The secret to successfully earning a merit badge is for you to use both the pamphlet and the suggestions of your counselor.

Your counselor can be as important to you as a coach is to an athlete. Use all of the resources your counselor can make available to you. This may be the best chance you will have to learn about this particular subject. Make it count.

If you or your counselor feels that any information in this pamphlet is incorrect, please let us know. Please state your source of information.

Merit badge pamphlets are reprinted annually and requirements updated regularly. Your suggestions for improvement are welcome.

Who Pays for This Pamphlet?

This merit badge pamphlet is one in a series of more than 100 covering all kinds of hobby and career subjects. It is made available for you to buy as a service of the national and local councils of Scouting America. The costs of the development, writing, and editing of the merit badge pamphlets are paid for by Scouting America in order to bring you the best book at a reasonable price.

Send comments along with a brief statement about yourself to
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SCOUTING AMERICA
MERIT BADGE SERIES

FARM MECHANICS



"Enhancing our youths' competitive edge through merit badges"

Scouting America

Requirements

Scouts should go to scouting.org/merit-badges/farm-mechanics or check Scoutbook for the latest requirements.

Scan this QR code for the latest Farm Mechanics requirements.

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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 might 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 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.



Safety helmet

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.

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 side shields 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.

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

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.



Hand Protection

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

- **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.

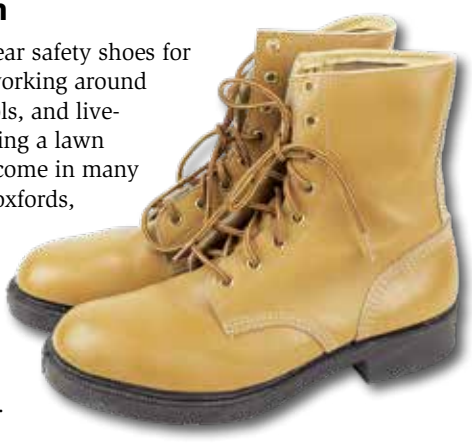
Keep your gloves clean. Replace worn or torn gloves.

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.
- Tie back long hair.
- 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.



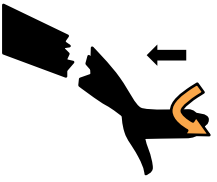
FIRE DANGER



EXPLOSION RISK



SHOCK DANGER



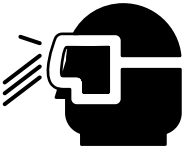
BEWARE OF MOVING PARTS



TOXIC FUMES



HOT SURFACE



WEAR EYE PROTECTION



DANGER OF FROSTBITE



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.



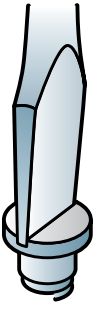
For electrical work, always shut off the power (never work near live wires) and use insulated screwdrivers that are specially designed to protect against shock. Plastic or cushion grips on tools are mainly for comfort; they do not insulate you from electricity. Only a tool specified as "insulated" will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

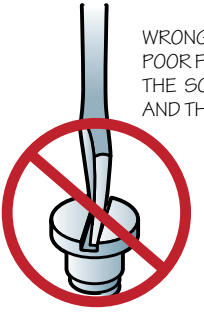
Never carry a screwdriver in the pocket of your clothes. You could get stabbed.



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.

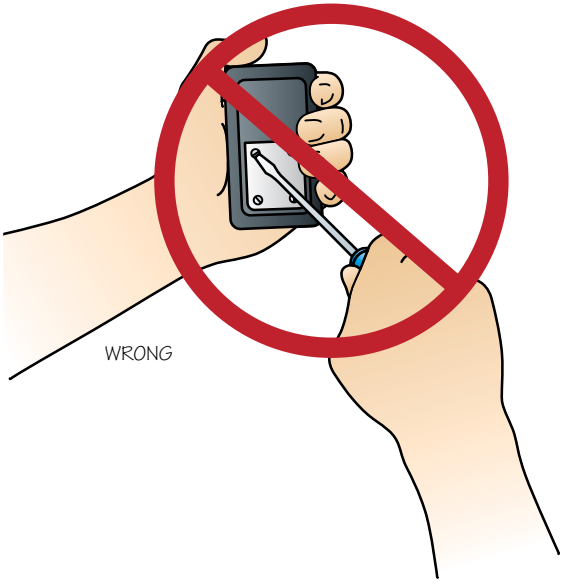
Use the correct screwdriver tip and size to fit the screw. A driver of the wrong size or type can slip out of the screw head and damage the work or stab you.

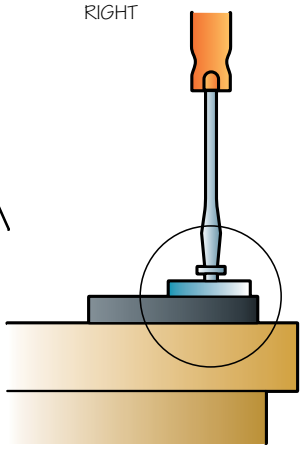
Do not use a screwdriver with a damaged tip. Worn tips slip more easily than sharp-edged tips. Dress a worn or rounded tip with a hand file to restore a straight, square edge. Throw away any screwdriver that has a split or broken handle.

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.

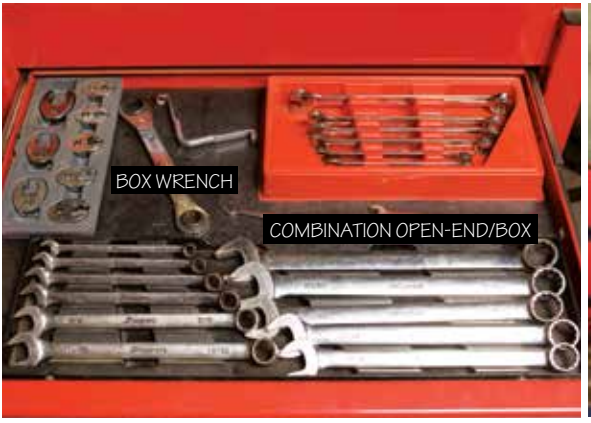




Work on a bench to keep a screwdriver from gashing your skin. Keep the handle directly over the screw head and turn with smooth, even strokes while applying steady pressure.

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.

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.

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.





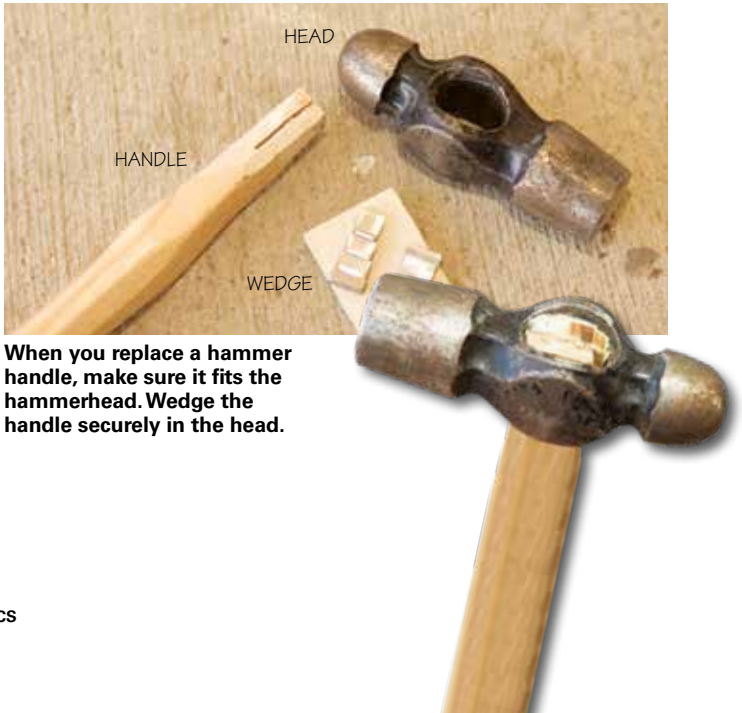
Grip the hammer near the end and strike the surface squarely. Do not extend your thumb along the hammer handle.

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.

The proper hammer for striking a tool such as a chisel or punch will have a striking face about ⅜ inch larger than the struck face of the tool. Never use a nail hammer to strike a steel chisel or similarly hardened object.

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

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.

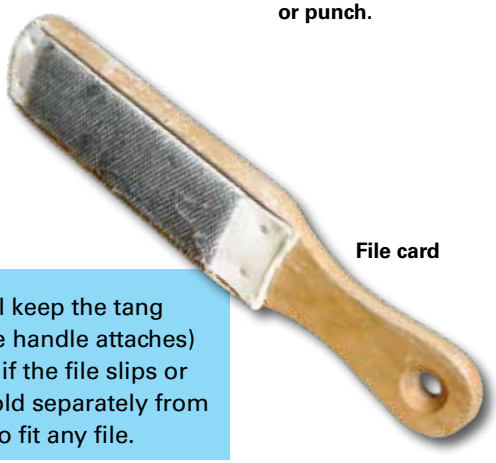


Use a hand file, *never* a grinding wheel, to dress the mushroomed head of a chisel or punch.

Hand Files

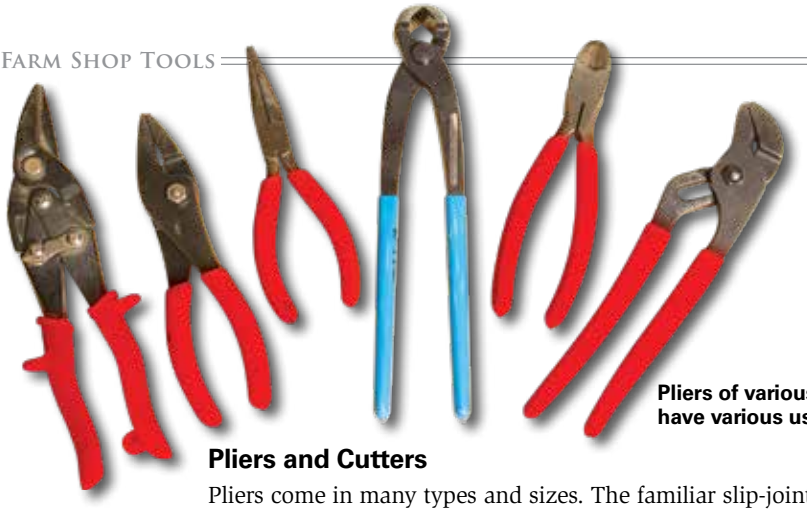
When using a hand file:

- **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.



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.

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

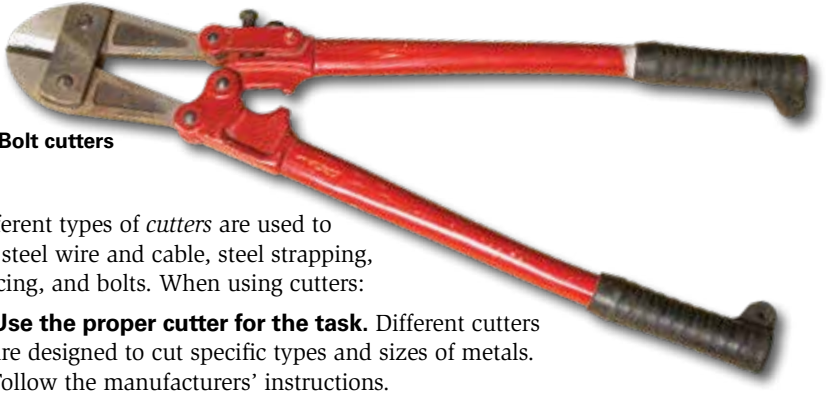
Choose the right pliers or other tool for the task:

- **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.



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.

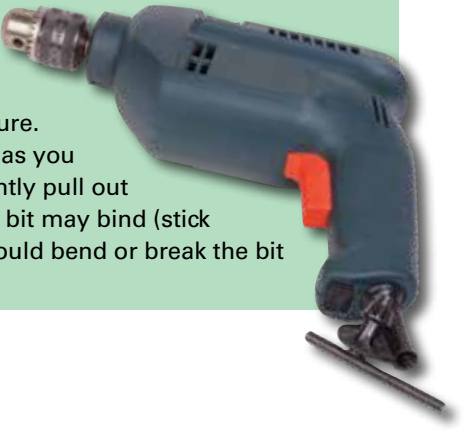
Use power tools only for the work they are meant to do. Let each tool work at its own speed without forcing it. Keep a firm grip on handheld power tools so they do not get away from you. Turn off the switch immediately if the tool stalls or jams.

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.



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

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.



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.



Chuck key

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.

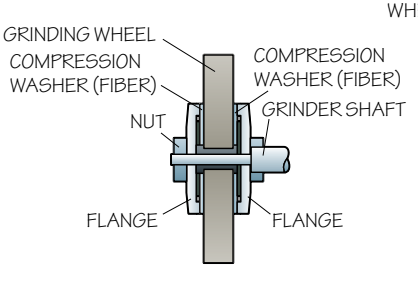
Stationary Grinders

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 ⅛ 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.

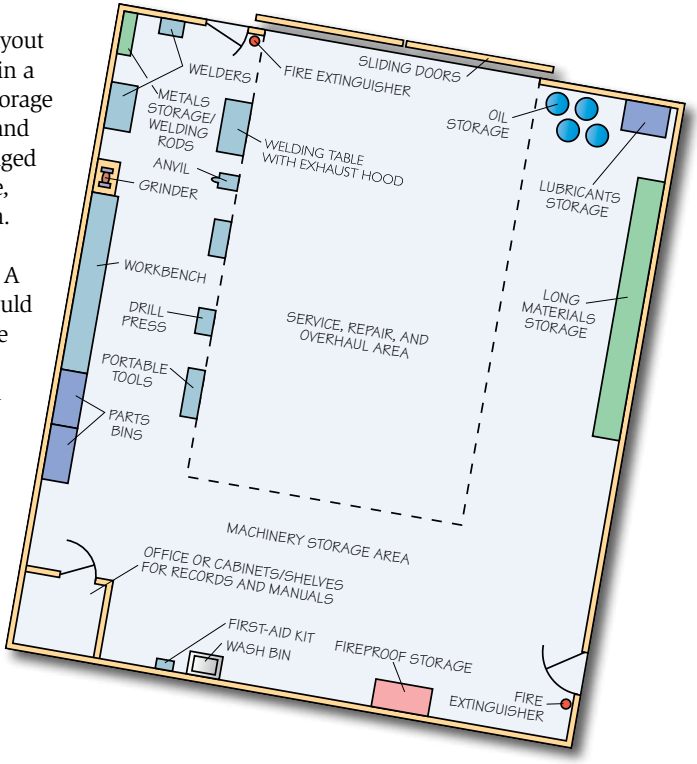

EXIT

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.



Ceiling-mounted heaters leave clear working space below.

- 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

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

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

Be prepared to fight these types of fires:

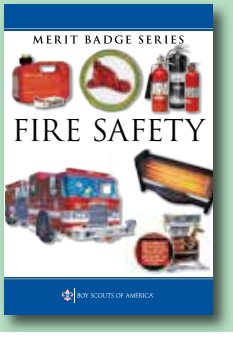
- **Class A**—Wood, cloth, paper, etc., needing the quenching effect of water
- **Class B**—Burning liquids (oil, grease, gasoline) that require a smothering effect
- **Class C**—Fires in live electrical equipment (motors, switches, heaters) where a nonconducting extinguishing agent must be used

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.



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.



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.

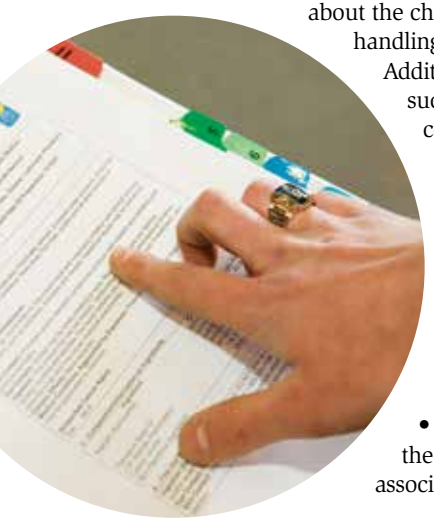
If you handle small amounts of flammable substances in a work area that does not have special fireproof cabinets, follow these general guidelines for safe storage:

- 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.

Safety Data Sheets

A safety data sheet, or *SDS,* 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.



SDSs have 16 sections that provide general information about the chemical, identification, hazards, composition, safe handling practices, and emergency control measures. Additionally, other technical and scientific information such as physical and chemical properties, exposure control information, and toxicological information is included. Sections 1-11 and 16 are required; sections 12-15 are not required by the Occupational Health and Safety Administration, so they are not listed below.

- **Section 1: Product Identification**—identifies the chemical and gives recommended uses. It also includes contact information for the company that makes or distributes the product.
- **Section 2: Hazard Identification**—the hazards of the product and the appropriate warning information associated with those hazards.
- **Section 3: Composition/Information on Ingredients**—the ingredient(s) contained in the product indicated on the SDS. It includes information including chemical names and common names of individual substances, impurities, and additives in the product.
- **Section 4: First-Aid Measures**—describes the initial care measures that should be given in cases of exposure, including description of important symptoms or effects and recommendations for immediate medical care and special treatment.
- **Section 5: Fire Fighting Measures**—recommendations for fighting a fire caused by the product, including characteristics of how the chemical burns and requirements for special firefighting procedures.

- **Section 6: Accidental Release Measures**—how to respond to spills and leaks, including cleanup practices and precautions to follow to minimize exposure.
- **Section 7: Handling and Storage**—guidance on safe handling practices and conditions for safe storage of the product.
- **Section 8: Exposure Controls/Personal Protection**—how much of the material you can safely be exposed to, what kind of processes should be used to control exposure, and what personal protective equipment and measures you should follow to prevent illness or injury from the product.
- **Section 9: Physical and Chemical Properties**—what the chemical looks and smells like, and other physical characteristics.
- **Section 10: Stability and Reactivity**—what conditions could cause the material to react dangerously with other substances, including when exposed to air, water, heat, and what physical changes might be observed that could be dangerous.
- **Section 11: Toxicological Information**—how you can be exposed to the product (inhalation, ingestion, skin and eye contact), what effects and symptoms might be observed from exposure.
- **Section 16: Other Information**—when the SDS was prepared or last revised, including what changes have been made to previous versions. Any other useful information for the product may be included in this section.

Be sure to obtain and read the SDS 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. Your counselor or shop teacher can also help you find the necessary data sheets.

Ask a farm equipment dealer or a tractor sales and service company for a copy of every SDS you need. Check with companies that sell oil and lubricants, and those that service and repair hydraulic systems. You often can find data sheets online.



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.

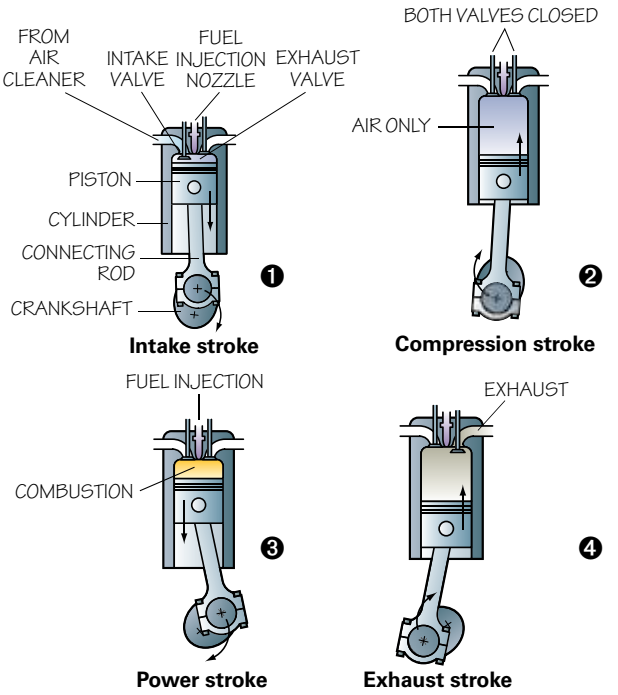
What Makes an Engine Run?

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.


8


9

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

filter air-dry thoroughly, for a day or longer. Do not use compressed air to dry a wet filter.

When the filter has dried completely, check it for damage by dropping a light inside and looking for bright spots visible in the paper from the outside. If you find holes or other damage, replace the filter. Also replace any filter that has been used for the recommended length of time, or that has been cleaned the maximum number of times.

If a secondary filter is present, it acts as a backup for the primary filter. If you find dust on the inner filter, it means that the outer, primary filter has failed. In that case, replace both filters. Do not clean a secondary filter or remove it except to replace it.



Check the operator's manual to learn how to remove, clean, and replace the air filter.

Before replacing or reinstalling a filter, use a clean damp cloth to wipe out the inside of the air cleaner case. Then install the filter, gasket end first. Replace the cover.

Service the air cleaner as recommended in the operator's manual, or more often on a tractor that is working a dusty field. Remove dirt and trash from screens, vents, and breathers. If the air cleaner has a dust cup, empty it after every day of use.

Fuel System

Use clean, fresh fuel. If the equipment's fuel system has water drains, use them often. Check daily for the presence of water or sediment. Some newer equipment has a "water-in-fuel" sensor. If the sensor indicates a contamination problem, promptly drain the water from the fuel system and change the filters.

Change a first-stage fuel filter every 500 hours of tractor operation, or more often if the filter becomes dirty. Replace the second-stage filter every 1,000 hours or each season, or more often if you are having fuel-quality problems, or as recommended in the operator's manual.

Not all fuel filters are alike. Check the operator's manual for instructions on removing and installing the filter (or filters). The basic procedure for changing filters on a diesel-fueled farm tractor is given here. For any tractor you service, however, always follow the recommendations in the manual.

Always stop the engine and let it cool before servicing the fuel filter. On a lawn tractor, drain the fuel tank or close the fuel shutoff valve before replacing the fuel filter. Failure to do so can cause a hazardous fuel leak.

Replacing a Fuel Filter

Step 1—Close the fuel tank shutoff valve.

Step 2—Clean dirt from the outside of the filter and the surrounding area.

Step 3—Drain the filter if it is equipped with a drain plug.

Step 4—Remove the filter as instructed in the operator's manual.

Step 5—If the engine has a cartridge filter, thoroughly clean the bowl with a brush or a lint-free rag.

Step 6—Replace the filter, installing new gaskets if separate gaskets are used.

Step 7—Loosen the vent plug (the bleed screw) and open the fuel tank shutoff valve.

Step 8—Bleed the air out of the filter, as instructed in the operator's manual. Air in a diesel fuel system will keep the tractor from starting or running properly.



Cooling System

The cooling system keeps an engine at the proper operating temperature. It protects against freeze damage, overheating, and corrosion. Check the cooling system daily and keep the radiator filled to the proper level—not overflowing—with the proper coolant.

If the equipment is leaking coolant, the engine will overheat. Look for leaks every day before taking equipment into the field. The most visible sign is dust sticking and building up at the site of a leak. Check the radiator, the radiator cap sealing gasket, the hoses, and the hose connections.



Keep the radiator and external screens free of dust and plant material. Dirt and dust will quickly block airflow.

To check the condition of coolant, **first wait for the engine to cool.** Then remove the radiator cap and check the coolant for signs of deterioration such as gelling, rusty color, or corrosion.

Change engine coolant and coolant filters as recommended in the operator's manual—usually once a year or every two years. Do not add unapproved conditioners or other additives to coolant. Conditioners other than those that come in the coolant itself can create a chemical imbalance and cause the coolant to thicken and work poorly.



DO NOT remove the radiator cap while the engine is hot. If the cap is removed when the engine is at operating temperature, hot steam and boiling liquid will spew out. You could be severely burned.

Cool Advice

- Warm an engine before starting work.
- Operate an engine within the range indicated as normal on the coolant temperature gauge.
- To avoid being badly burned by steam and hot liquid, let an engine cool before removing the radiator cap.
- Do not put cold water in a hot engine or hot water in a cold engine.

Think Green: Recycle

Waste materials from servicing and maintaining equipment should be recycled or properly disposed of so they will not endanger human or animal health or pollute the environment.



- **Used oil.** Recycle it. Do not dump it down the drain or on the ground. Some service stations and oil-change stations will accept oil for recycling. Some waste disposal companies will collect used oil from farms if quantities are large enough.
- **Oil filters.** Recycle oil filters if a recycling facility is available. State regulations vary on oil filter disposal, but in general filters can be taken to a landfill only if they have been "hot drained" at engine temperature.
- **Used batteries.** They must be recycled. Battery retailers are required to take one old battery for each one you buy. Manufacturers recycle batteries to produce new ones.
- **Used tires.** Tire dealers are required to take your used tires when you buy new ones. Some states have collection programs to clean up existing tire dumps and are finding ways to use old tires for fuel and for use in road resurfacing.

Hydraulic System Maintenance

A hydraulic system should contain no air bubbles in the fluid. That is why you hear mechanics talk about "bleeding the air" out of brake lines.

A hydraulic system operates by the pressure created when oil or another fluid is forced through a line or hose. The hydraulic fluid transmits the pressure applied at one point to another point, multiplying the force in the process (a small *applied* force produces a large *working* force). Hydraulics provide the stopping power of brakes on a car, for example.



Check the fluid level in the hydraulic system regularly. Keep it filled to the proper level with clean hydraulic fluid of the type recommended in the operator's manual.

Fluid leakage is a fire hazard and, if left unrepaired, can cause major damage to a hydraulic system. Check all hydraulic lines and connections for leaks every 50 hours, or daily if your operator's manual recommends doing so. Look for:

- **Pressure-side leaks.** Locate leaks in the pressure side of the system by inspecting the outside of lines and connections. Use cardboard, *not* your hands, to check for hydraulic leaks.
- **Air leaks.** If the system is drawing in air, the fluid in the reservoir will bubble and foam.
- **Pinched or dented lines.** Line restrictions can cause loss of hydraulic power. Replace damaged lines.

Caution: Escaping fluid under pressure can penetrate the skin, causing serious injury. Avoid this hazard by relieving pressure before disconnecting hydraulic lines. Tighten all connections before applying pressure. Always use a piece of cardboard to check for hydraulic leaks—**never** use your hands. If high-pressure fluids enter your skin, seek medical help immediately.



Tighten any fittings that you find to be leaking. Use two wrenches to avoid twisting the lines. Tighten the fittings only until snug and the leak stops. Do not overtighten.



When tightening leaking hydraulic fittings, use two wrenches to avoid twisting the line, and tighten only until snug.

Electrical System Maintenance

Keep electrical connections and terminals tight and clean. Leave connectors alone if you can. When handling those that must regularly be pulled apart and reconnected, always pull them apart by holding the connector, not the wire. Before reconnecting them, check for dirt, debris, and corrosion.

Push connectors together firmly but do not force them. If you must use force, that could indicate problems with corrosion or misaligned pins. Connectors in corrosive environments, such as on fertilizer equipment, are especially at risk of corrosion. Clean them after each season of use.

Make sure spade-type connectors grip firmly. Loose spade connectors can lead to random electrical failures.

Wiring *harnesses* are systems of insulated wires bound together with terminals ready to be attached.



Inspect electrical wiring when the equipment is cold. Be sure connections are solid and no wires are abraded.

Regularly inspect wires, cables, and harnesses for wear and abrasion. Run your fingers over spots you can't see. If you see or feel any type of wear, or find wires rubbing against parts of the machinery, move the wires if possible, or protect them with pieces of PVC conduit. Rodents can chew and damage electrical wires. Protect farm equipment from rodents during storage.

Keep battery fluid levels full (unnecessary on sealed batteries) and make sure the terminals are clean. If the terminals are corroded, loosen the corrosion with a stiff brush. Sprinkle a baking-soda solution (4 tablespoons of baking soda mixed in a quart of water) over the terminals, then flush it off with water.

Check that battery cables are in good shape, including the ground connection. With more computer-based electronics in tractors and other farm equipment today, a good ground is especially important. Replace worn battery cables.

To make a solution for cleaning battery terminals, mix a quarter pound of baking soda in a quart of water.

Checking a 12-volt Battery's Voltage

Step 1—Connect a digital voltmeter's positive lead to the positive battery terminal.

Step 2—Connect the voltmeter's negative lead to the negative battery terminal.

Step 3—System voltage should read 12.0 to 12.6 volts DC or higher with no electrical loads on the system.



Care of the Power Train

Different gear combinations transmit power at different speeds and with different amounts of turning force, or torque. Low gear combines low speed with high power. High gears transmit more speed but less turning force.

Power from the engine is transmitted to the drive wheels or the power-output shaft of a machine by means of the power train. The transmission is one component of the power train. A transmission uses a series of gears to convert the power produced by an engine into the turning force and speed required by the wheels or the output shaft.

The connecting set of gears and shafts by which power is transmitted from an engine to the machinery it is driving is called the *power train.*

Most farm tractors have manual transmissions. If you know someone who drives a stick-shift car, then you are familiar with the basics of a driver-operated clutch and a movable gearshift lever. You manually shift gears to operate at the appropriate speed and power.





When the clutch pedal is depressed, the engine and transmission are not connected.

The transmission connects to the engine through the clutch. When the clutch pedal is depressed, the engine and the transmission are disconnected. When the clutch is engaged, the gears inside the transmission engage, and power is transmitted from the engine to the driven machine.



Many machines also have power takeoff (PTO) clutches. A PTO shaft allows the engine power of a tractor to drive attached machinery or implements. For safety, keep all PTO shields in place.

Transmission-Hydraulic Fluid

Most tractors use combined transmission-hydraulic fluid to lubricate the power train and operate the hydraulic system. In any tractor, use the type of fluid or fluids recommended in the operator's manual. Check fluid levels daily and maintain their proper levels. Change fluids and filters at the recommended intervals. Avoid contaminating fluids with water or dirt. Always clean dust and dirt from around fill plugs, dipsticks, and drain plugs before removing them.



Transmission fluid level is checked with a dipstick. The operator's manual will specify the correct fill level and what type and weight of transmission fluid to use.



Follow the instructions in the operator's manual for greasing a machine. The manual will tell you how often grease is needed, where to put it, and what kind to use.

Greasing

For part of optional requirement 4(a), you are to grease the fittings on an engine-powered machine. For this task, you will use a *grease gun*. Some grease guns are air-powered—compressed air forces the grease from the gun and into the fittings on the machinery. Other common types of grease guns are hand-powered—you manually pump grease into the fittings.

Here are a few pointers on proper greasing.

- Keep grease in clean, dry containers. Dirt or moisture can ruin moving parts.
- Clean fittings before applying grease, and wipe them clean after applying grease.
- Lubricate a machine *after* using it, not just before. Warm parts take grease better than cold metal.
- Do not overgrease. Applying too much lubricant is a common mistake.

Maintenance Schedules

Keep a record of what you do to service and maintain machinery, and when you do it. Routine maintenance tasks will need to be done after every 10 hours of operation. Refer to the manufacturer's recommended service schedule. Also pay attention to the maintenance reminders that pop up on the electronic instrument displays of newer tractors and combines.

Before starting or using any engine-powered machinery or equipment, perform a preoperational check:

- ☐ Check the engine coolant.
- ☐ Check the engine oil.
- ☐ Check the hydraulic and transmission fluid.
- ☐ Check the battery voltage.

Other items to check regularly, as needed or recommended, may include these:

- ☐ Tires—condition and pressure
- ☐ Drive belts—tension
- ☐ Nuts and bolts—tightened to proper torques
- ☐ Other—_____
  (add as appropriate for specific machinery)



Regularly check the condition of tires. Keep tires properly inflated.

Winter Storage

The operation of some machines does not stop at the end of the growing season. In some areas, however, little or no field work is done for several months, and farm machines are stored for the winter. One recommended winter storage procedure is described here. You should follow the storage instructions in the operator's manual.

- ☐ Wash or clean the machine.
- ☐ Drain the engine oil and replace the oil filter. Put in new oil that is a lighter viscosity than the oil used when the machine is being heavily used. Let the engine run so all parts get well oiled.





- ☐ Drain the transmission and hydraulic systems. Refill with the correct fluid and a corrosion and rust inhibitor, if recommended. Operate the systems to circulate clean fluid.
- ☐ If you do not use antifreeze, drain and flush the cooling system and leave the drain plugs out.

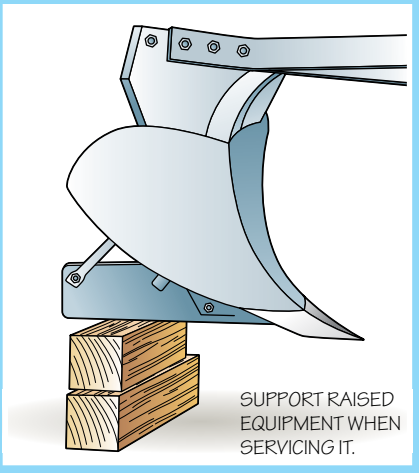


- ☐ Drain the fuel tank (gasoline and diesel only). Do not empty an LP-gas fuel tank without checking with your LP-gas dealer. Remove, clean, and replace the fuel sediment bowl and filters. Add 2 gallons of fuel (mixed with rust inhibitor, if recommended) to the fuel tank. Run the engine for several minutes and then drain the tank again, as well as the fuel lines and carburetor. Leave all drain cocks open.
- ☐ If recommended, add rust inhibitor to the engine crankcase and air intake. Using plastic bags and tape, seal the ends of the air inlet pipe, exhaust pipe, crankcase breather pipe, and hydraulic system breather pipe.

- ☐ Remove and check the battery. If it is properly charged, store it in a cool, dry place where the temperature will stay above freezing. Check the battery every month during storage, and recharge if necessary.

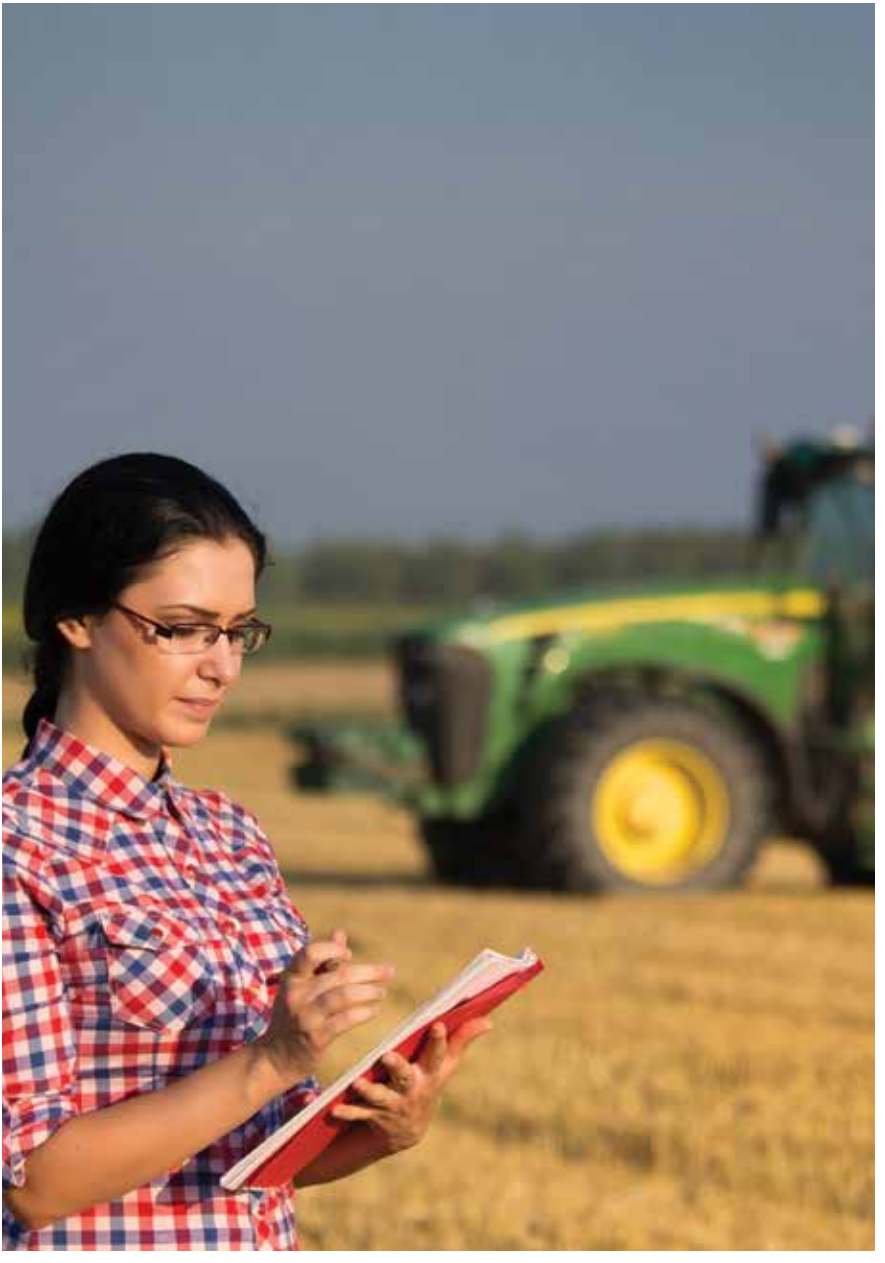


- ☐ Remove any weights from the machine, including from the tires. Drain water from the tires if there is danger of freezing. Remove the tires if the machine is not to be supported off the ground during storage. If you do not want to remove the tires, raise the machine so that the tires are off the ground. Support the machine securely with support stands or blocks.
- ☐ Check and inflate tires to normal pressures.



If a machine must be serviced in the raised position, use jack stands and block it up.

- ☐ On machines with a conventional dry clutch, block the clutch pedal in the disengaged position. Release the tension on all drive belts and chains. Apply grease or rust preventative to chains.
- ☐ Clean off rust, then prime and paint those areas to prevent further rusting.
- ☐ Coat all exposed metal surfaces, such as axles and hydraulic piston rods, with grease or a rust and corrosion preventative. Lubricate all points that normally require lubrication.
- ☐ Make a list of parts or repairs that are needed to prepare the machine for operation when it is removed from storage.
- ☐ Put the machine under cover. If the equipment is not stored in a building, cover it with a tarpaulin.



Safety With Agricultural Machinery

Anyone who operates farm machinery should follow these safety practices.

- Conduct a preoperational inspection. Walk around the machine, looking carefully for any safety hazards or problems such as broken parts, loose nuts, or leaking hoses.
- Allow only one person to a machine—do not carry riders. Never let anyone sit on a tractor's fenders or ride on the drawbar or on towed machinery.
- Wear the seatbelt on farm machinery thus equipped.
- Engage the clutch slowly, especially on a hill and when pulling out of a ditch.
- On rough ground, use low gear. Never drive in high gear when people are around.
- Keep the transmission in gear—do not "coast."
- Wait for the tractor to stop and set the brakes before getting off. Never jump from a moving tractor.
- Keep all safety shields and guards in place.
- Always shut off machinery before making adjustments or repairs.

For all work in, on, and around machinery, remember that he who works the safe way lives to play another day.



Any farm machine designed to travel between 25 and 40 miles per hour must display the speed identification symbol (SIS), *upper right,* showing its maximum speed. This symbol must be used with the slow-moving vehicle (SMV) emblem, *right,* which identifies those vehicles that are traveling at 25 mph or slower. Both symbols are displayed on the rear of the vehicle when it is driven on a public road.

Keep equipment clean. Mud or grease on machinery steps and surfaces can cause serious falls.



All farm machinery should carry a fire extinguisher.

Safety With Tillage Tools

Plows cut and loosen the soil. A harrow is drawn over plowed land to level the soil surface and break up clods. Cultivators stir the soil and control weeds in growing crops. These and other kinds of machines for working the soil are known as *tillage* tools.



Chisel plows do not invert soil.



Harrows level the soil.



Field cultivators prepare a seedbed for planting by burying crop residue and mixing the soil.

When hitching up a tractor to a tillage tool, stay in your seat on the tractor. If the equipment does not have an automatic hitch, you might use a long rod with a hook on one end to lift the hitch bar or tongue into position. Then lean over and drop the hitch pin into place. If you must get off the tractor to hitch up machinery, be sure to come to a complete stop and set the tractor brakes before you step down.



The drawbar is a heavy steel bar that extends rearward from under the tractor. Tillage machines and other farm implements attach to the drawbar or to a three-point hitch. Never allow anyone to ride on the drawbar or on towed machinery.





After the drawbar pin is in place, *above center,* a keeper pin, or R-clip, *above,* should be inserted into the hole at the bottom of the drawbar pin to keep it from loosening.

Safety With Planting Equipment

Row-crop planters place seeds in the soil at the proper depth and spacing. A grain drill plants small grains such as wheat and oats close together. Air seeders that allow tilling, seeding, and fertilizing in one pass are popular where grain is produced on large, flat areas of land, such as the Great Plains. Transplanters and other specialized planters are used for fruits and vegetables such as strawberries and tomatoes, and even for planting trees.



A grain drill plants small grains.



A row-crop planter drops seeds at regular intervals within the row. On newer machinery, electronic monitors count the seeds as they drop and control the seeding rate so that neither too much seed nor too little gets planted.



An air seeder combines tilling, seeding, and fertilizing in one field pass.

Use the right-size planter for the project and for the tractor you are using. If the weight of the planter is too much for the tractor, it could overturn. Operate at a safe speed; allow plenty of room for turning.

Make sure the planter has no broken, damaged, loose, or missing parts. Lifting and lowering devices, especially, should be in good working order. Be sure gears and chains are properly and securely shielded.

Safety With Harvesters

Mowers, windrowers, rakes, balers, combines, cotton strippers, potato diggers—these and other kinds of harvesters bring in the crops. A windrower cuts hay and places it in a row to dry. Balers pick up hay and roll or tie it into round or rectangular bales. Small grains and seed crops like wheat, oats, barley, rice, corn, soybeans, sunflowers, and peanuts are harvested with combines.



Windrower





Large round hay baler



Small rectangular baler

Never make adjustments or repairs when machinery is running.

Harvesting equipment is complicated. The various machines have cutters, knives, teeth, blades, beaters, and other mechanisms that can inflict severe injuries. When you prepare a harvester for the harvest season, make sure the safety releases work properly and the shields or guards for cutters, gears, belts, and revolving shafts are securely in place. Keep all equipment properly adjusted. Always stop the tractor engine before working on a mower, baler, or other harvesting equipment. Follow all safety precautions and procedures listed in the operator's manual.

Many harvesters have special attachments. Use the right attachments for the task.



Combines

A combine carries out ("combines") five steps in harvesting a crop. It cuts, threshes, and cleans seed or grain, lifts the seed or grain to a storage tank or bin, and returns the straw and stalks to the ground, all in one operation.

Corn combine





A combine with a full grain bin is top-heavy and can easily overturn if not driven with care.

Most self-propelled combines are powered by diesel engines similar to tractor engines. Before starting a combine engine, be certain no one is on or around the combine's moving parts. Keep a combine clean. Trash accumulating around the exhaust system can catch fire. Every combine should carry a fire extinguisher. Before storing a combine, clean it of all dust and chaff, inside and out.

Inspect a combine before taking it into the field. Before you make any adjustments, be sure you know and understand what takes place in the machine. Follow the instructions in the operator's manual.

Cotton Pickers and Strippers

Two basic types of self-propelled machines are used to harvest cotton. *Cotton pickers* remove the cotton lint and seed from only the bolls that have matured. Revolving spindles catch the lint and pull it from the open bolls. Green bolls are left on the stalks to be harvested after they have matured.

Cotton strippers remove all the cotton bolls from the stalks, the green ones as well as the mature bolls. A stream of air is usually used to separate the lighter mature bolls from the heavy green bolls.



Green cotton boll



Mature cotton boll and cotton lint

Cleaning a cotton picker or stripper—cleaning it well and often—is more critically important than with most other machines. Leaf trash, dead plant parts, and cotton lint are highly flammable. When such materials build up, fires can easily start.

Help prevent fires during cotton harvesting by keeping the engine clean and free of lint, dust, and dead leaves. Regularly clean the area between hot-running engine parts and the hood. Also check exhaust pipes and the muffler for leaks. Hot exhaust gases or sparks can start fires. ***Let all parts cool before you touch or clean them.***



Cotton stripper

Cotton pickers and strippers are uniquely complex machines with more safety hazards than most other equipment. You should leave most of the maintenance and service work on these machines to a knowledgeable adult.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Careers in Agricultural Mechanics



Hundreds of different professions fall under the general heading of "agricultural mechanics." In this field, you might work on engines small or large, on farm implements, tractors, combines, chainsaws, lawnmowers, diesel trucks—the list is long. You might work in a rural community or in a city. Agricultural machinery is used in urban areas to install and maintain turfgrass and other plants at ball fields, golf courses, and parks. If you enjoy fixing things, if you like working with tools and machinery, then you will want to look into the great variety of career opportunities involving agricultural mechanics.

Tractor or Farm Equipment Mechanic

From your work for the Farm Mechanics merit badge, you have a good idea of what a mechanic does to maintain and repair farm machinery and vehicles such as tractors and harvesters. Good mechanics are logical thinkers and troubleshooters who are able to figure out what is wrong with a piece of machinery and how to fix it. They are good with details and careful in their work.

Not surprisingly, a mechanic needs manual dexterity. Handling tools skillfully and making adjustments precisely are essential abilities.

Also vital—and less obvious—are good communication skills. When someone brings a malfunctioning machine into the shop for repair, the mechanic starts to diagnose the trouble by listening to the customer describe the problem, asking questions, and paying attention to the answers. Good listening skills and people skills are important.

Education and Training Required

In school, take agriculture and shop classes that offer hands-on experience in mechanics, welding, automotive repair, small-engine repair, basic electronics, and (if offered) such specialties as turfgrass management or greenhouse and grounds maintenance. Join the National FFA Organization, an agricultural education organization designed for students. Agriculture is increasingly computerized. As a tractor or farm equipment mechanic, you will work on computer-controlled machinery and use computerized diagnostic tools.

The different career paths you might follow can include

- Specialized training by machinery manufacturers
- Two-year technical (associate's) degrees from community colleges
- Four-year technical (bachelor's) degrees from universities and colleges

Most farm equipment mechanics work for tractor and equipment dealers, adjusting and repairing machines at the dealership or in the field. Employers generally prefer to hire people who have completed formal training programs after graduating from high school. Many of the large tractor and equipment manufacturers have training programs to prepare individuals to work at their authorized dealerships. These training programs may be hosted at the dealerships or at community colleges or other technical institutes. Graduates of these programs are ready to work for specific manufacturer dealerships. Community college programs give students the chance to take additional coursework to earn an associate's (two-year) degree in a technical field. The extra courses prepare students to go beyond repair and maintenance positions. With the additional training, graduates may move into supervisory and business roles.



A mechanic who uses high-tech tools and techniques is generally known as a technician.

Some colleges offer two-year certificate programs for turfgrass and agricultural equipment service technicians. Technicians who are formally trained in the maintenance and repair of agricultural machinery are in demand.



Diesel Mechanics and Service Technicians

Diesel engines power not only farm tractors, combines, work trucks, and pickups, but also big-rig trucks, buses, and passenger cars. Bulldozers, cranes, road graders, and railroad locomotives also are diesel-powered. Career opportunities are good for qualified diesel mechanics and service technicians.

Technicians may specialize in engine repair, transmission work, electrical systems, or brake systems. In smaller shops, however, a technician commonly handles all kinds of repairs, from working on a vehicle's electrical system one day to doing major engine repairs the next.

A diesel engine can have various electronic controls and onboard computers. In shops today, diesel service technicians use handheld or laptop computers to diagnose engine problems and adjust settings. To keep up with constant changes in technology, technicians must take training and learn new techniques.

Many community colleges and vocational/technical schools offer programs in diesel mechanics. Programs lasting one to two years lead to a certificate of completion or to an associate's degree. Many employers prefer to hire graduates of these kinds of formal training programs because they have a good foundation in the latest diesel technology and electronics.

Experienced technicians may move into field service positions, where they have more chances to tackle problems independently and earn better pay. Technicians and mechanics with leadership skills may become shop supervisors or service managers. Those who are good at sales sometimes become sales representatives. Some experienced mechanics open their own repair shops.

ASE Certification

The nonprofit National Institute for Automotive Service Excellence has a voluntary certification program for mechanics and technicians. The ASE administers more than 40 exams. The tests are grouped into specialties for automobile, medium/heavy truck, school bus, and other technicians as well as engine machinists, parts specialists, and electronic diesel engine diagnosis specialists.

To become ASE-certified, a candidate must pass at least one exam and provide proof of two years of relevant work experience. To remain certified, those with ASE credentials must be retested every five years. The tests are not easy. About one out of three test-takers fails.

ASE-certified technicians usually wear ASE insignia and carry credentials that list their exact areas of expertise (brakes, engine repair, etc.). To learn more, visit the ASE website with your parent or guardian's permission. (See the Resources section of this pamphlet.)

College/University Programs

Earning a bachelor of science degree from a university or college prepares graduates for management positions at machinery dealerships or related businesses. There is less emphasis on you "turning wrenches" and more on directing the people, money, and machinery at a business or facility. Courses of study in this area include agricultural systems management, agricultural engineering technology, and agricultural business.



If you are interested in the design and manufacturing of farm tractors and equipment, consider earning a degree in agricultural engineering or a similarly named program. To teach agriculture at the high school or college level, you will need a degree in agricultural education.

Preparing for College

Get involved in the agriculture program if your school offers one. Take English, math, biology, chemistry, physics, computer classes, and business classes. At college you will study these subjects as well as economics, communications, and mechanics. Depending on your specialty area and interests, you may study hydraulic systems, diesel power systems, power transmission, machine instrumentation and controls, electronics and electrical systems, soil and water conservation, natural resources, engineering design, or machinery safety.

Computer skills are essential. Agricultural mechanics students learn to use computers to control machines, plan layouts of equipment and buildings, and create graphics for written reports, to name only a few applications.



Agricultural systems management is a field of study that combines agricultural sciences, engineering principles, and business management. ASM students learn about soils, crops, and natural resources. They also learn about engines, electronics, and hydraulics. On the business side, they study economics, finance, and accounting.

Career Prospects

College graduates with expertise in agricultural mechanics work for many different kinds of manufacturers that make farm, forestry, construction, lawn-care, and landscaping equipment. They may sell tractors or show customers how the equipment works, or teach dealers how to install and service equipment. Some graduates manage farms and agriculture-related businesses. Some work in the food industry; others work for government agencies or research centers.

Ag engineers and ag systems graduates are in demand. Farm equipment manufacturers need more engineers than are graduating from universities. Their broad-based, practical education qualifies them for a wide variety of careers in management, marketing, sales, and service.

Whichever path you choose—technical training or college degree—a rewarding career awaits as you pursue opportunities in agricultural mechanics.





In many ways, plant nurseries and greenhouses are like small, enclosed farms. Some agricultural engineers specialize in designing practical and efficient greenhouses. At NASA, engineers with this special expertise are designing greenhouses that could someday be built on Mars to help feed the first Martian colonists. Here on Earth, engineers design planting and transplantation equipment for use in greenhouse and nursery operations.

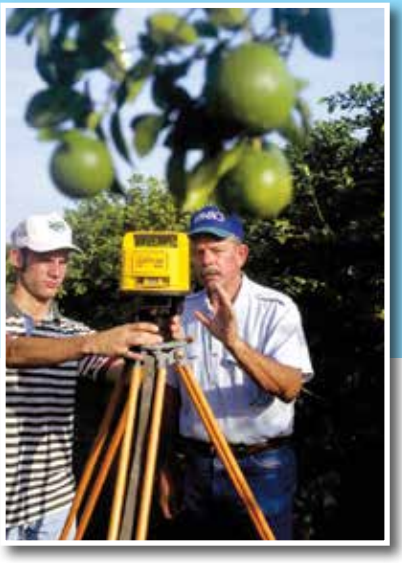
Possible Careers in Agricultural Mechanics

Technical Training

- Diesel mechanic or service technician
- Heavy construction equipment technician
- Lawn equipment service mechanic
- Parts specialist
- Service manager
- Shop supervisor
- Small-engine mechanic
- Tractor or farm equipment mechanic
- Turfgrass and agricultural equipment service technician
- Welder

College Degree

- Agribusiness management
- Agricultural engineering
- Agricultural machinery and safety
- Agricultural systems management
- Farm management
- Food processing plant operations
- Forest engineering
- Golf course management
- Machine systems engineering
- Manufacturing
- Marketing
- Natural resources conservation and protection
- Nursery and greenhouse engineering
- Power systems and machinery design
- Product sales
- Technical support and service
- Vocational agriculture instruction



Survey work can be one facet of a career in natural resources conservation.



Farm Mechanics Resources

Scouting Literature

Automotive Maintenance, Composite Materials, Electricity, Electronics, Energy, Engineering, Environmental Science, Fire Safety, First Aid, Forestry, Plant Science, Soil and Water Conservation, and *Woodwork* merit badge pamphlets

With your parent or guardian's permission, visit Scouting America's official retail site, **scoutshop.org**, for a complete list of merit badge pamphlets and other helpful Scouting materials and supplies.

Books

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Welding. John Deere Publishing, 2008.

Organizations and Websites

American Society of Agricultural and Biological Engineers
2950 Niles Road
St. Joseph, MI 49085
Telephone: 269-429-0300
asabe.org

Associated Equipment Distributors
600 22nd St., Suite 220
Oak Brook, IL 60523
Telephone: 630-574-0650
aedcareers.com

Association of Diesel Specialists
400 Admiral Blvd.
Kansas City, MO 64106
Telephone: 816-285-0810
diesel.org

Case IH
621 State St.
Racine, WI 53404
Telephone: 877-422-7344
caseih.com

Deere & Company World Headquarters
One John Deere Place
Moline, IL 61265
Telephone: 309-765-8000
deere.com

National Farm Machinery Show
P.O. Box 37130
Louisville, KY 40233-7130
Telephone: 502-367-5200
farmmachineryshow.org

National FFA Organization
6060 FFA Drive
P.O. Box 68960
Indianapolis, IN 46268-0960
Telephone: 317-802-6060
ffa.org

National Institute for Automotive Service Excellence
101 Blue Seal Drive SE, Suite 101
Leesburg, VA 20175
Telephone: 703-669-6600
Toll-free information line: 888-ASE-TEST
ase.com

National Safety Council
Agricultural Safety
1121 Spring Lake Drive
Itasca, IL 60143-3201
Telephone: 800-621-7615
nsc.org

Planning Farm Shops for Work and Energy Efficiency
Purdue University Cooperative Extension Service
extension.purdue.edu/extmedia/ae/ae-104.html

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Though intended as an aid to youth in Scouts BSA and qualified Venturers and Sea Scouts in meeting merit badge requirements, Scouting America's merit badge pamphlets are of general interest and are made available by many schools and public libraries.

Always check scouting.org for the latest merit badge requirements. If a Scout has already started working on a merit badge when new requirements for that merit badge are introduced, *they may continue to use the same pamphlet to earn the badge and fulfill the requirements therein.* In other words, the Scout need not start over again with the revised requirements.

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