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4-H TRACTOR PROJECT

First Year

Getting Acquainted With Your Tractor

The 4-H Tractor Project gives you an opportunity to "Learn by Doing." The project consists of units designed to be used over a three-year period. By the time you complete all of the units, including the various "hands-on" activities, you should be a competent and safe tractor operator. How skilled you become will depend upon the amount of practice you get as you progress through each lesson in the tractor manuals. Even if you are not able to practice operating a tractor frequently, you will still acquire the necessary knowledge to understand how one functions efficiently and safely.

The Tractor Project has three overall objectives that you must understand and accomplish. The facts and skills to meet them are not contained in any one unit but are present throughout the project. Know your objectives so that you are constantly aware of what you are trying to learn as you work through this project.

Objectives

Safety. You must learn to be safe around a tractor, whether it is running or not. You must learn to distinguish between safe and unsafe conditions and practices. And, you must help others who work around tractors to understand the need for safety as well as you do.

Care and maintenance. You will need to become familiar with the various parts and systems of the tractor, how they function together, and how to know when they are operating properly. When you understand this, you will then be better prepared to actually operate a tractor and use it as it was designed to function.

The value of a tractor as a farm production machine. You will need to understand that the tractor is really a business asset, that is, a machine one uses to make work easier, produce goods and, it is hoped, earn a profit. The older you get and the longer you continue in the tractor project, you will appreciate how important it is to make sure the tractor is operated safely and efficiently and is properly maintained.

The objectives above are what the 4-H Tractor Project is all about. Good Luck! And remember, in 4-H we "Learn by Doing."

What To Do

Your 4-H Tractor Project has three parts. This set of lessons for the first unit acquaints you with your tractor and teaches the importance of tractor safety. Even if you think you are familiar with tractors, carefully study the materials in this manual because you might become aware of something you hadn't thought about before. In most of the lessons there are activities called "Learn by Doing," "Making Safety Work," and "Digging Deeper." Try to complete as many of the activities as possible, either alone or with other members of your club or group, depending upon the type of activity. If you need help, be sure to call upon someone else for their ideas. Remember, the activities will help increase your knowledge and skills.
Let's Begin

Accidents and Young People

Almost two million people die in the United States each year. More than twenty thousand of them are aged 14 or younger. Figure 1-1 shows the causes of death among persons aged 14 and under. As you can see, accidents cause almost half those deaths.

What about tractor accidents? About one out of every four farm accidents involves tractors and farm machinery. Look at Table 1-1 which shows work-related tractor and farm machinery accidents according to the age of the injured person. You can see that persons aged 14 years old and younger (just like yourself) and those in the next age group, when combined, have about the same number of tractor accidents as persons in each of the next two groups. These accidents happen even though younger people are working fewer hours on the farm than persons in the older groups.

Figure 1.1

ACCIDENTS CAUSE NEARLY AS MANY DEATHS AMONG PERSONS 14 YEARS AND YOUNGER AS ALL OTHER CAUSES TOGETHER.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>47%</td>
</tr>
<tr>
<td>Homicide</td>
<td>4%</td>
</tr>
<tr>
<td>Congenital Illness</td>
<td>8%</td>
</tr>
<tr>
<td>Cancer</td>
<td>10%</td>
</tr>
<tr>
<td>All others</td>
<td>31%</td>
</tr>
</tbody>
</table>

Operating a tractor is serious business and a full-time job. Make up your mind that you are going to be a safe tractor operator—starting now! Here are important safety rules that you must always follow:

The operator must be the only person on the tractor. No extra riders!

Keep young children off tractors and away from areas where machinery is working.

Use caution when getting on or off the tractor.

Think and practice safety.

Why is safety so important? Because people can be injured or killed if safety is not practiced. Let's look at some accident statistics. Maybe then you can appreciate the extreme need for safety.
Looking at the 5-14 year old statistics alone, five percent may seem like a small number. However, this number used to be extremely high. Persons in this age group (and other age groups) were frequently being injured. Therefore, the federal government passed workman safety laws, and farm machinery and tractor manufacturers added safety devices and decals to equipment and started educational safety programs which have helped reduce the number of injuries in all age groupings. This is why you should be extremely careful and obey all tractor safety rules—so that accident rates, injuries and death rates will continue to decline. Obeying the rules could keep you from hurting or killing yourself, a family member or a friend.

Designers and safety experts planned that only one person at a time should ever be on a tractor? That person should be the tractor operator and should ride only in the operator’s seat. Remember the rules given at the beginning: Keep young children off tractors. In general, No extra riders!

One more thing. Look at the numbers in Table 1-3. Many tractor and machinery accidents occur when equipment is not running. Many of these accidents involve falls. Be cautious when mounting or dismounting from a tractor. Use steps and handholds provided and watch your step. And, be sure to keep work areas clear of items that can cause you to trip and fall.

---

**Table 1-1**

<table>
<thead>
<tr>
<th>Age of operator</th>
<th>Number of injuries (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 14 years</td>
<td>5%</td>
</tr>
<tr>
<td>15 - 24</td>
<td>24%</td>
</tr>
<tr>
<td>25 - 44</td>
<td>33%</td>
</tr>
<tr>
<td>45 - 64</td>
<td>32%</td>
</tr>
<tr>
<td>over 65</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Many tractor-related deaths occur among children younger than ten who are probably too young to operate a tractor. How do you suppose so many accidents happen to them? The National Safety Council reports that most of these were "extra riders" on the tractor or implement being pulled. (Look at the numbers in Table 1-2.) Most likely, the child fell off the tractor or implement. Generally, a tractor has only one seat. Don’t you think then that…

---

**Table 1-2**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Fatalities (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 5 years</td>
<td>35%</td>
</tr>
<tr>
<td>6 - 10 years</td>
<td>33%</td>
</tr>
<tr>
<td>11 - 15 years</td>
<td>21%</td>
</tr>
<tr>
<td>All other ages</td>
<td>11%</td>
</tr>
</tbody>
</table>

---

**Learn to "Think" Safety**

Because you cannot predict exactly when an accident will happen, you must learn to think about safety at all times. If you know someone who has been injured in a farm...
accident, ask them if they knew beforehand that they might be in danger. Chances are that if they had taken a few moments to think about what they were doing, they could have avoided the accident. As you work through the tractor project, learn to anticipate dangerous situations.

Thinking and practicing safety are up to you and all others who work around tractors and implements. Machinery manufacturers have made the job easier by providing alert signs to warn you of dangerous situations. These signs, usually in the form of decals on tractors and implements, help you know how to protect yourself and others. Take the time now to learn what the Safety Alert Signs mean (shown in Figure 1-2). Operator's manuals also feature these and other alert messages.

As you progress through the 4-H Tractor manuals, you will become familiar with many safety signs, warnings and tips. Learn what they mean and practice applying them. Remember, safety cannot be acquired just by knowing the rules. You have to practice safety!

An accident can only happen under one or two conditions: When you do something that is unsafe, or when you allow an unsafe condition to exist. Remember, a tractor is faster and more powerful than you are. You can be the master over the power and speed of a tractor with your ability to think. Learn to correct unsafe conditions and guard yourself, your family and friends against potential hazards. Think ahead and avoid hazardous situations!

Figure 1.3
THE NO RIDERS SYMBOL SHOULD BE MOUNTED ON EVERY TRACTOR.

Context:

The "Safety Alert Symbol" is commonly used on safety signs found on agricultural equipment. The symbol means Attention! Be alert! Your safety is involved.

Alone it is a white exclamation point with a red triangle; when printed (in an operator’s manual, for example) the triangle is black.

The CAUTION sign (BE CAREFUL on some machines) is a general reminder to tell the operator that certain safety practices must be observed. It also identifies some of the less serious hazards. These signs are black and yellow.

A WARNING sign alerts the operator that a greater risk is involved for a specific potential hazard. This sign is also black and yellow.

DANGER means that one of the most serious potential hazards is present. Unsafe operating techniques or bad work habits in this area could lead to serious accidents and personal injury. The DANGER sign is red and white.

The universal Slow Moving Vehicle (SMV) symbol is required to be mounted on farm machinery and other vehicles traveling at less than 25 miles per hour on public roads.

Careful Carl knows the importance of following tractor operation and safety rules. Take his advice and you will learn a lot about tractor safety, operation, care and maintenance.
Learn by Doing

Along with other club members in the tractor project, or together with family members, list several ways carelessness can cause falls around the farm, especially with tractors and other machinery. (HINT: Remember to consider such factors as the weather and clothing being worn.) What should be done to prevent each of the dangerous conditions you listed?

Be sure to learn what the CAUTION, WARNING and DANGER signs mean. Don’t forget their different colors. Compare decals on tractors and other machines. Compare the messages found on safety alert signs in your operator’s manual. How many other messages can you find? What do they mean? Do you understand why one and not another was used in each case?

If your family owns tractors or other machinery, check to make sure all safety decals are present. The owner’s or operator’s manuals show where all signs are located on the equipment. If you need to replace decals, your dealer can supply new ones. You can do the same thing for other tools and equipment such as power grinders, lawn mowers, garden tractors, etc.

Digging Deeper

Accidents kill as many young people as all other causes together. Compare tractor injury or death rates of people aged 14 and under in your county, township or state. Make a chart and plot the statistics in ten-year intervals. Begin in the 1900’s and work toward the present, noting every decade. Have injury and death rates increased or decreased? How have tractor safety features contributed? Keep your statistics for club presentations. (NOTE: Contact the National Safety Council, 444 North Michigan Avenue, Chicago, IL 60611. You can also contact law enforcement agencies and local libraries for your facts.)

CHECKING UP ON SAFETY

1. More people over 65 are involved in tractor “extra rider” fatalities than children aged 14 and under? T F

2. More accidents are caused when machinery is stationary than when it is being operated? T F

3. When you have finished using the tractor, the quickest and safest way to get off is to jump off? T F

4. The “danger” alert sign is usually red and white? T F

5. List four safety rules that you have learned: A B C D

6. How should you mount and dismount the tractor?

7. More young people aged 14 and under died from (A) homicide, (B) accidents, (C) illness? 

8. What is the usual color of “warning” alert signs: (A) yellow/white, (B) red/white, (C) yellow/black, (D) red/yellow?

9. More farm accidents were caused by (A) tractor driving, (B) falls, (C) inhaling gas fumes?

10. What is the most important thing you learned in this unit?
Today's modern tractors are marvelous, complex machines. Tractors are used virtually everywhere and in all seasons of the year. You don't have to be on a farm to see them operating. Drive along any highway and you can see a tractor mowing or pulling a load. Even in the biggest city they are used for cutting grass in parks and large lots or are equipped with backhoes for digging ditches or performing other chores.

Many years ago, a farmer using hand tools needed about a week to cultivate one acre of land. With a horse and plow, he could do the work in a day or so. With a small tractor and plow, he could do the same amount of work in one hour. The tractor has played a large part in helping the U.S. farmer produce enough food to feed himself and about 60 other people. Very simply, the tractor has revolutionized our society, especially in agriculture.

Like pulling a plow. Steam tractors or engines also supplied belt power for operating threshing machines and sawmills.

In 1892, the first gasoline-powered tractor was perfected. Although this tractor did not have the features to do many things other tractors would soon be doing, it still was an important invention. From that time onward, tractors powered by gasoline (and later kerosene) could carry enough fuel to work for a day. They could be operated by a single person. Extra men with teams of horses were not needed to haul fuel and water, as had been the case with steam engines. Improvements came almost every year as engineers, designers and inventors found new and better ways to get more work from the tractor.

A Machine To Do Work

Tractors do work. Whether it's a small garden tractor or a large tractor used on a huge farm—all operate on the same principles. A tractor is a power plant that converts chemical energy stored in a fuel into mechanical energy. The mechanical energy is then applied where it is needed to do work. Energy from the engine is moved or transmitted by belt drives, gears, clutches, wheels or even liquids (or some combination of these) to finally do work. Parts of the tractor involved in power transmission help make up different systems of the machine, as you will see later in lesson 4.

All the work we get from the tractor does not come cheap. The modern tractor and its implements together cost many thousands of dollars. Operating expenses (including fuel, lubricants and replaced parts such as filters) add up to many, many more dollars. If a tractor is not maintained and operated properly, costs can increase dramatically. Poor maintenance can lead to a major problem in the engine or some other critical system, and repair costs can be very high. If a breakdown causes some timely farm operation like harvesting to be postponed for even a few days, then even more money may be lost.

Owning or being responsible for maintaining and operating a tractor is a major responsibility. That's why the objectives of this project are so very important. Can you remember what they are? (1) Safety, (2) Proper care and maintenance of the tractor, and (3) Valuing the tractor as a business asset used to produce goods and profits.
Learn by Doing

Visit a local museum. Look at old tractors used in agriculture. Some local dealers may also have old tractors which they collect. If none are available, look at pictures in an encyclopedia or old farm and tractor magazine.

View films or slide sets on tractor history. Compare the features on early and modern tractors. How have safety features changed?

Give club demonstrations or presentations on how safety features have improved as tractors have changed.

Ask local dealers if they know of an antique tractor club in your area. Contact the club for a visit or ask your leader to arrange a club tour.

Collect photos or magazine pictures of tractors. Put together a scrapbook or develop a slide set. Give a demonstration or speech on the history of the tractor.

Interview older farmers or family members about the tractors they have used and their experiences with them. Record the interviews for use in 4-H presentations or local radio programs related to 4-H or agriculture.

See if you can find an old tractor that you or your club can begin to restore. This can be an excellent "hands-on" experience as you learn about the different systems of the tractor.

Help your club present a "Farm Day," "Agricultural Day" or "Antique Tractor Restoration Day" at a local mall, shopping area or town park. Display different tractor models or restored tractors. Restored tractors can be judged on an individual member basis or club basis if more than one club sponsors the event. Also, add educational programs to inform the public about how the tractor has helped the farmer feed people; the cost of tractors today; various uses of the tractor; etc. You may even be able to sell vegetables if your club members have produce available.

Digging Deeper

Find out as much as you can about early tractors. How have such things as instruments, engines, fuels, etc., changed?

Who were the pioneers in building early tractors? Learn about the lives of the first inventors and engineers like John Froelich, C. W. Hart, C. H. Parr, John Deere, Cyrus McCormick and others.

When did tractors first appear in your area? What makes were available? How have they changed?

(HINT: Consult local libraries, tractor dealers, historical societies, antique tractor clubs and older farmers in your area.)

Highlights In Tractor Development

1892 First successful gasoline-powered tractor developed. John Froelich developed the first internal combustion engine tractor, to be operated successfully. The new tractor completed a 50-day threshing run.

1901 First tractor factory established. C.W. Hart and C.H. Parr began to manufacture gasoline-powered tractors in Charles City, Iowa.

1918 Practical power take-off mechanism introduced. The PTO allows part of the tractor engine power to be used to operate equipment that is pulled by the tractor or mounted on it. PTO standards were adopted in 1927 by the American Society of Agricultural Engineers (ASAE).

1923 First tractor with side-mounted fenders. Farmers have complained about mud being kicked up by tractors for years. Now, the fender directs the mud away from the tractor rather than onto the road. The side-mounted fenders improve the road's appearance and help the farmer work more efficiently.

1931 Diesel tractors built. The first diesel tractor was a track type (crawler) powered by a four-cylinder engine. A two-cylinder gas engine was used for starting. The first commercial wheeled tractor with a diesel engine was manufactured in 1933.

1933 Low-pressure pneumatic tires manufactured. Rough road and rubber tires improved tractor performance and fuel economy.

1939 Gas-powered tractor introduced. Tractors burning liquid petroleum gases were improved throughout the life of the tractor. The feed of the carburetor was improved to allow better engine idling. The fuel tank and feed system were improved to handle the non-standard fuel.

1949 The three-point hitch was introduced. The three-point hitch on modern tractors is designed to work with all types of implements, both old and new. It is easily adjustable and can be used for either the tractor's engine or an auxiliary power source.

1955 High-low power shift transmission introduced. This feature provided additional gearing ratios and enabled the operator to shift gears while moving, without disengaging the transmission clutch.

1958 Hydrostatic transmission introduced. A hydrostatic transmission is a hydraulic system that controls the speed and direction of the tractor. Power from the engine is used to control the hydraulic fluid. The speed and torque can be varied smoothly while the unit is running, which makes an excellent tractor for farm implement work.
All tractors today have "internal combustion engines." This term means that the engine makes its power by burning fuel inside the cylinders. Many of the engine parts illustrated in Figure 3-1 are common to all internal combustion engines. Let's look at some of the basic engine parts listed below and see how each functions. To make it simple, let's use a single-cylinder engine to identify those parts, then we'll look at the four-cycle engine.

Cylinder is a hollow tube in which the pistons work.

The piston. A piston is a movable plug. It goes up and down like a plunger in a bicycle pump. It is held in the cylinder by the connecting rod. The rod connects the piston to the crankshaft. When expanding gases push the piston down, the connecting rod pushes on the crankshaft and makes it turn. This is the turning force called torque that is eventually used to do work.

Piston rings. Piston rings seal the compression in the combustion chamber and also help to transfer heat.

Connecting rods. Connecting rods transmit the motion of the pistons to the crankshaft.

The crankshaft. The crankshaft receives the force from the pistons and transmits it as rotary driving power.

On the end of the crankshaft is a circular disc called the flywheel. It smooths out the flow of power and helps keep the pistons moving. It keeps the parts spinning even after you stop cranking the starter.

Timing drives. Timing drives link the crankshaft, camshaft and other key parts together to make sure that each does its job at the right time.

Now that you are familiar with the basic parts that make up a simple single-cylinder engine, it's time to move on and explore how these parts work together to make an engine run. For this we will start with a basic four-stroke cycle engine. (See Figure 3-2.)

Most of today's tractors have four-stroke cycle engines. The Four-Stroke Cycle Engine is by far the most common type of internal combustion engine. Not only is it found on most tractors, but also on many other machines, from lawnmowers to the fanciest automobiles. We call this a four-stroke cycle engine because of four things that happen in the cylinder during strokes of the piston—intake, compression, power and exhaust. Let's look at the four strokes of a running engine. Figure 3-3 on page 12 illustrates what happens during each stroke.

The Intake Stroke

Let's start with the piston at the top of the cylinder and see what happens as the engine runs. The first stroke is called the intake stroke because, as it travels downward, the piston pulls in air and fuel from the intake manifold. The intake valve opens just before the piston starts...
The Compression Stroke

When the piston reaches the bottom and starts upward, the intake valve closes. The cylinder is full of the fuel mixture. Now the piston squeezes the mixture in the top of the cylinder. Because of the squeezing, this is called the compression stroke. We know how much compression is done by referring to the compression ratio. If a cylinder holds eight pints of air and fuel when the piston is at the bottom but there is only room for one pint when the piston is at the top, we say the compression ratio is eight to one—always written as 8:1. Tractor engines have different compression ratios just as cars do. Gasoline or LP-Gas engines (liquefied petroleum gas) usually have ratios ranging from 7:1 to 10:1. Diesel engine ratios range from 15:1 to 20:1 or even higher. Figure 3-4 compares two compression ratios.

It is a basic physical law that compressing a gas raises its temperature. The tighter it is squeezed, the hotter it gets. In a tractor cylinder with a compression ratio of 7:1 or 8:1, the temperature of the fuel mixture may go up a couple of hundred degrees Fahrenheit. In a diesel engine with a compression ratio of 15:1, the temperature will jump to more than one thousand degrees.
Figure 3-3

Simplified operation of the basic four-stroke cycle engine (gasoline shown.)

Intake
Fuel-air mixture is drawn into cylinder from carburetor through open intake valve by down-stroke of piston.

Compression
Mixture is compressed by up-stroke of piston. Both intake and exhaust valves are closed.

Power
Compressed mixture is ignited by spark plug and expanding gases force piston to bottom of cylinder. Valves remain closed.

Exhaust
Piston on up-stroke forces burned gases from cylinder through open exhaust valve.

Figure 3-4

Comparison of compression ratios.

<table>
<thead>
<tr>
<th>Unit Volumes in the Cylinder</th>
<th>1</th>
<th>8</th>
<th>1</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 to 1 Ratio</td>
<td></td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>16 to 1 Ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The more you compress the fuel mixture, the faster the gases expand after they start to burn. It's like squeezing or compressing a spring. The tighter you squeeze it, the more push it will have when you let it go. So the higher the compression pressure, the higher the power output. This is true for engines which compress fuel and air. It may not be true for a diesel, as we will see in lesson 6.

The Power Stroke

While the mixture is still being compressed and just before the piston reaches top center, a high-voltage spark flashes between the electrodes of the spark plug (or fuel is injected into the cylinder of a diesel engine.) The piston is traveling so fast that almost before the mixture starts to burn, the piston is at the very top of its travel. There it receives the tremendous push of the burning expanding gases. The piston is thrust rapidly downward, forcing the crankshaft around.
The Exhaust Stroke

Just before the piston reaches the bottom of the power stroke, the exhaust valve opens. Exhaust gases rush out. They are under their own power at first because they are still expanding. Then, as the piston drives upward, the rest of the gases are pushed out. This ends the exhaust stroke.

Can you summarize what happens during the four strokes? Fuel is burned within the confined space of the cylinders. The chemical energy is converted during burning into mechanical energy. Hot gases from the burning fuel expand and force the pistons to move downward in the cylinder. When several pistons are connected together on a crankshaft, and if fuel is burned in the cylinders in the proper sequence, rotary motion is produced by the crankshaft.

Whether or not you have seen the inside of an internal combustion engine, you experienced its mechanical principles the first time you rode a bicycle. Your feet and legs acted like the pistons and rods. Because the pedals were offset and opposite each other, you were able to convert the mechanical energy of moving your legs during pedaling into rotary motion at the crank.

That’s the four-stroke cycle engine. Always remember the four things that happen in the cylinder during the four strokes of the piston—intake, compression, power, and exhaust. The piston goes down and up twice for every power stroke while the flywheel goes around twice. That makes four strokes for a complete cycle. We usually drop the word “stroke” and refer to the engine as a four-cycle engine.

Engine Firing

Tractors manufactured today have either two, three, four, six or eight cylinders. The construction shown in Figure 3-5 is commonly used on a four-cycle engine having four cylinders. This type of engine fires every half-turn; that is, fuel is burned in one cylinder each half-turn. Starting at cylinder No. 1, we note that when the engine is turned one-half turn, No. 2 and 3 pistons will move up. Either piston could be ready for firing, but the firing (combustion) order depends on the design of a particular engine. The firing order of a four-cylinder engine is either 1-2-4-3 or 1-3-4-2. The most used firing order of six-cylinder engines is 1-5-3-6-2-4. Look in a tractor operator’s manual and see if you can find the firing order for that tractor.

Figure 3-5

ARRANGEMENT OF THE INTAKE AND EXHAUST PORTS AND VALVES OF A FOUR-CYLINDER ENGINE.
Learn by Doing

Study the parts of a four-cycle engine (i.e., valves, cylinders, pistons, etc.).

Practice identifying internal engine parts. Study Figures 3-1 and 3-2. Name the parts aloud without peeking at the diagrams.

Visit a local tractor dealer. Watch a mechanic working on internal engine parts.

Demonstrate disassembling or cleaning engine parts. You may want to use parts from a lawnmower or an old car. Collect some old engine parts. If possible, and make a display showing their operation.

---

Checking Up on the Four-Cycle Engine

The illustration shows some parts of an engine. Fill in the blanks with the numbers which correspond with the parts in the illustration. You may have to "dig deeper" to identify some of the parts.

- Part
- Rocker arm
- Cylinder
- Valve
- Cylinder head
- Water pump
- Timing drives
- Connecting rod
- Main bearings
- Crankshaft
- Oil pump
- Crankcase
- Flywheel
- Piston
- Piston rings
- Fan

1. Name the four strokes of a four-cycle engine.
2. What is the purpose of the intake valve?
3. What is the purpose of the exhaust valve?
4. What is meant by compression?
5. One common firing order for a four-cylinder engine is A) 1-2-3-4 B) 1-2-4-3 C) 1-3-2-4 D) 1-4-2-3.

Lesson 3
Introduction to TRACTOR SYSTEMS

BASIC ENGINE SYSTEMS

There are many, many systems that support an engine to help it function properly. Some of these systems are basic to any engine—lawnmower, automobile, tractor, etc. Other systems are specifically designed for tractors. In this lesson you will be provided basic information about both types. Let’s begin with the basic engine systems.

Ignition System

The ignition circuit makes it possible for the engine to start. When you place the key in starter and turn, you expect the engine to start. This is the first step in the starting process. However, the ignition circuit is only one part of a larger engine system responsible for the engine starting. This larger system is called the electrical system. The electrical system will be discussed later in this lesson in the section on Tractor Systems that Transmit Power.

Intake and Exhaust System

An engine must “breathe” to supply energy just as you do (Fig. 4-1). The intake and exhaust systems breathe for an engine. They carry the fuel-air mixture into the engine and remove the exhaust gases after combustion (Fig. 4-2).

THE INTAKE SYSTEM

The intake system supplies the engine with clean air of the proper quantity and temperature for good combustion. The intake system has five basic parts: air cleaners, turbocharger (if used), air inlet, intake manifold, and intake valves.

Figure 4-2

A SIMPLIFIED VIEW OF INTAKE AND EXHAUST SYSTEMS.

Air cleaners filter dust and dirt from the air traveling to the carburetor. Turbochargers, when used, increase final tractor power by forcing more air or fuel-air mixture into the engine cylinders than the engine could draw in by itself. The air inlet supplies fuel mixed with incoming air in the proper ratio for combustion and also controls engine speed. (On spark-ignition engines, this mixture comes from the carburetor. On diesel engines, air only is pro-
vided, with fuel injected later at the engine cylinders.) The intake manifold conducts the fuel-air mixture (pure air in diesel engines) to the engine cylinders where intake valves open to admit the air or fuel-air mixture to cylinders for burning.

THE EXHAUST SYSTEM

The exhaust system collects the exhaust gases after combustion and carries them away from the engine and the tractor operator’s position. This system actually has three jobs: (1) removing heat; (2) muffling engine noise; and, (3) carrying away burned and unburned gases.

The exhaust system has three basic parts: exhaust valves, exhaust manifold and muffler. Exhaust valves open to release burned gases from the cylinder after combustion. The exhaust manifold collects the exhaust gases and conducts them away from the cylinders. And, the muffler reduces the sound of the engine during the exhaust period.

Exhaust gases from an engine contain carbon monoxide, a deadly gas. It is colorless and odorless, but it can KILL. Careful Carl says, “Never run the tractor engine inside a closed building or in any other confined area where fresh air cannot circulate freely!”

Lubrication System

The engine lubrication system performs many important functions. First, it lubricates moving parts to decrease friction and wear, thereby prolonging the life of parts. Second, it helps cool moving parts of the engine (Fig. 4-3). It also cleans, seals, absorbs shock and cushions; reduces corrosion and transmits power within the engine.

Figure 4-3
MAJOR PARTS OF AN ENGINE LUBRICATING SYSTEM.

On four-cycle engines the oil pump pushes oil (a lubricant) through and over all moving parts of the engine. A reserve of oil is stored in the crankcase for circulation through the system. Oil from the crankcase is filtered to remove dirt and other impurities, and then recirculated throughout the engine.

Cooling System

The engine cooling system regulates temperatures and prevents the engine from overheating. Overheating could burn up the engine parts and that means money! Two types of cooling systems are used in modern engines: liquid cooling and air cooling.

LIQUID COOLING

The liquid cooling system has many parts. Most important of these are the radiator and pressure cap, thermostat, fan and fan belt, water (or coolant) pump and connecting hoses. Figure 4-4 shows a typical liquid cooling system.
The radiator stores the liquid for operating the cooling system of the engine. As liquid coolant is pumped through the engine, the coolant picks up much of the heat produced by combustion and friction. The hot coolant flows through the radiator and is cooled by fresh air. The liquid then is available for recirculating throughout the engine. Water by itself is not a satisfactory coolant because it can freeze or boil away. If water in the cooling system freezes in the winter, it will expand and may crack the engine block. If the water overheats in summer, it evaporates and the engine could burn up. Therefore, special coolants are mixed with the water. These coolants help maintain satisfactory temperatures throughout the engine, regardless of the season.

AIR COOLING

Air cooling is common on small engines. Engines on lawn mowers, motorcycles and most garden tractors are all cooled by air. Some large engines used as power units for many machines are often air cooled, and some makes of automobiles and farm tractors have air-cooling systems.

In the air-cooling process, a very efficient fan forces cool air over the hot surfaces of the engine to help carry off the heat. Specially formed sheets of metal (called shrouds) are often used to help direct cool air to the hottest areas needing to be cooled. The surfaces of air-cooled engines are also shaped so that combustion and friction heat is removed efficiently.

A good example of a tractor using the air-cooling system is the Deutz tractor. This is an imported tractor and is widely used in the United States.

TRACTOR SYSTEMS That Transmit Power

A tractor is a machine to do work. But how is that work done? What makes the tractor move? Let's look at some of the systems that help generate power to make the engine operate.

Electrical System

The electrical system makes it possible for the engine to start. This system consists of three important circuits—the starting circuit, the ignition circuit and the charging circuit. The starting circuit converts electrical energy from the battery into mechanical energy to crank the engine. The ignition circuit creates the spark which ignites the fuel-air mixture to power gasoline or LP-Gas engines. LP-Gas is short for “liquefied petroleum gas.” It is sometimes indicated as LPG. Remember, spark ignition is present only on gasoline and LP-Gas engines, NOT on diesel engines. (We will see why this is true in lesson 5 and 6.) The charging circuit recharges the battery and generates current during operation. Components of a typical engine electrical system are shown in Figure 4-5.

Electrical power flows in other circuits to operate lights and open and close valves. It also monitors the operation of other systems and instruments on the tractor itself and on machines such as planters, sprayers and combines.
Hydraulic Systems

Hydraulic power is produced on a tractor by pumping oil under high pressure to points where work is done. The hydraulic systems provide the "muscles" for controlling various tractor operations. The tractor in Figure 4-6, has a single hydraulic system to steer, brake, control implements and supply remote operation of tools.

The most common hydraulic functions found on modern tractors involve: steering, brakes, transmissions, implement control, remote cylinders and hydraulic motors. These functions may use a common hydraulic fluid supply or each may have its own reservoir where oil is stored.

The fluid in a hydraulic system serves not only as the power-transmitting medium, but also as the system's lubricant and coolant. You must, therefore, carefully follow your operator's manual for selecting the recommended fluid and servicing any hydraulic system on your tractor.

Power Train

As the engine burns fuel and develops power, mechanical linkages must transmit this power to the locations where work is to be done. Figure 4-7 shows a basic power train of a tractor.

A modern tractor can do work at several points. One place is at the drive wheels: the two rear wheels in a two-wheel drive tractor or all wheels in a four-wheel drive unit. Rotary motion or "torque" produced on the engine crankshaft is moved through the clutch into the transmission. There, by directing torque to move through either a few or perhaps several gears and shafts, speed of the engine crankshaft is reduced or increased. Torque is transferred from the output side of the transmission, through the differential, to the final drives (Fig. 4-8).

Figure 4-7

ARRANGEMENT OF THE POWER TRAIN IN A MODERN TRACTOR.

The differential consists of sets of gears arranged to change the direction of the torque along the drive shaft by 90 degrees. The differential gears not only direct the proper amount of torque to each drive wheel, but also enable the two wheels to rotate at different speeds when the tractor is turning. In a four-wheel drive tractor, the driving force also is transferred to a second differential, which directs the torque to the front wheels.

All work is done at the drawbar (or the three-point hitch near the drawbar). Many types of implements can be attached to help do that work.

Power Take-Off Unit (PTO)

The power train also furnishes torque for the power takeoff unit (PTO). This is another point from which work is done. The PTO enables the power developed by the tractor engine to drive mechanical systems of other implements such as balers, corn harvesters, mowers, rakes, tillage equipment and other similar machinery. The PTO system of a modern tractor is shown in Figure 4-9.
Fuel Systems

Gasoline, LP-Gas and diesel engines all have different fuel systems. These engines get their names from the fuel they use and the way the fuel is ignited in each system.

Gasoline and LP-Gas engines use an electrical spark to ignite the fuel-air mixture, therefore, they are commonly referred to as "spark-ignition" engines. Diesel engines, however, use the heat of compressed air for ignition. The two types of fuel ignition systems are summarized in Figure 4-10. We will learn more about the parts of each fuel system in lessons 5 and 6.
Learn by Doing

Identify and learn the external parts of a tractor. Pay special attention to those concerned with safety.

Give an illustrated talk on identifying engine parts. You may want to select one of the systems discussed in this unit and demonstrate those parts.

Locate and identify these systems on a tractor:
- Electrical system
- Intake and exhaust systems
- Lubrication system
- Cooling system
- Hydraulic system(s)
- Power train
- Fuel system

Making Safety Work

Problems in some systems on the tractor can cause fires. Although you might follow all safety rules for handling fuels, accidents such as broken fuel lines or sudden leaks can still happen. In only a second or two the tractor can be seriously damaged or someone can be badly burned. Make sure your tractor has a fire extinguisher on it. Be sure the extinguisher is one rated for burning fuels and electrical fires. It should be a pressurized dry chemical extinguisher rated for A, B and C class fires.

Visit your local fire department. Have a firefighter explain the different classes of fires and demonstrate the proper use of fire extinguishers.

What kinds of fire extinguishers are there? Are they all operated the same way?

Digging Deeper

Tour the shop of a local tractor dealer and talk with a mechanic. Observe the mechanic (or an older member of your own family) working on engines or some other system. Why are the repairs needed? Was the tractor involved in an accident, or did someone neglect to perform some service on the tractor?

Prepare a simple display for your club to demonstrate how the ignition system, fuel system and engine work together during operation.

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Checking Up On
Basic Tractor Systems

1. The starting circuit and ignition circuit are part of which system: (A) fuel (B) hydraulic (C) electrical?
2. Which one of the following is NOT part of the engine cooling system: (A) water pump (B) oil pump (C) radiator?
3. Name a deadly exhaust gas: (A) carbon dioxide (B) carbon monoxide (C) carbon tetrachloride.
4. What is an "internal combustion engine"?
5. How are gasoline and LP-Gas fuel systems alike?
6. How is the diesel engine fuel system different from the gasoline or LP-Gas engine fuel system?
7. What is the main function of the tractor "hydraulic system"?
GASOLINE and LP-GAS ENGINES

Gasoline and LP-Gas engines are both spark-ignition engines. In lesson 3 you learned that at the end of the compression stroke, a high-voltage spark flashes between the electrodes of the spark plug to ignite the fuel-air mixture in the cylinder. This is the primary feature that makes these engines different from the diesel engine.

The difference between gasoline and LP-Gas engines is mostly in the fuels they use and how these fuels are supplied and prepared for combustion. Let's take a closer look at these two engines.

Gasoline Fuel System

Gasoline and LP-Gas engines have some parts that are similar and others that are different. In the gasoline engine, the three main fuel system parts are the fuel tank, the fuel pump and the carburetor. Figure 5-1 shows a simplified fuel system for a gasoline engine.

The fuel is stored in the fuel tank. As fuel leaves the tank, the space it occupied must be replaced by air from outside. This is accomplished by a vented fuel cap—a cap having one or more tiny holes to allow air to pass. Always be sure the vent holes are open in the cap. If they are not, fuel cannot flow into the supply lines. Fuel is moved from the tank to the carburetor by the fuel pump. (In some systems, fuel is supplied to the carburetor by gravity flow and there is no fuel pump.)

The carburetor does two jobs: (1) atomizes fuel for the engine; and, (2) provides the proper fuel-air mixture. The carburetor measures the fuel and air that are to be mixed and supplied through the manifold to the cylinder. Carburetors are precise instruments that perform under several different conditions: during either hot or cold engine starting; for idling; partial throttle; acceleration or speeding up; and, for high speed operation.

The carburetor is an important part of the engine and fuel system because, here, the proper amounts of fuel and air are mixed for combustion, allowing the engine to start. Without this proper mix, the fuel would not ignite and the engine would not start.

To get the proper fuel-air mixture, the carburetor must break down or atomize the fuel into tiny droplets, and mix them with the right amount of air. Fuel is atomized by forcing it through a nozzle and into a high-speed flow of air. Figures 5-2 and 5-3 illustrate the principles of carburetion. The amount of air moving past the fuel jet in relation to the amount of fuel being metered into the stream determines the richness of the mixture, that is, the ratio of fuel to air.

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Figure 5-1

ARRANGEMENT OF COMPONENTS IN A GASOLINE FUEL SYSTEM.
Gasoline carburetors can be adjusted if they are not working properly. However, they normally need adjusting only after they have been removed for repair. If adjustments are needed, consult your operator's manual to see what the proper settings should be.

## Selecting Fuel for Gasoline Engines

Fuel recommendations given in your tractor operator's manual must be followed exactly. Most gasoline tractors are designed to operate on "Regular" grade fuel. *Never use non-leaded gasolines unless your tractor's manual specifies they can be used in the engine.* Non-leaded fuel can damage some tractor engines. Using more expensive "Premium" grade fuels in engines designed to operate on Regular gasoline will probably waste money. The engine is not able to develop extra power from the Premium fuel and there is no advantage to be gained.

Your fuel dealer supplies different blends of gasolines for the various seasons. If you use the recommended grade of fresh, clean gasoline, you should have no problems from the fuel itself.

## Alternative Fuel for Gasoline Engines

Gasohol, a mixture of 90 percent unleaded gasoline and 10 percent ethanol (grain alcohol), is available in many areas as a substitute for gasoline. However, in engines used infrequently, water may combine with the alcohol and cause serious corrosion or damage.
to some engine parts. Therefore, some engine manufacturers have not approved use of gasohol in certain engines. Always be sure fuel is compatible before using it in an engine or the warranty may be voided.

**LP-Gas Fuel System**

An LP-Gas engine is similar to a gasoline engine. They both have spark ignition, but they differ in the way the fuel is ignited. LP-Gas is vaporized before it reaches the carburetor while gasoline remains a liquid until that point. This is the basic difference between the two systems.

The LP-Gas fuel system has four basic parts (Fig. 5-4). The pressurized fuel tank stores the liquid fuel under pressure. A space for vapor is left at the top of the tank. The fuel strainer cleans the liquid fuel, then the converter changes the liquid fuel to vapor by warming it. The carburetor mixes the fuel vapor with the proper ratio of air so the fuel will ignite and the engine will start.

The most common method of supplying LP-Gas to an engine is the liquid withdrawal system (Fig. 5-5). The vapor withdrawal system, in which vaporized gas is drawn off the top of the tank, is normally used only for starting up. Once the engine begins to warm up, the liquid system is switched on.

In the liquid system, hot coolant from the engine circulates through a heat exchanger where some of the heat is transferred to the liquefied petroleum. This heating speeds up vaporization and ensures that only LP-Gas vapor reaches the carburetor.

**Selecting Fuel for LP-Gas Engines**

Most LP-Gas used in engines today is all propane or a mixture of mostly propane with some butane.
LP-Gas must be stored and handled in high-pressure containers to keep it in liquid form (Fig. 5-6) because it vaporizes very easily. It normally remains a liquid only when under pressure. Therefore, it must be kept in strong tanks.

LP-Gas fuel supplied by a reliable dealer should cause no problems in your tractor engine. Like gasoline, LP-Gas is blended for use in cold or warm seasons. Thus, you should use fuel that is as fresh as possible.

Figure 5-6
LP-GASES ARE STORED IN HIGH-PRESSURE TANKS.

Learn by Doing
Inspect the fuel system of a spark-ignition engine (either gasoline or LP-Gas) on a tractor, truck or automobile. Identify the various parts you find.

Checking Up On Gasoline and LP-Gas Engines
1. Gasoline, LP-Gas and diesel tractors can use the same fuel? T F
2. Gasoline and LP-Gas both reach the carburetor in a liquid state? T F
3. Gasohol fuel is just as safe for an engine as gasoline? T F
4. Which one of the following is NOT a spark ignition engine: (A) Gasoline, (B) Diesel, (C) LP-Gas? (B) Diesel
5. What are the two main functions of the carburetor? (A) Filling the fuel tank, (B) Adjusting the blend of air and fuel, (C) Filtering the fuel
6. What does the height of a muffler mean? (A) The engine is loud, (B) The engine is quiet, (C) The engine is out of balance

Careful Carl has four important rules for refueling the tractor.

Never let anyone smoke or have any type of open flame near fuel storage areas, especially when refueling is underway!

Let a hot engine cool for at least five minutes (and if possible, even longer) before refueling. It's the fuel vapor which burns. If fuel spills, always let it evaporate before starting the engine.

Refuel outdoors, especially LP-Gas tractors. Vapors which collect indoors can cause an explosion.

Never fill the LP-Gas tank more than ¾ tank full because overfilling can cause excessive pressure inside the tank. This will cause the relief valve to open, wasting fuel and perhaps creating explosive conditions.

Digging Deeper
Consult your local library. Read up on alternative fuels for gasoline engines. Find out who is manufacturing "gasohol" and what some of the problems are in perfecting it. Give an illustrated presentation at a club meeting. Illustrate and discuss the pros and cons of alternative fuels.
Diesel engines are found on most newer tractors. In many respects they are similar to gasoline or LP-Gas engines. Oil lubrication, air supply and basic cooling of the engine are normally done the same ways in all three engines. However, you have already learned that the diesel engine has no electrical ignition system, and its fuel system is completely different from the other two types of engines. In this lesson we will see how a diesel engine operates.

Diesel Fuel System

Figure 6-1 shows the main components of a fuel system. Diesel fuel flows by gravity from the main tank into the engine supply line, or in modern high-speed engines, is pumped by a fuel transfer pump. The filtering stages are more complex than in a gasoline engine because diesel fuel reaching the precision-made final injectors must be very clean. Most systems, therefore, use a first-stage screen filter to trap large dirt and dust particles. Then at least two other stages (usually called primary and secondary filters) help further filter the fuel to ensure that only clean fuel is pumped to the injection system. The fuel system also normally has some device for trapping any water which may be mixed with the fuel.

In operation, fuel flows by gravity pressure from the fuel tank to the transfer pump. The transfer pump pushes the fuel through the filters, where it is cleaned. The fuel is then pushed on to the injection pump where it is put under high pressure and delivered to each injection nozzle exactly when needed. The injection nozzles atomize the fuel and spray it into the combustion chamber of each cylinder. Combustion in the diesel engine occurs as the fuel charge mixes with hot compressed air, when the piston is reaching the end of the compression stroke. No electrical spark is used, unlike in gasoline or LP-Gas engines. The injected fuel is ignited by heat alone.

Therefore, the air must be very hot (a thousand degrees or more). Thus, compression ratios in diesels are typically about twice as high as those of spark-ignition engines. While the ratio

![Diagram of Diesel Fuel System](image-url)
in a gasoline engine might be 8:1, that of a diesel may be 16:1 or even higher.

Various kinds of injection systems are used on different engines. The arrangement of the injection pump and the injector nozzles may be any of four types. Each cylinder may have its own pump and nozzle in its own line (individual pumps); individual pumps may be built into a common housing with individual lines running to each injector (an in-line pump); individual pumps and nozzles may all be built in a single housing (a unit injector); or a single pump may feed individual nozzles through their own lines (a distributor pump). This last example is the one used in Figure 6-2. It and the in-line types are widely used, especially on off-the-road farm and industrial machines. The unit injector is common on larger engines.

Figure 6-2
EXAMPLE OF A DIESEL FUEL INJECTION SYSTEM.

![Diagram of a diesel fuel injection system.]

The biggest cause of problems in the diesel fuel system is dirty fuel and water getting into the pumps and nozzles. Therefore, it is extremely important that diesel fuel be stored properly and that filters and water traps are checked whenever recommended in your operator's manual. Because the injection pumps and nozzles are precision-made, they should only be serviced by a person especially trained to work on them.

**Diesel Engine Air Intake System**

Unlike gasoline or LP-Gas engines, diesels do not have carburetors. Instead, the incoming air goes directly to the intake manifold from the air cleaner. Air enters the cylinder at the intake valve, which operates the same way as in a gasoline or LP-Gas engine.

Diesel engine intake systems may be equipped with two components not normally found on farm tractor gasoline or LP-Gas engines. These are the turbocharger and the intercooler.

**Turbochargers.** Many diesel tractors use a turbocharger to help them develop more power. Figure 6-3 shows a turbocharger and other components of a diesel air supply system. The heart of a turbocharger is a small shaft with a fan-like turbine at each end. The shaft and turbines are connected so they rotate as one part (called a rotor). The rotor assembly is enclosed in a housing which is connected to the intake and exhaust systems of the tractor.

When the engine starts, the exhaust gases flow through the turbocharger and cause it to spin rapidly (sometimes 100,000 revolutions per minute or more). The rapid turning causes the compressor end of the shaft to compress incoming air and force more air into the cylinder. Since more air is present in the cylinder, more fuel can be injected, and the engine can efficiently develop more power.

Figure 6-3
THE INTAKE SYSTEM OF A MODERN DIESEL ENGINE, SHOWING THE AIR CLEANER, TURBOCHARGER AND INTERCOOLER.

![Diagram of the intake system of a modern diesel engine, showing the air cleaner, turbocharger and intercooler.]

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**Intercoolers** are sometimes used on turbocharged diesels (Fig. 6-3). When a turbocharger compresses the intake air, it gets hot just like the air gets hot inside a diesel cylinder as it is compressed by the piston. If the air could be cooled between the turbocharger and the engine, the cooler air would contract and still more air could be pushed into the cylinder. An intercooler does just that. The intercooler is a radiator that takes heat out of the air after it has passed through the turbocharger compressor, but before it reaches the engine.

**Selecting Fuel for the Diesel Engine**

As was mentioned earlier, dirt and water cause most problems associated with diesel fuels. The fuel storage tank should be constructed so that any water and sediment can be drained periodically from the end opposite where the tractor filler hose is connected. This means keeping the tank tilted slightly so dirt will collect away from where fuel is being drawn off into the tractor.

Your fuel supplier can furnish the proper diesel fuel recommended for your tractor. Operator’s manuals frequently specify grade No. 1-D fuel for cold weather operation and engines running with variable loads and speeds. No. 2-D fuel is used in warmer seasons and when engines are operating at more uniform speeds with relatively high loads. You must, however, check the tractor manual concerning proper fuel recommendations for your tractor. Engine design determines which grade of fuel to use, and using the wrong grade could ruin the engine.

**Alternative Fuels**

Vegetable oils are receiving considerable attention as fuels for diesel engines. Although diesel engines will run on vegetable oils, many questions remain to be answered before they can be recommended for use in farm machine engines. Tractor manufacturers currently will not guarantee their engines if a vegetable oil is used as the fuel, but this may change as research progresses.

**Learn by Doing**

Locate and identify the components of the fuel and air supply systems on a diesel engine.

Try squeezing the oil from sunflower seeds between two paper towels. Squeeze peanuts with a squeezer or grinder. You won’t be able to obtain enough oil to run an engine but you’ll get the general idea.

**Checking Up On Diesel Engines**

1. How is the diesel fuel system different from the gasoline fuel system?

2. The biggest causes of problems in the diesel fuel system are

3. What is the function of the diesel “injection system”?

4. What function does a “turbocharger” serve?

5. What does the “intercooler” do?

6. Fuel in diesel engines is ignited by: (A) spark plug (B) boiling oil (C) heat of compression
The purpose of preventive maintenance is to promote optimum performance and prevent costly repairs. If you are a good tractor operator, you will acquire an awareness about a tractor. You will take a few minutes before starting it up to just look around and make sure that there is nothing loose or leaking. You will learn to listen to the way the tractor runs, how it sounds, and you will be able to hear when it is telling you something is wrong and may need adjusting.

Although you will always be following the maintenance procedures in your operator's manual, there are certain things that you will be doing very frequently. These include checking parts and fluid levels; lubricating; replacing filters; refueling; checking tire pressures; and making other visual inspections.

Here's one good maintenance tip you should always follow. Keep a careful record of all maintenance performed on your tractor. Many operator's manuals have pages where you can record many of the periodic procedures. If your manual doesn't have these pages, you can easily make up sheets. List each maintenance job performed and the date it was done.

Here are some items that will need periodic inspection in the various tractor systems.

The Electrical System

All electrical wires and connections must be clean and secure.

The battery must be kept fully charged and filled with water. It must also be kept clean. Failure to maintain the battery properly can shorten its life. The battery can become defective and lose its charge.

Several other parts in the electrical system may sometimes need servicing especially if the tractor is not operating properly. Until you fully understand the tractor's electrical system, you should always work with an adult who knows how this system functions.

Spark plugs and distributor points must be clean and properly adjusted ("gapped"). This maintenance, along with "timing" of the distributor, is usually part of an engine "tune-up."

Other simple maintenance in the electrical system may include checking the carbon brushes in the alternator or generator and brushes in the starter, again observing or working with an adult.

Lubrication System and Greasing

The many different oils and greases used by your tractor are called lubricants. A lubricant forms a thin film between moving parts to make them slippery and help reduce wear and friction.

To understand how a lubricant works, try this demonstration. First, make sure your hands are dry. Then rub the palms of your hands together rapidly. Notice how quickly your hands get hot. Now try it again with a few drops of new crankcase oil on your hands. This time they are slippery and do not get hot. This is how oil works in the engine of your tractor. Just as it did with your hands, the oil makes a film that keeps an engine's moving parts separated. As a result, the engine runs cooler, with less wear and friction. Did you notice how the oil cleaned the palms of your hands? Oil is also used to keep the engine clean.

Use the Proper Lubricant

There are many places in your tractor where oil is used. The oil in the crankcase keeps the engine clean, reduces wear, cuts down on friction, cools, seals compression, and makes the

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engine run quietly. Oil is used in the transmission, differentials and wheel drives to maintain a protective film on the gear teeth. Oil is used in the hydraulic system to operate cylinders and raise or lower implements or work remote machinery. Different types of oil are usually required for each of these systems. Be sure to follow the recommendations in your operator’s manual and use the proper oil for each purpose.

Greases are lubricants too. They are stickier and thicker than oil, so they will stick to gears and bearings. Greases are available for many special purposes. Again, the tractor operator’s manual will specify which grease to use in each location. Greasing is something to be done on a regular basis. Certain parts must be greased daily.

Don’t forget that other equipment being used with the tractor has maintenance requirements too. Machines that have many moving parts, for example, hay balers and cubers and harvesters for most crops need to be checked and lubricated just as often as the tractor itself.

You will want to schedule maintenance so that it becomes a part of your daily farm operations. It should be done either when you come in from the field or just before going out in the morning.

You will find that when the wheels, axles, etc., are still warm from working, they will take the grease better than when cold. By getting out the grease gun and attending to that part of maintenance first, while the tractor is cooling, you can save time. The next morning the tractor and machinery will be ready to roll, except for the pre-operating inspection.

Checking Fluid Levels

This is another of the daily maintenance procedures. Among the fluids that need to be checked are the coolant and the engine oil. Although not required daily, be certain to check other fluid levels when called for in your operator’s manual. These other fluids include the liquid in the battery, and oil in the transmission, final drives, hydraulic system and any other locations.

Changing Engine Crankcase Oil

Your operator’s manual will tell you when to change the engine’s oil. This will need to be done after a certain number of operating hours. The oil filter may not need replacing with every oil change, but be sure this is also done on time.

You must follow oil changing instructions given for your tractor. This means changing oil on time and using the proper grade of oil. New

A daily “countdown” is the first part of Careful Carl’s tractor operating procedure. While he’s checking over the tractor, he also plays it safe. You should play it safe too!

Never service or make adjustments while the engine is running or while the tractor is moving.

When working near the tractor battery, be extra careful because all exposed metal parts are electrically “alive.” If metal objects come in contact with the two battery terminals or the ungrounded terminal (usually the + or positive terminal) and another part of the tractor, an explosion could occur.

The liquid inside the battery is a strong acid. It causes severe burns when in contact with the skin and can quickly eat through clothing. If you should get acid on your skin, flush the skin with plenty of fresh water. If you get acid in your eyes, flush them with water for at least 15 minutes and get prompt medical attention.
oil which has only been used a few hours looks very dirty, but that’s because it’s doing its cleaning job. The point is, you can’t tell from its appearance when oil needs changing. Change it according to instructions in your manual.

Always change the oil soon after the engine has been run. Dirt and other contaminants are still suspended in the liquid and you can be sure they will drain out with the old oil. After refilling the crankcase and replacing the filter, recheck the oil level. The oil should have time to drain back into the crankcase before its level is checked. Start the tractor and check for any leaks around the drain plug and filter.

Servicing the Cooling System

Maintenance to the cooling system includes checking the coolant level daily and adding water or coolant as necessary. Your operator’s manual will tell you when you should change coolant and flush and clean the system. It will also give you the specifications for fan belt tension, should that need adjusting.

Checking Coolant

Coolant is very hot and under high pressure when the engine is running. Be sure the engine has cooled before checking the coolant level. Loosen the pressure cap to the first stop to relieve any pressure still in the system, then remove the cap completely.

Your operator’s manual will tell you where the liquid level should be when the system is cool. Depending on the engine and system, this could be from 1/2 to 2 inches below the cap (Fig. 7-2). Never overfill the system because coolant must expand when hot and too much liquid will only overflow and be wasted. On the other hand, make sure there is always enough coolant so the system will operate properly.

Servicing the Hydraulic System

Preventive maintenance to the hydraulic system or systems involves making sure the oil fluid level is always according to specifications in the tractor manual, changing the fluid and filters when required, and keeping the system free of leaks.

Hydraulic fluid has many of the same jobs as engine oil and it can wear out too. It should be changed on time, when called for in the operator’s manual. Be especially careful when checking for leaks in the system. Hydraulic fluid is under very high pressure and even a tiny stream from a pinhole in a hose or from around a fitting can pierce the skin.

Maintaining Gasoline and LP-Gas Fuel Systems

As long as fuel is kept free of dirt and water, maintenance to the fuel system of spark-ignition engines is relatively simple. Because LP-Gas is kept in sealed tanks during all stages of delivery, dirt is not a major problem. This is not true with gasoline. Follow the recommendations of your tractor manual for servicing the engine fuel filters.

Carburetors are precision instruments. They can be adjusted if necessary, but this should only be done by someone well-acquainted with their operation. It will be best if you watch an adult or older teen do the adjustments until you can learn more about the inside of the carburetor.

Maintaining Diesel Fuel Systems

The importance of supplying the diesel engine with clean fuel was stressed in the last lesson. Because the injection pumps and nozzles are so precisely built, even the tiniest dirt particles can clog the system or cause excessive wear. Water in the system can cause rust, which leads to clogging and rapid wear. Operator maintenance to the diesel fuel system is limited to keeping fuel as clean as possible by servicing the various filters according to the manufacturer’s recommendations.
Refueling

Whenever possible, refuel in the evening so the fuel tank is full during the night. This prevents water condensation in the fuel tank that can lead to problems in the fuel system. Never refuel the tractor while it is still hot. Let the engine cool down so that if any fuel should spill, there will be less danger of fire or explosion.

A Clean Air Supply

Engines require huge amounts of clean air for mixing with fuels. Any time the flow of air is restricted for any reason, engine performance will suffer. Ordinary air enters the intake system to the carburetor through one or more cleaners. The first stage is often called the pre-cleaner and the second stage, the air cleaner.

Both stages contain filters to trap all types of dirt particles. Filters may be dry types or oil bath filters. Your operator’s manual will tell you which types are suited to your tractor and how they should be serviced. Checking the air filters is one maintenance step where the tractor operator must use good judgment. Remember, under dusty conditions air filters will have to be changed more frequently than under normal conditions to help trap the excess dirt and dust.

Leaks in the connecting pipes, loose hose connections, or damaged gaskets which permit dirty air to enter the engine can defeat the purpose of the air cleaner. Remember, dirty air going directly into an engine cylinder will cause wear of moving parts.

Other Visual Inspections (tires and fittings)

There are several other things to check on the tractor before going to the field. Remember to always check for loose fittings and bolts and nuts. There is good reason for this. As soon as a nut loosens, the two pieces being held together start to shift. They no longer hold together with a tight grip but start knocking at each other. Soon the holes wear out of shape and the bolts become bent or shear off. The pieces can fall apart and rust begins to penetrate the inside of the machinery. In either case, that means money for costly repairs.

Always keep tires properly inflated. Keep an eye on such things as the pattern the tires make in the soil. Most operator’s manuals will show you what the pattern should look like and also tell you the proper air pressure for the tires. Improper inflation not only causes rapid tire wear but can also seriously affect traction and lead to inefficient operation and higher costs.

There are many simple adjustments the tractor operator can make without having to call the serviceman. All of these adjustments are described in the tractor operator’s manual. Learn to follow the instructions in your operator’s manual and never assume that everything is working properly unless you know it is for sure. Major maintenance or overhaul of complicated systems should not be attempted by you. Until you learn more about the various systems and parts, always work with an adult or older teen when doing any complicated maintenance. Remember, proper operation and maintenance will go a long way toward preventing the need for major repairs.

Learn by Doing

Help your parent or club organize a farm maintenance shop. Keep the area neat. Make sure storage area is adequate to prolong the life of equipment.

Identify and organize maintenance tools needed. Replace missing tools.

Make sure shop is well-lighted, ventilated, etc.

Find or replace all operator’s manuals for your family’s farm equipment. Locate these manuals in one place. They will become your reference library.

Locate your operator’s manual library in a safe, handy place in the shop.

Develop a maintenance schedule for your tractor(s). Consult your operator’s manual.

Make sure safety symbols and decals are on all tools and equipment.

Get your parent or leader to help you with basic maintenance operations such as changing oil, filters, checking transmission fluid, checking tire pressures, etc. When you are sure you can do these tasks correctly, assume basic maintenance of your tractor.

Keep records of when you perform any maintenance on the tractor.

Help local farmers inventory their shops and find out what is missing. Your club might want to help raise funds by selling tools, fire extinguishers, first-aid kits, etc.

Practice disassembling and cleaning an engine from a lawnmower or an old car. Collect some old tractor engine parts, if possible, and make a display showing their operation.

Digging Deeper

Obtain an operator’s manual for an LP-Gas engine, gasoline engine and diesel engine. Compare the likenesses and differences in tractor
maintenance schedules.
Visit a local dealer. Talk to a mechanic about the differences in maintenance of older tractors vs. newer tractor models. Identify some of the new features on tractors that indicate "it's time for maintenance."

Checking Up On Tractor Maintenance and Service

1. Which item is NOT considered a tractor lubricant: (A) oil, (B) grease, (C) coolant?
2. It is best to refuel a tractor engine while it is still hot?
3. If the engine crankcase oil appears black, that's a true indication that the oil is dirty and needs changing?
4. Engine lubricating oil and hydraulic fluid may be used interchangeably?
5. Match the word on the left with the correct phrase on the right:
   - dip stick
   - coolant
   - filter

   A fluid that regulates internal engine temperatures and must be checked regularly.
   A device that screens and removes solids from a liquid or from the air.
   Instrument used to check the engine oil level.
Preparing Yourself TO DRIVE

Look at Figure 8-1. It shows the typical safety features you will find on most modern tractors. Learn where each of these features is located on your tractor and what function each serves. If you have a tractor available, use it to locate these parts. Knowing where special features are located and how to operate and control them can be one of the safest practices you will learn when preparing yourself to drive.

If typical tractor features were not illustrated below, how would you learn the various features on a tractor? How would you know how to start and operate the tractor correctly? Where would you find information on maintenance? How would you know when to change the oil or grease the tractor parts? Do you know the answer to these questions? Of course, the correct answer is: IN THE OPERATOR'S MANUAL.

Operator's manuals are furnished with every new tractor. Even if you were to buy a used tractor and the original manual had been lost, you could still obtain the proper manual from a dealer or from the manufacturer if the manuals are still available. Knowing what information is in the operator's manual is important to your safety and to prolonging the life of your tractor.

THE OPERATOR’S MANUAL

There are several types of important information in the operator's manual. These include:
- Safety rules.
- A basic description of the tractor including its specifications.
- General instructions about all the controls and instruments and how they are operated.
- Maintenance procedures that must be followed to keep the tractor functioning properly.
- Instructions for making simple adjustments that need to be done from time to time.

Figure 8-1

TYPICAL SAFETY FEATURES AVAILABLE ON MOST MODERN TRACTORS MANUFACTURED IN NORTH AMERICA.

- Power Steering
- Handholds for Mounting
- Seat Belt
- Headlights
- Work Light
- Skid Resistant Platform, Steps, and Pedals
- Shroud and Shield for Fan and Alternator
- Turn Signals
- Fenders
- Controls
- Tall Lights Reflectors
- Slow-Moving Vehicle (SMV) Emblem
- Hydraulic Power Lifts
- Hazard Warning Decals
- Wheel Weights
- Break-Away Hydraulic Couplers
- 3-Point Hitch
- PTO Shield
- Protective PTO Shaft Cap
- Drawbar
It's easy to see that the operator's manual has a lot of information in it. You can't memorize all of the information, but it is more important that you know what facts are in the manual and where they are found. Then if you need to know something quickly, you can go directly to the section that tells you what you want.

Tractors are complex machines and all makes and models have some differences. While many tractors—and especially those of the same manufacturer—may have similar features, various models have different operating specifications and limits. These must be followed if the tractor is to perform efficiently and last a long time. Be very sure you are using the correct manual for a given tractor!

Safety Rules

The operator's manual is an excellent place to learn the rules for safe tractor operation. Not only do all manuals discuss general safety rules, but each one also points out the safety features and practices that apply to a specific tractor model. In addition to the international safety alert signs, manuals frequently highlight safety tips and rules with dark type or in boxes so they are easily seen. Therefore, all tractor operators should be aware of safety rules, signs and symbols.

The operator's manual is not the only place you will find caution statements and safety rules. You have already learned that safety decals and other instructions can be found on the tractor itself. Always follow these warnings to protect yourself and the tractor from unsafe or improper operation.

Operating Limits and Specifications

What is the proper engine speed for operating your tractor? What are the inflation pressures for the tires? Do you know what type of engine oil to use in your tractor during summer months? The answers to these and dozens of other important questions are in the tractor operator's manual, too. For example, using the proper oil in different seasons can greatly influence engine performance and reduce wear. Making sure that tires are properly matched, adjusted and inflated will protect them from wearing too fast and, at the same time, play a big part in getting maximum pulling power from the tractor. Look through an operator's manual for the various operating limits and specifications. Try to determine why each group is important.

Controls and Instruments

Because the operator's manual is written for a particular tractor, some of the basic explanations deal with the controls and instruments. This section of the manual tells how to start, operate and shut down the tractor properly. Certain controls might have to be operated in sequence and the manual will tell you this. The instruments on the control panel show you how the tractor is functioning at all times. If you know how all the instruments should read during normal operation, then you will know when all systems are within their proper limits.

Maintenance Procedures and Adjustments

Another extremely important section in the operator's manual is the part describing maintenance procedures. This section tells you what should be checked and how often. Like safety, correct maintenance is an everyday practice. Aircraft crew members check their aircraft between flights. Truckers inspect their rigs during fueling and at rest stops. The tractor operator should do the same thing. Tractors should be checked before and after each operation. Some maintenance operations are performed every day; others every few months.
Every good tractor operator will know when maintenance is needed on his or her tractor.

**Learn by Doing**

Locate and identify the typical safety features on a modern tractor. Study Figure 8-1 and your operator's manual. Locate these features on your tractor without looking at a diagram.

Get out your tractor operator's manual. See if you can locate and identify any special features on your tractor that are not listed in Figure 8-1.

Become familiar with your operator's manual for the tractor. Practice locating different items in the manual, such as "the capacity of the fuel tank." Do you know where to look? Parents or leaders can help you practice. Have them call off items for you to locate. When you have problems, turn to the index or contents page. Remember, the objective is to "know your operator's manual!"

By now you should know where all the safety decals are located on your tractor. Look over the tractor again and be certain that all missing decals have been replaced. Also, make certain that all decals are legible and can easily be read.

**Digging Deeper**

Look at three or four used tractors. Which one would you buy? Why? Point out favorable and unfavorable features. Have an adult or your leader assist you in evaluating your decision.

**INSTRUMENT PANEL**

Pilots of space capsules and jet aircraft use instrument panels to tell them if all systems are working properly. Pilots also have all the controls within reach while they are flying their craft. They seldom have to leave their seats to perform their duties.

The same is true for the tractor. All instruments and controls for operating the tractor are within sight and reach of the operator. The instruments and controls on any one tractor will vary according to the model and the features it has. Figure 8-2 shows the instrument panel of a modern tractor. Figure 8-3 illustrates how colors are utilized with universal symbols for operating instruments.

The operator's manual is the source that will explain the function of each gauge, light, lever and button. The manual for your tractor will give correct readings for all the instruments and tell you what to do if trouble is indicated. Let's look more closely at the main instruments.

![Figure 8-2](image)

**THE INSTRUMENT PANEL OF A MODERN TRACTOR. THIS MODEL USES WARNING LIGHTS TO MONITOR SOME FUNCTIONS.**


**Oil Pressure Indicator**

An oil pressure gauge is used on some tractors to show the amount of pressure in the engine lubrication system when the engine is running. Some tractors may have a warning light instead of the gauge to indicate low oil pressure.

The gauge or warning light shows you if the oil pump in the crankcase is working. It does not always mean that oil is circulating properly through the engine, and it does not show the oil level. If, for example, an oil line is plugged, the proper pressure still will be shown by the gauge, but some part of the engine may not be getting enough oil.

It takes a while for the pump to build up oil pressure when the gauge is started. That's why low pressure may be indicated every time you start the tractor. If the correct pressure is not indicated within a few seconds after starting, shut off the tractor until you can locate and correct the problem.
Charge Indicator

The charge indicator—or ammeter—may also be a gauge or a warning light. Both show you whether the generator or alternator is charging the battery properly. Like the oil indicators, however, charge indicators do not show the actual electrical charge in the storage battery. Both types of charge indicators are connected to the starting switch and will normally show discharging after the switch is turned on and before the engine is started. Discharge may also show when the the engine is running at a slow idle speed. You should shut off the engine at once when trouble is indicated by this gauge or light.

Fuel Gauge

Most modern tractors have a gauge that shows how much fuel is in the tank. A good tractor operator never lets the tank run dry. This is particularly important if the tractor burns diesel fuel or LP gas. Every time a diesel tractor runs out of fuel, time is lost because the fuel system must be vented of air after refueling and before re-starting. If you run out of fuel with an LP gas tractor, you may be a long way from the fuel storage tank. Since LP gas is stored under high pressure you would need special equipment for refueling away from the tank. Diesel tractors have elaborate filtering systems for the fuel. Some diesel tractors have a fuel pressure gauge to show when fuel filters are plugged with dirt.

Engine Speed Indicator

All tractors built today have an instrument called a tachometer to show how fast the engine is running. It is calibrated in revolutions per minute (RPM) and tells you how fast the crankshaft of the motor is turning. The speedometer shows the tractor's ground speed in miles per hour (MPH).

Hour Meter or Proofmeter

This instrument may be built into the tachometer or speedometer, or it may be a separate gauge. It shows the number of hours the tractor engine has operated. It is an essential instrument for helping keep track of the tractor operation so that you can perform periodic maintenance steps when they are due.

Temperature Gauges

Modern tractors may have several types of temperature gauges or warning lights. The most common one is the cooling system gauge which measures the temperature of the coolant circulating through the system. When the engine has warmed up sufficiently, the gauge will indicate "normal" or "run", or the dial may show the actual coolant temperature. If the coolant temperature remains too cold, the engine will not develop its full power and there will be rapid wearing of moving parts. If the engine runs too hot, serious internal damage can occur. In either case the engine should not be operated until the problem is found and corrected.

Many tractors now also have a temperature and pressure gauge for the transmission. The transmission fluid is often used as hydraulic fluid also, so the temperature of the system may depend on the amount of hydraulic system usage; as well as how hard the tractor is pulling. Your operator's manual will tell you the normal limits for the system and what to check if problems occur.

Hobar publications, St. Paul MN
CONTROLS

The controls on your tractor enable you to "tell" the tractor what to do. Figures 8-4 and 8-5 show typical operating controls for the steering column and operator's console of a modern tractor. Remember that controls may be located elsewhere on another tractor.

In order for you to become a safe and skilled tractor operator you must know the function of each control. You will also have to be able to find and use these controls quickly, so you can react in an emergency to stop the tractor or operation of an implement.

Seat Adjustment

Let's start with the seat on your tractor. It should be adjusted to the position that permits you to operate all of the controls from a comfortable sitting position. Most tractors have seats that can be raised or lowered, moved forward or backward, as well as adjusted to the weight of the operator.

Starting Controls

Controls for starting tractors vary somewhat between models. The most common controls are:

1. A key to turn on the ignition and provide power to the starter and engine. On some tractors the key also operates a switch to open and close a fuel supply valve.

2. A starter button that completes the electrical connection to the starter motor. Sometimes the key serves this purpose and when it is turned further in its slot, the engine cranks (Fig. 8-6).

Figure 8-5
OPERATOR'S CONSOLE CONTROLS FOR A MODERN MANUAL SHIFT TRACTOR.
1 Throttle hand lever; 2 Gear shift control lever; 3 Range shift control lever; 4 Engine stop control; 5 Hitch control lever; 6 PTO control; 7 Sensing control lever; 8 Remote hydraulic control levers (one lever for each remote system).

Figure 8-6
COMBINATION IGNITION SWITCH AND STARTER.
Off Position
ACC Position
IGN Position
Start Position
**Clutches and Shifting Levers**

A clutch is a device for disengaging or disconnecting a rotating shaft. We have already mentioned one clutch—the main or engine clutch used to disconnect power from the engine to the transmission when you want to stop or change gears. When disengaged, the gearshift lever can be moved to the desired position. When the clutch is engaged, that is when the pedal is released, the tractor will start moving. To be safe, always engage a clutch gradually after checking to the front, rear and both sides of the tractor.

A type of cluching mechanism is also used to control power to the PTO shaft or belt pulley. In most cases these clutches can be used when the tractor is moving. Your operator's manual will describe which types of clutches are on your tractor.

There may be only one or several gear shifting levers on your tractor. Modern, heavy tractors often have several power and speed ranges available. Shifting between these ranges is done with different levers. Sometimes it is possible to change ranges and directions without using the clutch.

**Engine Speed Control**

The engine speed control is often called the "throttle." Actually, it is a governor control on most tractors. On gasoline or LP-Gas tractors, the throttle lever regulates the governor spring pressure, and a rod leading from the governor controls a throttle plate in the carburetor throat. The throttle plate controls the amount of fuel and air mixture entering the cylinders. The speed of an engine is determined by the amount of fuel and air mixture that is burned during the power stroke.

**Brakes**

Unlike a car or truck, the brakes on a tractor are used for more than slowing down or stopping. Tractor brakes have three functions: (1) to assist two-wheel drive tractors in making short turns in field operations; (2) for emergency stops; and, (3) for parking. Your tractor is equipped with two brake pedals; each one controls the brake on one side of the tractor. If only one pedal is pushed, pressure is applied to the brake in the wheel on that side of the tractor. This slows or stops movement of that wheel and causes the tractor to turn in a circle until the brake is released. Most four-wheel drive tractors have only one brake pedal so there is no brake assistance when turning.

The two brake pedals may be locked together to stop both wheels evenly during travel on the road. For traveling in "road gear" both brakes must be locked together. If you hit only one brake hard when the tractor is traveling fast, the tractor may upset. Always keep both brakes adjusted equally.

Most modern tractors have power or hydraulic brakes. These require less foot pressure, so you need to be very careful in operating them until you are familiar with how they act.

**Steering**

The steering wheel is used to transmit turning effort to the front tractor wheels. Turning effort may be transmitted by shafts, linkage and gears, or it may be transmitted by oil under pressure. Most newer tractors use the latter system called "hydrostatic power steering." Less effort is required to turn the steering wheel, which helps make it less tiring to operate the tractor on rough ground or for long periods.

Four-wheel drive tractors may steer by angling the wheels (crab steering) or by pivoting the tractor in the center (articulated steering). Tractors with articulated steering can easily crush a person standing near the pivot point as they are turned.

**Hydraulic Controls**

The hydraulic system of your tractor may have several different levers. These control the various remote systems and the three-point hitch. Your operator's manual will tell you how the systems operate and which levers control which functions.

**Universal Symbols**

Figure 8-7 shows several universal symbols you are likely to find on your tractor. Learn their meaning so you will know them instantly if needed.
Careful Carl has four safety tips you should heed while learning about tractor controls—

Know the controls and what they do! Put all controls in neutral before starting the engine (newer tractors can’t be started unless this is done).

Do not attempt to start or operate the tractor unless you are in the operator’s seat.

Use the seat belt when your tractor is equipped with a roll-over protective (ROP) frame; always check to make sure the belt is in good condition. Do not use the seat belt if the tractor is not equipped with a ROP device.

Be careful how you dress when operating the tractor. Don’t wear loose clothes that can catch on pedals or become entangled in moving parts. Make sure boots and shoes are slip-resistant.

Learn by Doing

Sit on the tractor and become familiar with the instruments and controls. Practice adjusting the seat to the position most comfortable for you.

Practice locating tractor controls while blindfolded. This will enable you to become familiar with their location so you can find them quickly in an emergency.

Learn the universal symbols for instruments and controls. Practice identifying them.

Give a club demonstration or a speech on the functions of the controls.

Now is an important time to learn other universal tractor symbols. Study and learn those in Figure 8-7. Then turn to your tractor operator’s manual and see if you can find new or different symbols not listed here.
STARTING AND STOPPING THE TRACTOR

You have now learned basic facts about some of the main systems of the tractor. You have also learned many safety rules as well as the importance of making sure your tractor is ready to operate.

Learning the proper way to start and stop a tractor is another important step toward becoming a safe, skilled tractor operator. The best place to start is by reading your operator's manual. Study the manual carefully to learn the exact procedures for your tractor.

General Starting Procedures

Not all tractors use the same starting procedures. This is particularly true for diesel or LP-Gas engines. Here are some rules that should be included in the procedures for starting any tractor safely.

1. Make a daily maintenance and safety check as outlined in the previous unit.
2. Sit in the operator's seat. Adjust the seat so you can reach and operate all of the controls.
3. Place the gearshift in "Neutral" or "Park". This is necessary on some tractors to make the starter work.
4. Make sure the PTO and hydraulic lift levers are in the "neutral" position.
5. Look out for the safety of others. Check carefully to make sure any persons who may be nearby are well out of the way of the tractor and any equipment that may be attached.
6. Put your foot on the clutch. Depress the clutch by pressing down. This reduces the load on the starter and is a good safety precaution in case the tractor is in gear. On newer tractors, a safety switch is provided so the tractor cannot be started unless the clutch pedal is depressed.
7. Turn on the switch and start the tractor.
8. After the engine starts, let it run at half throttle for a few seconds to let the oil pressure stabilize. Avoid pulling heavy loads for the first few minutes of operation.

Starting a Gasoline Engine

In order for a gasoline engine to start and run, the mixture of air and fuel delivered to the cylinders must be in the proper ratio. It takes about 13 1/2 pounds of air to provide enough oxygen to burn 1 pound of fuel for full-load operation. However, an engine with the carburetor adjusted properly for full-load operation may not start without "chooking." The engine must be choked to start properly in cold weather.

The choke is a valve in the carburetor that cuts down on air intake for starting a cold engine. When the choke valve restricts the air flow, more fuel is pulled into the engine; the fuel-air mixture is said to be "rich". When the intake manifold begins to heat up, more of the fuel is vaporized and the choke can be opened. Excessive choking causes many troubles. Raw gasoline washes the oil from the pistons and cylinder walls. Fuel dilutes the oil in the crankcase. When the engine puffs black smoke from the exhaust, it is telling you that the mixture is too rich.

Starting an LP-Gas Engine

LP-Gas tractors are started almost the same as a gasoline tractor. Most LP-Gas engines are designed to start on the vapor from the special fuel tank. After starting the normal fuel delivery system takes over.

Normally the vapor valve is opened for starting and the liquid valve is left closed. The vapor valve should be opened slowly, allowing vapor from the top of the fuel tank to become available. If this valve is opened too quickly, the sudden rush of gas will cause the excess gas valve to close. You will then have to wait a few minutes for the excess gas valve to open again.

The purpose of the excess vapor gas valve is to provide an instant shut-off in case a leak develops in the fuel line from the main tank.

Once the LP-Gas engine has started and warmed up to the proper operating temperature, the liquid withdrawal valve should be opened and the vapor valve closed.

Starting a Diesel Engine

You have already learned that diesel engines do not use a spark for igniting the fuel in the cylinder. Due to the cold temperature of the cylinder and surrounding parts, diesels need some kind of help in starting, particularly in cold weather. Sometimes a heating element is used to heat the air before it reaches the cylinder. More common now is a special device for injecting a small quantity of ether gas with the first few turns of the engine by the starter.

Diesels do not have a choke. In cold weather, excess fuel is supplied by adjusting the throttle or by pushing an excess fuel button.
Don't be in a big hurry to start up or shut down your tractor! Haste can lead to carelessness and accidents. Follow the advice of Careful Carl as he shows you what to do.

Be sure the gearshift is in Neutral or Park before starting the engine.

Don't forget the safety and maintenance check before you start your tractor.

When stopping, reduce engine speed before coming to a halt. Then let the engine run a few minutes at reduced throttle to cool down before shutting off the ignition.

Choking the engine in cold weather gives the proper air-fuel mixture for starting. With a diesel, you might want to use a starting fluid for quick starting and warmup in cold weather.

Finally, remove the ignition key and set the brakes before leaving the tractor.

Then carefully dismount.
If the Engine Doesn’t Start

If the engine—whatever its type—doesn’t start on the first try, wait until the engine parts stop rotating before trying again. If the starter is engaged while the engine is turning, there is a chance of damaging the starter or the ring gear of the engine. In trying to start any tractor, don’t engage the starter for longer than 15 seconds at a time to prevent the battery from overheating, running down, and to protect the starter motor.

Failure to start after several attempts indicates either that something in the starting sequence has not been done or that something may be wrong with some system of the tractor. Perhaps you forgot to turn on the fuel supply, or there might be a loose or broken ignition wire. Then too, the engine may be flooded by excessive choking, or perhaps you did not have the choke out at all. If you cannot find the trouble right away, check with someone who is familiar with the tractor.

On the diesel tractor, the fuel shut-off control must be returned to the RUN position before the engine can be started.

Tractor Driver Certification

If you are 14 or 15 years old and want to be employed off your family’s farm, you must complete the “Hazardous Occupation Certification Program.” This program is required by the U.S. Department of Labor to make sure that you can safely operate farm tractors and machinery. Check with your leader or Extension 4-H Agent to see when and where the training will be held.

A student manual titled “Safe Operation of Agricultural Equipment,” is available for use in the certification program. Write to Hobart Publications, 1234 Tiller Lane, St. Paul, Minnesota 55112. Order number 10076. The manual was written for use by the Cooperative Extension Service, 4-H and Vocational Agriculture Departments.

If you’re younger than 14, you may want to take the classes to help you personally develop farm machinery operation and safety skills. However, you cannot become certified until age 14.

Now that you have learned some safety practices and can start and stop a tractor, it’s time to begin acquiring some basic driving skills. Try the following “Learn By Doing” activities.

Stopping the Tractor

Just as it is important to know how to start the tractor, there are some rules that must be followed when the engine is shut off. The following procedure is suggested. Your operator’s manual will tell you any other things which should be done.

1. Reduce the engine speed with the throttle and let the engine idle for a few minutes. This cools down the engine some and helps prevent warped valves and damaged turbochargers. It also will help keep the engine from backfiring.

2. Shut off the engine. This is done with a switch on a gasoline or LP-Gas tractor. Diesels usually have a fuel shut-off valve, either separate from or included with the throttle.

3. When the engine is completely stopped, put the gearshift lever in “Park” or low gear. Putting the transmission in gear or park will prevent the tractor from rolling away if it must be parked on a slope.

4. Set the brakes. This will also help to make sure the tractor will not accidentally roll downhill.

   Use caution when dismounting from the tractor. A safe tractor operator doesn’t jump on or off a tractor. Use the steps and handholds that are provided and watch your step!

Learn by Doing

Practice getting on and off your tractor properly. How many “paths” are there for mounting and dismounting?

Practice starting and stopping the tractor.

Practice backing the tractor and forward turning.

Drive around open areas, without implements attached, to get the feel of driving.

If your county has a Junior Tractor Operator Contest, plan to enter it. Check with your leader or Extension 4-H Agent.

Learn to operate the garden tractor with a small wagon or other implement such as a plow attached. Practice starting, stopping, backing and turning with the wagon or implement attached.
Checking Up Before You Drive

1. What kind of fuel does your tractor use?

2. What are your tire sizes? front ____________ correct air pressure ____________
   rear ____________ correct air pressure ____________

3. Draw a diagram of the gearshift pattern on your tractor.

4. How many different speeds does your tractor have? forward ____________ backward ____________

5. List some common causes of poor engine starting or failure to start:

6. List the steps in stopping and shutting off the tractor for the night:
   (a) ____________________________
   (b) ____________________________
   (c) ____________________________
   (d) ____________________________

Member Record

To help you summarize your experiences in this first-year tractor project, complete the questions below. (Copy questions onto another sheet of paper to allow space for answers.) This is a sample record sheet. Your leader may have a different form that is used in your county or state.

1. My personal goals for the GETTING ACQUAINTED WITH YOUR TRACTOR project manual were:

2. To achieve these goals, I carried out the following activities:
   (Also list who helped you, such as parents, mechanics, farm equipment dealers, Amoco or other fuel and lubricant dealers, etc.)

3. This year the most important things I learned were:

4. I am using the following safety practices:

5. I carried out the following leadership activities:
What's Ahead...

This concludes Unit I in the 4-H Tractor Project series. You should have learned many new things about tractor safety, operation and maintenance, including the importance of reading your tractor operator’s manual.

In Unit II you will be provided more indepth study on tractor systems, fuels, lubricants, safety and record keeping. And, for the anxious member, you will be introduced to tractor driving.

You just experienced sitting on the tractor, learning the controls, and even starting and stopping the tractor. Well...the next step is driving. Of course there will be additional safety precautions to follow, and you'll also have to learn basic "rules of the road."

Hope you'll join me for Unit II, "ASSURING SAFE, EFFICIENT TRACTOR OPERATION." It's going to be an exciting experience. See you then!
Glossary

ACCIDENT An unplanned occurrence, frequently caused by carelessness or other causes.

ADDITIVE A substance added to oil to enhance certain properties. For example, a material added to engine oil to lessen its tendency to thicken at low temperatures.

ANTIFREEZE A material added to water to lower its freezing point, such as ethylene glycol, alcohol, etc.

ATOMIZE To reduce to minute particles or to a fine spray.

CARBURETOR A chamber in which precisely controlled amounts of gasoline or LP-Gas are mixed with air to form a readily combustible fuel mixture.

COMBUSTION The process of burning.

COMPRESSION The reduction in volume by squeezing together, as in the “squeezing” of a gas.

COMPRESSION RATIO A numerical comparison between the volume of air or fuel mixture in a cylinder before compression and the volume after compression. A ratio of 16 to 1 (16:1) is typical for tractor diesel engines and an 8:1 ratio is common for gasoline engines.

COOLANT A liquid circulated through an engine to absorb and release heat. Usually a mixture of water and antifreeze or rust inhibitor.

COOLING SYSTEM The tractor system which maintains the engine at its optimum operating temperature. When the engine is cold, the cooling system helps to increase the internal temperature so the engine runs most efficiently. When the engine is hot, the system works to cool internal engine parts. The cooling system may also help regulate operating temperatures of other systems, such as cooling transmission and hydraulic oil, etc.

DIESEL An internal combustion engine in which air is compressed in a cylinder until the air becomes hot enough to spontaneously ignite fuel injected into it. The combustion actuates a piston in the cylinder.

DIFFERENTIAL An arrangement of several gears which (1) transmits power from the engine to the wheel drive axles, and (2) allows each drive wheel to rotate at a different speed and still propel its own load.

ELECTRICAL SYSTEM In a tractor, the electrical energy from a storage battery and a generator or alternator which is used to crank the engine, ignite fuel in the engine (gasoline or LP-Gas) and operate controls, switches, instruments, lights and warning devices.

ENERGY The capacity for doing work.

ENGINE, EXTERNAL COMBUSTION A machine using energy from an outside source (for example, steam produced in a boiler) to produce mechanical power to do work.

ENGINE, INTERNAL COMBUSTION A machine using energy created by burning a fuel within the engine itself to produce mechanical power to do work.

EXHAUST SYSTEM The tractor system which carries gases, noise and some heat produced during internal combustion away from the engine and the operator’s station.

FILTER A device that removes solids from a fluid.

FIRING Combustion of a fuel in a cylinder to actuate a piston. FIRING in a spark-ignition engine is controlled by the delivery of the spark through the spark plug. In a diesel, FIRING is controlled by the injection of the raw fuel into the hot, compressed air in the cylinder.

FIRING ORDER Order in which the numbered cylinders of an engine fire. The firing order for a given engine depends upon its design. The order is written, 1-2-4-3, 1-5-3-6-2-4, etc.

FUEL A combustible substance which when burned releases large amounts of chemical energy. Fuels normally used in tractors are refined petroleum products or natural gases to which are added certain other chemicals used to make the fuel burn more efficiently or to protect engine parts.

GOVERNOR CONTROL A device to control and regulate engine speed. May be mechanical, hydraulic or electrical.

HYDRAULIC PRESSURE Pressure exerted through the medium of a liquid.

HYDRAULIC SYSTEM System of a tractor in which a pumped liquid is used to do different kinds of work, such as raise and lower implements, shift gears, assist in steering, and otherwise transfer power from the engine to working points.

IDLE Refers to the engine operating at its lowest speed with the machine not in motion.

IGNITE To catch fire.

INJECTION PUMP Part of the diesel fuel system used to meter and deliver fuel under pressure to the engine injector.

INJECTOR Part of the diesel fuel system that receives a metered charge of fuel, then injects the charge of fuel into a cylinder or chamber at high pressure and at the proper time. Also called “injection nozzle.”

INHIBITOR A material that slows or restrains some chemical reaction, such as a rust inhibitor.

INTERCOOLER Sometimes referred to as the aftercooler. A radiator-type of assembly sometimes used with a turbocharger on a diesel engine. The intercooler cools hot air leaving the turbocharger so that a greater quantity can be forced into the cylinder for compression.

LP-GAS (Liquified Petroleum Gas) Made usable as a fuel for internal combustion engines by compressing volatile petroleum bases to liquid form. When so used, must be kept under pressure or a low temperature in order to remain in liquid form until used by the engine.

LUBRICATION Application of a substance such as a grease or oil to provide a protective film between two surfaces in contact. The lubricant reduces friction, wear and heat buildup between the parts.

MACHINE A group or assembly of parts arranged to transmit forces, motion and energy from one part to another in some predetermined manner.

POWER The ability to perform work. Measured in units of force per units of time.

POWER TAKEOFF (PTO) A mechanical attachment to the power train of a tractor that is used to transmit power to an implement or other auxiliary unit.
POWER TRAIN The overall system of a clutch, transmission, differential, final drives and drive wheels which transmits power from the tractor's engine to the drive wheels or an output shaft (such as a power takeoff).

RATIO The relation or proportion that one number bears to another.

SAFETY The state or condition of being safe from causing or undergoing loss and/or injury.

SLUDGE A pasty substance formed from the mixture of petroleum products, oil and water. It clogs oil lines and interferes with engine lubrication.

SOLVENT A solution which dissolves some other material. For example, water is a solvent for sugar.

STROKE The movement of a piston in a cylinder in a single direction. In an internal combustion engine, piston strokes are named for the process which each stroke causes to occur—intake, compression, power and exhaust.

TORQUE The effort of twisting or turning. A combination of forces used to produce motion.

TROUBLESHOOTING A process of diagnosing the source of the trouble or troubles through observation and testing.

TURBOCHARGER A turbine unit powered by exhaust gases from the engine which compresses fresh air, allowing more to be supplied to an engine so additional power can be developed.

References

The following publications were used in compiling this 4-H Tractor manual. They can also be used to supplement the 4-H Tractor program materials.


Fundamentals of Machine Operation: Tractors; John Deere Service Training, Dept. F, John Deere Road, Moline, IL 61265.

Fundamentals of Service: Engines; John Deere Service Training, Dept. F, John Deere Road, Moline, IL 61265.


Massey Ferguson Product Information Manual (MF 48), Massey Ferguson, Inc., 1901 Bell Avenue, Des Moines, IA 50315.

Massey Ferguson Product Information Manual (MF 2000), Massey Ferguson, Inc., 1901 Bell Avenue, Des Moines, IA 50315.


Safe Operation of Agricultural Equipment: Student Manual; Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112.
SELF-EVALUATION SHEET

4-H TRACTOR—**UNIT 1**

Return to: Educational Aids
National 4-H Council
7100 Connecticut Ave.
Chevy Chase, MD 20815

1. How old are you? ________
2. Are you a Male ________ Female ________?
3. How many girls are there in your club who are taking this project? ________
4. Why did you enroll in this project? ______________________________________

5. Did you like doing the activities? Yes ________ No ________ Why? ________
   (Please explain "why" regardless of your answer)
________________________________________________________________________

6. Did you like having the "Checking Up" section at the end of each lesson? Yes ________ No ________
   Why? _______________________________________________________________

7. What did you learn in this project that you didn't know before? List.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

8. Are any of the words too difficult? Yes ________ No ________
   (If yes, please list those words)
________________________________________________________________________

9. Would you recommend this project to your friends? Yes ________ No ________ Why? ________
  ________________________________________________________________________

10. Was the manual aesthetically appealing? (Consider whether you liked the use of color; paper; illustrations; arrangement of content easy to follow, etc.)
    Yes ________ No ________ Explain _______________________________
   ________________________________________________________________________

11. List three words that describe this project manual. _______________________
    ________________________________________________________________
    ________________________________________________________________

12. What suggestions would you have for strengthening and improving this manual?  
    ___________________________________________________________________
    ___________________________________________________________________
    ___________________________________________________________________

13. Additional Comments: _______________________________________________
    ___________________________________________________________________

NOTE: Thanks so much for completing this evaluation sheet. Your comments will assist us in the future production of 4-H materials for your age group.