Overview
As mentioned in Lesson One, tractors have played an important role in increasing farm productivity, and contrary to what many think, enhancing the safety and health of farmers, ranchers, and agricultural workers. Prior to the introduction of the tractor most farm work was done manually or with animals. During the first half of the 20th Century, the leading cause of farm-related fatalities was livestock, including horses and bulls. The rapid, wide-spread use of tractors greatly reduced the exposure to horses and dramatically reduced the number of people needed to farm. As tractors replaced horses, they also replaced to a large degree, horses as a major source of injury. It would be extremely difficult for young people today to imagine farms and ranches without large green, red, blue, and orange machines crisscrossing the fields.

A tractor is much like a car or truck. It has an engine, cooling system, transmission, fuel, and electrical systems, an operator's station, and in most cases wheels. Tractors operate like a truck with a steering wheel, throttle, brakes, clutch, or transmission gear selector. There are, however, many differences, including a long list of hazards that a tractor operator needs to be aware of.

Lesson Two provides a “big picture” look at the tractor by covering its basic operating components, the importance of the operator’s manual, use of standardized color coding on controls, information provided by the control panel, instrument warning systems, and universal symbols.

Note: Point out that it is not the intention of this presentation or the GEARING UP FOR SAFETY Program to teach specific service or maintenance skills. For assistance in completing maintenance tasks, the operator should refer to the equipment service section of the operator’s manual or contact the implement dealer.

Opening discussion questions:
1. If diesel fuel or gasoline became impossible to obtain and farmers had to return to using horses and mules, would there be fewer or more injuries? Why?
2. Who can list the major systems found on a modern farm tractor?
Lesson Two will discuss the basic tractor components such as the engine, exhaust system, hydraulic system, etc. It does not, however, cover the parts or components that make up the core systems. For example, discussion might take place on the cooling system during which the radiator is identified, but the system will not be broken down into the thermostat or the role of the pressure cap or overflow system. This Lesson also discusses the importance of the operator’s manual, the color coding system found on modern agricultural equipment, how to interpret the operator’s control panel, including audible alerts, visual alerts, warnings, and universal symbols including hand signals.
Basic Components/Systems of a Tractor and Their Functions

Competency 2.1
Identify the following ten basic components or systems of the tractor and briefly explain their functions.

The components or systems of a typical farm tractor include: (This could be done with an actual tractor during a walk around discussion)

1. **Engine**
   - Component of the tractor that converts fuel energy (diesel or gasoline) into a mechanical motion
   - Driving force that moves tractors and agricultural machinery
   - Internal combustion engine of two types:
     a. **Gasoline engine**
        - takes in a mixture of gasoline and air, compresses it, and ignites the mixture with a spark
        - the most widely used type of tractor engine before 1960
     b. **Diesel engine**
        - takes in a mixture of diesel and air, compresses it, and the heat created by the compression ignites the fuel
        - the most widely used type of engine on tractors today

2. **Fuel system**
   - Stores fuel and delivers it to the engine directly using fuel injectors or indirectly using a carburetor
   - Consists of fuel tank, fuel pump, fuel lines, fuel injectors, or carburetor
   - Gasoline engines generally use either carburetion (air and fuel is mixed before the air enters the cylinder) or port fuel injection. (Fuel is injected near the intake valves just prior to the intake stroke)
   - Diesel engines use direct fuel injection. (Diesel fuel is injected under high pressure into cylinder)

3. **Cooling system**
   - Keeps the engine from overheating by transferring heat to the air through a coolant solution that is pumped throughout the engine within a system of lines, engine ports, and hoses
   - Permits engine to operate at normal operating temperature when the weather temperature is cold
   - Consists of radiator, fan, lines and hoses, and coolant solution (usually a mixture of antifreeze and water)
   - Cools parts of the tractor for safety and to prevent mechanical damage
   - Some tractor engines have been designed to be air cooled. These engines do not use liquid coolant but rather large amounts of air to cool the engine components
**Basic Components/Systems of a Tractor and Their Functions**

Electrical system

Hydraulic system

**Competency 2.1 continued…**

4. **Electrical system**
   - Involves the production and distribution of electricity from the battery and alternator/generator
   - Provides power to starter, lights, switches, control panel, horn, etc.
   - On gasoline engines it produces a high-voltage electrical charge and transmits it to the spark plugs via coil and ignition wires

5. **Hydraulic system**
   - Provides power using highly compressed hydraulic fluid to perform various tasks on the tractor and to supply hydraulic power to implements hooked up to the hydraulic system
   - Force that is applied at one point is transmitted to another point using an incompressible fluid
   - Hydraulic fluid is usually oil based
   - Force is usually multiplied in the process
   - Consists of pumps, valves, cylinders, and conduits
   - Lesson Five will cover remote hydraulic systems in more detail
Competency 2.1 continued…

6. Transmission
   - Contains assembly of gears and associated parts by which mechanical power is transferred from the engine to the drive system
   - Allows for increased speed or increased torque
   - Some transmissions are operated by hydraulics similar to an automatic transmission found in a car

7. Operator’s station (ROPS/cab)
   - ROPS
   - Cab (environmentally controlled)
   - Controls

8. Hitching system
   - Used to attach equipment to the tractor
   - Drawbar
   - Three-point hitch

9. Traction system (tires and tracks)
   - Tires
   - Tracks
   - Types of traction systems include:
     - 2WD – 2-wheel drive. Drive force is provided by the rear wheels.
     - MFWD (mechanical front wheel drive) – Real wheel drive with front-wheel assist
     - 4WDAS – 4-wheel drive with articulated steering
     - 4WD – 4-wheel drive
     - T - Tracks

10. Operator's instructions (operator's manual, warnings)
    - Primary source of information that an operator needs to know to safely and effectively operate a piece of equipment
    - Every modern piece of agricultural equipment comes with an operator’s manual
### Which is the most important component?

<table>
<thead>
<tr>
<th>Transmission</th>
<th>Operator station</th>
<th>Hitching system</th>
<th>Traction system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator’s manual</td>
<td>Electrical system</td>
<td>Hydraulic system</td>
<td>Cooling system</td>
</tr>
<tr>
<td>Engine</td>
<td>Fuel system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Activity**

**Competency 2.1 continued…**

**Activity:**

- **Step #1:** Provide each student with one post-it note
- **Step #2:** Ask students to write on the post-it note the component that they feel is the most important from those on this slide
- **Step #3:** Have students stick their post-it note to a wall in the classroom
- **Step #4:** Group the responses to identify the most common response

**Answer:** Operator’s manual

**Discussion**

Why is the “operators manual” the most important component of a tractor?

1. It is the primary source of information that an operator needs to know to safely and effectively operate a piece of equipment
2. It contains a lot of safety information
What types of traction systems are found on agricultural tractors?

**Activity:**

**Step #1:** Prior to revealing the types of traction systems, ask students to brainstorm on the types of traction systems used on agricultural tractors.

**Step #2:** After several possible answers are provided, reveal the pictures of types of traction systems, one at a time.

**Traction system (tires and tracks)**

- Types of traction systems include:
  - **2WD – 2-wheel drive**
    - All of the drive force is supplied by the two rear-wheels. Some farmers will add a second tire to each side of the rear (2-tires per side total, often referred to as duals) to provide additional traction
  - **MFWD – Real wheel drive with front-wheel assist**
    - The major drive force is provided by the two rear tires. The front wheels are powered to assist the rear wheels providing additional traction to the tractor. Some farmers will add a second tires to both back wheels as well as both front wheels (duals)
  - **4WDAS – 4-wheel drive with articulated steer**
    - Drive force is provided by all four tires. Turning is provided by the tractor articulating (pivoting at the point behind the cab and in front of the rear tires)
  - **T – Tracks**
    - Drive force is provided through a track-based systems
    - Some tractors provide a one-track system on each side of the tractor. Other tractors use a two-track system (one track for the rear drive and one tractor for the front drive) on each side of the tractor as shown in the picture
Competency 2.2
Locate and interpret the appropriate section of the operator’s manual that explains the use and function of primary controls found on agricultural tractors and self-propelled equipment

- Students should be able to read the basic safety information found in the operator’s manual. **Note:** Refer to an actual operator’s manual for a tractor and show examples of the caution, warning, and danger labels found in the manual.

**Key point:** The control systems in tractors are continually evolving. GPS-based guidance systems for autonomous operation are being implemented. Tractors of the future likely will not have some of the components mentioned below as completely autonomous operated vehicles are developed and deployed.
Primary Controls on Tractors

### Competency 2.3
Locate and explain the function of each of the primary controls found on typical agricultural tractors and self-propelled equipment, including:

**Typical controls found on a tractor include: (could be done while examining an actual tractor)**

1. **Brakes** – The pedal or pedals that are located on the right-hand side of the floorboard of the operator's station. Used to slow down or stop the tractor or self-propelled equipment. Tractors are usually equipped with two brake pedals that independently brake the rear wheels to allow for tighter turning radius. When traveling on public roadways the two brake pedals need to be locked together. Large 4-wheel drive tractors will have only one pedal.

2. **Steering wheel** – Used to turn the wheels and change the direction of the tractor.

3. **Throttle** – Used to control the flow of fuel into the engine and therefore the engine speed.

4. **Clutch** – The foot pedal (typically on the left-hand side of the floorboard) and mechanism that disengages the engine’s power from the drive wheels. When the clutch is depressed, the power to the drive wheels is disconnected. The clutch is used when the operator shifts gears or is bringing the tractor to a stop.

5. **Transmission selector** – Used to change the tractor’s speed. Many newer tractors have some form of an automatic type transmission that uses hydraulic power to permit changing gears without the use of a clutch.

6. **Parking brake** – Used to help stabilize the tractor or self-propelled equipment when parked. Typically engaged by pulling the parking brake lever or moving the transmission control lever to the “PARK” position.

7. **Auto steer** – Tractors and self-propelled machines are utilizing GPS and camera vision technology to auto guide the machine.
Competency 2.3 continued….  

Typical controls found on a tractor include: (could be done while examining an actual tractor)

8. **Turn-signal control** - Usually a lever that turns on a flashing light on either side of the tractor or combine to indicate which direction the operator plans to turn.

9. **PTO-engaging control** – Usually located to the right of the operator when seated. Engages and disengages the PTO. PTO systems are designed to operate at 540 RPMs (1 3/8", 6 spline shaft), 1,000 RPM (1 3/8", 21 spline shaft) or 1,000 RPM (1 ¾", 20 spline shaft).

10. **Hydraulic controls** – Usually located to the right of the operator when seated. Controls the flow rate and direction of hydraulic fluid.

11. **Windshield wipers** – Used to clean off dust, debris, rain, and snow from cab window.

12. **Battery disconnect switch** – Cut ALL power to the tractor.
Primary Controls on Tractors

13. Fuel tank shut-off valve – Most tractors have a valve that allows the fuel to be shut-off at the tank. On tractors or machines with electrical fuel pumps, the pump acts as a shut-off when the key is moved to the “off” position
14. Hazard lights control – Usually a button that turns on flashing yellow lights to indicate the tractor/equipment is a hazard to approaching or following vehicles.
15. Fuel shut-off Mechanical – The switch or knob used to stop the flow of fuel to the engine, therefore shutting down the engine
16. Fuel shut-off Electric – Some tractors use an electronic system where the fuel shut-off is a function of the key/switch
17. Lights – Modern farm equipment is equipped with lights for road travel and for conducting field work. Road travel lights include: flashing amber lights, turn signals and headlights. Field lighting include high powered lights which at minimum provide excellent views to the front and rear of the machine. Side view lighting is common on newer machines
18. Window defroster control (not shown) – Redirects air flow to windows or conducts heat through internal wires in windows to prevent or diffuse condensation, snow, or ice build-up on windows
19. Horn – Modern tractors and other self-propelled equipment often are equipped with a horn

Competency 2.3 continued…

Typical controls found on a tractor include (could be done while examining an actual tractor)
Competency 2.4
Explain the reason for using color coding on primary controls found on agricultural tractors and self-propelled equipment.

Review the following:

- Developed to make switches and controls readily recognizable for most makes and models of tractors and self-propelled machines.

- Allows operator to quickly identify controls within the tractor cab and helps facilitate training for new equipment.

- Helps reduce the potential for activating the wrong control.

- Compare color coding used on other products.
Competency 2.5
Identify the following applications of color-coding used in a typical operator station.

**Activity:**
Step #1: Display the slide
Step #2: Ask students to form groups of 2 to 3
Step #3: Instruct each group to identify the machine function with the appropriate color code
Step #4: Discuss the function and why uniform color coding is important. Move to the next slide to display the answers

1. **Red** – Controls that stop engine
2. **Orange** – Controls that alter machine ground motion such as engine speed and transmission levers
3. **Yellow** – Controls that engage powered components including the PTO
4. **Black** – Controls that adjust machine function

**Key Points:**
1. The pictures show that the controls are illustrated with color coding. Bright colors make the PTO engagement control highly visible in yellow along with the ground motion controls in orange.
2. Most older tractors are not designed with color coded controls, and the operator will have to be become familiar with the function of each control. Refer to the operator’s manual for descriptions of control functions.
Competency 2.6
Locate the appropriate section of the operator’s manual that explains the instruments and their functions, and explain the proper responses to abnormal readings.

Refer to operator’s manual, and explain that the layouts for instrument panels and formats for the operator’s manuals vary widely by make and model of equipment.

It would be beneficial to display operator’s manuals for several models so that students can familiarize themselves with various layouts and formats.

Some instruments are simple gauges while others are detailed digital readouts.

Some newer tractors include a combination of analog and digital gauges.
Competency 2.7
Identify, locate, and explain the function of each of the following instruments found on typical tractors and self-propelled equipment

Instruments typically found on tractors and self-propelled equipment include:

1. **Tachometer**
   - Gauge which indicates the engine speed in revolutions per minute (RPM)
   - Typically, the tachometer notes that display is in “RPM x 100” or “RPM x 1000”.
   - Tachometer is also used to indicate PTO speed.

2. **Oil-pressure gauge/light**
   - Displays the status of the oil pressure in the engine
   - The picture on the top right shows the universal symbol for oil pressure

3. **Battery-charge indicator**
   - Indicates when the battery is being discharged or being charged
   - May display the amount of charge the battery is receiving
   - The picture on the bottom left shows the universal symbol for battery charge indicator

4. **Temperature gauge/light**
   - Indicates the temperature of the engine coolant
   - Too high of a temperature can mean the engine is overheating

**Key point:** Some modern engine instrument panels may indicate the operator should “CHECK ENGINE”. If this instruction is given, the operator should refer to the operator’s manual.
Competency 2.8
Recognize and interpret the following audible and visual messages that might be encountered on modern agricultural tractors, combines, other self-propelled equipment, and trucks. (These might not be present on all vehicles)

Audible and visual messages on modern agricultural tractors and other self-propelled equipment include:

1. **PTO engagement warning** (top right symbol on slide)
   - Visual warning – a light in the main control panel
   - Operators should ensure the PTO is disengaged before starting equipment

2. **Back-up warning devices**
   - Audible warning – usually a intermittent beeping sound
   - All government vehicles and equipment are equipped with these devices
   - Newer pickup trucks and self-propelled equipment are sometimes equipped with them
   - Farm tractors are typically not equipped with this type of warning

3. **Hazard warning lights indicator** (bottom right symbol on slide)
   - Visual indicator light found on the dash
   - Button has a triangle on it and controls the hazard warning lights on the outside of the tractor

4. **Turn signals** (top left symbol on slide)
   - Visual indicator light found on the dash
   - Newer tractors have turn signal controls that are similar to automobile controls
   - Usually, the control is a lever on the left side of the steering wheel which controls the turning lights on the outside of the tractor

5. **Seat belt warning** (bottom center symbol on slide)
   - Warning can be audible and/or visual depending on the make and model
   - Found mostly in trucks and cars
   - Not typically found on farm tractors

6. **Parking brake engaged warning** (bottom left symbol on slide)
   - Warning can be audible and/or visual depending on the make and model
   - Usually indicated by a light on the instrument panel showing the word “brake” in red or the universal symbol for parking brake in red
Why are Universal Symbols Used?

Competency 2.9
Explain the reasons for the use of universal symbols on agricultural tractors and machinery.

- Enable people to communicate
- Save time
- Prevent incidents that could cause property damage
- Reduce risk of injury
- Remove language barriers

Briefly discuss the following origins of universal symbols.
- Developed to standardize control symbols on all makes and models of tractors
- Reduces confusion when operating multiple tractors
- Assists workers with low reading levels. Utilizes pictures instead of words for increased understanding
What do the following universal symbols on tractors and machinery represent?

Competency 2.10
Locate and interpret the use of specific universal symbols found on agricultural tractors and machinery using the operator’s manual.

Note: Use operator’s manual and actual tractor to point out various symbols.

Activity:
Step #1: Starting with the top left symbol, ask students to suggest what the symbol represents
Step #2: After several possible answers are provided, reveal the answer

A few examples are on the slide:

Top

Left safety alert symbol, means “Attention! Become alert! Your safety is involved!”

Center left fast

Center right hour meter/elapsed operating hours

Right basic symbol for engine coolant

Bottom

Left hazard warning lights

Center left slow

Center right basic symbol for fuel or fuel system

Right basic symbol for engine oil
What do the following universal symbols on tractors and machinery represent?

Activity:
Step #1: Starting with the top left symbol, ask students to suggest what the symbol represents.
Step #2: After several possible answers are provided, reveal the answer.

Discuss the following examples of universal symbols on the slide:

- **Top**
  - Left: grease (top) or oil (bottom) lubrication point
  - Center: (crush point) crushing of whole body - force applied from above
  - Right: auger conveyor

- **Bottom**
  - Left: thrown or flying object - whole body exposure
  - Right: danger hazard sign

Competency 2.10 continued…
Competency 2.11
Identify and briefly explain the function of typical safety features found on modern agricultural tractors, including:

Typical safety features found on modern agricultural tractors include: (Consider using an actual tractor to point out these safety features)

1. **Neutral-start switches** – Allows the engine to be started only when the tractor is in neutral or park. Helps prevent unintentional start-ups and runovers

2. **Field and highway lighting** – Lights that allow the operator to see better while working at night and allows others to see the tractor at a distance

3. **ROPS – Roll Over Protective Structure** – Provides a safe zone for the operator in the event of a tractor rollover. Modern cabs are ROPS-equipped. The three types of ROPS are: 2-post, 4-post, and Cab-equipped

4. **Seat belt** – Prevents the victim from being thrown from the tractor in the event of a rollover
Safety Features on Modern Tractors

- Power steering and brakes
- Safety signs
- Ergonomic seat and control layout
- Standardized controls
- Slip-resistant surfaces
- Mirrors and cameras
- Hand-holds and steps
- Climate control with air filtration

Competency 2.11 continued...

Typical safety features found on modern agricultural tractors include: (Consider using an actual tractor to point out these safety features)

5. **Power steering and brakes (not shown)** – Allows for better maneuvering and stopping of the tractor with less operator effort

6. **Safety signs (not shown)** – Alerts the operator of potential safety hazards

7. **Ergonomically designed seat and control layout** – Help reduce fatigue

8. **Standardized controls** – Color coded controls that reduce the confusion when working on multiple tractors

9. **Slip-resistant surfaces** – Assure stable footing and prevent falls

10. **Mirrors and cameras** – Allows operator to see in directions that might otherwise be difficult such as blind spots

11. **Hand-holds and steps (not shown)** – Allow for safe access to the tractor’s operator station

12. **Climate control with air filtration** – Reduces the level of dust and maintains a comfortable temperature
Importance of Universal Hand Signals

- Enable people to communicate when beyond hearing range
- Save time
- Prevent injuries
- Reduce risk of severe injury or death
- Removes language barriers

Competency 2.12
Explain the importance of being able to use and interpret standard hand signals when working around agricultural equipment

The purpose of hand signals include:
- Enable people to communicate when they are beyond hearing range or near loud machinery
- Save time
- Prevent incidents that could result in property damage
- Reduce risk of severe injuries or death
- Removes language barriers
What is the hand signal for each of the following functions?

1. **Start engine**
   - Simulate cranking of an engine by moving arm in circular motion at waist level

2. **Stop engine**
   - Draw either hand, palm down, across the neck in a “throat-cutting” motion

3. **Come to me or come help**
   - Raise arm vertically overhead, palm to the front, and rotate in large horizontal circles

4. **Move toward me or follow me**
   - Look toward the person or vehicle you want moved
   - Hold one hand in front of you, palm facing you and move your arm back and forth

**Competency 2.13**
Explain the message associated with each of the following commonly-used hand signals

**Activity:**
- **Step #1:** As each “message” is displayed, ask the students to demonstrate the hand signal that may be utilized to signal the message.
- **Step #2:** Point out to the students that if each farmer developed their own hand gestures for their farming operation then communicating when you move to another farm would be difficult if not impossible. It would be similar to communicating using two different languages.

Demonstrate the following hand signals. Divide up the class and see if they can communicate to each other using just hand signals.

1. **Start engine**
   - Simulate cranking of an engine by moving arm in circular motion at waist level

2. **Stop engine**
   - Draw either hand, palm down, across the neck in a “throat-cutting” motion

3. **Come to me or come help**
   - Raise arm vertically overhead, palm to the front, and rotate in large horizontal circles

4. **Move toward me or follow me**
   - Look toward the person or vehicle you want moved
   - Hold one hand in front of you, palm facing you and move your arm back and forth
Competency 2.13 continued…

Demonstrate the following hand signals. Divide the class and see if they can communicate to each other using just hand signals.

5. Move out or take off
   - Face the desired direction of movement; hold arm extended to rear
   - Swing arm overhead and forward in direction of desired movement until it is horizontal (palm down)

6. Speed up
   - Raise hand to the shoulder, fist closed; thrust the fist upward to the full extent of the arm and then back to the shoulder rapidly several times

7. This far to go
   - Place palms at ear level, facing head, and move laterally inward to indicate remaining distance to go

8. Slow down
   - Extend arm horizontally sideward, palm down; wave arm downward at 45 degrees several times, keeping arm straight; raise arm to horizontal and repeat cycle several times
What is the hand signal for each of the following functions?

9. Lower equipment
   - Make circular motion with either hand pointing to the ground

10. Raise equipment
    - Make circular motion with either hand at head level with index finger up

11. Stop
    - Raise hand upward to full extension of arm, palm to front (hold position until signal is understood)

Competency 2.13 continued...

Demonstrate the following hand signals. Divide the class and see if they can communicate to each other using just hand signals
How could this have been prevented?

Youth involved in tractor accident dies from injuries

Gearing Up Daily News

Rolfes – A Rolfes youth died from injuries sustained when he was trapped between the wheels of a tractor and a tree for several hours on Saturday afternoon. Dale Whiley, 15, of Rolfes, died Tuesday at the University of Iowa Medical Center. Whiley, of 3521 Lowellville Road, was flown to the hospital after a friend found him trapped around 2:00 p.m. His parents, Joseph and Paula, were not home at the time. Whiley was doing some lawn work on private property near Grisham Road when the tractor apparently struck a tree, knocking Whiley from the tractor and pinning him against another tree, according to reports from the Knox County Sheriff’s Department.

Case Study
Ask the students to analyze the case study, identifying the issues that led to the accident and what could have been done to prevent it from occurring

Review
Use the review questions included in the lesson plan to assess how much the students absorbed from the lesson. If students are unable to answer a question correctly, review the related subject matter and encourage students to ask for clarification if they don’t understand.